Hot metal transport

Yannick Larrivé* looks at what to consider when implementing a Manufacturing Execution System (MES) to optimise the transport management of aluminium between reduction and casthouse, during the commissioning of a green field smelter.

In a previous article (September/October 2009 issue of Aluminium International Today), KEOPS Technologies explained how challenging the management of transport of hot metal can be – especially in large smelting facilities – because the production of hot metal is a continuous process that can be referred to as a “push” process, and the casting process is a batch process frequently driven by specific customer alloy requests.

The article also showed, that by deploying a Manufacturing Execution System (MES) that provides functionalities to schedule the smelting and casting operations and to align those schedules, the utilisation of an MES will lead to a major improvement in the effective and efficient management of the transport of hot metal in a smelter. Some mentioned benefits were:

• Reduced crucible movement in the potline resulting in an increase in the number of pots tapped
• Increased potline capacity use
• Increased number of crucibles delivered
• Reduced delivery time to the furnace
• Reduced heat loss and energy consumption
• Increased furnace capacity use
• Accurate match of quality in hot metal and alloy requirements.

This article discusses aspects that can impact the implementation of these MES functionalities in a smelter plant, especially a green field plant. Some of these aspects are related to systems integration and schedule execution and can lead to on-demand rescheduling.

Integrating schedule

Generally, the Casting Schedule is generated by an Advanced Planning and Scheduling (APS) system. To generate the schedule, the APS requires data that is often available in the MES such as Production Requests generated by the ERP from Customer Requests, Product Information, Production Rules, Equipment Definition, and Availability and Material Definition. The APS can also consider metal used for other sources such as re-melting, recycling or dross processing centres.

To integrate all these elements, interfaces need to be defined between the MES and ERP as well as between the APS and MES. Because in most implementations, MES has interfaces with both APS and ERP. Having an interface between APS and ERP is not advised. This reduces the number of communication channels and touch-points and therefore reduces the amount of troubleshooting and failures. Having a MES based on an ISA-95 Object Model helps develop an interface model that is well understood by all parties and implemented quickly.

In a majority of plants, the potline control system or MES is often provided by the potline technology supplier and often owns information about hot metal availability and quality. Therefore an interface is developed to exchange this information with the casthouse MES, ensuring that the hot metal tapping/delivery schedule can be generated. This information is usually made available when the metal height in the pots is measured. If the hot metal availability and quality information is then processed by an advanced algorithm that groups the pots together for the tapping operation. That advanced algorithm often uses linear programming to achieve optimal tapping operations.

From the pot grouping information and the casting schedule, the hot metal delivery schedule is generated and pushed to the potline control system or MES by synchronising the Tapping Operations and the Casting Schedule. An important factor to consider when publishing the hot metal delivery schedule is that the potline and the casthouse may not be operating on the same shift schedule, which can have an impact on how and when the hot metal delivery schedule is published.

Equipment availability

During the commissioning phase, the availability of equipment that is used in the tapping and transport of hot metal, such as overhead cranes and transport vehicles, can vary greatly. It is not uncommon to see stoppages or other events that make the equipment unavailable.

This affects the timely delivery of hot metal to the casthouse. This means that the planned tapping of hot metal can be performed later or earlier or even that the hot metal be substituted by tapping pots other than the one planned to be tapped. Depending on the implementation of the potline control system or MES and equipment available, this information may or may not be updated and sent to the casthouse MES.

Similar issues can arise for Treatment Stations and Holding Furnaces as hot metal is delivered to the casthouse. In most cases, the hot metal is considered delivered to the casthouse when it arrives at a Treatment Station. At this point, the Treatment Station expects Treatment Recipe Parameters, which are normally determined by the hot metal planned furnace destination. However, the planned furnace of a hot metal delivery might not be available to receive the hot metal because it is not early or late on the casting schedule, or the furnace is started against furnace scheduled operations different than originally planned.

For it is mostly the bottleneck of operations, the availability of Casting Centres has a considerable impact on the adherence to the schedule. If a Casting Centre is not available because of an unplanned downtime, this can lead to an overflow of hot metal coming to the upstream furnaces.

Information availability

Because the transport of hot metal implies that some personnel and equipment are mobile, providing them with the right information at the right moment is crucial. Having the information as soon as it is available can help streamline the hot metal delivery and improve decision making. Network coverage and devices available to the personnel can vary from few locations with fixed MES stations with wired network to mobile MES stations with WiFi network.

To reduce those issues, On-demand Re-Assignment (either manually or automatically) must be performed so that the schedules are resynchronised based on the actual operation status.

On-demand re-assignment

Upon reception of hot metal, an inspection is performed on the planned furnace
destination. If the destination is not available a new destination must be selected. Because the treatment station is expecting operation parameters, this decision must be taken quickly. To allow this, a cascade update of trip destinations is performed. It takes into account Estimated Delivery Times, started Holding Furnaces, and aligns late not-started planned Furnaces with the current time. This improves the short-term hot metal Delivery Schedule. This operation can be performed automatically by the system but there might be situations where a manual intervention is required. Typically, this would mean having no started furnace that can receive that specific quality of hot metal. This information might be sent back to the potline MES or control system based on its requirements or functionalities.

Having the casting schedule updated to reflect the current status also helps archive a better schedule of hot metal delivery. Implementing a process that pushes the Casting Schedule back in time based on current status but without re-sequencing the scheduled casts will improve the quality of the mid-term Trip Delivery Schedule.

Lastly, using a solver to optimise Trip Delivery Schedule by taking into account constraints such as chemistry, Furnace Charge target weights, crucible turnaround times and by minimising lateness in the casting schedule will enable the system to automatically mix different grades in furnaces (bad quality, hot metal dilution).

A typical cost function to minimise could be as follows:

\[
\text{Minimize Cost} = \sum \text{cost of deviation of hot metal chemistry vs. target Furnace Hot Metal Grade} + \sum \text{Furnace Completion Costs} + \sum \text{crucibles waiting time costs} + \sum \text{Delay on Casting costs}.
\]

This will improve the long-term hot metal delivery schedule.

**Benefits**

The implementation of a MES in the casthouse area that provides advanced scheduling functionalities, supported by strong execution and monitoring capabilities, and advanced analysis tools, brings significant improvements to casthouse operations with respect to the management of the crucibles transporting hot metal.

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