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Aluminium: now more sustainable than ever.

Introduction

A global pandemic and global warming combined have put productivity and sustainability front and centre of business priorities. The Industrial Internet of Things (IIoT) is changing the face of industrial process efficiency and providing exciting opportunities for improvements that can directly impact carbon footprint and the bottom line.

Aluminium is a critical asset to many industries, not least due to the way its sustainable and lightweight properties can reduce environmental impact. It is also 100 per cent recyclable.

In recent years, aluminium recycling has become an important tool for producers keen to continue using the versatile raw material while cutting down the environmental impact of their activities.

The aluminium recycling process uses 95 per cent less energy than producing primary aluminium. This makes 'secondary aluminium' desirable to manufacturers looking to improve their sustainability credentials.

However, as things stand, the aluminium recycling sector is heavily reliant on an operator's skills and experience to predict when the aluminium has reached tapping temperature. This, combined with the significant variability that is inherent in the remelting process, can often lead to suboptimal performance and inconsistent results. This means longer cycle times, reduced energy efficiency and increased aluminium losses.

In 2020, world-leading industrial gas company, Air Products joined forces with Tandom Metallurgical Group, producer of aluminium alloys, master alloys and recycle aluminium products, scrap and dross, to explore how the introduction of smart technology – such as equipment sensors and associated analytics – could generate data, which could be used to boost efficiency and productivity, improve yield and reduce carbon emissions.

Together, they embarked on a ten-month study, designed to benefit the whole sector. Air Products utilised its Air Products Process Intelligence (APPI) Process Advisor system to capture and use equipment, process, and operational data to create a digital twin of Tandom's remelting process.

The digital twin model of the equipment or melting process uses data to determine the efficiency of the melting process, calculating exactly when the metal inside has reached optimal yield conditions. Real-time closed or open-loop feedback is provided to operators, either automatically shutting down the burner or alerting them that the metal has reached the required temperature for tapping. As new data continues to feed into the model, machine learning technology also improves its predictions over time.

The study, which is now complete, has provided a blueprint for future working across the sector, proving that data collection technology can transform the aluminium recycling process – making it more efficient, time saving and more environmentally friendly.

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Innovation

The use of Industry 4.0 technology is a brand-new innovation in the aluminium recycling process, bringing an exciting new way of working into the sector and utilising the latest advanced technology to drive efficiencies and reduce the environmental impact of the work. By taking advantage of Industry 4.0 technology, the APPI Process Advisor system provided new data insights to Tandom personnel at all levels. This meant operators and management were allowed to have remote access to real time and historical data, which brought a greater understanding of performance and reduced downtime by allowing maintenance issues to be identified more quickly.

The team at Air Products designed the system to capture all operational data that was traditionally recorded on paper, which reduced errors in data collection and provided Tandom with their operational data in real time. Storing the records digitally also meant that the Tandom team could quickly analyse furnace performance, leading to more accurate decisions affecting productivity.

Traditionally, this is a sector that has relied solely on human skills and experience of an operator to predict when the aluminium has reached tapping temperature. This often leads to inefficiencies and inaccuracies. The APPI Process Advisor system was developed to address these issues and provide more consistent and accurate results in aluminium remelting. The team at Air Products developed a digital twin model of the melting process that uses first principles of physics, combined with statistical data analysis from real time and historical data to calculate when the metal inside the furnace has reached tapping temperature. The digital twin model prediction removes the need for an experienced operator to decide when the furnace should be tapped, reducing human error. The results showed that metal tapping temperature was significantly lower and more consistent, which increased aluminium yield and productivity, as well as reducing fuel consumption and hence, carbon dioxide emissions.

The team at Air Products analysed the data from more than 2,400 melt cycles to understand the relationship between tapping temperature and performance. A clear relationship between tapping temperature and aluminium oxidation was identified, showing an exponential increase in aluminium oxidation with an increase in temperature above the aluminium melting point (660oC). This was in line with academic lab studies published in the literature and was the first study of its kind to be carried out on a production furnace and confirm that this relationship can be seen. The insight can now be used in conjunction with the APPI Process Advisor system to reduce tapping temperature and hence improve aluminium yield. Furthermore, preventing the metal from overheating also saves energy and time, as the majority of the melt cycles were overestimated by the operators without the aid of the model.

