Tension Leveling and Skin Passing in a Galvanizing Line

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Demand for galvanized sheet has grown strongly in accordance with increasingly severe requirements of ultimate users for particular characteristics and quality. This demand, coming at a time when the majority of the steel industry's products are finding fewer outlets, has been able to develop due to the introduction of higher-quality galvanized sheet, with varied coatings, providing precise mechanical characteristics and surface conditions. These products have outlets in the building, domestic appliances, metallic furniture, and automobile industries. It can be seen, therefore, that new products with more added value have become available on the market for new applications, whereas, in the past, it was necessary to paint after forming.

In order to obtain high-quality products, galvanizing lines need new equipment and automatic control systems. One of the essential elements of these lines is the skinpass/leveler section, which is the object of this article.

The skinpass/leveler section of a galvanizing line is designed to give the sheet, in conjunction with a zinc bath, its final characteristics of resistance, pliability, flatness, and surface condition. The principle was adopted more than 30 years ago and consists of passing the strip through a rolling mill and roller-leveler while first imposing on it very high tension.

Many diverse solutions have been chosen to apply high continuous tension on the strip by the use of two groups of bridle rolls. The oldest and simplest method is by rigid gearing between the bridle rolls, giving fixed amplification of tension across them, together with an adjusting differential, providing elongation, positioned between the two groups of bridle rolls. Later developments produced electric or hydraulic drives, which allowed better control of intermittent slipping.

The general tendency was to use the classical non-motorized 2-high, with several variants as 4-high. This type of machine imposes numerous tasks for the user because of the diameter of the work rolls and ensuing difficulties. This led some users to use 2 x 2-high mills to ensure that one set of clean rolls was always available.

The leveler itself has two or three clusters of flexing rolls which, under the effect of the tension imposed on the strip, subject the strip to plastic deformation and bring all the metal fibers to the same length, thus making them flat.

The combination of a mill and a leveler forms an assembly of two very different machines whose role is essential to obtain a good product and which can only be fulfilled if the very precise conditions of tension imposed on the strip on either side of each of them are released.

Passing steel sheet through a skinpass mill imposes tension and compression on the metal, the effect of which is to modify the metal's mechanical characteristics and metallurgical properties and to give a particular desired surface. The yield point present in the steel after annealing will be altered by light cold rolling. At the same time, the rolling will permit the partial transfer of cylinder roughness and give the surface of the sheet its desired condition. For a given product, attaining these properties necessitates the appropriate adjustment of the rolling mill's running parameters -- RSF (roll separating force), strip tension, and roll crown.

The entry and exit tensions of the skinpass mill are, therefore, an integral part of the process necessary to obtain the required product characteristics, and for a nonmotorized mill of the Redex-Sendzimir type, the tension at the exit side corresponds, for a current galvanizing line, to a stress of approximately 7,000 to 28,000 psi, the stress at the entry side being approximately 20% less, regardless of the product thickness.

Considering the leveler, the entry and exit tensions correspond to the diameters of the flexing rollers -- the diameters of these rollers are a function of the thickness of the strip to be flattened. The combined effect of the tension/flexion causes the section of the metal to be worked in the plastic zone beyond its yield limit, thus inducing elongation. Theoretical analysis of this phenomenon allows determination of a given elongation that is necessary to be applied to the strip at entry and exit of the leveler. Generally, it can be stated that the necessary entry and exit tensions are slightly different for thin sheets and greatly different for very thick sheets

The difference in tension between entry and exit, called losses in the leveler, increases with thickness. The stress at the entry side is sometimes only 10% of the stress at the exit side.

It is therefore necessary, for a given elongation, that the stress at the entry side be rapidly reduced as the sheet thickness increases, while the skinpass requires the stress at its exit to be reasonably constant. These two contradictory conditions demand a method of achieving different tensions at the skinpass exit and leveler entry.

The skinpass entry and leveler exit tension being determined by the (outer) groups of tensioning bridles, the intermediate tensions can then be controlled in two ways:

1. either by motorizing the skinpass mill where the energy introduced can be used to allow variation and reduction of the exit tension -- a solution with numerous practical inconveniences;
2. or by isolating the skinpass and the leveler by means of an intermediate motorized bridle designed to reabsorb the desired difference in tension between the two machines. This second solution presents numerous advantages for the operation and for the price of the skinpass equipment. This arrangement has been chosen for the specially developed nonmotorized skinpass mill for galvanizing lines and to which reference will be made later.

