PERFORMANCE AT TERNIUM PLTCM PLANT*

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Abstract
The Pickling Line and Tandem Continuous Mill (PLTCM) at Ternium Pesquería Facility with a Five Stands, Six High configuration started in 2013. Manufactured by PRIMETALS, to produce steel to exposed automotive market, Turnkey project, with supervision of best practices from Nippon Steel. The main equipment that the process has are; Laser welding machine, 3 loopers, Scale Breaker, jet Pickling tanks, Inspection Station and COGNEX System Side Trimmer (flying width change), Type of Mill: UCMW(S) Carrousel, 2 Tension Reels. The principals goals are, Simulate production programs, validate materials for thin thicknesses before processing, low Re-welds, optimization use Cognex, good performance in Thickness, flatness and productivity.

Keywords: PLTCM; Simulate; Tracking; Inspection.

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1 INTRODUCTION

The preparation for the start-up of the PLTCM, a shadow training was carried out in related processes such as the Pickling and Tandem in Frio, similar processes were also visited outside the country, to strengthen the operative practices, there was special technical training for the Welder Laser and for Level 1 and 2 for automation.
For start of the PLTCM, the logistics of material accommodation, the arrival of material to the plant and how the programs should be lowered to avoid additional movement and to supply the entrance beam and give fluidity to the material were developed. A weekly plan was developed where priority is given to ensure quality for the automotive Exposed market, through the arrangement of campaigns, and quality validation before the Exposed process, having as pivot the Maintenance day, where there are tasks oriented to the assurance of the quality and preventive to critical equipment. Supply the entrance beam and give fluidity to the material.

The operational model of the PLTCM is based on prevention to ensure the quality and continuity of the process, the main concepts are defined in programming guidelines, to ensure continuity, a simulation of the production program to avoid problems of continuity and quality, an analysis of the conditions of the hot band that will be laminated to thin and ultra-thin thicknesses, a weekly preventive maintenance, respecting the recommendations of the equipment manufacturers, a follow-up to alarms.

2 MATERIAL AND METHODS

2.1 Programming guidelines

Rules of change of thickness <30%, width <100 mm and steel grade <100 Mpa up to 440 Mpa and in front of 200 Mpa.

Separation of Steel Groups (1), and division of thicknesses for bright rolls 5 to. Stand. Table 1

	Grado de Acero y Rango de Espesor
1	DQIF, DQ, DDQ, EDDQ.
2	CQ, 270BH, 340BH, 340IF y 390IF
3	Fosforo, CQBPMS, 340SS
4	390HSLA, 440IF, 440HSLA, DP590, DP780 Y DP980
	Espesor de: < 0.5 - 0.33 Con RODILLOS BRILLANTES
	Rango Espesor: <0.30 - 0.25 - 0.18 Con RODILLLOS BRILLANTES

Table 1 Groups of steel grades, for welding

This is for the order of programming to comply with the guidelines for welding by steel grade. The rule of thin thicknesses is for the use of bright rolls in Stand 5. Schematic diagram grades of steel figure 1.

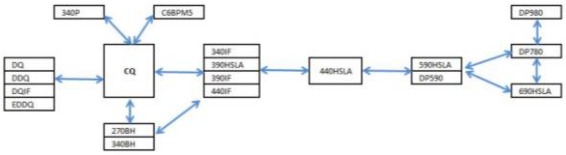


Figure 1. Schematic diagram grades of steel.

There is a Weekly schedule, where the start is marked on the Maintenance day, where it is prepared for everything to ensure the Exposed campaign, which is given regularly 8 hours after the start

There is a Weekly Programming, where the start is Campaigns are National Industrial Products, Automotive Exposed Products, Industrial Thin, Hard Structural and Industrial, Hard Not Exposed automotive, Ultra-thin, gauges, Phosphorus and Silicon Steel.

2.2 Program simulation

All production programs in the PLCTM are simulated. The main purpose of this is to foresee any violation of the programming guidelines, as well as any condition that could endanger the continuity of the process. The simulation tool uses Excel as an interface(2), as seen below, figure 2.

