Enhancing Quality Control for Long Products With Robotics and Computer Vision

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ABSTRACT

Steel production necessitates continuous quality monitoring throughout the process. Historically, the steel industry has lagged in adopting certain technological advancements due to its harsh production environment, resulting in lower efficiency and higher risks for workers who perform many operations manually. This study shows the latest developments in the long products quality control, with the implementation of an automated system for some operations, which currently exposes operators to significant danger, like cutting and removing material samples from rods and long products on the cooling bed or measuring laminated surface quality in the rolling mill. By automating this task, we aim to enhance production efficiency and improve worker safety.

Keywords: cooling bed, sample cutting, robotics, artificial vision, rolling mill, quality control

INTRODUCTION

As material moves along the cooling bed immediately following the rolling process, it is essential to take product samples for qualitative and dimensional inspections. The traditional method requires halting the process mechanisms—such as transition chains, rollers, or the cooling bed—while a human operator enters the hazardous area to manually cut and retrieve the steel sample from the desired product. This approach presents significant drawbacks, impacting both safety and production efficiency.

The process is inherently risky for operators, exposing them to dangerous conditions near hot and moving materials. Furthermore, the criticality of the operation often results in extended downtime, as the line must remain stopped until all sampling activities are completed. Another recurring issue relates to the quality of the sample extracted. The difficulty of accessing the material frequently leads to imprecise cuts, necessitating additional processing once the sample reaches the testing area, further delaying quality control workflows.

Integrating an automated cutting-edge sampling system can address these challenges. The robot not only eliminates the need for human intervention in dangerous zones but also ensures consistent, high-quality sample cuts, reducing rework and minimizing process interruptions. This advancement represents a significant step toward safer and more efficient steel production practices.

