HOT ROLLING TECHNOLOGY FOR FUTURE MILL CONCEPTS[1]

Stephan Krämer[2]
Stefan Berger[3]
Kurt Eckelsbach[4]
Andreas Töpfer[5]

Abstract
The large number of newly installed conventional hot strip mills proves, that this plant type continues to be one of the most important and powerful metallurgical tools for the production of high-quality hot strip. From HSM owners, today the market demands a broad range of products with high quality (geometrical tolerances, mechanical properties). Intensive competition increases the necessity for economically efficient solutions. To meet these requirements, state-of-the-art plants are rated with much higher drive powers, roll forces and torques, more efficient cooling systems and stronger coilers than former ones. SMS Demag as all-inclusive supplier has developed a number of innovative solutions, which are characterized by a combination of mechanical design and automation technology. Examples for new hot rolling technologies: Camber free rolling: Camber in the transfer bar is eliminated by the interaction of strong hydraulic side guides and the automated Roll Alignment Control (RAC); Powerful microstructure models: They enable the monitoring and influencing of mechanical product characteristics and the optimization of the process control for steel grades difficult to roll; Compact cooling: In combination with a powerful cooling model a decisive feature for the production of innovative steel grades; UNI plus coiler: Based on the well-proven SMS Demag coiler design, the UNI plus coiler is designed especially for high-strength thick pipe grades; Modularization of mill design: Cuts investment costs, speeds up commissioning and simplifies maintenance; Plant and process monitoring: Enables an optimized, state-orientated maintenance thus avoiding production losses.
Keywords: Hot rolling mills technology; Camber free rolling; UNI plus coiler.

TECNOLOGIAS DE LAMINAÇÃO DE TIRAS A QUENTE PARA FUTURAS CONCEPÇÕES DE INSTALAÇÕES

Resumo
O grande número de plantas convencionais de laminação de tiras a quente recentemente instaladas mostra que esta tecnologia continua sendo uma das mais importantes e eficientes "ferramentas" metalúrgicas para a produção de tiras laminadas a quente de alta qualidade. O mercado exige dos operadores das usinas de laminação um leque muito amplo de diferentes tipos de aço, com elevada qualidade quanto às tolerâncias geométricas e propriedades mecânicas. Ao mesmo tempo, em função da competição intensa cresce a demanda por uma produção economicamente eficiente. Para poder cumprir estes requisitos, as instalações atuais são dimensionadas com potências de acionamento, forças e torques de laminação muito mais elevadas, dispositivos de resfriamento mais eficientes e bobinadeiras mais fortes do que antigamente. Além disso, a SMS Demag como ofertante de sistemas desenvolveu uma série de inovações para os sistemas fornecidos pela empresa, caracterizadas por uma combinação de projeto mecânico com tecnologia de automação. Alguns exemplos para a nova tecnologia de laminação de tiras a quente: laminação sem problemas de cambagem: a cambagem da pré-tira é evitada através da conjugação de guias laterais hidráulicas reforçadas e pelo alinhamento automático dos cilindros (Roll Alignement Control); modelação das propriedades estruturais: permite monitorar e influenciar as propriedades mecânicas do produto, bem como otimizar o controle do processo no caso dos tipos de aço de difícil laminação; resfriamento compacto: este é um componente decisivo para a produção de tipos de aço inovadores, juntamente com um eficiente modelo de resfriamento; UNI plus Coiler: baseado no consagrado projeto de bobinador SMS Demag, especialmente desenvolvido para qualidades de tubo de alta resistência e grande espessura; modularização do trem de laminação de tiras a quente: com esta concepção é possível reduzir os custos de investimento, acelerar o comissionamento e simplificar a manutenção; monitoramento da planta e do processo (Plant and Process Monitoring): possibilita uma manutenção otimizada, orientada para o estado da planta, evitando assim interrupções na produção.
Palavras-chave: Tecnologia de laminação a quente; Laminação sem problemas de cambagem; UNI plus Coiler.

[1] *Technical contribution to 44th Rolling Seminar – Processes, Rolled and Coated Products, October 16 to 19, 2007, Campos do Jordão – SP, Brazil.*
[2] *Dipl.-Ing., Executive Vice President, Hot/Cold Rolling Mills Division, SMS Demag AG, Germany.*
[3] *Dipl.-Ing., General Manager Technical Sales, Hot/Cold Rolling Mills Division, SMS Demag AG, Germany.*
[4] *Dipl.-Ing., Vice President, Hot/Cold Rolling Mills Division, SMS Demag AG, Germany.*
[5] *Dipl.-Ing., Senior Project Manager Technical Sales, Hot/Cold Rolling Mills Division, SMS Demag AG, Germany.*

MARKET DEVELOPMENT

Looking back on the development of the steel industry over the last 15 years, a major characteristic is the unexpected renaissance of the hot rolling mill. Out of the approx. 180 million t of hot strip capacity newly installed worldwide since 1990, about two thirds were produced by way of conventional hot strip mills.

