REVAMPING OF SKIN PASS SECTION FOR AUTOMOTIVE PRODUCTS *

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Abstract
Due to the increasingly stringent requirements and the needs of the automotive industry, galvanizing lines for automotive products have to be modernized and improved. Beginning of 2017, SEGAL, a Tata Steel CGL located in BELGIUM and fully dedicated to automotive market, placed an order to increase the line capacity from 550kt/year to 600kt/year to process a wider range of steel grades and improve the product quality according to automotive requirements. To improve quality, a major revamping of the skin pass was necessary. The objectives were first to increase the work roll diameter from Φ560mm to Φ650mm to be able to transfer the required roughness with low elongation on soft material and second to increase the rolling force and tension to reach higher elongation on high strength steels. The result was the adaptation of the whole skin pass mechanics. Old mechanical elongation system has been replaced by a completely new single AC motor with helical gearbox at each bridle roll. John Cockerill achieved such complicated revamping in a very short time since the shutdown started only 6 month after the contract signature. The shutdown down schedule has been optimized with pre-erection works and the teams working 24/7 to implement all the changes. The complete project (skin pass, furnace, loopers) have been adapted during the three weeks shutdown. Today the customer can use both 560mm and 650mm work roll diameters. Thanks to the use of the new 650mm work roll diameter, the customer is able to make the same elongation using a bigger roll force (average 20% more), which has strongly improved the roughness transfer to the strip and the removal of the defects. SEGAL is really satisfied able to produce and supply higher quality automotive products to his customers.
Keywords: Skin pass; Automotive; Cold rolling; Revamping

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1 INTRODUCTION

The SEGAL Continuous Galvanizing line (CGL) is a strategic line for TATA steel. The line was initially designed and commissioned in 1986 with the target of EDDQ grades. The CGL is fully dedicated to automotive market and produces GI/GA exposed up to1900mm strip width. Due to the evolution of the products from soft grades to advanced high strength steel (AHSS), the line as designed initially needed a major revamping to improve the quality and capacity.

The revamping of the SEGAL line in Belgium had two objectives. The first objective was to increase the annual capacity of +/_ 10%. In order to achieve such a production, it was necessary to focus on the following points:

Increase the furnace capacity by addition of an inductor at the furnace

- Increase the cooling capacity, which was done by implementation of one BLOWSTAB® cooling box
- A new water quench
- Increase the entry looper capacity, by addition of four strands by replacement of a two roll steering unit by single rolls steering units.
- Increase of the inspection looper capacity

The second objective was upgrade the Skin pass section to able to produce a wider range of steel grades including AHSS. The request was :

- Increase the tension at the entry of the skin pass from 6 to 12 tons in order to reach higher elongation on high strength steels
- Increase the tension at exit of tension leveller up to 30t
- Change the motorization and elongation concepts from DC motor with complete mechanical elongation system (one main motor with elongation motors) to new individual AC drive system (one motor and one gearbox per roll)
- Increase the work roll diameter from Φ560mm to Φ650mm (Φ560mm and Φ440mm previously) in order improve the overall quality and roughness transfer on soft grades. For the same grade and elongation, the force needed with bigger Φ650mm work rolls is higher and therefore has a better effect to remove strip surface defects.
- Increase the roll force from 1000t to 1200t to increase the elongation

The constraints of the project were substantial as follow :

- Order placed early February 2017 and shutdown in August 2017. Only 7 months for engineering, supply and transport.
- Revamping of the Skin pass initially delivered by another supplier with only paper drawing available, without complete update of design and modifications.
- Only three week of shutdown.
- Reuse existing rolls and chocks (no new operational spare parts)
- Low CAPEX
- Keep existing passline in the skin pass

3 RESULTS AND DISCUSSION

3.1 Tension increase

The purpose was to increase the front and back tension in the mill as well as in the tension leveller. The previous mechanical elongation system (see figure 1) had some issues :

- High annual maintenance costs
- The mechanical design was not suitable for the new target tensions

The gearboxes were installed on different levels and therefore access for maintenance was not easy.