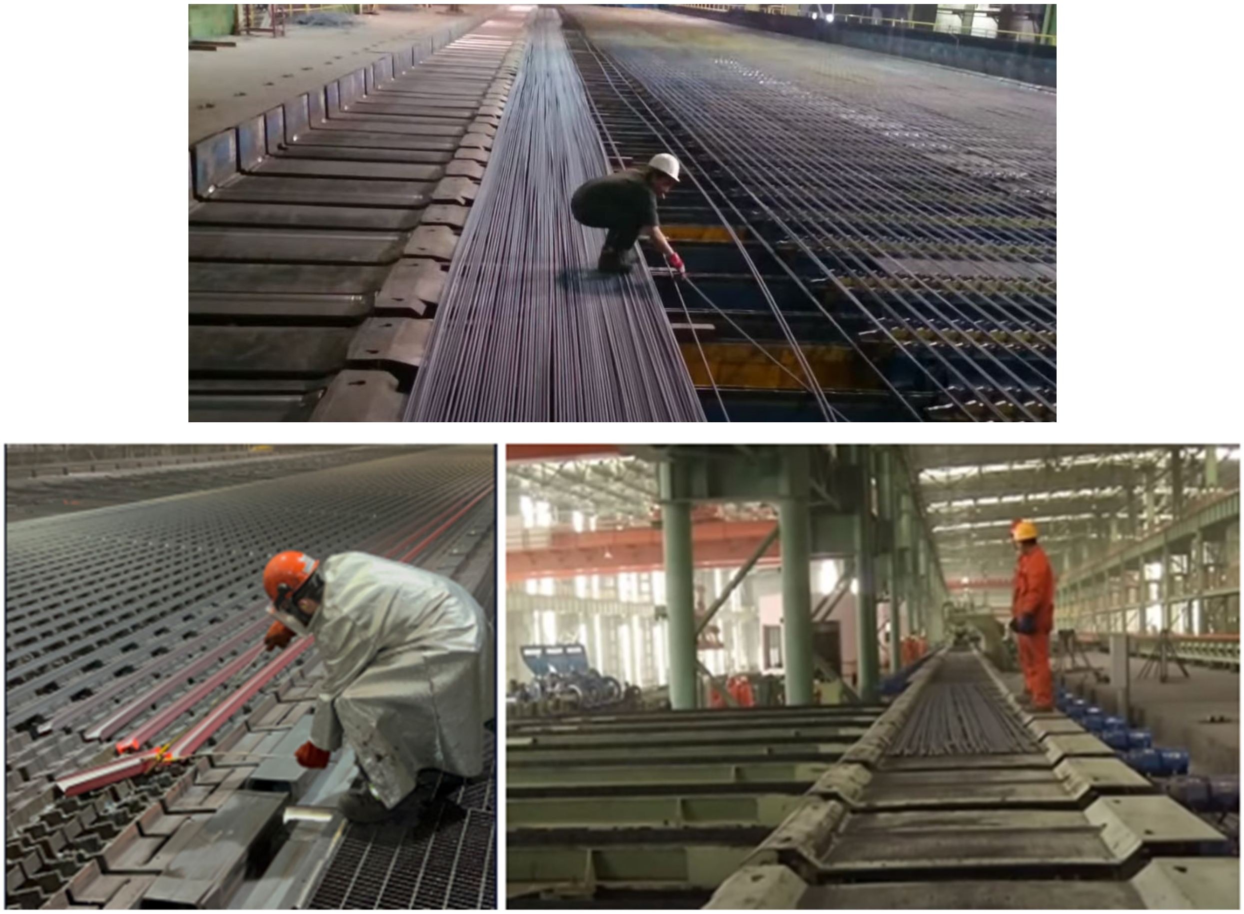

Figure 1: Manual handling of steel bars on cooling bed

Even in optimal conditions, when proper safety logic is integrated into automation, the area is still considered critical due to the hot material and other residual risks that remain. A robotic integration allows for this operation to be carried out without production stops, while no human has to enter the cooling bed area. The sample can be cut and removed by the robot that would dispose of it in a proper area where the operator can pick it up safely.

To eliminate the above drawbacks, the current project aims at realizing a fully automated system for complete cutting/sampling of steel samples from bars positioned on a cooling bed. Such a system would allow for an automatic operation that removes the necessity of an operator accessing a dangerous area while at the same time greatly improving production efficiency by reducing process stops.

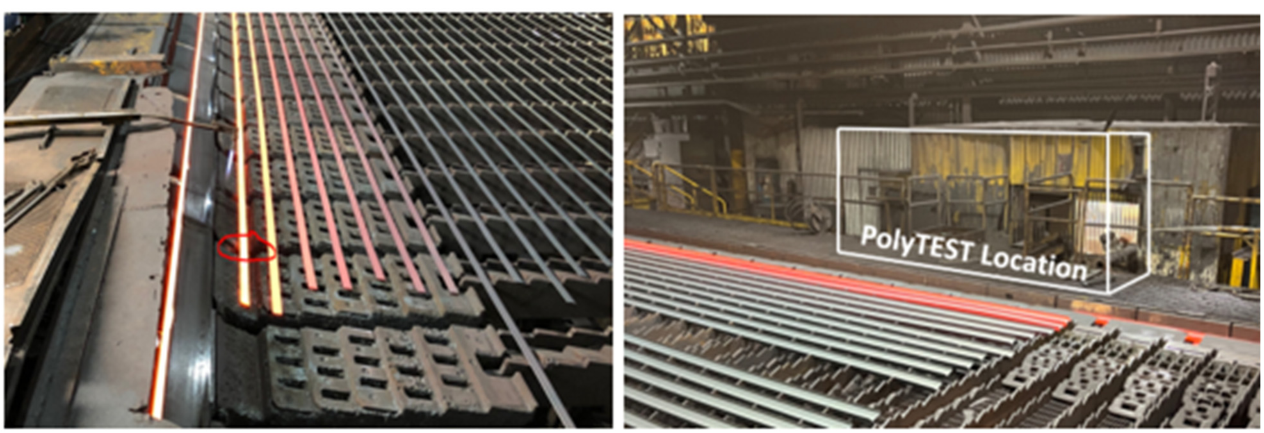

Figure 2: PolyTEST location

SYSTEM DESCRIPTION

Robot

The main component of the system is the 6-axis industrial robot, which allows handling procedures to be done in any layout configuration thanks to its flexibility in terms of reachability. The example in the following figure shows a typical example of an application in its simplest form, where a robot (for this example, an ABB 6700 – 3.05 175kg model) is fixed in the operating position next to the cooling bed. The degrees of freedom of the robot allow it to cover a length of about 150-200cm along the cooling plate.

