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MODERNIZATION AND UPGRADE OF COLD ROLLING FACILITIES UNDER SPECIAL CONSIDERATION OF DISCONTINUOUS MILLS[1]

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Abstract
After a period of consolidation in recent years, the world´s steel markets expand again. Rolling mill owners are well advised to take time by the forelock and upgrade their plant and equipment to the state of the art in technology in order to meet future demands. Looking at the cold rolling capacities installed worldwide, it becomes obvious that especially in North and South America as well as in Europe many discontinuous mills are operated. SMS Siemag as full line supplier of integrated solutions for cold rolling technology, has developed a number of innovative systems to support both: continuous as well as batch operation. One of these, which takes the special needs of discontinuous mills into account, is Total Roll Gap Control – a new threading assistance system. In addition, the paper presents a number of technical solutions recently developed with a focus on challenges deriving from different materials and the demand for more efficient mill operation.
Keywords: Cold rolling technology; TRC threading assistance system; Rolling assistance system.

MODERNIZAÇÃO E UPGRADE DE INSTALAÇÕES DE LAMINAÇÃO A FRIO CONSIDERANDO-SE ESPECIALMENTE LAMINADORES DE OPERAÇÃO DESCONTÍNUA

Resumo
Após um período de consolidação nos últimos anos, o mercado mundial de aço está novamente em expansão. As empresas de laminação estão conscientes da necessidade de aproveitar esse tempo e atualizar as suas plantas e equipamentos com as tecnologias mais modernas, de forma a atender futuras demandas. Observando-se as capacidades de laminação a frio instaladas ao redor do mundo, torna-se evidente que muitos laminadores em regime de operação descontínua permanecem em funcionamento, especialmente na América do Norte e do Sul, bem como na Europa. A SMS Siemag, um fornecedor da linha completa de soluções integradas em tecnologia de laminação a frio, tem desenvolvido uma série de sistemas inovadores para atender as demandas específicas de laminadores em qualquer uma das duas configurações de operação: descontínua ou contínua. Um deles, que leva em consideração a necessidade específica de laminadores em regime de operação descontínua, é o *Total Roll Gap Control* – um novo sistema de suporte ao ajuste de cilindros. Além disso, este trabalho apresenta várias soluções desenvolvidas recentemente com foco nos desafios derivados do processamento de diferentes materiais e de uma demanda por operação mais eficiente do laminador.
Palavras-chave: Tecnologia de laminação a frio; Sistema de entrada assistida TRC; Sistema de laminação assistida.

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1 INTRODUCTION

Everywhere in the world, operators of cold rolling mills are interested in increased yields and better product quality. In addition there is a growing demand for plants capable of handling an even wider product mix, including niche products, as well as to produce strips in smaller quantities, thus to increase flexibility in meeting their customers demands. These demands have to be fulfilled by new plants as well as by old ones, therefore modernizations are also important.
A look at the cold strip capacities installed world wide shows that especially in North America and Europe, a relatively large number of discontinuous-operation plants are in use. The dominant version in Asia is the continuous type.

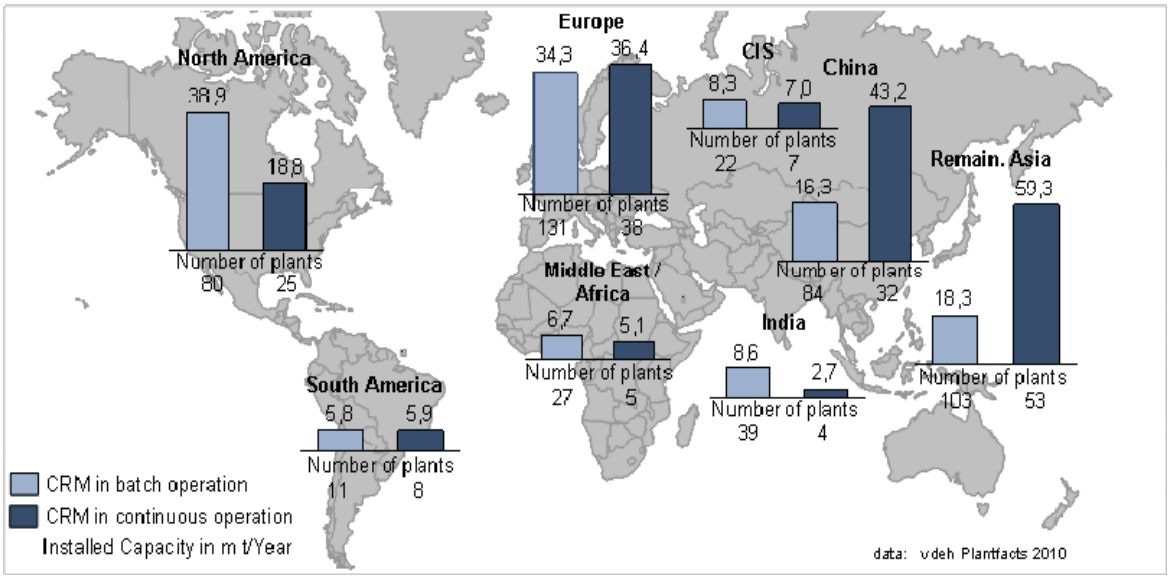

Figure 1. Cold strip capacities globally installed: batch versus continuous operation.

