Challenges in Operation of Rodding Induction Furnaces in Ma'aden

Arvind Verma[1] and Ghanem Al-Osaimi[2]
1. Lead Engineer Carbon Technical
2. Manager Carbon Technical
Ma'aden Aluminium Company, Ras Al Khair, Saudi Arabia
Corresponding author: vermaa@Maaden.com.sa

Abstract

The Ma`aden Rodding Shop induction furnaces have had a consistent performance over the years despite increased production due to amperage increase. However, several challenges and interruptions were encountered during the initial years of production with frequent stoppages of rodding production on furnaces due to:

- Improper operational control on the materials,
- Metal temperature control,
- Relining practices and relevant tools optimization for relining and measurements,
- Absence of digitalization to capture the real time data without any alarm system,
- Sinter programs based on the available raw material and design gaps to control the sinter curve at initial cycles,
- Absence of furnace planning system to cover all related activities of the furnaces, including scheduled preventive maintenance (PM),
- Failure to keep correct liquid level inside the furnace without affecting production.

These problems were addressed one by one. The outcome of these changes was seen immediately. Increased furnace life was achieved, and there has been almost no production loss due to service life of the furnaces during the last 7 to 8 years. This paper will cover our experience over the years with rodding shop changes and industry benchmark control of the rodding process.

Keywords: Rodding shop, Induction furnace, Digitalization, Induction furnace lining life.

1. Introduction

Ma'aden Aluminium (MA) is a joint venture between the Saudi Arabian Mining Company (Ma'aden) and Alcoa. Almost ten years after its establishment, Ma'aden Aluminium is now a fully integrated aluminium processing complex worth 10.8 billion USD.

The Alumina product from the Ma'aden refinery unit is processed in our fully operational 720 smelting pots, which are operated at 410 kA after amperage creep-up. The smelter was designed for 720 pots with an original pot amperage of (370-390) kA with an annual production capacity of (740 000 – 780 000) t/year.

The primary Aluminium is produced using the Hall-Heroult process with the consumption of Carbon blocks called anodes. These anodes are part of Rodded anodes as electrical carrying conductor in the electrolysis process. Rodded anodes are the final product of Rodding shop along with Crushed bath and Crushed butts. The Rodding shop primarily consists of major material handling units to recycle the spent butts from Reduction after the electrolysis process and mostly struggle with reliability issues due to the nature of process.

Apart from material handling and recycling, the prime function of Rodding is sealing anode blocks with the processed stems by pouring the liquid Cast iron at around 1485 °C. For melting this Cast iron, 3-tonne Coreless Induction furnaces are generally used. Ma'aden Rodding has three units of Induction Furnaces to cater the daily requirement of around 55 tonnes of molten metal supply for sealing around 580 Rodded assembly as a final product for Reduction.

As a basic principle of Induction, an alternating electric current from an Induction power unit flow into a water-cooled copper coil (Figure 1). Electric current flowing in one direction in the induction coil creates an electromagnetic field that induces an electric current flow in opposite direction in the metal charge inside the furnace, producing heat that rapidly causes the metal to melt [1]. The copper coil is kept from melting by cooling water flowing through it. These furnaces operate at a nominal frequency of 250 Hz with output of 1500 kW.

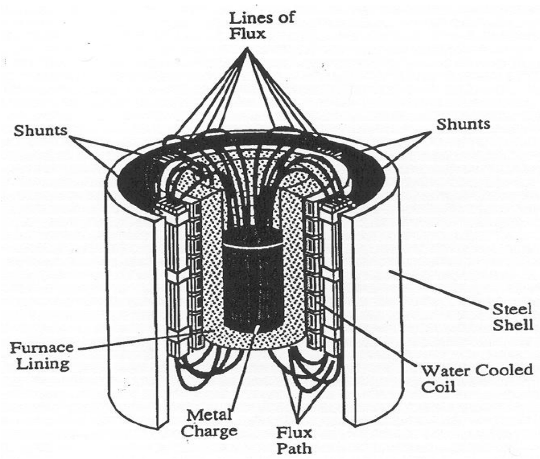

Figure 1. Typical induction furnace cross-section.

The focus of this paper is mainly on the Hot side (Induction furnace and Casting area) challenges and stabilization over the years of operations by implementing several modifications, industry best practices, digitalization, and data analysis methods.