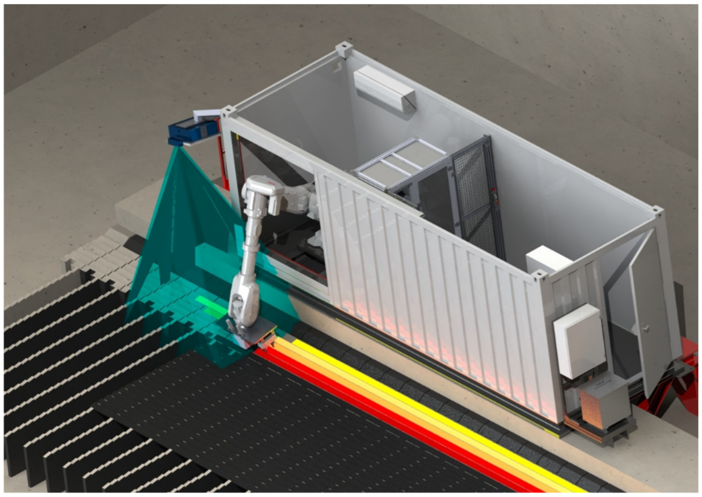

Figure 3: Render example with an integrated container housing

Vision System

The third key component of the device is the artificial vision system. The arrival position of the material to be cut can be identified using 2D/3D scanning systems. The artificial vision system can be physically static and independent from the robot movements or mounted directly on the robot tool.

In either case, the camera is calibrated with both the type of material to be identified as well as with the robot itself. After the image acquisition, the algorithm determines the best position and communicates it to the robot that executes the movement.

The specific type of 3D scanner and/or 2D camera depends on the material to be detected and the required performance.

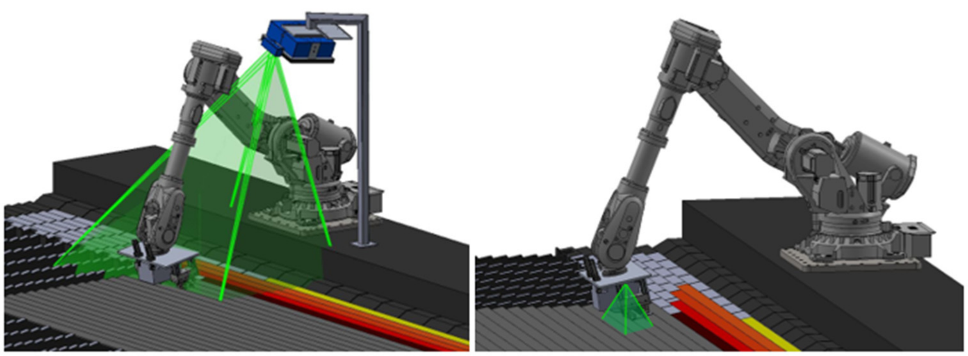

Figure 4: Vision system comparison between fixed and tool mounted

Additional Axis and AMR Integration

The evolution of the system would be the integration of a smaller-size robot on an automatically guided vehicle. This way the positioning of the robot can be even further enhanced compared to an external rail/axis system. The other advantage would be the automatic disposal of the sample, with the robot delivering the collected samples to the test facility, completely removing any need for the operator to access the production floor.

CASE STUDIES

After the initial concepts, Polytec designed and successfully commissioned three variations of the automatic sampling robot.

The working principle is the one described previously. In all systems, the main tasks are the following:

1. Bar recognition with vision system and lance preparation
2. Cutting of a complete section
3. Bar transportation on a sampling table
4. Sample cut and bar disposal

The following is an example of the cutting steps on a system in the test phase.

