OPTIMIZATION OF THE USE OF TENSION LEVELER ROLLS (SCALE BREAKER)*

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Abstract
ArcelorMittal's pickling and cold rolling line has been demanded to increase production since the installation of equipment in 2015. In addition to improving productivity related to these new equipment, several additional jobs were planned and executed on equipment already installed has been carried out in order to improve the efficiency of the line. The present work exposes what was done in the scale breaker (tension leveler) to improve the availability results of the section and consequently of the line.
Keywords: pickling and cold rolling; scale breaker; automation; setup.

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1 INTRODUCTION

The ArcelorMittal Vega Strip and Cold Rolling line, built in 2003 with capacity for 880,000 tonnes of flat steel per year, has been receiving constant investments to increase its production capacity. In 2010 the installed capacity was raised to 1,440,000 tons per year with the installation of drum shear and second tension reel at the exit of the Cold Rolling Mill (LAM). As early as March 2015 the fourth acid pickling tank was installed, raising its capacity to 1,600,000 tons per year [1]. However, some additional work was planned on specific equipment already installed, seeking further results, in this study it was identified that the scale breaker (Tension leveler), equipment that is installed before the pickling tank and that is part of the coupled line of pickling and tandem cold mill rolling (PLTCM) as shown in figure 1, could contribute with the results the line providing greater productive times.
To reach this objective, a work group was assigned to work with a focus on reducing unproductive time due to exchange of cassettes of tension leveler without this action influencing the quality of the product.
The tension leveler aims to improve flatness by applying elongation in the material according to figure 6, using combined tensile stresses with simultaneous use of the leveling and bending unit as represented in figure 3, where the plastic deformation occurs "Zhai R discuss that [2] External plastic deformation and internal elastic deformation ".
The equipment also performs the breaking and partial removal of the oxide layers present on the surface of the material according to figure 4 and 5, applying combined efforts, this characteristic of using typical hybrid tension and bending loads, which are the different combinations of tension and bending during the bending deformation involved in this process [2]. The oxidation present on the steel surface is more fragile when compared to the raw material (steel), for this reason during the application of the combined forces it fractures opening cracks and partially detaches from the base metal facilitating the work of complete removal of the oxidation in the next process, the chemical pickling.

The group created had the attributions of actions mapping, quantification of its effect on the key indicator and the conduction of the projects necessary to reach the established goal.
Old condition, need for line stops for changing the rolls and cassettes of the tension leveler according to figure 2B, causing an average unproductive time in tandem cold mill of approximately 1.5 hours per month.
The need to increase production of PLTCM encouraged the search for new developments, this occurred at a time where also occurred the growth of production of HSS and AHSS in the production line, materials with specific needs and higher load on the tension leveler and its elements (support rollers and work rolls), thus, after a future evaluation of criticality, we identified that the equipment would tend to generate even more unproductive times due to these new load demands.

2 MATERIAL AND METHODS

To allow the quantification of the gains of each mapped initiative and the correct management of resources to prioritize the ones with the highest results, the following KPIs were defined.
KPIs:
- Tandem cold mill stop time (h);
- Campaign mileage for tension levelers (Km).

PLTCM line specific data:
- Speed in the pickling process (maximum speed of 200mpm);
- Laminator input speed (limited to 210mpm);

The pickling and lamination line is a coupled line according to the layout of figure 1.

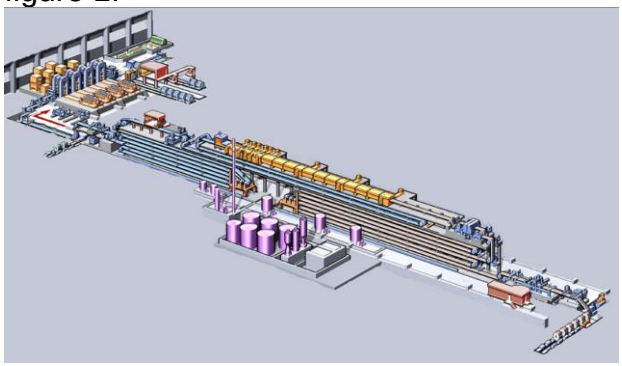

Figure 1: Layout of PLTCM and Tension leveler (scale breaker) point installation.

