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The life of an embedded service robot

Cycle time in pot hood handling is a key acceptance factor for the new ECL embedded service robot (ESR), and is just one of a range of challenges this machine must face in a hostile environment where maximum accuracy and efficiency are demanded.

Note: *ECL has joined Fives as from July 2015. With the acquisition of ECL, Fives is extending its product range and strengthening its position as a world leader for key process equipment used in the different sectors of aluminium production, not least in the pursuit of a modern, automated, efficient and green smelter facility.*

Robotics

The automation of modern aluminium plants together with the introduction of robotics is not a current trend but potentially a future factor able to reduce OPEX, boost productivity growth and improve HSE performance. Many physical and rather dangerous tasks in pot-lines are still required to be carried out by a floor operator. The manual manipulation of pot hoods required for anode changing is a good example. The Embedded Service Robot (ESR) is an additional tool of the ECL Pot Tending Machine (PTM) designed and developed to assist the pot-room operators during this operation. The ESR is based on industrial robotics able to perform many different duties with limited impact on PTM cycle time.

The aims of primary aluminium producers are no different from those of any other industry facing the constant challenge of cost reduction whilst meeting all Health, Safety, Environment and Quality requirements. Over the last two to three decades, developments in automation have contributed significantly to these design requirements. Devices such as Programmable Logic Controllers (PLC) installed on overhead cranes have opened new possibilities which are only limited by employed hardware performance, and imagination.

Automatic pot tending machines

ECL first introduced PLC to the PTM 20 years ago as part of its innovation programme, and from this point it has never ceased in its endeavours to harness and maximise the use of the technology to combine movements, increase speeds, assist operator control, give precise indications for troubleshooting, and ultimately perform tasks automatically.

Along with the introduction to the market of the 'New Generation' PTM in 2005, an ambitious programme was launched with two targeted steps for automating its pot-room operations:

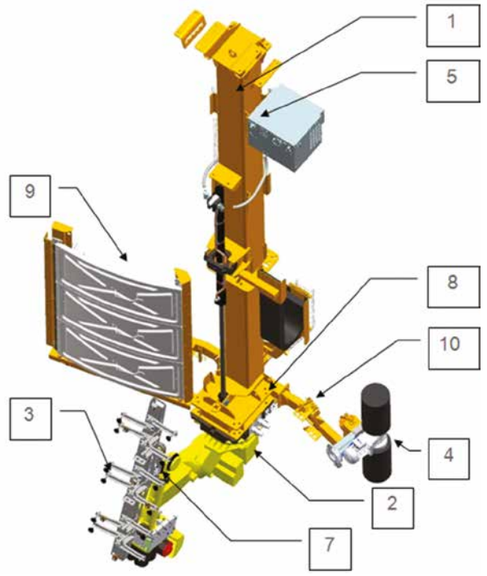
1. The single-man PTM: removal of the floor operator
2. The automatic PTM: removal of both operators.

Many technological building blocks were needed to realise this automation project, and they have been progressively developed, largely by in-house engineers.

Embedded service robots

The ESR is a modular system based on a 6-axis industrial robot (Fig. 1) adapted to the harsh environment of a modern smelter production line, i.e. intense magnetic fields, dust, corrosive environment, high temperatures. Its speed and load capacity have been carefully dimensioned to maximise its versatility. The robotic arm can be fitted with various specialised tools stored on board the system.

One of the main drawbacks of an on board pot hood handling device is its negative impact on cycle times. The speed of pot hood handling has been one of the top objectives of the development, which has led to innovative features: the 6-axis industrial robot is much faster than other mechanical solutions. The additional time needed for opening, brushing the small slabs, and closing the pot is no more than 1 minute and 40 seconds!