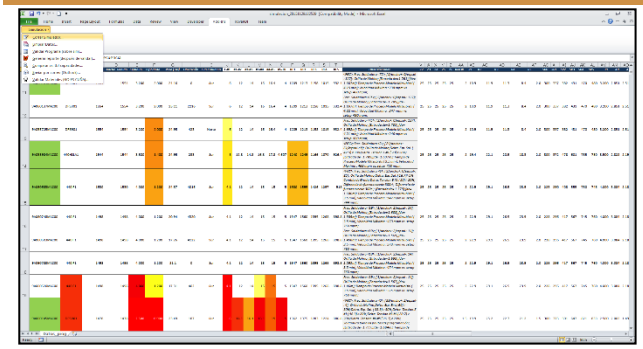


Figure 2. Example of simulated program

With the alarms detected in the simulation, adjustments are made (get a roll that eliminates the jump width, thickness, grade or tension or rolling forces) or changes in the order, or remove some rolls of the campaigns.

The simulator is run again, and validated, by agreeing Programming, Processes or Production. If look good we can already go down to the floor, with indications of alarms and even cases of having to go through a false welding (Soft Threading) because you do not have the right roll to give continuity in order, or remove some coils of the campaigns.

2.3 Analysis of hot band conditions Program validation of thin materials.

Before processing materials to thin of Hot Band 2.5 towards minor thickness are analyzed with this process, to lower the precise indications if it brings a significant defect that has to be taken into account in the PLTCM to avoid a strip break or mark the rolls.

The detections of the Parsyteck of the Hot Mills are taken into account, if you have observations the roll, if you pass to the skin pass and if there are changes in the meters the defects, and if they were cut there or not.

It focuses the distances along the coil, at what distance from the edge and the face in which they are.

And the observations of the coils that present some situation are lowered, in order to lower the speed in time and validate the observations, with the Cognex validate the gravity and in the inspection area, to take actions regarding the rolling that will be given, if it is at low speed or if it is decided to separate the defect in the Mill. (3)Schematic flow process to analysis figure 3

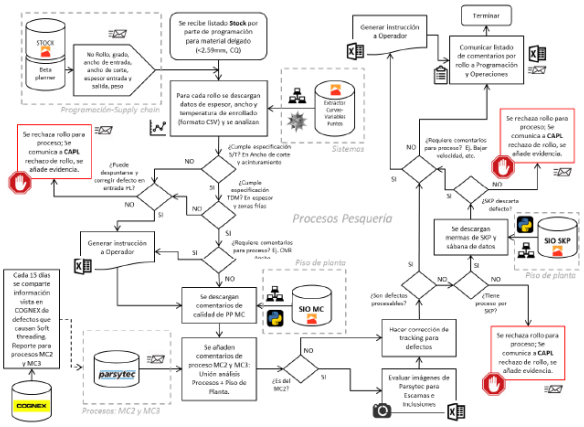


Figure 3. Flow chart for the revision process with thickness less than 2.6 of the hot band. It is a process that reviews 100% of the programmed coils and at the end the program is delivered to the operator with comments from each coil.

2.4 Automatic practice of drop-outs at entry (DAT's).

By means of a thickness table, steel grade widths and supplier, automatic trimming at the entrance is optimized. To ensure the Welding, due to problems of flatness, thickness and to avoid marks by stains in IF's materials

2.5 Control of variables in automatic. (Main tracking's from entry levelers, welder schedules, tensions across process, elongations, loopers, speeds, etc.)

The PLTCM is governed by a central system called HTCMD. This system is the intermediate layer between Ternium Systems and the PLCs. It is responsible for calculating each configuration and activating them in synchronization with line tracking. Each configuration has a series of variables that are extracted from predefined tables or calculated on the fly.

For the operation of Tracking there are 6 physical welding detectors and 18 via software through the process to ensure it. (4) Figure 4.

To make adjustments, operation screen is made manually figure 5.

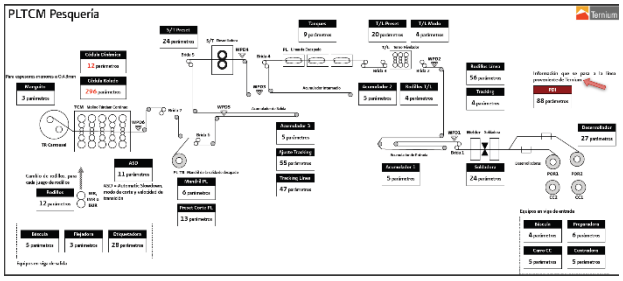


Figure 4. Shows each of the configurable devices and the number of necessary variables. The most complex configuration is the rolling configuration (it is calculated at least 3 times per coil).