Against this background, SMS Siemag, as a systems supplier of integrated solutions for rolling mill technology, has developed a large number of systems to meet, beside others, also the special requirements of discontinuous plants.
Our latest developments include:

- TRC threading system;
- plants for special steel grades;
- CVC® plus M18/4 rolling mill;
- extended bending system (EBS) for skin-passing mills;
- LQL low quantity lubrication;
- rolling oils and emulsions from SMS lubrication.

2 MATERIALS AND METHODS

2.1 Total Roll Gap Control (TRC): System for Automatic Threading

Discontinuous cold rolling mills have many advantages. They offer scope for flexible planning of production and cost-effective processing of small batches. However, disadvantages are, e.g., higher idle periods and more operating personnel than continuous plants. Further threading in and out causes more often marking of the work rolls or even cobbles. The number of unscheduled roll changes and breaks are

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higher and consequently productivity is reduced. Even in case threading in and out runs smooth, yield is reduced by off-gauge length.

Figure 2. Advantages and disadvantages of discontinuous mills.

Therefore SMS Siemag developed “Total Roll Gap Control” (TRC) to make threading in and out safer and to reduce off-gauge length to a minimum, resulting in a higher yield and boosting the economic efficiency of the discontinuously working plants

TRC is a special technological assistance system implemented in the level 2. As precondition to do this, roll gap setting is improved by thickness control based on direct roll gap measurement. This simplifies the overall control strategy of the discontinuous cold rolling mill. A coupling of gap adjustment and drive control is no longer given. Besides adjusting the overall rolling speed, the drives are only used for the tension control.

The TRC assistance system comes into play when the strip is being threaded in and out. It considers the wedge profile and thickness deviation at the strip head and tail ends, and ensures strip flatness and straight flow. Depending on the material properties the incoming thickness deviation and profile at strip head and tails ends, it keeps roll force within calculated as well as adjustable limits considering the biting condition and ensuring the flatness of the head end or tail end. The assistance system stays active only as long as necessary during threading in and out, and it does not affect body thickness quality as well as flatness. All this helps to keep the strip thickness in tolerance as soon as possible – while threading in – and as long as possible – while threading out. This makes threading in and out safer and in addition reduces the off-gauge length, as well as fast commissioning of the system is ensured.

For the first time SMS Siemag installed the innovative TRC threading assistance system in a four stand batch tandem mill at Bilstein GmbH & Co. KG, Germany, as part of a comprehensive revamp. Bilstein rolls a wide product range, including standard steel grades up to micro-alloyed high strength steels. Further our customer processes narrow and slit strips with different strip wedges, which is an additional challenge for threading. Apart from the supply of powerful mechanical equipment, SMS Siemag installed an integrated automation system, including level 1 and level 2. TRC as part of the new automation system allows a full automatically threading in and out procedure.

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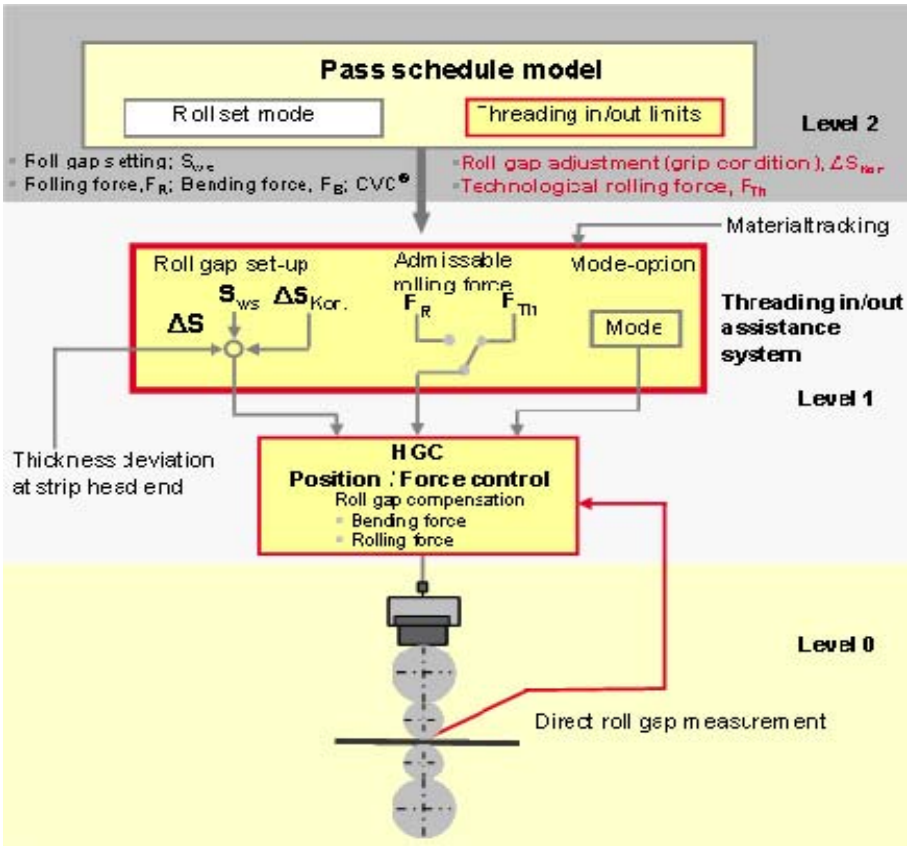

