CASE STUDY

BOOKLET

KISEM DAY | 2023 EDITION | VOL. 1

TEXTILE

ENERGY SAVING OPPORTUNITIES IN BOILERS

IIT Madras

Assessment Date: 25-29 July 2023

Summary:

The detailed energy assessment of boilers carried out in a textile manufacturing plant in Theni, Tamil Nadu, identified the possibilities of energy saving and the implementation resulted in a saving of about ₹3.60 million per annum in boilers alone. Assessment recommendations amounting to ₹1.3 million were recommended. The major cost savings of ₹2.11 million per annum resulted from reducing excess air to acceptable limits. Reduction in boiler blowdown resulted in a saving of ₹123,505 per annum. Also, increasing the feed water temperature resulted in an additional saving of ₹1.36 million per annum. The total implementation had an ROI in about 4.3 months.

Boilers and their operating conditions:

There were two boilers in the plant – 4 TPH Wood fired Boiler and 6 TPH Coal fired Boiler. Both boilers have a rated pressure of 10.5 barg and are operated with cut in and cut off pressure of 6 and 7 barg respectively. The Gross Caloric Value (GCV) of wood and coal used in the plant are 2,300 kcal/kg and 4,500 kcal/kg respectively. Both boilers have an air preheater, ID and FD fans without VFD. The feed water temperature for both the boilers are 65.5 °C. The cost of wood and coal are ₹5 and ₹8 respectively.

Boiler 1 products steam at the rate 1.5 tons per hour while consuming wood at the rate of 500 kg per hour. It has a flue gas temperature of 250 °C. The steam to fuel ratio is 3.0 kg steam per kg of wood. Boiler 1 has an overall combustion efficiency of 77%.

Boiler 2 products steam at the rate 2.25 tons per hour while consuming coal at the rate of 416 kg per hour. It has a flue gas temperature of 126.48 °C. The steam to fuel ratio is 5.41 kg steam per kg of wood. Boiler 2 has an overall combustion efficiency of 71%.

Excess air loss in Boiler 1:

Typically for an old Single Pass wood fired boiler, the excess air requirement is 100%. But the actual excess air in Boiler 1 was 123%.

Excess air loss in Boiler 2:

Typically for a Fluidized Bed Combustion (FBC) coal fired boiler, the excess air requirement is 60%. But the actual excess air in Boiler 2 was 337%, which is very high.

Blowdown losses:

As water gets converted into steam in the boiler, the dissolved particles in water gets concentrated in the boiler. Having high Total Dissolved Solids (TDS) water in the boiler reduces its performance by the formation of scales. As a result, water is removed from the boiler periodically to keep the TDS in check. This water removal is called blowdown. Since water is removed at high pressure and temperature, a significant energy is wasted during blowdown. Blowdown can be reduced by using low TDS water and maximizing condensate recovery.

The total steam generation for both the boilers was 90 tons per day. The feed water rate was 35% with an TDS of 280 ppm. The maximum recommended TDS for the boilers is 3000 ppm. The blowdown for the boilers was 3.6%.

The blowdown percentage can be reduced to 1.5% by bringing the condensate recovery from 65% to 85%.

Overview:

A boiler is a closed vessel that heats water or other fluids to generate steam, which can be used for a wide range of purposes such as heating, power generation and industrial processes. Boilers are commonly used in industries such as manufacturing, healthcare, foodservices among others. The basic principle of a boiler is to convert water into steam with heat energy. This is done by burning fuel in a furnace, which produces hot gases. These gases are then passed through a heat exchanger where they transfer heat to the water. The water is heated until it reaches its boiling point and vaporizes into steam.

In South India, the commonly used fuel in boilers are Biomass Briquettes, coal and wood.

Usually, all boilers are provided with excess air for complete combustion to take place. The requirement for excess air depends on the type of fuel and boiler. Providing more air than required reduces boiler efficiency because we are taking air at ambient temperature and heating it to a higher flue gas temperature unnecessarily. Excess air also increases ID (Induced Draft) and FD (Forced Draft) fans power consumption.

Condensate recovery:

Condensate recovery not only reduces blowdown losses but it also increases boiler efficiency since condensate water has high energy because of its high pressure and temperature. As more condensate recovery is done, more energy can be saved. During audit, the condensate recovery for the boilers was at 65%. It can be improved to 85% by installing more condensate systems in the plant processes. Increasing condensate recovery increases feed water temperature.

Recommendations:

Install oxygen sensor in the boilers to control Variable Frequency Drive (VFD) of the ID and FD fans to reduce excess air to recommended levels. Bring condensate recovery to 85% by installing more condensate recovery system for all processes in the plant to increase boiler efficiency and reduce blowdown.

Return on investment:

The cost of installing oxygen sensor and VFD for ID and FD fans for Boiler 1 and 2 was ₹200,000 and ₹500,000 respectively. The cost of installing new condensate recovery system for all the process was ₹600,000. The return on investment (ROI) was approximately 4.3 months.

Recommendation	Saving in kg of fuel	Saving in Rs.	Investment cost in Rs.	ROI in Months
Reduce Excess air in Boiler 1 to 100% from 123%	58,420	292,100	200,000	8.2
Reduce Excess air in Boiler 2 to 60% from 337%	227,150	1,817,200	500,000	3.3
Bring blowdown to 1.5% from 3.6% by increasing condensate recovery to 85%	19,598	123,505	600,000	4.8
Increase feedwater temperature from 65.5 °C to 85 °C by increasing condensate recovery to 85%	214,344	1,363,752		
Total		**3,596,557**	**1,300,000**	**4.3**

Energy saving measures:

For annual calculations, 300 working days per year and the 24-hour operation are considered.

- Reducing excess air to 100% will save wood consumption in Boiler 1 by 58,420kg per annum.
- Reducing excess air to 60% will save coal consumption in Boiler 2 by 227,150 kg per annum.
- Reduces blowdown to 1.5% and will save 11,093 kg wood and 8,505 kg coal per annum.
- Increasing feed water temperature to 85°C by increasing condensate recovery reduces fuel consumption by 2.05% in both boilers.

Industrial Energy Assessment Cell
KISEM

Industrial Energy Assessment Cell (IEAC)
Kotak IITM Save Energy Mission (KISEM)
Indian Institute of Technology Madras, Chennai
Ph: +91 90033 59811 Email: ieac2@icsrpis.iitm.ac.in

TEXTILE

ENERGY SAVING OPPORTUNITIES IN AIR COMPRESSORS

IIT Madras

Assessment Date: 02-06 May 2023

Summary:

The detailed energy assessment of compressors carried out in a textile mill in Dindigul, Tamil Nadu, identified the possibilities of energy saving and recommended a saving of about ₹4.95 million per annum in compressors alone. Assessment recommendations amounting to ₹1,900,000 was proposed, resulting in a saving of about 60% on the original energy consumption of compressors.

Compressor layout:

In the plant, compressors are used for Carding, Comber, Simplex, Spinning, Autoconer and cleaning purposes. There are three reciprocating compressors in the plant operating at 8 barg – two 45kW (250 CFM) compressors and one old 45 kW compressor. The old 45 kW is used as backup compressor and rarely used. No dedicated fresh air intake ducts was installed

Audit analysis:

Actual compressed air requirements of plant:

For various machines in the plant, the actual compressed air requirement is measured using a compressed air flow meter and total actual compressed air

S. No	Machine name	Required CFM	Qty	Total CFM	Remarks
1	Nestiling	3	4	12	
2	Veetal	5	1	5	
3	Carding LC300A/V3	0.5	14	7	
4	Carding LC33	0.5	3	1.5	
5	LD2	0	3	0	
6	Unilap	4	2	8	
7	LRSB 851	0	3	0	
8	LRSB 951	0	3	0	
9	Comber	0.5	14	7	
10	Simplex LF 1400A	0.5	7	3.5	
11	Spinning LR6 (Auto Doff)	5.5	2	11	16's CHY
12	Spinning LR6 (Auto Doff)	1.5	3	4.5	40's CHY
13	Spinning LR6	1	12	12	
14	Autoconer savio	14	6	84	Cuts 140
15	Autoconer	12	2	24	Cuts 140
16	Cleaning	25	1	25	
17	Others	10	1	10	
	Total			215	

Overview:

Compressors are present in almost all textile industries and the energy consumed by the compressors generally forms a significant part of the energy bill of the industry, particularly in small and medium industries. Thus, any improvement in performance of compressor by the way of leakage reduction, re-configuration, optimal pressure setting, utilization, and proper piping will result in substantial energy saving.

In general, a leakage of 1 CFM will result in a loss of about 4.8 kWh per day.

requirement of the whole plant was calculated as below.

The plant has a total compressed air requirement of 215 CFM. Allowing a 10% allowance for air leakage, the compressed air requirement of the plant was 237 CFM.

Leakage study:

A detailed air leakage study was carried out in the entire plant using an ultrasonic air leak acoustic imager and a total of 196 air leakage points of various severity have been identified.

In the air leakage study, it is found that there is a 60% leakage on the 45 kW Compressor 1 by studying its loading and unloading pattern when all the air usage in the plant had been stopped.

Specific power consumption:

The design-specific power consumption of the compressors was 0.2 kW/CFM. New energy efficient screw compressors have a specific power consumption of 0.15 kW/CFM for compressed air generation at 8 barg. And the installation of VFD will eliminate the unloading energy loss of the screw compressor. Further, by regular compressor maintenance and using cool, clean and dry air intake will result in decreased specific power consumption.

Return on investment:

The cost of the new screw compressor of 55 kW along with VFD and arresting the leakages is ₹1,900,000. The ROI is approximately 4.6 months.

Recommendation	Saving in kWh	Saving in Rs.	Investment cost in Rs.	ROI in Months
Installation of a new energy efficient 55 kW screw compressor with VFD and arresting air leakages	4,50,000	49,50,000	19,00,000	4.6

Recommendation:

- Periodically check and arrest air leakages.
- Replace the two reciprocating compressors with a single 55 kW screw compressor with VFD.

Energy savings:

- For annual calculations, 24-hour, 360 working days per year and the power cost at ₹11/kWh are considered.
- Currently, the compressor power consumption was 2500 kWh per day.
- Arresting air leakages and replacing the two compressors with a single new 55 kW Compressor with VFD having a specific power consumption of 0.15 kW/CFM delivering 257 CFM, the energy consumption of the compressors was reduced to 1000 kWh per day.
- Cumulatively the net resultant was 60% energy saving on the original consumption of the compressor.

Industrial Energy Assessment Cell
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Industrial Energy Assessment Cell (IEAC)
Kotak IITM Save Energy Mission (KISEM)
Indian Institute of Technology Madras, Chennai
Ph: +91 90033 59811 Email: ieac2@icsrpis.iitm.ac.in

TEXTILE

ENERGY SAVING OPPORTUNITIES IN HUMIDIFICATION PLANT

IIT Madras

Assessment Date: 08-09 May 2023

Summary:

The detailed energy assessment of Humidification Plant (HF Plant) carried out in a textile mill in Dindigul, Tamil Nadu, identified the possibilities of energy saving and recommended a saving of about ₹4.46 million per annum in Humidification Plant alone by keeping supply air flow 10% higher than exhaust air flow, replacing damaged ducts and having proper maintenance. Assessment recommendations amounting to ₹1,500,000 was proposed. It is a 37 % saving on the original power consumption of the Humidification Plant.

Working of the Humidification Plant:

The Humidification Plant adds moisture to air supplied to various yarn and textile processing area to maintain the required high relative humidity. Water is made into aerosols by numerous nozzles by spraying into the incoming air stream. Since the latent heat of vaporization is taken from the air, the air temperature is reduced.

There are two main fans (Supply and Exhaust) in the HF Plant. Supply fan is used to supply fresh air into the HF Plant. The fresh air duct is provided with a filter to remove any particulate matter in the fresh air. It is also provided with a damper to control the amount of fresh air entering the HF Plant. The Exhaust fan is used to remove the polluted air (with yarn threads) from the process area. The exhaust duct has a rotating drum filter to capture the yarn threads in the exhaust air. The captured yarn threads in the filter are periodically removed by the suction nozzles near the filter automatically. The exhaust duct also has a damper to control the amount of return air back to the humidification plant after filtration.

To ensure HF Plant is capable of meeting the needs of the factory throughout the year, the internal and external air conditions are based on the hottest and driest season (summer season).

Observation:

In the plant, cotton is processed. Cotton requires a Relative Humidity (RH) of 65 -85% for spinning. There are five Humidification Plants in the factory.

Low air washer efficiency:

The supply and exhaust air conditions of the HF Plants are as follows.

HF Plant	Dry bulb, °C	Wet bulb, °C	RH, %	Dry bulb, °C	RH, %	Air Washer Efficiency, %
	Initial			Final		
Autoconer	30	27	79.1	28	92.5	67%
Spinning 1	32.5	27	67.7	29	89.1	64%
Spinning 2	32	26.5	64.8	28	88.8	73%
Simplex	30	27	79.1	27.5	88.7	83%
Carding	30	26.5	75.9	28.5	89	43%

Overview:

Humidification plants are integral part of textile industry. Usually, there will be many Humidification Plants in a typical textile industry as humidity is integral for manufacturing processes. Controlling the humidity of indoor air has a direct positive impact on productivity and is essential for ensuring quality in the textile sector. Yarn and textiles, particularly natural fibers, are very sensitive to air quality. Inadequate humidity levels frequently result in the tearing of yarn, which interrupts production, causing costly disruptions.

The decrease in electrostatic discharge (ESD) from materials being treated is another important benefit of optimal air humidity in the textile production process. By maintaining an RH of around 50%, static build-up is naturally dissipated.

Improved humidity also effectively prevents typical health-related illnesses of employees associated with a dry working environment.

The fans are the main energy consuming equipment in the Humidification Plant. Thus, any improvement in the performance of fans by way of minimizing pressure drop, reconfiguration, proper ducting and maintenance will result in substantial energy savings.

Air washer efficiency is calculated by dividing actual reduction in air temperature by ideal reduction in air temperature. The ideal output air temperature is wet bulb temperature at inlet and it is achieved when Relative Humidity reaches 100%. Usually, the air washer efficiency should be above 85%. Here, the air washer efficiency is poor due to clogged water nozzles and low air flow.

Clogged nozzles

Damaged ducts

Damaged eliminator sheets

Supply and exhaust flows:

The actual air flow deviates from the design air flow because of high duct lossesdue to damaged ducts. Replace damaged ducts to increase flow of both supply and exhaust fans. The supply and exhaust flow for the five HF Plant are tabulated below.

HF Plant	Supply				Exhaust				
	Design Flow	Actual Flow	Actual Power	Flow per kW	Design Flow	Actual Flow	Actual Power	Flow per kW	Excess Supply flow
Autoconer	90,000	55,833	19.98	2,794	90,000	73,749	14.57	5,062	-24%
Spinning 1	1,15,000	79,695	30.15	2,643	1,15,000	92,291	31.22	2,956	-14%
Spinning 2	1,15,000	79,695	30.93	2,577	1,15,000	92,291	22.64	4,076	-14%
Simplex	45,000	32,310	15.98	4,044	45,000	26,996	6.90	3,912	139%
Carding	45,000	31,420	13.01	4,829	45,000	30,368	7.17	4,235	107%

Also, keep the supply air flow 10% higher than the exhaust air flow so that almost all supply air exits through the exhaust fans and is filtered. The amount of return air and fresh air can be adjusted through dampers, according to requirements.

Each HF Plant has one, two or three supply and exhaust fans. Since the Humidification Plant is designed for summer conditions, it is underloaded during night and non-summer months. But all fans are running at all times. During underload conditions, only fresh air and return air dampers are used. They don't reduce power consumption.

Instead, install VFD for at least one supply and exhaust fan in an HF Plant and operate them based on indoor Relative Humidity.

Return on investment:

The estimated cost of installing VFDs for at least one fan in supply and exhaust in each HF Plant replacing damaged ducts and regular maintenance were ₹1,500,000. The ROI was approximately four months.

Recommendation	Saving in kWh	Saving in Rs.	Investment cost in Rs.	ROI in Months
Install VFD for at least 1 supply & exhaust fan in each HF Plant				
Improve air washer efficiency by proper nozzle maintenance and air flow	405,000	4,455,000	1,500,000	4.0
Improve CFM/kW by reducing duct resistance				

Recommendation:

Install VFD for at least 1 supply and exhaust fan in each HF Plant to reduce power consumption during non-peak times.

Bring air washer efficiency to above 85% by doing proper maintenance on water nozzles and maintain good air flow.

Improve CFM/kW by reducing repairing damaged ducts.

Energy savings:

The overall energy consumption of the five HF Plant was 10,95,000 units per year. Installing VFD for at least one supply and exhaust fan in each HF Plant, regular nozzle cleaning and maintenance would save around 405,00 units per year. The cost of electricity is 11 per kWh. The cost of VFD was 1,500,000. The ROI was four months.

TEXTILE

ENERGY SAVING OPPORTUNITIES IN WASTE RECOVERY SYSTEM (WRS)

IIT Madras

Assessment Date: 02 - 06 May 2023

Summary:

The detailed energy assessment of waste recovery system (WRS) carried out in a textile mill in Dindigul, Tamil Nadu, identified the possibilities of energy saving and the recommended saving of about ₹1.98 million per annum in WRS alone by replacing filter material, repairing mechanical drive of blower and arresting air leakages. Assessment recommendations amounting to ₹200,000 were implemented. It is an 28.57 % saving on the original power consumption of the WRS.

Configuration:

There are two waste recovery systems in the plant – VXL 1 and VXL2. Both WRS system are similar in specification, and have a 37-kW blower each.

Carding machines 1 to 11 are connected to VXL 1 and carding machines 12 to 20 are connected to VXL 2.

High Power consumption of blowers:

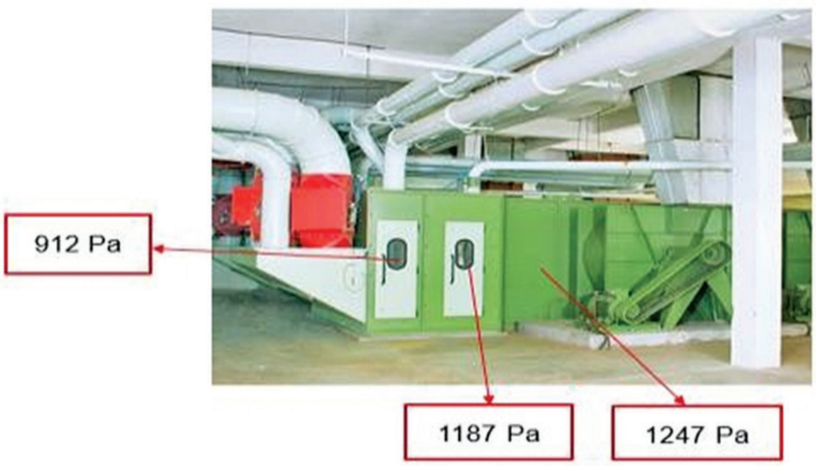
It is also found that under similar operating conditions (similar flow and fan side pressure), the VXL 1 blower is consuming high power (37.0 kW) compared to VXL 2 blower (26.13 kW). Upon further inspection, it is found that it is due to a faulty mechanical drive in VXL 1.

Pressure drops across primary and secondary filters:

The vacuum pressures measured before and after the primary and secondary filters in the VLX 1 and 2 are shown below.

It is found that both WRS produce

VXL Line 1



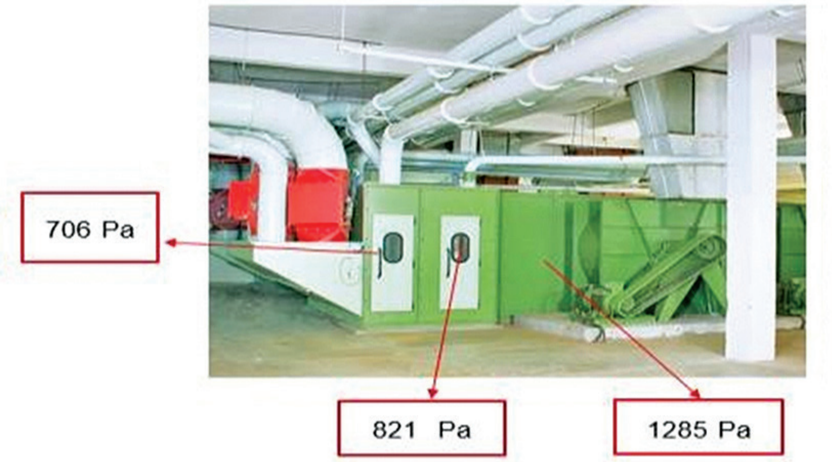
Connected Carding : 1 - 11
Power Consumption : 37 kW

Overview:

Textile mills have been operating the waste recovery system (WRS) to suck the waste from the cards, combers and blow room. The waste consists of short cotton fiber which are undesirable in the yarn. The waste thus collected is made into a bale by the WRS. Each waste producing machines such as cards, combers and blow room are having ducts through which, the waste is sucked into the WRS. The main component in an WRS is the blower. The blower produces the necessary suction pressure in the duct where waste removal is required. The waste collected is made to pass through 2 filters – primary filter and secondary filter. The primary filter collects majority of the short fibers and the secondary filter collects micro dust in the air stream.

The blowers are the main energy consuming equipment in the WRS. Thus, any improvement in the performance of blowers by way of leakage reduction, optimal pressure drop setting across filters, re- configuration, and proper piping will result in substantial energy savings.

VXL Line 2



Connected Carding : 12 - 20
Power Consumption : 26.13 kW

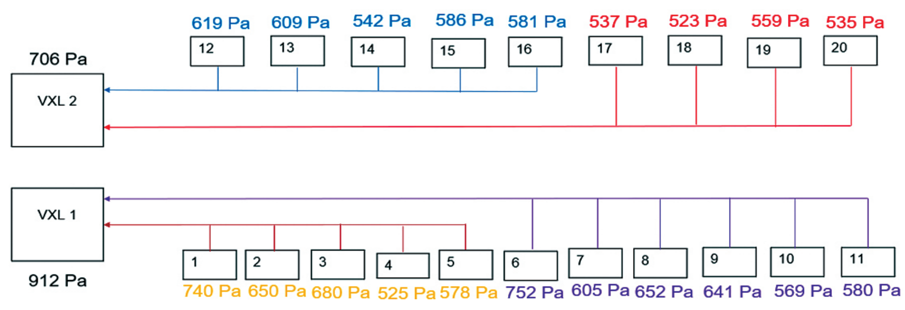
similar fan side pressure (1247 Pa & 1285 Pa for VXL 1 & 2 respectively). But much of the suction pressure produced by the VXL 2 is lost across the primary and secondary filter of VXL 2 compared to VXL 1.

This pressure loss is due to improper and damaged filter material in the VXL 2 machine. Proper filter material should be used for maintaining the design pressure drop across the filters.

Damaged filter material

Pressure drops due to air leakages:

The VXL 1 & 2 have two main ducts that further branches to connect to individual carding machines. The suction pressure in the individual carding machines were measured and are show pictorially below.



The carding machines connected to VXL 1 reach 752 Pa only and the carding machines connected to VXL 2 reach 619 Pa only. The pressure losswas high after accounting for duct loss. It was due to high air leakages in the ducts which connects VXL machines to the individual carding machines.

Return on investment:

The estimated cost of arresting air leakages, using correct filter material and repairing mechanical drive were ₹200,000. The ROI was approximately 1.2 months.

Recommendation	Saving in kWh	Saving in Rs.	Investment cost in Rs.	ROI in Months
Arrest all the licker-in, flats suction air leakages identified in the carding machines and check it periodically.				
Replace the damaged filter cloth.	180,000	1,980,000	200,000	1.2
Check and repair mechanical drive end				

Recommendation:

- Proper pressure drop across the primary and secondary filter should be maintained by using proper filter material with correct thickness. Filter material should also be replaced periodically.
- Check for air leaks and arrest periodically in the ducts connecting VXL machines to the individual combers to reduce pressure drops in the combers.
- Check and repair the faulty mechanical drive and reduce power consumption of blower.

Energy saving measures:

For calculations, 300 working days per year & ₹11 per unit are considered.

The Overall energy consumption of the two VLX Machines is 2,100 units per day. So, each carding machines was provided with about 4.3 units per hour. But, the standard energy requirement per carding machine is only 3 units per hour. A saving of 600 units per day can be achieved by replacing filter cloth with correct thickness, repairing mechanical drive in VXL 1 and arresting suction air leakages.

FOUNDRY SECTOR

ENERGY SAVING OPPORTUNITIES IN INDUCTION FURNACE

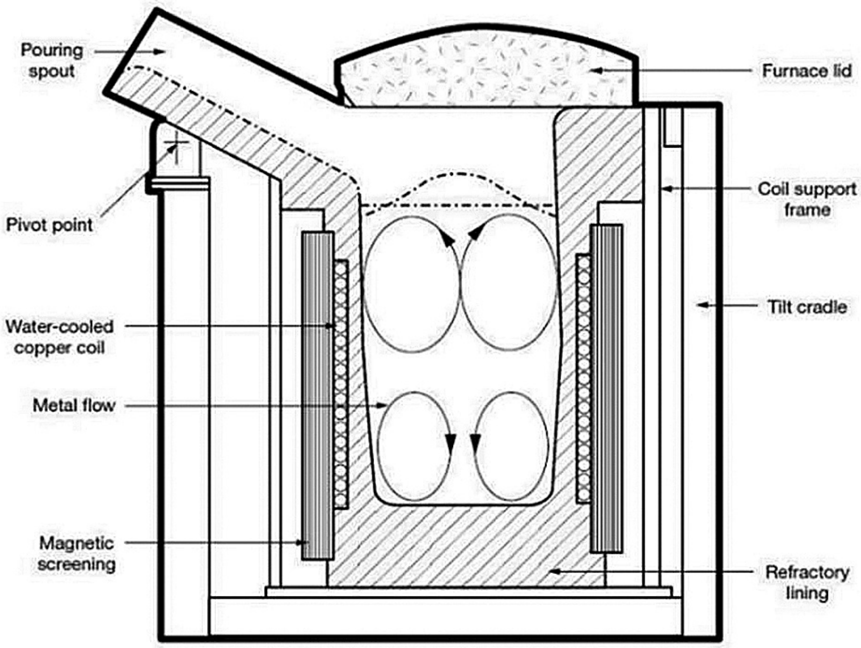
IIT Hyderabad

Assessment Date: 7 - 10 Aug 2023

Summary:

The detailed energy assessment of induction furnace was carried out at one of the foundry units situated in Sanga Reddy District, Telangana. Identified considerable annual energy saving potential opportunities in the furnace operation which are resulted in attractive monetary savings. This was achieved with simple low-cost investment and by following good operating practices. The energy assessment was focused to reduce specific energy consumption of furnace which in turn resulted in improved productivity.

Schematic diagram of induction furnace



Configuration:

There are two coreless induction furnaces installed in the plant used for melting of iron to obtain pourable liquid metal to foundry process. The rated power capacities of the induction furnaces are 450kW/200kg & 250kW/500kg. Dedicated Transformer installed to step down 11kV to 650 V that feeds three phase AC power to a suitable Power Converter (Conventional SCR based with pulse firing scheme), which then converts power to required form as required by the furnace coils. In the coreless type, charge is placed in a crucible which is surrounded by the coil circulating single phase alternating current. The coil is continuously cooled by forced circulated water. Operating frequencies range from utility frequency 50 up to 1200Hz depending on the type of charge being melted, the capacity(volume) of the furnace and the melting rate required. Melting operation is done on a batch basis, stock charging per batch depending on the type and range of product manufactured. Batch wise performance of the furnaces was studied. The melting point of charge is 1200°C and furnace temperature is goes up to 1550°C.

Overview:

The primary activity of the foundry shop is metal casting to produce Steel and Alloy Steel Castings by melting raw material and pouring into the mould.

Furnaces are used to melt the metals. Solid, liquid, and gaseous fuels are used in the furnaces. Induction furnaces use electricity as the energy input. In general, furnace consumes more than 60% of energy consumption of the plant. The operation and maintenance of the furnace is directly proportional to its energy consumption. By handling the raw material properly, proper loading pattern, optimized operation and maintenance of the furnace will result in reduced Specific Energy Consumption.

450kW/2000kg-Induction furnace

Impact of Assessment
Observations:

The furnace is being operated with low input power at the beginning. Slowly, the power is increased as the metal is heated. This way of operation increases the duration of batch from 4hr to 5.5 hrs thus increasing the SEC of furnace.

The furnaces are being loaded with charge material by leaving large amount of air gaps inside the crucible.

The input charge is loaded with the portion of material extending out of the furnace crucible leaving no provision to place the lid.

This abnormal loading is due to the availability of charge material in curved shapes and lengthy slabs. This loading pattern affects the basic functionality of furnaces as the charge material is not completely subjected to magnetic field generated by the coil. Due to the extending portion of charge material furnace mouth is kept open which causing radiation losses from molten metal surface.

Before assessment

Post implementation

Recommendation:

- Cut the raw material into smaller pieces to suit the size of the furnace crucible. These pieces to be bundled and fed to the furnace to minimize the air gaps.
- Provide the lid to the furnace to avoid radiation losses.
- Operate the furnace by providing full power from the beginning to end of the batch.

Energy saving & investment:

SEC before assessment:
0.825kWh/kg

SEC post implementation:
0.628kWh/kg

Annual Energy Saving:
1.4L kWh

Annual Monetary Saving:
14.4L

Investment:
2L

Simple payback period:
2 months

PRESSURE DIE CASTING

ENERGY SAVING OPPORTUNITIES IN FUEL OIL FIRED FURNACE

IIT Hyderabad

Assessment Date: 25 - 28 Sep 2023


750kg/hr Oil fired furnace

Summary:

The detailed energy assessment of oil-fired furnace was conducted at one of the pressures die casting industry established in outskirts of Hyderabad, Telangana. The assessment was focused on identifying the energy losses which can be minimized to improve the efficiency of the furnace. The energy saving opportunities are identified in the furnace, which are noteworthy yet, having minimum investments. The furnace is operated at the efficiency of 39% and the specific fuel consumption of the furnace is 64 liters/MT.

Configuration:

The industry adopted two oil fired furnaces to melt the Aluminum ingots and scrap material to produce molten metal used for pressure die casting. One furnace is always in working condition and other one is kept standby. The working furnace is capable of melting 750kg/hr and also having molten metal chamber to hold the 1000kg molten metal at 7300C after the melting at 6600C. The furnace contains two burners one is for melting and other is for holding chamber. The charge is dumped using a motorized trolley which moves from ground level to top of the furnace opening along the track. The lid opening mechanism is automized with the trolley movement so that lid opens before trolley reaches the furnace opening and closes when the trolley returns to its original place. The trolley carries 130kgs of charge each time and dumps 6 times per hour and causing lid to be kept opened for 9min in every hr. When the lid is opened the flue gases escapes form the opening due to the positive pressure created inside the melting chambers by the combustion air blower.

