Energy Conservation in Induction furnace

Programme on Energy Conservation in Foundry Industry

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The Energy and Resources Institute
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Melting furnace
Introduction and working principle

Two main types
- Coreless
- Channel

Medium frequency coreless type
- Frequency: 500 – 2000 Hz
- Crucible size: 50 kg – 20MT
- Switching device: SCR or IGBT

Laws governing induction heating
- Electromagnetic induction
- The joule effect
Introduction and working principle
Losses in induction furnace

- Transmission losses
- Converter losses
- Capacitor bank losses
- Conduction heat loss
- Radiation losses
- Coil losses
Losses in induction furnace

Energy consumption mains
side 525 kWh/t

517 kWh/t

8 kWh/t losses transformer

500 kWh/t

17 kWh/t losses converter

495 kWh/t

5 kWh/t losses capacitor bank

405 kWh/t

89 kWh/t electrical losses coil

396 kWh/t

9 kWh/t thermo losses

Enthalpy at 1.500 °C
Energy conservation measure

Selection and sizing

- Induction furnace selection
- Technology: SCR or IGBT
- Furnace sizing
- Cooling water circuit installation

Best operating practices

- Charge preparation and charging
- Melting and making melt ready
- Emptying the furnace
- Furnace lining
- Energy monitoring and data analysis
Selection and sizing – Before installation

Crucible size
- Melt rate handling capacity
- Moulding capacity
- Number of crucible

Panel capacity and type
- Technology: SCR or IGBT
- Panel capacity: Power density (kW / kg)

Cooling water circuit
- Pump specification
- Type of piping and size of piping
Selection and sizing – Before installation

**Pump specification**
- Flow rate, lpm (litres per minute)
- Head, m
- Power rating, hp / kW
- Pump-motor set efficiency, %
  - 34%, 37%, 40%, 47%, 59%

**Piping**
- To minimize friction loss
- Water velocity typical design 1.8 – 2.0 m/s
- Based on economics
Specific energy consumption

• Typical values for cast iron foundries

<table>
<thead>
<tr>
<th>Location</th>
<th>Average (SEC kWh/tonne)</th>
<th>Best (SEC kWh/tonne)</th>
</tr>
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<tbody>
<tr>
<td>Kolhapur</td>
<td>624</td>
<td>511</td>
</tr>
<tr>
<td>Belgaum</td>
<td>603</td>
<td>539</td>
</tr>
<tr>
<td>Europe</td>
<td>571</td>
<td>507</td>
</tr>
</tbody>
</table>

Kolhapur – 63 units
Belgaum – 15 units
Europe – WB report 2012
Analysis – Power Curve

Induction furnace power curve

Delay in spectro analysis
Analysis - Discussion

Temperature drop

Delay in spectro analysis

Power, kW

0 50 100 150 200 250 300 350 400 450 500

1:05:00 PM 1:07:00 PM 1:09:00 PM 1:11:00 PM 1:13:00 PM 1:15:00 PM 1:17:00 PM 1:19:00 PM 1:21:00 PM 1:23:00 PM 1:25:00 PM 1:27:00 PM 1:29:00 PM 1:31:00 PM 1:33:00 PM 1:35:00 PM 1:37:00 PM 1:39:00 PM 1:41:00 PM 1:43:00 PM 1:45:00 PM 1:47:00 PM 1:49:00 PM 1:51:00 PM 1:53:00 PM 1:55:00 PM 1:57:00 PM 1:59:00 PM 2:01:00 PM 2:03:00 PM 2:05:00 PM 2:07:00 PM
Analysis - Discussion

Induction furnace power curve

All moulds not ready

Small ladle pouring, power loss during pouring
Analysis - Discussion

Induction furnace power curve

Power, kW

0 50 100 150 200 250 300 350 400 450


???
Analysis - Discussion

Dual-trak furnace, poorly utilized

???
Analysis - Discussion

Induction furnace power curve

Almost Ideal
Best operating practices

- Charge preparation and charging
- Melting and making melt ready
- Emptying the furnace
- Furnace lining
- Energy monitoring and data analysis
Charge preparation and charging

Weighing and arranging the charge

Free from sand, dirt, oil and grease. Rusty scrap: Less metal per charging. Clean, dry and dense: 10 kWh per ton

Maximum size of charge: (1/3)rd of opening diameter

Do not charge beyond coil level

Proper charge sequence to be followed. Pig iron to be charged. Fill the gaps with turning and borings
Charge preparation and charging

Foundry return should be tum/shot blasted. Contains 3 – 5% sand by weight.

Process control through melt managers, leads to less interruptions.

Limit use of baled steel and loose boring.

Use charge driers and pre-heaters to remove moisture and pre heat the charge.
Charge preparation and charging
Charge preparation and charging
Follow melt process, always run furnace at full power

Use lid mechanism, 5 – 8 % energy lost through radiation
Typically 20 – 30 kWh per tonne saving using lid

Avoid build-up of slag on furnace walls

Proper tools and techniques should be used for de-slagging

Spectro-testing lab must be located near to melt shop

Avoid un-necessary super-heating of metal. 50 °C leads to more than 25 kWh per tonne
Melting and making melt ready
Emptying the furnace

Optimization of the ladle size to minimize the heat losses and empty the furnace in the shortest time

Optimization of the ladle transportation

Plan melting according to moulding. Metal should never wait for mould rather mould should be ready before metal

Use of ladle pre-heater. Proper positioning of burner is important to get uniform heating

Quantity of liquid metal returned to furnace must be as low as possible

Glass-wool or ceramic-wool cover for pouring ladle

Minimize plant breakdown by implementing a planned maintenance schedule
Emptying the furnace
Furnace lining

Select the correct lining material

Do not increase lining thickness at bottom or sidewalls. Increase in lining means reducing capacity of furnace

Do not allow furnace to cool very slow. Forced air cooling helps in developing cracks of lower depth, this helps in faster cold start cycle

Cold start cycle time should be ideally not more than 120% of normal cycle time

Coil cement should be smooth, in straight line and having thickness of 3 to 5 mm

While performing lining ensure that each layer is not more than 50mm. Compaction is better with smaller layer

Monitor lining performance
Energy monitoring and data analysis

Separate energy meter for furnace must be installed

Monitor energy consumption on heat by heat basis

Analyse them in correlation with production data to arrive at specific energy consumption of furnace on daily basis

Any peak or valley in data must be studied and investigated

ENERGY MONITORING is the first step for achieving ENERGY SAVING
Be the change you want to see in the world