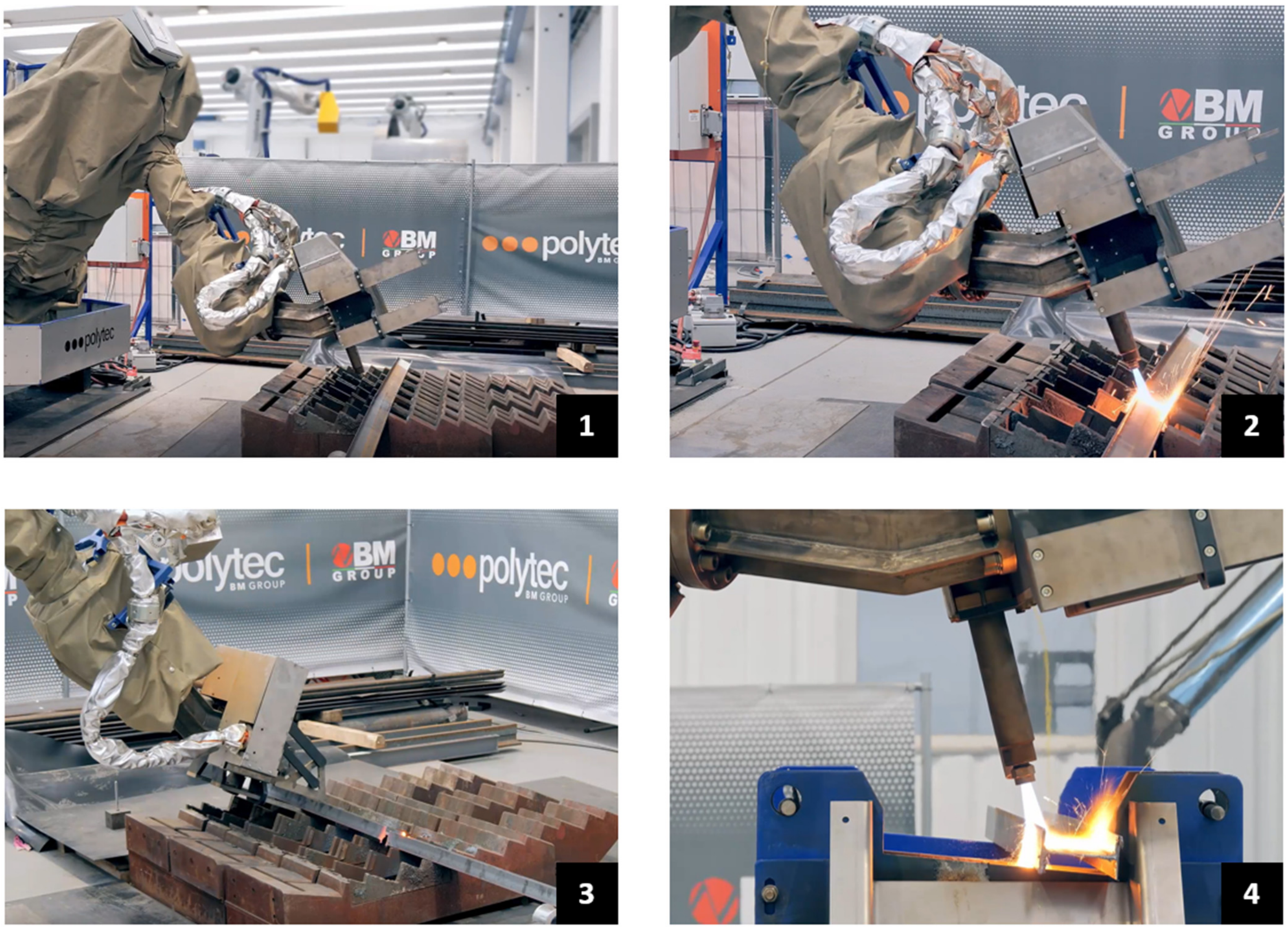

Figure 5: Sampling steps of a test unit

The cycle time varies depending on the profiles shape and size. An average sampling time is around 20seconds, with no production or cooling bed interruption.

Thanks to its flexibility, the robot can be further equipped with motion tracking, to perform the cutting and the pickup from the bed while it's doing the movement sequence.

