The Application of MHD Side Stirrer Technology to Aluminium Melting Furnaces for Operational Efficiency Improvement - A Case Study

Presented by

Alan M Peel C.Eng
Managing Director, ALTEK Group

Pierre Yves Menet
CONSTELLIUM Technology Centre, Voreppe
 Agenda

– Why Stir a melting furnace?
– EM Stirring Technology - How does it work?
– ALTEK ‘Air Cooled’ Technology
– Side Mounted Stirrer Operation
– Some operational Benefits and Results
– Summary
Why Stir a furnace?
Why STIR the metal in recycling?

The "ICEBERG" effect!!
Heat Transfer in the melt cycle

Start of melt cycle

Radiated Heat Transfer

Start of melt cycle

Radiated Heat Transfer

Start of melt cycle

Radiated and conductive Heat Transfer

Start of melt cycle
Furnace Heat Transfer

Conduction + convection

\[ Q_{\text{rad total}} = Q_{\text{rad gas}} + Q_{\text{rad wall}} \]

\[ Q_{\text{rad total}} = Q_{\text{bath absorbed}} + Q_{\text{bath reflected}} \]
Re cap – Why STIR the metal?

- Improved heat transfer efficiency of the furnace
- Improved temperature homogeneity
- Improved chemical homogeneity
- Reduced energy consumption
- Reduced cycle time – increased production
- Reduced dross generation
- Easier dross skimming
- Less damage to refractory
- Consistent accuracy of temperature – reduced pit waiting time and out of specification casts
- Door closed stirring (minimised door open time)
The Temperature of the metal is the single most controllable factor that determines dross generation in a furnace.
EM Circulation

How it works?
History - Growth in EM Devices

EM Pumps and Stirrers - Market Growth

- EM Side
- Stirrer - Air
- EM Pumps
- EM Bottom
- Stirrer - Air
- EM Stirrer - China
- EM Stirrer - Channel
- Port Type
- Stirrer
- EM Stirrer - Water

EM Stirring – How it works

EM Stirring well proven – Over 700 applications

I : Induced current
H : Magnetic Field Intensity
F : Electro-magnetic force
V : Travelling Velocity of magnetic field
Stirring Velocity Effects
Furnace Stirring

- If high alloy (such as 5xxx etc.) OR
- Scrap as part of charge

- Stirring will:
  - Reduce dross (10 to 30%)
  - Increase productivity (10 to 20%)
  - Improve quality
  - Reduce energy

.....A Good Practice
EM Stirring – Metal Movement

This bath is 1000mm deep
EM Stirring Technology
EM Stirring – Older technology

1. Required water for cooling medium
   - More complex installation – water quality, piping, back up systems
   - Safety concerns with water in basement area under furnace

2. High energy consumption
   - Higher operating costs

3. Quite inflexible controllability
   - Reduces effects within melting cycle

4. Limited application capability
   - could not easily be fitted as side mount
EM Stirring - A New Approach

1. Simple and reliable construction
2. No water in the inductor – no water in furnace basement area – *lower risk and less complicated installation*
3. Novel inductor design and control techniques leading to significantly lower power consumption
4. Side Mount capability
5. Multiple furnace capability
6. Lower installation cost and work required
7. 100% UK manufacture and full CE compliance
ALTEK EM Stirrers

- Original design has been operating for 10 years in RUSAL group – 40 References
- Bottom or side mounted
- Available for refractory/SS plate thickness combinations of 400mm, 500mm and 700mm
- Individual furnace or multiple furnace applications
- Air cooled
Cooling Requirements

- Cooling requirements
  - How can we get away with air cooling only?
  - Essentially the bigger the cross section area of the copper (we have a solid copper bar), the smaller the power!

