Compendium of energy efficient technology measures for secondary steel electric induction furnace (EIF) sector

under the project

"Upscaling energy efficient production in small scale steel industry in India"

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List of abbreviations and acronyms

AusAid	Australian aid program
CCM	Concast machine
CO_2	Carbon dioxide
CT	Cooling tower
DRI	Direct reduced iron
EIF	Electric induction furnace
EE	Energy efficient
HP	Horse power
IF	Induction furnace
INR	Indian rupees
GHG	Greenhouse gases
GWh	Gigawatt hour
IRR	Internal rate of return
kWh	Kilowatt hour
Lps	Litre per second
SEC	Specific electricity consumption
SMEs	Small and medium enterprises
TOD	Time of day
UNDP	United Nations Development Programme
VFD	Variable frequency drive

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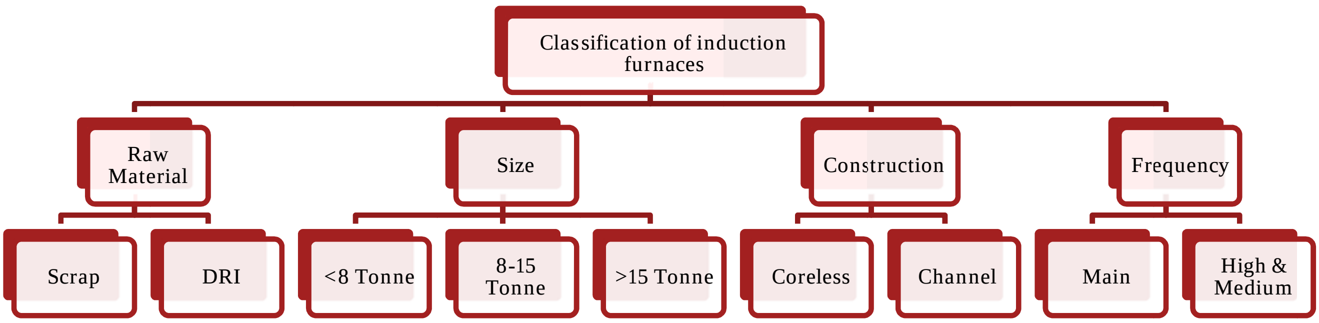
1. About the induction furnace sector

Today, India is the 4th largest producer of steel in the world. Out of which small and medium industry constitutes a significantly share of 32% in total steel production. India is the largest producer of steel in the world through Induction furnace technology. The induction furnace sector comprises around 1,200 units in 2011-12, scattered across the country. The total production in 2011-12 in the country via Induction furnace route was around 22.9 Million tonne[1].

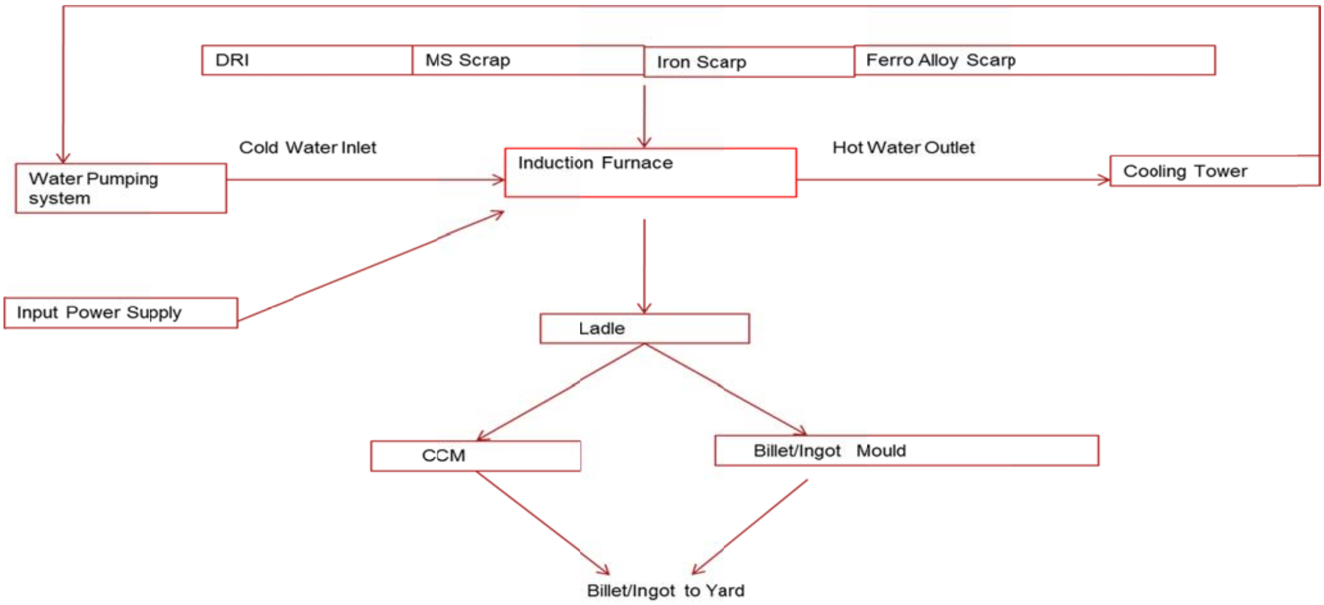
In today's scenario Induction furnaces can be classified based on raw material, size, construction and operating frequency of furnaces. Figure 1 captures the detail classification of induction furnaces.

Classification of induction furnaces



Typically, an induction furnace plant consists of furnace, ladle, ingot mould/CCM and raw material yard with cooling water system, cranes etc. **Error! Reference source not found.** below captures the typical process flow of an induction furnace unit.

Typical process flow of an induction furnace unit



[1] http://www.aiifa.org/contents/display/slug:about

2. Background of the project

The UNDP in association with the Ministry of Steel, government of India and AusAid is implementing a project titled **Upscaling energy-efficient production in small scale steel industry in India**. The project was launched in 2013 with the objective to introduce energy efficiency measures and technologies in the electric induction furnace sector. This project targets the following:

- Facilitate the diffusion of energy-efficient technologies in the secondary steel EIF sector to reduce end-use energy levels and reduce associated GHG emissions
- Improve productivity and cost competitiveness

The outcome of the overall programme is to pilot energy-efficient technology packages and measures in five model units of the induction furnace sector. In order to achieve this, a study on the exploration and description of economically viable energy-efficient technology options, packages and practices for the secondary steel EIF sector was undertaken. The following key activities were undertaken as part of this exercise.

- Energy audits of 10 induction furnace units in India (6 scrap based units and 4 DRI based units)
- National and international scouting to identify best technologies and practices
- Consultation workshops for stakeholders inputs

2.1. Project approach

In order to assess the current energy consumption levels and identify the possible technology packages & options to improve energy efficiency; 10 EIF units were audited across the geography of the country. EIF units were shortlisted by UNDP based on an open invitation.

Before proceeding with the audit, a data collection format was prepared and finalized in consultation with UNDP. To perform the audits, all the EIF units were divided into three major sections to identify technology packages and practices. These sections were:

1. Raw Material Section
2. Induction Furnace Section
3. Auxiliaries Section

Data measuring and recording instruments were used to record the energy consumption profile of different energy consuming equipments, power quality, operation of cooling water systems and other operating practices being followed.

2.2. Project analysis

2.2.1. Energy audits

10 EIF units were audited across the country to understand the operational behaviour of furnaces by considering:

- Types of raw materials being used – scrap, sponge iron/ DRI, pig iron, combination of these
- Raw material charging/ feeding mechanism for the furnace
- Induction furnace operation by considering heat/cycle time, furnace lining & sintering practices
- Auxiliary system including cooling water system
- Specific energy consumption of the furnaces

2.2.2. Scouting of technologies

The scouting of appropriate energy efficiency interventions available nationally and internationally in the EIF sector was done through literature review, discussions with technology providers, subject matter experts and unit owners, industry associations. A detailed analysis of the best available technologies nationally and internationally was carried out and the technologies appropriate to Indian conditions were identified. Some case studies were also prepared based on the information gathered during the discussions with sector experts.

