Original Article

Automatic slab allocation at ArcelorMittal Pecém: enhancing logistics efficiency, minimizing inventory aging, and boosting productivity

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Abstract

The efficient allocation of steel slabs that do not meet primary sales specifications is a critical factor in steel manufacturing, directly impacting overall metallurgical yield, storage duration (aging), and operational process efficiency. This technical paper details the development and implementation of an advanced automatic slab allocation model at the AM Pecém plant. Resulting from a multidisciplinary collaboration between the Metallurgy and Information Technology (IT) departments, the solution employs computational logic to optimize material movement, significantly reduce the allocation cycle, and increase overall productivity. Integrated with the MES system, the new model executes automated allocation routines every 12 hours, prioritizing sales orders that maximize the added value of reallocated material and minimize losses due to scrap.

Keywords: Automatic allocation; Inventory aging; Productivity; Optimization.

1 Introduction

In the complex steel production chain at ArcelorMittal Pecém, the compliance of slabs with the technical specifications required by the customer is essential for them to be classified as "Prime." However, failures or anomalies throughout the production process may compromise the quality of the slabs, resulting in non-conformities that prevent their immediate use according to the original order.

These downgraded slabs are kept in stock, awaiting opportunities to be applied in new orders. The process of analyzing and reallocating these slabs for new sales orders is called allocation. Managing this inventory represents an ongoing challenge, both from an operational and economic standpoint, requiring effective strategies to minimize losses and optimize resources.

Keeping products in stock beyond what is necessary can generate a series of negative impacts on industrial operations. Excess inventory ties up capital, occupies physical space, and increases storage costs. According to Gianesi and Biazzi [1], inadequate inventory management can lead to conflicts between company departments such as operations, finance, and marketing, compromising overall business performance. The systemic approach proposed by the authors highlights that, beyond simply optimizing local indicators, it is essential to align inventory management with the organization's strategic objectives, seeking a balance between service level and economic efficiency.

Historically, at the Pecém plant, this process was carried out manually through the MES (Manufacturing Execution System). The MES is a computerized system for real-time production control and management. It acts as a bridge between planning systems (ERP) and shop-floor operations, monitoring and recording all stages of the manufacturing process. In the steelmaking context, MES tracks the slabs produced, their characteristics, and movements, ensuring full traceability and execution in accordance with production orders. Li and Wang [2] highlight that advanced MES systems enable real-time control and traceability, which are critical for operational efficiency in steel manufacturing. However, the allocation process used to require significant time and technical knowledge from the inspection, metallurgy, and production planning and control (PCP) teams.

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Each slab was individually evaluated, with manual searches in the system to identify compatible sales orders, reflecting the challenges commonly associated with MES implementations in complex industrial environments, as discussed by Gonçalves [3] in his analysis of MES technologies in the steel industry. Figure 1 illustrates a prime slab and the criteria for prime slab classification controlled in the MES.

Faced with the need for modernization and increased efficiency, ArcelorMittal Pecém chose to implement an automated slab allocation system. This initiative aims to reduce processing time (lead time), improve material traceability, optimize the use of production assets, and increase resource reuse, aligning with Lean Manufacturing principles applied to internal logistics. The automation of the allocation process thus emerges as a fundamental strategy to promote gains in operational efficiency and sustainability.

The automatic allocation of slabs in stock also contributes to their reuse in new orders classified as Prime. This increases the company's profitability by reducing losses associated with discounted sales or disposal as scraps.

2 Development

2.1 Technical analysis of the preexisting process

An in-depth analysis of the allocation flow for non-conforming slabs revealed a sequential process with multiple manual interventions and interdepartmental dependencies. From the identification of dimensional or chemical discrepancies, through the evaluation of slab characteristics and manual search for compatible sales orders, to the registration of the allocation in the system, the slabs remained in stock. Figure 2 illustrates the flowchart of the manual allocation process previously in place at ArcelorMittal Pecém.