Collaboration

This project is an example of how collaboration between industry and specialist third parties is critical – and can create significant results. The partnership didn't just theorise about identifying an innovative approach to achieving greater productivity, efficiency and sustainability. The collaboration was a crucial element in sharing expert insight, user experience and commercial goals, to make sure the technology was fit for purpose. Thanks to the willingness of both organisations to collaborate and share data, there is now a model in place for the wider sector to follow.

Each organisation had an important role in the partnership:

- Tandom Metallurgical Group is a major aluminium recycling business that is committed to continuous improvement. Its experience in the sector allowed it to identify the problem or challenge – namely inefficiencies in the overall melt cycle that were directly affecting productivity, energy consumption and yield, but it needed Air Products' digital expertise in collecting and analysing sufficient levels of data to create a baseline, and its support in using Industry 4.0 technology to apply aw solution.
- Air Products is a partner to a range of sectors and industries. Its experience and in-house expertise allowed it to develop a digital twin and, thanks to the partnership with Tandom, collect a substantial amount of base data. This then informed the application of its 'Process Intelligence System' which sees Industry 4.0 Technology added to the furnace.

Regular dialogue was key. The model was developed onsite at Tandom's factory, which makes this work different to Air Products' other development projects, which are mostly undertaken within a laboratory setting or at an Air Products' site. Therefore, the Air Products' team visited the site weekly to work alongside the operators, operators' supervisors and maintenance manager to make sure they understood what the project's objectives were. It also meant that Air Products' engineers could monitor how the technology was being used, if it was working well and make any adjustments as necessary whilst listening to feedback.

One of the key challenges was to build the operators' confidence. It was vital to listen to their feedback, as it would help the team to make any changes and in turn, build trust in the technology. The model's tapping temperature was initially set much higher to guarantee the aluminium was ready for tapping; if it was too cool, the metal would freeze as it moved along the 30-40 metre launder, causing product loss and a significant clean up. Once confidence was built, the temperature was reduced to 720°C.

Therefore, communication also played an important role in making the partnership a success. It was beneficial to have different opinions from both teams, so every detail could be reviewed and challenged to make sure the right decisions were being made. Without good communication, the technology – and partnership – wouldn't have worked and the operators may not have had the confidence to use the model.

Impact

The collaborative ten-month study conducted by Air Products and Tandom has generated some incredibly exciting results.

Data was analysed to determine aluminium oxidation losses over a large number of cycles, and regression analysis showed an exponential relationship between yield loss and metal tapping temperature.

Baseline data was then compared with data from cycles that were completed using the digital twin, which found that an accurate model of end-of-melt prediction, and timely burner shutdown control, provided secondary aluminium producers with significant benefits in production and yield, as well as energy savings:

- More than 1,400 cycles were analysed and compared with base data from over 1,000 cycles, and the overall average tapping temperature was successfully reduced by 44°C – where some materials improved more than others. The average temperature reduction corresponds to a yield improvement of 0.5 percent.
- The importance of tapping temperature on aluminium loss was also revealed. Tapping liquid aluminium at 900°C (1,652°F) as opposed to 750°C (1,382°F) for a charge material with 80 per cent aluminium content, will lead to an additional yield loss of about 3 per cent.
- Reducing the metal tapping temperature also led to an average of 15 per cent reduction in energy consumption. Energy usage goes hand-in-hand with carbon dioxide emissions and 15 per cent energy savings is equal to the same percentage reduction in CO2 emissions.
- Furthermore, an average time saving of 5.7 per cent was also achieved, due to using the digital twin.