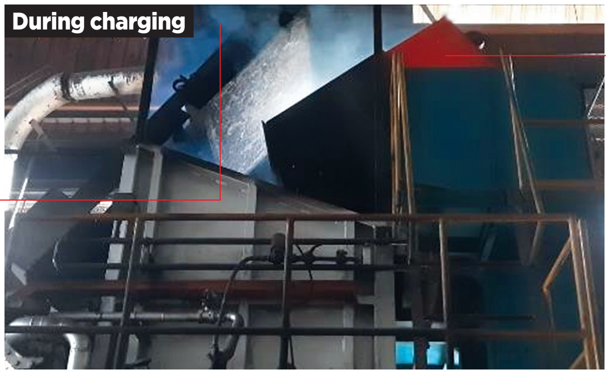
Overview:

Pressure die casting is a quick, reliable and cost- effective manufacturing process for production of high-volume metal components that are net- shaped and have tight tolerances. Basically, the pressure die casting process consists of injecting a molten metal alloy into a steel mold (or tool) under high pressure. This gets solidified rapidly (from milliseconds to a few seconds) to form a net shaped component. This component is subjected to further machining process to get the final finished product.

Pressure die castings process is used to produce automotive parts, aerospace components, electric motor housings, kitchen ware and general hardware appliances such as plumbing parts etc.

Observations:

1. The lid is opened for 1.5 min and waiting for trolley in each dumping process.
2. The actual dumping of charge happens only for 15 sec.
3. Considerable amount of flue gasses at high temperature are escaped from opening when the lid is opened.
4. Switching on the chimney ID fan to remove these excess flue gases leading to additional energy consumption which otherwise escapes due to the natural draft created by chimney.



Recommendations:

- Reduce the lid opening time from 90 sec to 20 sec. for each charge.
- Relocate the limit switch which senses the trolley movement such a way that trolley reaches first and wait for the lid to be opened at the furnace opening.

Energy saving and investment:

Lid opening time before assessment: **90 sec.**

Lid opening time post assessment: **20 sec.**

Annual fuel savings: **11.4kL**

Annual monetary savings: **5.5L**

Investment: **1L**

Simple payback period: **3 months**

Industrial Energy Assessment Cell
KISEM

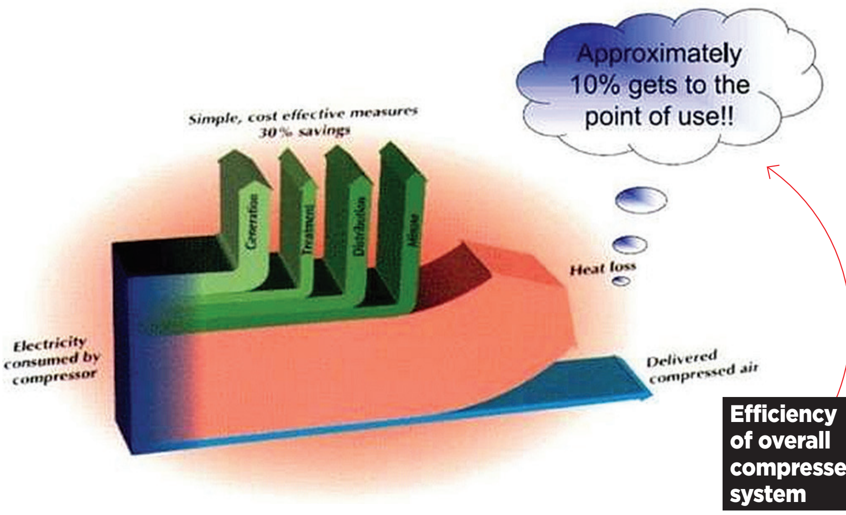
Industrial Energy Assessment Cell (IEAC)
Kotak IITM Save Energy Mission (KISEM)
Indian Institute of Technology Hyderabad, Kandi
Ph: +91 9739315201 Email: energy.assessor01@ieac.iith.ac.in

FOUNDRY SECTOR

ENERGY SAVING OPPORTUNITIES IN COMPRESSED AIR SYSTEM

IIT Hyderabad

ELGI 15 kW Compressor



Efficiency of overall compressed air system

Summary:

The detailed energy assessment of compressors and compressed air distribution systems are conducted in one of the foundry shops situated in Telangana. During the assessment the team focused on identifying the misuse of compressed air, leakages in distribution system and finding out alternate ways to replace the compressed air. The annual energy consumption of compressor was found to be 54,870 kWh. The compressor was in unloading condition for 80% of its running durations.

Configuration:

The industry has installed one 15kW screw compressor which is cable of producing 2.15 m3/min compressed air at 9bar. The compressed air is being used for driving the pneumatics tools, cleaning the casting molds and operating the pneumatic valves. The maximum air pressure required at the user point was at 6 bar for all the applications. The pneumatic sand rammer was used for hardening the molding sand during mold preparation.

The pneumatic chippers were used for breaking the molds after casting, remove the burrs and excess projections on the castings. These pneumatic tools are used intermittently for a duration of 5-6 hrs/ day. The compressor was running for a total 22 hrs/day, out of which 18 hrs were in unloading condition due to varying load and pressure.

Assessment Date: 07 - 10 Aug 2023

Overview:

Compressed air is a popular energy source as it is safer and easier than alternative options like steam, electricity, and batteries. It is used in many applications such as pneumatic tools, control systems, spray painting, injection molding etc. Hence in industries it is often regarded as the fourth utility, after electricity, natural gas, and water.

However, compressed air is more expensive than the other three utilities when evaluated on a per unit energy delivered basis due to inefficiency of compressed air system. Only 10 – 30% of energy reaches the point of end-use, and balance 70 – 90% of energy of the power of the prime mover being converted to unusable heat energy and to a lesser extent lost in form of friction, misuse and noise.

Observations:

1. The pneumatically operated tools were used for ramming the molding sand.
2; Leakages were identified at 15 locations in distribution lines causing considerable wastages.
3. The pneumatically operated weld chippers are used for removing burs on castings and breaking the molds.
4. The requirement of compressed air at the user point is only at 6bar, however the compressed air produced is at 9.5bar. The increase in pressure unnecessarily consumes higher energy.
5. Compressor was being unloaded for 18 hrs a day from its 22 hrs operation.

Using compressed air for such kind of application is not economical when electrically operated tools are available. By utilizing electrically operated tools the 90% of the energy which is lost due to inefficiency of compressed air system can be saved directly.

Before assessment

Pneumatic tools used for casting molds

Recommendations:

1. To replace the pneumatically operated tools with electrically operated tools.

2. Arrest the leakages at joints and fittings.

3. Reducing the compressed air pressure setting from 9.5 bar to 7.5 bar.

4. Installation of VFD for reducing unloading durations.

Energy saving and investment:

Annual energy consumption before assessment: **54,870 kWh**

Expected annual energy savings: **35,671 kWh**

Annual monetary savings: **3.7L**

Investment: **1.3L**

Simple payback period: **4 months**

Industrial Energy Assessment Cell
KISEM
Industrial Energy Assessment Cell (IEAC)
Kotak IITM Save Energy Mission (KISEM)
Indian Institute of Technology Hyderabad, Kandi
Ph: +91 9739315201 Email: energy.assessor01@ieac.iith.ac.in

PRESS & FABRICATION INDUSTRY

ENERGY SAVING OPPORTUNITIES IN PRESS MACHINE (METAL STAMPING)

IIT Bombay

Assessment Date: 16 - 22 April 2023

Summary:

The detailed energy assessment of press machines carried out in a group of press and fabrication engineering industries in Chhatrapati Sambhajinagar (Aurangabad), Maharashtra, identified the possibilities of energy saving and the implementation resulted in a saving of about 4.42 million per annum in press machine by installing tuned VFD. Assessment recommendations amounting to 33,50,000 were implemented. It is a 70% saving on the original power consumption of press machines.

Configuration:

This industry is having many plants in different areas of Maharashtra where press machines from three plants have been studied. There are nearly 160 press machines available for different applications such as manufacturing of precision sheet metal stamping components, welded assemblies and fine blanking etc. Many machines run idly even during non-peak production times that resulted in excessive energy consumption. All the press machines are of different specifications in tonnage and some are used with flywheel drive.

No-load power consumption of motors:

It is also found that under similar operating conditions when there is no job in between the dies of press machine, the motor runs continously at the same speed and consumes power when there is no pressing. From 160 machines, around 75 machines have different specifications and use, and out of which 35 machines consume more no-load power.

Difference in power at idle running:

The study involves collecting data on machine specifications and energy consumption patterns of Plant 1 to compare the diffrence in power consumption at different stroke. The data reveals the extent of idle running periods and the associated energy consumption of big press machines that can be optimized.

Machine Details

Sr. No.	DESCRIPTION OF MACHINE	CAPACITY SPECIFICATION	MOTOR HP	Motor kW	No Load Power (kW)	Energy can be saved (kW)
1	PNEUMATIC PRESS	250 TON	20	15	1.6	1.12
2	PNEUMATIC PRESS	80 TON	10	7.5	1.80	1.26
3	PNEUMATIC PRESS	63 TON	7.5	5.5	1.9	1.33
4	PNEUMATIC PRESS	150 TON	15	11	1.23	0.861
5	PNEUMATIC PRESS	200 TON	20	15	1.9	1.33
6	PNEUMATIC PRESS	100 TON	15	11	6.4	4.48
7	PNEUMATIC PRESS	100 TON	10	7.5	2.1	1.47
8	PNEUMATIC PRESS	110 TON	20	15	4.5	3.15
9	PNEUMATIC PRESS	60 TON	7.5	5.5	2.5	1.75
10	PNEUMATIC PRESS	80 TON	10	7.5	4.1	2.87

Overview:

Press machine is a metal forming machine tool which is designed to form or cut metal by applying mechanical force or pressure. With the help of a press machine, metal can form any desired shape without the removal of chips. Press machines are used in the fabrication engineering industry to apply pressure to a workpiece to change its shape and form. Punching, blanking, bending, coining, embossing, and flanging are all stamping techniques used to shape the metal.

The manufacturing facility in question operates multiple pressing machines that are used for various metal forming processes. The issue faced by the industry is energy consumption resulting from the idle running of press machine, this energy can be reduced at certain % by installing VFD.

Presses are available with and categorized by different types of actuating mechanisms that produce and exert the force necessary to execute the fabrication process including:

- Mechanical Presses
- Hydraulic Presses
- Pneumatic Presses

Mainly, these three types of press machines are available in the industry.

Sr.	Description	No-Load			Empty Stroke			On-Load		
		Nm	Nfw	Power (kW)	Nm	Nfw	Power (kW)	Nm	Nfw	Power (kW)
1	PNE. PRESS 400TON	1798	334	2.5	1753	323	3.1	1676	310	4.5
2	PNE. PRESS 45TON	1482	993	2.3	1441	992	2.36	1476	991	2.37
3	PNE. PRESS 60TON	1492	202	2.5	1497	506	3.1	1483	508	2.8
4	PNE. PRESS 80TON	1493	392	4.1	1472	391	4.3	1482	387	4.4
5	PNE. PRESS 100TON	1383	363	6.4	1377	359	6.8	1302	356	6.4
6	PNE. PRESS 350TON	1495	391	1.5	1290	385	3.7	1483	387	3.9
7	PNE. PRESS 45TON	1490	753	0.50	1470	745	2.5	1467	739	2.5
8	PNE. PRESS 200TON	1137	306	1.9	1013	289	21.3	974	281	23.7
9	PNE. PRESS 160TON	1491	603	1.23	1483	594	4.90	1473	595	5.90

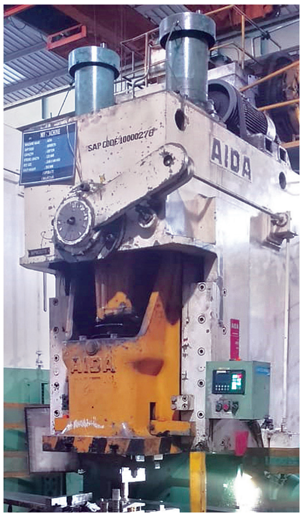
This machines are running idle and consuming more power, approximately 70% of the no-load power can be saved by installing closed loop VFDs to mainly to big press machines more than 60 Ton.

Return on investment:

The estimated cost of installing VFD to required big machines were ₹33,50,000 combining all three plants. The ROI was approximately 9.1 months.

Mechanical press machine

Hydraulic press machine



Pneumatic press machine

Recommendation	Saving in kWh	Saving in Rs.	Investment cost in Rs.	ROI in Months
Install VFD for pressing machine	4,18,219	₹44,28,979	₹33,50,000	9.1

Recommendation:

- Recommended to install closed loop VFDs to adjust the speed of the motor and power based on specific requirement of the task, which can result in energy savings by stabilizing the power consumption of press machine at no-load running time.
- Pressing machines that are installed with VFDs can operate at variable speeds, which allows them to be more flexible and efficient than machines that operate at a fixed speed without VFD.
- In summary, pressing machines equipped with VFDs offer greater flexibility, improved efficiency and reduced wear and tear compared to machines that operate without VFDs.

Energy savings:

The overall energy consumption of all the press machines was 5,97,456 kWh per year. So, a saving of 4,18,219 kWh per year was achieved by installing closed loop VFDs to required big press machines.

Industrial Energy Assessment Cell
KISEM

Industrial Energy Assessment Cell (IEAC)
Kotak IITM Save Energy Mission (KISEM)
Indian Institute of Technology Bombay, Mumbai
Ph: +91 9447407201 Email: sreepk.iitb@gmail.com

INDUCTION FURNACE STEEL MELTING

ENERGY SAVING OPPORTUNITIES IN SCRAP HANDLING

IIT Bombay

Assessment Date: 15-18 March 2023

Summary:

The detailed energy assessments were carried out at a secondary steel manufacturing plant and a foundry which is manufacturing cast iron products for automobile industry. It identified the possibilities of energy saving, which after implementation, resulted in a saving of about ₹5.5 crore per annum in scrap handling alone. It is a 10% and 17% saving on the original power consumption of the respective industrial furnaces.

Configuration:

The steel manufacturing plant has five 8-ton capacity induction furnaces. Cycle time for 8 Ton, 2000 kW induction furnace is 3 hours as per the operating practices of the plant to get a temperature around 16000C. The specific energy consumption is in the range of 750 kWh where the standard achievable is between 500 – 550 kWh only. The minimum charging time per cycle is 55 to 60 minutes. The foundry has a 6-induction furnace of 1 ton capacity whose having cycle time of 40 minutes, 1200 kW induction furnace as per the operating practices of the plant to get a temperature around 12000C.

Improper scrap handling practices:

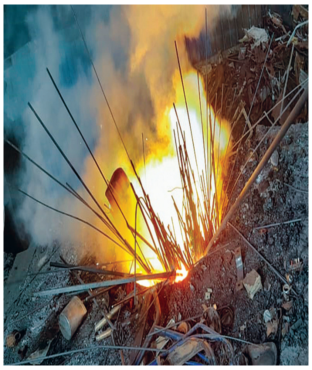
No segregation: Heterogeneous mix of raw materials (scraps) will happen because of the lack of segregation. The absence of segregation in steel manufacturing plants often occurs due to the shortage of time, skilled labours and equipments.

Not weighing scraps: Failing to accurately weigh scrap materials prior to processing can lead to inaccurate inventory records, cost overruns, and difficulty in tracking material usage.

Charging of unwanted metals: Including unwanted or non-recyclable metals in the charging process can reduce the quality of the final steel product, increase energy consumption and contribute to environmental pollution.

No segregation

No weighing of scraps



Charging of rods

Overview:

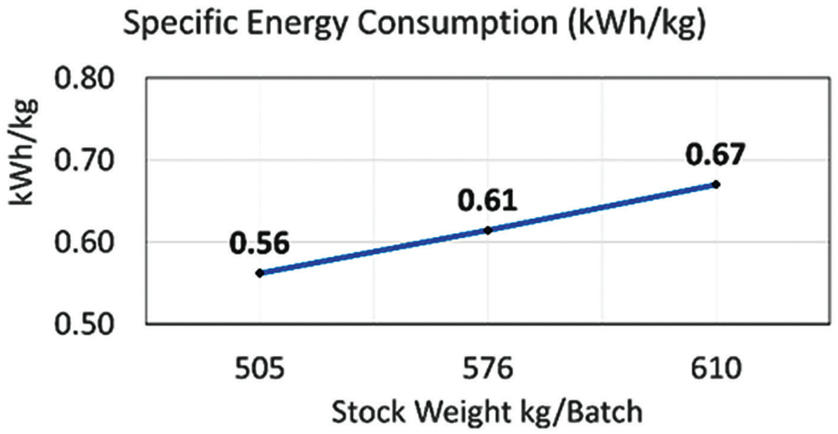
Scrap handling is an important aspect of metal recycling that involves the safe and efficient management of scrap materials as they are transported, stored, and processed. The consequences of improper scrap handling practices within a steel manufacturing facility, encompassing issues of non-segregation, lack of weighing oversight, and the inclusion of unwanted metals during the charging process is a major problem in the current scenario. These issues have far-reaching impacts on encompassing the operational inefficiencies, diminished product quality, increased resource consumption, and environmental irregularities. A set of strategic solutions such as encompassing meticulous cleaning, segregation processes and the introduction of hydraulic pressing machines for efficient scrap bundling by implementing these methods, substantial cost savings can be realized, while simultaneously enhancing product quality and fostering a range of additional benefits. The proper management of scrap materials emerges as a linchpin in the pursuit of sustainable and efficient operations for steel manufacturers.

Optimizing charging in an iron melting coreless induction furnace:

In the foundry, non-optimized charging of scrap happens that is, the aluminum bars were directly feeding into the furnace without optimizing the size of bars based on the furnace. During the Energy Audit, it was proposed to optimize the charging in furnace chamber completely utilizing the space after shredding and pressing the scrap properly. The specific energy consumption reduced from 670 kWh/MT to 560 kWh/MT.

Non optimized charging of scrap

Optimized charging of scrap



Variation in SEC based on charging

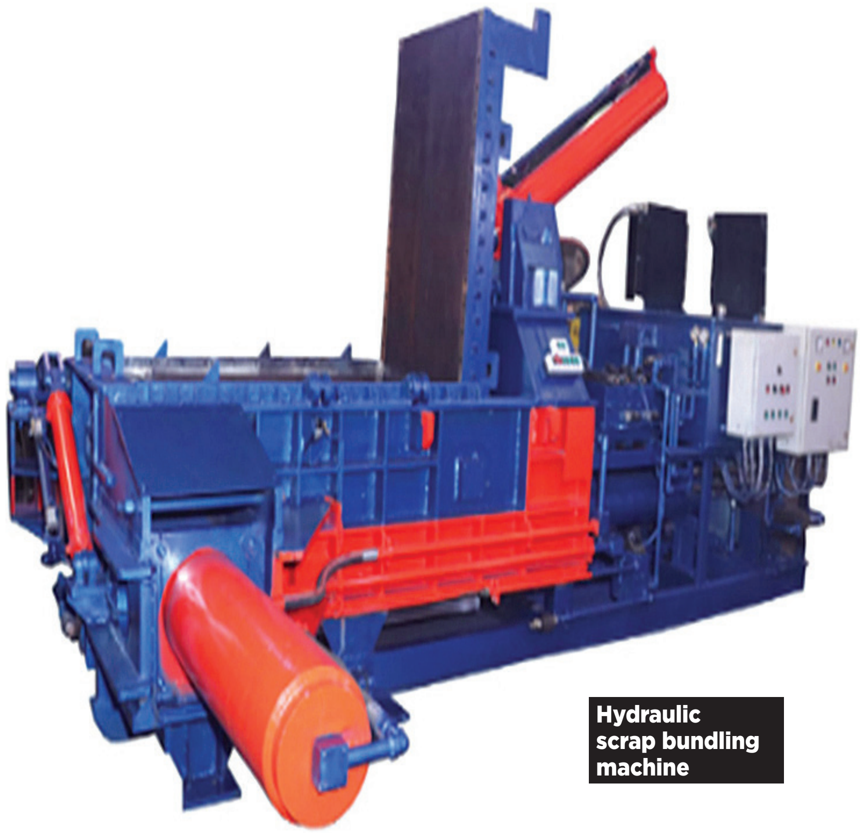
Impact of improper scrap handling:

Inadequate scrap handling can result in delays, increased processing times and higher labor costs due to manual sorting. The inclusion of unwanted metals can lead to lower-quality steel products, increasing the likelihood of defects and customer dissatisfaction. Valuable scrap materials are underutilized, leading to a high demand of primary raw materials and associated costs. Emissions of pollutants, higher energy consumption, and the improper disposal of unwanted metals can have adverse environmental impacts including air and water pollution. The charging time of each furnace is very high because of improper scrap handling. Instead of that proper handling of scrap can reduce the charging time along with the reduction in specific energy consumption of furnaces.

Methods to overcome improper scrap handling:

Implement the weighing procedures for scrap materials which helps to maintain proper records and reduce cost. A systematic segregation process, categorizing scrap materials based on their composition and quality. Cleaning and sorting process to remove non-recyclable or unwanted materials from the scrap stream. Implementing hydraulic pressing machines to efficiently bundle and compact scrap materials. This reduces the volume of scrap, making it easier to handle, transport, and store. This enables more precise control over material usage and minimizes contamination alone.

Segregated, bundled, weighed scraps



Hydraulic scrap bundling machine

Return on investment:

The estimated cost for cleaning, segregating the scraps and bundling the scraps using a hydraulic presser is ₹13,00,000. The ROI was approximately 0.3 months. In the foundry the recommendation's immediate return on investment is notably swift due to its minimal cost requirements. The only action needed is to make the practice of completely utilizing the space after shredding and pressing the scrap properly as a regular and consistent part of the foundry. By implementing this straightforward and cost-effective measure, businesses can immediately gain the benefits. The minimal expense of incorporating these recommendations into the standard procedure yields an almost immediate ROI by reducing energy consumption, improving product quality, and aligning with sustainability objectives. This makes it a highly effective and prudent choice for enhancing overall efficiency in manufacturing.

Recommendations	Saving in kWh	Saving in Rs.	Investment Cost	ROI
Clean, segregate the scraps and use a Hydraulic presser for bundling the scraps.	4,18,219	5,09,04,360	13,00,000	0.3
Optimize the charging in furnace chamber completely utilizing the space after shredding and pressing the scrap properly	6,70,965	46,96,756	NIL	Immediate

Recommendation:

- Acquire and maintain equipment or machinery like magnetic separators, eddy current separators, and optical sorting systems for the cleaning and sorting of scrap materials.
- The volume of scrap can be reduced by using hydraulic pressing machines by compacting scrap materials into manageable bundles.
- Systematic segregation helps for better control over material usage and enhances the efficiency of downstream processes.

Energy savings:

The overall energy consumption of all the furnaces in secondary steel is 5,69,40,000 and for foundry is 41,61,072 units per year So, a saving of 4,18,219 units and 6,70,965 units per year was achieved by cleaning, segregating the scraps and bundling the scraps using a hydraulic presser and optimize the charging in furnace chamber completely utilizing the space after shredding and pressing the scrap properly.

INDUCTION FURNACE STEEL MELTING

ENERGY SAVING OPPORTUNITIES IN ROLLING MILL & CCM

IIT Bombay

Summary:

The detailed energy assessment of continuous casting machine (CCM) and rolling mill carried out at one of the secondary steel Industry in Nagpur, Maharashtra, identified the possibilities of energy saving and the implementation resulted in a saving of about 3.98 million per annum in mills by doubling the line from CCM to Mill and open both nozzles in the tundish by increasing the flow of molten metal from the ladle. This action enabled both paths to operate simultaneously, improving the continuous casting process. Assessment recommendations amounting to ₹5,00,000 were implemented. It is a 50 % saving on the original power consumption of Rolling mills.

Configuration:

The industry located in Nagpur boasts two plants that employ an identical steel manufacturing process. The manufacturing process commences with the melting of raw materials in furnaces. Once the materials have been melted to the desired temperature, they are efficiently transferred to the Continuous Casting Machine (CCM). Within the CCM, the molten metal is carefully shaped into billets, which serve as the primary raw material for subsequent processes. The billets are then fed into three rolling mills; each with a unique size - 14'', 16'', and 20''.

Continuous casting machine running with one strand:

It is found that when only one nozzle of tundish was opend and for that 1 strand all 3 rolling mills are running from which 2 mills are effectively utilized for 24 hrs but 1 is running without load simply to avoid breakdown issue. it is utilized as a standby, allowing billets to be rerouted in case of breakdown ocuurs to the current running mills, rest of the time it is running ideally. At other case at a same time the tudish has two converging nozzles in which one was opened fully and other was closed.

Current and recommended condition OF CCM:

Figure 1 is the current condition of the plant where one nozzle of tundish is open and only one billet is coming out from that strand. If both nozzles are opened, the line from CCM to mills can be doubled and used for both mills to increase productivity. Only around 12m line doubling is required with both nozzles of tundish operated simultaneously by increasing the ladle discharge to tundish. As the flow of molten metal through the CCM increases the time taking for ladle emptying can also be reduced by half. Along with this as the ladle emptying time decreases the radiation losses occurring can also be saved.

Assessment Date:15- 18 March 2023

Overview:

In the secondary steel industry, the role of the continuous casting machine (CCM) is paramount in enhancing productivity. One technology that has revolutionized the steel production process is Continuous Casting.

A recent energy assessment in a secondary steel manufacturing facility highlighted the importance of optimizing CCM operations. The CCM in question provides billets for three rolling mills, with diameters of 14", 16", and 20". To mitigate productivity losses caused by breakdowns, a unique approach is implemented. Typically, two of the rolling mills operate continuously for 24 hours, while the third running idle to avoid breakdown loss issues. However, instead of keeping the third mill idle, a new strategy is put in place, opening both nozzles of the tundish and increasing roller capacity on the rolling mill to two-way for a distance of 12 meters. This action, which enable the simultaneous operation of both tundish paths, result in significant benefits. This innovative recommendation is estimated to save 6000 units per day in terms of productivity, demonstrating a practical and efficient approach to improving operations in the secondary steel industry.

Figure 1 Single nozzle operation at CCM

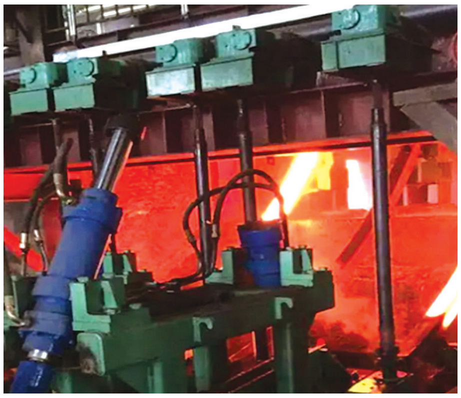


Figure 2 Recommended situation using both the nozzle along with 2 mills.

Figure 3 Current condition of CCM in plant

Figure 4 Only 1 billet coming at a time

Figure 2 is the example of other steel industry, which is also having a same working process and the mill is working efficiently with both working strands.

In Figure 4 as we can see only one billet is coming out from the CCM to rolling. Second path of tundish is closed so that rolling mill is idle running according to the industry that rolling mill should continuously running to avoid occurring breakdown losses. But the idle running also consumes more power meantime the industry can operate all rolling mills with both the nozzle opening and all 3 mills running efficiently. Figure 5 is a visual demonstration of CCM, two strands working.

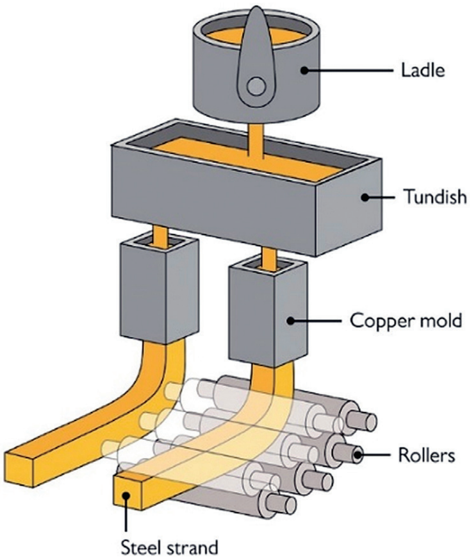


Figure 5 Demonstration of CCM

Recommendation	Saving in kWh	Saving in Rs.	Investment cost	ROI
The line from CCM to mills can be doubled and used for both mills to increase productivity.	44,61,148	3,98,82,663	₹5,00,000	0.2

Recommendations:

- Recommended to implement certain improvements.
- Firstly, opening both nozzles of the tundish and increasing the flow of molten metal from the ladle can optimize the material transfer it helps in increasing billet production.
- Secondly, increasing the number of rollers to a two-way system for a length of 12 meters can enhance the rolling mill's capacity and throughput. This modification will enable a more efficient and continuous production of steel products, reducing downtime and maximizing output.
- Lastly, automating the mills can bring about significant advantages in terms of precision, speed, and overall process control.

Energy saving and investment:

From this recommendation the company is saving 6000 units/ Day in terms of productivity that saves ₹1.5 crores.

Industrial Energy Assessment Cell (IEAC)
Kotak IITM Save Energy Mission (KISEM)
Indian Institute of Technology Bombay, Mumbai
Ph: +91 9447407201 Email: sreepk.iitb@gmail.com

ENGINEERING – AUTO PARTS

ENERGY SAVING OPPORTUNITIES IN HOLDING CUM MELTING FURNACE

IIT Bombay

Summary:

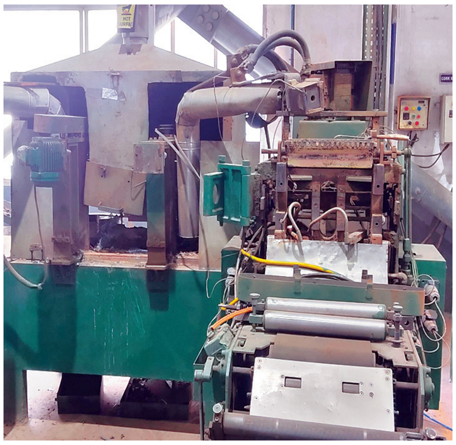
The detailed energy assessment of holding cum melting furnace carried out in an auto mobile parts in Chhatrapati Sambhajinagar, Maharashtra, identified the possibilities of energy saving and the implementation of auto-pouring technology in pressure die casting (PDC) machines yields significant savings in both thermal efficiency and productivity. The thermal savings, amounting to ₹7.5 lakhs, reflect the reduction in radiation losses and enhanced energy efficiency. The integration of auto-pouring systems translates into substantial productivity savings in terms of time. With a daily operating span of 17.5 hours for the plant, the adoption of auto-pouring allows for the saving of 4.4 hours during this period. This time gain is pivotal, as it can be reallocated to boost the production activities.