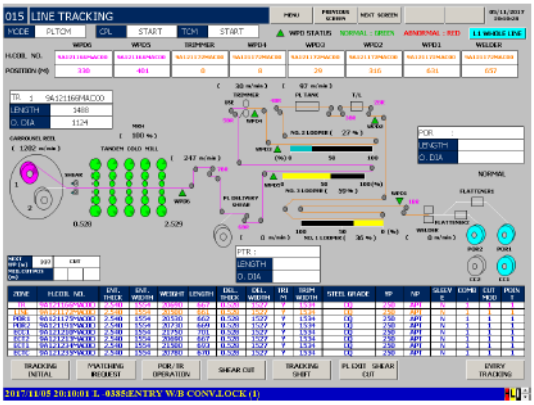


Figure 5. This screen is used to verify the tracking in real time and make corrections with the process in stopped

2.6 % Rewelds, in Lesser Welding Machine Miebach.

It has the monitoring equipment of welding on line that qualifies it, to define if it is sent or a Reweld is made, an additional test is carried out of stuffing on both sides every shift (8 hours) to validate that the team is rating the Welds well.

In the commissioning of the Welder, about 1000 welds were made, and several micro hardness tests were made through both materials and at the welding point, to determine the welding certificates, for the same grades of steel and for steels of different grade.

The technical support of Miebach was obtained for the validation of certificates and training in Germany and in the field during the commissioning.

To obtain a performance in Rewelds, all maintenance recommendations received by Miebach are followed up (5).

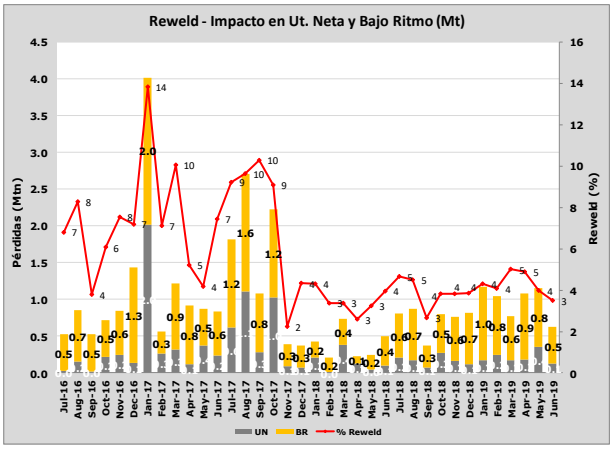
Weekly preventive, the most basic.
Validation of Calibrations related to Geometry. (Within tolerances religiously).

- Calibration of Tables to ensure a correct Gap between sheets.
- Calibration of height support discs, to ensure positioning in the vertical.
- Calibration of the Laser Trigger Point, Laser vs Gap between sheets.
- Adjustment of the nozzles that provide a Helium atmosphere on the weld.
- Cup tests.

Annual preventive,
General Review of Generators

- General Review of the or Transformer (Thermography and Valuation Review in HMI).
- Tubes "Tetrodes".
- Water Change of the cooling circuits Aluminum and Copper.
- Engines and Vacuum Pumps Revision and or Change every 2 years.
- Resonator, Check the condition of the quartz tubes that are not damaged.

It takes a rigorous indicator to see the impact on delays and low production rates and its loss in tons. Graph 1.



Graph 1. Impact of rewelds on delays and low rhythms of production.

2.7 Pickling Automation and Speeds by steel grade.

For the control of Concentrations of the Pickling tanks, it has in-line density meters that have a closed loop for the aggregates in automatic, it also has level control and automatically goes by pass by having delay and taking start 1 minute.

When restoring the flow to tanks, it is reversed a few meters and it is started again towards the exit to avoid staining.

According to the grade of steel, the speed limit in the pickling tanks is adjusted. Being the EDDQ, the most restricted in speed. Exit to avoid staining.

