

## Automatic Butt Control in Rodding Shop, Feedback after Two Years of Industrial Operation

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### Abstract

SOFIA (Smart On the Fly Inspection and Analysis) is a patented solution developed by Fives for butts inspection between two rodding shop machines. The principle is to measure the butt with fixed laser scanners placed around the butt track, to reconstruct the 3D model and finally to measure virtually the geometry and reflectivity of the model. Trimet France has been operating the first equipment for two years. The special arrangement of the laser allows there the control of two types of butt (4 stubs in line and hexapod) with a single equipment. The butt thickness, the level of top oxidation, the amount of residual bath after shot blasting and the spikes location are some examples of controls. Electrolysis process control integrates these measurements and follows them on a regular basis.

**Keywords:** Rodding shop, Butt control, Residual bath, Anode defect.

### 1. Introduction

Butt geometry seen in the rodding shop is the consequence of the combination of the anode forming and baking processes on one side, and the carbon consumption and oxidation in the electrolysis pots on the other side. Measuring this geometry allows then to give indications on these processes and can help evaluating and improving them.

However, in the vast majority of smelters, this type of measurement is carried out manually and from time to time, resulting in data of low accuracy and representing a very small sample of the production.

Fives has then developed a patented solution [1] called SOFIA (Smart On the Fly Inspection and Analysis) for the inspection of butts or rods between two machines in a rodding shop. This solution makes it possible to automatically control the entire production with a high accuracy. The first system has been implemented in the rodding shop of Trimet Saint Jean de Maurienne, as part of a cooperation agreement. The system has been measuring the butts after the shot blasting machine since November 2019. The purpose of this paper is to share the results and feedbacks of this new type of equipment, operated in industrial environment for near two years.

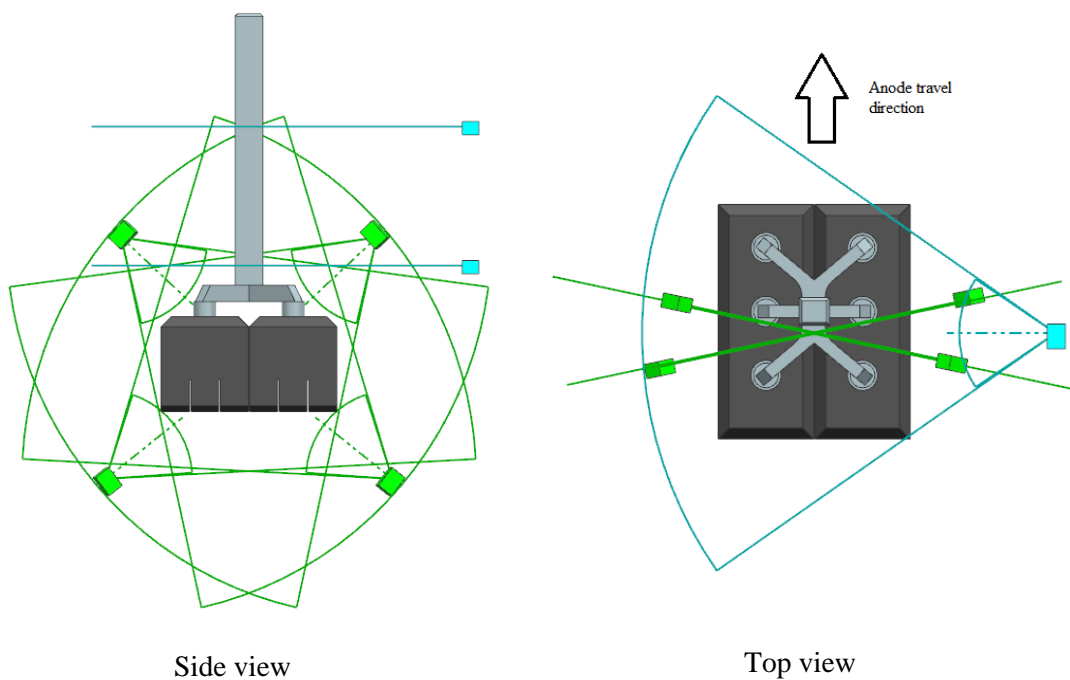
## 2. SOFIA Description

### 2.1 Principle

The special feature of the system is that the measurement is done on the fly, while the butt moves between two rodding shop machines. The butt does not need to stop and therefore there is no need to modify the Power-and-Free conveyor.

