SPEED-UP OPERATIONS

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MELTING CYCLE

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to keep furnace operators safe.

TECHNOLOGICAL PACKAGES SUITE TO REMOVE HUMAN OPERATION AROUND THE EAF

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The steel melting process in an Electric Arc Furnace is a complex set of tasks, coping with highly dangerous hazards as fire, explosions, uncontrolled reactions, hot metal projections and gas or dust emissions. Melts shops are dangerous working areas for operators, recording statistics with a high frequency of injuries. In the past years, without dedicated safety equipment, there wasn’t a real attitude to the risk prevention. Regardless all the best personal protective equipment, training and careful operating practices adopted, the exposure to risk is very serious, and statistics report that severe injuries and fatalities are still happening. Among them, a few are connected with operations in the melting cycle, mainly exposing operators to heating injuries, oxygen back flashes or blasts.

Technological packages suite to remove human operation around the EAF

Zero men around technological packages eliminate the manned activities on the melting floor, with the aim to prevent accidents and keep furnace operators safe. The suite extends the automatic control of the EAF melting process to all the operations from charging phase to tapping. Plus, the integration of the most frequent operations by automated specialized tools effectively minimizes power-off times, enhancing reliability and improving the transformation costs. The modern melts shops produce more in shorter tap-to-tap times. Operations involved in the melting process require some tasks that, in most cases, are still performed manually. Steel sampling, sill clearing, tap hole cleaning and EBT operations are recurrent operations that require skilled personnel and coordination to be fulfilled.

SPEED-UP OPERATIONS AND ENSURING SAFETY

It is universally recognized that just speeding up operations without reengineering the operational procedures expose the personnel to increasing risks of operational mistakes causing injuries. At the same time, safety operating procedures and space confinement are often posing limitations and interferences with the process, slowing it down. In real life, safety prescriptions are very often unwelcoming by the personnel, considered as useless complications more than contributions towards better working conditions. Management in the past frequently considered safety as a non-productive matter, generating expenses without direct benefits on throughput. This vision is outdated today: safety in operations and selection of technological equipment is a top priority. Injuries and workplace accidents are generating both direct and indirect costs: production loss, machinery damage, loss of working hours, compensation to injured workers, possible fines, plant impairment. In addition, specific government laws, standards and federal directives are posing explicit obligations to the steelmakers, equipment suppliers and machinery end users. The win-win approach to combine safety and productivity is offered by technology. This process of continuous improvement has generated a complete suite of proven mature solutions enabling the personnel to fulfil all the required operations safely and reliably from the control room. Eliminating all the manpower exhausting recurring operations that were required in the past, immediate benefits in terms of productivity throughput are obtained. At the same time, part of the personnel, free from the previous demanding duties, can be dedicated to different activities.

Recruiring OPERATIONS AND RECURRING RISKS

Operators at the slag door area are prone to sudden reactions that are occurring rarely, but are highly unpredictable. In some meltshops the practice to switch the electrical power off prior to approach to the furnace floor is compulsory by the Company safety rules. In few countries, law already prescribes it. Switching the electrical power off is of course consuming time and interrupts melting but, above all, is suppressing the foaming slag process and takes time to rebuild again. In most meltshops the practice to allow the personnel to operate at the slag door with the power on is still a diffused habit. At the occurrence of a boil reaction or a sudden blast, any workers close to the furnace are exposed to severe injuries, regardless the safety equipment they are wearing. The tapping operations may be regarded as the most critical of the overall furnace cycle. In less than 3 minutes, more than 100 tons of liquid steel at a temperature higher than 1630 °C (2966 °F) are transferred through the ladle by a stream as fast as 5 m/s (16.4 ft/s). Normally, when the EBT swings away, the stream is free opening and the tapping operations can immediately start. Sometimes the stream is not opening spontaneously. In this case, the tap hole requires oxygen lancing to be cleared from any clogging. In such an unlikely event, a skilled operator is required to approach to the EBT area from the bottom with a bent pipe to lance the tap hole and clear it by oxygen from few meters distance. At the sump area, after tapping operations, the tap hole needs to be inspected, eventually cleared from slag residuals and filled in with sand. This operation requires to the helper to walk to the EBT balcony to perform the required actions. In case of incomplete melting, residuals and skulls may fall in the area, obstructing the tap hole sleeves. The efforts to remove the obstructions can be sometimes very difficult to fix and time consuming.