Configuration:

The first plant has three holding cum melting furnaces, each having a rated capacity of 300 kg (55kW) are used in PDC machine. All the furnaces are working for 17.5 hrs continuously. In this plant an automatic jaw is used for pouring the molten melting. While the second plant has 6 PDC machine with auto pouring system having holding cum melting furnaces of 18kW. The furnaces are working for 22 hours.

Holding cum melting furnace with and without the facility of auto pouring:

In the first industry, molten metal transference from furnace to die relies on an automatic jaw system. The inherent mechanism of the automatic jaw, while effective in its purpose, it requires a certain amount of time to complete the pouring action, thereby contributing to a slower pace of production. This approach of time delay in the pouring process, impacting overall production rates. The second industry has embraced innovation with an auto-pouring facility. This automated system avoids the need for a manual jaw, facilitating a continuous and seamless pouring process. Unlike the first industry, where the pouring mechanism relied on the automatic



PDC with auto pouring system

Furnace with jaw (first plant)

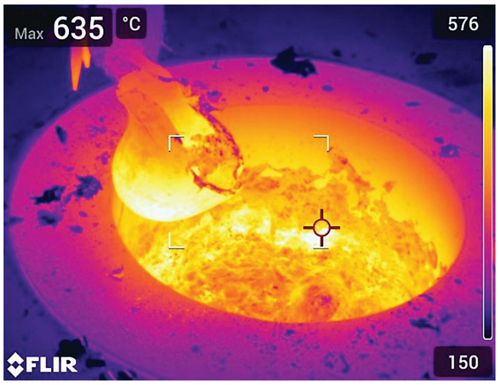
Assessment Date: 23 - 25 August 2023

Overview:

Pressure die casting is a widely employed method in metalworking industries for the efficient production of complex metal parts. This overview explores the differences between two pressures die casting industries, both utilizing holding cum melting furnaces. The key distinction lies in their pouring mechanisms: one relies on an automatic jaw system for pouring molten metal into the die, while the other incorporates an advanced auto-pouring facility. The first industry employs a conventional automatic jaw system for pouring molten metal from the furnace to the die. However, this method introduces a time lag in the pouring process, impacting the overall production rate.

The second industry has invested in an auto-pouring facility, revolutionizing its casting process. The automated system eliminates the need for a manual jaw, enabling a continuous and seamless pouring process.

The holding cum melting furnace machine is the main energy consuming equipment in the auto parts manufacturing industries. Thus, any improvement in the performance of holding cum melting furnace by auto pouring will result in substantial energy savings.



Radiation losses in first plant's furnaces

Opening in furnace because of using jaw

jaw system with inherent time delays, the second industry's adoption of an auto-pouring facility represents a departure from such limitations. This automation not only focuses on the pouring operation but also eradicates the downtime associated with manual intervention, resulting in a substantial increase in production rates.

Decrease in radiation loss of holding cum melting furnace machine by auto pouring:

An instrumental benefit of the auto-pouring system is the marked reduction in radiation losses. In the manual jaw system, frequent furnace openings expose molten metal to the ambient environment, leading to heat dissipation. The auto-pouring system, by contrast, operates without the need for continuous furnace openings thereby minimizing radiation losses. This not only contributes to energy savings but also increases the overall thermal efficiency of the casting process.

Return on investment:

The estimated cost of installing auto pouring Holding cum melting furnace is ₹5,00,000. The ROI was approximately 8 months.

Recommendation	Saving in kWh	Saving in Rs.	Investment cost in Rs.	ROI in Months
Installing auto pouring system in holding cum melting furnaces.	79,948	₹7,55,509	₹5,00,000	8

Recommendations:

It is strongly recommended that the industry currently utilizing furnaces with an automatic jaw system considers adopting an auto-pouring facility. The implementation of auto-pouring offers substantial benefits. Additionally, the auto-pouring system eliminates the need for frequent furnace openings, minimizing radiation losses. This strategic shift can significantly improve operational efficiency, reduce costs

Energy saving and investment:

The overall energy consumption of the Four PDC machine each have a melting cum holding furnace is 19,36,28 kwh. So, a saving of 79,948 kWh per year was achieved by auto pouring.

RE-ROLLING MILLS

ENERGY SAVING OPPORTUNITIES IN RE-HEATING FURNACE (RHF)

IIT Bombay

Assessment Date: 07 - 10 Aug 2023

Summary:
The detailed energy assessment of re-heating furnace (RHF) carried out in a re-rolling mill in Jalna, Maharashtra, identified the possibilities of energy saving and the implementation resulted in a saving of about ₹7.2 lakh per annum in RHF alone by installing oxygen analyzer along with VFD. Assessment recommendations amounting to ₹3 lakhs were implemented. It is a 20% saving on the original fuel consumption of the RHF.

Configuration:
In the context of two re-rolling mills, each operates with distinct reheating furnace systems, with both having a capacity of 2TPH. Both the re-heating furnaces employs an oxygen analyzer in which one industry relies on real time values from the oxygen analyzer and manual control. In the particular mill manual, control of excess air at particular time intervals is carried out to optimize excess air. The analyzer relies on experienced operators for damper adjustments, achieving optimized excess air levels without much potential variations in oxygen levels and temperature uniformity. The other industry follows complete automated system for excess air control. But the mill doesn't get any benefits from automated control of oxygen levels, leading to energy inefficiency, inconsistent heating with environmental impact. The system thoroughly studied and checked by the IEAC team and the fault was with the oxygen sensor.

Plant A: Manual controlling of damper adjustment based
In the first industry (Plant A), the oxygen analyzer plays a pivotal role in conjunction with skilled operators. Real-time data on oxygen concentrations is harnessed to its full potential. Operators adeptly use this information to manually adjust damper settings based on billet sizes, maintaining a fine-tuned control over excess air levels. This harmonious combination of technology and human expertise leads to notably low excess air levels, with associated benefits including cost savings.

CO (ppm)	CO_2 (%)	O_2 (%)	NO (ppm)	T1 (°C)	Excess Air (%)
10348	18.5	1.8	698	628.6	10
10230	18	2.2	695	627.5	12.8
9639	17.5	2.7	691	627.1	17.5
8523	16.6	3.6	694	626.5	22.9
7029	16.2	4	694	626.1	24.7

Table 2 Re-heating furnace without oxygen analyzer (controlled manually)

Overview:
In the realm of industrial reheating furnaces, the use of oxygen analyzers plays a vital role to improve overall operational efficiency. Here offers a comparative analysis of two distinct industries, each equipped with the oxygen analyzers in the re-heating furnace. In one of these industrial settings, despite the unquestionable advantages brought by the oxygen analyzer, the challenge of high excess air levels persists. This anomaly can be attributed to a fundamental problem in operational execution. The errors in the analyzer, leads to the inaccurate measurements which can results in the inaccurate excess air levels.

The other industry has more strategic approach. Skilled operators adeptly use the real time information to manually adjust VFD settings. This harmony between technology and expertise has led to remarkably low optimum excess air level. It emphasizes the need for continuous training and calibration in the operation of oxygen analyzers as well as the value of human expertise in optimizing combustion control.

Plant B: Oxygen analyzer neglected

In the second Industry (Plant B), the reheating furnace incorporates an automated oxygen analyzer excess air control system, even though the plant has the issue of excess air levels when the IEAC audit team measured the same. The oxygen analyzer is designed to provide real-time data of oxygen concentrations in the furnace, enabling precise control of the combustion process. However the neglegance in oxygen analyzer's regular calibration and maintenance to ensure accurate readings, the analyzer is providing incorrect data, which leading to improper adjustments of combustion parameters and excess air. The amount of air supplied by the FD fan affects the combustion process, and an excess air beyond the standard values can lead to inefficiencies. This results in excess air levels that are higher than optimal, impacting energy efficiency, environmental compliance, and temperature uniformity within the furnace. Excess air can waste too much energy and increase operating costs.

By adjusting the speed of the FD fan with a VFD, the amount of air delivered to the furnace can be precisely controlled. With a VFD, the FD fan speed can be reduced during periods of lower demand, preventing excessive air supply and helps regulate the air-fuel ratio, and this, in turn, affects the combustion temperature within the furnace and improving overall efficiency.

Return on investment:

The estimated cost of reducing excess air by checking oxygen analyzer and optimize FD and ID fan according to the real time values from analyzer were ₹3 lakhs. The ROI was approximately 5 months.

CO (ppm)	CO_2 (%)	O_2 (%)	NO (ppm)	T1 (°C)	Excess Air (%)
63	7.1	13.5	225	606.5	184.5
63	7	13.7	218	622.2	189.6
64	6.9	13.8	215	636.2	190.7
65	6.9	13.7	217	648.8	190.3
65	6.9	13.8	222	658.8	193.5
64	6.8	13.8	228	668.9	193.2
62	6.9	13.8	233	677.9	191.3
61	6.9	13.8	236	685.9	192.7
60	6.9	13.8	240	693	194.1
58	6.8	13.9	245	698.9	198.6

Table 1 Re-heating furnace with oxygen analyzer

Recommendation	Fuel Saving in Kg.	Saving in Rs.	Investment cost	ROI
Oxygen sensor should be checked regularly with control mechanism.	41,763	7,22,006	3,00,000	5

Recommendations:

The key to effective oxygen analyzer-based control in reheating furnaces lies in different factors like the proper functioning of the analyzer and the control.

System, VFD to FD & ID fans etc. For Plant A, maintaining consistency in manual control and considering technological enhancements can further optimize their approach. For Plant B, it is imperative to address calibration and maintenance issues and evaluate furnace equipment efficiency.

In summary, the FD fan and the reheating furnace are interrelated in the context to maintain efficient combustion and temperature control. Proper coordination and control of the FD fan help to optimize the air-fuel ratio, ensuring that the reheating process is energy-efficient.

Energy savings:

The overall fuel consumption of the plant B reheating furnace is 2,06,380 Kg per year from a saving of 41,763 Kg per annum was achieved by optimizing the FD fan speed. The feedback from oxygen analyzer to the VFD of FD & ID fans will help to ensures that there is sufficient oxygen for the combustion process, allowing the fuel to burn efficiently.

Industrial Energy Assessment Cell
KISEM
Industrial Energy Assessment Cell (IEAC)
Kotak IITM Save Energy Mission (KISEM)
Indian Institute of Technology Bombay, Mumbai
Ph: +91 9447407201 Email: sreepk.iitb@gmail.com

ENGINEERING - AUTO MOBILE PARTS

ENERGY SAVING OPPORTUNITIES IN PRESSURE DIE CASTING (PDC) MACHINE

IIT Bombay

Assessment Date: 23 - 25 August 2023

Summary:

The detailed energy assessment of pressure die casting (PDC) machine carried out in an auto mobile parts in Shendra, Chhatrapati Sambhajinagar, Maharashtra, identified the possibilities of energy saving and the implementation resulted in a saving of about 3.29 lakhs per annum in PDC machine by installing PID controlled thyristor convertor for reducing the maximum demand. It will give a 22% saving on the original billed demand consumption of the PDC machine.

Configuration:

There are four PDC machine in the plant – PDC1, PDC2, PDC3 and PDC4 that are connected to separate three melting cum holding furnace, which contains 12 resistive coils each. The furnaces are of capacity 300kg which is melting cum holding furnace and of power consumption 55kW is used in PDC machines. The power control mechanism in one of the furnaces is SCR control mode-based system and rest all are RTD (Resistance Temperature Detector) control mode-based.

Maximum demand consumption of furnace:

Under similar operating conditions (similar load and mould), it is found that furnace with SCR based control mode has a load curve which is linear where as the furnaces which are having RTD based control mode has non-linear. The maximum demand is higher in RTD based than SCR based control mode which can be identified in Fig. 1 and 2.

Resistance temperature detector control-based furnace

The Resistance Temperature Detector (RTD) control system in a furnace refers to a method of monitoring and regulating the temperature inside a furnace using RTD sensors.
If the temperature is below the desired set point, the control system can switch ON the power supplied to the heating elements, raising the temperature inside the furnace.
Conversely, if the temperature is above the setpoint, the power supplied to the heating elements is cutoff.
Loading curve of the RTD control based Furnace is shown in Fig 1.

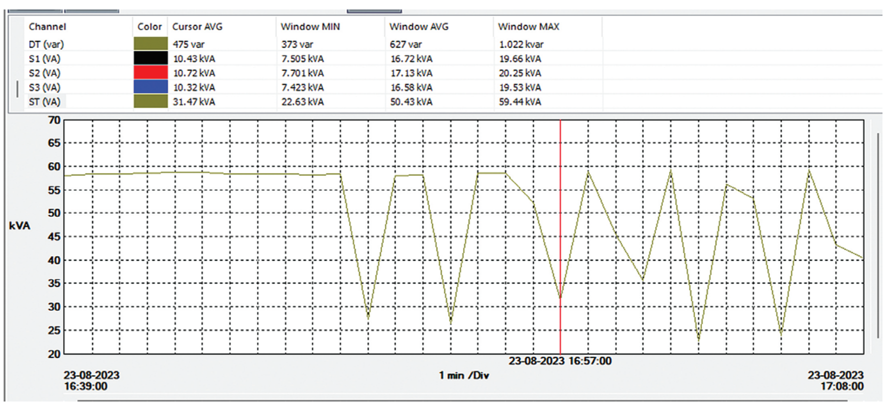


Figure 1 kVA Reading of Furnace

Overview:

Auto mobile parts industry uses various machineries. One of the most important machineries is pressure die casting. It is a metal casting process that is characterized by forcing molten metal under high pressure into a mold cavity. The mold cavity is created using two hardened tool steel dies which have been machined to the desired shape and size. The molten metal is forced into the mold cavity by a plunger or piston. This pressure die-casting machine using melting cum holding furnace whose control mechanism is done by resistance temperature detector to ON/OFF the furnace whose load curve is not linear which increase the maximum demand.

The PDC machine are the main energy consuming equipment in the auto mobile parts. Thus, any improvement in the performance of PDC machine by using PID controlled thyristor converter furnace-based control mode will result in substantial energy savings.

PID control thyrister convertor furnace

A PID controlled thyristor converter furnace is a type of electric furnace that uses a thyristor converter to control the temperature of the furnace. PID control is a type of feedback control that uses a proportional integral and derivative term to control the output of the system The PID controller use to calculate an output signal that is sent to the thyristor converter. The thyristor converter then uses this signal to control the flow of current to the furnace. This allows the temperature of the furnace to be controlled very precisely. Loading Curve of Furnace with SCR control is as shown in Fig. 2.

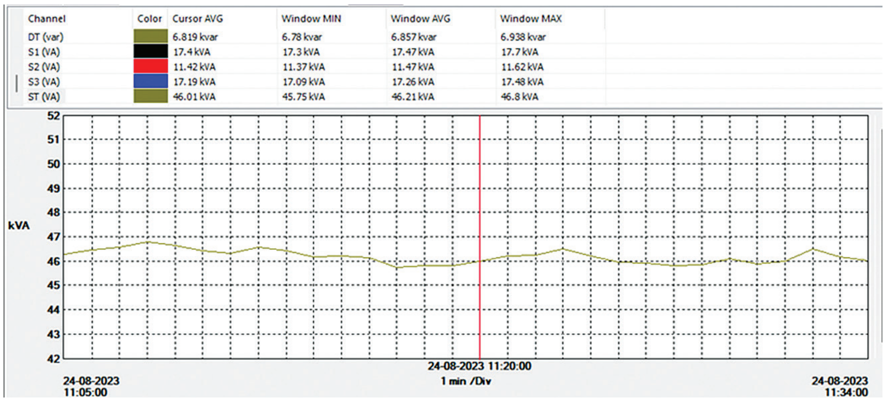


Figure 2 kVA Reading of Furnace

Return on investment:

The estimated cost to install PID controlled thyristor converter is 3lakh. The ROI was approximately 11 months.

Recommendation	Saving in Rs.	Investment cost in Rs.	ROI in Months
Install PID controlled thyristor converter Furnace and reduce maximum demand.	₹3.29 Lakhs	₹3 Lakh	11

Benefits of PID controlled thyristor converter furnaces:

1. Precise temperature control
2. Energy efficiency
3. Fast response time
4. Stability and robustness
5. Reduced variability in output

Recommendations:

Two Furnaces are operating in ON/OFF control mode and consuming maximum demand and it can be reduced by installing PID controlled thyristor converter Furnace.

Energy savings:

The overall billed demand power consumption of the four PDC machine having separate three melting cum holding furnace is 172 kVA. So, a reduction in power demand of 38 kVA was achieved by Installing PID controlled thyristor converter Furnace.

Industrial Energy Assessment Cell
KISEM
Industrial Energy Assessment Cell (IEAC)
Kotak IITM Save Energy Mission (KISEM)
Indian Institute of Technology Bombay, Mumbai
Ph: +91 9447407201 Email: sreepk.iitb@gmail.com

IRON AND STEEL INDUSTRY

ENERGY SAVING OPPORTUNITY BY USING IGBT INSTEAD OF SCR IN POWER CONTROL MODULE OF INDUCTION FURNACE

IIT Bombay

Assessment Date: 05 - 08 April 2023

Summary:

The detailed energy assessment of induction furnace carried out in an iron and steel industry in Hatkanangale, Kolhapur, Maharashtra identified the possibilities of energy saving and the implementation of IGBT based induction furnace yield to give a substantial 15% reduction in energy consumption.

Configuration:

Two iron and steel plants were studied that are into casting. All the configurations were same in both plants. The plants have two induction furnaces each having a rated capacity of 0.5 ton is used for melting the metal. First plant has IGBT control whereas the second plant with SCR control. Both the furnaces in the plants work for 24 hrs.

IGBT based Induction furnace and SCR-based induction furnace

In the first plant, 0.5-ton IGBT-based induction furnace consume average less power as well less time to melt the metal as compare to second plant for one heat. Because of the IGBT-based induction furnace with 24 pulse which allow for precise control over voltage, frequency, and phase angle, enabling more advanced control strategies. This helps to improve the overall power factor and reduce reactive power consumption. The SCR-based induction Furnace have primarily control the firing angle and provide basic ON/OFF control and require additional power factor correction circuits to achieve similar benefits.

Three cycles were studied in both the plants and for both the furnaces. The different values got during the cycle study of both the plants with the SEC are as follows in Table 1:

Plant	Furnace Number	Parameters	Cycle - 1	Cycle - 2	Cycle - 3	Average	Plant Average SEC
Plant - 1 (IGBT Based)	Furnance -1	Metal in kg	490	503	530	507.67	544.96
		Energy in kWh	268	270	293	277	
		SEC in kWh/Ton	546.939	536.779	552.83	545.52	
	Furnance -2	Metal in kg	478	498	521	499	
		Energy in kWh	263	265	287	271.67	
		SEC in kWh/Ton	550.209	532.129	550.864	544.4	
Plant - 1 (IGBT Based)	Furnance -1	Metal in kg	487	510	521	506	638.29
		Energy in kWh	311	324	341	325.33	
		SEC in kWh/Ton	638.604	635.294	654.511	642.8	
	Furnance -2	Metal in kg	469	504	513	495.33	
		Energy in kWh	295	319	328	314	
		SEC in kWh/Ton	628.998	632.937	639.376	633.77	

Table 1 SEC of different furnaces

Overview:

Induction furnaces are vital components in metal processing industries, playing a crucial role in melting and refining metals. The choice of technology used in these furnaces significantly impacts energy efficiency, production costs and overall operational sustainability. This case study delves into the comparison between two plants utilizing induction furnaces, one employing Silicon Controlled Rectifier (SCR) based furnaces and the other utilizing Insulated Gate Bipolar Transistor (IGBT) technology.

The SCR-based induction furnace has been a longstanding choice for many industries due to its reliability and robustness. However, advancements in power electronics have led to the emergence of IGBT-based furnaces, with 24 pulse offering greater energy efficiency and improved control over the melting process.

The primary focus of this case study is the energy consumption in both types of furnaces. The SCR technology, while effective, is known for its relatively lower energy efficiency compared to IGBT. The power consumption of IGBT-based Furnace is yield to give a substantial 15% reduction in energy consumption.

The specific energy consumption in both the plants are as per the graph shown below Fig 1.

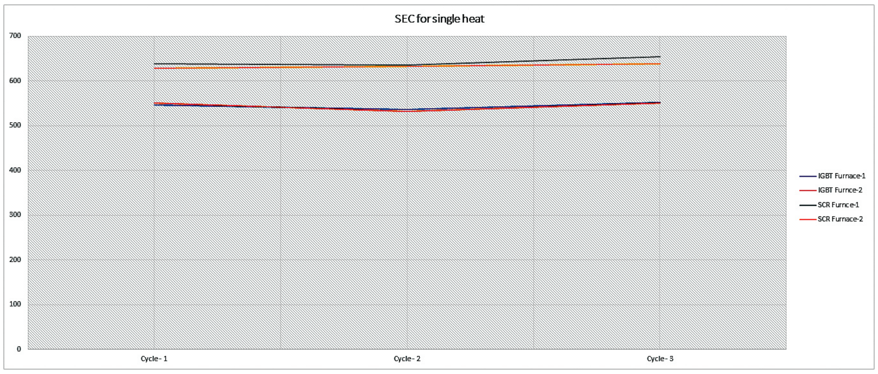


Figure 1 SEC for single heat

The fast-switching capabilities of IGBTs help minimize harmonics, resulting in cleaner power supply and reduced stress on the electrical system. SCRs, however, can introduce higher harmonic content, requiring additional measures for harmonic mitigation.

Both IGBTs and SCRs can incorporate soft starting techniques to reduce the inrush current during startup. However, IGBTs generally provide better control and smoother ramp-up of voltage, resulting in gentler and more controlled starting of the induction furnace. IGBT control mechanisms generally offer higher overall efficiency compared to SCR control mechanisms because of lower conduction and switching losses, resulting in reduced power dissipation and improved energy efficiency. SCRs, especially in lower pulse configurations, may have higher losses and lower.

IGBT-based induction Furnace has constant power factor above 0.96 for 6 pulses,0.985 for 12 pulse and .997 for 24 pulse converters, at any load condition whereas SCR based induction furnace does not have constant power factor which mainly depend on the load condition. Energy monitoring and data logging system is available in IGBT-based induction Furnace which helps in accurately track the total power consumption of plant and manages plants overall load factor. Automatic sintering cycle programmed as per user requirement is also available in IGBT-based induction Furnace.

Return on investment:

While installing IGBT-based power module for induction furnace involves an initial capital investment of ₹10 lakh, the long-term energy savings contribute to a shorter payback period.

Recommendation	Annual Saving in kWh	Saving in %.	Investment cost	ROI
Install 24 Pulse IGBT power module instead of SCR in Furnace	13 Lakh	15	₹30 Lakh	3.8 Months

Recommendations:

SCR-based induction furnace consumes more power as compare to IGBT-based induction Furnace. So, IGBT technology in induction furnaces can yield significant energy savings, operational advantages, and environmental benefits.

Energy savings:

The IGBT-based furnace has consistently outperformed the SCR-based counterpart in terms of energy efficiency, with the projected 15% savings being realized.

Industrial Energy Assessment Cell
KISEM
Industrial Energy Assessment Cell (IEAC)
Kotak IITM Save Energy Mission (KISEM)
Indian Institute of Technology Bombay, Mumbai
Ph: +91 9447407201 Email: sreepk.iitb@gmail.com

COPPER INDUSTRY

OPTIMIZING CHARGING RATE IN CHANNEL INDUCTION FURNACES

IIT Indore

Summary:

The detailed energy assessment of channel type upcast induction furnace conducted in a copper industry was carried out in Indore, Madhya Pradesh. Here, the molten stock is drawn slowly through upcaster and a cylindrical copper rod comes out continuously, which has a diameter of 20mm. The rod is further processed to fabricate copper components. We have identified the possibilities of energy saving and the implementation resulted in a saving of about ₹7.5 lakh per annum in the channel induction furnace alone by slightly increasing the draw rate. It has the potential to save 29.48% of the energy usage of the channel induction furnace itself. The electrical energy savings in units of energy is 0.11 MU.

Configuration:

Name of Furnace	Rated Power (kW)	Rated Weight (kg)	Type	Process	Fuel	Operation	Stock
Furnace - 1	80	1750	Induction (Channel Type)	Melting, Holding & UpCasting	Electricity	Continuous	Copper
Furnace - 2	120	2500	Induction (Channel Type)	Melting, Holding & UpCasting	Electricity	Continuous	Copper

Channel induction furnace copper drawing:

The upcasting and copper drawing are shown in the figure.

The melting of copper is taking place at 1085°C with AC voltage of 380V and frequency of 50 Hz, the melting and casting process works for 24X7.

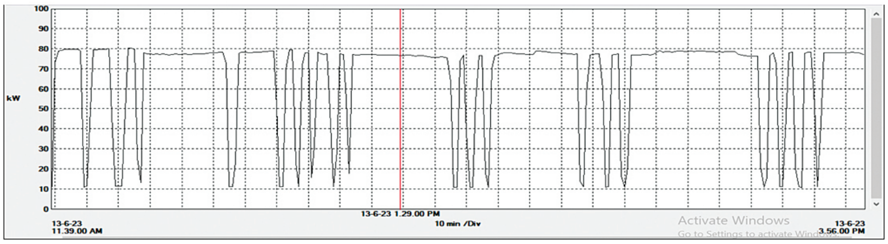
In upcaster the feeding of material at input and production of casting products is a continuous process. In 80 kW furnace, the stock draw rate was set to 20.8 m/hr.

It was proposed to optimise the wire drawing rate (melting and production

Assessment Date: 12-18 June 2023

Overview:

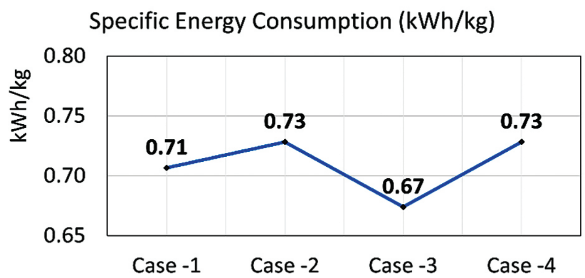
Copper demand in India has surged to 1,522 KT in the year 2023 as per data from the International Copper Association. Copper and its wide applications in electrical wiring and distribution systems allows efficient transmission and distribution of electricity with minimal energy loss, thereby reducing energy consumption and costs. Copper is also a key component in industrial and home appliances where it is used in windings to achieve higher efficiency and lower energy consumption, resulting in significant energy savings of up to 30%. Copper plays a vital role in Electrical Power Distribution, E – Mobility, Renewable Energy (RE), railways and all sectors of economy. 34 % increase in demand has been noticed. It is predicted that the demand may increase upto 45% by 2035 due the increased penetration of RE and E – mobility in India. The major energy use in the copper industry is for the melting of copper. The stock draw rate and shape of the cast are controlled by the upcaster. By changing the drawing speed of stock, the production rate can increase without affecting the electric energy input for melting. Which can reduce the specific energy cost of melting and energy savings can be achieved.



Electrical loading profile of 80kW furnace

rate simultaneously) by optimising the draw velocity as per design settings. Four cases are studied by changing the draw velocity without affecting the quality of production. The variation of specific energy consumption with draw velocity is shown in the graph.

The specific energy consumption was reduced from 709kWh/MT to 500kWh/MT.



Variation in SEC based on draw rate

Particulars	Baseline	Proposed	Unit
Drawing rate	20.8	26	m/hr
Production Rate	92	115	kg/hr
Specific Energy Consumption	0.709	0.500	kWh/kg
Annual Production	514711	514711	kg
Annual Energy Consumption	364930	257356	kWh
Annual Energy Conserved	107575		kWh

Return on investment:

There is no financial investment required to change the draw velocity and increase the production rate. Consequently, there is an immediate return on investment.

Recommendation	Saving in kWh	Saving in Rs.	Investment cost	ROI
Optimize the loading of furnace by slightly increasing the draw rate from 20.8 m/hr to 26 m/hr and reduce specific energy consumption near to 0.5 kWh/kg and specific energy cost to Rs.3.95/kg	107,575	753,022	Nil	Immediate

Recommendations:

In the existing stage, the product draw rate for an 80kW furnace is 20.8 m/hr. It is proposed to optimize the draw rate from 20.8 to 26 m/h. By increasing the product raw rate (production rate), reduce specific energy consumption near to 0.5 kWh/kg and specific energy cost to Rs.3.95/kg.

Energy savings:

The specific energy consumption will reduce from 0.709 kWh/kg to 0.50 kWh/kg. The yearly energy and monetary savings are proposed to be 107575 kWh/year and ₹7,53,022/year respectively.

Industrial Energy Assessment Cell
KISEM
Industrial Energy Assessment Cell (IEAC)
Kotak IITM Save Energy Mission (KISEM)
Indian Institute of Technology Indore, Indore
Ph: +91 7907150282 Email: aneeshrajendran@iiti.ac.in

ALUMINIUM INDUSTRY

FUEL SWITCHING TO ELECTRICITY IN MELTING FURNACES

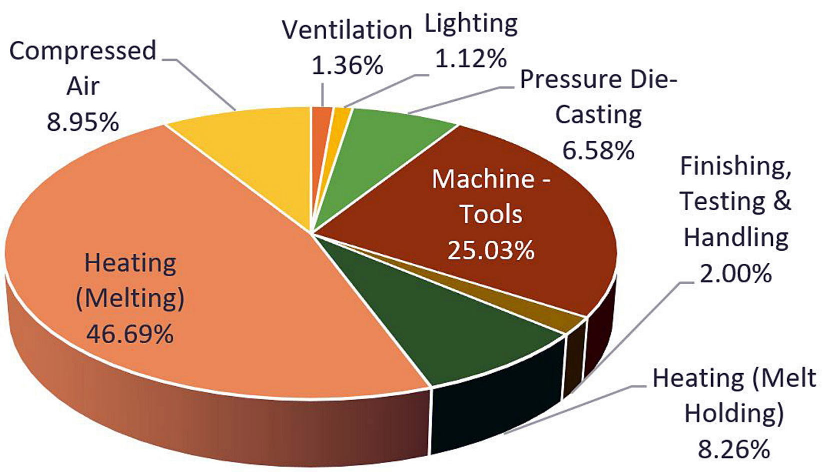
IIT Indore

Summary:

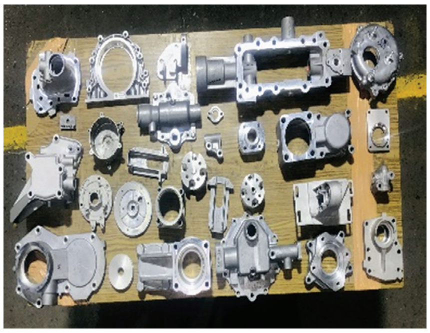
The detailed energy assessment of a CNG-fired aluminium melting furnace carried out in an aluminium Pressure Die Casting (PDC) industry in Pithampur, Madhya Pradesh, identified the possibilities of energy saving, and the implementation resulted in a saving of about ₹46.5 lakh per annum by switching the fuel and melting furnace alone. Which has the potential to save 1 MU of electricity with a ₹25 lakh investment. About 47% of the total energy share of the industry is for the melting of aluminium.