Figure 3. Technological features of the TRC System.

2.1.1 Operational results of the TRC system of Bilstein tandem cold mill

The improved process stability as well as the faster and more reliable threading in and out, together with new and more powerful drives, resulted in an increased production of 20%. At the same time, we were able to reduce the off-gauge length by some 50%. For the four stands tandem cold mill off-gauge length becomes smaller than the interstand distance between stand three and four. In addition the advanced automation reduces the personnel required to operate the tandem cold mill.

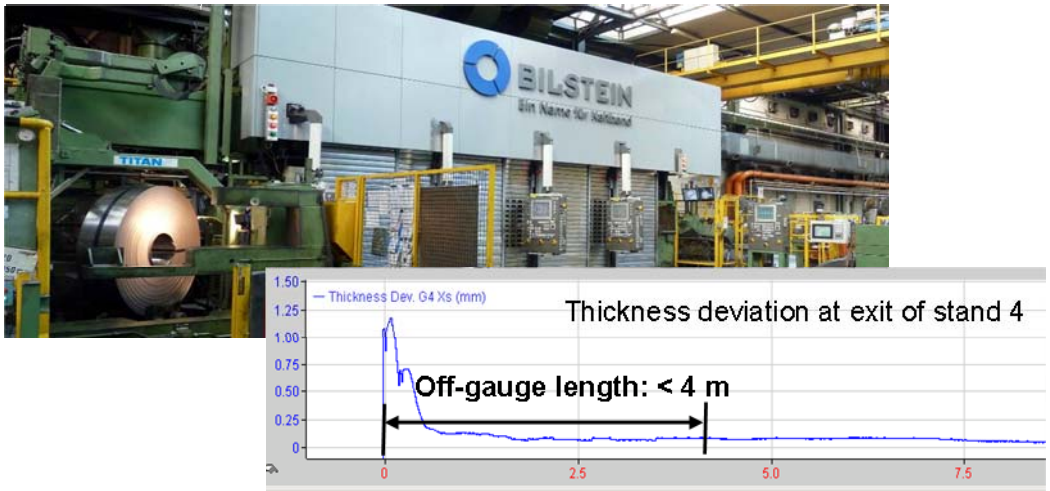

Figure 4. Operational results of the TRC system: off-gauge length at exit of stand 4.

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2.2 Mill Concepts for Special Grades

2.2.1 CVC® plus 18-HS mill for stainless steel

The CVC® plus 18-HS mill stand design from SMS Siemag combines an 18-roll mill stand with our practice-proven CVC® plus technology. It can be used in reversing mills as well as in tandem mills for efficient production of stainless steel strip.

The CVC® plus 18 HS is in principle a 6-high mill with driven intermediate rolls which are axially shiftable and equipped with roll bending devices. The small work rolls are laterally supported at entry and exit sides by supports which are fixed in the so-called cluster. The cluster arms are adjustable both for entry and exit sides by movable support bridges which are installed in the mill housing and driven by screws.

The benefit of this millstand type is that with the CVC® plus technology the roll gap geometry can be adjusted in a wider range. By this flatness defects of higher order can be corrected more efficiently and strip quality is improved.

