

Hot Strip Mill Process Flow, Cobble Generation & Preventive Action

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Abstract - The Hot Strip Mill (HSM) is a critical process in steel manufacturing used to convert slabs into hot rolled coils by using (220-260) mm thick & width (900-2250) mm of length 4 meter – 1150 meter through controlled thermo-mechanical operations. During rolling, maintaining strip stability within the finishing mill stands is essential to ensure product quality and continuous operation. However, defects such as cobble formation can occur, leading to production loss and equipment damage. A cobble is characterized by uncontrolled folding or accumulation of the strip due to instability in rolling conditions. This study focuses on understanding the Hot Strip Mill process, identifying the causes of cobble generation, and analyzing process parameters such as Center Line Deviation (CLD), differential roll force, strip tension, and temperature, width, the Based on data analysis, suitable preventive measures and corrective actions are proposed to reduce cobble occurrence, improve mill efficiency, and enhance product quality.

CHAPTER – 1

INTRODUCTION

STUDY ON HOT STRIP MILL PROCESS FLOW, COBBLE GENERATION & PREVENTIVE ACTIONS.

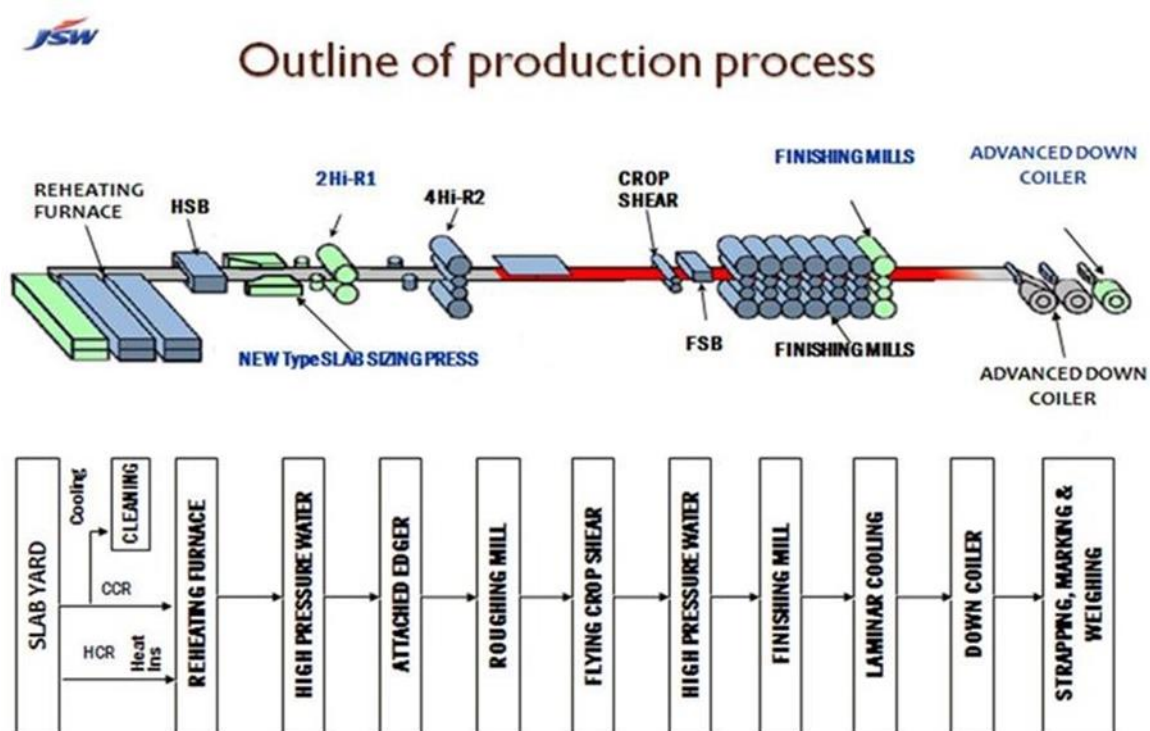
The Hot Strip Mill (HSM) is one of the most important units in an integrated steel plant. It processes reheated slabs into thin strips through roughing and finishing mills. The slabs are heated to high temperatures (1150–1250°C) in a reheating furnace and then rolled in multiple stages to achieve the desired thickness and properties. The rolling process involves precise control of various parameters such as temperature, roll force, strip tension, and speed. Any deviation in these parameters can lead to instability in strip movement, resulting in defects such as cobbles. Ensuring stable strip flow is therefore essential for efficient mill operation.

In a typical HSM, steel slabs (220–260 mm thick) are reheated to ~1150–1250°C, rough-rolled into transfer bars (~20–40 mm), and then finish-rolled in a tandem mill (often 6–7 stands) to final gauge (1.2–25 mm) at high speeds (up to 20+ m/s). The temperature of finishing mill entry temperature is maintained up to 1140°C & exit temperature is maintained up to 850-940°C. During coiling the temperature is achieved up to 450-650°C by producing the coil diameter of 700-2250 mm with 28 tons weight.

Cobbles primarily occur due to instability: differential elongation across the strip width causes waviness, camber (curvature), or buckling, which the rolls/looper cannot handle, leading to pinching or piling. Temperature variation, width deviation, and gauge variation are interconnected root causes because they induce uneven deformation resistance, flow stress, and elongation.

Temperature variation (across width/length or head-to-tail) alters local hardness/ductility → uneven reduction → flatness defects or camber.

Gauge variation (thickness spikes or wedge) amplifies load differences between stands. Width deviation (from edging issues or contraction) affects tracking and side-guide contact.



3.2 Rolling Type

- ☐ It is the process of plastically deforming metal by passing it between rolls
- ☐ It is widely used to convert steel ingots from bloom, billets and slabs and subsequently into plates, sheet and strips.

Advantages

- ☐ provides high throughput
- ☐ provides good control over the dimensions of the finished product.

In Hot Rolling

- ☐ metal is rolled at a temperature below its re crystallization temperature
- ☐ higher reduction in the cross section is achieved

3.3 Rolling process

Rolls transfer energy to the strip through friction. As the strip is dragged by the rolls into the gap between them. It decreases in thickness while passing from the entrance to the exit, meanwhile its speed gradually increases from the entrance to exit.

V_0 = input velocity V_f = final or output

velocity R =roll radius

H_b =back height

H_f =output or final thickness

3.4 Hot strip mill details

☐ Raw material:	Slabs
☐ Final product:	Coils
Slab-size	
☐ Thickness:	220-260mm
☐ Width:	900-2250mm
☐ Length:	11 mm
☐ Weight	36 Ton
Strip size:	
☐ Thickness:	1.2-25mm
☐ Width:	900-2250mm
Coil size:	
☐ inner diameter:	762mm
☐ outer diameter:	1000-2150mm
☐ coil weight max:	35 tones

Per day, Production will be 600 to 640 coils in Hot strip mill -2

Typical Applications of steel

- ☐ Structural members, trenches
- ☐ Tubes and pipes-galvanized pipes, black tubes
- ☐ White goods outer sheets
- ☐ Air ventilation ducts
- ☐ Automobile body and structural members
- ☐ Cross country petroleum pipes
- ☐ Floor plates
- ☐ Storage systems, furniture

Main areas in Hot strip mill (HSM)

- ☐ Slab yard
- ☐ Reheating furnace
- ☐ Hydraulic Scale Breaker
- ☐ Slab Sizing Press
- ☐ Roughing Mill 1
- ☐ Roughing Mill 2
- ☐ HHC, Crop shear & Finishing scale breaker(FSB)
- ☐ Finishing mill (F1 to F7)
- ☐ Run out table (ROT)
- ☐ Down coil
- ☐ Roll Shop
- ☐ Utility & Power system

SLAB YARD

- ☐ Slabs after continuous casting from SMS II (Steel Melting Shop) and arranging them according to grade, width and length wise in slab yard.
- ☐ Supplying slabs according to rundown pattern prepare by PPC to Reheating furnace.
- ☐ Slab will be loaded on slab charging table by overhead gantry type crane, and transferred to slab weighing table and Furnace entry table.