Some major technology packages and energy efficient pratices identified during scouting and also identified during the energy audits were:

S. No.	EE Technology packages	EE practices/options
1	Installation of shredding machine and shredded scrap charging through bucket or vibro-feeder	Use of Neutral Lining
2	Replacement of coil cradle of old furnace	Avoid superheating of molten metal
3	Installation of CCM for billet making	Overfilling (metal above the coil level) of furnace during the melting
4	Sintering panel for sintering heat	Installation of VFD on the air compressor
5	Scrap preheating	Installation of EE pumps
6	Ladle preheating	FRP blades in cooling tower

The sector experts involved in the study by PwC team has provided advisory services to many of the overseas EIF plants. They developed a few case studies from their experience with some of the efficient EIF plants overseas. The salient features of these case studies are given below:

Case Study of a Nigerian EIF Plant

- About plant
  - Location of plant: Nigeria
  - Furnace capacity: 15 tonne with 5000 kW (X 2) with CCM
- Earlier practices
  - Frequency of lining : after every 20 heats
  - Sintering time: 150 minutes
  - Sintering with same electrical panel and loss in production
- Improved practices
  - Sintering by portable diesel based burner
  - Extra production of 225 tonnes per month per furnace
  - Better sintering/Increase lining life

Case Study of a Bangladesh EIF Plant

- About plant
  - Location of plant: Bangladesh
  - Furnace capacity: 30 tonne with 10,000 kW (X 2) with CCM
- Earlier practices
  - Scrap without processing
  - More carbon in the liquid metal
  - No use of Vibrator machine for lining work
- Improved practices
  - Installation of shredding machine and vibro-feeder
  - 100% shredded scrap is used for uniformity of scrap and increasing bulk density
  - Heat time/cycle time reduced by 15-20 minutes and power consumption reduced by 40-50 kWh per tonne due to better power coupling
  - Extra production at lower operating cost

2.2.3. Consultation meeting

Two consultation meetings were organized to share the findings of the study and acknowledge feedback of different stakeholders on the identified options. Major highlights of the stakeholder meetings were:

First stakeholder consultation meeting - Explore the different technology options

First stakeholder consultation meeting was held on 21st August 2014, at Hotel Imperial, New Delhi. The meeting had participants from key stakeholder groups including Induction Furnace Association members, Industry bodies, Induction Furnace and equipment suppliers, Consultants as well as Induction Furnace unit owners. Total 35 participants attended the stakeholder meeting. The objective of first stakeholder consultation meeting was to present the findings of the studies conducted by PwC and explore different EE technology options for EIF. Different technology providers also shared the technologies being provided by them to improve energy efficiency in the EIF units. All the stakeholders agreed to the findings of PwC and appreciated the idea and initiative of UNDP to assess the energy efficiency potential and develop some model units in this sector.

Second stakeholder consultation meeting - Finalisation of the identified technologies options

Second stakeholder consultation meeting was held on 9th October 2014, at Hotel Le Meridien, New Delhi. The meeting got participation from key stakeholders including Induction Furnace Association members, Industry bodies, Induction Furnace and equipment supplier, Consultants as well as Induction Furnace unit owners. Total 38 participants attended the stakeholder meeting. The objective of second stakeholder consultation meeting was to finalise the different EE technology options for EIF. Second consultation meeting was also intended to acknowledge the feedback from different stakeholders on identified technology packages/options for EIF. All the stakeholders appreciated the findings and analysis carried out in the study and suggested next action to plan the model EIF units in the country.

Draft compendium was shared with all the stakeholders to request their feedback on the identified EE technology options. A week’s time was provided to the stakeholders to give feedback on these technology options. Based on the comments received in the feedback, compendium was modified and finalized.

3. Compendium of energy efficient technology measures for electric induction furnace (EIF) sector

Based on the complete analysis after energy audits, scouting and consultation meetings, following EE technology options and packages were recommended. Stakeholders' response was also taken up and the compendium was finalized. The following technology packages and options are proposed for both scrap and DRI based units.

Table 1: List of possible EE technology packages/options

S no	Technology packages
1	Installation of shredding machine and shredded scrap charging through bucket or vibro-feeder
2	Replacement of coil cradle of old furnace
3	Installation of CCM for billet making
4	Sintering panel for sintering heat
5	Scrap preheating
6	Ladle preheating
	Other EE practices/options
7	Avoid superheating of the metals
8	Avoid overfilling (metal above the coil level) of furnace during the melting
9	Installation of EE pumps
10	FRP blades in cooling tower
11	Installation of VFD on the air compressor

For all proposed options, detailed cost benefit analyses was carried out in order to assess energy savings potential and payback period. Next section of this compendium provides details of all the technology packages which include:

- Present practice,
- Proposed technology,
- Salient features, investment and benefits of proposed technology
- Cost benefit analysis of each option for adoption both in scrap and DRI based units[2].

[2] Sample calculation has been considered for one scrap based unit and one DRI based unit. The DRI based unit has captive power plant while the scrap based unit utilizes the power from grid.

3.1. Installation of shredding machine and scrap charging through bucket or vibro feeder

3.1.1. Present practice

Scrap is the major raw material in induction furnace units across India especially in northern and western India. In these areas the scrap quantities being used normally are more than 70%. The present practice suggests that a majority of induction furnace unit feed unprocessed scrap. The unprocessed or non-shredded scrap is fed with the charge mix either by magnet or through a manual charging mechanism. Due to this charging practice, the bulk density of the scrap charge is low which results in air pockets (voids) between the scrap pieces that subsequently leads to low power density, ultimately increasing the heat/cycle time. Best charging practices such as bucket charging or charging through vibro-feeder is also not possible for non-shredded scrap, leading to the furnace operating at low efficiency.

3.1.2. Proposed technology

The size and shape of scrap plays an important role in running the EIF at full power/load, which is the best operating practice. The more the EIF runs at full power, lower will be total energy losses leading to lower specific energy consumption. The best practice is to use dense scrap charge for a faster melt rate and lower energy consumption. Small and dense scrap pieces are preferred for optimum results.

Figure 1: Shredding machine

Source: Jain Hydraulics

To adopt this best practice, it is proposed to use shredded scrap in induction furnace. Thus, a 'shredding machine with bucket/vibro-feeder' is an important technology package for induction furnace units.

A shredder is a machine that cuts large scrap pieces into smaller pieces and compresses them into pieces with higher bulk density. The shredder also removes rust and dust from the scrap. In the shredder, the scrap is cut into small pieces by specially designed hammers.

The shredded scrap because of its higher bulk density increases the charging rate and also helps in better power coupling (means maximum power input which increases the melt rate) thus reducing heat/cycle time. The shredded steel scrap has many advantages over other types of scrap particularly when used in an induction furnace:

- Better power coupling
- Less slag generation because it is free from dust and rust
- More lining life
- Better productivity
- Less air pollution

3.1.3. Salient features, investment and benefits

The following table describes the salient features, application, technological advantages, limitations and cost benefit of the installation of Shredder:

Table 2: Shredding machine - Salient features, investment and benefits

Particulars	Description
Salient features	• A shredding machine with 250 hp motor can shred around 3 tonnes scrap per hour[3]. • Automatic control functions for monitoring and control of the feed-in materials in order to maximise the driver motor performance and to increase the average shredding rate

[3] There are other capacity shredders also available in the market

	• Reliable operation and ease of maintenance of the shredding plants at a lower processing cost-per-tonne of scrap
Application	• A shredding machine provides uniformly sized dust-free scrap with good bulk density.
Technological limitation	• As such, there is no technological limitation, but the apprehension with the shredding machine is its applicability only for light commercial scrap. Supply and availability of light commercial scrap is a concern in India.
Estimated investment	• INR 75 lakh (approximate cost for shredder machine for 250 hp motor) and INR 15.50 lakh for bucket and vibro feeder
Estimated implementation period	• 15 to 20 days
Expected benefits	• Electricity consumption can be reduced by 5 to 10% per heat.
Estimated payback on investment	• 12 months for scrap based unit as they are dependent on grid power which is costly • 23 months for DRI based unit as they normally use their captive power which is cheaper in comparison to grid power

3.1.4. Sample calculation for energy saving potential

The sample calculation has been done taking a real-time case study of a scrap based induction furnace unit having a furnace capacity of 8 tonnes/heat.

Table 3: Sample calculation for shredding machine in scrap based unit (8 tonnes/heat)

Parameters	Unit	Value
Average production per heat	Tonnes/heat	8.45
Average slag generation per heat	%	5%
Average charge input per heat	Tonnes/heat	8.90
Scrap quantity in charge mix per heat	%	90%
Out of the total quantity of scrap feeding in charge mix, scrap which can be fed after shredding	%	40%
Quantity of shredded scrap	kg/heat	3202
Average electricity consumption per heat	kWh/heat	5393
Average heat time	Hours	2.00
Average number of heats in a day	Number	10
SEC of induction furnace (present)	kWh/tonne	638
Cycle time reduction	Minutes	11
Percentage reduction in cycle time after shredder installation	%	9.17%
New cycle time after using shredded scrap with bucket	Hours	1.82
New average electricity consumption per heat	kWh/heat	4898.92
New SEC of induction furnace	kWh/tonne	579.75
Electricity saving potential	%	9.17%
Electricity saving potential	kWh/day	4943.87
Electricity consumption in the shredding machine	kWh/day	1305.50
Net electricity savings due to shredding machine	**kWh/day**	**3638.37**
Number of operating days in a year	Number	300
Electricity saving potential	**kWh/year**	**1091509.91**
Electricity charges	**INR/kWh**	**7.16**
Annual monetary saving in INR	**Lakh/year**	**78.15**
Capacity of shredding machine having 250 hp motor		**3 tonne per hr**
Price of shredding machine in INR	**Lakh**	**75**
Price of bucket and vibro feeder for scrap feeding in INR	Lakh	15.50
Simple payback period	**Months**	**13.90**

GHG reduction potential[4]	tCO_2/year	851.38

The sample calculation has been done taking a real-time case study of a DRI based induction furnace unit with the furnace capacity of 12 tonnes/heat.