SOFIA is composed of several fixed laser scanners arranged around the trajectory of the butt:

- Two horizontal lasers (in blue in Figure 1) measure the position of the stem at two different levels. This gives the precise position of the butt in the environment at all times.
- Vertical lasers (in green in Figure 1) measure simultaneously the geometry of the butt and of the stem.



**Figure 1. SOFIA Principle.**

## 2.2 3D modeling

The geometry of the butt is then calculated by transferring the vertical lasers measurements to the stem reference defined with the horizontal lasers measurements. The position and balance of the butt are then taken into account and corrected so that the 3D model is reconstructed according to the real butt (Figure 2).



Figure 2. Example of butt 3D model.

## 2.3 Butt Measurement

The 3D model then consists of a cloud of points. Each point has its own 3D coordinates and also a reflectivity property which has been directly measured by the lasers.

The 3D coordinates of the points are used for geometry measurements, for example:

- Lengths: butt thickness, Stem thickness, distance between the stem and the butt
- Volume: carbon volume
- Detection of special geometry defects such as broken corners and spikes



Figure 3. Example of spikes detection.

Reflectivity is used for bath detection. The contrast between the black carbon and the white residual bath is detected and measured in parallel to the 3D position. This then allows the calculation of the cleanliness level of the butt.

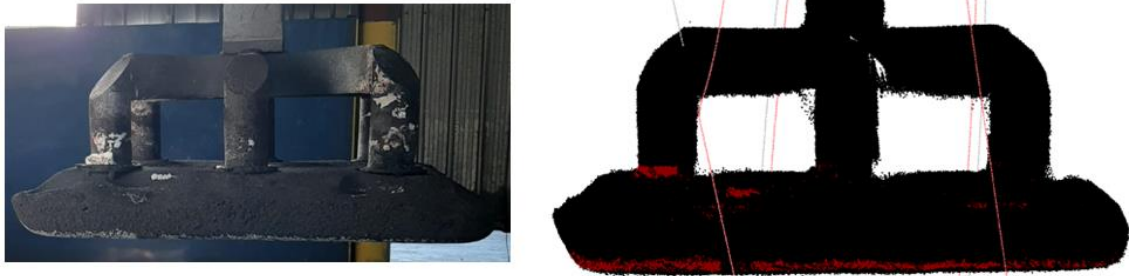


Figure 4. 3D representation of the residual bath in red.

### 3. Adaptation to the Trimet St Jean de Maurienne Specific Context

Based on these principles, SOFIA is very flexible and can be adapted to all practical needs. The quantity and position of the lasers do not modify the main algorithms and can therefore be placed according to local constraints.

#### 3.1 Types of butt

Two types of butts were measured by SOFIA. The first one was a four-stubs in line butt (Fig. 5A), the second one was a six-stubs hexapod butt (Fig. 5B). The lasers were positioned to get a good model of both butt types.



Figure 5. Two types of butts measured by the same SOFIA system.

#### 3.2 Free path for vehicles

The measurement area of SOFIA is a passage for vehicles and pedestrians, as shown in Figure 6. Therefore, all lasers were placed on one side to keep the traffic space free.



**Figure 6. Space available for traffic in front of SOFIA.**

#### 4. Sofia Measurements in Trimet St Jean de Maurienne

##### 4.1 Regular follow-up with dedicated application

Once Sofia measurements were validated, Trimet Saint Jean de Maurienne (SJM) developed an application for the visualization of the results. This application allows tracking daily, weekly and monthly results of both potlines. Examples of the information extracted from the analyses are listed below and a typical graphical representation of the data is shown in Figure 7.