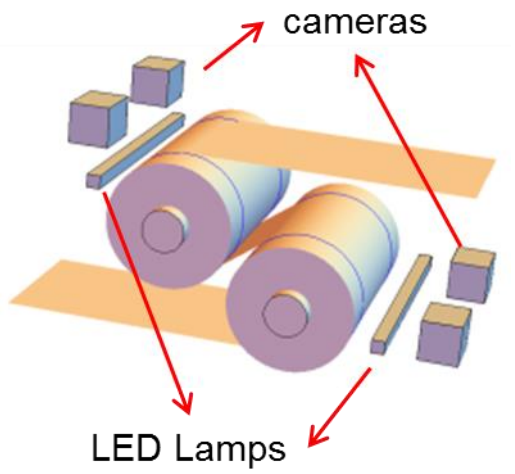


Figure 6. Schematic position of the cameras after pickling process, for inspection of the 2 sides.

2.8 Side Trimmer Control

In automatic, the speed is reduced before the weld arrives to the side trimmer, and according to the Equivalent Carbon the Gap and Lap are adjusted,

It has the automatic change of width in flight (FWC) if the change in width does not exceed 150 mm.

For changes greater than 150 mm. It is necessary to make a notcher before to arrive at the side trimmer to adjust the width.

Figure 7. Pulpit side trimmer with inspection zone.

2.9 Surface Quality Inspection (at Side Trimmer Pulpit)

There´s an automated surface inspection system located at the exit of the Pickling line Figure 6. Between this system and the side trimmer pulpit figure 7,(where the quality inspector is working) there's an intermediate looper, giving enough time to stop the strip at a desired position in order to be evaluated or inspected..

There is an audible alarm for severe defects that are validated and a catalog of defects with different colors to detect the most severe ones.

It has automaticity to lower speed according to the severity and also to stop the process before entering Tandem in Frio.

2.10 Cold Rolling Concept

All stands count Type of Mill: 6-High mill, UCMW(S) figure 8.

With this design the mill adjusts to the width of the strip, displacing the relief of the intermediate rolls, remaining close to the edge of the strip.

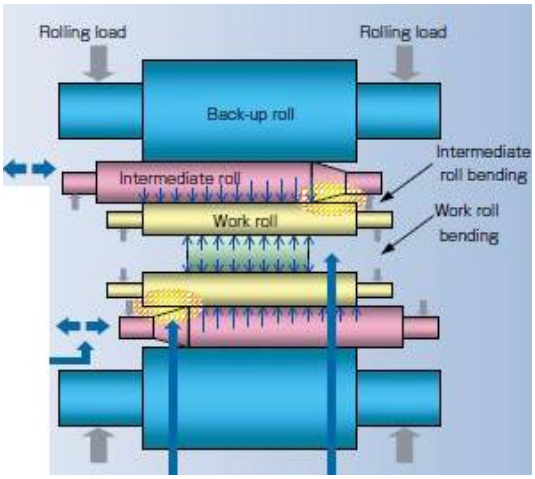


Figure 8. Schematic concept 6-High mill, UCMW(S) from PRIMETALS.

2.11 Control de Planeza

When it is rolled to the maximum width of the mill, the flatness is easier having results less than 10 Units I, in all stands account for the control with positive bending in the intermediate rolls, bending positive and negative in work rolls, and Tilting.
The function in automatic with Shape meter ABB has loop control with last stand bending in work rolls independent drive side and operator side and control tilting in the last stand too. Table 2.

With the automatic flatness control has the selective cooling to control the thermal expansion of the work rolls, flatness chart, figure 9, and example strip figure 10.

Flatness Tolerance

Material	Thickness [mm]	Flatness Tolerance [I-unit]
CQ, DQ, EDDQ, HSLA up to 390	0.18 ≦ h ≦ 0.30	8
	0.30 ≦ h ≦ 0.40	7
	0.40 ≦ h ≦ 1.00	6
	1.00 ≦ h ≦ 1.80	5
	1.80 ≦ h ≦ 3.50	5
HSLA up to 590	0.40 ≦ h ≦ 1.00	8
	1.00 ≦ h ≦ 1.80	8
	1.80 ≦ h ≦ 3.50	8
HSLA up to 780 HSS up to 980	1.00 ≦ h ≦ 1.80	9
	1.80 ≦ h ≦ 3.50	9

Table 2. Relationship of steel grades, thicknesses with the tolerances of plane that are obtained with the concept of Mill and its control developed from PRIMETALS.