Configuration:

There are two melting furnaces available in the industry.



Particulars	Type	Capacity	Stock	Operation
MF -1	Gas fired - Tilting	570 kg	Aluminum Ingots	Batch
MF -2	Gas fired - Tilting	270 kg	Aluminum Ingots	Batch



Assessment Date: 28-31 March 2023

Overview:

The aluminium industry in India is growing day by day, and exports worldwide are increasing year after year. The aluminium production of Indian companies contributes nearly 2% of India's GDP. The automotive sector consumes 40–45% of secondary aluminium in India. The automobile parts are mainly made by Pressure Die Casting (PDC) of aluminium.

In an aluminium PDC industry that manufactures different automotive and general engineering products, it is observed that the melting of aluminium scrap and ingots is done in an open-type CNG-fired tilting furnace. The specific energy cost of aluminium melting seems very high at ₹7.92/kg. By switching the fuel to electricity and using a closed-type electrical melting furnace, the specific energy cost of aluminium melting can be reduced to ₹2.73/kg.

Observations in melting furnace:			
Particulars	**Value**		**Unit**
Average fuel cost	8		Rs/kg.
Fuel firing rate	124	78.6	SCM/Batch
Average GCV of Fuel	8500		kCal/SCM
Typical batch duration	1.5	3	hrs/batch
Molten Metal Outlet Temp.	685	730	°C
Air to Fuel ratio	15.4	9.48	kg/kg
Efficiency of furnace	19.97	20.17	%
Specific Energy Consumption	1221.32	1260.57	kCal/kg
Specific Fuel Consumption	0.144	0.148	SCM/Kg
Specific Energy Cost	7.903	8.157	Rs/kg

Fuel switching from CNG to electricity:			
Particulars	**Baseline**	**Proposed**	**Unit**
Fuel Type	CNG	Electricity	
Furnace - Efficiency	20%	85%	%
Specific Energy Consumption	1221	285	kCal/kg
Specific Fuel Consumption	0.144		SCM/kg
		0.331	kWh/kg
Specific Energy Cost	7.92	2.73	₹/kg
Annual Production	896730	896730	kg
Annual Energy Cost	7102102	2445777	₹
Annual Monetary Savings	4656324		₹

The CNG-fired furnace is inefficient compared with an electrical furnace. A major portion of the supplied heat is lost in flue gas and radiation.

Return on investment:

The estimated cost of arresting air leakages using correct filter material and repairing mechanical drive were ₹200,000. The ROI was approximately six months.

Recommendation	Saving in kWh	Saving in Rs.	Investment cost	ROI
Switch to Electrical resistance melting furnace having low specific energy cost at Rs.2.73/kg	975976	46,56,324	₹25,00,000	6

Recommendations:

Since the efficiency of an open-type gas-fired melting furnace is low, switch to an efficient closed-type electrical melting furnace to reduce the specific energy cost from ₹7.92 to ₹2.73/kg of melting. It has the potential to save 80% of energy for melting.

Switching to electrical melting not only saves energy costs but also reduces carbon footprints, leading to sustainable manufacturing.

Energy savings:

The efficiency of a CNG furnace is only 20%, and its annual energy consumption is 1273148 units. By switching to an energy-efficient electrical furnace, annual energy consumption can be reduced to 297172 units. It gives a total monetary benefit of ₹46,56,324/ annum.

Industrial Energy Assessment Cell
KISEM
Industrial Energy Assessment Cell (IEAC)
Kotak IITM Save Energy Mission (KISEM)
Indian Institute of Technology Indore, Indore
Ph: +91 7907150282 Email: aneeshrajendran@iiti.ac.in

PAPER INDUSTRY

REDUCING MECHANICAL TRANSMISSION LOSSES IN BELT AND PULLEY SYSTEMS

IIT Indore

Assessment Date: 28-31 March 2023

Summary:

The detailed energy assessment of belt slip and transmission losses of machineries conducted in a paper industry in Madhya Pradesh. By assessing more than 15 machines that use conventional flat belts and V belts for power transmission, like the chest agitator, vacuum pump, and turbo, it was observed that about eight machines had a higher belt slip of more than 30%. The energy loss by transmission can be resolved by replacing the conventional belt with cogged V-belts, which can save to a tune of 6 lakh unit of electricity and a monetary saving of ₹50 lakh annually.

Configuration:

Name of Machine	Type	Capacity (kW)	Rated speed (RPM)
Vacuum Pump 1	3 Phase IM	132 kW	975
Vacuum Pump-2	3 Phase IM	132 kW	975
Turbo	3 Phase IM	55 kW	1430
Chest Agitator 1	3 Phase IM	11 kW	1430
Chest Agitator 6	3 Phase IM	11 kW	1430
Chest Agitator 2	3 Phase IM	11 kW	1430
Chest Agitator 5	3 Phase IM	11 kW	1430
Chest Agitator 3	3 Phase IM	11 kW	1430

Energy savings by switching over to cogged belt:

The main reason for belt slips is: type of belt, insufficient tension, low friction coefficient of belt with pulley, misalignment, wear and ageing of belt, etc.
In conventional belts, these issues are high, which leads to high belt slip. By using a cogged V belt, which has a good traction mechanism, reduced tension requirements and higher power transmission capacity, the slip percentage can be reduced to an optimal level of below 3%.

Overview:

The Indian Paper Industry accounts for about 1.6% of the world's production of paper and paper board. There are over 650 paper mills in the country producing different types of paper using various raw materials. The consumption of different grades of paper has been growing in line with the country's GDP growth. Pulp and paper manufacturing industries in India consume about 11 ton of steam and 1500 units of electricity per ton of paper production. Hence, the industry is considered as one of the energy intensive sectors.

In the paper industry, various machines cater to the paper manufacturing processes; most of them are driven by three-phase induction motors. Some motors and machines used for pulp preparation are connected by a belt and pulley system for power transmission by considering the distance between the motor and machine as well as the motor's safety under dynamic loads. By conducting the study, it seems that in some flat belt and V- belt drives, the belt slip is high, which leads to energy loss by transmission, which can be resolved by using cogged V-belts. In some motors direct coupling is also feasible rather than belt and pulley system.

Name of Machine	Motor Pulley Size (cm)	Driven Pulley Size (cm)	Motor Speed (rpm)	Driven Speed (rpm)	Slip (%)	Annual Energy conserved (kWh)
Vacuum Pump 1	50	113	931.4	331.7	19.51%	133199
Vacuum Pump-2	50	113	943.8	336.9	19.33%	188300
Turbo	32	56	1555	649.4	26.92%	91674
Chest Agitator 1	30	65	1390	440.3	31.37%	51788
Chest Agitator 2	30	65	1079	332.1	33.31%	33331
Chest Agitator 3	30	65	992.8	308.6	32.65%	30396

Energy savings by direct coupling of chest agitator motors			
Particulars	Baseline	Proposed	Unit
Percentage slip	34	8	%
Power Consumed by the Chest Agitator Motor	11	5.06	kW
Numbers	2	2	kW
Daily Working Hours	24	24	Hr/day
Daily Energy Consumed	528	242.88	kWh
Annual Energy Consumption	158400	72864	kWh
Annual Energy Conserved	85536		kWh

In two agitator motors, direct coupling is possible. In direct coupling, there is no transmission loss.

Return on investment:

The investment has to be made for the purchase of new clogged belts and for direct coupling of shafts.

Recommendation	Saving in kWh	Saving in Rs.	Investment cost	ROI
Reduce slippage in belt and pulley system through replacement of conventional V-belts with Cogged V-belts and reduce motor speed using existing VFD	528688	4303517	₹28500	1
Reduce energy lost in transmission by direct coupling the machines.	85536	696263	₹80000	2

Recommendations:

Reduce slippage in the belt and pulley system through the replacement of conventional V-belts with cogged V-belts and reduce motor speed using existing VFDs for chest agitators 1, 2, and 3, Turbo 600 and Vacuum Pumps 1 and 2.

Reduce energy lost in transmission by direct coupling the machines for chest agitator 5 and 6.

Energy savings:

By changing belt type, 528688 kWh of energy and ₹4,30,3517 of money per year can be saved. And by giving direct coupling to the motor, 85536 kWh of energy and ₹6,96,263 of money can also be saved.

Industrial Energy Assessment Cell
KISEM
Industrial Energy Assessment Cell (IEAC)
Kotak IITM Save Energy Mission (KISEM)
Indian Institute of Technology Indore, Indore
Ph: +91 7907150282 Email: aneeshrajendran@iiti.ac.in

AUTOMOBILE INDUSTRY

ELECTRIC HEATERS TO HEAT PUMPS FOR ENGINE CYLINDER WASHING

IIT Indore

Assessment Date: 03- 13 July 2023

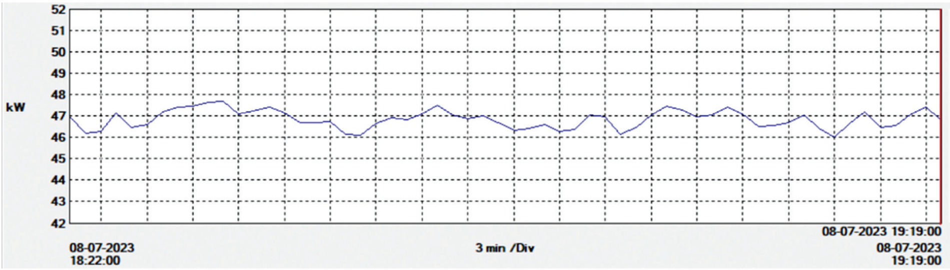
Summary:

The detailed energy assessment of an electric heating system is conducted in a reputed automobile industry in Madhya Pradesh. Here, conventional electric resistance heaters are used to heat the coolant circulated in the IC Engine Cylinder Head Washing (CHW) unit. By replacing the conventional heater and installing an air-to-water heat pump, 2.2 lakh units of electricity and ₹17 lakh operational costs can be saved annually.

Configuration:

In the existing configuration, 48kW Electric resistance heater is used in the CHW.

CHW is a process that has to be done for the cylinder head unit before going for the cylinder head and block assembly in an IC Engine production line. In the washing unit, there is a temperature demand of 70°C which has to be supplied to the coolant liquid by a resistance heating arrangement.

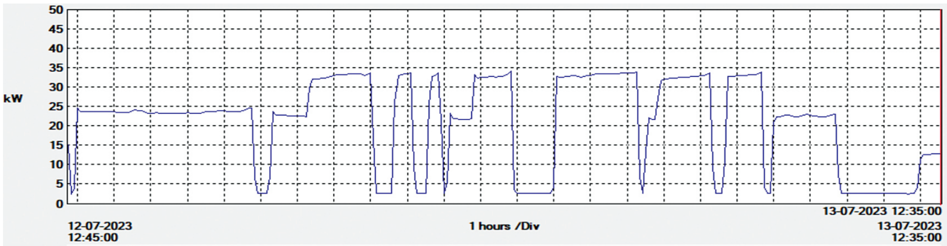


Overview:

The automotive industry in India is the third largest by production in the world, as per 2023 statistics. As of 2023, India is the third largest automobile market in the world in terms of sales. In 2022, India became the fourth largest country in the world by the valuation of its automotive industry. India is emerging as a global automotive hub. The automobile sector has seen a compound annual growth rate (CAGR) of 15% during the last five to seven years. In an automobile assembly plant, energy is used in curing ovens of painting lines, compressed air requirements, lighting, air conditioning in office spaces, painting (fans and curing), material handling, welding, robotic arms, machining, etc.

In an engine manufacturing process, an electric resistance-type heating system is used for the heating of coolant in the Cylinder Head Washing (CHW) unit. It was proposed to switch over from conventional electrical resistance water heaters to the state-of-the-art, energy efficient air-to-water heat pump to conserve energy.

Switching over to heat pumps		
Parameter	**Value**	**Unit**
Power Consumed by Existing Heater	46.87	kW
Energy Consumption by Existing Heater	35.16	kWh/hr
Average Heater Efficiency	80%	%
Thermal Energy Demand	28.13	kWh/hr
Avg. COP of Proposed Heat Pump	3.00	kW_{Th}/kW_{Ele}
Electrical Power Input to Proposed Heat Pump	9.38	kW_{Ele}
Heating Capacity of Proposed Heat Pump	10.00	TR
Daily Operating Duration	24	Hrs
Annual Electricity Consumption of Existing Heater	308002	kWh
Annual Electricity Consumption of Proposed Heat Pump	82134	kWh
Annual Energy Conserved	**225868**	**kWh**



Heat pumps work based on the principle of the refrigeration cycle. In an air-to-water heat pump, the air side acts as an evaporator and the water side acts as a condenser. In a heat pump, it is possible to use electric supplied energy and heat extracted from the air jointly for heating applications. This makes heat pumps an energy efficient solution in comparison to conventional electric heaters for low-temperature applications. Hence, it is proposed to install energy efficient air to water heat pump combined with plate heat exchanger and keep existing electric resistance heaters as standby.

Return on investment:

There is no financial investment required to change the draw velocity and increase the production rate. Consequently, there is an immediate return on investment.

Recommendation	Saving in kWh	Saving in Rs.	Investment cost	ROI
Install Energy Efficient Air to Water Heat Pump combined with Plate Heat exchanger and keep existing Electric Resistance heaters as standby	82,134	17,16,596	₹5,60,000	4

Recommendations:

Since the efficiency of an open-type gas-fired melting furnace is low, switch to an efficient closed-type electrical melting furnace to reduce the specific energy cost from ₹7.92 to ₹2.73/kg of melting. It has the potential to save 80% of energy for melting.

Switching to electrical melting not only saves energy costs but also reduces carbon footprints, leading to sustainable manufacturing.

Energy savings:

The efficiency of a CNG furnace is only 20%, and its annual energy consumption is 1273148 units. By switching to an energy-efficient electrical furnace, annual energy consumption can be reduced to 297172 units. It gives a total monetary benefit of ₹46,56,324/annum.

Industrial Energy Assessment Cell
KISEM
Industrial Energy Assessment Cell (IEAC)
Kotak IITM Save Energy Mission (KISEM)
Indian Institute of Technology Indore, Indore
Ph: +91 7907150282 Email: aneeshrajendran@iiti.ac.in

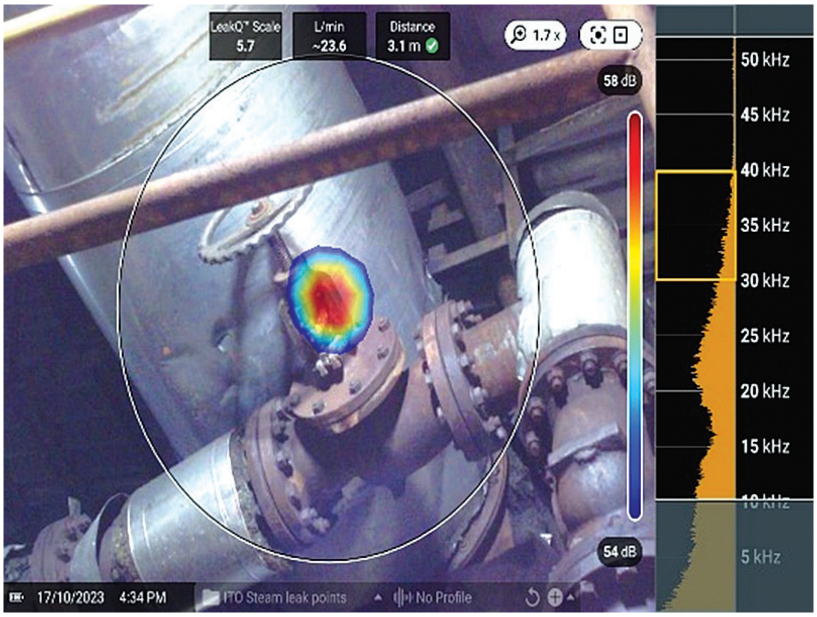
TEA EXTRACTION AND PROCESSING

ENERGY CONSERVATION OPPORTUNITIES IN STEAM SYSTEMS

IIT Indore

Summary:

The detailed energy assessment of a steam line and steam distribution systems is conducted in a reputed tea processing industry at Munnar, Kerala. The energy audit addressed an overall 7.25% loss of thermal energy from steam leakage points, faulty steam traps, loss of flash steam and non-insulated steam line pipes. An overall monetary savings to the tune of ₹44.62 lakh annually is assessed.



Configuration:

The steam is generated at a pressure of 15 kg/cm2 and used at various processes at a pressure of 10.5 kg/cm2. For steam generation, wooden chips and Furnace Oil (FO) fired Boilers are used. The wooden chips boiler having a capacity of 12 TPH is used as a primary for steam generation. The FO type boiler has a capacity of 10 TPH and is used as a standby or booster.

Steam leakage - The total steam leakage was estimated to 2848 kg/day from various leakage points. The steam leakage points were captured using acoustic imaging techniques.

Steam traps - Thermodynamic and Float type steam traps used in the steam lines. Certain steam traps were found defective due to leaks, stalling, water logging, passing etc. The steam trap health condition was identified using ultrasonic steam leak detection and thermal imaging techniques.

Flash steam – Flash steam loss was found at various locations in plant. It is estimated about 4500kg of steam lost in a day. Flash steam could be recovered and condensate recovery could be improved.

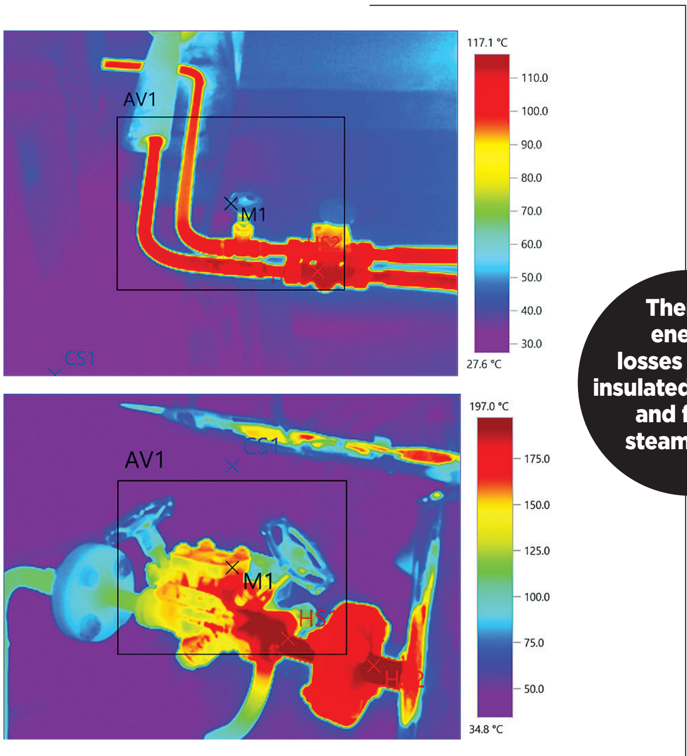
Non-insulated surfaces – Absence of thermal Insulation observed at steam lines, hot water lines, hot process lines and condensate lines. The pipe surface temperature is identified and captured using laser pyrometry and thermal imaging techniques. The maximum temperature observed is about 190°C and allowable pipe surface temperature is 60°C.

Assessment Date: 13-21 October 2023

Overview:

India is the second largest producer of tea after China. In the year 2021-22, Assam and West Bengal generated 83% of the yearly tea production. The balance 17% is generated from Kerala, Tamil Nadu and Karnataka. Among them, 80% of the tea produced in the country is consumed by domestic population. India is among the top five exporters in the world, making about 10% of the total exports.

This case study talks about energy conservation in steam systems in a typical tea processing plant. In India, the production of instant tea is from a very few industries and almost 100% is exported to America, Europe and other Asian countries for further blending and consumption. The major processes involved in tea extraction and processing are withering, CTC, extraction, pre-treatment, clarification, evaporation, spray drying and packing. In most of the critical processes for tea extraction, steam is a vital component. Steam generation costs about 1.6 to ₹1.7/kg in this industry. Energy conservation through steam savings is proposed.



Thermal energy losses in non-insulated surfaces and faulty steam traps

Scope of energy saving:

Sr. No.	Observations	Recommendation	Energy Saving (%)	Monetary Saving (Rs)	Simple Payback Period (Months)
1	Steam leakages at various points	Arrest the steam leakages by properly sealing the gaps	2%	₹1192340	2
2	Thermal energy lost by condensate accumulation in steam traps	Maintain traps and recover condensate	2%	₹1255976	2
3	Thermal energy lost as flash steam	Recover condensate using a SOPT Pump and pumping condensate directly to feed water tank	3%	₹1838704	5
4	Non-insulated surfaces of steam distribution lines and condensate lines	Provide thermal insulation at the high temperature surfaces and save fuel	0.3%	₹175033	4

In tea processing plants, 90 to 95% energy utililzation is from thermal scope. Hence, the consumption and scope of thermal energy savings is high. With the proposed energy conservation measures, the industries have opportunities to save energy, increase condensate recovery percentage, reduce the specific energy consumption and increase the overall efficiency of steam utilization.

Recommendations:

Steam leakage - Arrest all steam leakage points in the upcoming maintenance scheduled.

Steam traps - Provide regular check-up and maintenance of steam trap which reduce the loss of thermal energy and increase the condensate recovery percentage.

Flash steam – From the steam line the flash steam can be recover by using Steam Operated Pump Trap (SOPT)

Non-insulated surfaces – Providing thermal insulation to steam line and valves is the low hanging fruits which can address in a short time and save energy.

Energy savings:

By addressing losses only in steam systems, the industry have a scope of overall 7.25% thermal energy savings potential and an overall monetary saving potential of ₹44.62 lakh annually which could be paid back in three months.

Industrial Energy Assessment Cell
KISEM

Industrial Energy Assessment Cell (IEAC)
Kotak IITM Save Energy Mission (KISEM)
Indian Institute of Technology Indore, Indore
Ph: +91 7907150282 Email: aneeshrajendran@iiti.ac.in

BREWING INDUSTRY

PARTIAL FUEL SUBSTITUTION IN BOILERS USING SPENT GRAINS

IIT Indore

Assessment Date: 23 -28 October 2023

Summary:

The detailed energy assessment of partial fuel switching to spent grain is conducted in a brewery in Palakkad, Kerala. Here, 39% of the process output is spent grain. Through the concept of circular economy, the spent grain can be reused as fuel in the boiler. A total of 6183 metric tonnes of spent grain is produced annually. While doing partial fuel switching in boiler fuel, it has a potential of 11 million kWh of energy savings and ₹19 lakh of money savings.

Configuration:

Name of Furnace	Rated Power (kW)	Rated Weight (kg)	Type	Process	Fuel	Operation	Stock
Furnace - 1	80	1750	Induction (Channel Type)	Melting, Holding & UpCasting	Electricity	Continuous	Copper
Furnace - 2	120	2500	Induction (Channel Type)	Melting, Holding & UpCasting	Electricity	Continuous	Copper

Potential of spent grain for use as boiler feed:

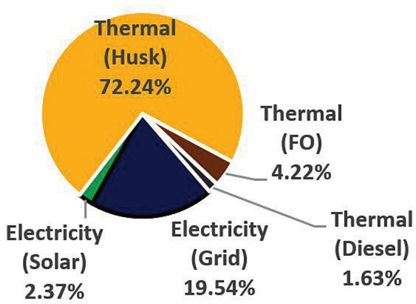


Figure- Utility consumption of energy in the plant

About 72% of the energy share is thermal for producing steam. Annually, about 4,126 MT of husk is used as fuel for the boiler, which shall yield 1,437 MTOE of energy annually and is used for steam generation. In brewing process, about 6,182 MT of spent grain is produced as byproduct. The wet spent grain has to be dried by using a dryer, and a fuel with an average GCV of 3800 kCal/kg could be obtained. By mixing this with rice husk, it can be fed to the boiler.

Overview:

In India, 14.6% of its population consumes beer, and the Indian beer market will reach ₹383.6 billion in 2022. And it is exhibiting a growth rate (CAGR) of 8.1%. Beer is an alcoholic beverage that is produced from malted grains, hops, yeast and water. Beer styles vary from light lagers to dark stouts and porters, with their own flavour profile and brewing procedure. Beer is manufactured in breweries, and wort making, fermentation, filtration, bottling and pasteurization are the key processes.

In the brewing process, steam is used for heating, cleaning, and pasteurizing. A large portion of the steam produced in a brewery is used in the extraction of sugar and flavours in the mashing process and for wort boiling, where beer is sterilised and stabilised. Boiler fuel for steam generation accounts for a major portion of utility costs. In the mashing process, the spent grain is obtained as a waste product. It is a biowaste that can be used as fuel by removing the moisture from it. It can be used for the partial substitution of fuel used in boilers. Spent grain can be considered a carbon-neutral fuel and the fuel substitute will not contribute to carbon emissions. By using this as additional fuel, the cost of fuel can be reduced.

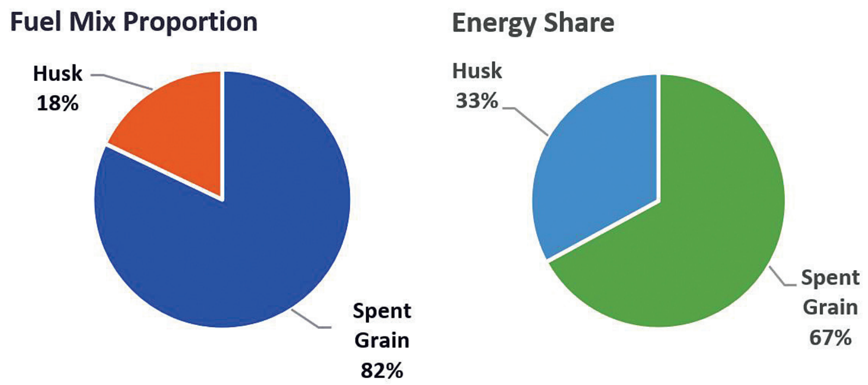


Figure- Fuel mix proportion and energy contribution post substitution

Paddy husk and spent grain samples

Particular	Value	Unit
Existing		
Annual Husk Consumption	4126	MT/Year
Proposed		
Annual Spent Grains Produced	6183	MT/Year
Annual Fuel (FO) Spent for drying	440	kL/Yr
Annual Net Energy Savings	967	MTOE/Yr
Annual Net Fuel Savings (Husk)	2776	MT/Year

Return on investment:

The byproduct – spent grain obtained could be reused free of cost. However, spent grain drier requires an investment. Based on the same, pay back is arrived.

Recommendation	Saving in TOE	Saving in Rs.	Investment Cost in Rs.	ROI
Partial fuel substitution of paddy husk with spent grains as boiler feed	967	19.23 lakh	₹10 Lakh	6 months

Recommendations:

Reuse and recycle spent grains as partial fuel for boilers as part of circular economy.

Energy savings:

In the existing condition, 4126 MT of paddy husk are used as boiler fuel annually. By using spent grain as fuel, it can reduce the husk quantity to 1349 tons. It will result in an energy saving of 967 MTOE and a monetary saving of ₹19.23 lakh annually.

Industrial Energy Assessment Cell (IEAC)
Kotak IITM Save Energy Mission (KISEM)
Indian Institute of Technology Indore, Indore
Ph: +91 7907150282 Email: aneeshrajendran@iiti.ac.in

PLASTIC INDUSTRY

ENERGY CONSERVATION IN INJECTION MOLDING MACHINE

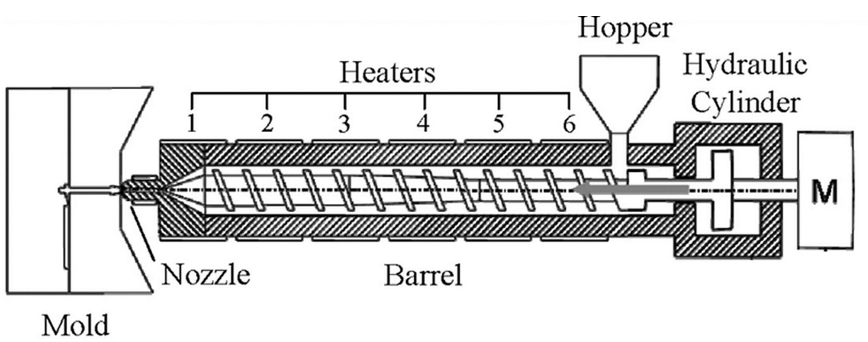
IIT Ropar

Summary:

The detailed energy assessment of 40 injection molding machines in a particular plastic industry in Rudrapur district was carried out and identified the possibilities of energy saving by incorporating better insulation with proper temperature control. We recommended a saving of about ₹4.67 lakh per annum with a payback period of 2.6 months by providing proper thermal insulation to the device, especially in the heater section of the barrel and material loading hopper. The plant has recently initiated the implementation of these recommendations.

Configuration:

40 molding machines are normally in operation and during the study 27 numbers of machines were considered as a sample for the analysis. The molding machine consists of a barrel with heaters over it and a material loading hopper with a pre-heater. The raw material is heated and melted then injected into the mold of desired shape.



High surface temperature and radiation heat loss:

The outer surface of heater sections in the molding machines is observed to be getting significantly hotter than they should. The absence of proper insulation is causing heat to escape in the form of radiation, which not only affects the efficiency of the machines but also contributes to an uncomfortable and potentially unsafe working environment. In fact, upon observation, it has become clear that the majority of our injection molding machines lack adequate insulation.

Quality deterioration due to improper temperature control:

Rejection rates were higher in the machines without insulation as compared with the machines with insulation. Also, the heater on-off control was made based on a timer-controlled relay rather than temperature-sensed feedback control. This also adversely affected maintaining a constant temperature in the barrel. The on-off cycle of heaters in molding machines with and without insulation as well as the thermal images are shown in the below figures.