- ☐ Thickness: 220 – 260 mm
- ☐ Length: 4700 to 1100 mm
- ☐ Width: 900 – 2200 mm
- ☐ Max Slab weight: 37 ton

REHEATING FURNACE

Type: walking beam type

- ☐ No. of Furnaces : 3
- ☐ Length (Wall to Wall) : 51200 mm
- ☐ Width : 11800 mm
- ☐ No. of Fixed beams : 4 – charging section 5 – Discharging section
- ☐ No. of Movable beams : 4
- ☐ Nominal distance between
Slab inside furnace : 50 – 100 mm
- ☐ Maximum OP Temperature : 1320 c
- ☐ Capacity : 350 tons/Hr. each Furnace
- ☐ Fuel : Designed to fire mixed gas

CO - 48%
 H2 - 17%
 CO2 - 29%
 N2 - Balance

- ☐ Heating Area
 - ☐ Recuperating Zone
 - ☐ Preheating Zone
 - ☐ Heating Zone 1 and Heating Zone 2
 - ☐ Soaking Zone
- ☐ To charge & discharge the slabs there are Charging & Discharging machines with respective roller tables
- ☐ The functions of this is to reheat the slabs to the rolling temperature
- ☐ Temperature maintained at each furnace is 1100-1200 celsius

HYDRAULIC SCALE BREAKER (HSB)

- ☐ The purpose hydraulic scale breaker is to remove the scales developed while reheating slab using high pressure descale water up to 220 bar high pressure

SLAB SIZING PRESS (SSP)

- ☐ SSP is placed right after the Hydraulic scale breaker
- ☐ SSP is used to reduce the width of the slab.
- ☐ SSP has a reduction capability of up to 300 mm & the reduction is done using anvils pressing the slab from either side.

ROUGHING MILL 1 (R1)

- ☐ Roughing Mill 1 is a 2 High Roughing Mill
- ☐ Both Top & Bottom rolls are drive by 2 - 3000KW Synchronous motors with separate Drives
- ☐ R1 has attached vertical Edger E1 (vertically Driven with separate motors of 1500 KW) with AWC (Automatic width control).
- ☐ Thickness 30– 60 mm
- ☐ No of passes: Min 1 & Max 3 passes

ROUGHING MILL 2 (R2)

- ☐ Roughing Mill 2 is a 4 High Roughing Mill
- ☐ R2 has Attached Vertical Edger E2 similar to E1 with AWC (Automatic width control).
- ☐ R2 having two works rolls and two back up rolls.

- ☐ R2 having two work rolls and two back up rolls.
- ☐ Roughing mill for effective slab reduction
- ☐ Roughing mill Top & Bottom work roll is individually driven by 2 - 3 phase synchronous motor that are 8000Kw each.
- ☐ No of passes: Min 3 passes (5 Passes Max 7 passes)

HEAT HOLDING COVER

- ☐ Heat holding cover is used to prevent Temperature loss from the transfer bar before material enters finishing mill stand.
- ☐ There are total 8 Heat holding cover.

Crop Shear

- ☐ Crop Shear is used to cut Head end & Tail end of the transfer bar.
- ☐ It consists of two blades
- ☐ Crop shear is driven by a 2500 kw motor

FINISHING SCALE BREAKER (FSB)

- ☐ FSB is similar to HSB, Descaling at FSB is done to remove the fine scale left or generated while rolling in RM by using 180 bar pressure waters.

FINISHING MILL (FM)

- ☐ FM is a Four High Non – reversing Mill
- ☐ It has total 7 stands
- ☐ F1 – F4 Pair cross technology
- ☐ F5 – F7 Work roll shift technology
- ☐ It has auto roll change using buggy

All 7 stands are driven by a 10000kw synchronous motor for each stand

Purpose of FM is to reduce the thickness of strip as per the customer requirements.

RUN OUT TABLE (ROT)

- ☐ Provide in between finishing mills and down coiler.
- ☐ ROT has 16 banks
- ☐ It is used for strip cooling purpose

- ☐ Strip coming out of finishing mill is at 850c-950c is cooled down to 150c-300c.
- ☐ Consists of water header for cooling at the top and bottom surfaces to strip
- ☐ Automatic cooling is done with respect to grade being rolled to achieve required mechanical properties.
- ☐ To move the strip the roller table is driven with 404 no. of 9KW motor

Down Coiler

- ☐ A down coiler coils the finished steel strip onto a high temperature mandrel.
- ☐ Totally three down coilers are there.

LITERATURE SURVEY

Hot Strip Mill (HSM) Cobble: Literature Review on Causes Related to Temperature Variation, Width Deviation, and Gauge Variation.

Temperature Variation as a Cause of Cobble

Temperature non-uniformity is one of the most cited primary causes.

Sources: Reheating furnace skid marks create cooler bands (differences up to 60°C across width). Uneven descaling, roll cooling, or inter stand cooling exacerbates this. Head/tail cooling during transfer also contributes.

Effects: Cooler edges/sections have higher flow stress → less reduction there → center waves or edge waves. This causes waviness, which propagates through stands, leading to buckling/cobble, especially in thinner gauges. High temperature variation (>20–30°C) correlates strongly with flatness defects.

Quantified Impact: In one study, reducing width-wise temperature variation from 25–30°C to 5–10°C (via furnace optimization, descaler, and roll cooling improvements) cut cobble rates by ~48%. Slab width temperature variation of ~60°C was directly linked to strip waviness and cobbles.

Related Mechanisms: Temperature affects scale formation (tertiary scale), which can influence friction and surface quality, indirectly contributing to tracking issues. Higher entry temperatures to finishing mill (>1070°C roughing) increase risks.

Modeling: Data mining (SVM for signal analysis, PLS, logit models) links temperature signals to cobble prediction. Multivariable control (AGC, looper, flatness) helps mitigate.

Mitigation from Literature: Uniform reheating, improved furnace zoning, edge heaters, precise descaling, and real-time pyrometry across width. Coil box technology retains heat uniformity.

Width Deviation and Its Role in Cobble

Width control is critical; deviations cause camber, steering problems, and side-guide impacts.

Causes: Uneven temperature (skid marks → differential contraction/expansion), poor vertical edging in roughing, roll wear, or tension issues. Patent literature notes skid-mark-induced temperature differences cause width variation at rougher delivery.

Effects: Width variation leads to camber (curvature in plane), causing lateral walk (strip tracking off-center). This results in edge buckling against guides, pinching in subsequent stands, or cobble. Thin strips and high speeds amplify this.

Interactions: Combines with temperature/gauge issues. Excessive transfer bar crown (from roughing roll wear) causes non-uniform elongation → buckling/cobble in F1 stand.

Control: Width meters, dynamic vertical roll adjustment, steering control techniques, and camber gauges in roughing. Load difference methods or vision systems for tracking.

Quantified: Even small offsets (e.g., 2mm guide misalignment) dramatically increase cobble risk, especially for thin gauges.

Gauge (thickness) variation interacts heavily with the above

AGC limitations, roll deflection/wear, temperature-induced flow stress changes, incoming bar gauge inconsistency, or looper/tension fluctuations. Load cell drift causes systematic bias.