The system below is equipped with an external axis to allow movement of several meters alongside the cooling bed.

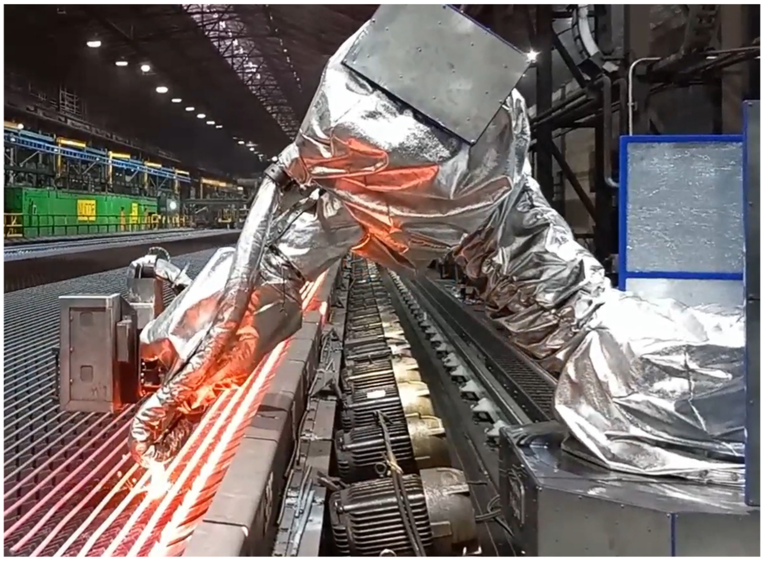

Figure 6: Sampling process in a steel plant

System Supervision and Industry 4.0 Integration
Given the high technology level of the devices used for the system, it is possible to include communication nodes with both plant level 1 to coordinate the robotic arm with the cooling bed automation, as well as higher levels for production interfacing.

The control of the robotic cell is done via a custom HMI page that can be placed either next to the action zone or inside the control room of the cooling bed, with an auxiliary page dedicated for the cutting system.

This, together with a connection to IoT services, allows real-time monitoring of the machine's performance as well as the impact on the production cycle.

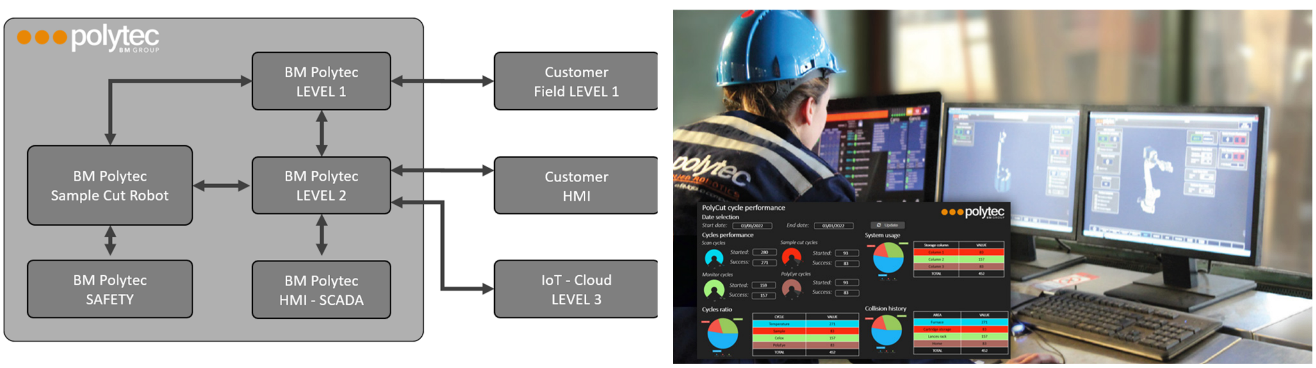

Figure 7: Network integration and system supervision

CONCLUSIONS

This last addition is proof of the advantages that robotic arms can introduce even in areas where automation was not considered up until today. The integration of the latest technologies in robotics, vision system, and artificial intelligence helps design new systems, further enhancing operator safety and productivity improvement in the harshest areas of the steel production process.