Embedded service robot: towards an automated, efficient and green smelter

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Abstract

The automation and robotics of modern aluminum plants are no trend but a key success factor to reduce OPEX, to boost productivity growth and to improve health, safety, environment and quality (HSEQ) performances. If increased productivity is one of the biggest reasons in justifying the use of automation, the operator safety is undoubtedly the number one priority for automating an industrial operation. Many physical and rather dangerous tasks in pot-lines are still to be carried out by floor operator. The manual manipulation of hood for anode changing operations is a good example. The Embedded Service Robot (ESR) is an additional tool of the Pot Tending Machine (PTM) designed and developed to assist the operator in this operation and safeguard him against the hazards of the smelter environment. The ESR is based on industrial robotics and driven in automatic, semiautomatic or manual mode. It would be able to perform many different duties with limited impact on PTM cycle time.

Keywords: Robotics, pot tending machine, single-man PTM, Embedded Service Robot, ESR.

1. Introduction

The aims of primary aluminum producers are no different from the ones of any other industry facing constant challenge of cost reduction while meeting all Health, Safety, Environment and Quality (HSEQ) requirements. The challenges are far above average industrial standards for three main reasons:

- The selling price of the product (primary aluminum) is mainly driven by the Market Exchange (LME or SME) on which producers have limited leverage,
- The Hall-Heroult electrolysis process is, by its nature, a highly risky operation generating noxious emissions, high amperages and hot temperatures,

The process cannot be interrupted, except in catastrophic circumstances; it requires equipment which can operate with a high and maximum availability level.
In light of the above, equipment designers have to market solutions offering a short return on investment, guaranteed availability and a wide range of HSE features. Over the last two to three decades, developments in automation have contributed a lot on these aspects. Devices such as Programmable Logic Controllers (“PLCs”) embarked on overhead cranes have opened new possibilities which were only limited by sensors performances, microprocessors capacity and… imagination. Who could have conceived in the 60’s that a simple query on Google search engine would be equivalent to the computation power used throughout the entire Apollo special program which has lasted for 11 years and 17 missions?

2. The automatic PTM

Fives ECL has introduced more than 20 years ago PLCs on its Pot Tending Machines (PTM) as part of the innovation program. It has never ceased since then to maximize the use of its power to combine movements, increase speeds, help operator’s decision, give precise indications for troubleshooting, and ultimately perform tasks automatically.
Along with the introduction on the market of the so-called “New Generation” PTM (NG PTM) in 2005, an ambitious program for automatizing completely the pot operations was launched with two targeted steps:

1. The “single-man PTM” enabling the removal of the floor operator who is especially assisting for anode change,

2. The “automatic PTM” enabling the removal of both the floor operator and the PTM driver, with monitoring tools located in the potline control room.

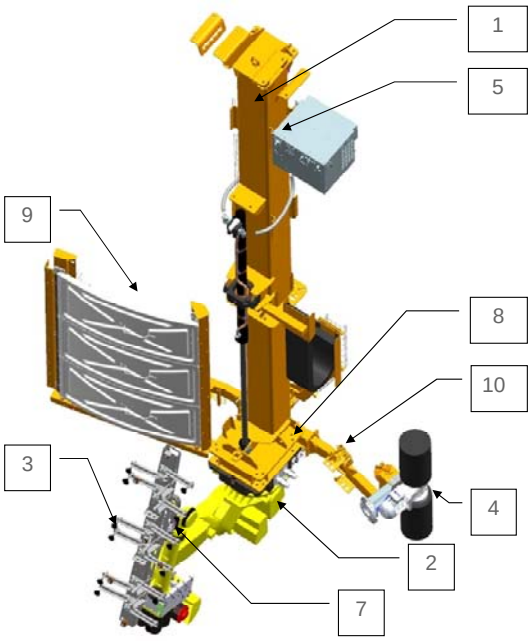
Many technological bricks were needed to achieve this automation project and have been progressively developed, mostly by Fives ECL in-house engineers. Efforts have particularly focused on the anode changing operation, which is both, the main and the riskiest task achieved by the human-assisted PTM due to the proximity of hot metal, live busbars and fluoride emissions from the spent anode removed from the pot. An on-the-fly gauging system was designed to supersede the manual chalk line principle and the semi-automatic anode levelling system (DIANA™) requiring a physical reference to set the new anode level correctly in the pot. The second main system conceived was a hood handling device in order to remove and reinstall automatically the hoods on the pots without any human intervention. Both systems were presented during the TMS conference of 2009 [1].

3. The Embedded Service Robot

Although two generations of hood handling devices were successfully tested in a real smelter environment, it appeared quickly that some technical limitations would jeopardize the generalization of such solution on the long term. More particularly, the total time needed for the removal and replacement of the hood was excessively increasing the cycle time, hence the workload, of the PTM. Moreover, the hood handling device was driven by numerical control technology which was both complex and unknown to smelters maintenance teams. A new philosophy and a different approach were needed. Whereas mechanical tasks had been replaced by automated systems, human tasks were to be replaced by robotics. Robotics was then opening new possibilities which could drive us beyond the original idea of carrying the hoods. The Embedded Service Robot (ESR) was born.

4. General description of the ESR

The ESR is a modular system based on a 6-axis industrial robot (see Figure 1) adapted to the harsh environment of a modern aluminum smelter production line: intense magnetic fields, dust, corrosive environment, high temperatures, etc. Its speed and load capacity have been carefully dimensioned to maximize its versatility. The robot is attached to a telescopic mast which is itself embarked onto the PTM. The robotic arm can be fitted with various specialized tools that are stored on-board the system.



#	Description
1	Telescopic mast
2	6-axis Robot
3	Hoods gripping tool
4	Floor brush
5	Robot controller
6	Pneumatic box
7	Tool quick-change system
8	Robot baseplate
9	Hood store
10	Tool store

Figure 1. Embedded Service Robot.

Figure 4. 6_axis robot.

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 requirements of Fives ECL to create an affordable tool. Smelters maintenance teams needs only a limited training session on robotics basics for becoming autonomous in troubleshooting and in repairing the ESR.

10. Fives ECL Innovation Policy

The ESR is patent pending under No. IR7961. It is part of Fives ECL constant effort to innovate and bring value to the primary aluminum industry. Fives ECL devotes more than 30 000 hours of R&D every year and entertains an important portfolio of patents.

11. Conclusions

The ESR is the ultimate tool embarked on to the Fives ECL PTM: automatic, versatile, fast and reliable. After decades of hydraulically, pneumatically and electrically driven movements, time has come to make a quantum leap in performance by robotics solutions. Hood handling and pot cleaning today have reached the industrial maturity, many other applications will come true tomorrow. Aluminum smelting technologies are evolving, so as the equipment designed by Fives ECL to serve them. The ESR is what you want it to be.

12. Reference

1. Nicolas Dupas, Electrolysis pots anode changing automation: Impact on process and safety performances, Light Metals 2009, pp 515-518.