By shifting the lateral side support and moving the work rolls in horizontal direction, it becomes possible to minimize the horizontal force and increase the process stability during rolling with such small work roll diameters.(1)

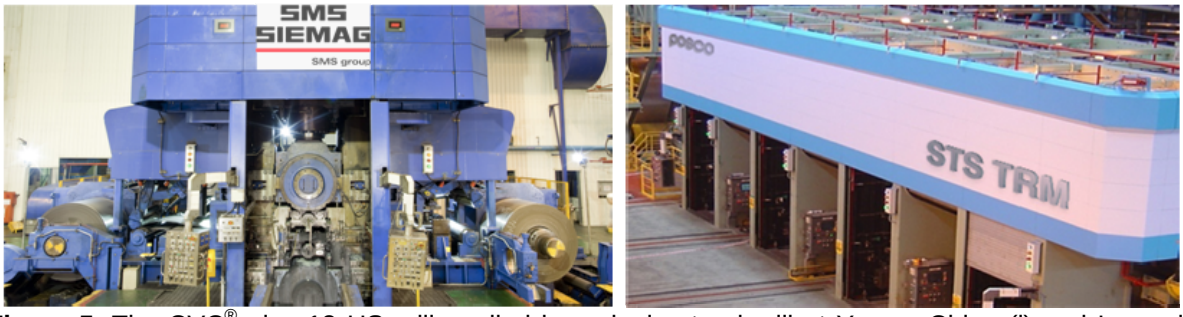

Figure 5. The CVC® plus 18 HS mill applied in a single stand mill at Yusco, China (l) and I a multi stand cold rolling mill at Posco, South Corea.

In 2007 we provided our Taiwanese customer Yusco with a single stand CVC® plus 18 HS reversing cold mill, designed for an annual capacity of 200,000 t. And recently, we supplied our South Korean customer Posco with a four-stand continuous tandem mill in CVC® plus 18-HS design with an annual capacity of 500,000 t.

2.2.2 Multipurpose rolling mill CVC® plus M18/4 - configuration for high flexibility

Apart from the major players in the world´s stainless steel business, which are able to operate a CVC® plus 18-HS mill at full capacity, there are customers, who produce a wide range of products, from carbon steels through high-strength grades to stainless steels, partly in small amounts. That's why SMS Siemag developed its multipurpose rolling mill CVC® plus M18/4.

This design makes it possible to change from CVC® plus four-high operation to CVC® plus 18-HS mode during a regular roll change. The intermediate and work rolls are arranged together with the supporting rolls in a change cassette, so that the entire set is changed at once. That eliminates any effect on rolling operation because alignment of the backing rolls is not necessary in the mill.

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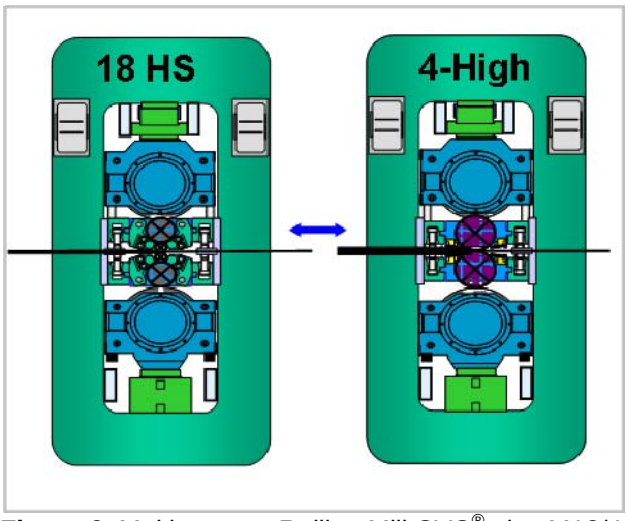

Figure 6. Multipurpose Rolling Mill CVC® plus M18/4.

Our CVC® plus M18/4 mill stands come with the following advantages:

- low investment costs, because of “two in one” concept;
- flexible production, from soft to extremely high-strength materials;
- high productivity due to higher reduction, reduced number of passes and minimized roll and mode change time.

2.2.3 Cold rolling mill configuration for silicon steel

Essential applications for silicon steel strip are machines, motors, transformers, electromagnets, relays and transmitters. For the rolling process of silicon steel there are some particularities to be mentioned. Before the first pass, the strip has to be pre-heated up to 150°C. Therefore rolling and recoiling temperature is higher compared to cold rolling of other material. Further strip tension is very low and high reductions need to be achieved in the first passes. In general the rolling process of silicon steel contains a certain risk for strip breakage. Cold rolling technology by SMS Siemag helps to minimize such risks and to achieve excellent strip quality.
For the cold rolling of silicon steel strip SMS Siemag offers three mill concepts. These are the CVC® plus-HS reversing mill as sexto and quarto and 20-high mill. Figure 7 gives an overview about these mill concepts, including the silicon grades preferred and the capability for each mill.