In the survey, we identified an average of 1.41 hours of tandem cold mill stoppages due to the exchange of work rolls and tension leveler cassettes for various exchange reasons, such as scheduled exchange, exchange for Oiled coils campaign, exchange for opportunity and finally exchange for quality events.
Based on this, an internal group of critical points was created, evaluating ideas, possibilities of installation, complexity and costs involved. Based on this the team drew up a separate action plan in three different main actions with two distinct objectives termed these as "Action" but developed in parallel.

- Action 1, with the aim of making the use of bending units of tension leveler more flexible;
- Action 2, with the purpose of adjusting the mileage of the rollers according to the usage demand (load);
- Action 3, in order to eliminate or minimize the need to change rolls with stopped line.

The previous situation, it is necessary to stop the section and consequently the line to realize the exchange of the three units (two of bending and one of leveling).

- Exchange for Oiled coil production: oiled coils production has direct shipment to customers and does not go through the cold rolling process (decoupled line).
  Previous situation, oiled coil material programmed on specific days, but work rollers of the bending units of the tension leveler were already well used, due to possibility of quality issues, we performed the exchange of the bending units in order to avoid any use mark.
- Exchange for opportunity: Realization of roll and cassette exchange during events beyond the tension leveler as tandem cold mill backup roll exchange.
  - Previous situation, change the rollers with little use and without defects, eventually away from the mileage limits in order to avoid a future stop to change the units, thus underutilizing the rollers and cassettes.
- exchange of rolls for quality events: frequency small of events.
  - Previous situation, Section stops to exchange rolls and cassets shortly after event identification.

2.1 Flexibilize the independent use of bending units.

Previous situation, the system had as premise the constant use of all units of tension leveler, using then two units of flexion (bending) and one of leveling of integral form.
In this way, to make feasible to use the tension leveling with only one bending unit in operation and a leveling unit, in order to make the use the more flexible, allowing the use of the equipment in a new and broader way, reducing punctual demands that were necessary in the previous operating condition.
The first analysis needed to assess the extent of application of flexibilization was to identify the behavior of the equipment in

the processing of various materials and dimensions in which the tension leveler was underutilized in the load term available during product processing (operated with low torque loads). After assessing the distribuitions of load by material and dimensional, we identified a considerable portfolio of products that the tension leveler would make the demands without many difficulties with only one unit of bending, in contrast a small percentage of product would have the effective need of full use of the units as HSS materials (DP780, 590, 500, 450) of medium to high cross section and all AHSS (Usibor, DP980, Trip 780, 690) independent of the cross section.

Tests were programmed and executed only with a bending unit according to image 02, in the selected materials, in addition, the other necessary point was the adjustment of bending transpassive (overlap) during the tests, necessitating a revision of the table of presets for a distribution of loads between the input and output of the equipment. In this way it was clear that the equippament was able to perform the work without impact on the equipment or product as planned, according to the real example indicated in figure 8, where a condition of using the Tension leveling with only one unit of flexion and one of leveling (interface screen of the human machine).

Note: AMV had the layout of only one unit of bending and one of leveling from the start in 2002 until 2014 where we installed the complementary unit (bending unit 1) for full use (three units together) in all products and dimensional to allow the production of HSS and AHSS materials, according to figure 2A.

