

## Maximize efficiency and safety of smelters through advanced multipurpose simulator solutions

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### Abstract

Modern smelters have made the reduction process efficiency and safety a key issue: produce more, faster in a safer environment. By designing and developing highly technical automated machines, equipment suppliers greatly help and support smelters in their objective. However it must be acknowledged that despite such innovation, human remains at the very heart of any operation (reduction process, operations on anode handling in the furnace area or rodding shop) and has a significant impact on it.

To avoid production losses, reduce maintenance cost and increase safety reflexes of the crane operators in case of emergency, ECL™ has recently endowed its PTM simulator with some new revolutionary functions. The operator, facing a double screen on which a 3D virtual environment is generated, will be now equipped with some 3D glasses putting him in a total virtual reality (Cabin rotation, cranes translations).

Well trained, the operator will fully contribute to improve production and increase safety of the smelter.

### Introduction

Five years have gone by since ECL™ has designed and commissioned in the Alcoa's first Greenfield smelter in Iceland the first Pot Tending Machine 3D driving simulator. Already installed in six smelters, this PTM simulator allows operators to optimize productivity, greatly increase potroom safety and significantly reduce the corrective maintenance tools. Endowed with some new functions, the original simulator is now equipped with a double screen on which the instructor can chose to generate either a 3D virtual potroom, a furnace area or a casting station. Three different applications in a same machine.

### The multipurpose simulator role and objectives

The role of the multipurpose simulator is to train new recruits as well as long time operators, even before enter the potroom, the furnace area or the rodding shop. The main goal of this virtual machine is to help trainees gain self confidence, accuracy, rapidity and a suitable level of dexterity to start production, drives safely and efficiently the Pot Tending Machine and the Furnace Tending Machine and operates accurately the casting station.

Let us recall that the traditional training is a costly and long process. Due to training duties, the PTM availability rate is low at smelter's start up and driving mistakes are common due to the complexity of the machines and the processes. This often results in broken PTM tools, damaged superstructure and positive raiser. Inadequate training puts the operators over stress and lack of self confidence, resulting in a low work pace before production start up and operators' driving mistakes.

Consequently, a solid recruitment preparation and a complete training program are critical to avoid low productivity,

unavailability of the PTM during repair, high maintenance costs, damages, or worse, injuries and fatalities.

### The multipurpose simulator principles

The trainee is put inside a real life crane control cabin that can be installed in a 5M×6m meeting room. Using real life driving controls (joysticks, selectors, emergency buttons and touch screen Interface (real PTM PLC)) the recruit faces a double screen. One screen is located in front of the trainee and another one under the cabin elevated from the floor by one meter. This double screen allows obtaining a real speed feeling and enables the operator to experience enhanced virtual driving conditions.

To increase realism, the recruit will be now equipped with some 3D active glasses on which a high performance optical tracking system is set up. The image reacts to eye's position which enables the driver to look "behind" obstacles such as a positive riser or a PTM or FTA tool. However, text displayed on the 3D projection will be made visible in two dimensional without glasses by the trainee as well as the instructor.

The virtual environment and crane designs are based on the real smelter's building, the electrolysis pots, the furnace, the rodding shop and the specific cranes that it will be using. Anode pallets, superstructures, hoods, positive risers, fume ducts and all the particular features for both potlines and furnace and the operation equipment can be programmed into the virtual reality environment.

In addition a portable "container" (figure 1) option including the complete multipurpose simulator (real PTM cabin and controls, PTM PLC and screen) can be installed from the beginning of the construction phase resulting thus in having operators fully trained before start up. This "portable" version can also be used on different sites using the same machines (potrooms and furnace).



Figure 1: Multipurpose 3D simulator, portable version

Each tool, function and production situation can be simulated and the driver will interact with virtual floor operators and virtual PTMs operating in the potroom. Training sessions are tailor-made to the smelter's requirements and the production (metal tapping, pot hood handling, single or double anode extraction...) and safety procedures are all taken into account.

Furthermore, the instructor and other trainees can visualize sequences of the double screen in 2D simultaneously and monitor the exercises in a separate room for training purposes.

### Training programs

Different comprehensive training programs for new recruits but also for long time drivers who have gained bad habits over several years of driving, have been created to facilitate step by step the improvement of operating skills. Depending on the application, the trainee

#### Driving initiation and dexterity

A typical training program begins with simple driving exercises (figure 2) to help the operators to master the basic PTM/FTA controls and avoid being disoriented when combining cabin rotation and cranes translations: long travel translation, cross travel translation, rotation or combination of movements.

