AUTOMATION OF THE OPERATION OF THE HOT-STRIP LAMINATION WORKING CYLINDER TRANSPORT DEVICE*

Ismael de Souza Dias[1]
Aloizio Cesar Gonzaga[2]
Gladston Santos[3]
Leandro de Paula[4]
João Junio Pereira Lino[5]
Danilo Deon do Nascimento[6]
Aline de Cássia Araújo[7]

Abstract

Looking for greater competitiveness, Gerdau started in 2013 the operation of its hot strip mill in Ouro Branco, being a milestone in Gerdau's history, where it definitely entered the flat products business. This mill consists of the reheating furnace, primary scaler, a Duo-reversible Quadrupole Steckel mill, accelerated cooling and final coiling. The Steckel mill works with two backup rolls and two working rolls, the backup rolls being responsible for supporting the rolling forces and the working rolls for shaping and surface quality to the strips, having as main requirement quality of surface finish. These rolls suffer high wear due to the lamination process and are exchanged with high frequency to ensure the quality of the laminated strips, after the exchange are sent to the Work Roll Shop for grinding and are positioned Grinded work rolls for the next planned change. This movement is accomplished through the crane and an exchange device that attaches to the cylinders to be transported from the Rolling Mill to the Work Roll Shop. The target in this article is focused on an improvement in this Device to increase operational safety and reduce stoppage losses downtime at the mill, improving the cost / benefit ratio and increase production.

Keywords: Hot Strip mill; Steckel mill; Work Rolls; Roll change; Lifting Tong

[1] *Senior Mechanical Technician, Senior Technician of Roll Shop. Hot Strip Mill of Gerdau Group, Ouro Branco, MG, Brazil.*
[2] *Mechanical Technician , Full Technician of Roll Shop, Hot Strip Mill of Gerdau Group, Ouro Branco, MG, Brazil.*
[3] *Mechanical Technician IV, Technician of Roll Shop. Hot Strip Mill of Gerdau Group, Ouro Branco, MG, Brazil*
[4] *Technical Electrical Maintenance II, Electrical Maintenance Plans. Hot Strip Mill of Gerdau Group, Ouro Branco, MG, Brazil.*
[5] *Mechanical Engineer, Master in Materials Engineering, Production Coordinator, Hot Strip Mill of Gerdau Group, Ouro Branco, MG, Brazil*
[6] *Production Engineer, Postgraduate in Project Management, Roll Shop Coordinator, Hot Strip Mill of Gerdau Group, Ouro Branco, MG, Brazil*
[7] *Trainee of Metallurgical Engineering, IFMG, Hot Strip Mill of Gerdau Group, Ouro Branco, MG, Brazil*

1INTRODUTION

One high quality strip means precision metallurgy, high strength and hardness with alloy addition levels that keep costs down and preserve weldability. It also means maintaining a precise thickness over the entire width as well as consistent flatness to ensure proper adjustment when the plate is being used. For the successful hot strip mill, the rolling mill is more than just the laminating chairs. Auxiliary processes, especially cooling and straightening, are vital for the quality and control of the process. In addition to operations and engineering, there is a business - a business that involves some of the most critical security applications and the most demanding customers in the industry. [1]

In the Hot Strip Lamination process, the slabs are cast in the steelworkers with the dimensions previously calculated according to the customers' needs are laid in a reheating oven, heated to a temperature of approximately 1200 ° C and hot rolled in the rolling mill Steckel Quadruo Duo-Reversible, which Works as rougher and finisher mill at the same time, dividing the lamination into two distinct phases, with its own controls and characteristics. This mill works with four cylinders, being two bacup rolls and two work rolls. The back up rolls have the main function of support the high rolling loads caused by the reduction of the thickness of the plate. The work rolls are in direct contact with the heated plate and its main function is to give shape, dimension and surface qualities to the laminated strips. [2]

The work rolls currently used in the rolling mill are delivered, mounted on their bearings and rectified by the Workshop. The work roll campaign is determined by the production mix according to customer demand. This average campaign, keeps the mill in operation for approximately three continuous hours. The capacity of the hot strip mil is requires that are necessary around 07 work roll changes per day.

The change of the work rolls is necessary due to the superficial wear of the and the wear due to the thermal rolling cycle that promotes surface microcracks in the cylinders. It is necessary to interrupt the productive process so that they are replaced, causing directimpact on the production volums of the line. This work roll change was designed to be automatically and to delay among08 or 09 minutes per change. In ours process the change still does not occur completely automatically, requiring the manual intervention of the operators in some steps of this activity. This projects are being developed to eliminate or mitigate these steps. After the rollers are changed in the mill, it is necessary to remove the used work rolls of the mill and send them to the workshop to be grind and to position a new pair of grinded work rollswith the ideal conditions of operation as a spare of the mill. In this specific activity, a potential of gain with the reduction of losses times and steps of the task through improvements on the device of change of the cylinders was identified.