Effects: Thickness spikes or wedge create differential elongation/loads → flatness loss or instability between stands. Bad flatness leads to cobble via loss of control. Low-thickness bars (<20mm in some contexts) are prone. Gauge affects bite conditions and friction.

Interactions: Temperature variation causes localized gauge spikes (cooler areas resist reduction). Width and gauge together influence profile/crown, leading to edge waves or center buckles.

Control: Advanced AGC (automatic gauge control), multivariable techniques, feedforward from upstream sensors, and profile/flatness models. X-ray gauges, profile meters.

Overall Interactions (Temperature-Width-Gauge): These form a feedback loop. Temperature drives property variations → uneven gauge/width reduction → shape defects → cobble. Data-driven models (SVM, ANFIS, etc.) predict risks from combined signals.

Additional Contributing Factors

Flatness defects in transfer bars, head-end curving, equipment misalignment, roll wear/spalling, looper failure, guide misalignment.

Process parameters: High speeds, thin gauges, chemistry (e.g., higher P/Si affecting scale/strength).

Detection: Mill signal analysis (forces, speeds, temperatures), vision systems, predictive ML.

Objectives

One of the major challenges faced in a Hot Strip Mill is cobble generation. A cobble occurs when the strip loses its intended path during rolling and becomes folded, twisted, buckled, or wrapped around mill equipment. Such incidents can lead to severe production losses, damage to equipment, increased maintenance requirements, safety concerns, and deterioration of product quality.

The occurrence of cobbles is generally associated with process disturbances such as thickness deviation, width variation, temperature imbalance, improper tension control, equipment malfunction, and guide misalignment. Since cobble incidents affect both productivity and operational reliability, it is important to understand the factors responsible for their occurrence and implement suitable preventive actions which reduces cobble.

Modern steel plants operate under highly competitive conditions where production efficiency and product quality are of utmost importance. Even a single cobble event can result in substantial losses due to mill stoppage, material wastage, manpower involvement, and equipment recovery activities.

As production targets continue to increase, maintaining strip stability throughout the rolling process becomes increasingly important. Understanding the relationship between process parameters and cobble formation can help operators detect abnormal conditions at an early stage and prevent severe operational disruptions.

Main Objective of the Study

The primary objective of this project is to investigate the causes of cobble generation in the Hot Strip Mill and develop effective preventive actions that improve strip stability, product quality, equipment reliability, and overall production performance.

Study of Cobble Formation Mechanism

The first objective is to understand how cobbles are generated during rolling operations. Cobble formation is often the result of a sequence of process deviations rather than a single isolated event.

A detailed understanding of the formation mechanism provides valuable information for implementing corrective and preventive actions before severe strip failure takes place.

Identification of Major Causes

Another important objective is to identify the factors that contribute to cobble generation. These factors may include:

- Thickness deviation
- Width variation
- Temperature fluctuation
- Excessive strip tension
- Guide misalignment
- Roll wear
- Hydraulic system instability
- Sensor inaccuracies
- Operational errors

Understanding the contribution of each factor helps prioritize improvement activities

Analysis of Thickness Deviation

Thickness control is one of the most important requirements for stable rolling. Excessive variation in strip thickness can cause uneven deformation and unstable strip movement.

This objective focuses on studying the influence of thickness deviation on strip behavior and determining how deviations from target thickness contribute to cobble formation.

The analysis also aims to identify methods for maintaining consistent thickness throughout the rolling process.

Analysis of Width Variation

Strip width plays a significant role in guiding the material through successive rolling stands. Variations in width can affect strip tracking and increase the possibility of strip wandering.

This objective aims to examine the effect of width variation on rolling stability and evaluate how improper width control contributes to cobble generation.

Analysis of Temperature Variation

Temperature directly affects the mechanical properties and deformation behavior of steel during rolling.

Non-uniform temperature distribution can result in unequal metal flow, shape defects, edge cracking, and strip instability.

The objective is to investigate the influence of temperature variations on strip behavior and identify temperature-related conditions that increase the risk of cobble generation.

Evaluation of Process Stability

Stable rolling conditions are necessary for continuous production and quality improvement.

This objective focuses on evaluating critical process parameters such as:

- Rolling force
- Rolling speed
- Strip tension
- Thickness control
- Temperature control

Study of Equipment Performance

The condition of mill equipment significantly influences rolling performance.

Components such as rolls, guides, loopers, sensors, hydraulic systems, and cooling systems must operate

correctly to ensure smooth strip movement.

This objective examines how equipment-related issues contribute to cobble incidents and identifies maintenance practices that can reduce failures.

Historical Data Analysis

Past operational data provides valuable insights into recurring problems and process trends.

This objective involves reviewing previous cobble incidents to identify common patterns, affected rolling stands, product categories, and operating conditions.

The analysis helps establish a factual basis for preventive action planning.

Assessment of Production Losses Cobble incidents often result in:

- Production interruption
- Material rejection
- Increased downtime
- Additional maintenance activities

The objective is to assess the overall impact of cobble generation on plant productivity and operational efficiency.

Improvement of Product Quality

Stable rolling conditions contribute directly to improved product quality.

This objective focuses on reducing quality defects associated with strip instability and ensuring consistent dimensional accuracy.

Improved quality enhances customer satisfaction and reduces rework requirements.

Development of Preventive Actions

One of the most important objectives of this study is to identify practical preventive measures.

Potential preventive actions include:

- Improved process monitoring
- Better thickness control
- Enhanced temperature management
- Proper guide alignment
- Routine equipment inspection

- Effective maintenance planning Enhancement of Operational Safety

Cobble events can create hazardous conditions for operating personnel and nearby equipment.

This objective aims to improve safety by minimizing emergency situations associated with strip breakage and instability.

Improvement of Productivity

Reducing cobble generation contributes directly to increased production output.

The objective is to enhance mill utilization by minimizing downtime and maintaining continuous operation.

Establishment of Monitoring Practices

Continuous monitoring is essential for early detection of abnormal process conditions. This objective focuses on establishing monitoring practices for:

- Thickness
- Width
- Temperature
- Strip tension
- Rolling force

Timely monitoring enables operators to take corrective action before a cobble occurs. Long-Term Process Improvement

The final objective is to recommend long-term improvements that support sustainable operational excellence.

These recommendations may include technological upgrades, process optimization strategies, maintenance improvements, and enhanced training programs.

Scope of the Study

The scope of this study is limited to the investigation of cobble generation in Hot Strip Mill operations. The study primarily focuses on the influence of process parameters such as thickness, width, and temperature on strip stability.

The work includes analysis of operational conditions, identification of root causes, evaluation of equipment performance, and development of preventive measures.

The study does not focus on metallurgical property development or downstream processing operations. Instead, emphasis is placed on rolling stability and operational reliability within the Hot Strip Mill.

Expected Outcomes

The expected outcomes of the study include:

- Better understanding of cobble generation mechanisms.
- Identification of critical process variables.
- Reduction in cobble frequency.
- Improvement in strip stability.

- Enhancement of product quality.
- Reduction in downtime and production loss.
- Improved equipment reliability.
- Increased operational safety.
- Better utilization of mill resources.

Conclusion

Cobble generation remains one of the most significant operational challenges in Hot Strip Mill production. Through systematic analysis of thickness deviation, width variation, temperature imbalance, equipment performance, and process stability, it is possible to identify the root causes responsible for strip instability.

The objectives of this study are directed toward understanding these causes and implementing preventive actions that enhance productivity, improve quality, reduce downtime, and promote safe operation. The findings of this study can provide valuable guidance for achieving stable rolling conditions and improving the overall performance of Hot Strip Mill operations.

