Revamping of skin pass mill for automotive products

Due to the increasingly stringent product requirements, galvanising lines dedicated to automotive products have to be modernised in order to meet market needs. In 2017, Segal, a Tata Steel galvanising line in Belgium, placed an order with CMI to increase line capacity and to be able to process a wider range of steel grades.

The project was extremely demanding, with only seven months to evaluate options, design the modifications and manufacture equipment, and aiming for minimum use of new parts. Installation time was only three weeks during plant shutdown, requiring 24/7 operations during this time. The plant successfully re-started on time and to specification.

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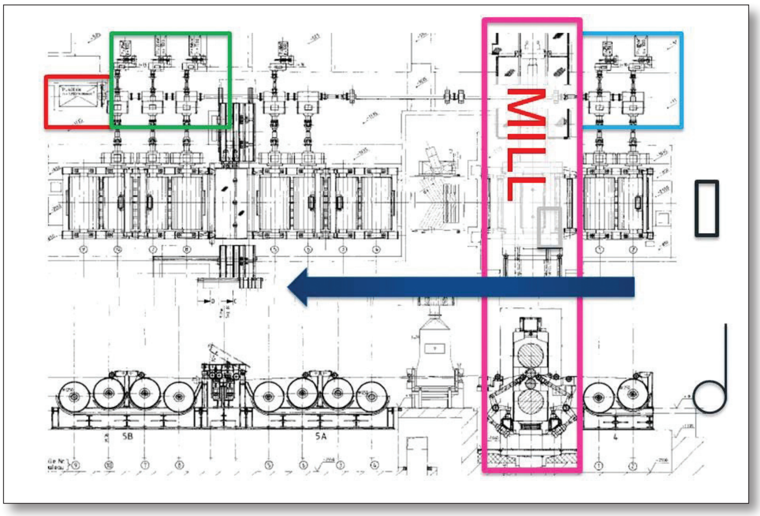

Fig 1 **Previous motorisation**

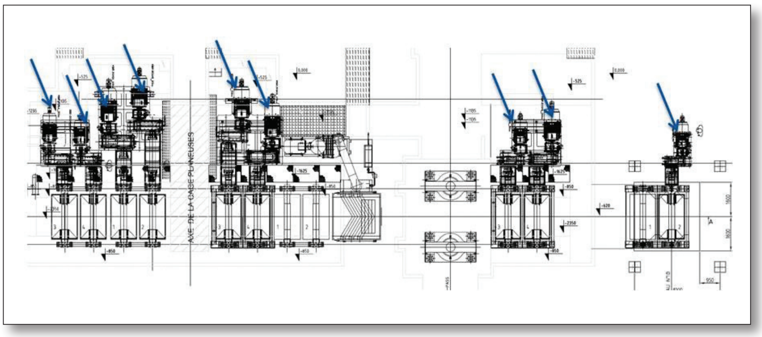

Fig 2 **New motorisation**

The Segal continuous galvanising line (CGL) in Belgium is a strategic asset for Tata Steel. Supplied by CMI, the line was initially commissioned in 1986 for processing extra deep drawing qualities (EDDQ) and today, it is fully dedicated to the automotive market, producing galvanised and galvanealed strip up to 1,900mm wide for exposed automotive parts. With the increasing demand for advanced high strength steel (AHSS), the line needed a major revamp, both to extend the steel quality range and increase plant capacity by 10%. To achieve such a production increase, it was necessary to implement the following points:

- Increase the furnace capacity by addition of induction pre-heating
- Increase the cooling capacity by implementation of CMI's patented rapid cooling technology BLOWSTAB®
- Install a new water quench
- Increase the entry looper capacity by addition of four strands, made possible by replacing the existing two-roll steering unit by single-roll steering units
- Increase the inspection looper capacity

Extending the product range, including AHSS, required the following modifications of the skin pass section:

- Increase tension at the skin pass entry from 6 to 12t in order to achieve greater elongation on high strength steels
- Increase tension up to 30t at the exit of the tension leveller
- Change motorisation and elongation concepts from DC motors with complete mechanical elongation system (one main motor with elongation motors) to an individual AC drive system (one motor and one gearbox per motor; *see Figures 1 & 2*)

- Increase the work roll diameter from 560 to 650mm in order to improve the overall quality and roughness transfer on soft grades. For the same grade and elongation, the force needed for Φ650mm work rolls is higher and this aids strip surface defect removal
- Increase the roll force from 1,000 to 1,200t to increase elongation.

This article describes only the skin pass part of the project, although the other parts were installed at the same time.