A complete new drive concept has been implemented (see figure 2).

Each roll is driven individually by AC motor and gearbox

The design of the rolls has been machined to fit to the new gear coupling

The pass line has been modified to add one bridle roll (one tensiometer and one motorized roll) at the skin pass entry to reach 12tons instead of 6 presently

Due to the height difference between the various roll axis and civil work, each frame has been designed as a platform with two motors and two gearboxes. This design minimize the loads on civil works as the torques are on opposite direction and the complete assembly is now on the floor level with an easy access for maintenance.

At the exit of the tension leveler, four rolls are now motorized in order to reach a maximum tension of 30.000kg in the tension leveler.

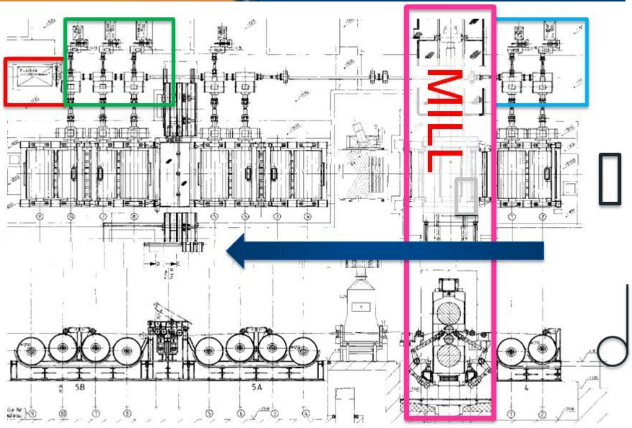

Figure 1: Old motorization concept, with one main motor and elongation drives.

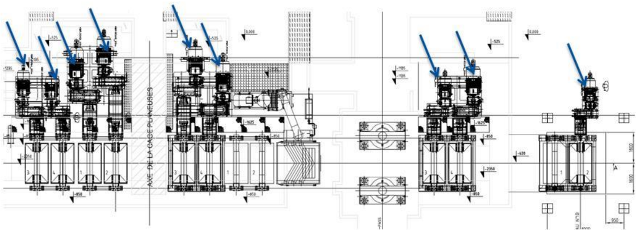

Figure 2 : New motorizations, with single motors and gearboxes, and one new bridle rolls

Figure 3a : Previous motorization

Figure 3b : During shutdown

Figure 3c : New motorization

3.2 Revamping of the skin pass mill stand

The skin pass has been already revamped in the past. Originally, there were only one work roll diameter of 440mm and back-up rolls of diameter 1100mm. The first revamping in 1998 was consisting of :

- Implement two work rolls diameters, 440-400mm and 560-520mm
- Back-up rolls reduced to 1000-910mm, to save space for implementation of the work rolls 560-520mm and avoid machining of the stands
- New bending blocks
- New passline adjustment as there are two different work rolls
- New roll force cylinders (1000t total), as longer stroke was necessary
- Work rolls chocks modified for work roll change

The main challenge was to be able to insert Φ650mm work rolls in the existing mill housing which has been already revamped. Indeed, the increase in rolls diameter to 650mm has following consequences on the design (see figure 4):

The top back-up roll chock interferes with the housing/passline adjustment by 90mm

The bottom back-up roll chock interferes with housing/roll force cylinder/rails

The work rolls cannot be inserted in the skin pass as the space between bending block wear plates was only 590mm

The work rolls Φ650mm is in interference with the anti-crimping rolls.