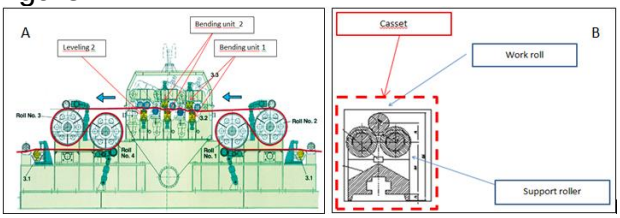

Figure 2. A) Simplified stretch bending unit layout with 3 units (2 bending and 1 leveling) in operation. B) Drawing of mounted casset of tension leveler.

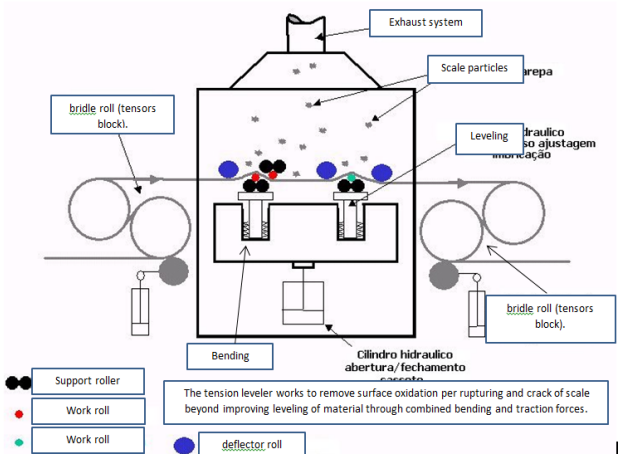

Figure 3. Simplified drawing of bending and leveling unit in work.

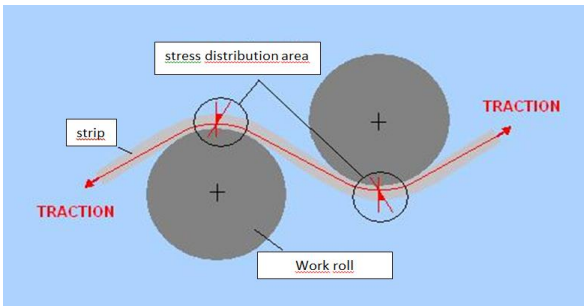

Figure 4. Simplified drawing of bending unit in work with flexion and stress distribution on material.

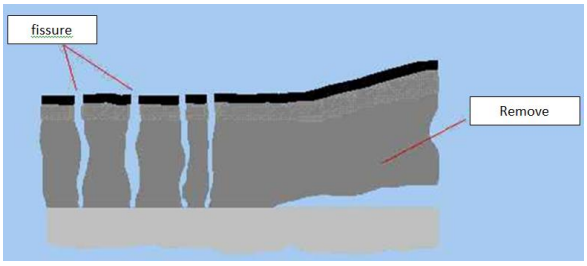

Figure 5. Simplified drawing of effect of combined forces in surface oxidation.

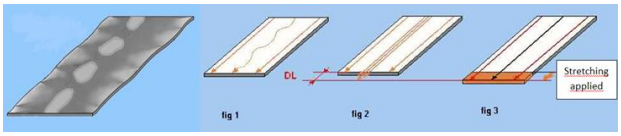

Figure 6. Simplified drawing bad flatness generalized before the tension leveler and the future flatness correction representation.

2.2 Adjust the mileage of the working rollers of the leveling according to demand of use (load).

The previous situation, the work rolls and the support rolls installed in cassettes of tension leveler figure 2B, had all the limiting isometric ranges to programed exchange, independently of utilization

position (leveling or bending), even if the loads were notoriously different between the leveling units and the bending units. This situation forced us the exchange the leveling unit ever when we exchanges of bending units, something that reduced the flexibility and consequently diminished the potential of the others improvements (previously listed actions).

The demand of this action was to adjust the mileage of the work rolls of the leveling unit, with the purpose of avoiding underutilization besides in parallel to enlarge the exchange window of the same, reducing the demand of exchange of the same,

Objective, to increase the rate of utilization of the rollers of the leveling unit and to enable its exchange always within the opportunities. We have seen through the grinding history that rollers used in the bending positions suffered greater wear compared to the rollers used in the leveling unit, another important point observed was that when there were premature wear events of the work rolls, this always occurred in the positions of bending which showed a greater work load on them.