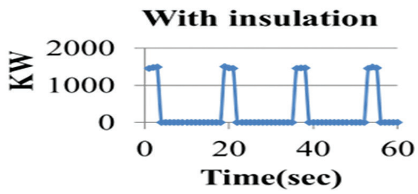
Assessment Date: 20- 23 May 2023

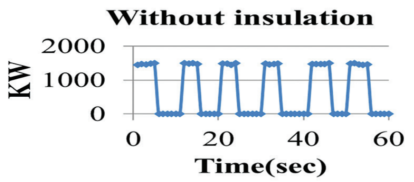
Overview:

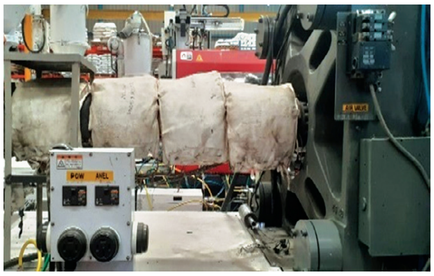
Injection molding machines and extrusion machines are two widely used machines in plastic industries. Both are very energy intensive and are contributing majorly to the energy bill. Both these machines have a large scope for energy conservation as both use electric heaters to melt the polymer during the process.

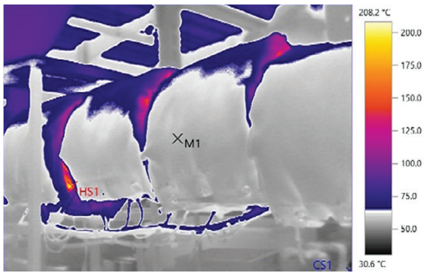
A case study on injection molding machine insulation is explained in this work. The high surface temperature on the barrel and heater section near the material loading hopper is observed in the molding machines due to improper insulation. The electric heaters are installed with on-off relay control to maintain a constant required temperature in these sections. As the insulation deteriorates more and more heat is wasted through the surface and power consumption gets increased.

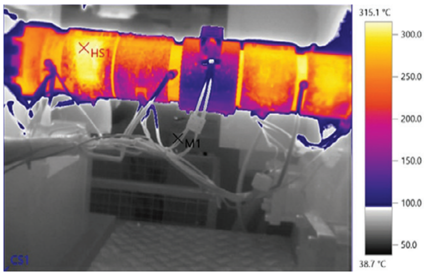
In this work, we studied the on-off pattern of electric heaters with insulation deterioration as well as the condition with and without insulation. It is observed that most of the relays are worked based on timer-based control rather than temperature-sensed feedback. This will also lead to a variation from the set temperature and thus affect the quality of production. Better insulation with proper temperature control will resolve this issue as well as improve the specific energy consumption.

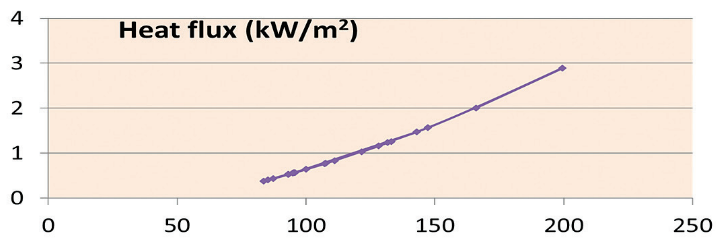












Recommendations:

To eliminate the radiation loss from the surface it is recommended to provide proper to the heater section in the molding machines. Along with this, temperature-sensed feedback control to the heaters will help in maintaining a constant temperature at the barrel.

The controller controls its temperature by cutting out the heater with proper temperature feedback. This will help in reducing the specific energy consumption with improved quality in product.

Energy savings:

We recommend insulating the heater section in barrels and material loading hopper along with proper feedback-based temperature control to avoid overheating. By providing proper insulation to all molding machines 51,902 units of energy can be saved annually which will contribute to an annual monetary savings of ₹4,67,122.

Return on investment:

The estimated cost for providing proper thermal insulation to all the injection molding machines is ₹1,00,000. The payback was approximately 2.6 months.

Recommendation	Saving in kWh	Saving in Rs.	Investment Cost	SPB (Months)
Provide proper thermal insulation to the heater section in all Moulding Machines	51,902	4,67,122	₹1,00,000	2.6
Provide proper control to the heater based on temperature-sensed feedback from the barrel				

Industrial Energy Assessment Cell
KISEM

Industrial Energy Assessment Cell (IEAC)
Kotak IITM Save Energy Mission (KISEM)
Indian Institute of Technology Ropar, Rupnagar
Ph: +91 9020090594 Email: staff.renjith.raj@iitrpr.ac.in

IRON AND STEEL

ENERGY CONSERVATION IN REHEAT FURNACE

IIT Ropar

Summary:

A comprehensive energy evaluation of a pulverized coal-fired reheat furnace was conducted at an iron and steel facility in Ludhiana District. This furnace is employed for heating ingots in preparation for the rolling process. Despite the incorporation of an air pre-heater, the observed efficiency of this continuous heating push-type furnace was found to be below 45%. The factors contributing to this include inadequate fuel combustion, heat loss through radiation from gate openings, and heat loss through flue gas, among others. Our analysis suggests that approximately 8% of the total loss is attributed to flue gas resulting from excess air. This study specifically targets this particular aspect of loss for further examination and improvement. Furthermore, we've identified radiation losses from the air inlet pipe after the air preheater, primarily caused by the lack of insulation. Additionally, it's noteworthy that the FD fan is controlled through throttling, despite the installation of a VFD drive.

Configuration:

The facility is equipped with a 200-ton capacity push-type reheat furnace, featuring a pulverized coal-fired system with four injectors. The ingots are fed through the preheat section and subsequently pushed through the heating and soaking zones, attaining temperatures within the range of 1200oC over a period of two hours. An air pre-heater has been installed to recuperate waste heat from the flue gas. Coal is introduced into the system along with preheated air to facilitate combustion. The reheated ingots are then directly transferred from the furnace to the roller mills via roller conveyors for the subsequent rolling process.

Excess air in flue gas and throttling of FD fan:

The flue gas analysis revealed an excess air percentage of 100%, with a stack temperature exceeding 460°C. Despite the presence of VFD drives for the FD and ID fans, their operational control does not currently align with the demands for optimal combustion. However, considering the present setup, implementing a closed-loop feedback mechanism using an oxygen sensor in the flue gas can effectively regulate both the FD and ID fans, ensuring that the excess air percentage is maintained within the recommended range of 10% to 20%. By implementing this energy conservation measure, the estimated outcome is a reduction in annual coal consumption by around 49 metric tons and a decrease in electricity consumption by 35,460 units per year.

Inadequate insulation at air inlet pipes:

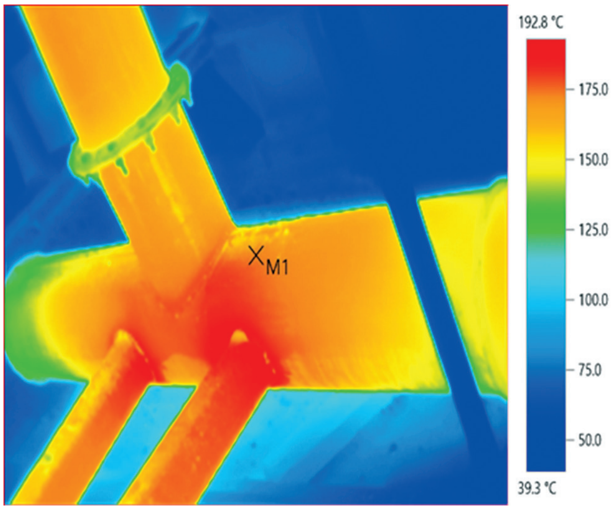
Insulation was not provided over the air inlet pipe after the air pre-heater, so a very high surface temperature (i.e., in the range of 170oC to 193oC) was observed in this pipe. Thus, the heat recovered from the flue gas through the air preheater is lost via radiation, leading to a decrease in the overall efficiency of the heat recovery system and a reduction in combustion efficiency. Insulating this pipeline effectively can eliminate the loss and enhance combustion efficiency by raising the air inlet temperature.

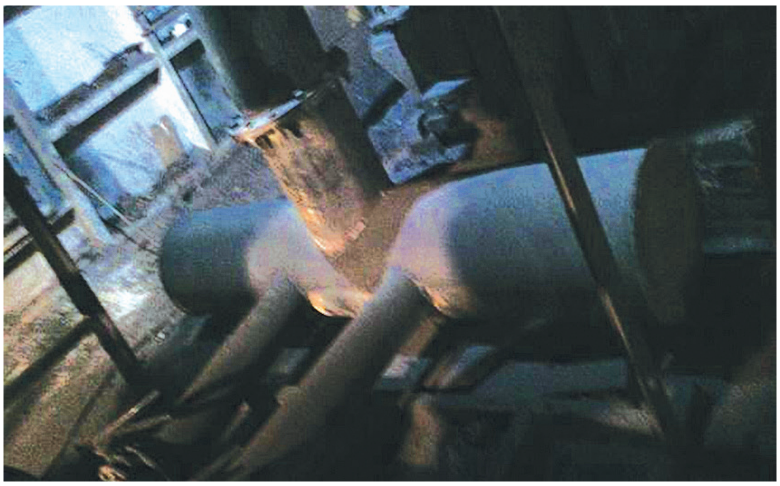
Assessment Date: 04 -07 Sep 2023

Overview:

Reheat furnaces play a pivotal role in various industries, especially in steel and metal production, as they are essential for the reheating of semi-finished products. These furnaces are crucial for heating metal billets or ingots to high temperatures, enabling the shaping and forming processes necessary for producing different steel products. However, given the focus on energy conservation and sustainability, there is an increasing emphasis on developing and adopting energy-efficient technologies and practices for reheating furnaces. Initiatives such as the implementation of advanced combustion systems, waste heat recovery, and improved insulation techniques are being encouraged to minimize energy consumption and reduce carbon emissions

The objective of this case study is to spotlight the challenges posed by the presence of excess air in the reheat furnace flue gas, affecting the furnace's overall efficiency. Moreover, the study seeks to offer effective solutions to alleviate this issue and enhance the furnace's performance.





Return on investment:

The anticipated cost of installing the oxygen sensor and ensuring adequate insulation for the air inlet pipe was evaluated at approximately ₹400,000, with a projected simple payback period of roughly four months.

Recommendation	Saving in kWh or tonne	Saving in Rs.	Investment Cost	SPB (Months)
Control both FD and ID fans with proper closed-loop feedback from the oxygen sensor in the flue gas to maintain the excess air percentage within the recommended range of 10 -20 %.	52.3 MT of coal and 35,460 kWh	12,94,225	₹4,00,000	4
Provide proper control to the heater based on temperature-sensed feedback from the barrel				

Recommendations:

The suggestions included regulating both FD and ID fans using a closed-loop feedback system from the oxygen sensor in the flue gas to ensure that the excess air percentage remains within the target range of 10-20%. This range ensures optimal combustion efficiency while minimizing heat loss, helping to achieve better energy utilization and reduced emissions. Likewise, it was advised to insulate the air inlet line to the furnace after the air preheater, resulting in enhanced combustion efficiency and minimized radiation loss from the air inlet line.

Energy savings:

Upon implementation, it was suggested that the annual savings in the furnace would amount to 52.3 tonne of coal consumption and 35,460 units of electricity, resulting in a cost savings of 12,26,495. Additionally, with a projected simple payback period of merely four months, the initiative was deemed not only financially advantageous but also a highly viable investment.

Industrial Energy Assessment Cell
KISEM

Industrial Energy Assessment Cell (IEAC)
Kotak IITM Save Energy Mission (KISEM)
Indian Institute of Technology Ropar, Rupnagar
Ph: +91 9020090594 Email: staff.renjith.raj@iitrpr.ac.in

IRON AND STEEL

ENERGY CONSERVATION IN FURNACE LADLE

IIT Ropar

Summary:

The detailed Energy Assessment of the furnace ladle was carried out in a foundry-based iron and steel unit in Ludhiana District. The facility was equipped with two 750kg induction furnaces, with one operating at a given time and the other held in reserve. The ladle utilized for transferring molten alloy from the furnace to the mold lacked adequate insulation. With the plant operating for 12 hours daily, it was necessary to pre-heat the ladle each day, and the molten metal itself from the furnace was used for this pre-heating.
Using molten metal to pre-heat the ladle is quite energy-intensive and expensive. Due to the inadequate insulation of the ladle, it struggles to maintain the necessary temperature during subsequent heating, resulting in a decrease in temperature. Consequently, to sustain the desired temperature within the prescribed limits for the casting process, an additional superheating process is implemented within the furnace. During the study, an average additional superheating of 127oC was observed in the furnace.

Configuration:

Two furnaces are installed in the plant with a capacity of 750 kg, with one operating at a given time and the other held in reserve.
The average energy consumption measured during the operation per heat is 539 kWh. The ladle employed for transferring molten metal undergoes preheating following its initial exposure to the molten metal. Subsequently, during subsequent heating cycles, the ladle is not preheated. Consequently, in order to sustain the necessary tapping temperature before the final casting process, an extra superheating step is performed within the furnace, typically raising the temperature by an average of 127oC from the first casting. Additionally, it should be noted that the current ladle exhibits inefficiencies in terms of its insulation, and it also lacks a proper ladle cover.

Unnecessary superheating of metal and radiation loss in ladle:

The pre-heating of the ladle in the first heating cycle with molten metal was observed to be very energy-intensive and expensive. In addition to that, as the preheating is not done in the consecutive heating cycle, the ladle was observed to be at a lower temperature before pouring. Therefore, there is an average temperature decrease of 127 degrees Celsius in the molten metal within the ladle even prior to the commencement of casting. To counteract this, an excessive 127°C superheating step is implemented within the furnace, presenting a critical concern in terms of energy consumption. Moreover, a substantial portion of the total heat loss within the ladle can be attributed to radiation escaping from the ladle opening. These losses can be effectively mitigated by introducing an LPG-based ladle preheater, alongside the implementation of adequate insulation and a cover for the ladle. LPG preheating in a well-insulated ladle not only enables better control over the metal's temperature for precise casting and improved product quality but also prevents thermal shocks, prolonging the ladle's lifespan and reducing

Assessment Date: 01- 03 June 2023

Overview:

In the Indian energy scenario, the foundry-based steel industry holds a significant position, contributing to the country's industrial growth and economic development. This sector plays a vital role in meeting the demands for various steel products in both domestic and international markets. However, this industry is also known to consume substantial amounts of energy, making it crucial to prioritize energy conservation measures.

Efforts in energy conservation within the foundry-based steel industry in India involve the adoption of various strategies such as improving energy efficiency in manufacturing processes, implementing advanced technologies for heat recovery, optimizing furnace operations, and promoting the use of renewable energy sources. Furthermore, initiatives focusing on the utilization of energy-efficient equipment and the implementation of energy management systems are also gaining prominence in the sector.

the need for frequent replacements, thereby leading to long-term cost savings. Moreover, it ensures smoother and more efficient casting operations. Addressing this issue is crucial to improve energy efficiency, reduce operational costs and align with the global commitment to sustainable and environmentally responsible manufacturing practices.

Recommendations:

Following an extensive evaluation, the study recommended the installation of an energy-efficient LPG-based ladle pre-heater to optimize the ladle's temperature management throughout every heating cycle. Emphasizing the significance of thermal efficiency, the report advised implementing robust insulation and a protective cover for the ladle to significantly reduce heat loss from the molten metal. These measures were proposed to enhance overall operational efficiency, minimize energy wastage, and improve the quality of the casting process. In addition to this ladle insulation prevents burns or injuries for workers and promotes a more comfortable environment, enhancing focus and productivity during operations.

Return on investment:

The estimated cost of implementing these measures is approximately ₹7,00,000. However, due to the projected efficiency improvements and cost savings resulting from these enhancements, the investment is expected to be recouped within a relatively short period of approximately nine months.

Recommendation	Saving in kWh	Saving in Rs.	Investment Cost	SPB (Months)
Pre-heat the ladle with an energy-efficient LPG pre-heater before each heating cycle	1,41,775	9,92,425	₹7,00,000	9
Ensure that the ladle is adequately insulated and equipped with a cover.				

Energy savings:

Implementing these recommendations can potentially cut the plant's energy consumption by 1,41,775 KWh, resulting in 9,92,425 cost savings annually with a simple payback period of nine months

Industrial Energy Assessment Cell
KISEM

Industrial Energy Assessment Cell (IEAC)
Kotak IITM Save Energy Mission (KISEM)
Indian Institute of Technology Ropar, Rupnagar
Ph: +91 9020090594 Email: staff.renjith.raj@iitrpr.ac.in

PLASTIC INDUSTRY

ENERGY CONSERVATION IN COOLING TOWER

IIT Ropar

Assessment Date: 13- 15 June 2023

Summary:

After conducting a thorough energy evaluation of the cooling tower installed in a plastic unit in Jhajjar, Haryana, numerous significant issues were pinpointed. Notably, it was discovered that the cooling tower was considerably oversized, with a capacity rating of 600 TR is being operated at only 79.37 TR. Additionally, it was observed that the cooling tower exhibited a notably limited range even when the flow was throttled. Another evident problem related to the cooling tower was the imbalance in the flow of cold and hot water. To rectify this, a measure was taken to interconnect the well, enabling a mixture of both hot and cold water. Furthermore, it was noted that the circulation pump, designed for both hot and cold water, was excessively oversized, contributing to the overall inefficiency of the cooling system.

To address these concerns, recommendations were made for downsizing or optimizing the cooling tower, improving temperature and water flow control, resizing the circulation pump, and implementing a better water distribution system. Upon identifying potential opportunities for energy conservation, the subsequent implementation led to annual savings of approximately ₹1.35 million specifically from the cooling tower, achieved with a minimal investment. Implementation and ongoing monitoring are recommended to ensure the continued optimal performance of the cooling tower. The plant has recently initiated the implementation of assessment recommendations.

Configuration:

The installation comprised a four-compartment, 600 TR forced draft cooling tower to cater to the cooling water demands of the injection molding machines at the facility. The underground hot well collects the hot water returned from the plant, which is then pumped to the cooling tower via two 11kW centrifugal pumps. Additionally, the cold water is initially stored in the cold well and subsequently circulated within the plant using two centrifugal pumps, one with a capacity of 30kW and the other with a capacity of 18.5kW.

Cooling tower oversizing:

During the study, the plant's projected heat load was determined to be 79.37 TR. Consequently, a 600 TR cooling tower was installed, resulting in a mere 14% capacity utilization. Oversized equipment tends to operate at suboptimal levels, leading to excessive energy consumption and operational costs can result in significant energy inefficiency. To rectify this problem, the plant should consider downsizing or optimizing the cooling tower to align its capacity more closely with the actual heat load, thereby reducing energy waste and related expenses.

Loss with inefficient cooling tower operation and water pumping:

The energy audit further revealed inefficiencies in the operation of the cooling tower. During the study, it was observed cooling tower range is 1oC, with the approach nearly approaching zero. The retention time for heat transfer between the cold water and molding machine was very small due to the higher mass flow rate. Furthermore, there was an imbalance in the mass flow rate between the cold and hot water lines. To ensure a steady level between the hot and cold wells, an interconnection was established. Consequently, this resulted in the mixing of hot and cold water, leading

Overview:

The plastic industry in the Indian energy scenario has a significant impact due to its extensive use of energy resources. Producing plastic components typically entails energy-intensive procedures like injection molding, extrusion, and thermoforming. These methods necessitate significant energy usage, mainly for heating, cooling, and molding plastic materials into the desired components. Hence, prioritizing energy efficiency measures and implementing energy-saving technologies is crucial for reducing the overall energy consumption during manufacturing operations.

Cooling towers play a critical role in the plastic injection molding industry by facilitating the effective cooling of equipment and molds during the manufacturing process. As plastic materials are injected into molds at high temperatures, cooling is essential to solidify and set the materials in the desired shape. Cooling towers facilitate the rapid and efficient dissipation of heat, enabling the plastic products to solidify quickly and maintain their structural integrity.

to the inefficient operation of the cooling tower.

Similar to the cooling tower, the associated pumping system was excessively oversized. Specifically, the cooling tower pump operated at 50% efficiency, while the circulation pump ran at approximately 37% efficiency. To rectify these inefficiencies, it was advised to incorporate a variable frequency drive (VFD)-based control system for the pumps, coupled with temperature-based feedback. This solution aimed to minimize energy wastage and optimize the overall performance of the water circulation system.

Return on investment:

The estimated cost of implementation will cost around ₹2,70,000. The SPB was approximately 2.4 months.

Recommendation	Saving in kWh	Saving in Rs.	Investment Cost	ROI
Operate only one compartment of the cooling tower (150 TR) for the existing plant load (79.37 TR)	1,66,999	13,35,995	₹2,70,000	2.4
Both hot and cold-water flow rate should be balanced and VFD drive can be used to regulate the flow. Also, separate both hot and cold well to avoid mixing of water				

Recommendations:

Based on the energy audit results, four primary recommendations were proposed. Firstly, by operating only one compartment of the cooling tower, designed for a 150 TR capacity, to match the existing plant load of 79.37 TR. Secondly, implementing Variable Frequency Drives (VFD) for the cooling tower and circulation pump to regulate water flow offers a substantial energy-saving opportunity. The third recommendation emphasizes regulating the circulation pump using temperature-based feedback. Furthermore, it is advised to prevent the mixing of hot and cold water in the well by disconnecting the current connection between the two. These energy-saving strategies collectively represent crucial steps toward enhancing the plant's energy efficiency and financial sustainability.

Energy savings:

Implementing these recommendations can potentially cut the plant's energy consumption by 1,66,999KWh, resulting in ₹13,35,995 cost savings annually.

Industrial Energy Assessment Cell
KISEM

Industrial Energy Assessment Cell (IEAC)
Kotak IITM Save Energy Mission (KISEM)
Indian Institute of Technology Ropar, Rupnagar
Ph: +91 9020090594 Email: staff.renjith.raj@iitrpr.ac.in

IRON AND STEEL

ENERGY CONSERVATION IN FURNACE

IIT Ropar

Summary:

A comprehensive energy assessment of the induction furnaces was conducted at an iron and steel facility located in Ludhiana, Punjab. Within this facility, two 7 MT furnaces are employed in a rotating manner for the purpose of melting metal. These furnaces are of the coreless induction type, featuring a water-cooled helical coil constructed from copper tubing, a crucible situated within the coil, and a supporting shell capable of tilting to facilitate the pouring of molten metal. The operation of these furnaces involves the use of alternating current passing through the coil, inducing alternating currents in the metal charge loaded into the crucible. These induced currents generate the necessary heat for the process, and the furnaces operate at high frequencies, with an average energy consumption rate of 4743kWh per heat recorded during their operation. Due to the operation of the furnace at a very high temperature, approximately 1570oC, without a properly insulated door gate, significant radiation losses are anticipated. Additionally, these losses are expected to escalate with prolonged delays during charging or during idle operations, particularly in the final stages of the melting process.

Configuration:

Two coreless induction furnaces, each having a capacity of 7 MT, operate in an alternating manner. Neither furnace is equipped with adequate door gates. The molten metal consistently attains an average temperature in the range of 1560 to 1570oC during each heating cycle. Furthermore, periods of idleness were observed during both the furnace charging process and before pouring, resulting in unnecessary superheating of the molten metal within the furnace.

Radiation losses:

Radiation loss from the furnace opening during idle time is a significant concern, primarily due to the extremely high temperatures maintained inside the furnace (i.e., above 1500oC). In the absence of active raw material charging, the furnace retains an elevated internal temperature and may lead to unnecessary superheating of molten metal, causing heat to radiate outward through the gate opening. This loss of radiation signifies a significant energy wastage and leads to higher operational expenses for the furnace. This wasted heat not only adds to energy costs but also creates safety concerns, as the exterior of the furnace can become dangerously hot. Higher energy consumption due to radiation loss can lead to an increased carbon footprint, negatively impacting the environmental sustainability of the industrial operation. Furthermore, extended exposure to elevated temperatures, particularly in the proximity of the furnace, may pose health risks to the plant's workers,

Assessment Date: 10- 12 May 2023

Overview:

The furnace stands as the primary energy-consuming equipment within the iron and steel industry, making its analysis of paramount importance. Given its substantial energy demand, comprehensively assessing furnace operations is pivotal for evaluating energy conservation opportunities. Analyzing the furnace's efficiency, energy utilization, heat recovery, and process optimization enables the identification of strategies to reduce energy consumption, minimize environmental impact, and enhance the overall sustainability of iron and steel production, making it a critical component in the industry's pursuit of energy conservation and efficiency improvements.

A case study on radiation loss through the gate opening in the furnace is explained in this work. Closing the furnace with a lid during idle periods effectively reduces this radiation loss, as it traps heat within and minimizes heat escaping into the surroundings. This practical step conserves energy and enhances the overall efficiency of furnace operations.

including heat stress, dehydration, and heat exhaustion. Efforts to address this radiation loss involve the utilization of insulation materials or the implementation of adjustable gating mechanisms for the furnace opening during the idle period between charging.

Furthermore, employing best operating practices for furnace charging can help minimize radiation loss, conserve energy, and promote a safer working environment. Managing radiation loss during idle periods is a key component of optimizing energy efficiency in the induction furnace and reducing operational expenses.

Recommendations:

The recommendation suggests installing well-insulated furnace door gates and implementing the practice of covering the furnace during the idle period of operation, such as between raw material charging and the final stage of superheating. This measure is proposed to effectively minimize the radiation loss from the molten metal. By adopting these strategies, the facility can expect to improve energy efficiency and reduce operational costs, while also ensuring a safer working environment for the personnel.

Return on investment:

The projected cost for implementing this recommendation is roughly ₹1,00,000, with an estimated payback period of only three months. This indicates that the initial investment is expected to be recouped in a relatively short timeframe, underlining the potential financial viability of the suggested solution. This cost-efficient measure not only promises immediate returns but also demonstrates a sound investment in enhancing the energy efficiency and operational sustainability of the industrial facility.

Energy savings:

As a result of the implementation, the estimated electricity savings amounted to 68,615 units, contributing to a significant annual monetary saving of ₹4,80,302. Furthermore, this efficient energy management approach led to an impressive calculated simple payback period of approximately 3 months, underscoring the cost-effectiveness and financial viability of the investment.

Recommendation	Saving in kWh	Saving in Rs.	Investment Cost	SPB (Months)
Properly insulated furnace door gates can be used during idle operation between the charging of raw material as well as in the final stage of superheating	68,615	4,80,302	₹1,00,000	3

Industrial Energy Assessment Cell
KISEM

Industrial Energy Assessment Cell (IEAC)
Kotak IITM Save Energy Mission (KISEM)
Indian Institute of Technology Ropar, Rupnagar
Ph: +91 9020090594 Email: staff.renjith.raj@iitrpr.ac.in

IRON AND STEEL

ENERGY CONSERVATION IN INDUCTION FURNACE

IIT Ropar

Summary:

A comprehensive energy assessment was carried out on two 8 MT induction furnaces in a steel industry based in Ludhiana. The assessment revealed the potential for energy savings through the implementation of certain best practices in furnace operation. During the study, it was observed that at the final stage of heating, the temperature gradient was in the range of 7°C per minute. Furthermore, a time delay is observed between the final temperature measurement and pouring without any control. These two elements will result in the undesired superheating of the molten metal within the furnace, resulting in significant energy wastage. Moreover, as the temperature of the liquid metal rises, the amount of radiation loss will also escalate, further contributing to a notable loss. With the implementation of some of the best operating practices, such as either reducing the delay time between the final temperature measurement and pouring or properly controlling the input power by adjusting the frequency of the power supply during the final stage of melting to decrease the temperature gradient, or both, we can effectively control these energy losses. in addition to this, installing an insulated door gate on the furnace will additionally decrease radiation losses during the furnace's idle operation. Based on these implementations, a potential annual saving of 14.5 lakh is suggested, with a simple payback period of only one month.

Configuration:

Two 8 MT induction furnaces were installed in the plant, one operational and the other on standby. The study recorded an average electricity usage of 5970 units per single two-hour heating cycle, with 10 cycles occurring daily. The study revealed an average delay time of 1.5 minutes between the final temperature measurement and pouring, resulting in an excessive superheating of 10°C.

Superheating loss and radiation loss:

The ideal temperature range for effective blending of alloying components and the viscosity required for smooth flow falls between 1570°C and 1580°C. Typically, during each heating cycle, approximately two to three readings are recorded to verify the attainment of this temperature range. Furthermore, even after reaching the desired temperature, there is a small delay, averaging around one and a half minute, before the pouring process begins. To assess the potential losses during this waiting period, several temperature readings were collected at one-minute intervals across various cycles. The rate of temperature increase during the last phase of heating was approximated to be 7°C per minute. This results in an additional 42.5 units of electricity consumed by the furnace in each heating cycle. By effectively managing the input power through adjustments to the power supply frequency in the final phase, the temperature gradient can be minimized. Consequently, both unnecessary superheating losses and radiation losses related to superheating can be eliminated. To further reduce radiation losses, it was suggested to install a well-insulated door gate for the furnace.

Assessment Date: 26-27 April 2023

Overview:

India is one of the largest steel-producing countries globally and has been actively working towards improving energy efficiency and reducing environmental impact in the steel industry. Induction furnaces are pivotal in achieving these objectives, primarily owing to their substantial energy intensity, representing more than 70% of the total energy consumption in a conventional foundry-based steel industry. While induction furnaces are recognized for their superior energy efficiency when compared to traditional blast furnaces, their efficiency can be significantly reduced due to poor practices resulting from unskilled operations. One such practice is unnecessary superheating of molten metal.

Superheating the metal is accepted to some extent as it can help achieve better temperature uniformity, enhanced mixing of alloying elements and reduced viscosity facilitating better flow and improved casting properties. Despite these advantages, superheating will lead to higher energy consumption and increased radiation loss from the metal. Also superheating can cause accelerated erosion of the refractory lining, potentially compromising the structural integrity of the furnace and requiring more frequent repairs or replacements.

Recommendations:

The suggestion was made to regulate the power input by adjusting the frequency of the power supply in the final phase of heating. This would minimize the temperature gradient and thereby prevent the excessive superheating of the molten metal. Existing controllers serve this purpose, so further investment is not required rather than implementing this as a best operating practice. Additionally, this will reduce the likelihood of additional maintenance requirements.

Energy savings:

Through a small initial investment, suggestions were made to save 58,342 units of electricity annually by addressing radiation losses, and an additional 1,48,895 units of electricity annually by curbing unnecessary superheating of molten metal. The projected simple payback period for the investment was just one month.

Return on investment:

With the existing controller, manual controlling is well enough to achieve these savings, so there is no investment required to implement this recommendation. Also, a minimal investment is required for an insulated door gate to the furnace with a simple payback of less than one month.