No more contact exists between the work roll chocks and the negative bendings cylinders located inside the back-up roll chocks

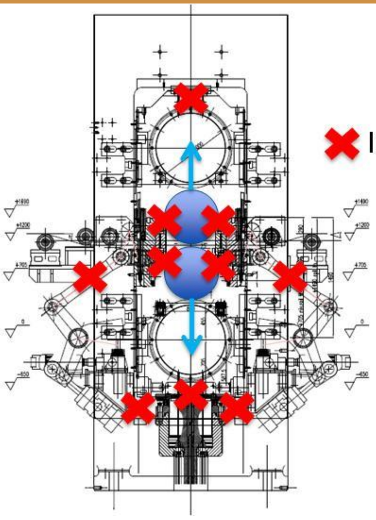

Figure 4 : Main interferences when implementing the work rolls Φ650mm inside of the skin pass

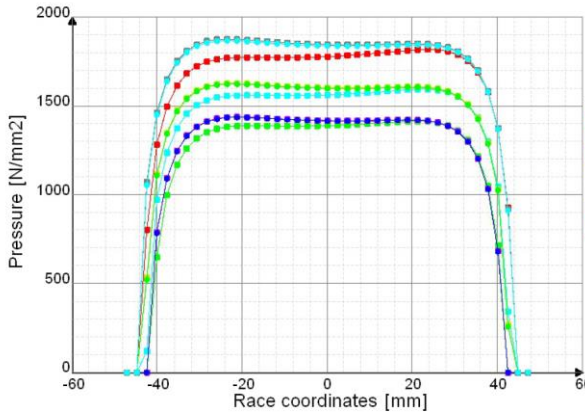

Figure 4a : Pressure distribution on BUR bearings for each bearing race, below 2000N/mm² (study from SKF)

In order to solve the problem of interference of the top chock, several solutions are possible. Either machine the housing, or machine the chocks or a mix of both solutions. After finite element calculations of the loads on chocks, bearings and housings, it has been demonstrate that a maximum of 90mm could be saved on the back-up roll chock while keeping an the acceptable range of stresses :

- Compressive stresses on the chocks around ~72MPa, a level that gives a negligible deformation (see fig. 4b and 4c)
- Chock thickness according to the main bearing suppliers recommendations
- Pressure distribution on the back-up roll bearing below acceptable limit, studied by SKF by finite elements (see fig. 4a)

This chock machining had tremendous advantages : reduced shutdown time, reduced CAPEX, machining done during production.

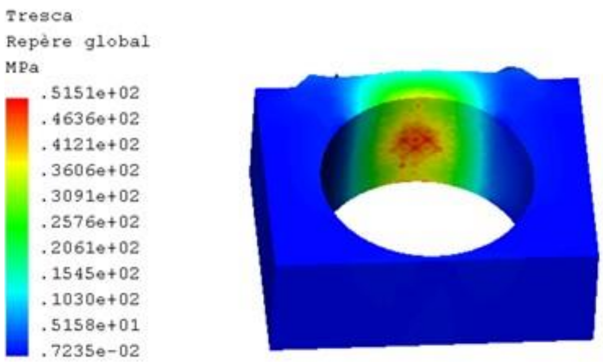

Figure 4b : Stresses on back-up roll chock before machining

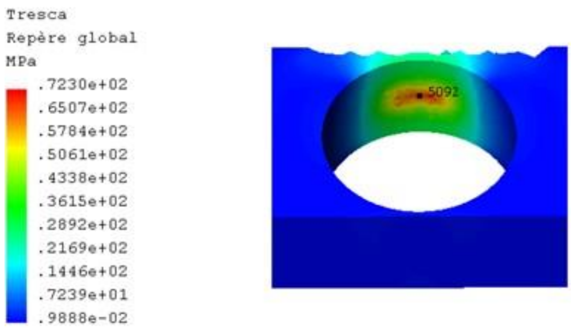

Figure 4c : Stresses on back-up roll chock after machining

Regarding the interference between housing/roll force cylinders and the bottom back-up roll chocks, the finite element study showed that the 90mm machining of the stand was not possible because the housing thickness is small leading to a not acceptable range of stresses (see figure 5a). The solution proposed to the customer was to optimize the design of the roll force cylinder. The optimization of stroke, seals and guiding system also been done by a finite element approach. The conclusion has been that a saving of 90mm on the cylinder was possible (see fig. 5b and 5c) The rails for back-up roll change has been changed, both inside and outside of the mill, reusing existing anchor bolts.