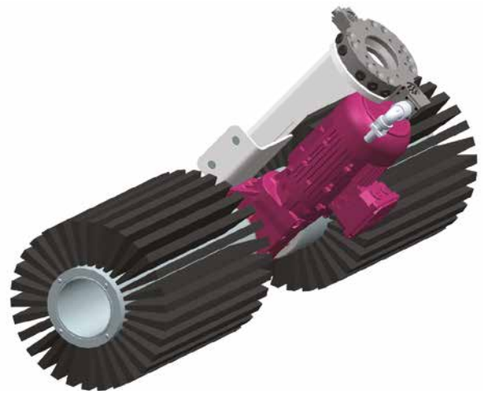


1. The modular embedded service robot is based on a 6-axis industrial robot.

2. The ESR must be able to precisely locate, handle and replace the pot hood under operational conditions.

Challenging operations

The primary aluminium smelter is a real-life environment, far from laboratory conditions. Not only must a pot hood be removed and replaced promptly, but there is no room for a wrong operation: the pot hood must be found by the ESR (Fig. 2) even if it is not precisely positioned and/or it is slightly damaged. Conversely, the pot hood must be replaced precisely in the free space of the pot. Robust algorithms were developed in order to reach high levels of accuracy and repeatability.



3. Rotating brush attachment to remove bath spillage.

4. The 6-axis robotic arm is a quick learner.

With such performance we are able to avoid virtually all manual operations, either directly on the pot-room floor or from the PTA operator cabin, as the sequences are fully automatic.

The potential for floor operator injury (particularly repetitive strain injury) generated by handling up to 3 tons of pot hoods per working shift is consigned to history. The automatic handling will provide for care of pot hoods in a manner far superior to that of human handling. This equates to extended lifetime for pot hoods and further savings for the smelter.

In terms of environment, the ESR has a great impact on reducing gas emissions through reduced and consistent pot opening time – one pot opened at a time – and optimal hood positioning. Less opening time than with manual operations and minimised air gap between hoods leads to less gas leakages escaping the Gas Treatment Centre.

Hood store advantages

One breakthrough innovation of the ESR is its capacity to store hoods in a dedicated embarked hood store (item 9 of Figure 1). It might sound like a costly idea to design an automatic storage system requiring more parts, sensors, locks and safety devices. On the contrary, it is a wise investment in terms of design, and it opens an infinite range of new possibilities. By storing hoods on-board, we release the robotic arm from the hoods removed from the pot. The arm then becomes free to perform other tasks, provided that specialised tools attached to the arm can be changed quickly.

Speedy brushing

Thanks to its 150 kg load capacity, operations which are beyond the physical capacity of even several operators can be envisaged. One of the first natural additional tools that have been developed for the ESR is a large rotating brush (Fig. 3) able to remove the bath spillage before closing the pot. The brush performs a complete sequence to clean the bath stays from the small slabs and working floor. Approximately 3 square metres become free of dust in less than 10 seconds!

There are numerous other tasks which can be performed by the ESR during the anode change: the pot is open and gives access to all the repetitive or random operations that are usually undertaken manually in the process. Even better, the speed and working load capacity of its arm introduces potential for additional tasks which have never been implemented due to technical restrictions. As an example, modern electrolysis technologies want to mitigate energy loss, and the ESR offers smart ways of saving the last millivolts before the connection of the new anode to the pot.

ESR implementation

The 6-axis arm (Fig. 4) will master its environment much faster than you can imagine, and will determine the optimum way of moving from point A to point B. The combined computing capacities of the on-board PLC and the robot create a powerful PTM where faster and more accurate operations than the ones performed by floor operators can be made automatically and in hidden time when needed.

In terms of maintenance, the ESR is only constituted of mature technologies which have proven to be very reliable in industrial environments, with low maintenance and high Mean Time Between Failures (MTBF). Components of world-class suppliers are adapted to the very stringent design requirements to create an affordable tool. Smelter maintenance teams need only a limited training session on basic robotics before becoming autonomous in troubleshooting and in repairing the ESR.

To conclude, the ESR is the ultimate tool to be engaged on to the PTM: automatic, versatile, fast and reliable. After decades of hydraulically, pneumatically and electrically driven movements, the time has come to make a significant advance in the performance offered by a robotic solution. Pot hood handling and pot cleaning today have reached the required industrial maturity. Many other applications will come true tomorrow. Aluminium smelting technologies are evolving, so has the equipment designed to serve them. The ESR is what you want it to be.

As a driver of sustainable industrial progress, Fives shares its customers' objectives to combine industrial performance with sustainable development. Within the aluminium business line of Fives, 3 to 3.5 million euro are invested annually in R&D, which has to date lead to a patent portfolio exceeding 40 international patent families.

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