Recommendation	Saving in kWh	Saving in Rs.	Investment Cost	SPB (Months)
Regulate the power input by adjusting the frequency of the power supply in the final phase of heating **An insulated furnace cover can be used during the idle operation of the furnace**	2,07,237	14,50,662	₹1,00,000	1

Industrial Energy Assessment Cell
KISEM

Industrial Energy Assessment Cell (IEAC)
Kotak IITM Save Energy Mission (KISEM)
Indian Institute of Technology Ropar, Rupnagar
Ph: +91 9020090594 Email: staff.renjith.raj@iitrpr.ac.in

WATER TREATMENT PLANT

ENERGY SAVING OPPORTUNITIES IN CETP-AERATION UNIT

IIT Gandhinagar

Assessment Date: 21- 26 Sept 2022 & 19 -24 February 2023

Summary:
The detailed energy assessment of aeration motor and blowers monitoring system are carried out in three industries at Common Effluent Treatment Plant (CETP) in Ahmedabad & Ankleshwar, Gujarat, identified the possibilities of energy saving and the implementation resulted in a saving of about 12-15% of electricity savings in aeration alone by automation i.e., close loop controlling of VFD with dissolved oxygen (DO) as per requirement. Assessment recommendations amounting to ₹10 lakh to ₹50 lakh per annum depending on the size of plant. CETP Ahmedabad partially implemented the DO controlling with help of motor ON-Off application and their savings are almost ₹8 lakh (since Jan-23) and it is estimated 12% saving on the original power consumption.

Configuration:

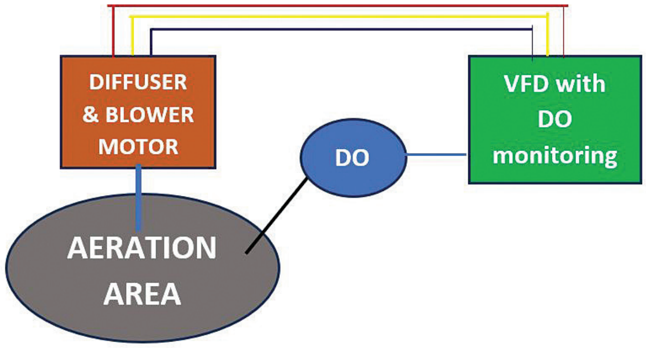
Every chemical industrial state (GIDC) has its own Common Effluent Treatment Plant (CETP), where all industries discharge their water after some pre-treatment. CETP receives water and do treatment and after that the treated water send to city mega line or in sea with booster pumps depending on the water parameter.

In CETP unit major power consumption area is aeration unit, we are focusing on this unit for energy saving. We had monitored the dissolved oxygen level for 12 hours and found that it is varying between 1.5 to 4.5 ppm with same set of machinery. As the effluent received from different industries, we are not able to control the water intake quantity and parameters.

CETP aeration unit mainly consist of one small blowers rating from 3.7kW to 5.5kW and diffuser motor rating varies from 22kW to 45kW. The main purpose of diffuser motor is for providing the stirrer action and blower provide the air to maintain DO level, so basically it is for mixing of air in water.

Operation and control of dissolved oxygen in aeration section:

Effluent water after some primary treatment reaches to aeration system where the air is added to the effluent to maintain COD in the water for achieveing this diffuser motor continuously stirrer the water and the aeration blower adds air in the diffuser shaft so that mixing will be proper. There are DO sensors that show the DO level in water. The diffuser motor and blower operations i.e., ON and OFF or frequency are monitored by DO level.

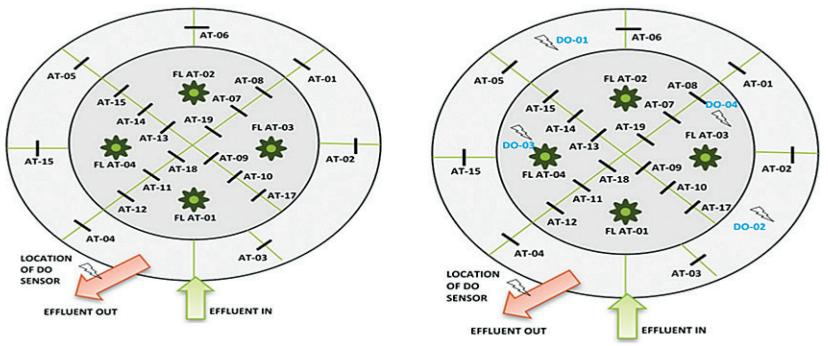


Overview:

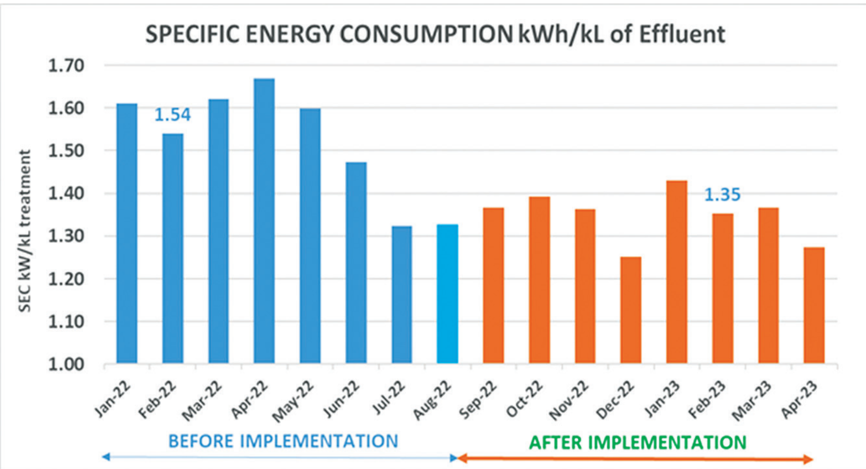
We had performed the study on Common Effluent Treatment Plant (CETP) near Ahmedabad and Ankleshwar region. CETP receives effluent water from different industries and hence it is difficult to maintain similar chemical properties of water. So, for varying COD and BOD in water it is difficult to operate the blowers and motors with fixed frequency or parameters hence it becomes difficult to operators to change the frequency or ON and OFF of any motors.

Schematic circuit for dissolved oxygen monitoring:

Previously there was no monitoring over the DO level or less monitoring due to the DO level crossing 4 ppm while as per Government norms, it is recommended to maintain the DO level up to 2 ppm hence excess air is provided to achieve the desired parameter. To control this excess air, we must do close loop monitoring of DO level either by VFD or by ON and OFF sequencing of different blowers.



Average Load kW - PAST	Average Load kW - Present
852.04	752.31



Return on investment:

Plant 1 had already installed the VFD in diffuser motor, but they are not monitoring it properly because of open loop controlling while Plant 2 had agreed in ON and OFF sequencing with DO level.

Plant 1 investment= Nil.

Plant 2 investment= Negligible (₹50,000/-).

Recommendations:

Install VFD with close loop controlling of DO level in aeration unit.

The aeration unit consists of a diffuser motor and a blower, blower used to flow the air inside the aeration tank while the diffuser helps in circulating or mixing that air inside the aeration tank for a uniform DO level. Due to that in aeration unit 10% of load is due to aeration blower while 90% of load is due to diffuser unit.

By observing the operation of this unit, we recommended to do close loop monitoring of DO with diffuser motor while the air blower will remain running on their full speed or sequencing the diffuser motor and blower motor on off as per DO requirement.

Energy savings:

We had done four plant aeration unit study and for this case study we are taking only two plant data because they had already implemented our energy conservation measures.

Plant 1 recommended savings 10,73,023 kWh.

Plant 2 recommended saving of 24,31,800 kWh.

Plant 1 achieved savings of 4,86,000 kWh (since Sept 2022) whereas Plant 2 achieved savings of 2,83,710 kWh (since May 2023) which results in monetary savings of ₹42,12,000 and ₹25,53,390 respectively.

COLD INDUSTRY

ENERGY SAVING OPPORTUNITIES IN COLD STORAGE CHILLER

IIT Gandhinagar

Summary:

The detailed energy assessment of chiller compressor was carried out in cold storage in Himmatnagar, Gujarat, identified the possibilities of energy saving and the implementation resulted in a saving of about ₹6,00,000 lakh per annum in compressor alone by automation i.e., taking VFD in line with compressor motor and suction pressure of compressor as input to VFD. Assessment recommendations amounting to ₹5,00,000 were implemented (since Apr-23). It is a 38% saving on the original power consumption of the single compressor unit.

Configuration:

There are five halls and each hall have six floors in which they are maintaining different temperature. For achieving the cooling demand of the plant there are four compressors running with common low-pressure (LP) receiver, high pressure (HP) receiver and cooling tower. There are two expansion valves installed, one near the LP receiver and the other near the diffuser side of each hall so that it will become easy to achieve the different temperature with the same set of machinery.

There is one ammonia transfer pump which transfer low pressure ammonia (LP receiver) to a common header from there it will get distribute in five pipelines and after heat transfer return to LP receiver, refrigerant gas will come up due to density difference while liquid refrigerant will go down. This refrigerant gas will suck by the compressor and then send to cooling tower specifically evaporative cooling tower and after changing its phase it goes into HP receiver and as per demand it goes into LP receiver.

Manual or human intervention in chiller operation:

It is found that all the process mentioned above takes place manually e.g., once temperature reaches, the operator will simultaneously switch of the compressor, ammonia pump and cooling tower.

Assessment Date: 27 - 28 Sept 2022

Overview:

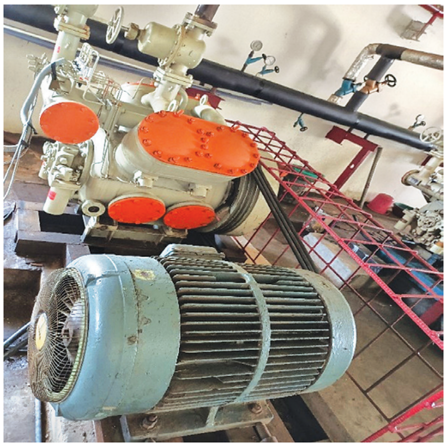
We had performed the study of Cold storages near Dehgam and Himmatnagar region, this region is well known for potato agriculture. After harvestings vast number of potatoes are available which need to store in proper storage space and temperature for increasing their shelf life.

For any cold storage the major load is chiller unit for maintain proper temperature in the space. Potato cold storage is one such place where the harvesters can keep their potatoes so that they remain fresh until they are not sold to anyone.

Mainly reciprocating type compressors are used with ammonia as refrigerant. Thus, any improvement in the performance of compressor and cooling tower will results in substantial energy savings.

Chiller System:

It is found that sometimes the pump and compressor remain ON once the temperature of hall reaches or sometime it is like ON and OFF operation. Since all compressors are connected in star delta connection, once the compressors are switched ON, it will increase the demand and due to exceeding of demand there should be penality to the customer through VFD close loop controlling the excessive demand are also in control because the ON and OFF cycle is reduced and manual intervention is also minimised.



1. Reciprocating compressor

2. Cooling tower

3. High pressure receiver

4. Low pressure receiver

Recommendations:

Install VFD with close loop controlling on chiller compressor.

Pressure transmitter is installed near the suction pressure gauge and after setting the minimum pressure of refrigerant gas it will increase or decrease the VFD speed of compressor as per demand.

Solenoid valve cum expansion device is also install just before the LP receiver so that when the level in the LP tank will reduce it will open and take refrigerant in the receiver and maintain LP receiver tank level.

Controlling sequence is like first compressor will be OFF, then pump, and at last cooling tower pump will be OFF and ON, and vice versa.

Energy savings:

Since the plant has four compressors, we had taken one unit for this study. The energy consumption of the compressor is 680 units. Running hours per day is 14hrs and annual running days are 270 days. After implementation of above measure energy savings achieves 12-20 units per hours depend on load condition.

Return on investment:

The estimated cost of VFD and close loop controlling was ₹300,000. The ROI was approximately 6 months.

Industrial Energy Assessment Cell
KISEM
Industrial Energy Assessment Cell (IEAC)
Kotak IITM Save Energy Mission (KISEM)
Indian Institute of Technology Gandhinagar, Gandhinagar
Ph: +91 9033798820 Email: rahuljayantibhai.p@iitgn.ac.in

TEXTILE INDUSTRY

ENERGY SAVING OPPORTUNITIES IN THERMIC FLUID HEATER

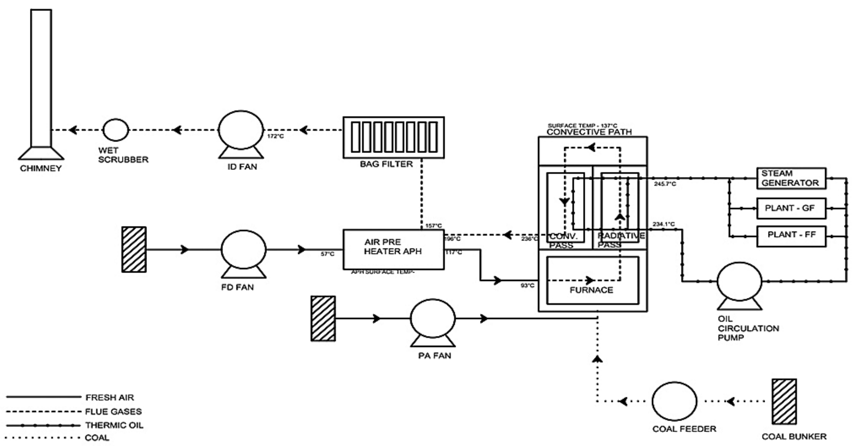
IIT Gandhinagar

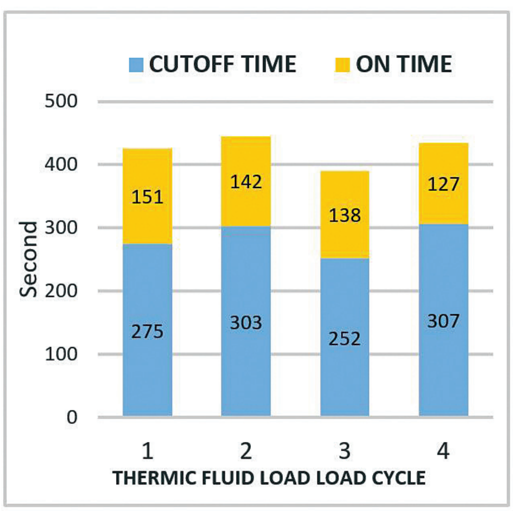
Summary:

The detailed assessment carried out in 25 lakh kCal thermic fluid heater in Surat textile plant. Thermic fluid system opportunities are identified in electrical energy as well as thermal energy. Opportunities identified during assessment are quantify in terms of 1.71 lakhs unit electrical energy and 268 ton of coal consumption. Overall energy savings identified ₹37.72 lakh per annum.

Configuration:

Plant has recently installed thermic fluid heater system for plant heating requirement in drying and printing applications. Following specifications of thermic fluid heaters. Thermic fluid capacity 2500U (25 lakh kcal) with coal fired FBC, 02 Pass system, APH as waste heat recovery device and Hot oil temperature 245 °C. Plant coal consumption is around 5 tons per day. Thermic fluid system having almost 20% of plant total Electrical load consumption. Plant doesn't have any coal measurement system. KISEM Team suggested a simple inhouse fabricated proximity sensor-based system to monitor plant coal consumption. KISEM team supported to perform for precise drop test for this system.





Frequent load unload pattern observed:

With coal measurements thermic fluid heater observed to operated with only 33% load as compared to design. Due to frequent loading and unloading condition thermopack is operated in a very inefficient manner. Difficult to maintain excess air level in furnace. From detailed investigation the following opportunities identified in thermopack boiler.

Assessment Date: 13-15 June 15 2023

Overview:

Thermic fluid heaters are used in the textile industry for various heating applications such as dyeing, printing, and finishing.

Like boilers, thermic fluid heaters (TFH) or fired heaters (FH) are units designed to transfer heat from combustion to a 'working' or 'thermic' fluid. However, a TFH or FH is not necessarily a pressure vessel and the working fluid—typically a petroleum-based oil—does not change from its fluid state.

The units operate in a closed loop with the thermic fluid picking up heat energy at one end of the loop and then transferring it to process equipment by indirect transfer via heat exchangers. TFHs and FHs are used for high-temperature heat transfer applications (270–300°C). They have advantages over boilers for applications requiring such temperatures: they avoid the need for high-pressure steam and the related complexities such as water treatment, pressure vessel regulations etc.

Apart from textiles, thermic fluid system is commonly used in heating applications in chemical industries.

1. Thermopack circulation pump power consumption

Thermopack circulation pump used to pump thermic oil to thermic fluid heater and to supply to plant. During power monitoring it was found that thermic fluid system consumes almost 20% of total plant power consumption and thermic oil circulation pump is the biggest motor in plant. Compared with the motor rated details of motor actual power consumption found marginally higher. Pump with connected motor with specification of 37kW pump and FLC 63A running with 71.75 Amps. During further investigation with OEM also, it was confirmed that pump is supplied with oversized impeller. Improper Impeller size is reason for overloading in pump. Opportunity found to trim impeller with optimum size. This suggestion was already implemented during energy Assessment by OEM pump power consumption reduced to 37.6kW with 61 Amps load. Savings of 12.74kW power consumption were immediately achieved during assessment. Depending on plant loading condition an opportunity identified to have a spare 30 kW pump with lower capacity.

Energy Savings of 20kW almost 7% of total plant load consumption reduction achievable with this implementation. As per standard design thermopack flowrate 6-8 CMH per 1 lakh kCal capacity with 20 Deg Temperature difference should be there. Excess or lower flow rate of circulation pump shows opportunity to save Energy in pumping.

Recommendations:

Reduce overloading of thermopack circulation pump with Impeller trimming.

Reduce electrical power consumption of thermopack with spare optimum sized TFH circulation pump.

Reduce oversized FBC bed size with reduction in number of nozzles to reduce fuel consumption in TFH.

Replace conventional LRB insulation with PERLITE insulation in TFH Body and insulate uninsulated parts of waste heat recovery section.

Advantages of PERLITE insulation:

1. 36% improved insulation performance compared with Conventional LRB insulation.

2. 15 years ling life of insulation.

3. Solid sections with accordance with surface geometry.

4. Chemically natural product.

5. Low water absorption properties.

6. Non-hazardous Disposal can be disposed in gardening.

7. Light wright

Industrial Energy Assessment Cell
KISEM
Industrial Energy Assessment Cell (IEAC)
Kotak IITM Save Energy Mission (KISEM)
Indian Institute of Technology Gandhinagar, Gandhinagar
Ph: +91 9033798820 Email: rahuljayantibhai.p@iitgn.ac.in

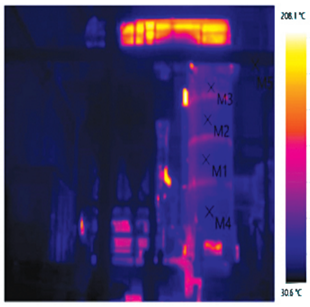
2. Improved PERLITE insulation in thermopack body and waste heat recovery

During thermal study of thermic fluid heater, we found some poor insulation and uninsulated parts in thermopack system. High heat loss found from thermopack body with conventional LRB Insulation. LRB Insulation work done with very poor workman practices and inefficient manner. We proposed to replace insulation with some new insulation material called PERLITE insulation. With conventional LRB Insulation surface temperature upto 70 Deg found in Thermopack body and be replacement with PERLITE Surface temperature drop to Avg 47 Deg. Also, insulation having 15 years of life compared to 5 years efficient life of LRB insulation.

Surface heat loss with LRB insulation 294 kcal/Sq m and 105 kcal/Sq m loss with PERLITE Insulation. Reduction in insulation losses found 36%. Main advantages of this insulation is it comes with Solid sections according to surface geometric requirement, Chemically natural product, comes with Water repellant coating, Non absorption of water, Nonhazardous disposal. So, only mechanical damage can affect insulation properties.

Moreover, this during thermal assessment of thermopack we found some uninsulated parts in waster heat recovery path. Due to uninsulated parts of waste heat recovery plant losing almost 10% of heat generated from furnace into surface heat loss.

Opportunity to save 519kg coal consumption per day with better insulation. Annually accounts 181 ton coal savings identified with the implementation.



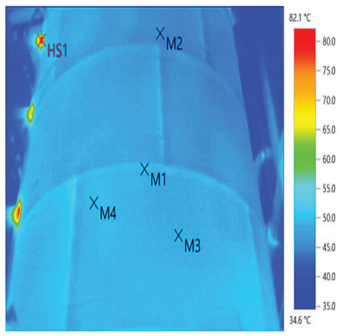
Picture parameters:

Emissivity: 0.95
Refl. temp. [°C]: 20.0

Picture markings:

Measurement Objects	Temp. [°C]	Emiss.	Refl. temp. [°C]	Remarks
Measure point 1	63.2	0.95	20.0	Thermpoack Body temp With LRB Insulation
Measure point 2	63.2	0.95	20.0	Thermpoack Body temp With LRB Insulation
Measure point 3	67.0	0.95	20.0	Thermpoack Body temp With LRB Insulation
Measure point 4	54.9	0.95	20.0	Thermpoack Body temp With LRB Insulation
Measure point 5	37.6	0.95	20.0	Ambient

Insulation - LRB Insualtion



Picture parameters:

Emissivity: 0.95
Refl. temp. [°C]: 20.0

Picture markings:

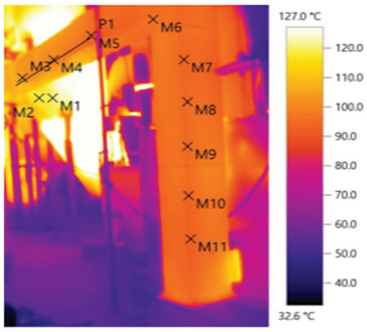
Measurement Objects	Temp. [°C]	Emiss.	Refl. temp. [°C]	Remarks
Measure point 1	47.7	0.95	20.0	CenterSpot
Measure point 2	44.0	0.95	20.0	-
Measure point 3	46.8	0.95	20.0	-
Measure point 4	47.6	0.95	20.0	-
Cold spot 1	34.6	0.95	20.0	-
Hot spot 1	82.1	0.95	20.0	-

Insulation - PERLITE Insulation

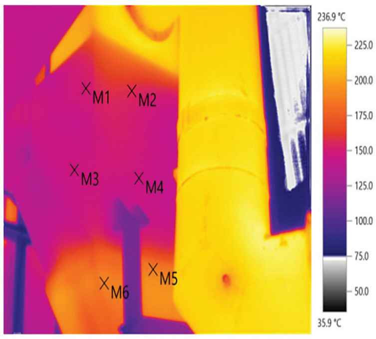
3. Reduce number of air nozzle to reduce bed size:

As per current plant load and future expansion plant under utilize Thermopack capacity which caused frequent loading unloading and difficult to maintain excess. As opportunity identified to reduce bed size with cutting OFF fluidized bed air nozzle, which can be again switch ON in future. 10% nozzle of bed switched OFF with OEM support and 5-7% reduction in fuel consumption achieved. This implementation required supported by OEM to maintain proper AF mixture and maintain draft and uniform fluidized action in furnace bed.

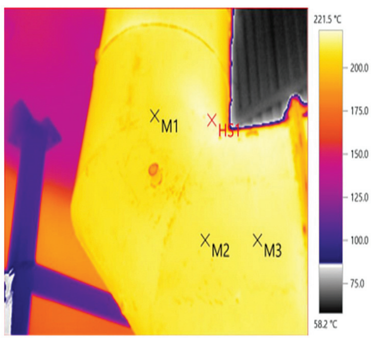
Fresh air to furnace after preheating in APH

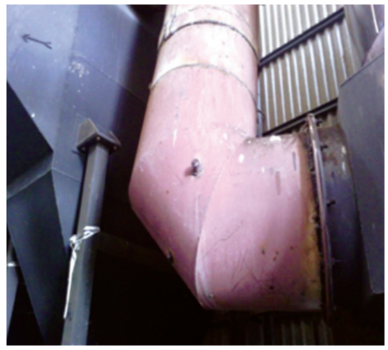


APH Body

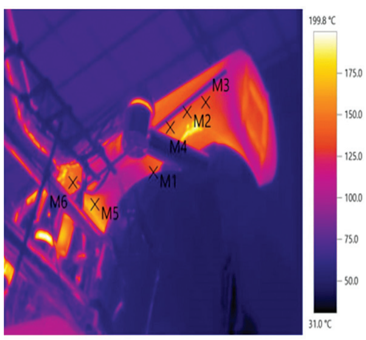


Exhaust duct from TFH to APH





Connective Path between 1 and 2 pass of TFH



Recommendation	Savings	Savings in Rs.	Investment	ROI
Impeller trimming in TFH circulation pump and spare pumps with lower capacity	171500 Units	₹13,51,420/-	₹4,00,000/-	3.5 Months
Improved insulation in TFH Body and uninsulated parts	181 ton Coal	₹16,34,850/-	₹5,70,000/-	4 Months
Reduce No of Nozzle in Furnace Bed	87.5 Ton of Coal	₹7,87,500/-	Negligible	-

CHEMICAL, CERAMIC INDUSTRY

ENERGY SAVING OPPORTUNITIES IN SPRAY DRYER SYSTEM

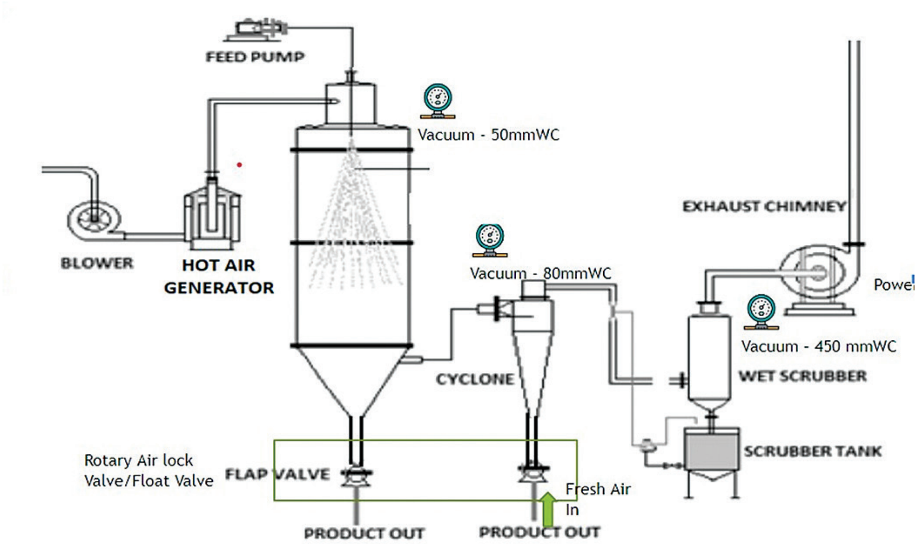
IIT Gandhinagar

Summary:

Spray drying technology having wide application in chemical and ceramic industries. Present case study is for chemical industry involved in manufacturing of dye stuff and intermediate. With application of VFD in ID fan and optimizing vacuum loss in system savings of 54235 units annually which accounts for 45% reduction in ID Fan power consumption. Annual energy savings of 5.40 lakh with 4.20 lakh investment and ROI of nine months. Spray dryer operated only 50 days per annum, so ROI is higher side. ROI will be two and a half months for 350 days operation.

Configuration:

Components in spray dryer system are slurry atomizer fed pump – to supply liquid slurry for drying, atomizer unit – to atomize liquid slurry to micro fine particle to increase surface area, hot air generator unit – to generate required qty and hot air at 500-600 deg temperature, FD, PA blowers – to maintain required draft in furnace, cyclone system collect additional drifted material. Scrubber – for more material recovery and ID fan. To maintain vacuum in entire system. For efficient spray drying action vacuum in spray dryer 20-50 mmWC need to maintain inside spray dryer. For continue operation ID Fan running continuously to maintain system running condition. Vacuum optimization and providing air locking practices are identified to save power consumption in ID fan. Also, optimum vacuum increases evaporation rate and productivity if spray dryer.



Assessment Date: 09-10 May 2023

Overview:

Chemical clusters are concentrated in WEST India. Gujarat having 53% of chemical production share of India. Major chemical clusters in Gujarat are in Ankleshwar, Bharuch, Vapi, Hajira, Jamnagar, Vadodara, and Ahmedabad. Chemical clusters are wide range of production process and versatile cluster in terms of type of utilities used in production.

Major chemical manufacturing process involves mixing, drying, heating, cooling and chilling reactions. Drying process is also sub divided into pressure drying, Vacuum drying, tray drying, spray drying, Hot air drying etc.

Spray drying technology is widely used in powder dyes manufacturing, power chemical manufacturing and effluent treatment processes. This application also finds one of the key roles in ceramic manufacturing process.

Liquid slurry formed with mixing of raw materials is supplied to atomizer. Atomizer unit atomize slurry into micro droplets and spray in opposite direction of Hot air. Hot air generated through Hot air generator with very high amount of Excess air. With physical contact of HOT air atomized slurry dried into fine powder and collected at bottom of spray dryer. ID Fan used to maintain vacuum in whole system.

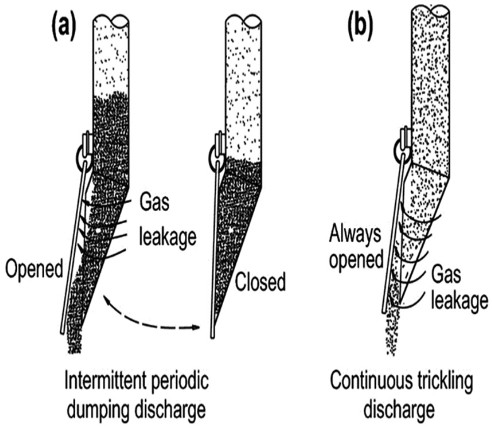
Higher power consumption on ID Fan in spray dryer:

During energy assessment of spray dryer section, it was found that ID is running with FULL load condition. ID Fan with 75 HP motor is running at 51.66kW power consumption. ID fan motor is not having VFD in spray dryer. ID fan motor is biggest motor in Plant.

With observation of high-power consumption in ID fan motor blower performance evaluation activity started. ID fan having rating of 450 mmWC vacuum capacity it is operating at full capacity of ID utilized in this case. This is very rare fan in Induced draft system. Further monitoring of vacuum in system it was found that fresh air intake from product cyclone and spray dryer. Vacuum measurement done in every equipment in system.