Experimental Investigation

Introduction

The experimental investigation was carried out to understand the factors responsible for cobble generation in the Hot Strip Mill and to identify suitable preventive actions. The study was performed using actual production records, mill operating data, cobble incident reports, and observations collected during routine rolling operations.

The experimental work focused on examining these parameters under actual operating conditions and evaluating their effect on strip stability.

Experimental Setup and Data Collection

The study was conducted in the Hot Strip Mill during normal production operation. Data were collected from the process control system, production reports, shift logs, and cobble records maintained by the operating department.

The information collected for analysis included:

- Slab dimensions
- Entry and exit thickness
- Strip width
- Furnace discharge temperature
- Finishing temperature
- Coiling temperature
- Rolling speed
- Rolling force
- Stand-wise process data
- Cobble occurrence details

Data from both normal coils and cobble-affected coils were selected for comparison.

The collected data were organized and reviewed to identify common patterns associated with cobble incidents.

Experiment 1: Analysis of Thickness Deviation and Cobble Generation

Thickness records were collected from coils produced during the observation period.

For each selected coil, the target thickness and actual thickness values were compared. The deviation between the desired value and the measured value was analyzed.

Special attention was given to coils that experienced unstable rolling conditions or cobble incidents.

Observations

During the investigation, it was observed that coils with higher thickness variation frequently experienced strip instability.

In several cases, sudden thickness fluctuations caused uneven metal flow through the rolling stands. The strip movement became irregular and showed a tendency to deviate from the center line.

When thickness variation exceeded the normal operating range, strip control became increasingly difficult.

Discussion

Thickness deviation affects deformation behavior during rolling.

When one portion of the strip undergoes greater reduction than another portion, differential metal flow develops. This condition can create localized stress concentration and unstable strip movement.

As rolling speed increases, even small thickness deviations may become significant enough to affect strip stability.

The analysis showed that maintaining accurate thickness control is essential for preventing cobble generation.

Conclusion

The experimental observations indicate that excessive thickness variation increases the probability of cobble formation. Improved thickness monitoring and effective gauge control can significantly reduce strip instability.

Experiment 2: Investigation of Width Variation and Strip Stability

Width measurements were obtained from production records and compared with planned product dimensions.

The study included coils representing different width ranges and product categories. The movement of the strip through the rolling stands and guide systems was also observed.

Observations

Several cobble incidents occurred in situations where width variation was higher than expected.

In such cases, the strip did not remain properly centered during rolling. Lateral movement increased, and guide interaction became inconsistent.

Some strips displayed edge instability before the cobble event occurred.

Discussion

Width consistency is important for maintaining stable strip travel through the mill.

Variations in strip width may influence guide performance and affect the ability of the strip to remain centered.

As the strip moves through successive rolling stands, even minor deviations may become amplified, resulting in unstable strip behavior.

The investigation confirmed that proper width control contributes significantly to stable rolling operation.

Conclusion

The study demonstrated that excessive width variation increases the risk of strip tracking problems and cobble generation. Improved width control practices can enhance rolling stability.

Experiment 3: Effect of Temperature Variation on Cobble Formation Temperature data were collected from different stages of the rolling process. Measurements included:

- Furnace exit temperature
- Roughing mill exit temperature
- Finishing mill entry temperature
- Finishing mill exit temperature
- Coiling temperature

The temperature history of normal coils and cobble-affected coils was compared. Observations
Many cobble cases were associated with uneven temperature conditions.

Temperature differences across the strip width were found to influence deformation behavior.

In certain instances, strips with significant temperature variation showed unstable movement during finishing mill rolling.

Discussion

Temperature directly influences material plasticity and rolling characteristics.

When temperature is not uniform, different portions of the strip deform differently under the same rolling force.

This creates unequal metal flow and may lead to strip instability.

The analysis indicated that maintaining uniform thermal conditions is essential for preventing cobble generation.

Conclusion

Temperature variation was found to be a major contributing factor to strip instability. Improved temperature control can reduce the likelihood of cobble occurrence.

Experiment 4: Study of Strip Tracking Deviation Experimental Procedure

Strip tracking behavior was monitored during rolling operations. Particular attention was given to:

- Strip centering
- Lateral movement
- Guide interaction
- Looper performance

The observations were recorded for both normal and abnormal rolling conditions.

Observations

Before many cobble incidents, noticeable strip movement away from the center line was observed. The magnitude of lateral movement generally increased as the strip approached unstable conditions.

Discussion

Stable strip tracking is essential for smooth rolling operation.

When strip movement exceeds acceptable limits, the possibility of contact with guides and equipment increases.

Such interactions can initiate strip distortion and eventually lead to cobble formation.

Conclusion

Strip tracking behavior can serve as an early warning indicator for potential cobble events. Continuous monitoring can help operators take corrective action before severe instability develops.

Experiment 5: Root Cause Analysis of Cobble Incidents Procedure

A detailed review of recorded cobble incidents was conducted. Each incident was classified according to the primary cause.

The causes were grouped into three categories:

- Process-related causes
- Equipment-related causes
- Operational causes Findings

The analysis showed that process-related factors accounted for the majority of cobble incidents.

Among these factors, thickness deviation, width variation, and temperature fluctuation appeared most frequently.

Equipment issues such as guide wear and sensor malfunction also contributed to certain incidents.

Operational factors including delayed response to abnormal conditions were observed in a limited number of cases.

Discussion

The findings indicate that cobble generation is usually the result of multiple contributing factors rather than a single isolated issue.

Effective prevention therefore requires a combination of process control, equipment maintenance, and operator awareness.

Validation of Preventive Actions

Following the analysis, several preventive actions were introduced and evaluated. These actions included:

- Improved thickness monitoring
- Enhanced temperature supervision
- Regular guide inspection
- Sensor calibration
- Improved process parameter review

After implementation, rolling stability improved and the frequency of strip instability events was reduced.

The observations confirmed that preventive measures are effective when consistently applied during operation.

Summary

The experimental investigation demonstrated that thickness deviation, width variation, temperature fluctuation, and strip tracking instability are important contributors to cobble generation in the Hot Strip Mill.

Among the investigated factors, thickness deviation showed the strongest influence on strip stability. The study also confirmed that proactive monitoring and timely corrective actions are essential for preventing cobble incidents.

The findings obtained from this experimental work provide a practical basis for improving process stability, reducing production losses, and enhancing overall mill performance.

Experimental Report & Analysis Report

RD: 232802(171 slabs, 103.74 km)