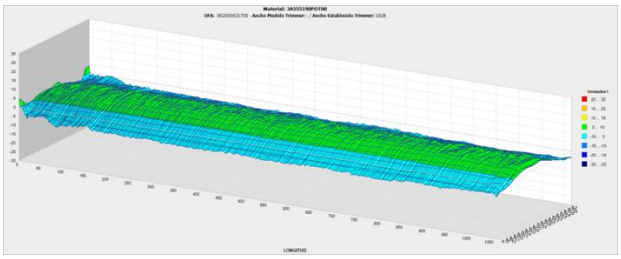


Figure 9. Flatness chart

Figure 10. Example strip flatness

2.12 Tandem Cold Mill Instrumentation

a) Entry Bridle rolls.

Maintains entry Tension to first Stand according to the tracking and has a preventive logic in case of variations to reduce the risk of strip breaks.

b) Strip centering device.

The steering rolls No.8 centers the strip with a maximum error of +/- 7 mm when left out the Mill protects and stops to avoid strip breaks.

c) Weld point detector 6.

Is used to control the tracking of the process the weld point detector No. 6 is the last one before entering the Tandem

d) Thickness gauges.

There are 1 before stand 1, after stand 1, after the stand 4 and 2 after the stand 5.

The last thickness gauge measures too. The thickness on both edges up to 150 additional thickness measurement at the center and has width measurement too.

The measurements of thickness in the edges is to use the Shifting of the work rolls of stand 1 and 2 to adjust the thickness in edges for the silicon steels.

e) Tension meters rolls (load cell).

There is 1 tensiometer before stand 1 and 4 more in each inter stand, and 1 more at exit of 5th stand.

The control of those tensiometers are from ABB.

f) Lesser speed meters.

There are 5 laser energy meters at the exit of each stand, are very important to close control to slip, Thickness, stable rolling.

g) Shape meter roll.

It is an ABB roll and the control acts in closed loop in stand 5, on the tilting and bending independent side operator and drive side and on the cooling of rolling solution of the 5th stand also.

h) Rolling force

To close loop control has pressure cell, roll Gap measurement and Bending force measurement.

2.13 Control Thickness.

The AGC control has;
Bisra, to first stand
Compensation of eccentricity to first stand.
Feed forward,
Mass flow,
Feedback,
Gauge meter
Acceleration and deceleration compensation
Automatic speed regulator
Automatic current regulator
Automatic Tension limit regulator
Automatic Tension regulator
Constant roll force control.

The tolerances obtained by this control is quite closed, we can see in table 3. Different steel grades end thickness.

Thickness Tolerance

Material	Thickness [mm]	Thickness Tolerance [+/−%]
CQ, DQ, EDDQ, HSLA up to 390	0.18 ≦ h ≦ 0.30	≦ 0.8
	0.30 ≦ h ≦ 0.40	≦ 0.7
	0.40 ≦ h ≦ 0.70	≦ 0.6
	0.70 ≦ h ≦ 1.00	≦ 0.5
	1.00 ≦ h ≦ 1.80	≦ 0.45
	1.80 ≦ h ≦ 3.50	≦ 0.45
HSLA up to 590	0.40 ≦ h ≦ 1.00	≦ 0.7
	1.00 ≦ h ≦ 1.80	≦ 0.65
	1.80 ≦ h ≦ 3.50	≦ 0.6
HSLA up to 780 HSS up to 980	1.00 ≦ h ≦ 1.80	≦ 0.8
	1.80 ≦ h ≦ 3.50	≦ 0.7

Table 3. Thickness tolerance defined by Hitachi/Mitsubishi

The AGC modes used have a stand configuration. The gains of the modes for each stand can be adjusted the keys are steel grade, thickness, width.
In case of any problem serious can be used conventional mode, while some adjustment is made figure 11.