Table 4: Sample calculation for shredding machine in DRI based unit (12 tonnes/heat)

Parameters	Unit	Value
Average production per heat	Tonnes/heat	12.50
Average slag generation per heat	%	15%
Average charge input per heat	Tonnes/heat	14.70
Scrap quantity in charge mix per heat	%	14%
Out of the total quantity of scrap feeding in charge mix, scrap which can be fed after shredding	%	70%
Quantity of shredded scrap	kg/heat	1441.18
Average electricity consumption per heat	kWh/heat	9614
Average heat time	Hours	3.00
Average number of heats in a day	Number	8
SEC of induction furnace (present)	kWh/tonne	769
Cycle time reduction	Minutes	10
Percentage reduction in cycle time after shredder installation	%	5.56%
New cycle time after using shredded scrap with bucket	Hours	2.83
New average electricity consumption per heat	kWh/heat	9079.56
New SEC of induction furnace	kWh/tonne	726.36
Electricity saving potential	%	5.56%
Electricity saving potential	kWh/day	4272.73
Electricity consumption due to shredding machine	kWh/day	522.20
Net electricity savings due to shredding machine	**kWh/day**	**3750.53**
Number of operating days in a year	Number	300
Electricity saving potential	**kWh/year**	**1125160.0**
Electricity charges	**INR/kWh**	**3.60**
Annual monetary saving in INR	**Lakh/year**	**40.51**
Capacity of shredding machine having 250 hp motor		**3 tonne per hr**
Price of shredding machine in INR	**Lakh**	**75**
Price of bucket and vibro feeder for scrap feeding in INR	Lakh	15.50
Simple payback period	**Months**	**26.81**
GHG reduction potential[5]	tCO_2/year	877.62

[4] 1 MWh =0.78 tCO_2 (CEA user guide for CO2 Baseline Database Version 8 (2013))
[5] 1 MWh =0.78 tCO_2 (CEA user guide for CO2 Baseline Database Version 8 (2013))

3.2. Replacement of coil cradle of old furnace

3.2.1. Present practice

In some induction furnace plants, furnaces are more than eight to 10 years old. These furnaces have dated types of coil cradle assembly while the latest furnaces have far more energy-efficient coil cradle assembly. Over time, the efficiency of old coil reduces as its shape gets distorted. Energy losses are high for old coil cradle assembly due to the following possible reasons:

- Non-uniform temperature gradient throughout the refractory
- Non-efficient shunt coverage
- Low current-carrying efficiency of the coil

3.2.2. Proposed technology

Replacement of an old coil cradle assembly of the induction furnace unit with a new and efficient design assembly can reduce electricity consumption during the melting operation. Latest coil cradle assembly is equipped with specially designed curved magnetic shunts and covers around 80% of coil periphery, which minimises stray losses and improves efficiency besides providing rigidity to coil cradle assembly. The shunts are carefully designed to provide a positive support to the coil. Cushioned insulating pads reduce noise and vibration and hence enhance overall efficiency of the shunts. The coil cradle assembly with the latest design maintains uniform temperature gradient throughout the refractory, prevents overheating and enhances refractory life.

Figure 2: Coil cradle assembly

Source: www.electroheatinduction.com

Therefore, the replacement of old coil cradle assembly can be a possible technology package to improve energy efficiency in existing induction furnace units. This option is more of a retrofitting option targeting existing inefficient induction furnaces.

3.2.3. Salient features, investment and benefits

The following table describes the salient features, application, technological advantages, limitations and cost benefit of the replacement of coil cradle assembly in old furnaces:

Table 5: Replacement of coil cradle - Salient features, investment and benefits

Particulars	Description
Salient features	• Low power dissipation • High current limitation • Resistance to corrosion • Less noise and vibration
Application	• Replacement of coil cradle assembly in 8 to 10 years old furnaces (retrofitting option)
Technological limitation	• Not applicable for newly installed furnaces
Estimated investment	• INR 25 lakh (approximate cost for 8-tonne induction furnace) • INR 28 lakh (approximate cost for 12-tonne induction furnace)
Estimated implementation period	• Two to four days
Expected benefits	• Savings in electricity by 15-20 kWh per tonne

Estimated payback on investment	• 11 months for scrap based unit as they are normally dependent on grid power which is costly • 21 months for DRI based unit as they normally use their captive power which is cheaper in comparison to grid power

3.2.4. Sample calculation of energy saving potential

The sample calculation has been done taking a real-time case study of a scrap based induction furnace unit with a furnace capacity of 8 tonnes/heat.

Table 6: Sample calculation for replacement of coil cradle in scrap based unit (8 tonnes/heat)

Parameters	Unit	Value
Average electricity consumption per heat	kWh/heat	5393
Average production per heat	Tonnes/heat	8.45
Average heat time	Hours	2.00
Average number of heats in a day	Number	10
SEC of induction furnace (present)	kWh/tonne	638
Reduction in electricity consumption due to new coil cradle	**kWh/tonne**	**15**
New SEC of induction furnace	kWh/tonne	623.26
Electricity saving potential	%	2.35%
Electricity saving potential	kWh/day	1267.50
Number of operating of days in a year	**Number**	**300**
Electricity saving potential	**kWh/year**	**380250**
Electricity charges	**INR/kWh**	**7.16**
Annual monetary saving in INR	Lakh/year	27.23
Price of replacement of coil cradle in 8 tonne old furnace	**Lakh**	**25**
Simple payback period	**Months**	**11.02**
GHG reduction potential[6]	tCO_2/year	296.60

The sample calculation has been done taking a real-time case study of a DRI based induction furnace unit with a furnace capacity of 12 tonnes/heat.

Table 7: Sample calculation for replacement of coil cradle in DRI based unit (12 tonnes/heat)

Parameters	Unit	Value
Average electricity consumption per heat	kWh/heat	9878
Average production per heat	Tonnes/heat	12.54
Average heat time	Hours	3.00
Average number of heats in a day	Number	8
SEC of induction furnace (present)	kWh/tonne	788
Reduction in electricity consumption due to new coil cradle	kWh/tonne	15
New SEC of induction furnace	kWh/tonne	772.61
Electricity saving potential	%	1.90%
Electricity saving potential	kWh/day	1505.00
Number of operating of days in a year	**Number**	**300**
Electricity saving potential	**kWh/year**	**451500**
Electricity charges	**INR/kWh**	**3.60**
Annual monetary saving in INR	Lakh/year	16.25
Price of replacement of coil cradle in 12 tonne old furnace	**Lakh**	**28**

[6] 1 MWh =0.78 tCO_2 (CEA user guide for CO2 Baseline Database Version 8 (2013))

Simple payback period	**Months**	**20.67**
GHG reduction potential[7]	tCO_2/year	352.17

[7] 1 MWh =0.78 tCO_2 (CEA user guide for CO2 Baseline Database Version 8 (2013))

3.3. Installation of CCM for billet making

3.3.1. Present practice

The present analysis suggests that most induction furnace units are still using moulds to cast the molten metal into ingots. The mould filling using the runner and gate system is the traditional practice of converting molten metal to ingots, although the system does not require any extra energy consumption except for the crane operation but for every heat/cycle. It has associated energy loss of melting almost 500 to 600 kg of molten metal in the runner and gates resulting in increased specific energy consumption. However, the waste metal of 500 to 600 kg is reused into the furnace as charge for melting.

