Energy Efficiency and Clean Energy Usage in Cast House Furnaces

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Abstract

Energy supplies have always been a premium commodity that greatly affect the operating viability of our plants, now more than ever our processes must reduce exposure to the ever-increasing costs associated with energy usage. This is a complicated scenario as we also have a need to use energy more cleanly to comply with the latest environmental legislation. The cast house is no exception to optimised efficiency demands, the big question is, how do we maintain high-performance cast houses while reducing the energy we use and can this be done while respecting a need to reduce the emissions from cast house equipment. In this paper Mechatherm will share its experiences in addressing these issues, including our recent experience in replacing a traditional natural gas combustion system with a hydrogen fuelled burner system. What are the challenges faced in implementing such projects? do the results meet the efficiency and environmental challenge?

Keywords: Energy efficiency, Emissions, Hydrogen Combustion, Cast house, Mechatherm.

1. Introduction

The production of aluminium requires the use of furnaces to convert aluminium into saleable formats. In every stage of this process, whether in refining and re-formatting into specific alloys, re-melting of solid aluminium or reclaiming and recycling scrap aluminium, the act of melting and treating aluminium is made in furnaces of several different types for the various applications associated with our diverse industry. Although these production processes are far less energy intensive than those associated with the extraction of aluminium from bauxite, reducing energy consumption in the cast house area is still a paramount concern; plants need to remain efficient and cost effective and, as an industry, we strive to optimise and prove our credentials as a green industry supporting the world's most recyclable metal.

Our industry faces big challenges ahead, the climate targets set by our governing bodies have become increasingly more ambitious as we try to mitigate against further contributions to climate emissions. The European aluminium industry is responsible for approximately 24 million tonnes of CO_2 equivalent emissions annually [1]. This accounts for about 2.3 % of the global aluminium industry's emissions [1], when considering the aluminium production process.

The industry is actively working towards decarbonisation, with a goal of achieving net-zero emissions by 2050. As an energy-intensive, though highly electrified, and hard-to-abate industry, it is easy to get focused on the reduction areas of plants and this is to a large degree justified; however, in the European arena where we increasingly move towards remelting and recycling, more efficient methods of achieving this must be considered and, given the large number of furnaces used in our industry, any optimisation of energy usage we can adopt will surely have a positive impact on the energy efficiency of our industry. Our challenge is to improve the performance of our cast house furnaces without also making them an energy drain or increasing the pollution contribution of these furnaces.

2. Current Status

Our industry has a core of conventional single chamber reverberatory furnaces that have been using the same basic design for several decades (Figure 1). There are more sophisticated furnaces for dealing with contaminated scrap, but these are not as numerous as the conventional furnaces on which we will focus here.

Figure 1. Typical single chamber furnace.

Unless cleaner forms of heating are available and suitable for the furnace application, such as access to cheap electricity for holding furnace applications, then the furnace will rely on some form of fossil fuel fired burner system for the heat input (Figure 2). A hard-wearing refractory lining is used to thermally insulate the furnace and prevent as much heat loss as possible.

