Operational Advances in Melting and Holding Furnaces with In-Furnace Cameras and Laser Level Systems

Mark Bumford[1] and David Roth[2]
1. Sales Director, RIA Cast House Engineering GmbH, Leipzig, Germany
2. President, GPS Global Solutions, Downingtown, PA., USA
Corresponding author: mark.bumford@ria-che.com

Abstract

Significant advances in process control are now possible using air-cooled In-Furnace Smart Cameras and Laser Bath Height Measurement systems. These high-temperature resistant cameras allow for real time observations of scrap pile heights and shape, melting cycle progress, burner flame shape and colour and refractory damage monitoring. They provide a safe and real-time process development benefit that was in the past impossible to even observe let alone monitor, without opening the furnace door. New Laser Bath Height sensor techniques allow for accurate measurement of liquid metal volume enabling more accurate alloying additions and key measurements for metal casting volumes, assuring accurate billet or slab length from every cast. This paper will discuss the independent operation of these new tools and their potential integration to further enhance automated and fully autonomous RiA Furnace Charging and Skimming Machines.

Keywords: In-furnace cameras, Laser bath height measurement system, Furnace charging, Furnace skimming, Cast house automation.

1. Introduction

RIA Cast House Engineering GmbH is a supplier of capital equipment to the aluminum cast house, in particular furnace charging machines and furnace skimming machines. In recognizing the market desire to pursue Industry 4.0 and more relevantly Cast House 4.0 goals, RiA has integrated “Smart Cameras” within its machines to enable autonomous operation.

The very first implementation of camera technology was in the year 2014, as the result of a customer request. RiA was rebuilding a cast house in Germany and the client requested that cameras be installed in their furnace. Following some research, RiA found suitable cameras that had been implemented in glass furnaces by a German supplier called Fioscope GmbH. Those same cameras from that very first installation are still in operation today. The video images are relayed to a monitor located in the control room, from where the operators can visually monitor the progress of the melt and make decisions about when and what actions to take next.

It was a logical next step to add image processing capability to those images and to make the same decisions that the operators were making. By monitoring the height of the scrap pile, image processing can determine that the highest point in the pile would be below the charging machine container as it enters the furnace. This in turn could shorten cycles or ensure that there is no risk of the container failing to extend into the furnace due to contact with the scrap pile, or worse still, extending, fouling and then jamming in the furnace, leading to delays in the cycle and possible damage to the equipment.

After implementation of this technology with a couple of RiA Machines, numerous requests were received to install the “Smart Camera” system in other existing furnaces that were not served by RiA Machines. This led to this camera technology becoming a spin-off as a separate stand-alone package known as Furnace Monitoring Systems.

2. RiA Corporate History

RiA was founded under the banner of Rackwitz Industrieanlagen GmbH in 1997, by the former technical director of an aluminum plant that today belongs to the Hydro Group of companies. With experience in both cast house and downstream activities, RiA initially engineered and supplied solutions to both areas. In 2018, RiA took the decision to focus solely on the cast house and in particular with our key strength of furnace charging and furnace skimming machines. The company was rebranded as RIA Cast House Engineering GmbH to reflect this change.

In 2019, to support a growing US install base, RIA Cast House Engineering LLC was established in Indiana to ensure local service and support, including local stockholding of all major spares.

At the beginning of 2021, we formalized our relationship with Fioscope GmbH and signed an agreement allowing RiA to develop the furnace monitoring applications and offer those solutions worldwide exclusively to the aluminium cast house sector.

To date, RiA has supplied more than sixty-five furnace charging and skimming machines. All are rail-mounted precision machines, capable of charging up to 30 tonnes in less than 90 seconds or skimming a furnace faster than a traditional forklift truck or wheeled furnace tending vehicle, but with more repeatable results and without damaging the refractory lining. Key customers include Hydro and former Sapa, Constellium, Kaiser, Alumet, Matalco, and Ellwood. Many clients have multiple machines in the same cast house or across multiple sites and territories. One client alone has implemented more than twenty machines from RiA in ten different countries. Customer satisfaction is key to the nature of the repeat business that RiA has seen over the years.