2.2 Architecture and implementation phases of the automatic allocation project

The implementation project for the automatic allocation solution was structured into three technically distinct and interdependent phases, aiming to ensure a smooth transition and maximum effectiveness of the new system:

Phase 1 – Refinement of Allocation Rules in the MES System: This initial phase focused on reviewing, formalizing, and incorporating more precise and comprehensive allocation rules into the existing Manufacturing Execution System (MES). Validations were implemented to compare dimensions (width, thickness, length), detailed chemical analyses (carbon, manganese, silicon content, etc.), and other metallurgical properties of non-conforming slabs with the specific requirements of open sales orders. Additionally, the system's query interface was enhanced using data visualization tools and advanced filters to facilitate the identification of potential matches between slabs and orders. As a result, the manual allocation process became more agile, and rules that would later be applied in automatic allocation could already be used. Figure 3 presents a schematic diagram of the data flow and validations implemented in MES.

Phase 2 – Integration and Functionalities in MES Mobile for Direct Allocation in the Yard by the Inspection Team: Aiming to optimize logistics operations in the slab yard and eliminate intermediate processing steps, new functionalities were developed and integrated into the MES Mobile application (MES system on an operational mobile device) used by the quality inspection team. Through mobile devices (industrial smartphones), inspectors gained the ability to record the characteristics of non-conforming slabs and perform real-time queries on possible destinations directly at the inspection site.

This integration enabled preliminary allocation of the slab in the system at the moment the specification non-compliance was identified, reducing the need for movement to stock areas. Figure 4 illustrates the MES Mobile interface and the modification in the allocation flow.

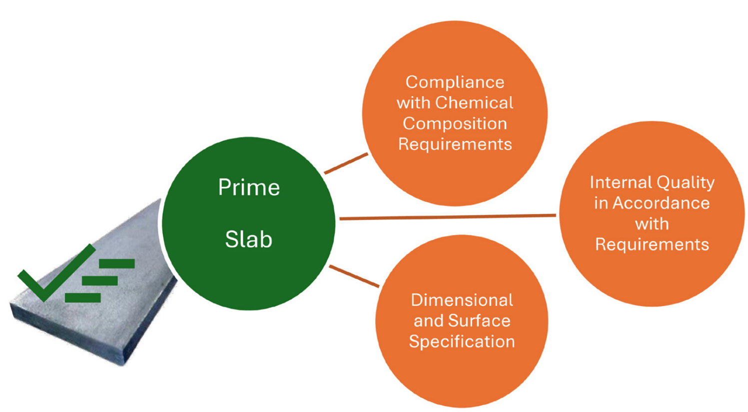

Figure 1. Criteria for Prime Slab Classification.