The Redex Continuous Stretching Leveling Skinpass Line for Galvanizing Installations

This development by REDEX has the advantage of combining all the necessary conditions for good results from the process.

The main points are the disposition and the drive of the tensioning bridles and of the Redex-Sendzimir mill.

The general layout of the line is shown in figure 1:

A – a 4-roll entry bridle tensioner

B – a Redex-Sendzimir rolling mill

C – an intermediate tensioning bridle

D – a leveler having two or three sets of flexing rollers

E – a 4-roll exit bridle

Motorization of the two Principal Tensioning Bridles A and E

Bridles A and E are driven via mechanical differentials by a single motor and a precise control system providing global elongation between them. This elongation, being the total elongation of the strip between these two sets of bridles, provides a working tension obtained by a difference in speed between the two groups. It is, therefore, a machine having an imposed elongation tied to the nature of the product and independent of its cross section.

The principle of the Redex drive is briefly described as follows: The increase in tension through entry bridle rolls is obtained by the progressive increase in tangential speed of the rolls, which is identical to that of the strip. There is no possibility of slip between the strip and the bridle rolls. The drop in tension through the exit bridle rolls takes place in a similar manner.

The Redex system incorporates differential units, as indicated in the following schematic layout. (figure 2).In each of the bridle groups, the torques are distributed so as to achieve optimum tension.

The tension progression depends upon the friction coefficient (f) of the roll surface and the angle of contact (delta) of the strip (factordelta ef). The distribution of torques and speeds (compensation of elongation during the initial tensioning phase) is made automatically by the differentials. The Redex differential system obviates, by complex electronics, any necessity for control of speed or torque at each of the tensioning rolls.

The required torque automatically shares itself on each roll by means of the differentials in the optimum proportion determined at the machine design stage. Consequently, unexpected slippage cannot take place between strip and rolls as any increase in tension is automatically distributed between the four rolls.

With regard to speed, this is also shared through the kinematic differential chain; each roll having the same linear speed as the strip in contact, such that the average of the sum of the speeds of each is proportional to the speed of the main motor.

The difference is speed between the entry and the exit is also obtained by differential (7 on figure 2), which causes a small difference in speed between these two groups of bridle rolls. This induces the required tension in the strip. A small, automatically controlled variator is used to produce this small difference in speed (between 0 and 3%), which corresponds to the elongation imposed on the strip.

The assembly constitutes a closed loop system driven by a single motor. This arrangement gives major advantages in simplicity of the electrical equipment, ease of adjustment and maintenance, and very low energy consumption.

Motorization and the Role of the Intermediate Tensioning Bridle

It has been shown that the braking and driving bridles impose a controllable total elongation on the strip. In practice, it is desirable to have precise elongation at the leveler and a separate precise elongation at the skinpass,the total elongation being the sum of the two. (See figure 3)

The leveler entry tension T3, and skinpass output exit tension T2, result from the elongation chosen and may be different in certain cases.

The elongation A1 at the leveler being fixed, it corresponds to the total elongation imposed by the two principal tensioning bridles before the skinpass is brought into service. The energy from the intermediate tensioning bridle will permit, when bringing the mill into service, the progressive attainment of the tension T2, while the total elongation increases to the value A1 + A2. Thus, the desired elongation at the skinpass is obtained without disturbing that chosen for the leveler.

The drive to the intermediate tensioning bridle is by a torque-controlled DC motor. Its absorbed power does not affect the total elongation, which remains as that imposed by the mechanical system between the two principal tensioning bridles at entry and exit. Conversely, incorrect regulation of this motor alters A1 and A2, their sum remaining constant.

In conclusion, the torque-controlled intermediate bridle permits control of the tensions between skinpass and leveler in a system that remains within the imposed elongation.