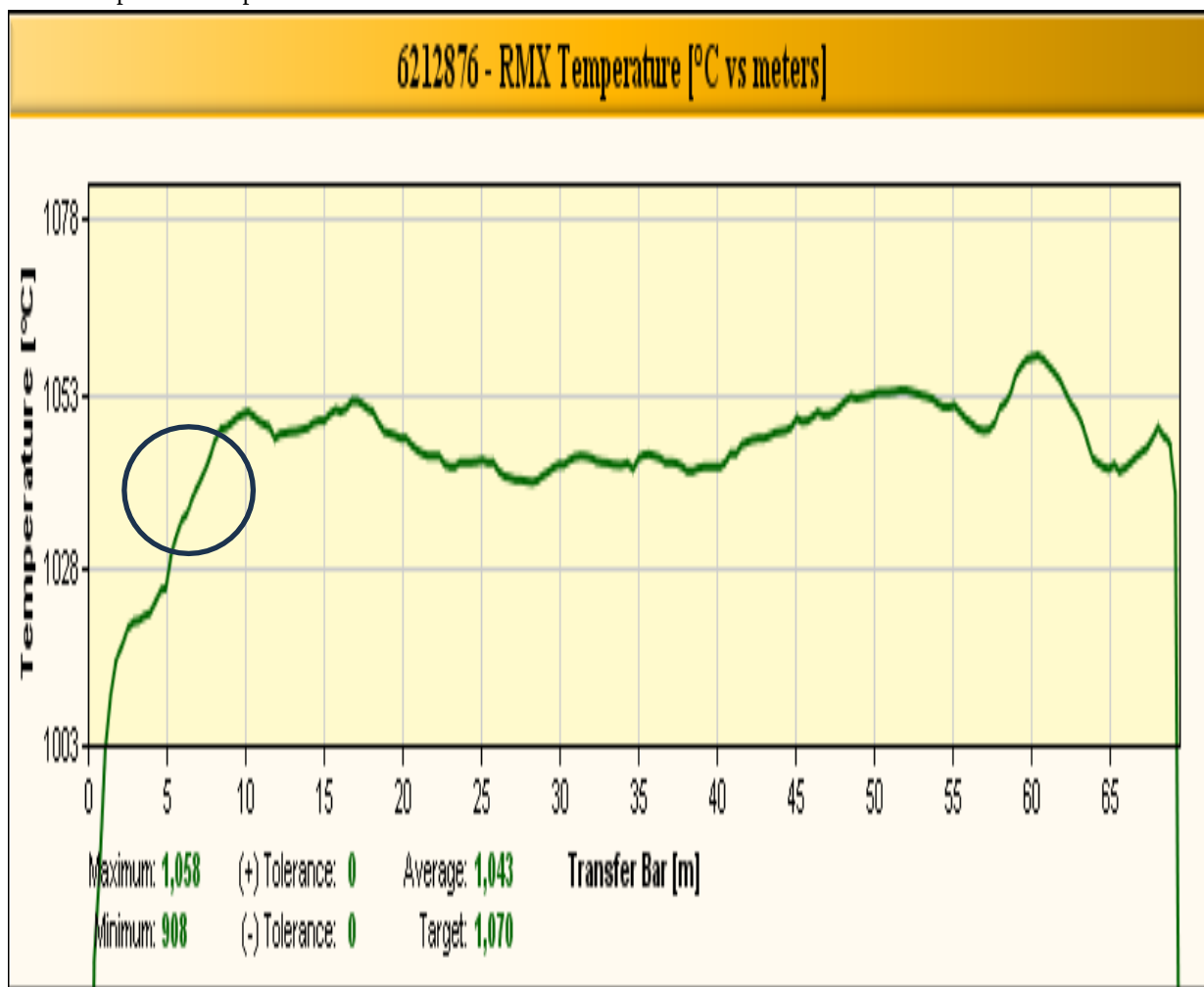
Cobble during the rolling of 232802047(JVHHTT1B10 3*1417)

Cobble due to HE hit to F6 entry center tong and material head end got fold.

Slab Discharging.



Temperature drop in head end.

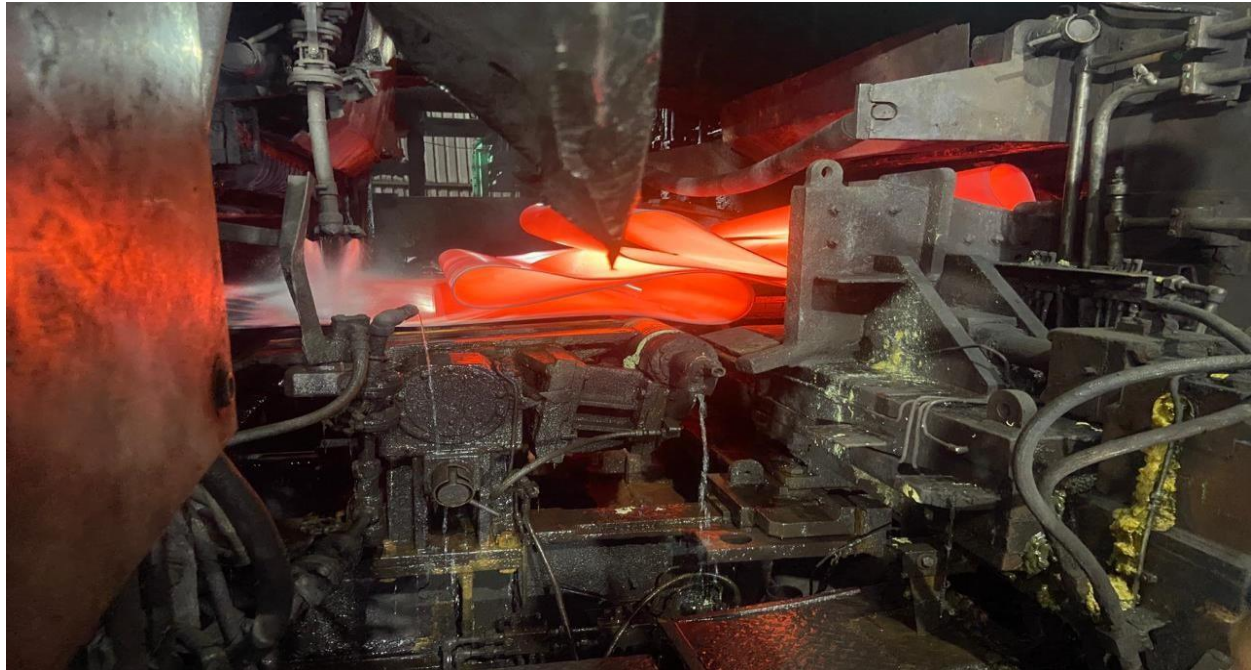


	Thickness [mm]	Width [mm]	Length [m]	Weight [kg]	FT [°C]	CT [°C]	Profile [μ]	Wedge [μ]	Flatness [μ]
Slab	220	1,495	8.83	22,640	-	-	-	-	-
PDI Aim	3	1,403	8.83	-	880	580	35	-	20
Coil Aim	3	1,417	-	-	890	580	-	-	-
Coil Actual	0	0	0	0	0	0	0	0	0
Furnace	1	Coiler	0	RM Descale	n/a	FM Descale	n/a		
SSP Draft	144	SSP FWD Press	24	SSP REV Press	0				
Coiler Residence Ref [sec]	180	Coiler Residence Act. [sec]	0	Fold Entry Flag	0				
Reject Reason	Cobble								

Finishing Mill Setup which is abnormal.