Figure 3: Mould filling using runner and gate system

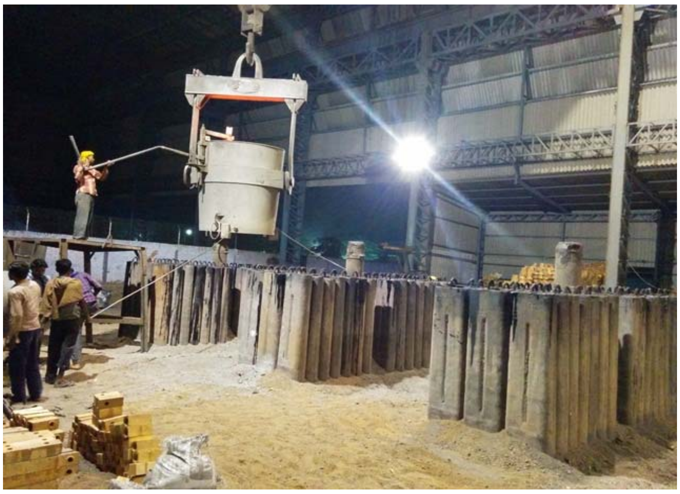


Figure 4: Runner and gate system

3.3.2. Proposed technology

The proposed technology option to avoid these losses and increase productivity is by installing CCM. This technology removes the traditional 'mould filling using the runner and gate system' and saves the energy loss of melting 500 to 600 kg of steel per heat thereby reducing the specific energy consumption at the final output. Output of CCM is billets of 100 x 100 mm and above. Compared to pencil ingots, billets have better quality and less rejection at the rolling end. Installing a CCM enhances the production and profit margin (as the market selling price of billet is higher by INR 400 to 500 per tonne as compared to billet). Therefore, the installation of the CCM machine can be a possible technology package to improve production and reduce the SEC at finished product in the induction furnace units.

Figure 5: CCM operation

3.3.3. Salient features, investment and benefits

The following table describes the salient features, application, technological advantages, limitations and cost benefit of the installation of CCM:

Table 8: Replacement of use of moulds with CCM

Particulars	Description
Salient features	• Increased production and reduced SEC • Overall process enhancement and energy saving and scope of additional production line in future • Excellent energy saving potential if clubbed with direct rolling • Reduced scale generation and support for direct rolling
Application	Installation of CCM to increase the net yield and improve the quality of final product
Technological limitation	• Need minimum two induction furnaces in running condition to give regular feed to CCM • Need space for installation of CCM
Estimated investment	INR 120 lakh (price of CCM equipment) + 150 lakh INR (expenses in civil and other work) = 270 lakh INR (total investment) with two stands provision
Estimated implementation period	Three to four months
Expected benefits	• Additional realisation of INR 100 lakh per annum for same production quantity • Savings in electricity by 10 to 12 kWh per heat
Estimated payback on investment	Approximately two to three years

3.3.4. Sample calculation of energy saving potential[8]

The sample calculation has been done taking a real-time case study of a scrap based induction furnace unit with the furnace capacity of 8 tonnes/heat.

Table 9: Sample calculation for installation of CCM for billet making (8 tonnes/heat)

Parameters	Unit	Value
Average electricity consumption per heat	kWh/heat	5393
Average production per heat	Tonnes/heat	8.45
Average heat time	Hours	2.00
Average number of heats in a day	Number	10
SEC of induction furnace (present): Scrap based	kWh/tonne	638
Recommended CCM size	Meter	4/7 radius
No. of stands in the proposed CCM	Number	2
Price of CCM in INR	Lakh	120
Expenses in civil and other work	Lakh	150
Total installation cost of CCM	**Lakh**	**270**
Reduction in wastage of metal per heat due to CCM	**Tonnes/heat**	**0.5**
Total wastage in a year without CCM	**Tonnes/year**	**1500**
Average tapping temperature	°C	1645
Initial temperature of charge	°C	40
Heat loss due to wastage in running system per heat	kcal/heat	189929
Energy loss due to wastage in running system per heat	kWh/heat	220.85
Electricity consumption in CCM and extra furnace operation due to high tapping temperature required	kWh/heat	209.00
Net electricity saving due to CCM operation	**kWh/heat**	**11.85**
Electricity charges	INR/kWh	7.16

[8] Sample calculation for 'installation of CCM' has been done only for scrap based unit. The DRI based units covered under the project had already installed CCM at their facility.

Annual electricity saving due to CCM	**Lakh/year**	**2.54**
Additional price on billets made through CCM	INR/tonne	400
Additional profit due to CCM in INR	**Lakh**	**101.40**
Total profit due to CCM in INR	**Lakh**	**103.94**
Number of operating days in a year	Number	300
Simple payback period	**months**	**31.17**
GHG reduction potential[9]	tCO_2/year	27.72

[9] 1 MWh =0.78 tCO_2 (CEA user guide for CO2 Baseline Database Version 8 (2013))

3.4. Installation of sintering panel for sintering heat

3.4.1. Present practice

Refractory or ramming mass plays an important role as refractory/insulation material in the induction furnace. Thickness of refractory lining keeps on reducing with furnace operation. After every 15 to 20 heats, ramming mass needs resetting or replacement in order to avoid furnace breakdown. The first heat after ramming mass resetting is called sintering heat and takes almost double heat time compared to normal heat time (as it requires slow heating from ambient temperature to approximately 1660° C). The sintering heat consumes much more energy, ultimately reducing the overall SEC. The present status suggests that none of the units have given due importance to this aspect and have been losing on energy and production.

3.4.2. Proposed technology

Figure 6: Sintering panel

Installation of the sintering panel can overcome the limitations associated with sintering heat. The sintering panel is a dedicated power panel applicable during sintering heat. During the sintering heat, it can share the load between the induction furnace under operation and the newly ready crucible that needs preheating before the charge feed. The load sharing can be done in a certain ratio, so that it does not affect the melting under the furnace and simultaneously preheats the newly ready crucible up to 500 to 700° C. With the installation of the sintering panel, heat time, production and overall power quality can be enhanced. Power sharing can increase the kVA utilisation index by up to 25 to 30%[10]. It reduces the heat time of sintering heat to normal heat time and will increase productivity. Also, it doesn't consume any extra power. The end result is reduced SEC, enhanced production and better power quality and utilisation during the sintering heat.

3.4.3. Salient features, investment and benefits

The following table describes the salient features, application, technological advantages, limitations and cost benefit of the installation of sintering panel:

Table 10: Installation of sintering panel for sintering heat

Particulars	Description
Salient features	• Reduction of sintering heat time to normal heat time • More heats in a day (enhanced production) • Reduction in SEC • Improved refractory life due to proper and gradual heating • Better power quality and improved kVA utilisation index
Application	Installation of sintering panel to improve heat time/production and power quality during the sintering heat.
Technological limitation	-
Estimated investment	Approximately INR 25 lakh
Estimated implementation period	Two to three days
Expected benefits	• Approximately 100 to 200 extra heats per year • Approximately 25 to 30% increase in kVA utilisation index
Estimated payback on investment	Almost two years

[10] Source: http://engineering.electrotherm.com/?page_id=35

3.4.4. Sample calculation of energy saving potential

The sample calculation has been done taking a real-time case study of a scrap based induction furnace unit with the furnace capacity of 8 tonnes/heat.

Table 11: Sample calculation for installation of sintering panel for sintering heat in scrap based unit (8 tonnes/heat)

Parameters	Unit	Value
Extra time consumed for sintering heat	Minutes	120
Frequency of sintering	Heats	15
Average production per heat	Tonnes/heat	8.45
Average number of heats in a day	Number	10
Average heat time	Hours	2.00
Average electricity consumption per heat	kWh/heat	5393
SEC of induction furnace (present)	kWh/tonne	638
Number of operating days in a year	Days	300
Total heats in a year	Heat/year	3000
Total sintering heat in a year	Heat/year	200
Extra available time for production due to installing sintering panel	Hours	400
Extra number of heat in a year	**Heat/year**	**200**
Extra production	**Tonne/year**	**1690**
Profit margin on extra production	INR/tonne	1000
Annual monetary saving in INR	**Lakh/year**	**17**
Price of installing sintering panel	Lakh	25
Simple payback period	**months**	**18**

The sample calculation has been done taking a real-time case study of a DRI based induction furnace unit with the furnace capacity of 12 tonnes/ heat.