The constraints of the project were substantial. Besides the overall project requirements, such as a short period of only seven months for engineering design, supply and transport to site, a plant shutdown of only three weeks, and a limited Capex, the skin pass section modernisation had to face additional constraints as illustrated below:

- Only incomplete paper drawings were available for the skin pass mill which had not been initially supplied by CMI
- Re-use of existing rolls and chocks was required by the customer, in order to avoid the addition of new operational spare parts
- The existing pass line in the skin pass mill was to be retained.

ENGINEERING PHASE

Tension increase The aim was to increase the front and back tension in the mill as well as in the tension leveller. The previous mechanical elongation system had some issues: namely high maintenance costs, unsuitable mechanical design for the new target tensions, and the gearboxes were installed on different levels, therefore access for maintenance was not easy.

To achieve design requirements a complete new drive concept has been implemented:

- Each roll is now driven individually by an AC motor and gearbox
- The existing roll design has been modified by machining to fit to the new gear coupling
- The pass line has been modified to add one bridle roll (one tensiometer and one motorised roll) at skin pass entry to attain12t tension instead of the previous 6t
- Due to height difference between the various deflector roll axes and civil work, each frame was designed as a platform with two motors and two gearboxes. This design minimises the loads on civil works as the torques are in the opposite direction and the complete assembly is now on floor level with an easy access for maintenance
- At the exit of the tension leveller, four rolls are now motorised in order to reach a maximum tension of 30t.

Figures 3a and 3b show the mill after dismantling and upon completion of the revamp.

Fig 3a Skin pass and motorisation completely dismantled

Fig 3b Top view of motorisation and skin pass after restart

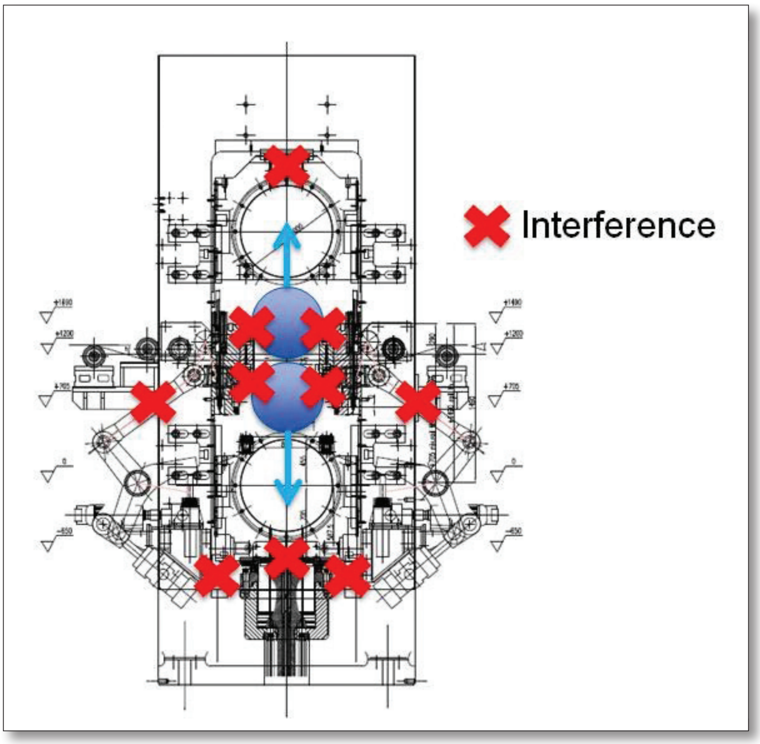

Fig 4 Main interferences when implementing the Φ650mm work rolls inside of the skin pass

Revamping of the skin pass stand The first modernisation of the skin pass mill in 1998 was implemented with two work roll diameters of 440-400mm and 560-520mm. This change led to the reduction of the back-up roll diameter to accommodate the larger work rolls and avoid the machining of the stands, as well as new bending blocks, a passline adjustment, new roll force cylinders (as longer stroke was necessary), and the modification of the work-roll chocks for work roll changes.

The main challenge of the most recent upgrade was to be able to insert even larger Φ650mm work rolls into the existing mill housing.

Figure 4 illustrates the main interference points when planning for Φ650mm work rolls.

In order to solve the problem of interference of the top chock, three potential solutions were possible: machine the housing, machine the chocks or a mix of both. After finite element (FE) calculations of the loads on the chocks, bearings and housings, it was demonstrated that a maximum of 90mm could be removed from the back-up roll chock while keeping the stresses within an acceptable range. This solution had tremendous advantages in terms of both reduced shutdown time and reduced Capex as machining was done during normal production operations.