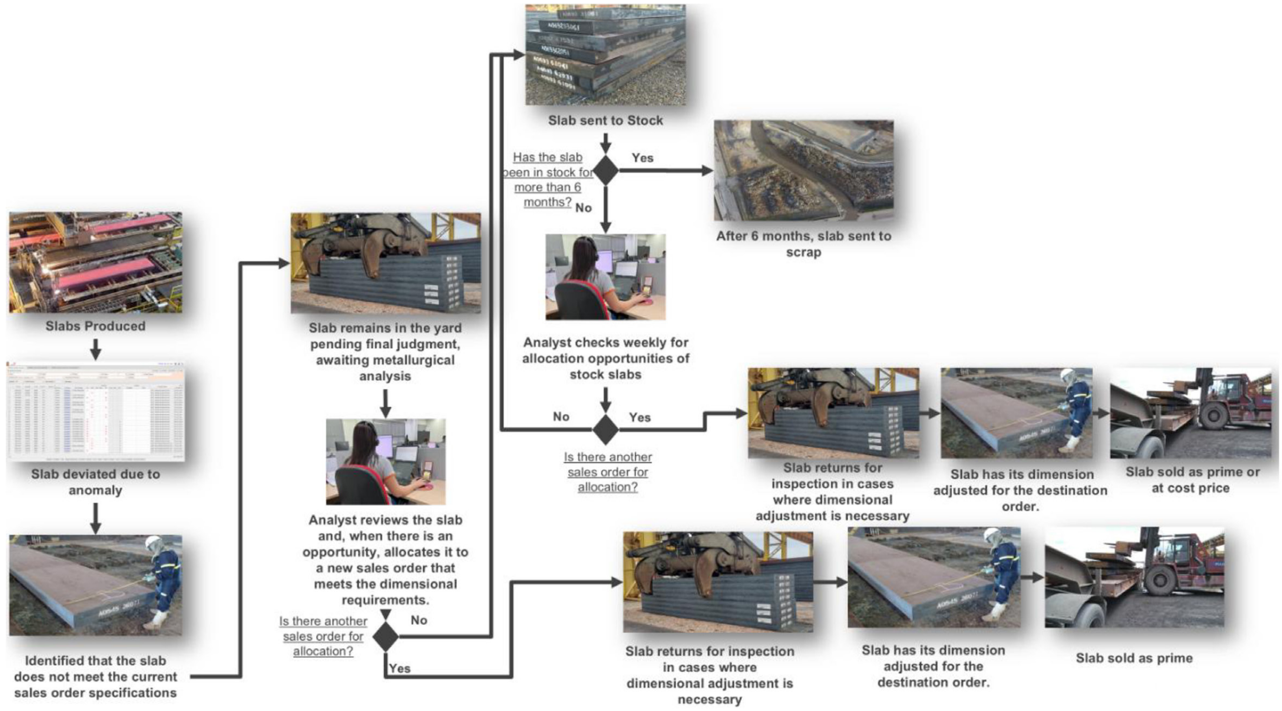

Figure 2. Flow of the Manual Slab Allocation Process (Previous).

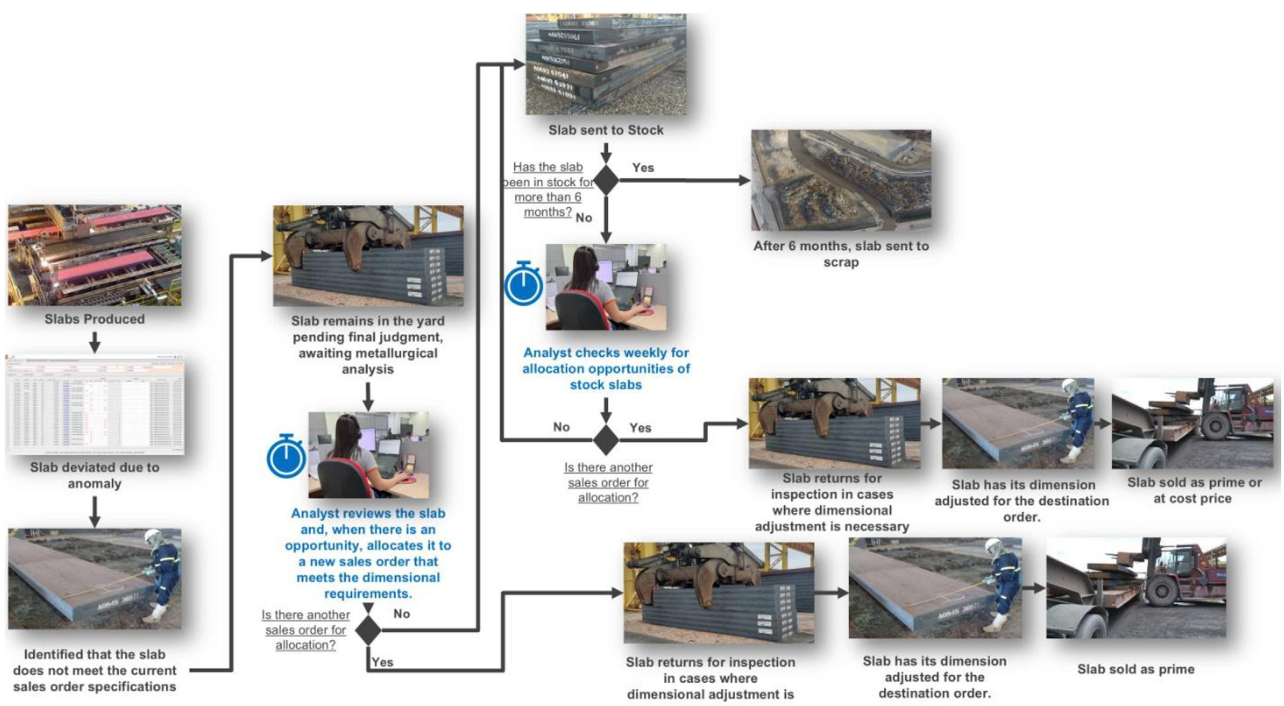

Figure 3. Data Flow and Validations in the Optimized MES System.