Table 12: Sample calculation for installation of sintering panel for sintering heat in DRI based unit (12 tonnes/heat)

Parameters	Unit	Value
Extra time consumed for sintering heat	Minutes	120
Frequency of sintering	Heats	15
Average production per heat	Tonnes/heat	12. 5
Average number of heats in a day	Number	8
Average heat time	Hours	3.00
Average electricity consumption per heat	kWh/heat	9614
SEC of induction furnace (present)	kWh/tonne	769
Number of operating days in a year	Days	300
Total heats in a year	Heat/year	2400
Total sintering heat in a year	Heat/year	160
Extra available time for production due to installing sintering panel	Hours	320
Extra number of heat in a year	**Heat/year**	**107**
Extra production	**Tonne/year**	**1333**
Profit margin on extra production	INR/tonne	1000
Annual monetary saving in INR	**Lakh/year**	**13**
Price of installing sintering panel	Lakh	25
Simple payback period	**Months**	**23**

3.5. Scrap preheating

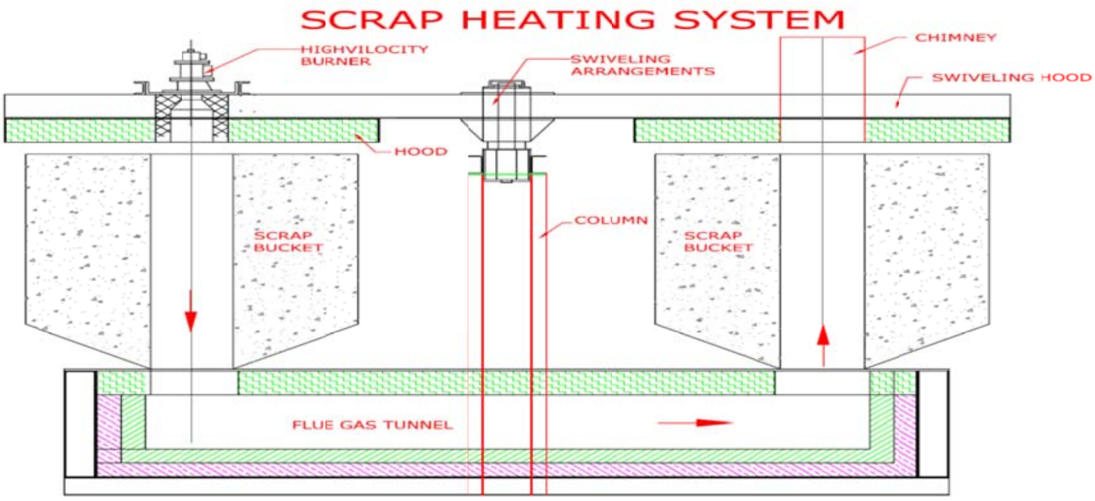
3.5.1. Present practice

Preheating of scrap is considered an energy-saving option to save energy. Market understanding suggests that units tried scrap preheating in induction furnaces, but with limited success. Presently, normal scrap at ambient temperature is fed to the furnace, ultimately consuming more energy (electricity) for melting, resulting in more heat/cycle time. Therefore, scrap preheating could be a better option if we have any waste heat available in the plant or even if any cheap source of energy is available. Using any cheap source of energy for scrap preheating can result in monetary savings as well as reduction in carbon emissions.

3.5.2. Proposed technology

Scrap preheating is proposed as one of the technology packages. By using a scrap preheater, scrap can be preheated from ambient temperature to 400 to 450° C. The scrap preheating system consists of a high velocity burner, blower, scrap basket, swivelling and temperature control mechanism. It is fabricated from mild steel plates of suitable thickness with two hoods fitted on its structural arm; one for firing and the other to collect the flue gases after routing through the charged basket kept for pre-heating, under the hood. The hood will be lined with ceramic fibre of suitable thickness. With the installation of a scrap preheater, the work of the induction furnace will be reduced as the power will be required to raise the temperature of the raw material from 500 to 1600° C instead of 35 to 1600°C. Thus, the overall heat /cycle time will be reduced, thereby reducing the SEC.

Figure 7: Scrap preheating system



Source: Encon Thermal Engineers Pvt. Ltd

If waste heat is not available in the plant, then furnace oil is used as a fuel in the scrap preheating system. The running cost of scrap preheating using furnace oil vis-à-vis electricity is calculated making the viability of this system dependent on the electricity tariff. It would be pertinent to mention that processed scrap is the pre-requisite requirement for scrap preheating. Preheating of scrap has the following advantages:

- Reduction or removal of moisture content in scrap
- Possibility of energy cost savings
- Productivity improvement by reduction in heat/cycle time of induction furnace

3.5.3. Salient features, investment and benefits

The following table describes the salient features, application, technological advantages, limitations and cost benefit of the installation of scrap preheating system:

Table 13: Scrap preheating - Salient features, investment and benefits

Particulars	Description
Salient features	• Scrap can be preheated upto 400 to 450° C. • High velocity burner and swivelling mechanism • To control and maintain the temperature of scrap accurately, the thermocouple will be fitted in the scrap pre-heater hood at suitable location.
Application	• Preheating of scrap using furnace oil
Technological limitation	• Viability depends on electricity tariff rate
Estimated investment	• INR 18 lakh (approximate cost for scrap preheating system)
Estimated implementation period	• One month
Expected benefits	• Net saving in running cost upto INR 800 per heat in case of electricity tariff is more than INR 7 per kWh • Net saving in running cost is negative if electricity tariff is less than INR 4 per kWh.
Estimated payback on investment	• Nine to 10 months for scrap based induction furnace plants with tariff rate is more than INR 7 per kWh • Normally not viable in case of DRI based induction plants with tariff rate is less than INR 4 per kWh

3.5.4. Sample calculation of energy saving potential

The sample calculation has been done taking a real-time case study of a scrap based induction furnace unit with the furnace capacity of 8 tonnes/heat.

Table 14: Sample calculation for scrap preheating using furnace oil in scrap based unit (8 tonnes/heat)

Parameters	Unit	Value
Scrap quantity used in charge mix per heat	%	90%
Scrap quantity used in charge mix per heat	kg/heat	8005.26
Average electricity consumption per heat	kWh/heat	5393
Average production per heat	Tonnes/heat	8.45
Average heat time	Hours	2.00
Average number of heats in a day	Number	10
SEC of induction furnace (present)	kWh/tonne	638
Weight of scrap to be pre-heated	kg/heat	8005.26
Pre-heating temperature of the scrap	°C	450
Raw material temperature	°C	40.0
Fuel to be used in scrap pre-heater	Type	Furnace oil
Specific heat of MS	kcal/kg °C	0.12
Heat required in pre-heating of scrap using FO	kcal	875242.11
Calorific value of furnace oil (FO)	kcal/litre	9346.5
Equivalent quantity of FO required	Litre	93.64
Cost of furnace oil	**INR/Liter**	**40**
Electricity charges	**INR/kWh**	**7.16**
Cost of furnace oil in pre-heating per heat	INR/heat	3745.75
Electricity consumption in blower of pre-heater	kWh/heat	16.60
Cost of electricity in pre-heating of scrap per heat	INR/heat	118.86
Total running cost in scrap pre-heating using FO based pre-heater	**INR/heat**	**3864.61**
Heat required in scrap melting upto 450 °C using electricity	kcal	562655.64

Calorific value of electricity	kcal/kWh	860
Equivalent quantity of electricity required	kWh	654.25
Cost of electricity in melting scrap per heat	**INR/heat**	**4684.44**
Net savings in cost for heating scrap/melt vis-à-vis to electricity	**INR/heat**	**819.83**
Number of operating days in a year	Number	300
Annual monetary saving in INR	Lakh/year	24.59
Price of scrap pre-heating system	**Lakh**	**18.00**
Simple payback period	**Months**	**8.78**

The sample calculation has been done taking a real-time case study of a DRI based induction furnace unit with the furnace capacity of 12 tonnes/heat.

Table 15: Sample calculation for scrap preheating using furnace oil in DRI based unit (12 tonnes per heat)

Parameters	Unit	Value
Scrap quantity used in charge mix per heat	%	14%
Scrap quantity used in charge mix per heat	kg/heat	2058.82
Average electricity consumption per heat	kWh/heat	9614
Average production per heat	Tonnes/heat	12.50
Average heat time	Hours	3.00
Average number of heats in a day	Number	8
SEC of induction furnace (present)	kWh/tonne	769
Weight of scrap to be pre-heated	kg/heat	2058.82
Pre-heating temperature of the scrap	°C	450
Raw material temperature	°C	40.0
Fuel to be used in scrap pre-heater	Type	Furnace oil
Specific heat of MS	kcal/kg °C	0.12
Heat required in pre-heating of scrap using FO	kcal	225098.04
Calorific value of furnace oil (FO)	kcal/litre	9346.5
Equivalent quantity of FO required	Litre	24.08
Cost of furnace oil	**INR/litre**	**40**
Electricity charges	**INR/kWh**	**3.60**
Cost of furnace oil in pre-heating per heat	INR/heat	963.35
Electricity consumption in blower of pre-heater	kW	16.60
Cost of electricity in pre-heating of scrap per heat	INR/heat	59.76
Total running cost in scrap pre-heating using FO based pre-heater	**INR/heat**	**1023.11**
Heat required in scrap melting upto 450° C using electricity	kcal	144705.88
Calorific value of electricity	kcal/kWh	860
Equivalent quantity of electricity required	kWh	168.26
Cost of electricity in melting scrap per heat	**INR/heat**	**605.75**
Net savings in cost for heating scrap/melt vis-à-vis to electricity	**INR/heat**	**-417.36**
Number of operating days in a year	Number	300
Annual monetary saving in INR	Lakh/year	-10.02
Price of scrap pre-heating system	**Lakh**	**18.00**
Simple payback period	**Months**	**Not viable**

3.6. Ladle preheating

3.6.1. Present practice

The partially heated ladle is filled with molten metal after tapping resulting in heating up of lining inside the ladle thereby lowering the temperature of molten metal. Therefore, the tapping temperature needs to be increased by a certain level to get the required temperature at the time of metal pouring in ingot moulds/CCM. Due to this, heat/cycle time is increased resulting in electricity consumption per tonne of production.