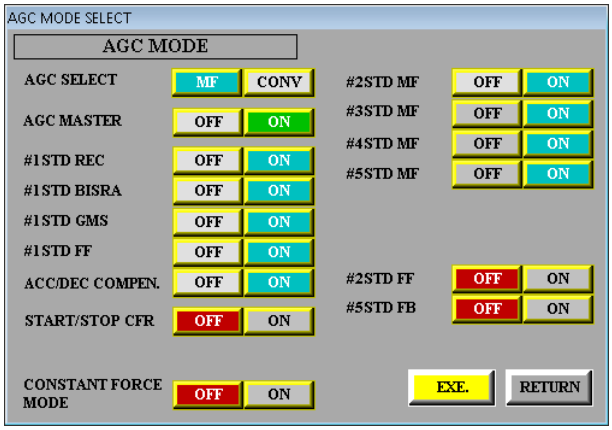
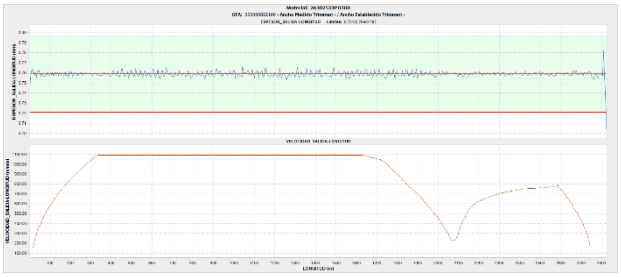


Figure 11. Example, Screen to select Automatic Gauge Control AGC modules (as seen by the operator).

The closed AGC control can be observed versus the specification limits of the customer order, Graph 2.



Graph 2. Impact of rewelds on delays and low rhythms of production.

To evaluate the thickness, there are rules according to the ranges of each manufacturing order and material that is outside the specification of the client is retained to be analyzed. Is given in figure 12.

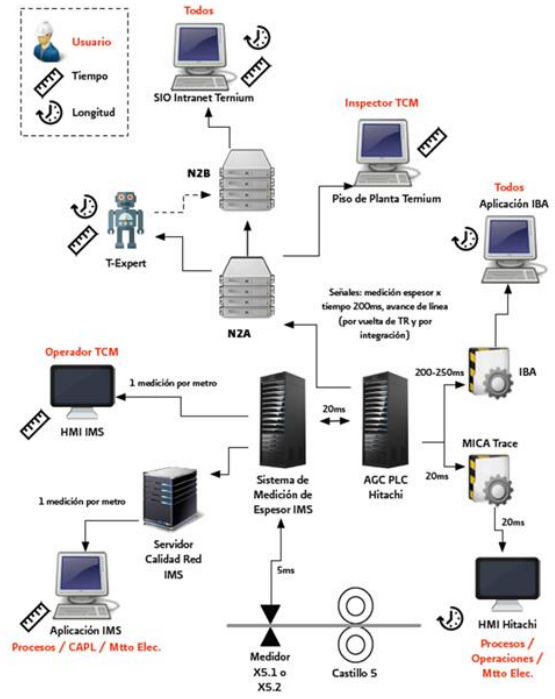


Figure 12. Schematic architecture of measure thickness (IMS), evaluation system T-Expert and Operators interface, in system Hitachi-Ternium. For detailed analysis we have the MICA Trace and the IBA Analyzer.

2.14 Rolling Schedule.

PLTCM has a Model for the set point of Rolling Schedules, it is adaptive and it learns and make corrects, make the most of the installed capacity to maximize productivity. To give maintenance of validates the behavior of parameters it is almost not necessary to make small adjustment at K constant model.

Only changes have been made in extreme products such as those in hard degrees and in high reductions, they are adjusted in tables, reductions, tensions and some values of bending and the Model learns and the standard is saved.

As soon as the coil is place at entry walking beam, a setup is calculated in order to verify all coil variables are in order. When the coil is welded, the setup is calculated again and it is stored at the PLC Memory. When the coil touches the first stand, real process data is sent to the HTCMD, so it could make corrections if needed.

In operation only some fields (black) can be moved, for adjustments of tables and other parameters only since level 2 can be made, all change is stored the original data and the changed value, figure 13 shown one schedule.

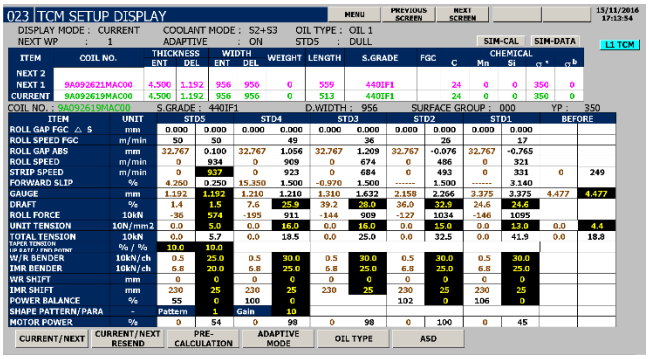


Figure 13. Example rolling Schedule. On the screen the current schedule is shown, the values of the set point and the real values, the schedule of the next coil can be adjusted before the Tracking arrive a certain distance from the Mill.