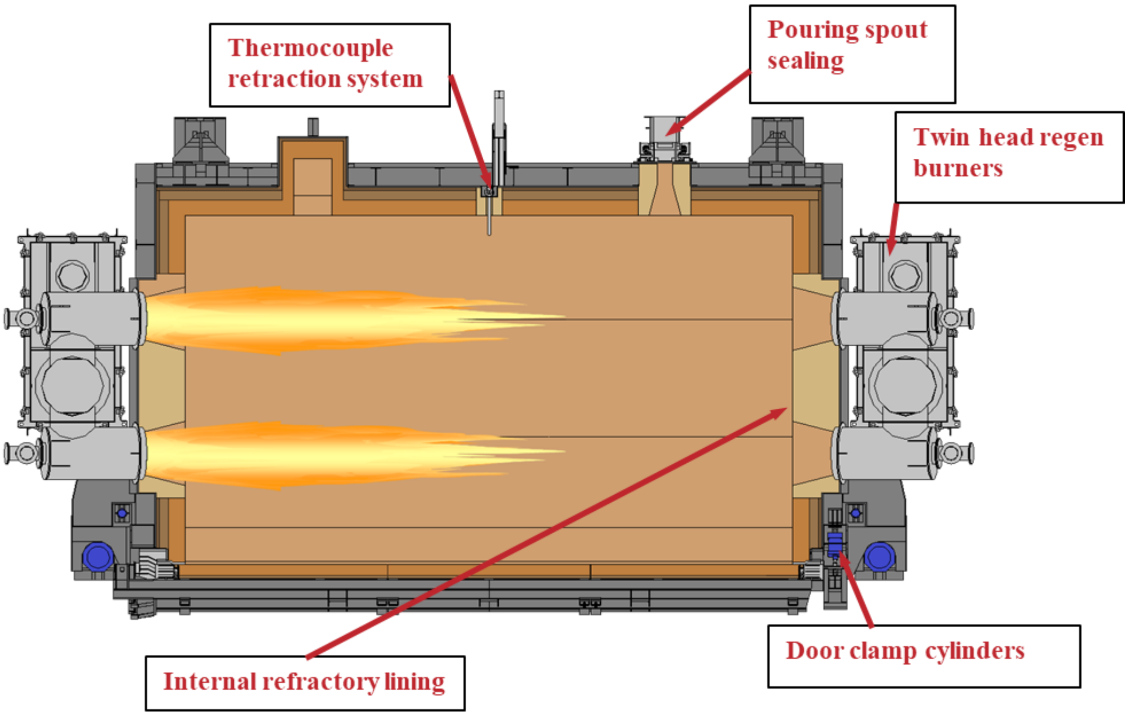

Figure 2. Plan view of a single chamber furnace, showing typical features.

Waste gases are released to atmosphere and with correct pressure control on the furnace we can ensure that cold air is not entrained into the furnace. Clamping and sealing of the main apertures on the furnace further reduce unwanted entrainment of external air. Occasionally, waste gases are adapted to run on hydrogen would be a conversion strategy, as the changes implemented require the system to operate in different parameters to that of a natural gas combustion system. An upgrade strategy could be the installation of a heat exchanger to recover heat for use with a cold air burner; general operation of the combustion system and the furnace remain effectively the same. Passive strategies are more likely implemented when a furnace is in the design stage where, for example, the refractory in the dry region of a chamber is profiled to encourage better fluid movement by the combustion products around the chamber and improve thermal energy transfer to the scrap or molten bath.

Integration of these strategies is not straightforward, tight project schedules do not often allow accommodation of development work to best optimise the process in question. Furthermore, resistance can be met when proposing the implementation of a technology which differs from the normal practices of the industry or the suggestion of changing operating procedures to make operational cost savings.

Hydrogen offers an appreciable means for furnace operators to reduce or offset their carbon fuel consumption and if a hydrogen combustion system is deemed necessary then it can be readily integrated into an existing system or new design. However, the distinct conclusion that can be drawn from hydrogen as an option is that it does not offer an avenue towards improving efficiency and reducing overall energy consumption. The combustion air fan may have a lower demand than that of natural gas, however; the thermal transfer is partially reduced as a result of the lower mass input into the furnace.

Some of the technologies discussed are still very much in the initial stages, the use of plasma torches to replace conventional burner systems show positive avenues for de-carbonisation while offering high level heating efficiencies and we wait for further feedback on the actual application of this technology in the field. Autonomous furnace operations can offer another way to optimise furnace operating efficiencies and creating a safe operation by removing operators from the danger zones, the equipment exists to enable us to create this but is still not yet widely accepted in our industry.

All other strategies and technologies presented in the paper are equally applicable to each furnace in our industry. What we can say is that the practicality of adopting them will be dependent on several factors and not all solutions will be applicable to each furnace or plant, depending on the technical and layout constraints within the plant, local infrastructures etc. However, what this paper shows is that there are many means to improve furnace efficiency, reduce consumption and ultimately reduce our impact on the environment, there is not a ‘one size fits all’ solution but as we mentioned at the start of this paper, small gains across multiple facets of a furnace design can offer tangible reductions for operating and environmental costs.

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