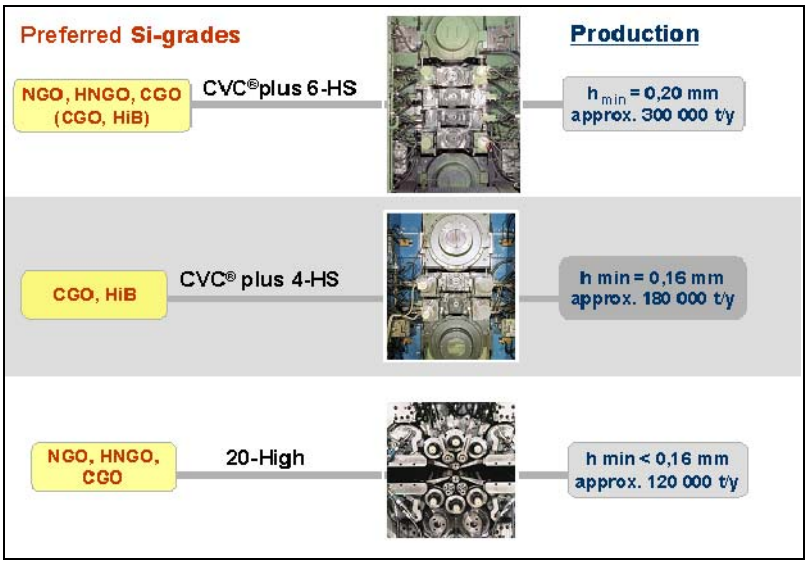

Figure 7. Mill concepts for silicon steel rolling by SMS Siemag.

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The CVC® plus-HS reversing mill in 6-high design allows rolling the widest range of silicon grades and has the largest annual capacity. In comparison, the quarto and the 20-high mill achieve lower final thicknesses. One reason for this is the higher stiffness of the mill stands. The CVC® plus-HS mill in 4 high design, can be equipped with slender work rolls by the way of comparison, which, in combination with the bigger backup rolls, create a favorable pressure condition in the roll gap.
The latest reversing cold mill reference for the rolling of silicon steel strip is Wisco, China. The powerful CVC® plus 6-HS reversing mill is designed to produce strip in widths of 750 mm to 1,280 mm and final thicknesses between 0.85 mm and 0.2 mm. Wisco uses the mill predominantly for the rolling of silicon steel strip in different grades with Si contents of up to 3.5%.
The rolling mill incorporates an array of high-tech components. These include the six-high mill stand with CVC® plus equipment, a positive and negative work-roll and intermediate-roll bending system, a strip cooling system as well as the multizone cooling system for the work rolls to set the roll configuration in keeping with the required roll-gap-geometry. The HS-system (Horizontal Stabilization) permits to set the horizontal forces acting on the rolls and enables the use of very slim work rolls. The job of Edge Drop Control system (EDC®) is to minimize the natural edge drop in the area of the strip edges which reduces material losses during subsequent trimming. Provided also with the X-Pact electrical and automation system by SMS Siemag, Wisco is able to attain an annual production of over 300,000 t of silicon cold strip featuring closest tolerances.

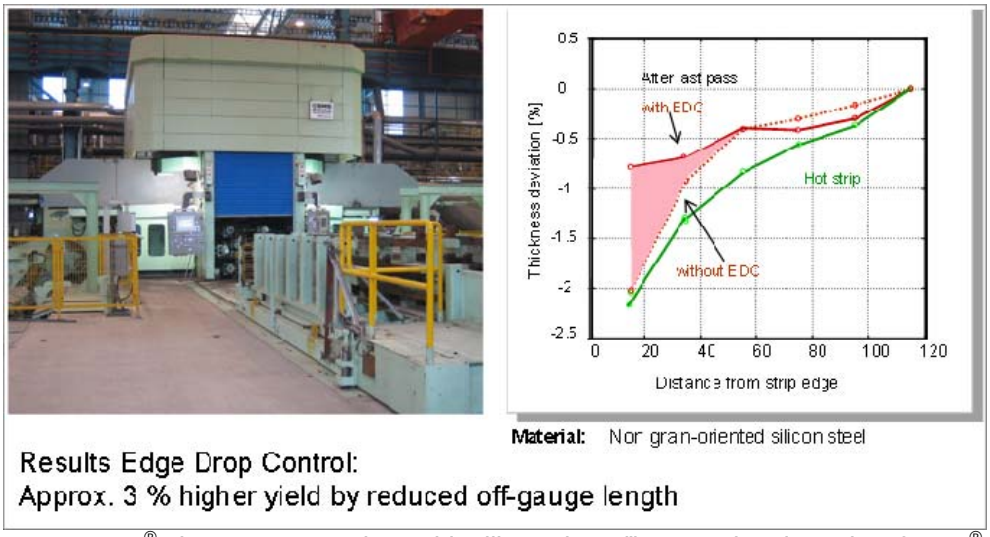

Figure 8. CVC® plus 6-HS reversing cold mill at Wisco (l), operational results of EDC® (r).