Power = \(I^2 R\)

Where \(R = r \times \frac{l}{s}\)

Where:
- \(r\) = resistance
- \(l\) = length
- \(s\) = area of inductor
Inductor Construction

- Impact of solid Cu over Cu tube
- Resistivity effect....
- $I^2 R$ effect on heating... and therefore cooling requirement

Also nothing to go wrong with solid bar, compared to wear, holes, build up in tubes.
Inductor Manufacture

- 100% manufactured in house by ALTEK
- Ensures control of quality
- Ensures reliability in operation

Also nothing to go wrong with solid bar, compared to wear, holes, build up in tubes.
The consequence - Lower Energy Cost

Comparison between ALTEK Air Cooled induction Stirring and conventional 'type'
Water Cooled Induction Stirring for electrical operating costs based on 60 Tonne
dome type furnace installation - ONE Stirrer only

- ALTEK Air Cooled
- Alternative Water Cooled
APPLICATIONS
Simple Bottom Mounted Installation
Simple Bottom mounted

Extrusion Melting Furnace
TOP CHARGE FURNACE

- Recycling Furnaces
Bottom Mounted – Top Charge Furnaces

- Bottom Mounted Type 700
- Can work through 700+ mm of refractory/SS plate and insulation
  – Ideal for dome type ‘top charge’ furnaces

Picture is HULAMIN in South Africa

Others references are:-
- Kaiser Trentwood
- Bridgenorth Aluminium (UK) (ELVAL)
Bottom Mounted – Top Charge Furnaces

Large US Dome Furnace – 750mm Hearth
Multiple Furnace Operations
Multiple Furnace Operation

- Fully automatic - with scissor lift and electrically driven trolley for multi furnace operation
Operational Benefits at CONSTELLIUM Neuf Brisach Plant, France
Operational Benefits

• Production Increase
• Energy Reduction
• Temperature Homogeneity
• Alloying Efficiency
• Dross Reduction
Side Mounted Stirrer - Installation

- Side Mounted at Neuf Brisach
- 400mm thick refractory wall
Side Mounted Stirrer - Installation

- Side mounted type fitted to a 70T ‘dry hearth’ stationary melting furnace
Melt Rate – Performance results

Melting Rate (T solid charge)

20% Increase in melt rate
Energy Reduction – Performance results

15% Energy Reduction in energy consumption (gas)
Temperature Homogeneity

Temperature homogenization effect of the EM stirrer
(0.5Hz - P(90%) - FDx- 3xxx - burners on)

EM stirrer fully power

Delta of 5°C after 4.5 minutes of stirring

Temperature vs seconds graph showing the temperature changes at the bottom and top of the melt.
Alloying Efficiency

Dissolution speed of Mn with and without electromagnetic stirring

Samples taken North door

Addition AM80 South door

With electromagnetic stirring
Without electromagnetic stirring, manual stirring only

22246 = Addition AM80 120 kg
22248 = Addition AM80 220 kg

= Manual stirring
# Dross Reduction

<table>
<thead>
<tr>
<th>EM Stirring</th>
<th>Melter Dross</th>
<th>Holder Dross</th>
<th>Melter + Holder total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Avg. ratio (%)</td>
<td>Avg. ratio (%)</td>
<td>Avg. ratio (%)</td>
</tr>
<tr>
<td>No</td>
<td>6.2</td>
<td>1.5</td>
<td>7.8</td>
</tr>
<tr>
<td>Yes</td>
<td>3.4</td>
<td>2.0</td>
<td>5.4</td>
</tr>
</tbody>
</table>

Dross Reduction of > 25%
Furnace Cycle Energy Usage

Stirrer setting and power consumption

Time (secs)

kWh

0  5  10  15  20  25  30

30 60 90 120 150 180 210 240 270 300

0% 20% 40% 60% 80% 100% 120%

kWh

Stirrer Setting
Summary

The operating results over a 3-year period have demonstrated the following benefits:-

• Specific energy consumption reduction (-10 to 15%)
• Productivity increase (ca. +15 to 20%) through reduction of melting time and alloying time
• Dross generation reduction (ca. -10 to 20%)

• As a consequence CONSTELLLIUM have invested in further ALTEK Siber Force Stirrers