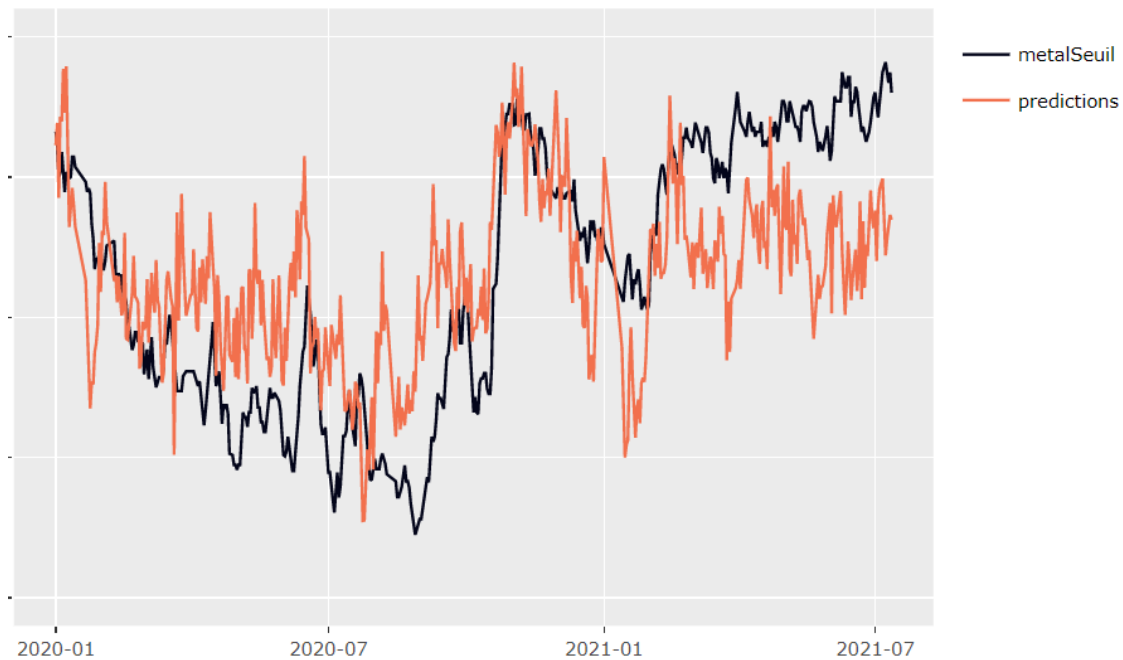
- Butt height
- Carbon under pin
- Butt cleanliness after shot blasting
- Butt volume
- Presence of spikes
- Number of butts processed



