International Journal of Scientific Research and Engineering Development-– Volume 9 Issue 3, May-June 2026
Available at www.ijsred.com

RESEARCH ARTICLE OPEN ACCESS

Improving Gross Yield in Hsm-3 by Optimising Crop End Cuts, Sampling and Reduction of Salvaging Loss- A Review

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Abstract:

Gross yield improvement is one of the major objectives in Hot Strip Mill (HSM) operations because yield loss directly affects production cost and profitability. In HSM#3, significant losses occur due to crop end cutting, sampling, scale formation, and salvaging losses. This review paper discusses the major causes of yield loss and the techniques used to reduce them. The study focuses on optimization of crop end cuts, reduction of sampling losses, and minimization of salvaging losses through improved process control, accurate strip measurement, and defect reduction techniques. Existing methods such as Laser Doppler Velocity Meter (LDVM), encoders, and Hot Metal Detectors (HMDs) are reviewed along with their limitations. The paper concludes that proper crop optimization, improved measurement systems, and better rolling process control can significantly improve gross yield and productivity in hot strip mills.

Keywords — Hot Strip Mill (HSM), Gross Yield Improvement, Crop End Cutting, Yield Loss, Reduction, Sampling Loss, Salvaging Loss.

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I. INTRODUCTION

The Hot Strip Mill #3 (HSM#3) operation is a critical component in steel manufacturing, where optimizing material utilization directly impacts overall profitability and sustainability. The efficiency of hot strip mills is critically dependent on maximizing gross yield, a metric significantly impacted by the precise management of crop end cuts and the subsequent reduction of salvaging losses. The reduction of material waste, particularly in the form of crop end cuts and other salvaging losses, presents a significant opportunity for enhancing the gross yield and overall operational efficiency within Hot Strip Mill operations. This paper investigates advanced methodologies for optimizing crop cutting strategies and minimizing salvaging losses, thereby directly contributing to improved metallic yield (Rizek et al., 2025). Specifically, this research focuses on the application of predictive modeling and real-time process adjustments to mitigate width-related defects and surplus material generation, which are primary contributors to yield loss in hot rolling processes (Latham & Giannetti, 2023; Zhao et al., 2020). Such advancements are crucial, as a substantial percentage of steel strips processed in Hot Strip Mills are either scrapped, sold at concession, or require additional processing due to various defects, a significant portion of which are width-related (Latham, 2023).