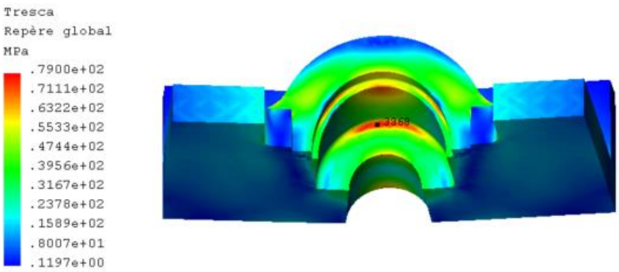

Figure 5a : Stresses at the bottom of the housing (without machining)

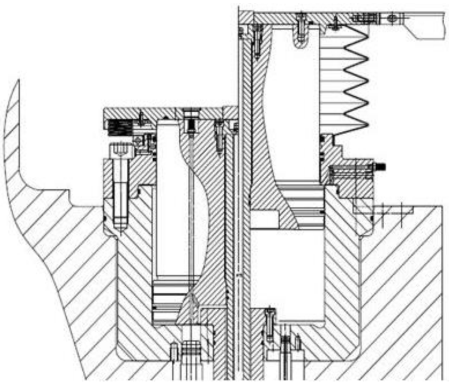

Figure 5b : Old design of the roll force cylinder

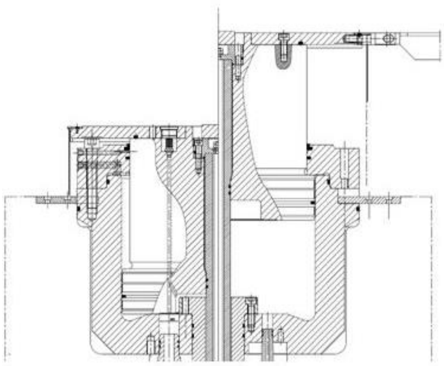

Figure 5c : New design of the roll force cylinder cover

In addition, the distance between the bending blocks wear plates had to be increased by 90mm to insert the work rolls Φ650mm. This had following consequences :

- Provide new bending blocks with new positive bending cylinder position (shifted by 45mm)
- As the positive bending cylinders have been moved, the bottom positive cylinder was not more in contact with the bottom chock. Therefore, bottom chocks needed to be adapted and bottom rail position aligned with top rail. New anti-crimping rolls were also provided.
- Due to the new rail position, it was not possible to insert the bottom work roll. Therefore, the design of the rails has been adapted with openings in the top roll and a system with two wheels had to be implemented in the top chocks. This means also to adapt pusher and rails on motor side and make a new trolley at operator side.
- The work roll chocks (top and bottom) had been completely modified for the 560mm work rolls, in order to implement a new solution for work roll change and . The solution implemented was to cut the ears of the chocks, and shrink a new piece with new wheels position. Intermediate plates have been implemented in order to cope with the new position of wear plates (see figure 6c).
- New chocks have been supplied for the 650mm work rolls, with completely new design (see figure 6d).

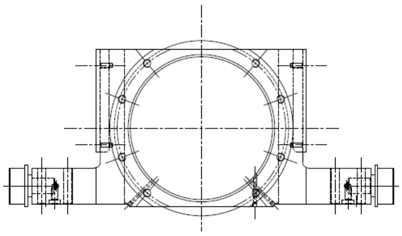

Figure 6a : Original chocks

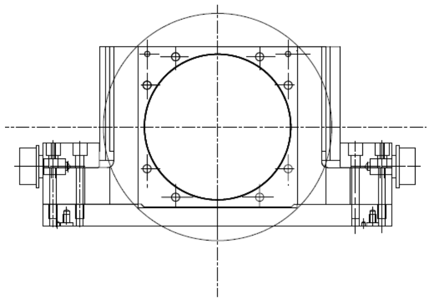

Figure 6b : First modification of the chocks for the 5650mm work rolls, done in 1998.