Phase 3 – Implementation of the Automatic Allocation Model Based on Optimization Algorithms: The final and central phase of the project involved the design and implementation of a fully automated computational allocation model within the MES system. Optimization algorithms such as heuristic and linear programming approaches are widely applied in industrial contexts to minimize losses and maximize resource utilization [4]. This model runs at regular intervals (twice a day) and employs optimization algorithms to analyze the database of pending sales orders and the inventory of slabs available for reallocation. The logic prioritizes identifying combinations that minimize material loss (considering factors such as dimensional differences that could lead to scrapping) and product delivery dates. Prioritization criteria include the dimensional tolerance allowed by the customer's specification, the chemical characteristics of the non-conforming slab in relation to the sales order requirements, and the potential for slab reuse with minimal rework. Figure 5 presents a detailed flowchart of the automatic allocation algorithm.

3 Results

The operationalization of the automatic slab allocation model at ArcelorMittal Pecém generated significant quantitative

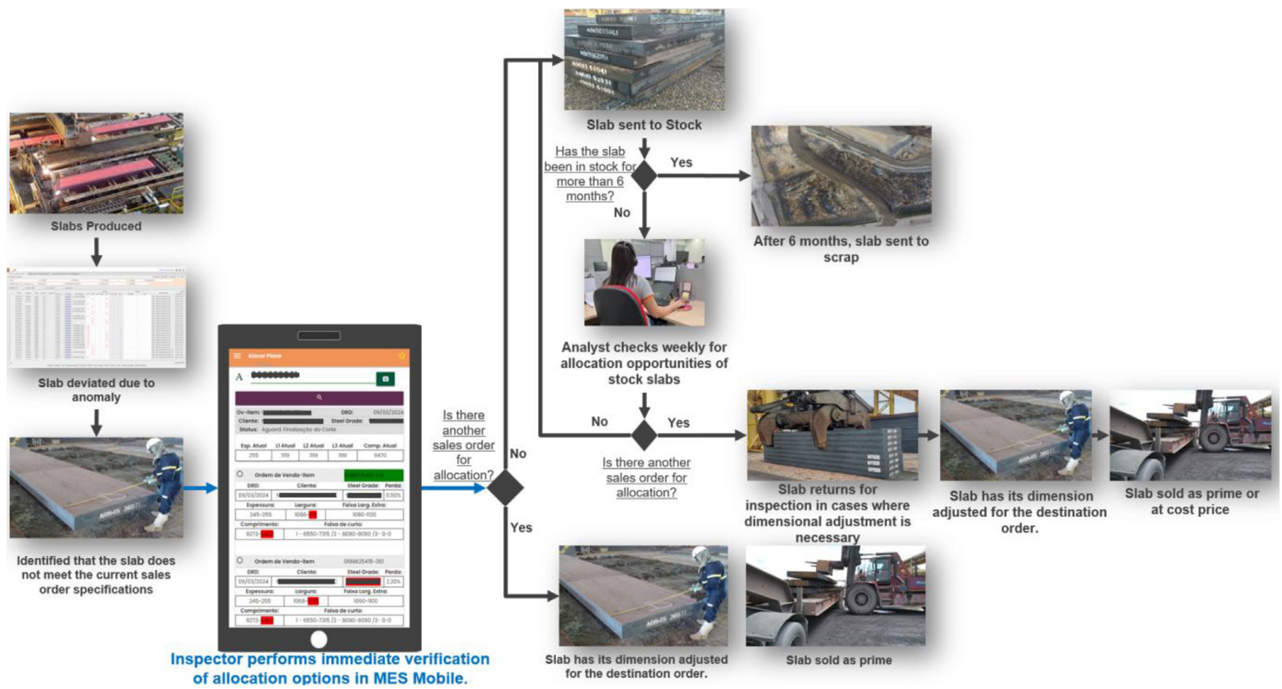

Figure 4. MES Mobile Interface for Direct Slab Allocation.