The project is focused on changing the work rolls to increase the availability of the mill to the production process by eliminating the timelosses to remove the used cylinders and positioning the new onesin the rolling mill side shift car. To make this movements with the work rolls, the transport device is used; figure 1.

The device, internationally known as Lifitng Tong, was designed, developed and supplied by the hotstrip mill manufacturer exclusively to perform this activity. In many integrated designs, these devices are developed with automatic systems, by PLC or by remote control, where there is no manual interference in the operation of the equipment. In this case the crane is automatic and incorporates Siemens CNC technology for all positioning movements of the bridge, trolley and lifting device, with a fully integrated PLC board in the numerical control system, which manages all transducers installed [3]. This model served as a reference for the development of the project aimed at reducing human activity at the device interface.

2 MATERIALS AND METHODS

The task of removing used cylinders and positioning of newwork roll in the swap car is executed by the operating team, with the help of a 125-ton crane and work roll exchange device, Figure [1];

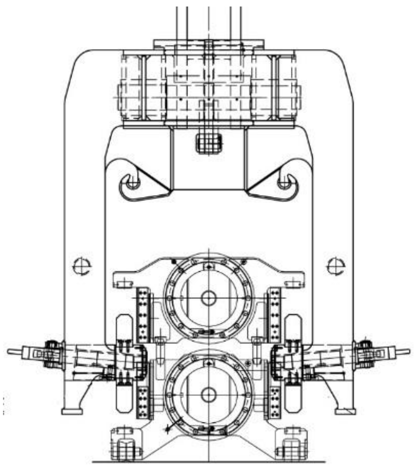

Figure 1 – Work Roll change Device

This device was supplied together with the rolling mill design, and its operation is completely manual, requiring human intervention on the four points to insert or extract the pins on the Work roll chocks. This activity generates two production stops between 2 and 4 minutes each, for the consignment of the laminator and access to the restricted space of the Safet Concept to make the manual coupling of the transport device in the cylinders. Due to the high number of daily exchanges, a cumulative monthly average around 800 minutes of operational stops was generated.

The project consists of automating the transport device allowing the operator to coupling the device through a hydraulic system, figure [2], remotely activated, giving conditions make the activity at a safe distance without needing to access the restricted space and do not consign the mill to do the withdrawal and positioning of the work rolls on the side shift car.

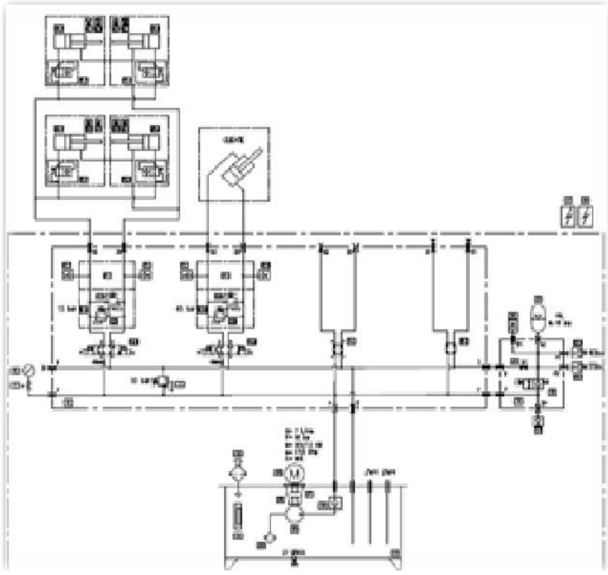

Figure 2 – Hydraulic diagram installed on the transport device

2.1 Fast Tool Exchange Methodology

The Fast Tool Change Systems methodology, whose main objective is the reduction and simplification of setup, analyzes the methodology proposed by Shingo (1996,2000) called the Single Minute Exchange of Die, freely translated by TRF foe tasks who takes times down 10 minutes. According to Shingo (1996,2000), the process of improvement in the proposed tool change time consists of four stages shown on the figure 3. [5]

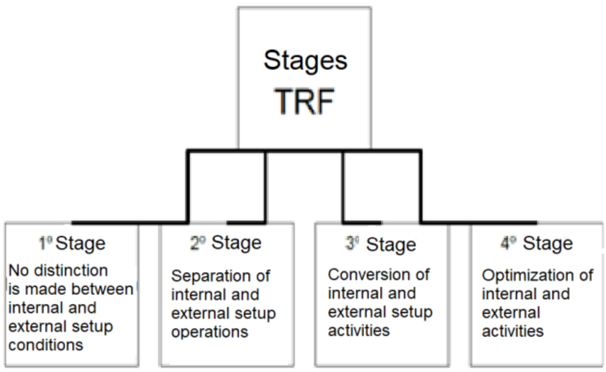

Figure 3 - Representation of the four stages of the Shingo TRF methodology.