3.6.2. Proposed technology

Ladle pre-heater is one of the possible technology options for the induction furnace. By using the ladle pre-heater, temperature can be raised by 300 to 350° C subsequently reducing the tapping temperature by 15 to 20° C in the furnace. In this technology package, the ladle is placed below the preheater by the overhead crane or forklift. Then, the lid is placed on the top of the ladle and the burner is energised with the help of light diesel oil (LDO). Subsequently, a high velocity flame leads to uniform heating across the ladle length eliminating the chances of any cold zone in the ladle. Ladle preheating time takes around 15 to 20 minutes just before tapping.

Figure 8: Ladle preheating system

Source: www.dhanaprakash.com

The lid of the preheating system is equipped with a tilting and swivelling mechanism for up/down and in/out operation. The ladle preheating system has an in-built recuperator and temperature controlling feature. The advantages of ladle preheating are as follows:

- Reduction in cycle/heat time and hence electricity savings per tonne production
- Better lining life of ladle
- Reduction in heat losses during transferring of ladle
- Better solidification of metal during pouring and casting

3.6.3. Salient features, investment and benefits

The following table describes the salient features, application, technological advantages, limitations and cost benefit of the installation of ladle preheating system:

Table 16: Ladle preheating - Salient features, investment and benefits

Particulars	Description
Salient features	• Temperature gain in ladle after tapping can be achieved by 300 to 350° C • Faster and uniform heating • Stainless steel lid with ceramic module lining • Motorised/hydraulic up down, tilting, swinging motion • High heat resistant burner • Temperature measurement and control • Continuous flame monitoring
Application	• Preheating of ladle using diesel before tapping
Technological limitation	• Viability depends on electricity tariff rate
Estimated investment	• INR 8 lakh (approximate cost for ladle preheating system)
Estimated implementation period	• One month
Expected benefits	• Net saving in running cost upto INR 300-350 per heat in case of electricity tariff is more than INR 7 per kWh • Net saving in running cost is negative if electricity tariff is less than INR 4 per kWh
Estimated payback on investment	• 9 months for scrap based scrap based unit as they are dependent on Grid power which is costly • Normally not viable in case of DRI based induction plants with tariff rate is less than INR 4 per kWh

3.6.4. Sample calculation of energy saving potential

The sample calculation has been done taking a real-time case study of a scrap based induction furnace unit with the furnace capacity of 8 tonnes/ heat.

Table 17: Sample calculation for ladle preheating using LDO in scrap based unit (8 tonnes/heat)

Parameters	Unit	Value
Tapping temperature	°C	1645
Temperature at pouring	°C	1620
Temperature of ladle before tapping	°C	800
Ladle preheat by using burner upto	°C	1100
Temperature gain due to preheating of ladle	**°C**	**300**
Average production per heat	Tonnes/heat	8.45
Average number of heats in a day	Number	10
Average heat time	Hours	2.00
Average electricity consumption per heat	kWh/heat	5393
SEC of induction furnace (present)	kWh/tonne	638
Due to preheating of ladle, tapping temp reduced by	°C	20
Due to preheating of ladle tapping temp	°C	1625
Reduction in cycle time due to ladle preheating	Minutes	2.5
Percentage reduction in cycle time	%	2.08%
New cycle time after ladle preheating	Hours	1.96
New average electricity consumption per heat	kWh/heat	5280.95
New SEC of induction furnace	kWh/tonne	624.96
Electricity saving potential	%	2.08%
Electricity saving potential	kWh/day	1123.61
Number of operating days in a year	Number	300
Electricity saving potential	**kWh/year**	**337081.80**
Electricity charges	INR/kWh	7.16
Annual monetary saving in INR	**Lakh/year**	**24.14**
Price of installing burner with cover	**Lakh**	**7.5**

Quantity of diesel consumption	Litre/heat	8.00
Quantity of diesel consumption	Litre/day	80.00
Quantity of diesel consumption	Litre/year	24000.00
Electricity consumption of blower in preheating ladle	kWh/heat	2.00
Electricity consumption of blower in preheating ladle	kWh/year	6000.00
Expense of electricity in blower	Lakh/year	0.43
Annual expense in preheating of ladle	**Lakh/year**	**14.11**
Net annual monetary savings	**Lakh/year**	**10.03**
Simple payback period	**months**	**8.98**

The sample calculation has been done taking a real-time case study of a DRI based induction furnace unit with the furnace capacity of 12 tonnes/ heat.

Table 18: Sample calculation for ladle preheating using LDO in DRI based unit (12 tonnes/heat)

Parameters	**Unit**	**Value**
Tapping temperature	°C	1668
Temperature at pouring	°C	1650
Temperature of ladle before tapping	°C	800
Ladle preheat by using burner upto	°C	1100
Temperature gain due to preheating of ladle	**°C**	**300**
Average production per heat	Tonnes/heat	12.5
Average number of heats in a day	Number	8
Average heat time	Hours	3.00
Average electricity consumption per heat	kWh/heat	9614
SEC of induction furnace (Present)	kWh/tonne	769
Due to preheating of ladle, tapping temp reduced by	°C	20
Due to preheating of ladle tapping temp	°C	1648
Reduction in cycle time due to ladle preheating	Minutes	2.5
Percentage reduction in cycle time	%	1.39%
New cycle time after ladle preheating	Hours	2.96
New average electricity consumption per heat	kWh/heat	9480.13
New SEC of induction furnace	kWh/tonne	758.41
Electricity saving potential	%	1.39%
Electricity saving potential	kWh/day	1068.18
Number of operating days in a year	Number	300
Electricity saving potential	**kWh/year**	**320455**
Electricity charges	INR/kWh	3.60
Annual monetary saving in INR	**Lakh/year**	**11.54**
Price of installing burner with cover	**Lakh**	**8**
Quantity of diesel consumption	Litre/heat	10.00
Quantity of diesel consumption	Litre/day	80.00
Quantity of diesel consumption	Litre/year	24000.00
Electricity consumption of blower in preheating ladle	kWh/heat	2.50
Electricity consumption of blower in preheating ladle	kWh/year	6000.00
Expense of electricity in blower	Lakh/year	0.22
Annual expense in preheating of ladle	**Lakh/year**	**13.90**
Net annual monetary savings	**Lakh/year**	**-2.36**
Simple payback period	**months**	**Not viable**

3.7. Avoid superheating of the metals

3.7.1. Present practice

Currently, all units with CCM are going for super heating of the metal/melt to ensure the optimum temperature at CCM considering the travel time. When CCM is engaged, super heating is conducted considering the waiting and travel time. The operator working on the furnace may not be confident about the temperature shown by the transducer, so he keeps providing extra heat to the melt till the CCM is ready to take up the melt for billet making. The image here shows the molten metal in a ladle with slightly high temperature due to extra super heating, left in an open environment to make it suitable for pouring into CCM.

Figure 9: Ladle transfer for CCM operation

3.7.2. Proposed measure and practice

As this is an operating practice, it needs to be checked to avoid super heating of the metal/melt. The operator working on the induction furnace needs to be trained, so that he/she effectively utilises the power for melting the metal.

3.7.3. Sample calculation of energy saving potential

The sample calculation has been done taking a real-time case study of a DRI based induction furnace unit with the furnace capacity of 12 tonnes/ heat.

Table 19: Sample calculation for avoiding excess super heating of metal in the furnace (mostly in units with CCM) (12 tonnes/heat)

Parameters	Unit	Value
Tapping time	Minutes	5.00
Average power input at the time of tapping	kW	2500
Average electricity consumption per heat	kWh/heat	9614
Average production per heat	Tonnes/heat	12.50
Average heat time	Hours	3.00
Average number of heats in a day	Number	8
SEC of induction furnace (present)	**kWh/tonne**	**769**
Power consumption in the superheating	kWh/heat	208.33
New average electricity consumption per heat	kWh/heat	9405.32
New SEC of induction furnace	**kWh/tonne**	**752.43**
Electricity saving potential	%	2.17%
Electricity saving potential	**kWh/day**	**1666.67**
Number of operating days in a year	Number	300
Electricity saving potential	**kWh/year**	**500000**
Electricity charges	INR/kWh	3.60
Annual monetary saving in INR	**Lakh/year**	**18.00**
Price to avoid superheating	Lakh	Nil
Simple payback period	months	Immediate
GHG reduction potential[11]	tCO_2/year	390

[11] 1 MWh =0.78 tCO_2 (CEA user guide for CO2 Baseline Database Version 8 (2013))

3.8. Avoid overfilling (metal above the coil level) of furnace during melting

3.8.1. Present practice

Figure 10: Overfilling of furnace

Currently, all the units audited were overfilling the furnace above the coil height. Nearly 8 inch or 0.2 m of height is provided above the coil, out of which most of the units were filling the furnace upto or more than 4 inch 0r 0.1 m above the coil. Overfilling the feed above the coil height has its own disadvantages. The heat transfer mechanism takes place from coil to melt via conduction till the coil height. Above the coil height, heat transfer is from melt to melt (or metal to metal) instead of coil to metal. It takes some extra time for the heat and affects the SEC of the furnace. Improper filling and melting also leads to voids in the furnace. The image here shows an overfilled furnace, where a magnet was being used for charge feed.