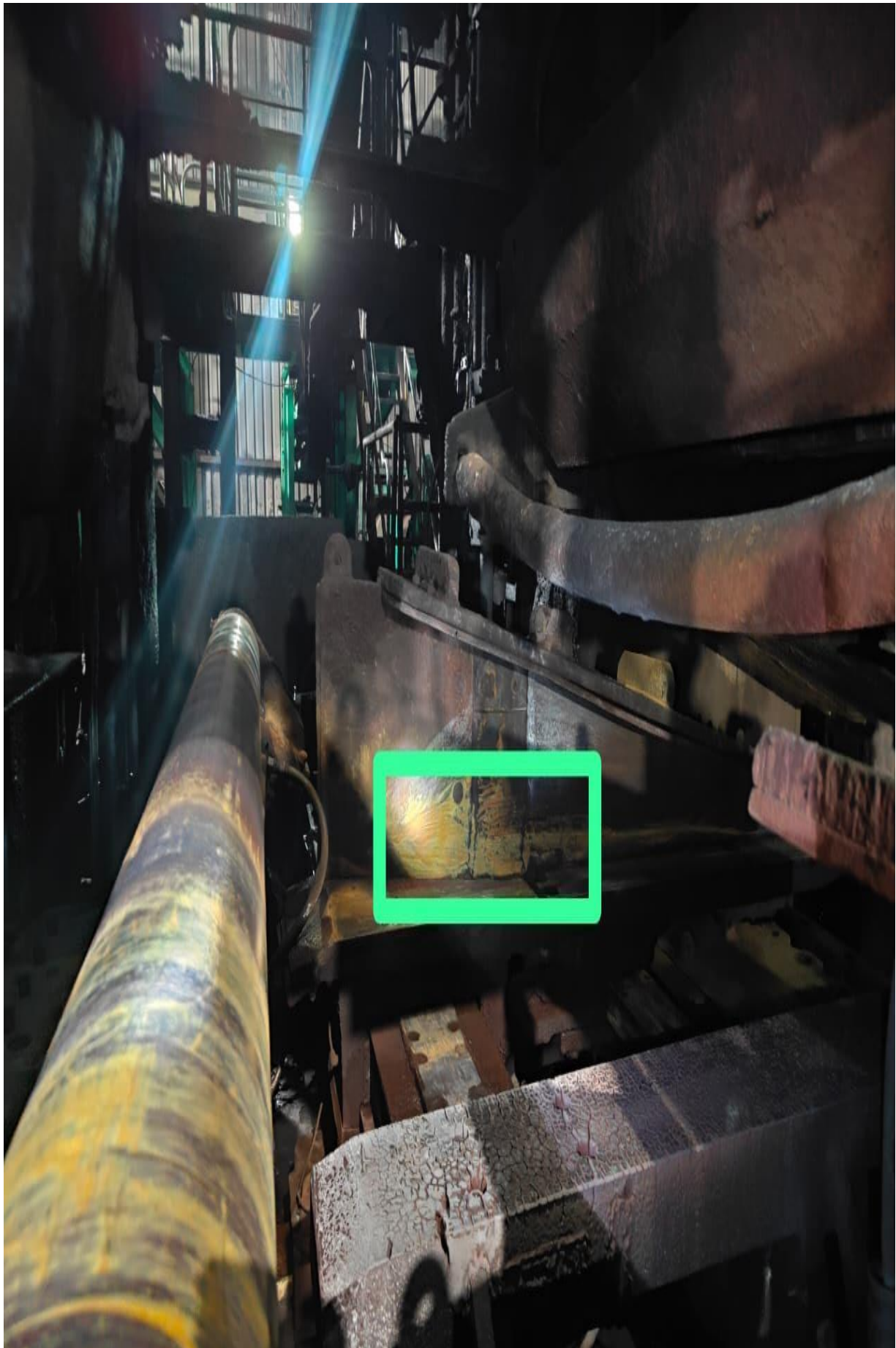


Cobble Material which stooped in Finishing Mill.

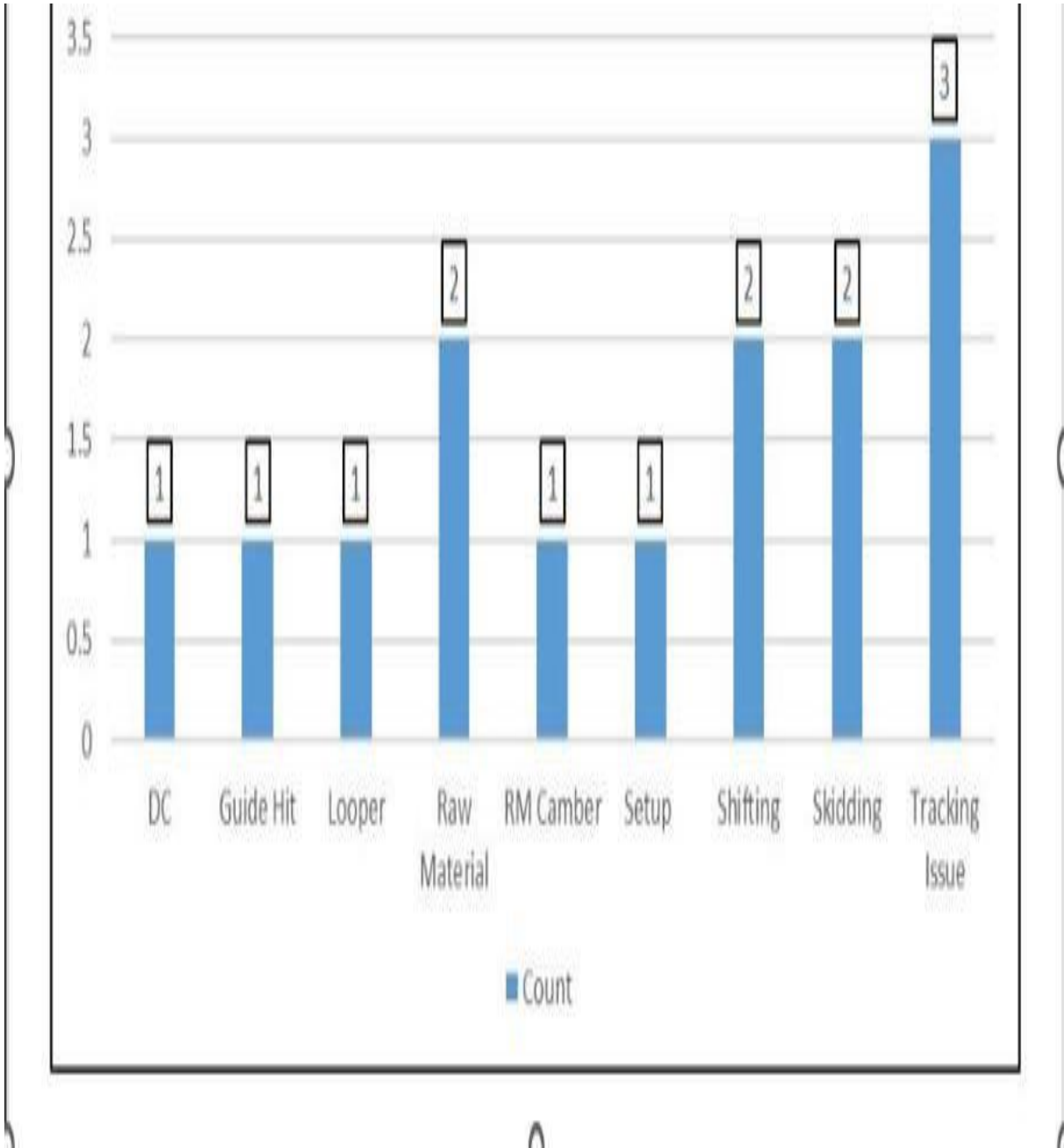


Miss Alignment in Guide





Cobble Graph



Cobble Analysis Report

Cobble Analysis								
Slab_id	Rundown_id	RHF	Grade	Thick (mm)	Width (mm)	Coil_id	Area	PMR Remarks
259380506	233532041	2	JVHDR03AS0	1.6	1264	7202792	ROT	CAMBER FROM FM
3203216206	233590076	1	JVHWA5A0S	2.4	1094	72027923	DC	DC COBBLE LOOP FORMED
3203119606	233612045	3	JVHC659N0S	2.8	1431	7202794	FM	SHIFTING F6 D/S, STRIP CHEW
3203181803	233614065	2	JVHIFFA00	3.3	1257	7202795	FM	MATERIAL HEAD END SHEARED
259531007	233619082	1	JVHCB03AE0	1.9	1100	7202796	FM	MATERIAL HEAD END SHEARED

Probable Cause
Material Head End Hit to ROT side guard & Loop formed in ROT as FM Camber observed at 82mm from F#7 So Q-Stop applied.
Material Head End hit to DC#1 unitroll#3 & Stopped due to previous Material tail end piece was stuck in the runit roll.
Material sheared from F#6 Stand due to shifting from F#5 as roll force was high.
Material sheared While shifting from F#6 - F#7 stand as reduction % was more in F#6 Stand as abnormal setup.
Material Head End Sheared from F#7 stand as looper#6 tension became '0' & raised angle upto 30 degree resulted in subsequent material shear.