2.2.4 Cold rolling mill configuration for titanium

For cold rolling of titanium strip the 20-roll mill is the type of mill best suiting from the technical and economical point of view. To prove this, the 20-roll mill is compared with a 6 high mill (Figure 9). As strip a titanium strip of the TA3 series with widths of 1.250 mm and an entry thickness of 1.0 mm is considered to be reduced within 6 passes to final thickness of 0,4 mm. The rolling speed is 70 m per minute. Using the 6-high reversing mill, for each pass a rolling force of 7.000 to 8.000 kN is required. Whereas using the 20-high reversing mill with its extremely slender work rolls, the necessary rolling force can be kept about 2.000 kN.

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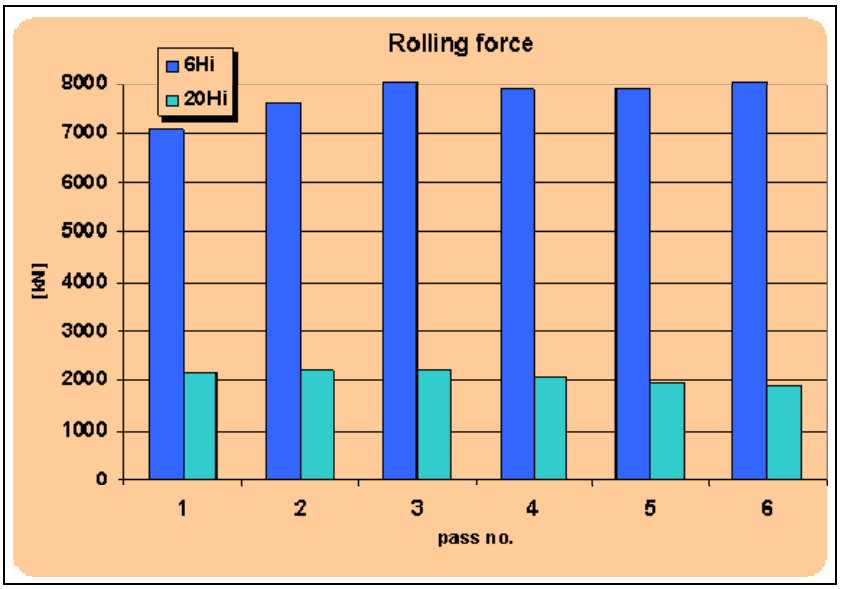

Figure 9. Cold rolling of titanium (TA3); comparison of rolling forces between 6-high and 20-high mill.

As the latest reference, SMS Siemag supplied a 20-high mill for the rolling of titanium strip to a Chinese customer, Hunan Xiangtou Goldsky Titanium Metal Company, who wants to branch out into the production of high-grade titanium strips. Comprising a type MB 22B-52" MonoBlock stand, the 20-roll cold mill will reduce hot-rolled titanium strips of the TA1, TA2 and TA3 series with a maximum thickness of 4 mm into cold strip with final gages of minimum 0.4 mm. The strips will have widths of up to 1,300 mm. The technical features of the mill design are hydraulic gap control, crown adjustment and intermediate roll shifting. The products achieved in this way feature closest thickness and flatness tolerances, and mainly serve for the manufacture of heat exchangers. The new mill can produce some 10,000 t of top-quality titanium strips annually.

Figure 10. MB 22-B52" mill for Hunan Xiangtou Goldsky Titanium Metal Company, carried out in all-in-one modular design, manufactured, pre-assembled in the Hilchenbach workshops of SMS Siemag.

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2.3 Skin-Passing Mills for a Larger Product Range

Due to the enlarged product mix, the skin pass mill has to meet different requirements. On the one hand, for ultra-soft material, like IF steels with very low strip elongation of 0.5% at very low roll forces must be rolled. On the other hand, high-strength strip requires high elongation corresponding with high roll forces.
The mill stand has to be designed to suit the maximum required roll force. Due to this, however, adjusting low roll forces becomes more difficult. For ultra soft material measures like increasing the work roll diameter, reducing tensions and the amount of emulsion used, will not be enough to keep the roll force controllable. Therefore, SMS Siemag has developed the Extended Bending System. For roll forces below 700 kN, the top backup roll is withdrawn from the working roll and the roll force is only applied through the roll bending system.