3.8.2. Proposed measure and practice

This is an operating practice that needs to be checked to avoid overfilling of the furnace during melting. The operator working on the induction furnace needs to be trained, so that he or she fills the furnace upto the desired coil height for effective and faster heat transfer. Although overfilling is associated with extra production, extra production can also be achieved if the furnace is filled to the desired coil height. It will result in reduced heat time thus allowing more heats per day to ultimately result in more production. Apart from more production, it will also reduce the SEC of the operation as compared to the SEC during the overfilling.

3.8.3. Sample calculation of energy-saving potential

The sample calculation has been done taking a real-time case study of a scrap based induction furnace unit with a furnace capacity of 8 tonnes/ heat.

Table 20: Sample calculation for avoiding overfilling of furnace during meting case scrap based unit (8 tonnes/heat)

Parameters	Unit	Value
Extra length above coil height	**meter**	**0.20**
Overfilling of metal above the coil height	%	50%
Overfilling of metal above the coil height	**meter**	**0.10**
Volume of furnace overfilled above coil height	m^3	0.08
Effective height of furnace former	meter	1.88
Total volume of furnace	m^3	1.52
Average production per heat	Tonnes/heat	8.45
Average electricity consumption per heat	kWh/heat	5393
Average heat time	**Hours**	**2.00**
Average number of heats in a day	Number	10
SEC of induction furnace (present)	**kWh/tonne**	**638**
Extra production due to overfilling	Tonnes/heat	0.46
Thermal conductivity of iron	W° C/m	80.20
Area of heat transfer	m^2	0.81

Thickness	m	0.10
Average tapping temperature	°C	1645
Initial temperature of charge	°C	40
Heat Transfer in conduction heating of overfilled metal	kW	1026.63
Heat loss due to overfilling in a heat	kcal	147624
Heat loss due to overfilling in a heat	kWh	171.66
Extra time in melting due to overfilling	Minutes	10.03
New cycle time after avoiding overfilling of furnace during the melting	**Hours**	**1.83**
New average electricity consumption per heat	kWh/heat	4942.42
New SEC of induction furnace	**kWh/tonne**	**618.32**
Electricity saving potential	%	3.12%
Electricity saving potential	kWh/day	1684.66
Number of operating days in a year	Number	300
Electricity saving potential	**kWh/year**	**505398.50**
Electricity charges	INR/kWh	7.16
Annual monetary saving in INR	**Lakh/year**	**36.19**
Price to avoid overfilling	Lakh	Nil
Simple payback period	months	Immediate
GHG reduction potential[12]	tCO_2/year	394.21

The sample calculation has been done taking a real-time case study of a DRI based induction furnace unit with the furnace capacity of 12 tonnes/ heat.

Table 21: Sample calculation for avoiding overfilling of furnace during meting case DRI based unit (12 tonnes/heat)

Parameters	Unit	Value
Extra length above coil height	**meter**	**0.20**
Overfilling of metal above the coil height	%	50%
Overfilling of metal above the coil height	**meter**	**0.10**
Volume of furnace overfilled above coil height	m^3	0.09
Effective height of furnace former	meter	1.88
Total volume of furnace	m^3	1.68
Average production per heat	Tonnes/heat	12.50
Average electricity consumption per heat	kWh/heat	9614
Average heat time	**Hours**	**3.00**
Average number of heats in a day	Number	8
SEC of induction furnace (present)	**kWh/tonne**	**769**
Extra production due to overfilling	Tonnes/heat	0.68
Thermal conductivity of iron	W °C/m	80.20
Area of heat transfer	m^2	0.89
Thickness	m	0.10
Average tapping temperature	°C	1668
Initial temperature of charge	°C	35
Heat Transfer in conduction heating of overfilled metal	kW	1151.60
Heat loss due to overfilling in a heat	kcal	226879
Heat loss due to overfilling in a heat	kWh	263.81
Extra time in melting due to overfilling	Minutes	13.74
New cycle time after avoiding overfilling of furnace	**Hours**	**2.77**

[12] 1 MWh =0.78 tCO_2 (CEA user guide for CO2 Baseline Database Version 8 (2013))

during the melting		
New average electricity consumption per heat	kWh/heat	8879.54
New SEC of induction furnace	**kWh/tonne**	**750.96**
Electricity saving potential	%	2.36%
Electricity saving potential	kWh/day	1813.64
Number of operating days in a year	Number	300
Electricity saving potential	**kWh/year**	**544092.78**
Electricity charges	INR/kWh	3.60
Annual monetary saving in INR	**Lakh/year**	**19.59**
Price to avoid overfilling	Lakh	Nil
Simple payback period	months	Immediate
GHG reduction potential[13]	tCO_2/year	424.39

[13] 1 MWh =0.78 tCO_2 (CEA user guide for CO2 Baseline Database Version 8 (2013))

3.9. Energy-efficient pumps

3.9.1. Present practice

A pumping system is an integral part of auxiliaries in the induction furnace operation. Pumps are installed for coil cooling, heat exchanger and panel cooling. Mainly, mono block type pumps are used in the cooling water circuit of the induction furnaces. The pumping system contributes to around 5 to 6% of the total energy consumption for per tonne of production. Existing pumps were found to be old and inefficient in majority of the units. The performance evaluation of some of the existing coil cooling pump indicates operating efficiency to be around 40%, which is quite low.

3.9.2. Proposed technology

In order to reduce the power consumption of the auxiliary system, it is recommended to replace the existing pump with an energy-efficient pump matching the designed head and flow. A comparison of performance of existing pumps with the more energy efficient pumps available in the market revealed that, there is significant energy saving potential, if these pumps are replaced.

3.9.3. Salient features, investment and benefits

The following table describes the salient features, application, technological advantages, limitations and cost benefit of the installation of energy efficiency pumps:

Table 22: Energy-efficient pump: Salient features, investment and benefits

Particulars	Description
Salient features	• Reliability and rugged in construction • Energy efficient motors • Ease in maintenance • Low energy consumption • Low maintenance cost • Less noise and vibration
Application	• Energy-efficient pump
Technological limitation	• Pump should be operated at best operating point of pump to get best efficiency
Estimated investment	• INR 3.20 lakh for 22 kW energy efficient pump and INR 3.00 lakh for 18.5 kW energy efficient pump
Estimated implementation period	• 2 days
Expected benefits	• Reduction in electricity consumption by 30 to 35%
Estimated payback on investment	• 6 months

3.9.4. Sample calculation of energy saving potential

The sample calculation has been done taking a real-time case study of a scrap based induction furnace unit with a furnace capacity of 8 tonnes/ heat.

Table 23: Sample calculation for energy-efficient pump (8 tonne/heat)

Parameters	Unit	Value
Pipe thickness	m	0.004
Pipe diameter	m	0.121
Pipe Radius	m	0.057
Area	m^2	0.010
Velocity of water	m/s	2.60

Water flow	Lps	26.07
Water flow	m^3/hour	93.84
Total head	M	43.00
Fluid density	kg/m^3	1000
Hydraulic power	kW	11.00
Power consumption of motor	kW	34.1
Motor efficiency	%	80
Power input to pump shaft	kW	27.26
Pump efficiency	**%**	**40**
Number of pump	Number	1
Existing power rating of pump	**kW**	**37.3**
Existing total energy consumption	kWh/year	245,304
Proposed power rating of pump	**kW**	**22**
Proposed total energy consumption	kWh/year	158,400
Annual electricity savings	**kWh/year**	**86,904**
Electricity charges	**INR/kWh**	**7.16**
Operating hours per day	Hours	24
Number of operating days in a year	Number	300
Annual monetary saving in INR	Lakh/year	6.22
Price of installing EE pumps	**Lakh**	**3.20**
Simple payback period	**months**	**6.17**
GHG reduction potential[14]	tCO_2/year	67.78

The sample calculation has been done taking a real-time case study of a DRI based induction furnace unit with the furnace capacity of 12 tonnes/ heat.