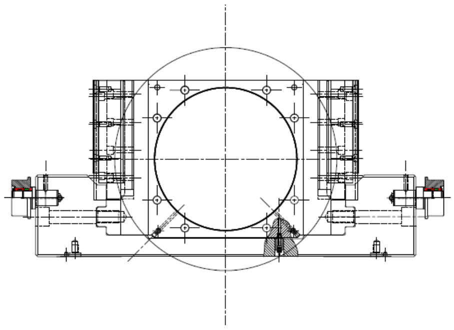

Figure 6c : Chock modified for the work rolls 560mm, with special piece shrunk on the existing chocks, and intermediate steel plates to move the wear plates.

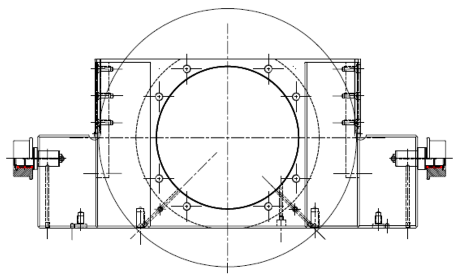

Figure 6d : New chocks for the bigger 650mm work rolls

Due to the increase of work roll diameter, an interference with the existing anti-crimping roll appeared. As it was not possible to solve this interference by modification of the existing design (technically very difficult and time consuming during shutdown), it was decided to provide new anti-crimping rolls, with a different mechanical concept. The new state of the art design is using slides and hydraulic cylinders. New entry and exit tables have been supplied, adapted to the new anti-crimping roll and with new tensiometers, suitable for increased tension.

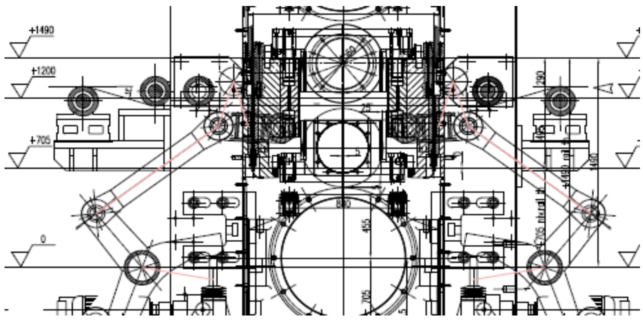

Figure 7a : Original anti-crimping and tables

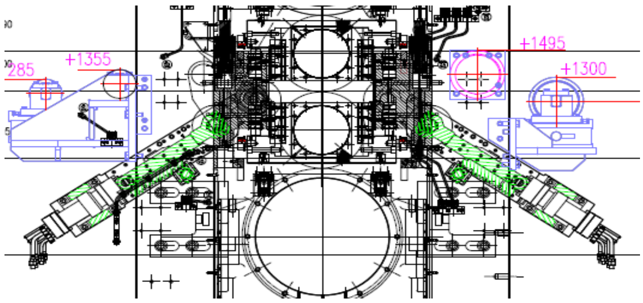

Figure 7b : New anti-crimping rolls and tables

The last customer request was to increase the roll force to 1200t on the strip. As the hydraulic station was already at high pressure, the only solution was to increase the piston diameter by 60mm and the cylinder body inner diameter reduced by 60mm by using better material. This new design has been checked by finite elements (see figure 8a). Indeed it was not possible to increase the outside dimensions of the roll force cylinder because the roll force cylinder was inserted inside the housing. The back-up roll design has also been checked. The conclusion was that the current back-up rolls were not suitable (see figure 8a). . Indeed, the back-up rolls are double casted and the mechanical properties of the roll journals are not suitable for 1200t regarding fatigue. The upgrade to 1200t is possible only provided that the customer purchase the new back-up roll with the same design but in forged material. No change in chock and bearings size is needed. Skin pass is therefore ready for 1200t operation.