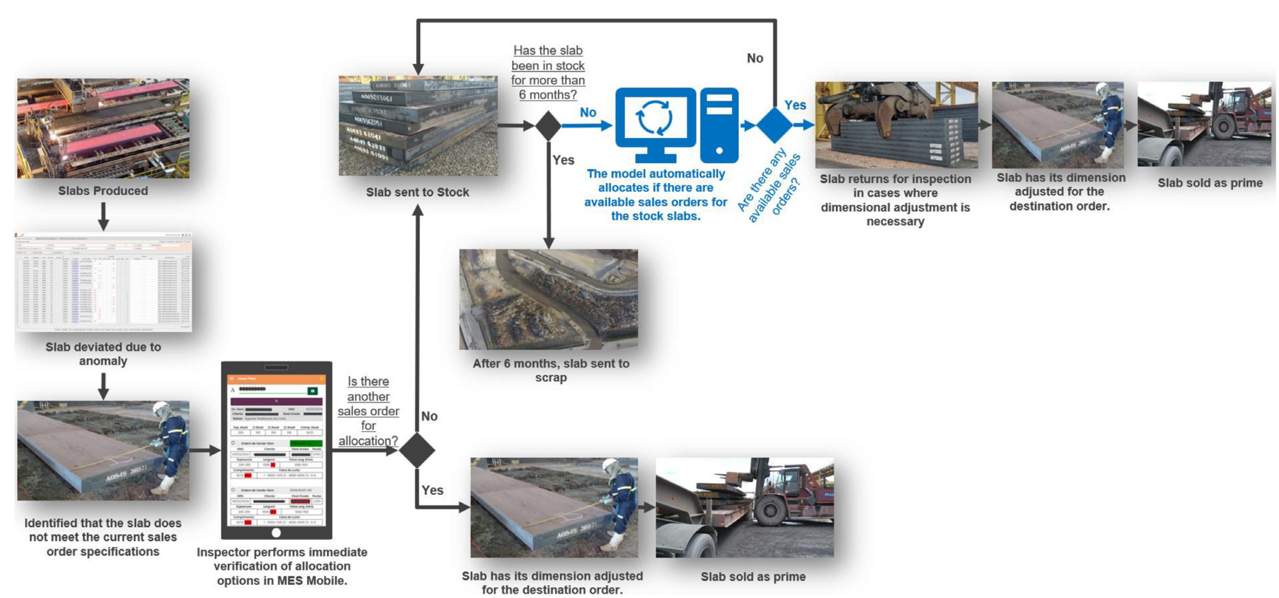

Figure 5. Detailed Flowchart of the Automatic Allocation Algorithm.

and qualitative results, demonstrating the effectiveness of the implemented approach:

Substantial Reduction in Manual Allocation Time: The average time spent on manual allocation per slab was reduced by 83%, dropping from an average of 6 minutes in the manual process to approximately 1 minute. This optimization freed up human resources for activities of greater strategic value.

Decrease in Inventory Aging: The periodic execution of the automatic allocation routine resulted in a significant reduction in the time non-conforming slabs remained in stock.

Increase in Overall Metallurgical Yield: The ability to intelligently allocate slabs that were previously considered scrap or sold at significant discounts raised the utilization rate of produced material, positively impacting the plant overall metallurgical yield with 17 kt of products allocated by the new system.

Optimization of Human Resource Allocation: Automating routine allocation tasks allowed the technical team to redirect their efforts toward analyzing the causes of non-conformity, implementing corrective and preventive actions, and other activities that contribute to the continuous improvement of the production process. Approximately 100 hours/month of manual work were eliminated.

Improvement in Internal Logistics Efficiency: More precise and targeted slab allocation led to a reduction in unnecessary movements in the yard, optimizing the use of handling equipment and reducing energy consumption.

4 Conclusions

The implementation project of the automatic slab allocation system at AM Pecém exemplifies the synergistic potential of integrating technical knowledge from the Metallurgy department with expertise in Information Technology to generate innovative and high-impact solutions in the steel industry. The automation of the allocation process demonstrated not only a significant increase in productivity and optimization of internal logistics, but also contributed meaningfully to loss reduction, improved inventory management, and enhanced overall operational efficiency. The allocation system was entirely developed within ArcelorMittal Pecém's MES, enabling low-cost automation with full software control belonging to the plant. The methodology and results obtained in this project may serve as a reference model for other industrial units seeking to improve their processes and achieve operational excellence through the adoption of automation and optimization technologies.

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