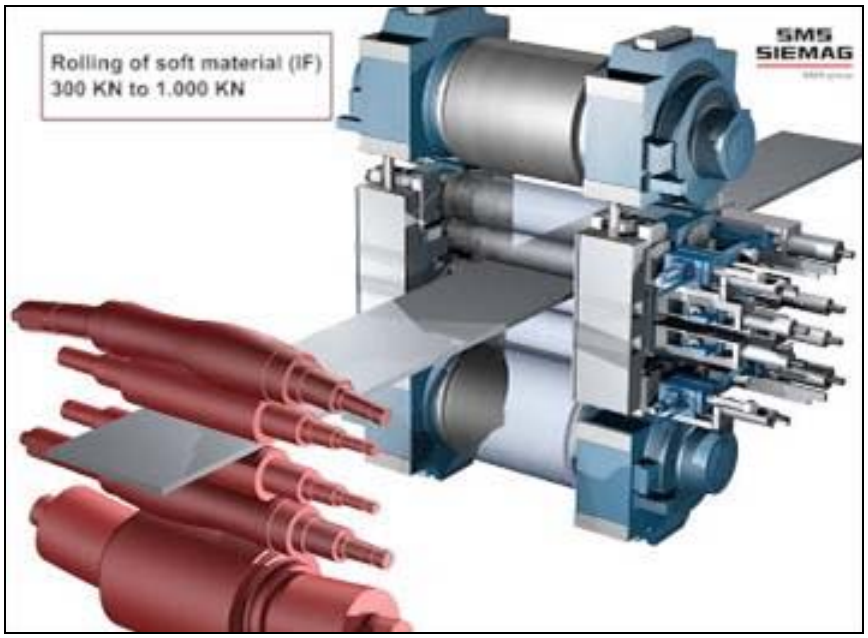

Figure 11. Skin passing of soft material: applying the rolling force by using the bending system only.

The latest references for the Extended Bending System are the CVC plus® 6-high inline skin-pass mills for Baosteel and for Handan Iron and Steel, both arranged in a continuous annealing line.

2.4 Low Quantity Lubrication for More Cost-Effective Skin-Passing

The low quantity lubrication combines the advantages of wet and the dry skin passing. It is installed at the entry side of the mill stand and applies only the amount of lubricant which is actually needed in the roll gap.

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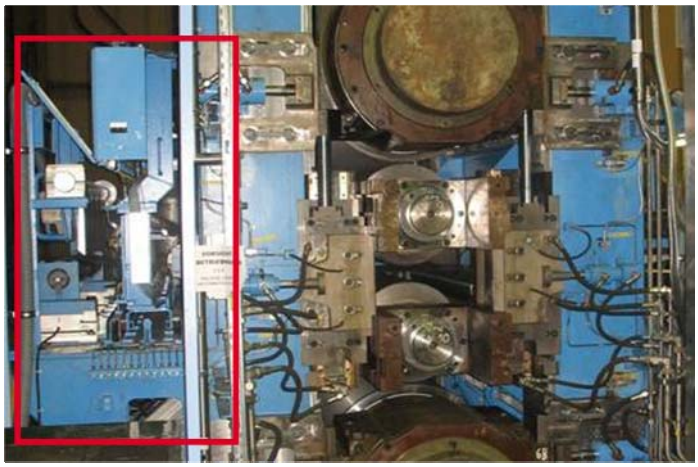

Figure 12. Low Quantity Lubrication (LQL): entry side arrangement.

The lubrication reduces the friction in the roll gap and thus the rolling force and improves the strip flatness. Figure 9 illustrates the clear reduction of roll force by low quantity lubrication for skin pass rolling of high strength steel strip (1,340 mm x 0.7 mm, elongation 0.7%), despite the fact that only top side was lubricated in the trial.

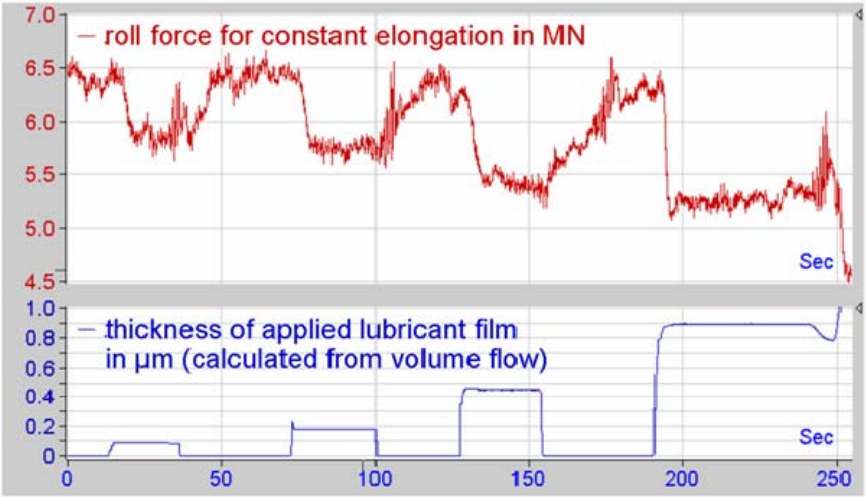

Figure 13. Roll force reduction depending on thickness of lubricant film (applied on top strip surface) at production test of low volume lubrication at skin pass mill in continuous annealing line of ThyssenKrupp Steel in Dortmund, Germany**.**

The low quantity lubrication applies only a film which is thinner than the combined roughness of the strip surface and roll. Therefore lubricant pockets which lead to imprints of the lubricant on the strip do not emerge (Figure 14).