Note: bending units use transcend (overlap) of up to 40mm already in the leveling unit this overlap rarely exceeded 6mm.

In this way we developed a usage test plan to apply to the leveling unit, raising the utilization rate according to a test plan. The results obtained showed that even with twice the mileage of the bending units, the leveling rolls did not present significant wear, making possible of changing them at scheduled stops without impacting the indicators.

Currently we have the standard leveling unit with utilization rates targeted at twice the mileage of the bending units.

Note: The implementation of items 2.1 and 2.2 made it possible to increase the average mileage of the work rolls of the leveling and bending units shown in figure 7.

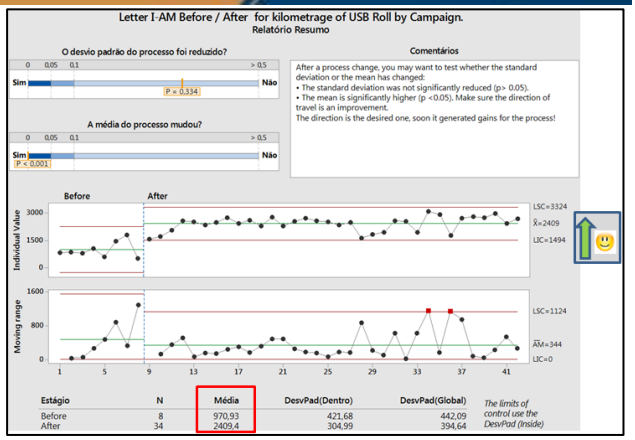

Figure 7. Increase the average kilometer of the tension leveler rolls (km).

2.3 Enable the exchange of the tension leveler units with the section running (bending unit).

Previous situation, exchanges only with section stop.

In this action the search for the feasibility of exchange of rollers and cassets of the tension leveler (bending units) with section running (full operation), aiming at reducing unproductive times by exchanges and also making available the conditions of use of rollers and cassettes as close as possible of mileage limits defined in the standards.

Objective, to develop method and conditions of change of the units of tension leveler, only if the premises of safety, quality of product and non application of overload (torque) on the equipment were met. Based on these premises a fully internalized technical staff was created with specialties of safety, quality, mechanical maintenance, electrical, automation besides the involvement of technicians and operation specialists.

Critical points of the project were analyzed and afterwards the development of meetings seeking the solution of each critical point, seeking to make feasible the activity, we saw the possibility of performing tests in three different phases for validation as detailed below.

2.3.1 – Realization of exchange of cassettes and rollers with stopped section, using remote control of the swap car and simulation of running line conditions (signal simulation only) to evaluate the

effectiveness of the changes created in software programming. This was the second phase of the project that consumed most hours of work, second only to the idealization and software modeling phase.

2.3.2 – Replacement of bending units with section at a slow speed (10mpm), evaluating safety conditions, performing radius of action studies of moving parts, lighting systems, operational training, interlocks, mechanical locks, distances between the moving belt and the surfaces of the work rolls which were inserted transversely to the movement of the strip. Tests performed were promising and safe, indicating feasibility of implementation.

2.3.3 – Realization of exchange of bending units with section at normal process speeds. After the validation of phase 2.3.2, we programmed several tests with follow-up and the results were again promising and after several exchanges with follow-up the phase was finalized and approved.

Figure 8 shows the real condition of using the tension leveler operation with only one bending unit and one leveling unit.