In the first stage, the main objective is to analyze the current setup operation, with the participation of the operators involved in the study preparation. In the second stage, which is considered the most important of the TRF implementation, the distinction between internal and external setup operations takes place. In the third, an analysis of the setup operation is performed, with the purpose of verifying the possibility of converting internal setup operations to external, that is, the setup conversion may occur. In the fourth stage, an analysis of each action of the internal and external setup operations is performed, seeking its rationalization by eliminating setup adjustments and operations. Thus, from these stages it is clear that the TRF is composed of two main actions, analysis and implementation, emphasizing the distinction between the internal and external setup operations and the rationalization of the component elements of the setup actions.
Based on the method and concepts of TRF, the problem analysis was done through the 5W1H diagram and a discussion of Brainstorming to propose ideas, solutions and analyze the feasibility and safety of these solutions.
After conducting the analysis of the process, the action plan, which is a set of countermeasures with the objective of blocking the root causes, should be established. For each countermeasure in the action plan, the 5W1H must be defined. What (WHAT) will be done, WHEN will be done, WHO will do, WHERE will be done, WHY will be done, HOW will be done and what will be the cost?. [6]
The PDCA methodology [7] was used to develop the project and plan its execution according to the diagram below. Figure 4.

Figure4 – PDCA Cycle

2.1.1 **Step P -Plan**

Target Setting: Reduce the total working cylinder change time by an average of 5 minutes, eliminating the stops for moving the carriage cylinders.
Problem analysis: Stopping is caused because the operator needs to access the restricted environment of the laminator's Safety Concept to manually attach the Swarf Device pins to the Work Cylinders.
Identification of causes: To access this restricted environment, the laminator can not be in operation, it is necessary to consign the laminator to allow the opening of the gate.
Elaboration of the action plan: A case study of success was done in other companies and units where this device exists with hydraulic and automatic drives. Figure [5]

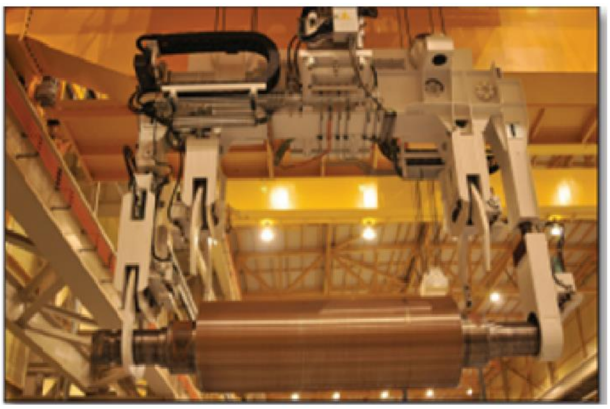

Figure 5 – Lifting Tong Pomini Tenova

A company with knowHow in hydraulics and automation was sought in the market. Together with the technical team involved in the project, the supplier developed the hydraulic drive system by remote control. It was carried out the purchase of the system according to the specification and within the current norms and planned the assembly and installation of the components in the device, according to the schedule.

2.1.2 D – Do

The assembly was executed according to the correct schedule in preventive stops and at times of availability of the transport device, during the routine, without impacting the rhythm of production of the mill. The system was designed to operate during the process of moving the cylinders with a battery that has the capacity to keep it running for the time needed to move the cylinders, and a pressure accumulator was installed to keep the pressurized system during the entire operation. In each hydraulic cylinder, end-of-stroke positioning sensors were installed to indicate to operators that all the pins were inserted in the chock holes, ensuring the operational safety of the device and the employees. A ball-and-socket system, was designed and manufactured to allow the hydraulic cylinder to have a pendulum movement which would be required and a inclinated shim with a 4 degrees, because of the inclination in the pins, to allow the hydraulic cylinder to work linearly in advance and return.

3 RESULTS AND DISCUSSIONS

During a period of 5 months, more than 4000 minutes of stops were registered and around 1700 occurrences of stops registered in the system SCP- Stop control system for the movement of cylinders of the carriage of the rolling mill.