**Figure 7. Screenshot of Sofia Application.**

#### 4.2 Use of SOFIA measurements for iron content optimization

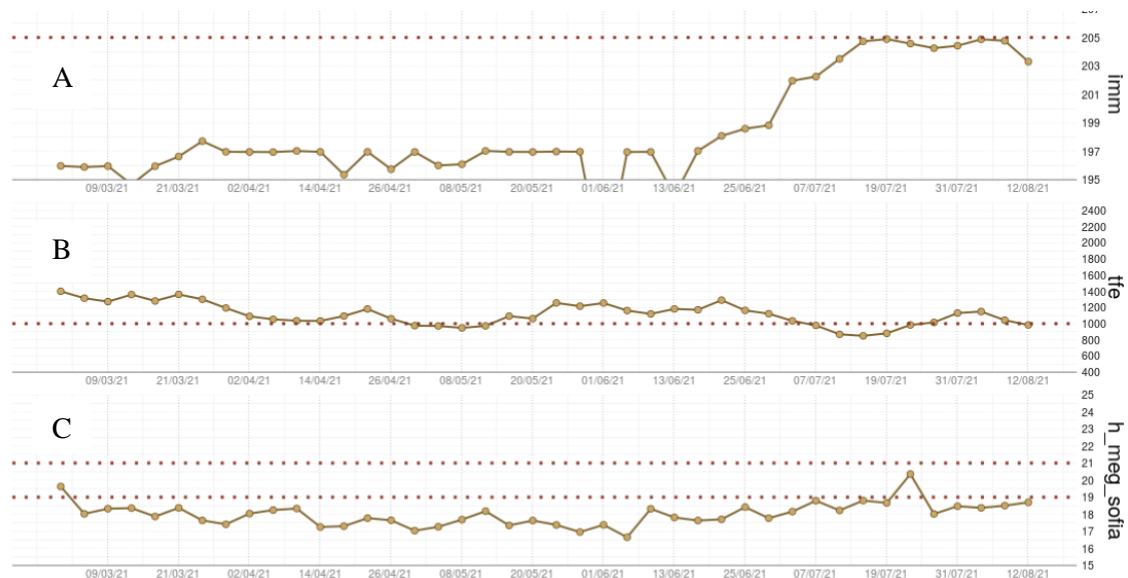
One of the main objectives of SJM potlines is to deliver to the casthouse a high percentage a metal with iron content below a limit. The Sofia measurements have proved very useful to reach this objective. In order to evaluate the effect of bath height and anode cycle on the percentage of metal with iron content below the limit, we managed to build a model based on the butt height measurements and other factors. The graph in Figure 7 compares the measured percentage of the metal (black line) and the predicted values using SOFIA algorithm (orange line) at iron levels below the limit value. One can see a very good correlation between the measured and the predicted values over more than 18 months of operation. The model thus allowed us to estimate the effect of a planned anode cycle duration change on the percentage of metal with iron below the limit.



**Figure 8. Model Prediction and actual Values of Percentage of Metal with Iron below the Limit.**

#### 4.3 Potline amperage rise

Figure 9 shows the variation of a potline amperage in kA(A), iron content (ppm) (B) and butt height (cm) (C) over 18 months. The amperage in potline was raised from about 196 kA to 205 kA in July 2021. With the knowledge of average butt heights below 19 cm before the amperage increase, we reduced anode cycle duration to keep iron levels stable during the amperage increase period.



**Figure 9. Amperage, iron and butt height evolution during amperage increase period.**

## 5. Main feedback after 2 years in industrial environment

### 5.1 Representative measurement

During the first installation phase, the correlation has been made between the measured trends and the real evolution of the process parameters in electrolysis. SOFIA is now fully integrated in the production monitoring and used on a regular basis.

### 5.2 Robust system

Since the start-up, no breakdown has been recorded, giving then a 100% service rate. The system is indeed quite simple, without any mechanical movement or motor thus being a system with low maintenance needs. Only regular cleaning of the dust on the windows is required.

The calibration has been originally performed at the system start-up and did not require re-calibration, despite the alternation of high and low temperatures from summer to winter.

### 5.3 Scalable system

Once the first measurements put in place and included in the dashboard, updates and additional measurements (carbon volume and bath cleaning quality) have been added without any physical modification. These new measurements have also been calculated retroactively on the butts already passed, giving then the full history since the initial set up. Moreover, the system can be configured without a physical assistance: all changes were made remotely using a secure connection, as the sanitary situation made it difficult to be on site anyway.

## 6. Conclusion

SOFIA has been operating for now two years in the industrial environment of the rodding shop of Trimet St Jean de Maurienne. It measures the characteristics of the butts for two different potlines at the outlet of the shot blasting machine.

The measurements have been integrated into the electrolysis dashboard and are used to monitor the process, to anticipate the consequences of a change and to optimize the rotation of the anodes.

The robustness of the system and the low level of maintenance have been demonstrated, ensuring high long-term reliability.

## 7. References

- [1] Vianney Boyer, Sylvain Georgel, Système de caractérisation d'une géométrie d'une charge suspendue, procédé utilisant un tel système et installation de production d'aluminium par électrolyse comprenant un tel système, *FR Patent no. FR3085204 A1*, filed August 23, 2018, granted February 28, 2020