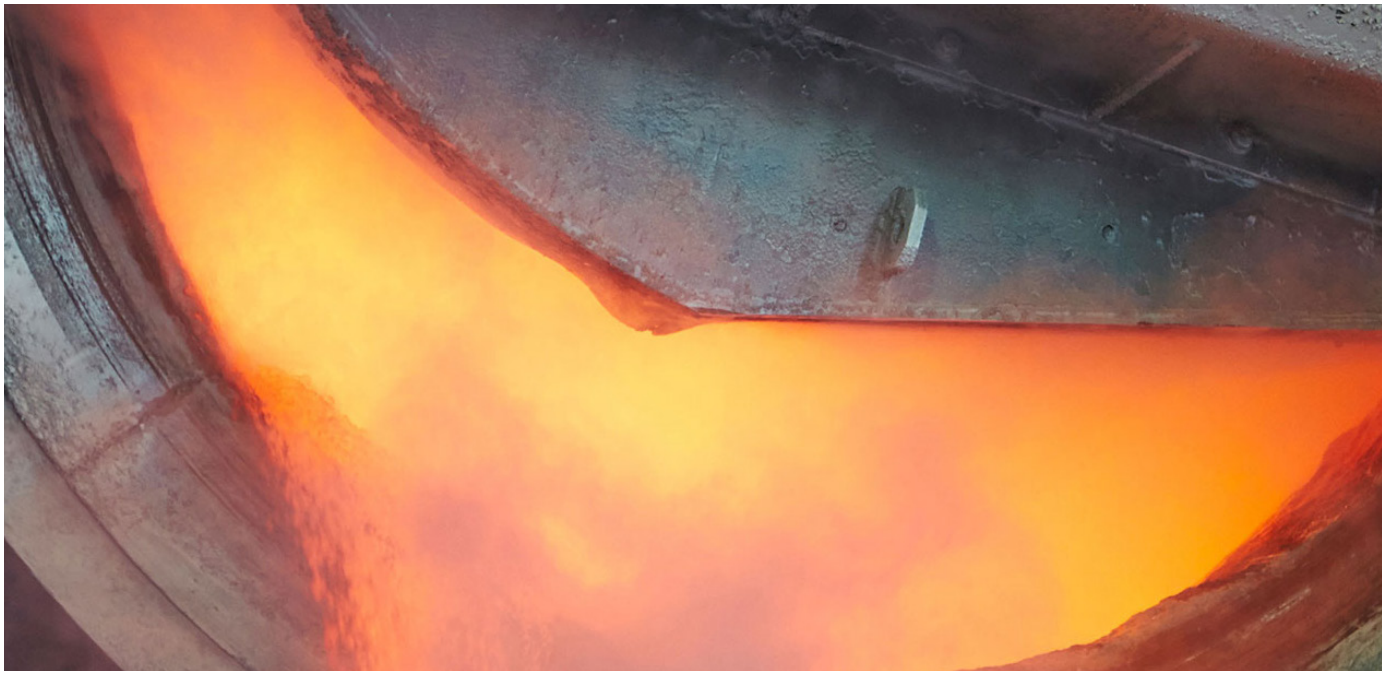
The findings have already directly impacted the efficiency and sustainability of Tandom's own operations. Mike Dines, Director, Tandom Metallurgical Group, said: "As a major recycling business we are always looking to add more value to our supply chain and sustainability is an essential part of that. We wanted to find a solution that would enable us to achieve greater efficiencies, while also making sure that we could achieve as high a yield as possible. Working closely with Air Products, we helped the team to collect a substantial amount of base data, before the 4.0 technology was added to the furnace, so they could see how the impact of using the equipment. We were really pleased with the result, as it not only improved our yield, but also reduced our energy usage too - reducing carbon emissions by 15 per cent and achieving the same amount in energy savings."

Thanks to the collaborative nature of the study, there is also now a practical, workable blueprint in place that Air Products is employing to benefit the wider aluminium recycling sector, as well as using it as a model to improve the efficiency and carbon footprint of other major industries, such as the food sector. Critically, the digital twin will continue to improve as more data is collected, ensuring a cycle of continuous improvement.

Summary

Aluminium matters. Not only does it supply some of the UK's leading manufacturing sectors, it is also 100% recyclable, making it a critically sustainable option when environmental impact is critical. But inefficiencies in the aluminium recycling process meant there was scope to further improve sustainability, and with it the efficiency and productivity of the sector.

Thanks to Air Products' and Tandom's collaborative use of smart data and Industry 4.0 technology, human error has been removed from the process, enhancing environmental and economic sustainability. This a first for this industry and is set to transform traditional ways of working.



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