Table 24: Sample calculation for energy-efficient pump (12 tonne/heat)

Parameters	Unit	Value
Pipe thickness	m	0.004
Pipe diameter	m	0.142
Pipe Radius	m	0.067
Area	m^2	0.014
Velocity of water	m/s	1.30
Water flow	lps	18.22
Water flow	m^3/hr	65.58
Total head	m	51.00
Fluid Density	kg/m^3	1000
Hydraulic power	kW	9.11
Power consumption of motor	kW	40.7
Motor efficiency	%	85
Power input to pump shaft	kW	34.61
Pump efficiency	**%**	**26**
Number of pump	Number	1
Existing power rating of pump	**kW**	**45**
Existing total energy consumption	kWh/year	293,184
Proposed power rating of pump	**kW**	**18.5**
Proposed total energy consumption	kWh/year	133,200
Annual electricity savings	**kWh/year**	**159,984**

[14] 1 MWh =0.78 tCO_2 (CEA user guide for CO2 Baseline Database Version 8 (2013))

Electricity charges	**Rs/kWh**	**3.60**
Operating hours per day	Hours	24
Number of operating days in a year	Number	300
Annual monetary saving in INR	Lakh/year	5.76
Price of installing EE pumps	**Lakh**	**3**
Simple payback period	**months**	**6.25**
GHG reduction potential[15]	tCO_2/year	124.78

[15] 1 MWh =0.78 tCO_2 (CEA user guide for CO2 Baseline Database Version 8 (2013))

3.10. FRP blades in cooling tower

3.10.1. Present practice

The induction furnace unit has cooling towers to serve the cooling water needs of coil and panel cooling. The cooling water from the cooling tower comes to the pump suction by gravity and the pump supplies it to the coil and panel of the furnace. The cooling water from the furnace then goes back to the cooling tower. Existing cooling towers had induced axial flow fans with metallic/aluminium blades. It is well known that metallic/aluminium blades are heavier and need relatively greater starting torque.

3.10.2. Proposed technology

The use of FRP blades instead of metallic/aluminium blades will save energy and improve the performance of the cooling towers owing to the better aerodynamic shape of its blades. The power measurements show that the fan with FRP blades consumes less power compared to the metallic blade fan. The difference in power consumption is around 25 to 30%. It is recommended to replace existing metallic/aluminium fan blades in the cooling tower with fibre reinforced plastic blades.

3.10.3. Salient features, investment and benefits

The following table describes the salient features, application, technological advantages, limitations and cost benefit of the installation of FRP blades in cooling tower:

Table 25: FRP blades: - Salient features, investment and benefits

Particulars	Description
Salient features	• Lower energy consumption of cooling tower fan • Better aerodynamic shape • Light in weight
Application	FRP blades for cooling tower
Technological limitation	-
Estimated investment	INR 0.50 lakh for FRP blades
Estimated implementation period	2 days
Expected benefits	Reduction in electricity consumption of cooling tower fan by 25 to 30%
Estimated payback on investment	10.35 months

3.10.4. Sample calculation of energy saving potential

Table 26: Sample calculation for replacement of metallic/aluminium blades of cooling towers with FRP blades

Parameters	Unit	Value
Rated power consumption of CT fan	kW	7.5
Existing power consumption of CT fan	kW	4.5
Operating hours per day	Hours	24
Number of operating days in a year	Number	300
Existing power consumption of CT fan	kWh/year	32,400
Anticipated savings with installation of FRP blades	%	25
Expected power consumption of CT fan after installing FRP blades	kWh/year	24,300
Annual energy saving	**kWh/year**	**8,100**
Electricity charges	INR/kWh	7.16
Annual monetary saving in INR	Lakh/year	0.58
Price of FRP blades	**Lakh**	**0.50**
Simple payback period	**months**	**10.35**
GHG reduction potential[16]	tCO_2/year	6.31

[16] 1 MWh =0.78 tCO_2 (CEA user guide for CO2 Baseline Database Version 8 (2013))

3.11. Variable Frequency Drive (VFD) on air compressor

3.11.1. Present practice

Compressed air requirement of the induction furnace plant is met by either the screw type or reciprocating type compressor. Study results indicates that compressed air is mainly used in CCM, mould bottom plate cleaning and other miscellaneous uses. It was found during study that reciprocating type compressors are used for the ingot making unit and screw type compressors are used for the billet making unit. Energy audit of some of them indicates that these compressors are operating without VFD although they have variable loading. Installation of VFD can save substantial energy in such a variable loading conditions.

3.11.2. Proposed technology

Variable frequency drive is a method of compressor control that provides efficient operation over a wide range by closely matching the output with the demand. It is proposed to use VFD on air compressors if they have variable loading character.

3.11.3. Salient features, investment and benefits

The following table describes the salient features, application, technological advantages, limitations and cost benefit of the installation of VFD in compressor:

Table 27: VFD on air compressor - Salient features, investment and benefits

Particulars	Description
Salient features	• Reduce energy consumption during no load/unloading of the compressor • Better controlling of operation and lowering the operating pressure
Application	• Reduce energy consumption for variable load on the compressor
Technological limitation	• Energy saving is possible if the compressors run for long period at part load • Energy savings is depend on the loading and unloading pattern of compressor
Estimated investment	INR 3 lakh for 30 kW VFD
Estimated implementation period	2 days
Expected benefits	Reduction in electricity consumption by 15 to 20%
Estimated payback on investment	39 months

3.11.4. Sample calculation of energy saving potential

Table 28: Sample calculation for installation of variable frequency drive

Parameters	Unit	Value
Loading time	%	60%
Unloading time	%	40%
Maximum loading power	kW	35.60
Minimum unloading power	kW	9.00
Electricity consumption	kWh	22.26
Electricity saved by installing VFD	kWh	3.56
Total operating hours of compressor in a year	Hour/year	6,000
Annual electricity savings by installing VFD	**kWh/year**	**21,361**
Percentage of energy savings	%	15.99%
Electricity charges	**INR/kWh**	**3.60**
Annual monetary saving in INR	**Lakh/year**	**0.77**
Price of installing 30 kW VFD for air compressor	**Lakh**	**3**
Simple payback period	**months**	**39.01**

GHG reduction potential[17]	tCO_2/year	16.66

[17] 1 MWh =0.78 tCO_2 (CEA user guide for CO2 Baseline Database Version 8 (2013))

4. Annexure A: List of Technology Suppliers and/or Manufacturers

Equipment/ Technology	Name of Supplier and/or Manufacture	Web link
Shredding Machine	Jain Hydraulics	http://jainhydraulics.com/
	Bharath Industrial Works	http://www.bharathindustrialworks.co.in/
Coil cradle	Electrotherm (India) Ltd.	http://www.electrotherm.com/
	Inductothem India Pvt ltd	http://www.inductothermindia.com/
	Megathem Electronics (P) ltd	http://www.megatherm.com/
	ABP Induction Systems	http://www.abpinduction.com/
CCM	Electrotherm (India) Ltd.	http://www.electrotherm.com/
	Concast (India) Limited	http://www.concastindia.com/
	SSS Tech Engineers	
Sintering Panel	Inductothem India Pvt ltd	http://www.inductothermindia.com/
	ABP Induction Systems	http://www.abpinduction.com/
Scrap preheater	ENCON Thermal Engineers Pvt. Ltd.	http://www.encon.co.in/
	SEVAT Group	
Ladle preheater	ENCON Thermal Engineers Pvt. Ltd.	http://www.encon.co.in/
	Dhanaprakash Industrial Corporation	http://www.dhanaprakash.com/
Pumps	M/s C.R.I. Pumps (Pvt) Ltd.	http://www.cripumps.in
	M/s Grundfos Pumps India Pvt. Ltd.	http://in.grundfos.com
	M/s Johnson Pump (India) Ltd.	http://www.johnson-pump.com/in/
	M/s Kirloskar Brothers Limited (KBL)	http://www.kirloskarpumps.com/
	M/s KK Pumps Industries	http://www.kkpumps.com/
	M/s KSB Pumps Ltd.	http://www.ksbindia.co.in
	M/s Shakti Pumps (I) Ltd.	http://www.shaktipumps.com
Variable frequency drive (VFD)	M/s ABB Limited	http://www.abb.co.in
	M/s Alstom Limited	http://www.alstom.com/
	M/s Danfoss Industries Pvt. Ltd.	http://www.danfoss.com/India/
	M/s General Automation	http://www.acdrivesindia.com/
	M/s Kirloskar Electric	http://www.kirloskar-electric.com/
	M/s Sakthi Electrical Control	http://www.sakthistabilizer.in/
	M/s Schneider Electric	http://www.schneider-electric.com/
FRP blades	Delta Cooling Towers Pvt. Ltd.	http://www.deltactowers.com/
	ABR Cooling Towers Pvt. Ltd.	http://www.abrcooling.com/
	Paharpur Cooling Towers Limited	http://www.paharpur.com/

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