The Redex-Sendzimir Skinpass Mill for Galvanizing Lines

The Redex-Sendzimir ZH-type Mill

Skinpass mills of 2-high configuration used generally in combination with a leveler have various disadvantages:

- long time for roll change (a crane is required),
- only one crown at a time is available in the mill,
- necessity to drive the workr rolls,
- heavy weight of chocks.

If the strip surface is not satisfactory, the line must be stopped for a long time in order to change the roll(s).

Sendzimir and Redex have developed a skinpass mill that is very convenient for galvanizing lines by improving the strip surface control and the transfer of roll roughness to the strip. This skinpass mill is of the 1-2 type (Sendzimir ZR 05-50 section). The housing is split into top and bottom halves, or beams, with the top beam able to be raised by hydraulic actuation. The mill is comprised of two work rolls, each of which is supported by two backup shafts containing bearings mounted between saddles. These, in turn, are attached respectively to each beam. The work rolls are 5.6" in diameter, and are of the floating type instead of being driven. The are supported on their whole length by 10 to 15 bearings, according to the maximum width of the strip to be processed.

Four mills of this type were built in the 1960s. Three were delivered to the French group La Galvanization. Of these, two were installed in the galvanizing line and the third was set up as a separate skinpass unit for aluminized strip, where more than one skinpass was necessary. The latter one had a crocodile-type housing. The fourth one was installed inside of a 2-high mill housing at Fabrique de fer de Maubeuge in France on a high-production galvanizing and painting line and was followed by a Wean triple-head leveling unit. Tension on this installation was 30 metric tons. However, thicker gauges were processed.

These small-diameter work rolls adequately transfer surface roughness, which was confirmed on the other similar mills as here above stated. Moreover, they proved excellent on a scale breaker installed and tried many years ago at the Midwest Division of National Steel, ahead of the sulfuric pickling line. Studies made by a specialized research institute, such as IRSID in France, do not show any significant variation of roughness imprint as a function of roll diameter. The only important factor is the work roll pressure, a standard parameter of one-third the depth of transformation applying in this case (see figure 4)

The lower beam includes a set of 10 to 15 hydraulic jacks connected to the lower saddles, allowing each one to apply separate pressure adjustable from the operator’s panel. These hydraulic jacks are connected to a set of solenoid valves, and thus the operator is able to apply to the strip a variable pressure transversely across its width, which will have the same effect as a continuous variable crown adjustment. Sensors are provided in order to control the corresponding effect, and on the operator’s panel a monitor indicator shows the crown setting of the mill.

An ultrafast roll-change device is located on both sides of the mill (front and back). This device includes guiding rails for two holding "cars" for the work rolls and their end thrust bearings, which are pushed simultaneously inside the rolling mill in opposite directions, one from back side and one from the front side.

Two sets of roll-holding "cars" are provided: One is inside the mill with the set of work rolls in operation. The other set is on each side of the rolling mill with a new work roll standing by.

The simultaneous pushing "in and out" mechanism of the rolls includes an additional drive for a slight longitudinal movement of the work rolls in order to obtain bright strip surface and to prolong roll surface life. Two small cranes are provided in front and behind the housing for roll transfer.

The Lever

Finally, a few words about the leveler used by Redex for this type of installation.

The leveling machine comprises two groups of two nonmotorized working rollers. The first cluster, the flexion rollers, in conjunction with the strip tension, imposes a deformation on the strip such as to elongate the metal fibers, the section being in the plastic zone. The second cluster, known as anti-dish, corrects the transversal deformation caused by the first. The two rollers of the flexion cluster have diameters corresponding to the range of sheet thicknesses.

This type of leveler is well known and is of a quality resulting essentially from the application of sound technology that facilitates maintenance, adjustments, and long life and service. It is produced with one or two clusters of flexion rollers depending on the range of sheet thicknesses to be covered.

In terminating, our thanks are expressed to the companies of Fabrique de Fer de Maubeuge, France, and La Magona d'Italia, Italy, who gave us their confidence and cooperation and thanks to whom it was possible to develop the equipment described. Additionally, I would like to extend belated thanks to the Ziegler group in France and to Sendzimir France S.A.R.L. for their past work in developing this mill and to my co-author, Mr. Helier Cividino, President of Redex, whose initiative permitted us to go ahead with this project.