Another issue to overcome was the interference between housing roll force cylinders and the bottom back-up roll chocks. An FE study showed that machining 90mm from the stand was not possible because the remaining housing thickness would be overstressed. The solution proposed was to optimise the design of the roll force cylinder. By optimisation of stroke, seals and guiding system it was concluded that a saving of 90mm on the cylinder was possible. The rails for back-up roll change have been changed, both inside and outside of the mill, reusing existing anchors and bolts.

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

New bending blocks with a new positive bending cylinder position (shifted by 45mm) were provided. This then meant that the bottom positive cylinder was no longer in contact with the bottom chocks, therefore these were adapted and the bottom rail position aligned with the top rail. New anti-crimping rolls were also provided.

Furthermore, due to the new rail position, it would not have been possible to insert the bottom work roll, so the design of the rails was adapted with openings in the top roll and a system with two wheels implemented in the top chocks. This also meant adapting the pusher and rails on the motor side and making a new trolley at the operator side.

During the first revamp in 1998, the work roll chocks (top and bottom) were modified for the Φ560mm work rolls in order to implement a new solution for work roll changes.

The solution implemented at that time, was to cut the ears off the chocks and shrink on a new piece with a new wheel position. Intermediate plates were installed in order to cope with the new position of wear plates. *Figure 5a* shows the original chock design (1986), while *Figures 5b and 5c* show the chock design and the amendments made in 1998.

During the 2017 revamp, the chocks were completely redesigned (*see Figure 5d*). To solve the problem of interference between work roll and anti-crimping roll it was not possible to easily or cheaply modify the existing design during shutdown. It was decided, therefore, to provide new anti-crimping rolls with a different mechanical concept using state-of-the-art slides and hydraulic cylinders. New entry and exit tables were supplied and adapted to the new anti-crimping roll and with new tensiometers suitable for increased tension.

Increase of roll force The final requirement was to increase the roll force on the strip to 1,200t. As the hydraulic station was already at high pressure, the only solution was to increase the piston diameter by 60mm and reduce the cylinder body inner diameter by 60mm by using better materials. Note: it was not possible to simply increase the outside dimensions of the roll force cylinder because the roll force cylinder was inserted inside the housing.

Additionally, following FE, it was determined that the back-up rolls were not suitable for the higher loads. These rolls were of double cast design and the fatigue properties of the roll journals were determined as being unsuitable for 1,200t loads. The upgrade to 1,200t was, however, possible by using forged back-up rolls and these are now in use.

CONCLUSIONS

- Customer requirements were very challenging regarding the highly technical engineering, as well as the short delivery and shutdown time.
- The entire project analysis and engineering was completed within three months.
- The complete motorisation concept has been replaced.
- For the skin pass mill, only the housing, the auxiliaries inside the cellar and the interconnecting piping have been retained. All other mechanical sub-assemblies had to be changed to accommodate the new configuration.
- During the shutdown, the teams worked 24/7 to implement all necessary changes.
- All parts of the modernisation project, the skin pass section, the furnace and the loopers, were successfully completed during the three-week shutdown. **MS**

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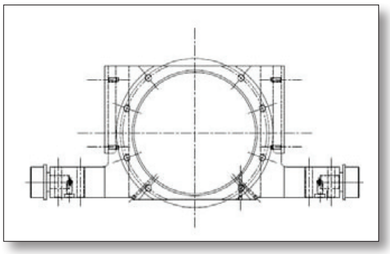

Fig 5a Original Chock design of Φ440mm work rolls (1986)

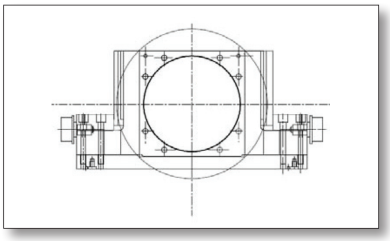

Fig 5b Chock design for the Φ560mm work rolls (1998)

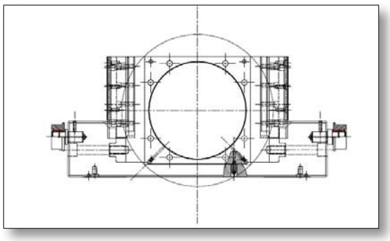

Fig 5c Chock modified for the 560mm work rolls, with special piece shrunk on the existing chocks, and intermediate steel plates to move the wear plates

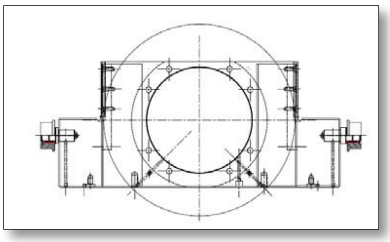

Fig 5d New chocks for the Φ650mm work rolls