Digital transformation of aluminum smelters

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Economic volatility, environmental concerns, and increased regulations are critical challenges faced by global aluminum producers. Improvement in aluminum smelters demands efficient and intelligent use of information available within the smelter. Customer satisfaction, quality and cost are key. Improvement in these key elements ensures protection against market pressures and allows high quality products to be produced. By introducing digital technologies in smelters, a digital manufacturing roadmap will deliver a significant leap in productivity, provide deep insights into the production process and unleash new revenue sources. Aluminum prices have flourished in all the metal exchanges globally over the last few months, providing an excellent opportunity to transform traditional smelting operations into digitally enabled operations.

IOT and igital use cases across aluminum smelters

- **Artificial neural networks and machine learning**
  Aluminum reduction cells often encounter substandard performance that can result in a dramatic increase in energy consumption, and increase the emissions of fluorocarbon gases. Artificial neural network and machine learning can facilitate in understanding and identifying the noise patterns like metal pad roll, and short circuiting sound, which in turn proactively notify operators to take appropriate action.

  Another significant use is estimating the alumina concentration and excess Alf3 % in the cells. The process comprises of performing variance analysis and applying analytics, which in turn helps in estimating parameters precisely and in detailed diagnosis (neural network has two steps for this use case—variance analysis and analytics. First, variance analysis is performed and then analytics is used to determine and predict the possible outcomes).

  A mathematical model of the process is used to model a system based on the relationship between input and output. The difference between the actual parameters and that of the modelled parameters are calculated and named as residuals. These residuals are further evaluated to estimate the optimum process parameters.

  Now, prescriptive analytics is applied by using optimization and simulation algorithms to estimate the precise process parameters. It can be used to quantify the effect on reduction cells by varying the alumina concentration and excess Alf3 %. It can assist in recommending the possible outcomes before the decisions are actually made. It not only predicts what will happen to the cell temperature, but also provides insights on why it will happen and prescribes for optimum cell temperature and excess Alf3 %.

- **Image analysis of cover alumina, and anode assemblies**

  Alumina and crushed bath are mixed together and supplied to pot-tending-machines (PTM) or to alumina or crushed bath hoppers. This composition plays a significant role in maintaining a good crust integrity, ensuring good productivity and low gas emissions. Higher gas emissions can lead to improper heat balance in the pot resulting in abnormalities. Image analysis can be used to identify the proper composition and detect uneven mixing that may cause quality issues. It can also facilitate in keeping stringent control over the heat balance in the pots, which will eventually drive the increase in current efficiency and high quality molten metal.

  The anode assembly is often inspected manually. The use of digital image analysis can save costs in the manual process and provide benefits such as identifying defective anodes, and determining whether the reduction cells and anode production

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parameters require adjustment based on the anode characteristics data.

- **Automatic thermal inspection of aluminum reduction cells**

  Globally, cell temperature measurements are performed manually in the smelters. Smelters experience cell leakages frequently, which is the most critical scenario in smelters and restarting a pot after leakage is extremely expensive. Use of thermal/laser guns will replace manual thermal inspection and assist in proactively identifying pots prone to leakages.

- **Automation and robotics**

  Traditionally, many critical operations in aluminum smelters are operated manually. These operations can be automated using robotics and automating the process. Some areas where digitization can be applied are:

  (i) Automatic pouring of hot molten metal in the furnaces in the cast house can improve process control for higher quality casting and lower energy consumption through better control over temperature and pouring speed.

  (ii) Remote controlled robots can perform critical process measurements in the reduction pots and furnaces, abolishing people being put in hazardous situations.

- **Connected customers and services**

  Digital tools have transformed the way a customer buys and shares their experiences in the aluminum industry. Digital channels like websites, blogs, and social platforms can be used for the buying process and to gather customer feedback. Analyzing customer feedback using digital tools enables understanding of customer expectations, assists in acquiring and retaining customers, and predicting and making suggestions for the customer's future needs—which will eventually improve customer delight.

Conclusion

60% of large aluminum producers will invest in digital technologies to improve and sustain customer delight, quality and cost. Use of digital techniques can assist in identifying anode effects proactively and identifying noise patterns in the pots so as to take proactive corrective actions. Digital image analysis can facilitate in identifying the proper anode crust composition that can be effective in maintaining proper heat balance. It will certainly be necessary for aluminum producers to reassess their production process and plan how to pave their way into future digital engagements in the manufacturing process, and leverage digital drivers for continuous business transformations.

About the author

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Vikas has over 14 years of industry experience with sectors like Mining & Metals, Utilities, Energy, and Port Operations. He has done his Bachelors in Computer Science & Engineering. Prior to joining at Wipro he had worked with Vedanta Ltd. & Balco.

In his role as an industry expert, he has led large turnkey projects in India for improving operational efficiencies, asset utilization, product quality, and cost reduction. He has contributed in connecting shop floor to top floor, enabling transparency across the organization. Currently, Vikas is responsible for clients under Natural Resources domain in current state assessment, solution development, creating sales enablement assets and responding to RFP's. He is responsible for identifying business pain areas that can be converted into opportunities for process improvement and business transformation using digital strategies enabling Wipro to achieve its goals.

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