Spray dryer system found with 50 mmWC vacuum sensor installed in spray dryer. Operators are operating ID fan damper to maintain 50 mmWC vacuum in spray dryer. To maintain 50 mmWC vacuum at spray dryer ID fan need to generate 450 mmWC vacuum at ID End. Abnormal vacuum drop of 350 mmWC found in path between spray dryer and ID fan. Due to high vacuum drop ID fan consume more power to maintain required vacuum in spray dryer. Detailed investigation of vacuum drop in system following reading found.

Location	Vaccum reading	observation
Spray dryer chamber	50 mmWC	Vacuum lost due to open Spray dryer bottom part
Cyclone inlet	80 mmWC	Vacuum lost due to open cyclone bottom section
ID fan suction	450 mmWC	ID fan suction having vacuum generation as per rated specification of ID Fan



High vacuum drop found in spray dryer cyclone connected near to ID fan. Large amount of fresh air intake found in cyclone bottom section. Reason identified as plant have removed flap valve provided by OEM and operate spray dryer with normal beg to collect power at bottom of equipment. Due to this wrong practice by high vacuum generated by ID fan is not reaching upto Spray dryer to maintain draft in plant. Additional fresh air from cyclone bottom part and spray dryer bottom introduces in system.

Reason for removal of flap valve found due to frequent maintenance issue in valve. Flap valve can get stocked by wet material inside the spray dryer. Spray dryer system due to malfunction of temperature of vacuum material may drop in form of lumps this was the reason of frequent maintenance in valve. Regular cleaning can reduce the maintenance of valve. Operation of flap valve is on gravity basis when pre weighted power collected over the valve than valve opens and closed with material fall down with gravity.

A simple way to maintain vacuum in system is using flap valve. However, in some cases if become ineffective during operation. Rotary air lock valve can place in these conditions. Currently System having 04 components in the system 02 Nos of cyclone and 02 numbers of water scrubbers. Pressure drop in system will be 50 mmWC per component totalizing 200 mmWC. ID fan required to maintain 200+50 = 300 mmWC vacuum at ID Inlet. With VFD ID Fan frequency will be 30-35 Hz and proposed power consumption is 28.12 kW for 300mmWC. VFD Can integrate with Spray dryer vacuum to maintain constant vacuum at spray dryer chamber.

Daily energy savings with 12hrs operation 565 units per day annually 54235 units with existing eight days per month operation. Annual monetary savings will be ₹5,40,731/- with investment of VFD ₹3.5 lakh and ₹70,000/- for rotary air lock valve. ROI will be 9.3 months in this case.

In ceramic Industry 20 mmWC pressure achieved with 150 mmWC pressure at ID fan.

ROI of implementation:

Recommendation	Savings in units	Saving in Rs.	Investment	ROI
Vacuum optimizing in spray dryer and VFD integration with spray dryer vacuum in ID Fan	54235	5,40,731/-	₹4,20,000/-	9 months

Recommendations:

Vacuum monitoring in spray dryer system to check arrest vacuum losses.

Use flap valve or rotary air lock valve to maintain vacuum in cyclone and spray dryer bottom area.

Install VFD in ID Fan. ID Fan always design to 4–5-time higher capacity than required in regular running conditions so it is recommended to always use VFD with interlock in vacuum.

For spray application VFD can integrate with spray dryer vacuum.

Loosing vacuum in during or to low vacuum on ducting have chances to damage ducting. If sufficient draft not maintained at furnace or Furnace main hot air Path than chance to damage furnace top surface and ducting also.

CHEMICAL INDUSTRY

ENERGY SAVING OPPORTUNITIES IN PUMPS WITH VARIABLE FLOW

IIT Gandhinagar

Assessment Date: 21- 26 Sept 2022 & 19 - 24 Feb 2023

Overview:

We had performed the study on Common Effluent Treatment Plant and chemical plant in and around Gujarat.

CETP has filter press unit, this unit is used for removing water from sludge so that transportation of sludge become easy and safe as per government requirement. Sludge transfer pump used to feed sludge in filter press unit during starting time when the filter presses clean or empty that time press inlet valve is fully open and bypass valve are closed but with time when filter press start choked the operator open the bypass valve to maintain the inlet pressure of filter press.

In chemical industry the chilled water demand is not fixed, it keeps varying as per process operation due this varying chilled water demand the pump efficiency gets deteriorate.

For addressing both issue our recommendation is use VFD with PT for pump operation.

Summary:

Pumps are the major machinery in any plant without pumps operation in any industry is not possible. In Common Effluent Treatment Plant, pumps are used for transferring the effluent from one tank to another while pumps are also used for feeding the slurry in filter press. In filter press operation we had observe that during startup time when filter press is empty or clean the feed valve is fully open but with respect to time as it starts choking the bypass line will open to maintain the pressure so that filter press bag would not damage.
In chiller plant, we had to check the secondary pump efficiency. There, we found that the pump is running at low efficiency because of high head and low flow with respect to the rated head. This condition arises due to operating the valve at the plant.
In this case study we are going to address this problem by our energy conservation measures.

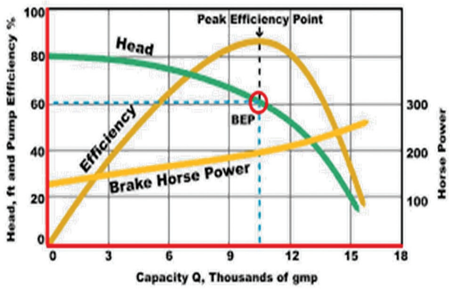
Configuration:
Filter press:

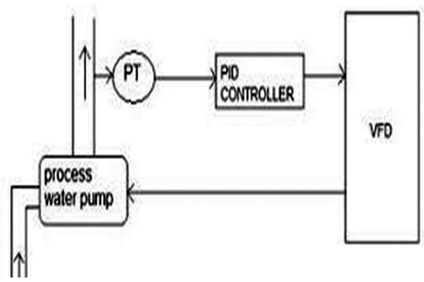
Sludge transfer pump feed the sludge from tank to filter, with time filter press start choking due to that pressure at the inlet of filter press will increase and this results in bag failure. For maintaining the inlet pressure plant operator used to open the bypass valve so that inlet pressure will maintain, and filter press operation will be safe. We recommended to use VFD with pump with close loop monitoring with pressure transmitter. This system maintains pressure of the filter press by monitoring the speed of pump motor so that no need to open the bypass valve of the system.

Chemical chilling plant:

In chemical plant, secondary pump is used to lift the water from cold well tank to plant vessel. In plant vessel operation there are different cycle of chilled water, cooling water and hot water due to different cycle when chilled water operation finished the valve of chilled water closed due to that head at pump increase and flow get reduce. For achieving the desired flow, our recommendation is to install pressure transmitter (PT) as close loop controlling of VFD operated pump motor.

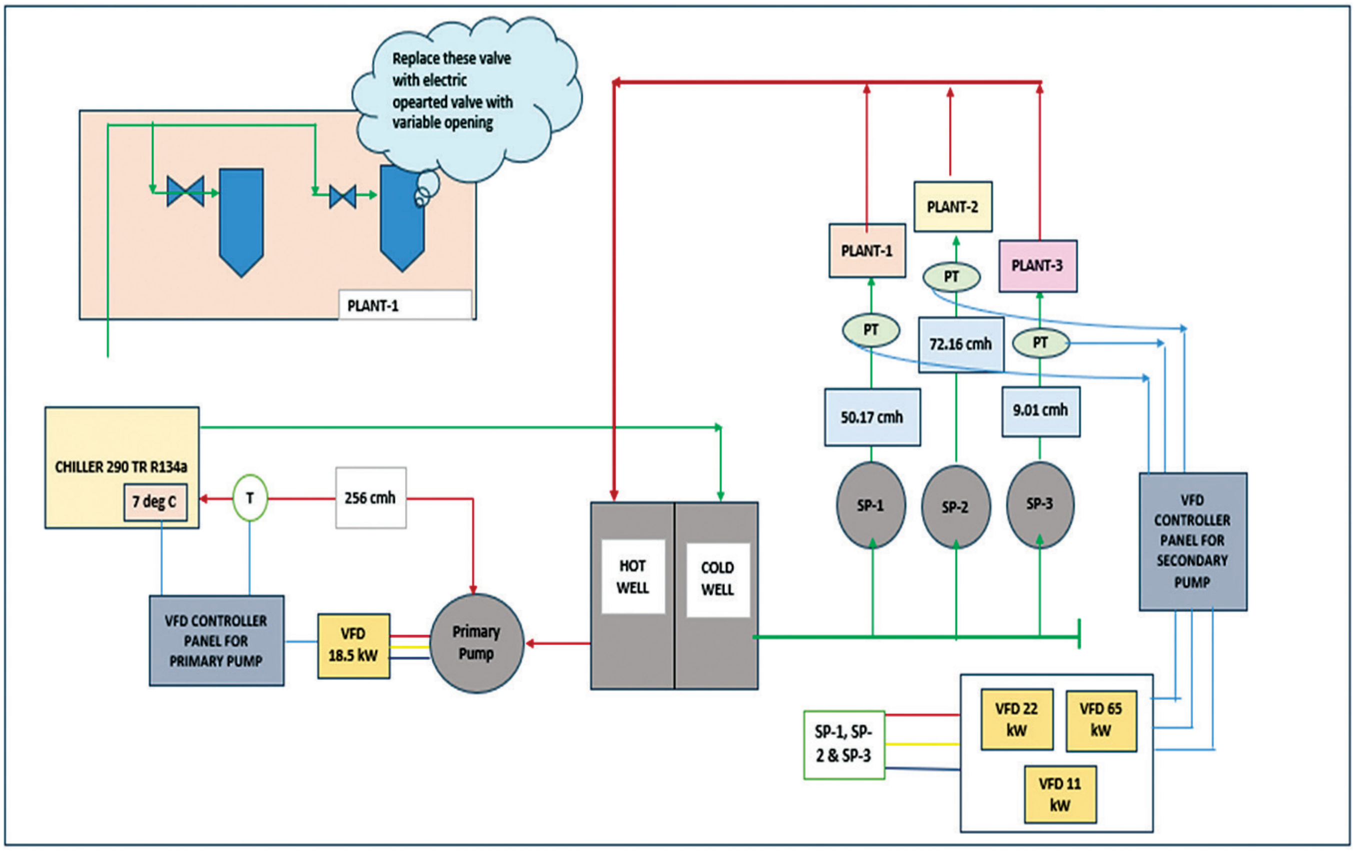
Energy Conservation Measures: Chemical Plant and Filter Press Plant:





1. Schematic of pump operation:

2. Chemical plant: Pump system



Parameter	UOM	Secondary Pump-1	Secondary Pump-2	Secondary Pump-3
Rated Power	kW	22	67	18.5
Rated Flow	cmh	117	216	70
Rated head	M	61.5	95	58
Rated Motor Efficiency	%	91	93.5	89
Actual Power Cons	kW	17.83	40.39	9.43
Actual Flow	cmh	50.7	72.16	9.01
Pressure (Discharge)	Kg/cm2	6.4	10	6
Pressure (Suction)	Kg/cm2	0.28	0.28	0.28
Actual head	M	61.2	97.2	57.2
Valve opening	%	100	50	100
Hydraulic Power	kW	8.455	19.113	1.404
Actual pump efficiency	%	**52%**	**51%**	**17%**

Filter No.	Filter Start			Filter Stop			Pump no	Cycle Time	
	Date	Time	Pressure	Date	Time	Pressure		Running Time	Drying Time
1	07-02-2023	16:00	4	08-02-2023	12:00	4.9	2	20 h	2h
2	08-02-2022	01:00	5.5	09-02-2023	22:00	6	3	21 h	2h
3	07-02-2023	00:00	5	08-02-2023	20:00	6	4	20h	2h
4	08-02-2022	12:00	4	09-02-2023	08:00	4	6	20h	2h
5	07-02-2023	19:00	4	08-02-2023	16:00	6	5	21h	2h

As from above table, it is clearly observed that the running cycle is 20 h out of that for 3h the bypass valve remains close and for 17h the bypass valve will open as per inlet pressure.

Return on investment:
Filter press unit:
Annual savings in kWh= 1,70,078
Monetary saving in ₹=15,30,702/- annum
Total Investment in ₹= 5,00,000/
Simple pay back= four months

Secondary pump: Chilled water system
Annual savings in kWh= 1,20,960
Monetary saving in ₹=11,12,832/- annum
Total investment in ₹= 6,90,000/
Simple pay back= 7.4 months

Recommendations:

Install VFD with close loop controlling on pump motor.

Pressure transmitter is installed near the discharge pressure gauge and after setting the minimum pressure of chilled water, cooling water or effluent it will increase or decrease the VFD speed of pump as per demand.

Don't operate the pump when filter press is not in line for pump safety.

Controlling sequence is like when pressure requirement is less than the set pressure the pump motor will run on 50 Hz as pressure increases more than the set point the VFD motor control the speed of pump motor due to operation of pump in such a way bypass valve opening would minimize or stop.

Energy Savings:

CETP plant has five filter press unit which results in saving of ₹15,30,702/- where as in chemical pump there are three secondary pumps after implementing the measures recommended savings are ₹11,12,832/-

CERAMIC INDUSTRY

ENERGY SAVING OPPORTUNITIES IN BALL MILLS

IIT Gandhinagar

Summary:

In the ceramic industry, appreciable savings in energy, resources and money can be achieved by adopting Best Operating Practices (BOPs).

The energy assessment of ball mills was carried out in ceramics industry in Morbi, Gujarat, and found the ECM in Ball mill the monetary energy saving of about ₹16,09,196 lakh per annum and annual existing unit consumption in ball mill is 39,42,720 kWh with proposed savings in kWh is 1,81,830 about 4.6% of annually unit saving opportunity for slurry preparation area.

Configuration:

Ball milling is the process of wet grinding a material into a uniform slurry form. It consists of an enclosed cylindrical drum containing multiple balls made of aluminum. Rotating the drum horizontally results in the collision of balls with the powder and water and makes it slurry. The slurry preparation in ceramics plant is the most important part of the process as it consumes 28% of total power. A three-phase synchronous motor is connected to the ball mill drum for rotating it at the required RPM during operation. A motor contains VFD which changes and regulates the RPM. A gearbox links the motor with a large ring gear attached to the drum, thus transmitting motion at the required torque.

Comparison:

As we have measured the RPM of motor and ball mills in both conditions i.e., 50hz and 45hz. At 50hz frequency the RPM of motor varying between 1349 to 1410 whereas at 45hz frequency the measured RPM is 1352 as well as for ball mills RPM is varying 11.5 to 12 at 50hz but surprisingly at 45hz the measured RPM is 12 to 12.5.

Assessment Date: July 31-Aug 04 2023

Overview:

Ceramic industries clusters are most energy intensive industries in MSME cluster in Morbi, Gujarat, mainly famous for ceramic tiles production and manufacturing over 70% of India's total ceramic tiles production.

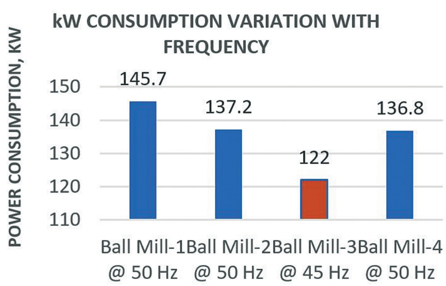
Slurry preparation in ball mill is the most important part of the entire ceramics manufacturing. The composition and grinding of the raw material determine the quality of the final product.

The raw material is mixed with water in a ball mill where wet grinding is carried out to increase the fineness of the material. The slip/slurry, that is formed, is kept agitated in agitator tanks to homogenize the solution. The grinding of raw material is carried out by ball mills or blungers.

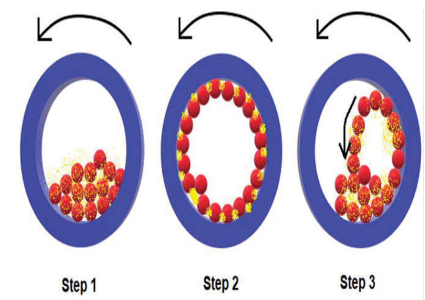
Ball mills or blungers:

1. Motor and ball mill attached with belt

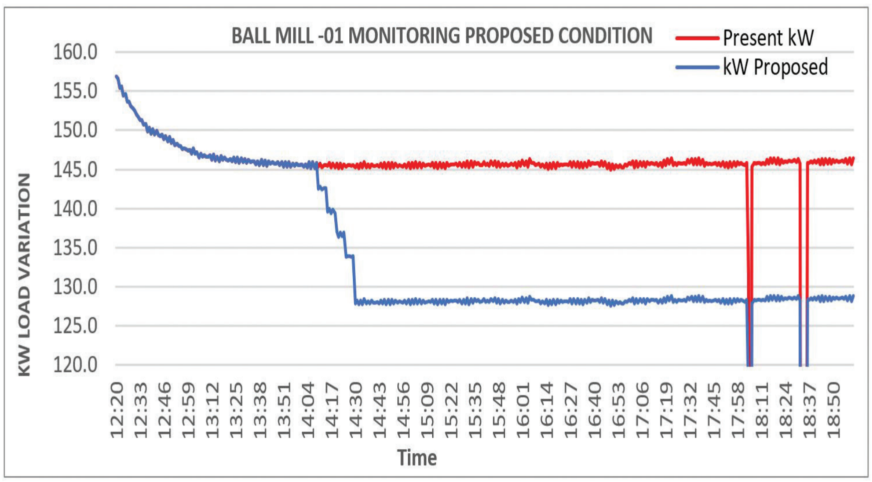
2. Power consumption difference



3. Horizontal ball mill rotation



4. Present vs proposed kW



Recommendations:

Plant Has Installed 05 Nos of Ball mill of 40 Ton material capacity. Ball mill relates to motor having 185 kW capacity. Average Each ball mill having 7 Hrs. operating cycle to achieve desired viscosity. Ball mills are operated on Average RPM of 12.5 - 13.5 In this plant 04 nos. of Ball mills operative all Ball mills are already equipped with VFD it reflects to 20% of saving but from varying frequency from 50Hz to 45Hz Very less effect on Ball mill RPM it reflects to 4.6% of additional saving. One ball mill is already running at 45 Hz. by Reduce the speed of ball mill 1,2 & 4 to 45 Hz once 110min/cycle complete.

Energy Savings:

At 50hz frequency the power consumption of ball mill three motors is 136. Whereas modulation of frequency from 50hz to 45hz the power consumption of ball mill motor is 123.1 kW with very less effects of RPM. In terms of kWh saving Motor save at least 66.2 kWh unit in single cycle i.e., one cycle is almost 6.66 hrs. Resulting in 1.81 lakh unit save annually.

Return on investment:

Immediate savings because VFD installed only modulation in frequency required.

Industrial Energy Assessment Cell
KISEM
Industrial Energy Assessment Cell (IEAC)
Kotak IITM Save Energy Mission (KISEM)
Indian Institute of Technology Gandhinagar, Gandhinagar
Ph: +91 9033798820 Email: rahuljayantibhai.p@iitgn.ac.in

CERAMIC INDUSTRY

ENERGY SAVING OPPORTUNITIES IN POLISHING SECTION IN CERAMIC INDUSTRY

IIT Gandhinagar

Assessment Date: July 31 to Aug 04 2023

Summary:

Detailed energy assessment of ceramic industries consists of detailed assessment of polishing section. Apart from achieving energy savings plant has challenges of high failure rate in motors and high compressed air usage. Energy savings practices with installing a motor protection device served both reduces motor failure rate and reduces energy consumption by reducing overload running condition by wrong practices by operator. Energy savings opportunity identified in implementation of motor protection device on polish machines and with replacement of belt with gear bases system opportunity identified to save 1.07 lakh units annually. With implementation of ECM plant able to save 9.51 lakhs Rs annually. Investment will be 2.88 lakhs with ROI of 2 months and additional savings in reduction in motor failure rate.

Configuration:

Plant have installed total 10 Nos of machine in polishing section. 04 machine are sizing machine that are used to cut the outer edge of time for uniform dimensions and other 06 machine are polishing machines. 04 Nos of 14 Head machine with normal polishing with 11 kW each head and 02 Nos of nano polish machine with 11 kW motor in each head. High failure rate observed in nano polish machines.

As shown in LHS image all polishing heads are having individual Amp meter to check motor loading Amps as well as heads are having two knobs for upward and downward motion of the vertical pressure head. Water and polishing liquid continuously sprayed on the top of sheet to maintain tile temperature within limit. Due to continuous water spray around the heads most of amp's meters are not working.

Plant having challenges of high motor failure rate in these machines. During energy we found that nano polishing machines are running with

Overview:

Ceramic industries are the one of the most energy intensive industries in MSME sectors. Morbi SME Cluster is mainly famous for Ceramic Tiles production and manufacturing over 70% of India's total ceramic tiles production.

Tiles manufacturing steps includes Wet grinding of raw materials, Spray drying, pressing in tile shape, drying, Glazing, firing & baking, Sizing & polishing,

Polishing is required for Vitrified Tiles. Polishing utilizes 40% to 45% of total electricity consumption in case vitrified units. After kiln the vitrified tiles are passed through polishing line. Polishing line consist of sizing, calibration, and polishing machines.

Series of multiple polishing machines with 10-15 heads used to polish top glazed surface of tile. After baking in kiln glaze become like a glass layer on top of the tiles. Rotating Head with Polishing shoes and heavy flywheels are pressurized by compressed air cylinders polishes glazed surface to achieve glossy or matt finish on the tiles surface.

Polishing section has highest nos of motors in running in the machine.

overloading condition. Due to non-working Amp meter near heads and unawareness of operator at machine excessive pressure observed on heads. Air pressure also not uniform in all heads. Heavily overloading in polishing motor becoming the reason of high motor failure rate and efficiency reduces 1% to 5% after rewinding of motors, most of the motors are 2-3 time rewinded. Following opportunities are identified during assessment to improve the system efficiency.

1. Motor protection device in nano polish machine heads

Overloading in motor found the major reason for motor failure. Due to application of excessive pressure in vertical head by operator causing overloading on motor. With motor load study it was found that 07 Motor out of 14 motors are running on overload condition and overloading found beyond service factor of the motor. Also continue monitoring on amp meter also not possible in wet conditions. Unavailability of skilled operator is also a barrier in achieving energy efficiency. So as ECM applicability of motor protection device identified in this case. MPD is a controller which can trip motor when there is abnormal voltage unbalance as well as when motor current increased beyond set limit. After this application 11 kW motor limit can set to 18-19 Amps to maintain motor within range of service factor. FLC of 11 kW motor found 17 amps.

With this application overloading issue of the motor is solved, due to wrong practice of worker motor will trip in overload condition and operator came to know that some excess pressure applied on motor. And immediately change the head position and save motor failure in overload condition.

Accumulating the overloading condition that can be saved in single machine is found 10-15 kW per machine. Typical case of machine savings identified 15.24 kW. Major motor failure rate can drastically reduce with the application. And not technical manpower required to regularly monitor this device.

Savings majorly applied in glossy finish product where intensive pressure required for polishing action. Annually 41328 units savings found directly with this device in every heads. Also, inefficiencies due to rewinded motor is reduced. Motor replacement with energy efficient motor is also planned in the app9.lication.

Investment of each device is around 2000 with installation and savings achievable 3.65 lakhs in two machines and ROI will be two months. We found major overloading issue in nano polishing machines, but it is applicable in every polishing machines.

An equipment safety device can also serve as energy savings implementation.

Recommendations:

Motor protection device in heads of nano polish machines.

Arresting leakage to maintain uniform pressure in polishing machines.

Replacement of belt pulley system with gear system to eliminate slip from the system.

Replacement of rewinded motor with energy efficient motor in polishing section motor.

2. Replacement of belt with gear system and leakage arresting in system

Head	1	2	3	4	5	6	7	8	9	10	11	12
Rated kW	11	11	11	11	11	11	11	11	11	11	11	11
Actual kW	9.7	10.1	10.3	17.6	12.9	14.9	14.5	12.8	13.6	11.9	9.2	11.9
Pressure	1	1	2.5	5	4	5	6	6	5	4	5	4.5
% Slip	12.4	11.2	12.8	12.4	13.8	14.0	12.8	10.9	9.8	11.1	14.4	12.5

Industrial Energy Assessment Cell
KISEM
Industrial Energy Assessment Cell (IEAC)
Kotak IITM Save Energy Mission (KISEM)
Indian Institute of Technology Gandhinagar, Gandhinagar
Ph: +91 9033798820 Email: rahuljayantibhai.p@iitgn.ac.in

During assessment of polishing machine uneven pressure found in the system. 19 Nos of air leakage point identified and arrested during assessment to achieve uniform pressure in heads. With leakage arresting slip monitoring also done in polishing heads. With motor RPM 980 and pully RPM 350 heads are rotating at average 310-320 RPM speed.
Conventional V belt system found in the motor and pulley. Also head pulley 11" and motor pully 4", arc of contact is very low. For all products 350 RPM required. We proposed to install gear-based system which is available as retrofit in the system to eliminate the belt slip and increase production speed or reduction in pressure on heads. In either way savings will achieve with application of this system.
Energy savings of 27.59 kW found in both machines. Annual energy savings of ₹5.86 lakh identified and with invest of ₹2.4 lakh in machine ROI found five Months.

ROI of implementation:

Recommendation	Savings in units	Saving in Rs.	Investment	ROI
Motor protection device in nano polish machine heads	41328	₹3,65,752/-	₹48,000/-	2 months
Replacement of belt with gear system and leakage arresting in system	66216	₹5,86,011/-	₹2,40,000/-	5 months

DIAMOND & JEWELRY INDUSTRY

ENERGY OPTIMIZATION IN DIAMOND AND JEWELRY INDUSTRIES

IIT Gandhinagar

Assessment Date: 16-19 June 2023

Summary:

Detailed energy assessment performed in Surat diamond and jewelry cluster for assessment to energy efficiency in this small-scale units. Average monthly billing of units is in the range of 1-2 lakh. Major load in the plant is electrical furnace and HVAC load. Major machining tools are pneumatically operated instruments. During detailed energy assessment of plant opportunities in electrical furnaces and HVAC System. Opportunity identified in furnace can achieve ₹64,755/- with investment of ₹5,000/- and ROI of one Month. Opportunities identified in HVAC system due to poor maintenance practices is ₹1,11,064/- in existing system without any investment and ₹3,36,211/- Savings with replacement of system with VRV based system ₹9,00,000/- ROI in the system 32 months.

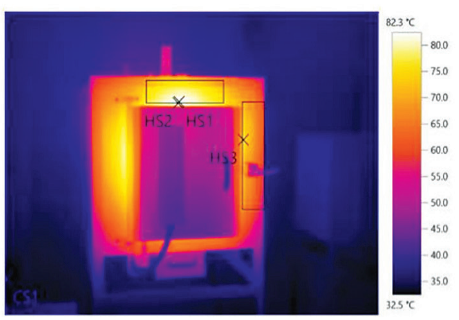
Configuration:

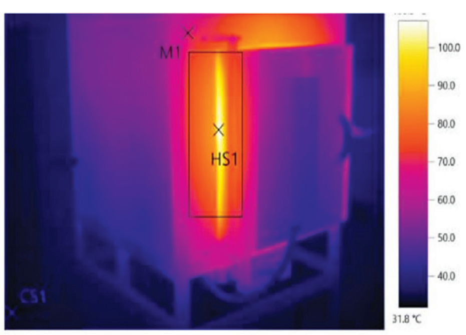
Plant energy consumption can divide into three sections. Furnace and ovens consist of 45% load, HVAC consumes 43% load and machine are carrying 12% load of plant. Following opportunities are found in diamond and jewelry units.

1. Poor insulation in electrical furnaces:

Melting is the key process of jewelry manufacturing. For melting of gold temperature in the range of 600-1100 deg to be maintained in furnace. This process furnace with 12 kW and 18 kW furnace for melting of gold. Due to resistive load in furnace PF 1 Maintained throughout the process. Melting cycle running 6-12 hrs depending on the process.

During thermal analysis high amount of air exfiltration found from furnace.



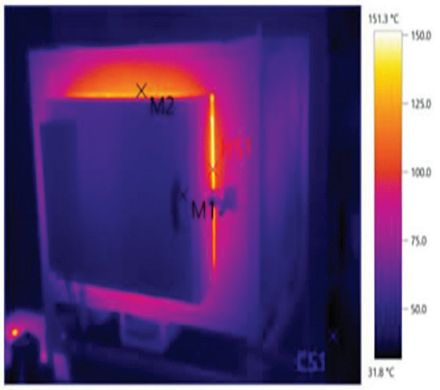


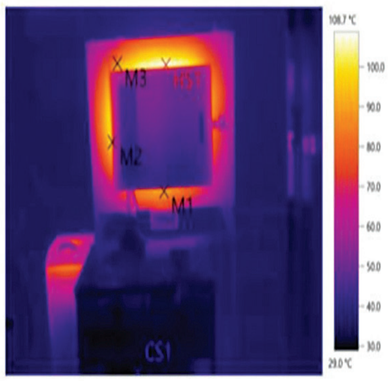
Overview:

India is the world's largest cutting and polishing center for diamonds, with the cutting and polishing industry being well supported by Government policies. Moreover, India exports 75% of the world's polished diamonds as per statistics from the Gem and Jewelry Export Promotion Council (GJEPC). Gujarat is home to the world's largest diamond cluster and essential processing hub between the miners and sorts of diamond and the mostly developed countries, 85% of the world diamond (57% by value) are cut and polished in Gujarat.

Diamond and jewelry cluster is one of the unique clusters majorly based in Surat, Gujarat. Jewelry making units are having low energy intensity. Despite having low intensity number of units is considerably high. Jewelry making process involves Melting of gold, silver or platinum, molding, cutting, machining polishing, cleaning, and final shining. Production process apart from melting furnaces are very low energy intensity tabletop single phase supply machines. Major load in the diamond and jewelry is HVAC system load and electrical furnace load.

Same losses found in another furnace also.