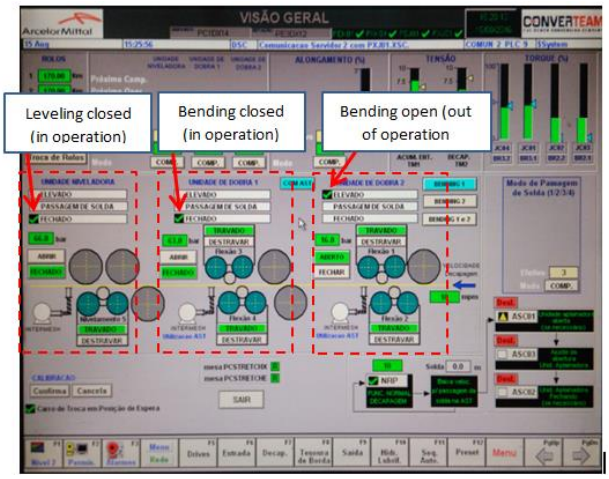

Figure 8. Interface human machine with only one bending unit in operation.

Note: the implementation of actions 2.1, 2.2 and 2.3 together made possible the improvement of unproductive times by exchanging elements of the tension leveler according to figure 9.

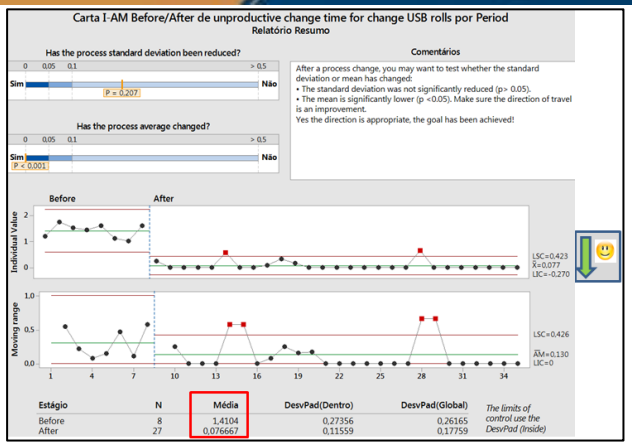

Figure 9. Unproductive time due exchange rolls of tension leveler.

2.4 Complementary gains not measured or treated in this article, but also suffered improvements in operational condition.

These works have also brought additional gains in other points not covered in this article, such as:

2.4.1 Reduction of the demand for labor to exchange the elements. Due to higher utilization rates, the exchanges of rolls or cassettes became less frequent, so less exchange rate.

2.4.2 Optimization of resources (manpower and cranes). Previously the exchanges were made during exchange backup roll of tandem cold mill, in this way the operators divided the cranes with the line entry maintenance activities and the activity of dryer roller exchange of pickling section. Today, due to the flexibility of the exchanges and the possibility of exchanging with a rolling section, this activity is completely independent and can be programmed according to need and availability, maximizing the use of the available resources (manpower and cranes).

3 RESULTS AND DISCUSSION

The projects conducted over the last few years to reduce the impact on unproductive times caused by roll and cassette exchange of tension leveler, showed that we obtained an average increase in time available for production in the pickling and lamination line of 1.31 hours / month, while actions aimed at maintaining the rolls of work and their cassettes, produced an increase in use per campaign of 148.15%.
These results also brought gains not measured in this article but informed in item 2.4 where the demand on labor and cranes were minimized and today can be adjusted according to the availability of the same ones.

4 CONCLUSION

With the integrated work of specialized internal teams and the use of internally developed tools and resources, ArcelorMittal Vega has been achieving results to increase the productivity of the pickling and rolling line by increasing the operational condition of the equipment by providing new means to perform tasks, thus increasing the availability of the equipment. So the main objectives identified at the beginning of the planning of reduction of unproductive times by exchange of rolls and cassets and the increase of the rates of utilization of the rolls of work were reached.
We also identify the evolution of the team involved that, with the support of the management, has been seeking new limits, breaking paradigms always working together for the developments, in this case the areas of operation, maintenance, quality and safety.
The factory has been able to produce without decreasing quality and safety since the implementation of the new methods, leading to rapid preliminary and final acceptance of the operation, maintenance and quality teams.

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