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Figure 14. Comparison of the strip surface quality with and without low quantity lubrication.

As a consequence, many strips, which usually are dry skinpassed, can be also wet skinpassed by using LQL. So customers can increase the proportion of wet-tempered products with several positive economical effects. Because of the lower rolling forces, wear on the rolls is reduced. While the consumption of lubricant is minimized, operating costs are cut and finally strip flatness is improved.

2.5 Tailor-Made Rolling Oils and Rolling Emulsions from SMS Lubrication

With our subsidiary SMS Lubrication, we have also established ourselves as a supplier of rolling oils and emulsions.
In the face of steadily increasing requirements on the rolling process related to

- availability;
- reduction per pass;
- rolling speed;
- surface quality;
- steep ramp-up curve an wide;
- product range.

Rolling oil and emulsion become more important for the process. Out of a multitude of commissionings of our rolling mills, we have learnt that a narrow toothwork between the supplier of rolling mills, the supplier of the cooling lubricant system and the supplier of lubricants plays a major role.
Only by use of tailor-made lubricants, optimized conditions in the roll gap during the rolling process can be assured. Beside our comprehensive knowledge about the rolling process and the roll gap conditions, we have advanced tools for the analytical determination of the requirements on the lubricants available. Taking into consideration the given rolling parameters, rolling stock and pass schedule calculations with our T-Roll model are provided.
This physical simulation considers thermal, mechanical and tribological process parameters and allows a prognosis of essential design parameters for the rolling process and the specific demands on the lubricant. In combination with the determination of the friction coefficients under realistic conditions in our newly developed test facility, process optimized high performance rolling oils and emulsions are developed.

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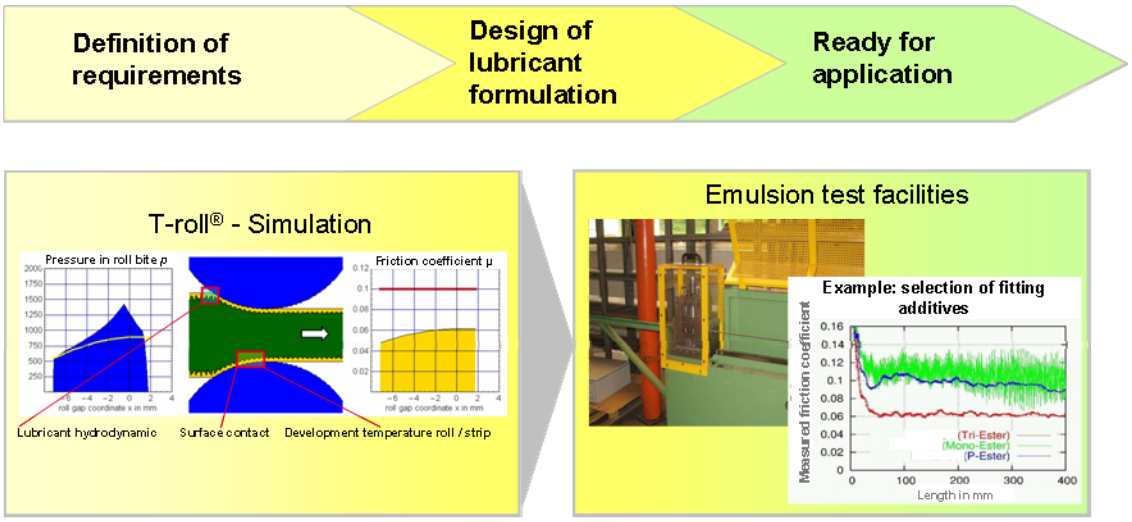

Figure 15. Process of creation of a tailor-made lubricant of SMS Lubrication.

What makes the products from SMS Lubrication stand out are low consumption, high lubrication effectiveness, low iron and oil residues on the strip, and therefore improved surface quality.
13 first fillings as well as a large number of re-fillings since 2009 prove the success of this method.

3 CONCLUSION

The paper has shown a number of the latest technologies by SMS Siemag for compensation of the special drawbacks of discontinuous mills, for special materials and for a more efficient operation.
Since 2000, we have constructed more than 80 new plants and carried out a large number of revamps. This underlines our global leadership as a supplier of equipment for cold rolling mills, as well as the high level of acceptance of our technological solutions. With our subsidiary SMS Lubrication, we have established ourselves as a supplier of tailor-made rolling oils and emulsions as well.

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