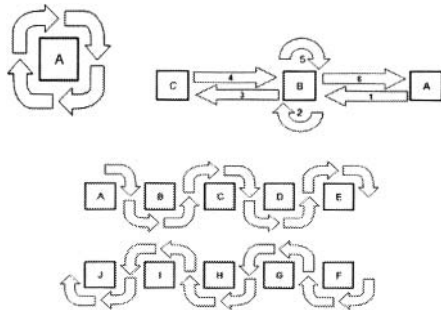


Figure 2: Example of simple driving exercise

#### Production process and anode handling related exercises

When a sufficient level of dexterity has been reached, the driver can start operating the virtual PTM (figure 3) and or FTA on the virtual pots, furnace successively using each crane's tools. These exercises include crust breaking, single or double anode extraction, anode hole cleaning, manual or automatic anode positioning and gauging, anode covering, metal tapping, anode lifting beam handling and crust bath tapping. As for exercises related with the FTA, the trainee can practice with anodes handling to load and unload the furnace pit, the filling of the furnace pit with packing material, the removal of the packing material from the furnace pit (sucking pipe).



Figure 3: PTM 3D image to be performed on double screen

#### Casting process related exercises

The two main groups of the casting station, anodes blocks handling equipment and the anode assembly station are totally simulated allowing the trainee to practice the whole casting process and gain the necessary skills to master all ladle movements: the ladle approach movement, the ladle tilting movement and the ladle cover motion.

#### Safety related exercise

Theses exercises allow the trainee to practice and to take the appropriate actions in the case of emergency or real life safety issue (presence of a floor operator, proximity of a potline vehicle, fire in the electrolytic cell).

#### Evaluation

Trainees are graded after each exercise by the simulator which files the diagram of each cabin rotation and cranes translation. Thus the trainer and the trainee have a global view of the progress achieved and competences still to be achieved so as to determine if the trainee is ready or not to work in the potrooms and the furnace area.

The replay function can also help the pilot to better understand his mistakes and improve his skills more quickly, using inside or outside views. At the end of the training sessions, full reports are generated for future reference.

Many criteria of evaluation are taken into account, such as brutality (use of the progressiveness of the joystick, dead man strumming, joystick strumming), precision (number of operations, trajectories), time, collision and breakages, respect of procedures, and safety.

The simulator is also used by the Human Resources department as an operators' recruitment tool. Specific programs have been developed to test, monitor and report on new recruits' abilities. It has been proven that drivers who get poor results with the simulator would be unable to properly drive a PTM or FTA. Thus the simulator simplifies and shortens the operators' recruitment process.

## **Maximize efficiency and safety of smelters**

### Reduction of training time

Already in use for 5 years in smelters around the world, Aluminium smelter complexes already supplied highlight that the PTM simulator shortens the required training time by at least 30 per cent, for both trainee and instructor. 84 hours training sessions for 60 operators versus 150 to 200 hours without the assistance of the simulator. The instructor workload is reduced significantly as all the exercises can be performed on a self service basis.

More importantly, the cranes's availability rate is greatly increased because they are not off-line for practicing purposes. This is most important at the smelter's start-up when the crane's workload is high and pots need to be more frequently attended.

The driving simulator also ensures that operators are familiar with the machine controls, the production process, and the operation procedures before they even start operating the real cranes. Their learning curve is accelerated with a faster acquisition of "muscle memory" of the PTM' and FTA's controls. They can therefore produce more and more quickly.

Newcomers driving mistakes and production process disturbances are consequently reduced. This contributes to a more efficient operation at the smelter's most critical time but it also significantly cuts down the number of expensive breakdowns and damages to pots and machines. This leads to saving of several hundred thousands of dollars every year in parts only, and a significant increase of the PTM availability rate.

The simulator also constitutes a reliable and simple tool for the performance monitoring of long-time drivers. It can be used to correct inadequate practices and bad habits gained over several years of driving.

In case of an equipment upgrade or the implementation of new tools on the PTM or FTA, the program can be modified to reflect the changes. New series of exercises will help long-time drivers to get accustomed and master the new functions.

### Increased safety

Aluminium smelter complex is a hazardous environment and the heavy machinery takes a large part in it. No other training mean can better help the crane operators to gain the appropriate safety reflexes in case of emergency.

Pilots are not only told what to do but are taught how to react when facing safety risk situations. Therefore, the multipurpose driving simulator greatly contributes to increasing the safety of the smelter.

## **Conclusion**

Here is the reality: produce more, faster in a safer environment. The multipurpose driving simulator is definitely a clear lever to reach a better efficiency and minimize production disruptions.