Among the several stops that generated a great loss in the volume of production, there is the stop to exchange the Side Shift cylinders, factors east, which contributed to reduce the productive capacity of the mill. Figure 6.

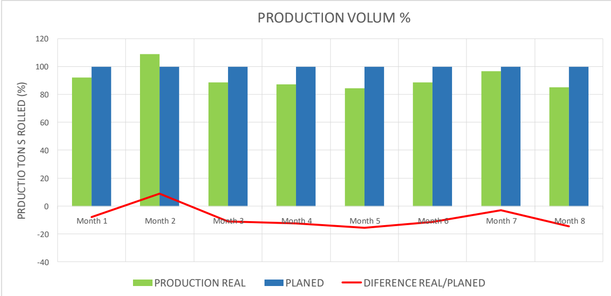

Figure 6 – Planned x Real production HSM.

After the implementation of the Improvement of the Exchange Device, there was no further occurrence of stopping production due to the movement of cylinders after the exchange. Considering the monthly average downtime recorded and taking into account the average productivity of the rolling mill, it was calculated anincrease in the availability of the rolling mill, allowing an increase of more than 2,714% tons monthly production in the rolling mill. By collecting the registered stop information and the production volume, the results are shown in figure 7 below.

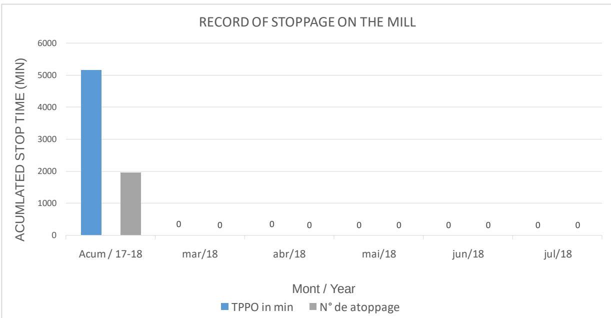

Figure 7 – Results of Time lost on the mil.

Considering the average monthly stoppage time and taking into account the average productivity of the mill, an increase in the availability of the mill was calculated, allowing an increase around2,714 % tons of monthly production in the mill.

With an increase in monthly production, it allows an increase about 2,75 % ton of hot strips in the process annually. Considering that the mill's demand is at the upper limit and the financial margin per tonne, there is a significant annual financial gain.

4 CONCLUSION

After the implementation of the project, the stops in the mill for the reason were eliminated to move the post-exchange cylinders, increasing the availability of the mill and increasing a monthly production volume. Another gain of high importance and relevance was in the scope of safety and ergonomics for the operation team, where currently the pins are actuated by means of hydraulic cylinders through a remote control, avoiding that the operator is near or under suspended load and needs to execute repetitive efforts to insert and extract the device pins in the rolling cylinders, improving the condition and good working posture for the operating staff.

REFERENCES

1. LAMINADOR Steckel. Disponível em: https://www.primetals.com/pt/portofolio/laminacao-a-quente-de-planos/laminador-steckel/>. Acesso em: 03 jul. 2018.

2. RIZZO, Ernandes Marcos da Silveira. Processo de Laminação dos aços: Uma introdução. São Paulo: ABM, 2007. 166 p.

3. DavideQuaglia, Francesco Auteri, Giovanni Boselliand Paolo Gaboardi. Roll shop design and equipment; 2013. p.146.

4. BARBOSA, Arízio de Abreu; SILVA, Flávio; PROCÓPIO, Luiz Otávio Torres. Utilização de cilindros de aço rápido (HSS) no laminador steckel da Aperam. Tecnol. Metal. Mater. Miner, São Paulo, p. 351-358, dez. 2013

5. NASCIMENTO, Danilo Deon. Metodologia de avaliação de um equipamento de usinagem de cilindros sobre a ótica do indicador de eficiência global dos equipamentos. 2008. 23 p. TCC (Engenharia de Produção)- Faculdade Pitágoras, Belo Horizonte, 2008.

6. Pinto, Yohana, Plano de ação 5W1H. Disponível em: <https://agrego.net/5w1h/>. Acesso em: 18 de outubro 2018.

7. LEONEL, Paulo Henrique, Aplicação Prática da Técnica do PDCA e das Ferramentas da Qualidade no Gerenciamento de Processos Industriais para Melhoria e Manutenção de Resultados - EPD/UFJF, Graduação, Engenharia de Produção, Juiz de Fora, 2008.