2. Methodology

Hot side stability starts with stabilization of Induction furnace operating practices and stable life cycle to avoid safety risks associated with molten metal handling while ensuring longer lining life of the furnace for uninterrupted production.

The Ma'aden Rodding shop started-up in mid-2012 with the Hot side equipment at first with the fresh new stems for sealing. Initially, several challenges were faced on the hot side especially with the molten metal availability due to various Furnace issues. As per design, two furnaces should be in operation at a given time and one should be kept on standby for maintenance & refractory activities. However, often only one furnace was available, due to various reasons:

1. Frequent trips during sinter cycle
2. Metal pouring practices for casting
3. No control on the molten metal temperature
4. Sinter curve optimization
5. Quality of charge metal

2.1 Frequent Trips During Sinter Cycle

Sintering is the first step immediately after completion of relining activity and has a major impact on refractory life. It is very important to comply with the complete sinter cycle until completion of the cycle. During initial operations, observed sinter cycle got tripped almost every cycle either

3. Summary and Conclusions

Consistent operational performance was achieved from the hot side with stabilization of Induction furnace availability. The Ma`aden Rodding shop did not suffer any production loss due to Furnace service life since many years of Operation which achieved by gradual improvement over the years by implementation of all modifications (Figure 16). Sustained performance assures the safe practices with low hazards on the high-risk molten metal area.

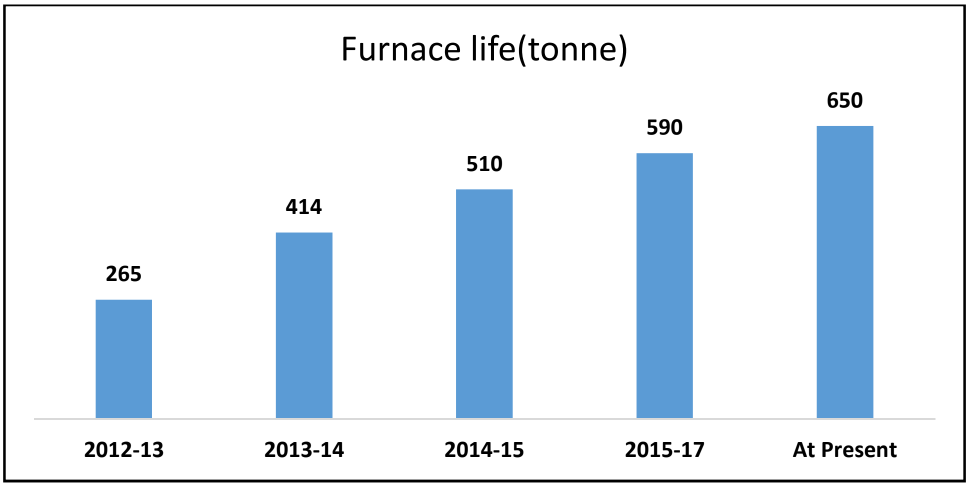

Figure 16. furnace life timeline, considering all different actions taken during the timeline.

Standardized work practices established based on trial results and Quality assurance drive emphasized the uninterrupted performance from Furnaces:

1. Ensured Furnace rotation plan including cast car ladles as part of weekly planning with all stakeholders and compliance on the agreed plan.
2. Daily monitoring of all critical furnace parameters captured and digitalized in system.
3. Periodic measurement and inspection of the furnace lining.
4. Stoppages of Furnace and ladle based on the agreed life cycle and measurement outcomes.
5. Furnace relining checklist for the relining services team and verification by Operation & Technical team
6. Furnace sinter process checklist with all mandatory instructions for the Furnace operators and verification by technical team.
7. Periodic water sampling and chemical dosing for all cooling tower and process water units. Regular blow-down based on the water analysis from the cooling towers.
8. Availability of run-out pits and emergency molds all the time as emergency back-up.
9. Alarm generation while exceeding the parameter specially the furnace temperature as warning and to shut off the power.
10. Compliance on standardized power requirement for all different process steps for better service life.

4. References

1. The Induction Foundry Safety Fundamentals Guide That Might Save Your Life, https://old.foundrygate.com/upload/artigos/7AYVjSZaiG3uklgLGr1EtPighkM6.pdf, (Accessed on 24 June 2023).
2. D. Molenaar and B.A. Sadler, Anode rodding basics, *Light Metals* 2014, 1263-1268