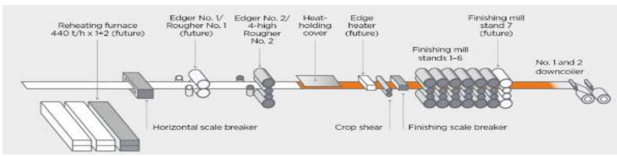

Figure-1: overview of the Mill

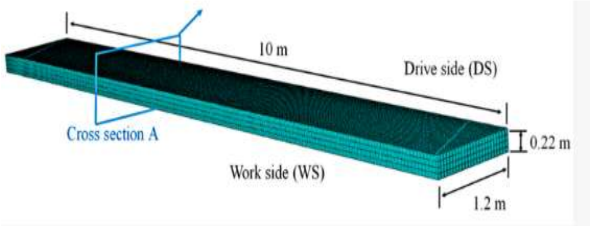

Figure-2: Slab

Figure-3: Coil

II. LITERATURE REVIEW

OPrevious research has extensively explored the impact of various rolling parameters on strip geometry and the subsequent generation of crop ends. Gross yield improvement has become a critical performance indicator in modern Hot Strip Mill (HSM) operations because even small reductions in yield loss can result in substantial economic benefits. Researchers and industrial practitioners have extensively studied various sources of yield loss such as crop end cutting, sampling losses, scale formation, cobbles, and salvaging losses. Several studies indicate that yield losses in hot rolling mills are primarily associated with inaccurate strip length prediction, improper crop optimization, process instability, and surface or dimensional defects generated during rolling. One of the major contributors to yield loss is crop end cutting at the head and tail portions of the strip. Earlier studies reported that excessive crop cutting is generally performed to eliminate defects such as fishtail formation, tongue defects, camber, and uneven strip profile. However, conservative crop settings increase metal loss significantly. To overcome this problem, researchers proposed optimization techniques based on accurate strip tracking and real-time process monitoring. Advanced automation systems using mathematical models have been developed to determine the minimum safe crop length while maintaining product quality. These models use rolling parameters such as strip width, thickness reduction, temperature profile, and tension control to optimize crop cutting. Several researchers have investigated the application of measurement technologies such as Laser Doppler Velocity Meter (LDVM), encoders, and Hot Metal Detectors (HMDs) for improving strip tracking accuracy. LDVM systems provide non-contact velocity measurement and improve strip length prediction accuracy compared to conventional encoder-based systems. Studies show that encoder systems are affected by slippage and mechanical inaccuracies, resulting in incorrect strip positioning and excessive crop losses. HMDs are widely used for strip detection and synchronization in mill automation systems; however, their performance may deteriorate due to scale formation, high temperature, steam, and environmental disturbances. Literature suggests that combining LDVM with HMD and encoder feedback improves measurement reliability and reduces crop end losses. Sampling losses are another important source of yield reduction in HSM operations. Samples are regularly cut for mechanical and metallurgical testing to ensure product quality compliance. Traditional sampling practices often involve oversized sample cutting, leading to unnecessary material wastage. Researchers proposed optimized sample sizing and automated sample cutting systems to reduce sampling losses while maintaining testing standards. Statistical quality control and online process monitoring techniques have also been suggested to minimize the frequency of destructive sampling by improving process consistency. Scale formation during reheating and rolling is also identified as a major factor affecting gross yield. Oxidation at high temperatures leads to scale generation, resulting in metal loss and surface defects. Literature indicates that reheating furnace temperature optimization, controlled oxygen atmosphere, and improved descaling systems can significantly reduce scale-related losses. Some studies also emphasize the importance of controlled rolling temperatures and shorter furnace residence times to minimize oxidation. Salvaging losses occur when strips are downgraded or rejected due to surface defects, dimensional inaccuracies, cobbles, or process interruptions. Researchers have identified improper tension control, roll wear, cooling non-uniformity, and unstable rolling parameters as major causes of strip defects. Advanced process control systems, automatic gauge control (AGC), and work roll shifting technologies have been implemented in many mills to improve dimensional accuracy and reduce rejection rates. Defect detection systems using machine vision and artificial intelligence techniques have recently gained attention for early identification of strip defects and prevention of salvage generation. Many studies also highlight the role of predictive maintenance and automation in improving overall mill productivity and yield. Real-time data acquisition systems integrated with Industry 4.0 technologies enable continuous monitoring of process variables and early fault detection. Machine learning approaches are increasingly being explored for yield prediction, defect classification, and process optimization in hot strip mills. From the reviewed literature, it is evident that gross yield improvement requires an integrated approach involving crop optimization, accurate strip measurement, reduction of sampling losses, control of scale formation, and minimization of salvaging losses. Although conventional technologies such as encoders and HMDs are widely used in hot strip mills, their limitations affect measurement accuracy and process reliability. Advanced systems such as LDVM, intelligent automation, and AI-based defect monitoring offer significant potential for improving yield and productivity. Therefore, effective implementation of optimized process control strategies and advanced measurement techniques can substantially enhance gross yield performance in HSM operations.

III. METHODOLOGY

This study proposes a methodology that integrates advanced sensor technologies, real-time data acquisition, and machine learning models to develop a predictive framework for optimizing crop end cuts and minimizing salvaging losses in HSM#3. This framework aims to precisely predict the optimal cut points, thereby reducing material waste from excessive cropping and minimizing the need for subsequent salvaging operations. The ultimate goal is to enhance the overall metallic yield and reduce operational costs by minimizing the generation of defective material that necessitates secondary processing or disposal. The methodological approach encompasses a multi-stage process, beginning with extensive data collection from various points within the rolling mill, including entry and exit gauges, temperature sensors, and strip width measurement devices.

IV. RESULTS AND DISCUSSIONS

The results of this review shows that significant improvement can be achieved in the hot rolling process by reducing yield loss and optimizing rolling parameters.

1. **Improved Width Prediction**
   The developed width prediction formula showed very high accuracy when compared with actual industrial measurements, giving reliable transfer bar width values.

2. **Reduction in Yield Loss**
   Losses due to crop cutting, scale formation, and defects were identified and reduced through better process control.

3. **Better Understanding of Material Flow**
   FEM analysis helped in understanding spread behaviour and material deformation during vertical and horizontal rolling.

4. **Reduction in Camber and Hooking**
   The use of camber measurement systems,

side guides, and rolling mill tilting reduced strip bending and improved strip alignment.

5. **Improved Product Quality** Defects such as edge cracks, roll marks, slivers, and flatness issues were minimized, resulting in better surface quality.

6. **Higher Production Efficiency** Optimized rolling conditions increased yield percentage, reduced waste, and lowered production cost.

V. CONCLUSIONS

This project focused on analyzing and reducing yield loss in the hot rolling process. The study identified major causes of loss such as scale formation, crop cutting, strip defects, camber, and measurement inaccuracies. Different strip speed measurement methods and rolling techniques were studied to understand their limitations in industrial conditions.

A width prediction and analysis approach was used to improve the accuracy of transfer bar width calculation during rolling. FEM modelling and industrial data analysis helped in understanding material flow, spread behavior, and camber formation. Experimental studies and simulations showed that proper crop control, improved measurement techniques, side guides, and rolling mill adjustments can reduce defects and improve process efficiency.

The results indicate that better process control and optimized rolling parameters can significantly reduce material waste, improve product quality, and increase yield percentage in hot strip mills. Therefore, the project contributes to improving productivity and reducing production losses in the steel manufacturing industry.

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