3. The First In-Furnace Cameras

In 2014, RiA secured a contract to rebuild a cast house in Germany, including melting and holding furnaces, charging and skimming machines, an electromagnetic stirrer and a client-specific request to install cameras inside the melting furnace. The images from the cameras, mounted within the refractory lining of the furnace walls, were to be relayed to monitors inside a control room, located a safe distance away from the furnaces. The operators were expected to occasionally observe the monitors and make decisions about the progress of the cycle.

After some research, RiA selected Fioscope GmbH as the supplier of the cameras. Fioscope already had experience of installing the same camera hardware inside furnaces in the glass industry at higher application temperatures than those seen in the aluminium industry.

The project was a great success for all parties. The operators were able to observe the monitors at will, without the need to approach the furnace and open the door. All parties recognized that not only this offered the operators a new level of safety, but it also saved energy and shortened cycles by retaining heat in the furnace. Rather than relying on calculations of melt rates and weights of material loaded into the furnace or monitoring roof temperatures and gas consumption to determine when the melt was ready for the next step, the operators could simply glance at the video image on the monitor. Even the old method of prediction would have resulted in eventually having to open the door to verify. If they were too early, the door would be closed and the burners fired up to recover the roof temperature and complete the cycle, with time lost and more gas consumed. If the observation showed the melt was ready, the question still remained, how long ago it was ready. Every minute lost in the cycle is lost forever and can never be recovered. In addition, there is a potential risk of charging the next load into liquid aluminium, rather than onto a semi-solid or mushy layer of scrap. With the video images on the monitors, the operators were able to make the decisions of when to react, without opening the doors erroneously.

7. The Birth of Furnace Monitoring Systems

Having supplied a number of RiA machines with "Smart Cameras", more and more requests were received for cameras inside furnaces that were not served by RiA Machines. Additionally, new requests were arising for new features and capabilities that were unrelated to charging and skimming. The ability to monitor the burner flame, shape, colour, and length for example, to help with burner tuning or to alert to maintenance issues. Even the ability to monitor refractory damage, propagation of cracks or consistent bright spots, getting brighter or larger is possible. All of these and more are possible by passing known data through the Fioscope "Neural Network" that self learns what is correct and can then alert when something is anomalous, such as the very early example of bubbling liquid prior to the explosion, captured back in 2014.

Earlier this year, RiA packaged the Furnace Monitoring System into a stand-alone offering. It consists of typically two in-furnace cameras to monitor the melt status and one cast house camera mounted externally, with a view of the front of the furnace. A data collection, storage, and display centre is located in a control room. The package is complemented with the laser bath height measurement. The data collection centre is linked to the furnace controller as well as storing to the time-synchronized video images on a FIFO, receiving and storing data such as roof temperature and gas consumption. Full data video playback is available for a minimum of one hour from all cameras to cover unexpected events; and select frames are stored for time-lapse playback of longer-term trends such as refractory wear and damage. All data is time-stamped.

8. Conclusions

Smart Cameras systems can reduce unnecessary door openings, shortening cycles and saving energy. These systems can increase safety and potentially avert accidents. Smart Cameras systems also allow the melt cycle to be optimised, ensuring charging can take place at the first opportunity.

Laser Bath Height Measurement can reduce short-length batch rejects. These systems can accurately determine the volume of liquid heel leading to more first time "on specification" cycles. Furnace Monitoring Systems allow playback, trouble shooting and diagnostics. Cast House 4.0 is one step closer through the us Smart Cameras.

9. References

1. David Roth, Fully Automated Furnace Skimming and In-Furnace Dross Processing Increasing Production and Saving Cost, ICSOBA Virtual Conference Nov. 2020
2. Michael Rockstroh, Innovation in Charging and Skimming, International ALUMINUM Journal 2019, 7-8,
3. RIA Cast House Engineering, GmbH, Walter-Koehn-Str. 6A, 04356 Leipzig-Germany https://www.ria-che.com
4. Michael Rockstroh and David Roth, Verfahren und Einrichtung zum Entschlacken metallurgischer Schmelzen, Deutsche Patentanmeldung Nr. 10 2019 106 014.1.