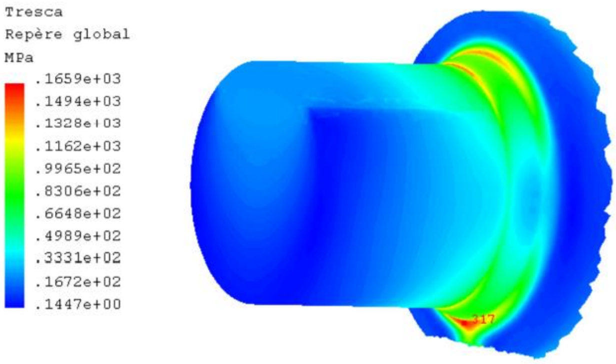

Figure 8a : Back-up roll neck constraints

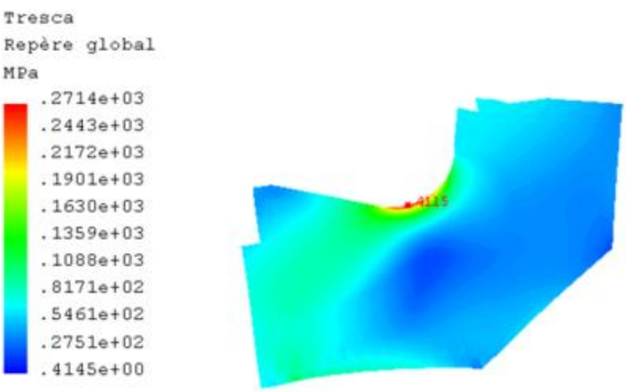

Figure 8b : Roll force cylinder constraints

3.3 Overview of the works during the shutdown

Figure 10a : Skin pass mill completely dismantled

Figure 10b : Same view after revamping

Figure 10c : Top view of skin pass and motorization completely dismantled

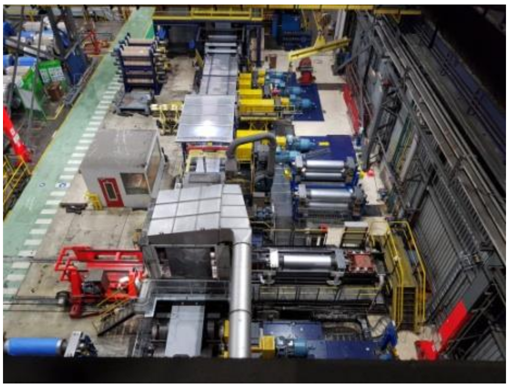

Figure 10d : Same view after revamping

3.4 Results

As shown in the below table, the use of bigger diameter allows to use a bigger roll force (average 20% additional) for the same elongation. This has strongly improved the roughness transer to the strip and more defects are erased from the strips.

Table 1. Force comparison with small and big work roll diameters

Product	Width [mm]	Thickness [mm]	WR dia. [mm]	Elongation [%]	Force [tons]	Force [tons/m]
SULC IF1	1591	0,697	554,5	1,689	460	289
SULC IF1	1611	0,694	649,8	1,437	540	335
SULC IF1	1794	0,746	553,4	1,431	470	262
SULC IF1	1810	0,769	649,8	1,627	573,1	318
220BH	1843	0,648	554,5	1,691	610	331
220BH	1864	0,702	649,8	1,705	735	394
180BH	1801	0,644	554,3	1,695	580	322
180BH	1810	0,699	649,6	1,612	750	414

4 CONCLUSION

The request of the customer was very challenging regarding engineering, delivery time and shutdown time. Complete analysis and engineering has been done within three months. The complete motorization concept has been replaced. For the skin pass mill, only the housing, auxiliaries inside the cellar and interconnecting piping have been kept. All other mechanical subassemblies have be changed to work in the new configuration.

JOHN COCKERILL achieved such complicated revamping in a very short time since the shutdown started only 6 month after the contract signature. The shutdown down schedule has been optimized with pre-erection works and the teams working 24/7 to implement all the changes.
The complete project (skin pass, furnace, loopers) have been adapted during the three weeks shutdown.
Today the customer can use both 560mm and 650mm work roll diameters. Thanks to the use of the new 650mm work roll diameter, the customer is able to make the same elongation using a bigger roll force (average 20% more), which has strongly improved the roughness transfer to the strip and the removal of the defects.
Today, Tata Steel SEGAL is really satisfied able to produce and supply higher quality automotive products to his demanding customers.
JOHN COCKERILL would like to warmly thank the SEGAL team for allowing the presentation of this paper.

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