2.15 Surface Quality Inspection PLTCM exit.

At the Exit of the TCM, 1 in 4 coils is inspected. Once laminated, the coil is transferred to an inspection TR/table. The surface (both sides) is stoned in order to exposed hidden defects (the personnel were trained by Nippon Steel). Figures 14 y 15.

Afterwards, the inspector submit his evaluation of the inspected coil at the Ternium Intranet, and the system acts accordingly.
All the information is available at the intranet Figure 16.

Figure 14. Operator stoning the bottom side to reveal defects very important practice to evaluate superficial quality for automotive market.

Figure 15. Operator stoning the top side to reveal defects.

Seven levels are handled in surface quality, up to level 3 is acceptable for exposed and up to 5 for not exposed.

With the inspection it is decided to send the material to subsequent processes. If there is a mark its development is measured and there is an automatic calculation with the diameters of the rolls to determine where the mark comes from, to change or clean the roll.

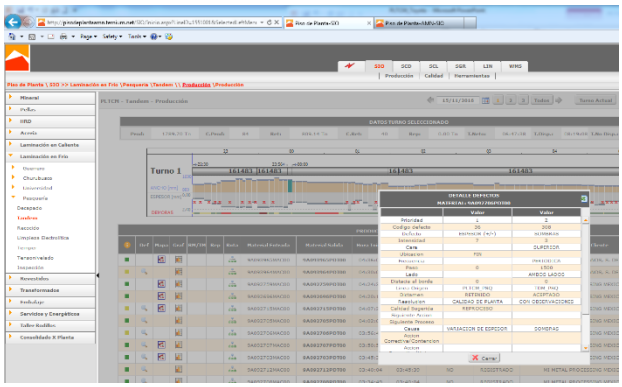


Figure 16. Example of quality related comments for a coil

3 RESULTS AND DISCUSSION

The main objectives of the PLTCM, low quality claims, low level of breakages,
Increased Process continuity and high productivity (Table 1).

Table 1. KPI´s PLTCM Ternium Pesquería

.KPI´s/year	Quality Deviations %	% Total Delays	Production MTons	Strip breaks, #/1000 coils
2015	0.72	71.1	1,177	
2016	0.59	69.7	1,392	3.5
2017	0.47	72.1	1,468	2.5
2018	0.43	72.2	1,557	1.5

4 CONCLUSION

Processing exposed automotive material, requires great discipline.

Cleaning the equipment every week, quantify the action of each machinery to respect the recommended preventive, give importance to the alarm events that throws the system, as alert to probable failures, continuous inspections of maintenance personnel.

Have always identified some fault in the sensors and keep the 237 automatic sequences operative.

The planning of the campaigns in order and quantity ensure more the quality of the product.

The review of the simulation of the program avoids risks in quality, breaks and ensures more the continuity of the process.

Acknowledgments

We recognize a great order in the commissioning by the technicians of Mitsubishi – Hitachi.

The tests for operational adjustments of the process, very objective and with small adjustments, achieve the expected results.

Good training and technical support for the Rolling model.

Level 2 very user friendly process control with options to adjust for the entire range of products, new products and test with different lubricants, so that the model learns with other lubricity.

Good training in best practices, with Nippon Steel and work together Mitsubishi - Hitachi TERNIUM, and Nippon Steel to

improve them, until the final acceptance test.

REFERENCES

1 Internal information, Development of standard practices of Ternium Mexico" Author(s). F.D. Rodriguez, C. Gómez de la Garza, J. Salinas Aug 2013.

2 Internal development. Offline program guidelines simulator: Author(s). Carlos Gómez de la Garza 2015.

3 Continuous improvement project Operational stability in thin gauges: Author(s). Carlos Gomez, Jorge Ramirez, Jorge Salinas 2016.

4 Operating manual, PLTCM Mitsubishi Hitachi:

5 Commissioning tests welder machine Miebach: Christian Garcia, Jorge Ramirez, Edgar Garza 2013.