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Picture parameters:

Refl. temp. [°C]:	20.0
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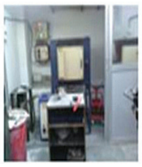
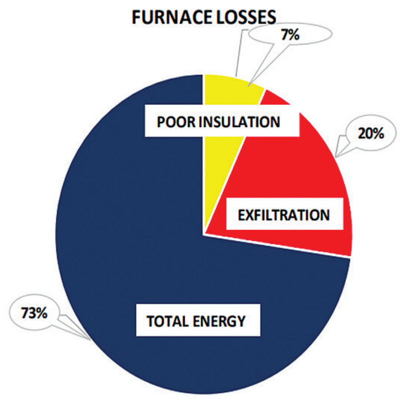


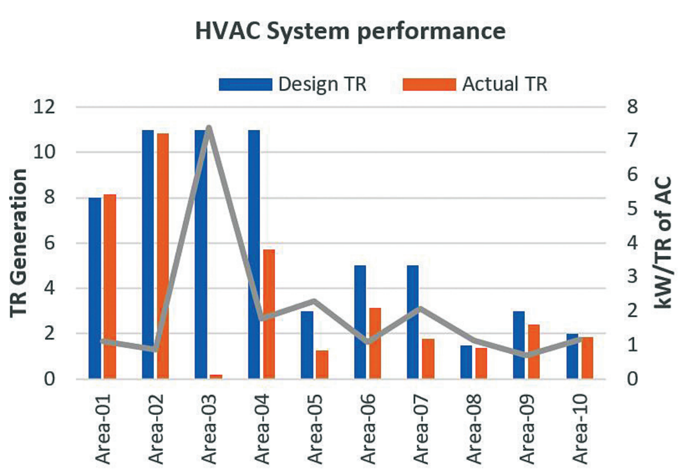


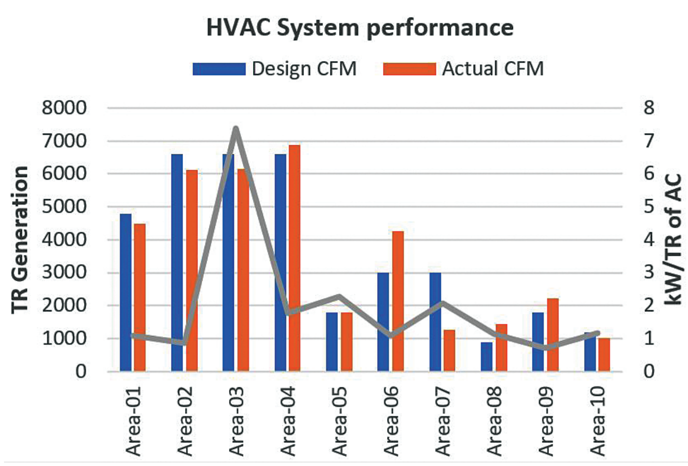
With thermal losses estimation we found almost 20% energy losses in furnace in form of air exfiltration and 7% Losses due to poor surface heat. So overall 27% heat loss found in furnace.

Furnace internal insulation done with fire bricks and solid material, but due to frequent movement of ladle and material insulation near door found damaged. Also, one circulation blower is placed inside furnace to ventilate air flow inside furnace.

Due to this continue exfiltration of hot air is there from furnace. To reduce this heat loss a lining of Asbestoses material in rope form done on the door.

With introduction of this lining, exfiltration losses from furnace reduce. This lining provides soft joint between wall of furnace and door which also reduces abrasion between two hard surfaces. With introduction of lining and replacement of damaged insulation plant energy savings of 6226 units identified with 12 hrs operation for 150 days annual operation. This material supplied with rope of strip shape which is fireproof and having good insulation properties at high temperature.





2. Maintenance of HVAC system:

During assessment of HVAC system in jewelry manufacturing units it was found that HVAC System running with higher SPC than standard SPC. Following reasons are found during assessment.
1. Improper HVAC system design **2.** Filter cleaning frequencies **3.** Improper charging of Refrigerant & Leakage of refrigerant.
For industry grade HVAC system should have power consumption of 1.2 to 1.5 kW/TR during operation. As shown in graph Area-01 and 02 is ideally operating condition of HVAC System. (Thumb rule to HVAC Design for space cooling 100 Sq feet Area 10 feet height 0.9 TR HVAC capacity required for operation, for of persons 0.04 TR/person can be considered. We need to add equipment heat load and we can easily get the required HVAC capacity upon these.)

Following case with HVAC
1. If design Flow and TR matches with Actual performance of AC, optimum performance of AC found.
(AREA-01,02,09,10)
2. If design Flow is matched with actual flow but TR found low, which can be reason for improper refrigerant charge in the system, check refrigerant level in AC. (AREA-03,04,05). HVAC system can supply higher TR also in case of high refrigerant charge but SPC at this condition increases. AC's supply temperature higher than 16 deg or ICE formation in expansion valve shows refrigerant low level in system.
3. Also, higher temperature in condenser unit more than 45 deg after condenser in liquid refrigerant line shows the poor performance of condenser unit. In such case compressor discharge pressure and temperature also increases. Compressor consumes more power to generate refrigerant effect at this condition, SPC Increases.
4. If actual flow is marginally higher or lower than design flow, we need to check and clean suction filters. (Area-06,07) To high flow can be there in case of damaged filters.

Arresting above points in all above points and with simple monitoring practices, lower SEC in HVAC system can be achieved. With servicing of higher SPC AC plant able to achieve 10679 units annually with negligible investment. Also, large system more than 30 TR can retrofit with VRV system VRV having SPC of < 1.0 kW/TR. Expansion is replaced by electronic expansion valve in the system and common condenser and compressor units can used in system. Annual energy savings of 32328 units achieved with this system.

ROI of implementation:

Recommendation	Savings in units	Saving in Rs.	Investment	ROI
Seal AIR gap on the door with asbestos rope/strip	6226	₹64,755/-	₹5,000/-	1 month
Good maintenance and monitoring practices in HVAC system	10679	₹1,11,064/-	Negligible	5 months
Replacement of existing system with VRV system	32328	₹3,23,328/-	₹9,00,000/-	32 months

Recommendations:

Reduce exfiltration from furnace door by using asbestos rope/strip on the door.

Replacement of damages insulation in electrical furnace.

Servicing of faulty Air conditioners and maintain SPC below 1.5 kW/TR in AC.

Replacement of conventional HVAC System with variable refrigerant flow type system.

PHARMA INDUSTRY

ENERGY SAVING OPPORTUNITIES IN BLOWER

IIT Gandhinagar

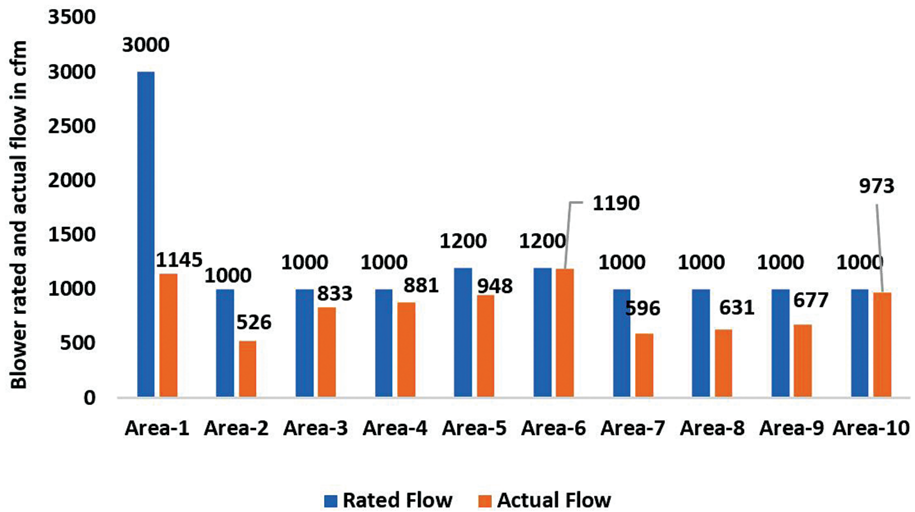
Assessment Date: 17- 18 Oct 2023

Summary:

In the pharma industry, the major load is the HVAC load we had done the analysis of the system and found that the air change per hour is greater than the actual requirement. Due to excess air inside the system blower power would also increase, but we cannot fix the flow because the filter chokes with time hence it is better to monitor the discharge pressure and achieve constant flow inside the system which helps to optimize the ACPH requirement of the system.

In this case study we are going to address this problem by our energy conservation measures.

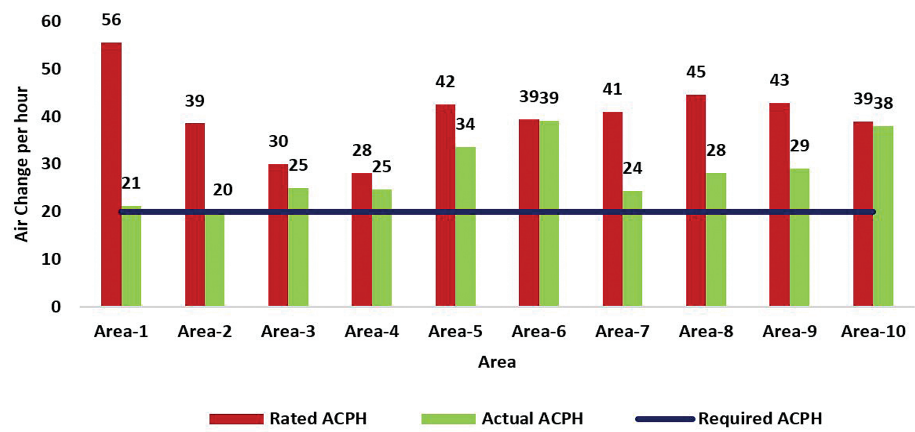
1. Filter choking:



Configuration:

We checked the blower flow and found that some of the area filters are choked which needs to be addressed to reduce the blower motor rpm.

2. High ACPH with choked filter:



We can clearly observe from the above graph that with a choked filter the ACPH in the system or area is greater than the required ACPH and once the filter cleaning done the ACPH are lies near the rated ACPH which is indicated by the red bar which is higher than the required one. So, it is recommended to adjust the flow as per pressure drop.

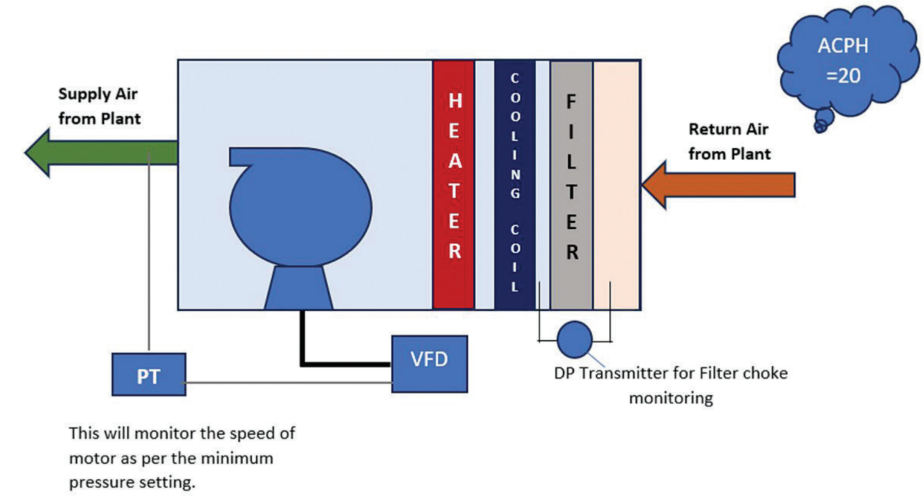
Overview:

We performed the study on 3 pharma units in the Ahmedabad region and found that the air change per hour is greater than the actual requirement as per their class as mentioned by ISO.

The Pharma unit major load is HVAC load, by optimizing the ACPH and proper filter cleaning we can reduce the blower power.

For addressing both issues our recommendation is to use VFD with a Pressure transmitter in line with the blower as close loop monitoring and for filter choking issues use a Differential pressure transmitter across the filters i.e., pre-filter & and fine filter for monitoring its cleaning frequency.

Energy conservation measure: Proposed System



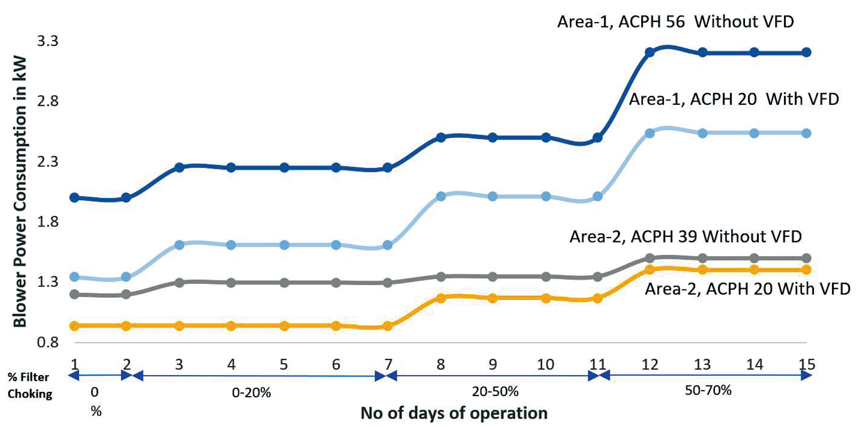
Schematic diagram of the proposed system

Filter cleaning monitoring:

The proposed ECM suggests installing Differential Pressure Transmitters across the filters to monitor the filter-choking issue and as per their DP reading, they can monitor filter cleaning.

Air change per hour monitoring:

We can monitor air change per hour by regulating the blower flow and this will be done by regulating the blower motor rpm. To achieve that we recommend then to maintaining the pressure level with the help of PT and blower VFD takes signal from PT and maintaining the flow as per requirements. Blower flow with choking filer is mentioned in graph.



Recommendations:

Install VFD with close loop controlling on the blower motor.

A pressure transmitter is installed near the blower discharge and after setting the pressure setpoint it will increase or decrease the VFD speed of the blower motor as per demand. This will help to maintain required ACPH in the area.

Differential pressure transmitters across the filters also required to monitor the filter choking.

So, after the implementation of both measure the plant optimized it air demand for maintain ACPH.

Investment & ROI:

Observation	Recommendation	Annual Electricity Consumption in kWh	Annual Savings in kWh	% Saving	Annual Monetary Savings in INR	Investment	ROI
ACPH inside the room is greater than the actual requirement	Use PT sensor and monitor the ACPH	53171	10995	21%	₹1,05,002	₹34,000	4

FMCG INDUSTRY

ENERGY SAVING OPPORTUNITIES IN PUMPS

IIT Guwahati

Summary:

The detailed energy assessment of pumps carried out in an FMCG plant in Kamrup, Assam, identified the possibilities of energy saving and proposed a saving of about ₹134,784 per annum in pumps alone by switching off unnecessary pumps. The Return on Investment (ROI) was immediate as there was no capital cost. It was a 16.45% saving on the original power consumption of the pumps.

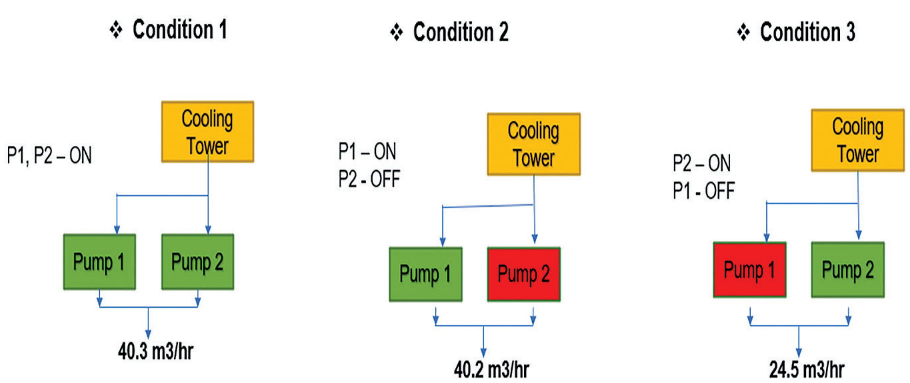
Pump Layout:

A 200 TR Cooling Tower has three centrifugal pumps for water circulation. Two pumps (Pump 1 and 2) are operated in parallel for providing cooling tower water to HCD (Health Care Department). The third pump (Pump 3) provides cooling tower water for cosmetics department exclusively. All three pumps are always ON during plant operating times.

Observation:

It is found that the Pump 1 and 2 that are operated in parallel have different closed value head or shut-off head. The 11kW Pump 1 have a shut-off head of 60m and the 3.7kW Pump 2 have a shut-off head of 23m. Different size pumps can be used in parallel, but they should have same shut-off head. If pumps with different shut-off heat are operated in parallel, the pump with higher head will do most of the work and the pumps with lower head will not produce any flow due to back pressure.

The flow rates and power of the pumps were measured when both are running and during when one of them is switched off. The flow rates of the two parallel pumps during different conditions are show below pictorially.



Assessment Date: 29 May-04 June 2023

Overview:

A pump is a device that moves fluids (liquids or gases), or sometimes slurries, by mechanical action, typically converted from electrical energy into hydraulic energy. A motor provides the necessary shaft power to the pump. The pump then uses this rotational shaft power to move the fluid by imparting hydraulic power to the fluid. The hydraulic power is induced to the fluid by means of pressure (or head) and flow to the fluid.

Though there are many different types of pumps, Centrifugal pumps are widely used because of its economical operation. Although positive displacement pumps are more efficient than centrifugal pumps, the benefit of higher efficiency tends to be offset by increased maintenance cost.

Pumps are the least efficient component in the pumping systems compared to other components like motors, coupling, piping, etc. Also, pumps consume a significant energy in a typical plant. So, any energy saving in pumps will lead to significant overall energy savings for an industrial plant.

Parallel operation:

When both pumps are running, the combined flow was 40.3 m3/hour. When Pump 1 was running, the flow was 40.2 m3/hour. In Condition 1, the power consumption of the Pump 1 and 2 are 12.19 & 2.4 kW respectively. In Condition 2, the power consumption of Pump 1 was same (12.19 kW) as during Condition 1.

Recommendation:

Since, the flow rate was same during both Condition 1 and 2, operate Pump 1 alone to save about 2.4kW in power consumption.

Return on investment:

The annul saving for switching off Pump 2 was ₹134,784. Since this is a no cost recommendation, the ROI was immediate.

Recommendation	Savings in kWh	Saving in Rs.	Investment	ROI
Switch off Pump 2	17,280	₹134,784	0	Immediate

Energy saving measures:

For annual calculations, 300 working days per year and the power cost as ₹7.8/kWh are considered.

Switching off pump 2 consuming 2.4 kW will result in a saving of 17,280 kWh per annum i.e., ₹134,784 on annual basis.

Cumulatively the net resultant was 16.45% power saving on the original consumption of the pumps.

Pumps operating in parallel should have same closed valve head or shut-off head.

Parallel operation of pump is recommended when there is high static head compared to dynamic head.

Two similar pumps operating in parallel doesn't produce twice the flow because of increased head loss due to faster velocity of fluid in the same pipe line.

Industrial Energy Assessment Cell
KISEM

Industrial Energy Assessment Cell (IEAC)
Kotak IITM Save Energy Mission (KISEM)
Indian Institute of Technology Guwahati, Guwahati
Ph: +91 9440539229 Email: saikumar.ganna@gmail.com

PLASTIC INDUSTRY

ENERGY SAVING OPPORTUNITIES IN TRANSFORMERS

IIT Guwahati

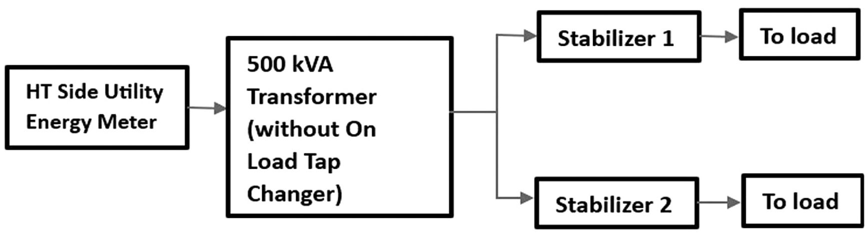
Summary:

The detailed energy assessment of transformers carried out in a plastic molding plant in Guwahati, Assam, identified the possibilities of energy saving and recommended a saving of about ₹456,231 per annum in transformers alone by replacing old transformer with new energy efficient transformer with on load tap changer. Assessment recommendations amounting to ₹600,000 is proposed. It is a 5.14% saving on the original energy consumption of the entire plant.

Original electrical supply layout:

The plant has one old 500kVA transformer without on load tap changer. Since voltage regulation is not possible at the transformer itself, the plant has installed two stabilizers of 300kVA each. On average, the loading on the stabilizer 1 & 2 are 63 & 100kVA respectively. So, the transformer itself has a loading of approximately 163kVA or 32.6%.

Original Electrical Layout



Analysis:

For a period of 24-hour, energy meter reading on the HT side and after stabilizers were monitored. On the HT side, the utility energy meter was used. After each stabilizer, a Power Quality Analyzer was installed to monitor the energy usage. The energy consumption for a 24-hour period is shown below. The utility energy meter has a multiplication factor of 500.

Location		Parameter	Value	Units
HT Side, Utility energy meter		Initial Reading	31,889.00	kWh
		Final Reading	31,895.19	kWh
		Difference	6.19	kWh
		Total Energy consumption	3,095	kWh
After Stabilizer	Stabilizer 1	Initial Reading	0	kWh
		Final Reading	1,284.58	kWh
	Stabilizer 2	Initial Reading	0	kWh
		Final Reading	1,624.17	kWh
	Total	Total energy consumption	2,908.75	kWh
Loss Calculation		Net energy loss	186.25	kWh
		Energy loss percentage	6.02	%

Assessment Date: 05 June 2023

Overview:

Transformers are needed for HT connections to step down the voltage. Electricity utility companies provide only HT connections for high power consuming customers like industrial plants, manufacturing hubs, multi stored building, etc. to cut down transmission losses. Transformers are high-efficiency devices, typically having an efficiency of more than 98%. Transformers also have a very long lifetime of about 30 years, if maintained properly. Broadly, there are two types of losses in transformers – no-load loss and load loss.

On load tap changer:

The on-load tap changer in a transformer provides constant voltage by changing the number of secondary windings in the transformer. It eliminates the need for separate voltage stabilizer.

The transformer and stabilizer have a combined loss of 6.02% which was very high. Stabilizer works similar like a transformer to change the voltage. So, it also has "no load loss" and "load loss" like a transformer.

New electrical supply layout:

To eliminate the very high losses in the transformer and stabilizer, the old transformer and the two stabilizers were replaced with a new energy efficient transformer with on load tap changer which can regulate the supply voltage without the need for stabilizer.

The no load loss and Load loss of the new transformer was 515 & 5,873 W respectively. The new transformer has the best efficiency loading point at 30% which is close to the plant requirement of 32.6%. The new transformer at 32.6% loading has a loss of 27.34 kWh per day. It was a significant reduction from the original loss of 186.25 kWh per day.

Return on investment:

The cost of the new energy efficient transformer was ₹600,000 and then annual energy saving was ₹456,231. The ROI was approximately 15.8 months.

Recommendation	Savings in kWh	Saving in Rs.	Investment	ROI
Replace old transformer & stabilizer with new energy efficient transformer	52,440.3	456,231	₹600,000	15.8

Energy Savings:

For annual calculations, 330 working days per year and the power cost as ₹8.7/kWh are considered.

The energy saving per day was 158.91kWh. In monetary terms, it amounts to ₹456,231 per annum.

Cumulatively the net resultant was 5.14% energy saving on the original consumption of the entire plant.

Industrial Energy Assessment Cell
KISEM

Industrial Energy Assessment Cell (IEAC)
Kotak IITM Save Energy Mission (KISEM)
Indian Institute of Technology Guwahati, Guwahati
Ph: +91 9440539229 Email: saikumar.ganna@gmail.com

FMCG INDUSTRY

ENERGY ASSESSMENT AND RECOMMENDATIONS IN CHILLER UNITS

IIT Guwahati

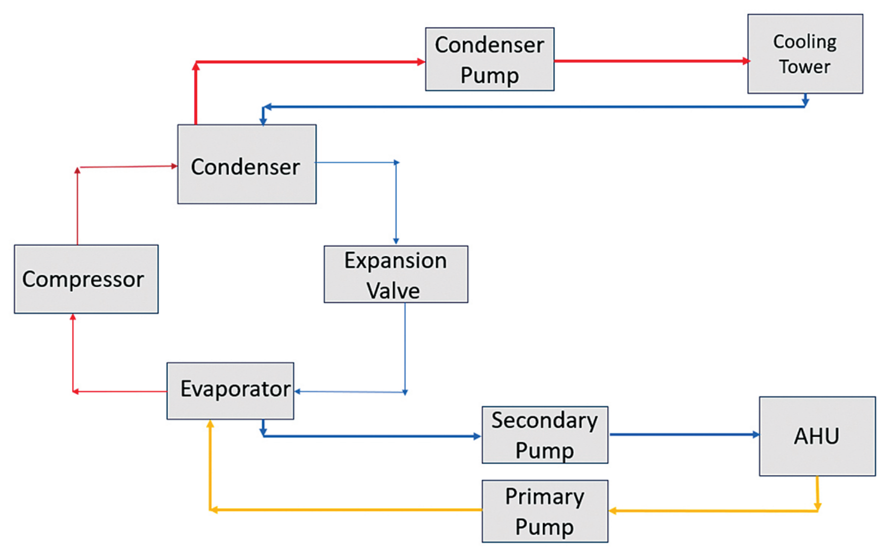
Summary:

The detailed energy assessment of chillers system is carried out in a FMCG industry in North East India. The assessment team identified the possibilities of energy saving of about three million per annum in chiller system by maintaining designated water flowrates in evaporator (chilled water) and condenser (cooling water) circuits, providing a bypass valve in the by-pass line at AHU and by providing the automatic valve in evaporator circuits to shut off water flow when the chiller is turned off. The above recommendations were contributing to 18% savings with respect to the current energy consumption of chiller section.

Configuration:

There are three water cooled chillers, each of 380 TR capacity in the facility. Three primary pumps (18 kW, without VFD) and three secondary pumps (37 kW, with VFD) are connected to the chiller network, operating independently. Only one chiller is in operation at normal operating conditions whereas more than one chiller would be operated during peak loads to cater the required load requirements. Schematic of one chiller configuration is given below.

Fig 1: Schematic representation of chiller configuration



Automatic valves in evaporator chilled water line:

During assessment, IEAC team found that chilled water from the process/ AHU is flowing into the chillers which are not in operation and getting mixed with cold stream of chilled water coming out from chiller which is in operation. This increases the load on the chiller, higher chilled water temperature in AHU/process as well as the pump power requirement.

Assessment Date: 29 May - 05 June 2023

Overview:

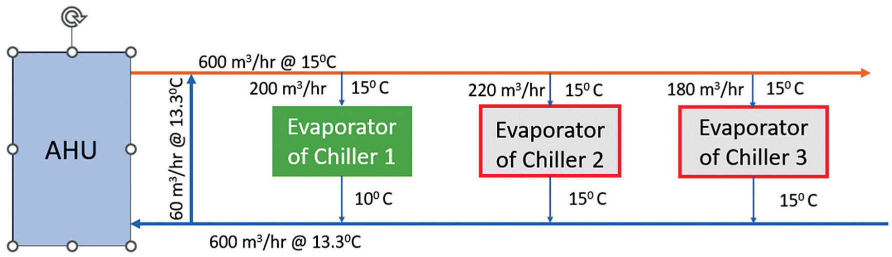
Chilled water is an essential utility in FMCG sector product cooling, air conditioning, process equipment cooling, etc., Chillers generate chilled water in the range of 70C to 150C based on the requirement. The four major components of chiller units are compressors, evaporator, condenser and pumps.

Air Handling Units (AHU's) are one of the major components in industrial air conditioning system for maintaining the indoor air quality, temperature & humidity. Based on the seasons and process requirements, AHU's use chilled water/steam/ hot water for controlling temperature and humidity of indoor air.

Pumps play a vital role in circulating chilled water to the AHU's/process and vice versa.

Mixing of hot and cold-water streams, and not maintaining designated flow rate of evaporator not only decreases the efficiency of chillers and AHU's but also increases the power consumption and decreases the life of pumps.

Fig 2: Schematic representation of actual operation of chiller section

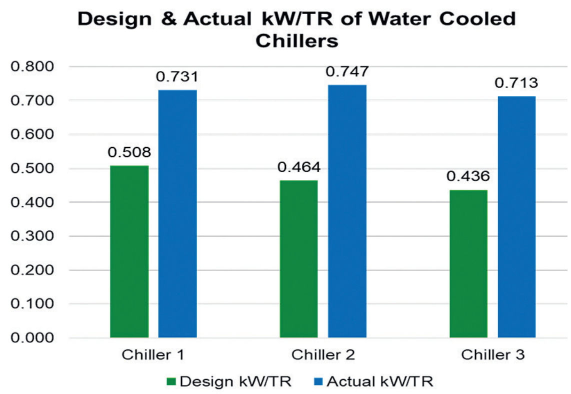


The above image represents the actual operating condition, where chilled water from AHU at 150C is being circulated into all the three chillers. Chiller 2 and 3 are not in operation but chilled water from AHU is going into the evaporator section of Chillers 2 and 3 and getting mixed with chilled water at 100C, which is coming out of Chiller 1 in the header line to AHU, increasing the temperature of supply water to around 130C.

Installing automatic bypass valve near AHU:

During assessment period it was found that, 10% of chilled water from chillers is flowing through bypass line, which does not have any valve and getting mixed with hot stream of water coming from AHU. (refer Fig.2) The mixing of water increases the load on the chiller and pumping power of the pumps.

Fig 3: Design and actual specific energy consumption of Chiller 1, 2 and 3



Improving specific energy consumption of chiller:

Mixing of chilled water from the evaporator with water at high temperatures before the process, reduces the cooling power. To cater the cooling load requirements, chillers had to operate more intensive which leads to the increased specific energy consumption. The design and actual specific energy consumption of chillers is presented in fig 3.

Recommendation	Savings in kWh	Saving in Rs.	Investment	ROI
Replace old transformer & stabilizer with new energy efficient transformer	52,440.3	456,231	₹600,000	15.8

Recommendations:

The IEAC assessment team had proposed the installation of automatic valves in the evaporator chilled water line and AHU bypass line to prevent the mixing of hot and cold streams and to maintain chilled water temperature as per process requirement, thereby reducing excessive pumping power. Additionally, the regular maintenance of evaporator and condenser tubes is recommended to improve cooling efficiency, ultimately lowering the chiller's specific energy consumption. It is suggested to incorporate the feedback from differential pressure transducer of AHU's to existing VFD's of secondary pumps. Chiller monitoring system was also proposed for improved operational efficiencies.

Energy saving & Investment:

The estimated investment for implementing the suggested recommendations is around 2.5 million. The overall energy savings would be about 3.9 lakh units of electricity and monetary savings of ₹3 million per annum. The payback period is about 10 months.

Industrial Energy Assessment Cell
KISEM
Industrial Energy Assessment Cell (IEAC)
Kotak IITM Save Energy Mission (KISEM)
Indian Institute of Technology Guwahati, Guwahati
Ph: +91 9440539229 Email: saikumar.ganna@gmail.com