CAPA
Level correction and adjusted done.
DC#1 Mandrel Dia increased from 752-769mm. Mandrel speed increased from 799Mpm-575Mpm.
Level correction and adjusted done.
Setup was modified.
FM Preferred thread speed changed from 580 Mpm to 600 Mpm & maximum speed changed from 640 Mpm to 680 Mpm. Looper#6 operating angle changed from 17 Degree - 18 Degree.

Major Reason	
Raw Material	DC 1
DC	Guide Hit 1
Shifting	Looper 1
Shifting	Raw Material 2
Looper	RM Camber 1
	Setup 1
	Shifting 2
	Skidding 2
	Tracking Issue 3
	Grand Total 14

Total Roll force:

F5 : 14685 to 15060kn F6 : 13041 to
 17228kn F7 : 12547 to 14513kn

Diff Roll force:

F5 : -337 to 137kn F6 : 187 to
 2187kn F7 : 375 to 1150kn

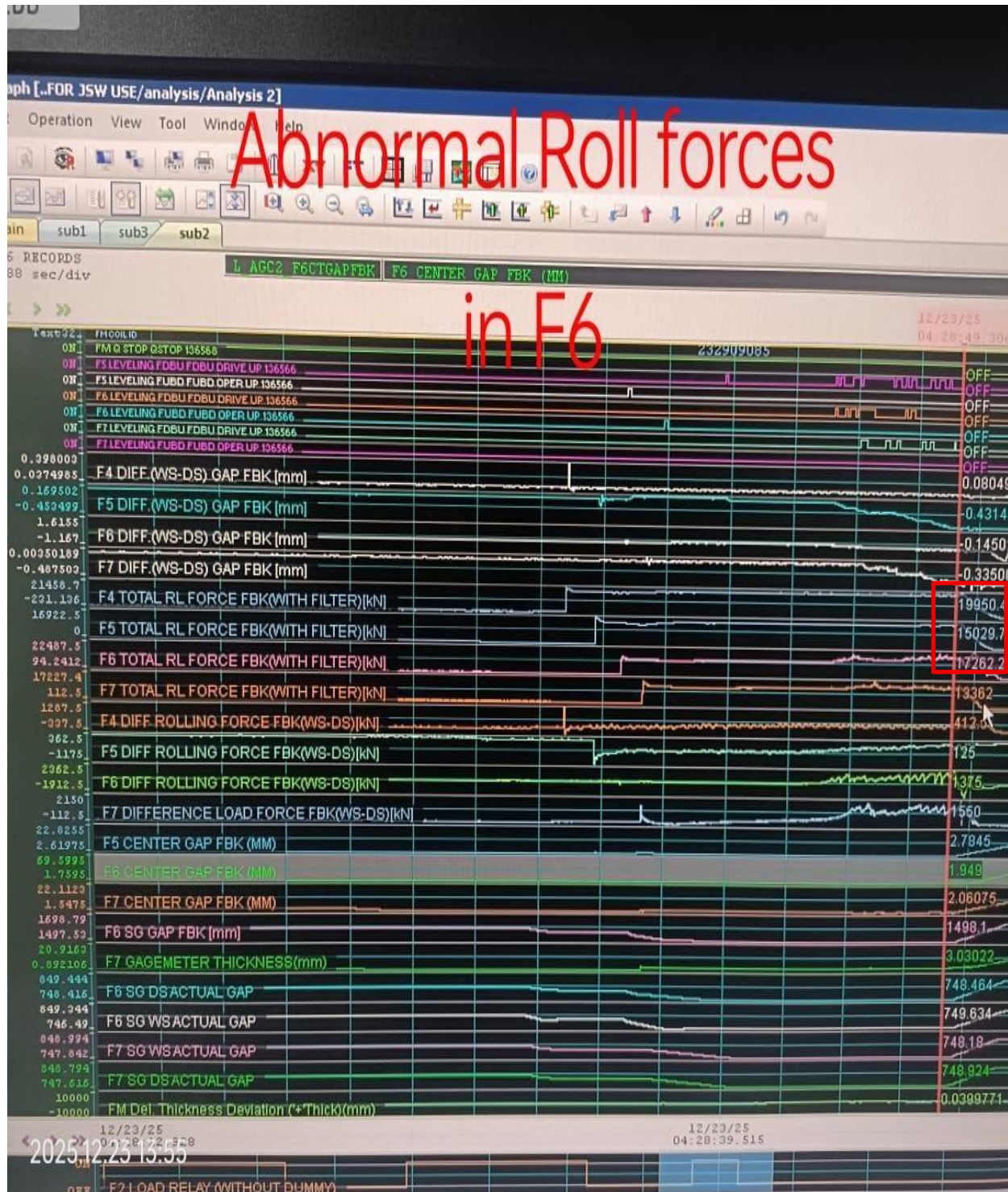
Diff Roll gap:

F5 : 0.10 to -0.15mm F6 : 0.09 to -
 0.27mm F7 : -0.06 to -0.26mm

Centre gap:

F5 : 2.84 to 2.75mm F6 : 2.69 to
 2.1 mm F7 : 2.15 to 1.93mm

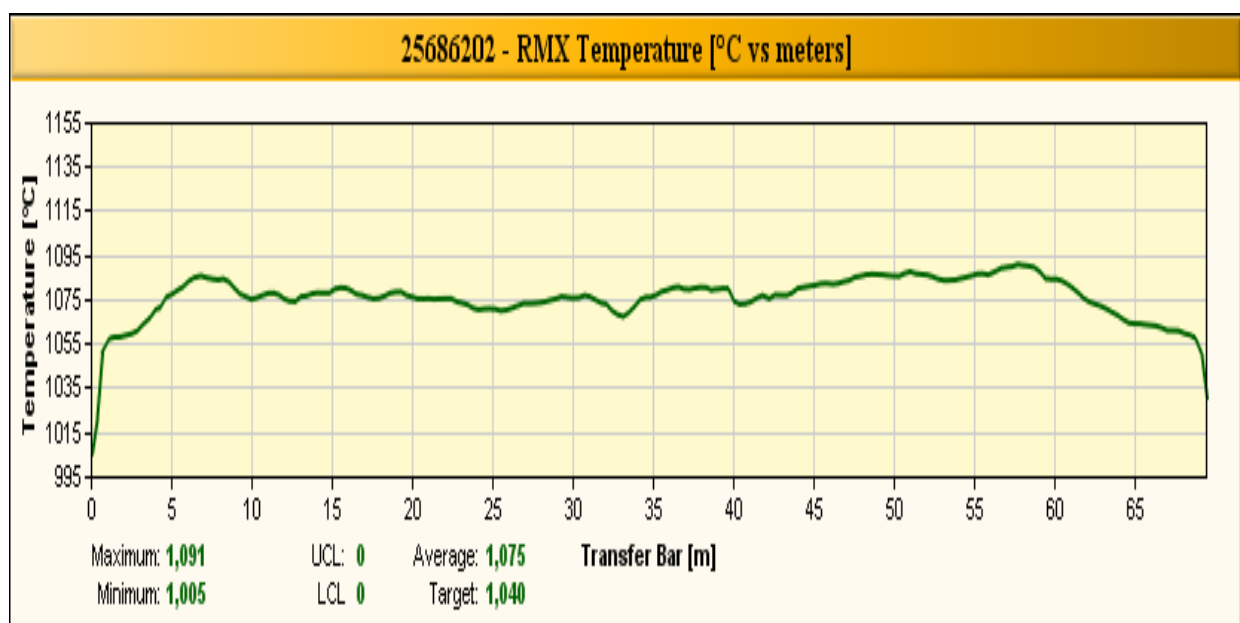
Level-2 Automation



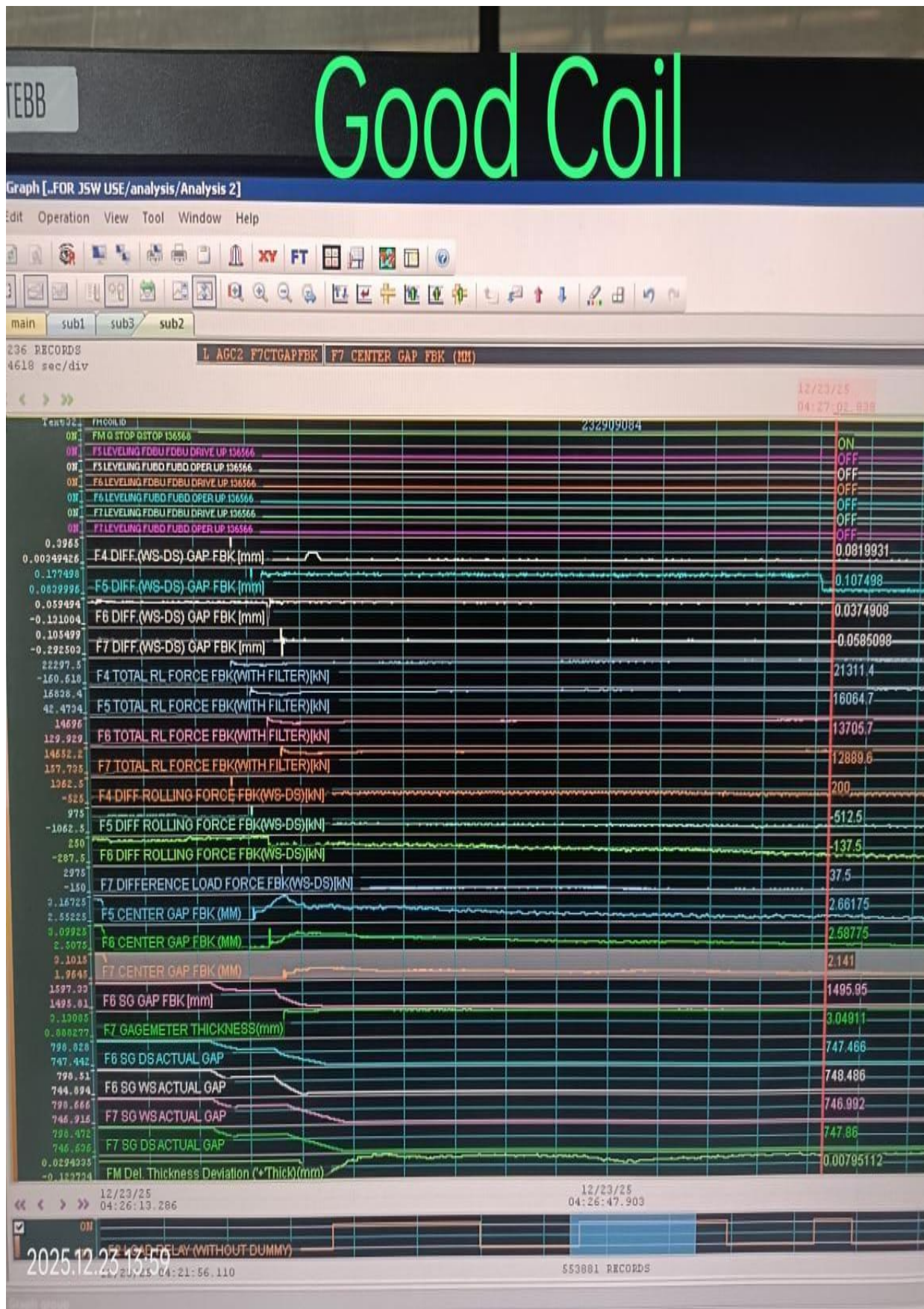
Comparison of Next Material (id-256862).

	Thickness [mm]	Width [mm]	Length [m]	Weight [kg]	FT [°C]	CT [°C]	Profile [μ]	Wedge [μ]	Flatness [I]
Slab	220	1,495	8.83	22,620	-	-	-	-	-
PDI Aim	3	1,403	8.83	-	880	580	35	-	20
Coil Aim	3	1,417	-	-	890	580	-	-	-
Coil Actual	3	1,415	664.43	22,620	886	579	86.435	27.859	30.084
Furnace	3	Coiler	1	RM Descale	12,1,1	FM Descale	123,		
SSP Draft	143	SSP FWD Press	24	SSP REV Press	0				
Coiler Residence Ref [sec]	180	Coiler Residence Act. [sec]	170						

Good Coil Graph



Level-2 Automation



Results & Conclusion

The study was carried out to identify the major process conditions responsible for cobble generation in the Hot Strip Mill. During the analysis, production records, rolling parameters, and process trends were reviewed. Special attention was given to thickness variation, width deviation, and temperature fluctuation because these parameters directly influence strip stability.

The collected data indicated that cobble generation is not caused by a single process parameter. Instead, it is the result of a combination of operating conditions that gradually reduce strip stability as the material passes through successive rolling stands. Whenever one or more critical parameters moved beyond the desired operating range, the probability of strip instability increased significantly.

Among the factors studied, thickness variation & temperature showed the strongest impact on strip movement. It was observed that strips having consistent thickness throughout the rolling process travelled smoothly through the mill without significant tracking issues. However, when thickness deviations occurred, uneven material flow developed between stands. This condition created variations in rolling force and strip tension, leading to unstable strip behavior. In several cases, excessive thickness variation resulted in strip wandering and eventually contributed to cobble formation.

The analysis also showed that width variation influenced strip guidance and edge stability. Strips with uniform width demonstrated better alignment and smoother movement through the mill stands. On the other hand, sudden changes in strip width created uneven load distribution across the strip. This caused difficulties in maintaining proper strip tracking and increased the chances of edge-related defects. In severe cases, width deviation contributed to strip instability and promoted cobble generation.

Temperature was identified as another important factor affecting rolling performance. The results showed that strips rolled within the specified temperature range experienced stable deformation and consistent material flow. However, when strip temperature dropped below the target level, rolling loads increased and material plasticity decreased. Such conditions made the strip more difficult to deform, resulting in shape defects, material skidding and unstable

movement through the mill. Temperature fluctuations across the strip width also created differences in elongation, which further affected strip stability.

The study further revealed that cobble incidents were more frequent during periods of process instability. Variations in rolling force, improper setup conditions, delayed process corrections, and equipment misalignment contributed to the occurrence of strip instability. In contrast, stable operating conditions resulted in smooth mill performance and significantly reduced cobble occurrence.

Implementation of preventive actions produced noticeable improvements in overall mill operation. Improved monitoring of rolling parameters helped operators identify abnormal conditions at an earlier stage. Better control of thickness, width, and temperature reduced process variation and improved strip stability throughout the rolling cycle. As a result, the frequency of cobble incidents decreased and product quality improved.

The results also indicated that regular equipment inspection played an important role in preventing cobble generation. Proper maintenance of guide systems, rolls, sensors, and cooling equipment contributed to stable rolling conditions. Mills that maintained equipment in good operating condition experienced fewer strip tracking problems compared to those operating with worn or misaligned components.