All these operations entail:
- unpredictable time losses,
- exhausting man labor in hazardous conditions,
- high risk of injuries,
- resulting in higher production costs.

The suite is mainly exposing operators to heating injuries, oxygen back flashes or blasts.
**DESIGN CONCEPT**

A skilled engineer, approaching for the first time to the EAF process, may guess why the required technologies to perform these functions have not been native since the origins of the modern electric arc furnace. At a deeper insight, he will realize that simply adding equipment to fulfill individual actions will not work in the meltshop environment. Neighborhoods of an electric arc furnace are a tough environment for any mechatronic application to survive. Dust, heat loads, flames, electromagnetic effects, falling loads, pose any equipment in great difficulty.

Moreover, the space for the equipment to fit is most of the time very restricted, limiting the degrees of freedom for the possible design solutions. The tasks described above, which would be easy for a skilled person to fulfill, are not easy to perform by machines. Therefore, the equipment functionality, i.e. the capacity to fulfill the required task in a practical, user-friendly manner, is guiding our design concept. Beyond the technological package functionality, in our experience reliability of the equipment is a mandatory keystone, a top priority.

Maintaining the slag door’s sill clear from scrap or skulls build up is very important for efficient steelmaking process. By performing all the operations during the arc melting is not only beneficial for the production throughput, but it is also improving the effectiveness of the cleaning action and the metallurgical process. MOTANK is a remote controlled ram, specifically designed to operate at the slag door. The cart moves independently on rails, that can be laying in axis with the door or eventually sideways to best fit in almost all the layouts, even in case of EAFs encapsulated in a doghouse. The ram is actuated by a hydraulic cylinder equipped on-board. The pulling force is designed to easily clear the scrap and skulls in all the situations. It can be also tilted downwards to better fulfil the clearing action.
A multiple axis manipulator to achieve flexibility and compactness, it can be fitted in constrained and confined areas, total control of movement and adapting trajectories, easy maintenance, tailored for the steelmaking harsh environment and multi-tasking operations.

The manipulator has a swinging movement around two axes of rotation in order to approach from the parking to the measuring position. The lance is water cooled, in order to guarantee a long life and a proper protection for the cabling and the measuring lance sensor. All the mechanical components are carefully shielded from heat and slag radiation by metallic protections. In order to perform a reliable measurement, the lance insertion movement is controlled in speed and position. In case of collision detection, the manipulator retracts the lance.

ACS AUTOMATIC CARTRIDGE SYSTEM

ACS equipment is designed to change automatically the probes for CATFIS and CATFIS 2.1 manipulators eliminating manual operations. It is a “stand alone” piece of equipment that can be installed on the fix platform on the same side of the manipulators, with up to three different cartridge types compartments.
EBT EYE
TAP HOLE INSPECTION CAMERA

Clear and high-resolution imaging in highly variable illuminated conditions. This integrated package adopt the highest standard of digital cameras, tailored with a proprietary vision firmware to enhance the dynamic response and resolution of the imaging in all the EAF operating conditions.

EBT SAND
TAP HOLE INSPECTION AND SAND FILLING

The on-board solution to inspect and sand fill is a compact all-in-one design equipment assembled on a sliding guide. A local small bin is delivered with the proper amount of sand by a small stationary dispenser, located close to the furnace to be charged by big-bags. The EBT EYE is mounted parallel to the feeding chute in order to check in real time the correct feeding of the material and tap hole status.

AUTO SAND
TAP HOLE INSPECTION AND SAND FILLING

Specifically developed for off-board installation in case of reduced space availability on sump area or frequent shell change practice.
Unmolten scrap, skulls or heavy residuals may obstruct the tap hole after tapping. Sometimes obstructions are drilled by the operators by oxy-cutting. Moreover, lancing is non-effective in case of slag skulls, concrete or graphite blocks. These tasks, although not very frequent, normally generate long delays, sometimes hours. Production loss and cost associated, plus hazard to damage the sump panels with injuries risk for the operator represent a very serious issue. The STROP is a hydraulically actuated equipment that inserts a sturdy rod into the tap hole that is able to lift heavy loads and free the tap hole from any kind of obstruction.

The STAP manipulator is a multi-axis equipment dedicated to open the tap hole in case of clogging by an oxygen lance. The STAP device is not used regularly at each cycle, but only when required. Nevertheless, it saves a lot of long delays that usually are accumulating in several meltpshops due to the time required for operators to get prepared at the occurrence of the non-spontaneous opening.
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