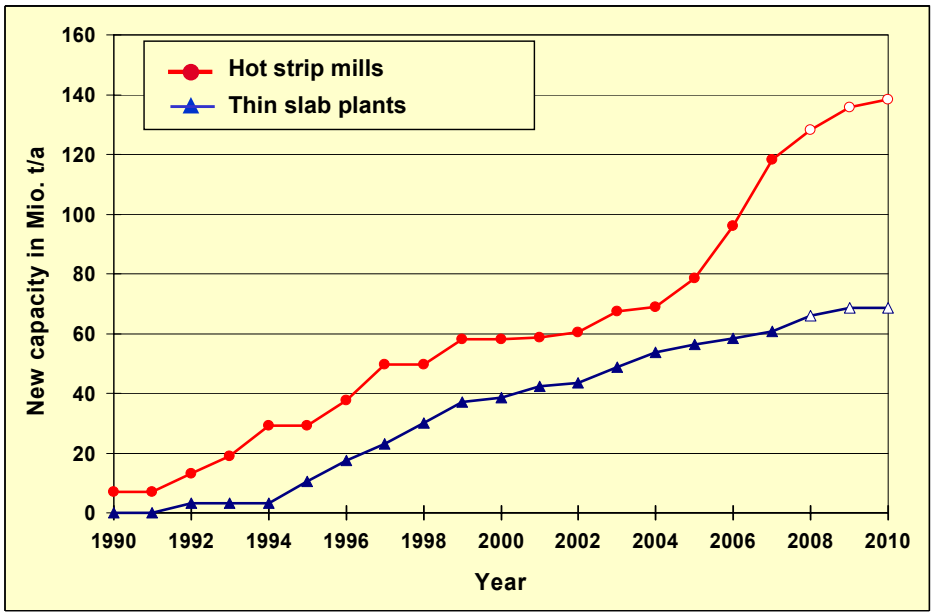

Figure 1: Expansion of hot rolling capacities since 1990.

In the process, the Asian growth markets were the most important regional focus for new plants, both for conventional hot strip mills and for thin slab mills: Firstly South Korea and China and for some time now India. In newly industrializing countries such as the Near East and Southeast Asia, new plants were erected in correlation with industrial-political strategies. The third growth region was North America. Here the mill owners counted above all on the thin slab technology which proved to be a suitable plant type in the strongly changing market. Also in Western Europe, this technology played an important role in the modernization of the steel industry.

HSM concepts

For conventional hot strip mills as well as for thin slab mills, SMS Demag is the unchallenged market leader. In the next two years alone, six new hot strip mills will go on stream with SMS Demag technology. Among the new plants are high-performance and compact hot rolling mills. The main difference between the two plant types is the coilbox which, in compact hot mills, is installed between the roughing and the finishing mill. It equalizes the transfer bar temperatures to the effect that with as few as six finishing stands final gages of 1.2 mm can be achieved. The output capacity of a compact hot mill is in the range of 3.5 million tpa, high-performance mills achieve up to approx. 5.5 million tpa.

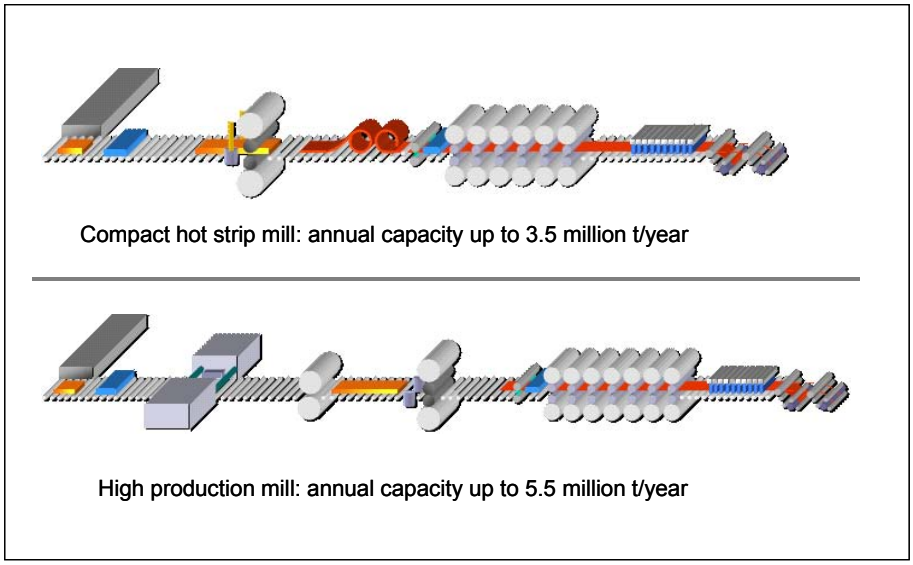

Figure 2: Concepts of compact and high production HSM.

Market demands

In recent years, the market did not only develop in terms of quantity but also in terms of quality. Today, of decisive importance for owners of hot strip mills is a broad range of products as well as meeting high product quality with regard to geometrical tolerances and mechanical properties. At the same time, the intensive competition increases the necessity for economically efficient production.
To meet these increased requirements, state-of-the-art plants and their components are designed for a significantly higher performance than former ones:

- Higher motor power, rolling torques and rolling forces for the production of high-strength materials
- Larger work roll diameters in first mill stands for increased reductions
- Smaller work roll diameters in last mill stands for lower final gages
- Higher water quantity in laminar cooling and more effective cooling devices (compact cooling) for more flexible cooling strategies
- Larger coiling capacity for an enlarged product spectrum.

Innovations

The advancement of plant technology becomes apparent in the large variety of decisive innovations by SMS Demag. They improve the hot strip quality, enable narrower tolerances and an enhanced dimension range or support the development of new steel grades. Moreover, the innovations aim at improving the economic efficiency of the rolling process, for example by higher plant availability and better process stability.

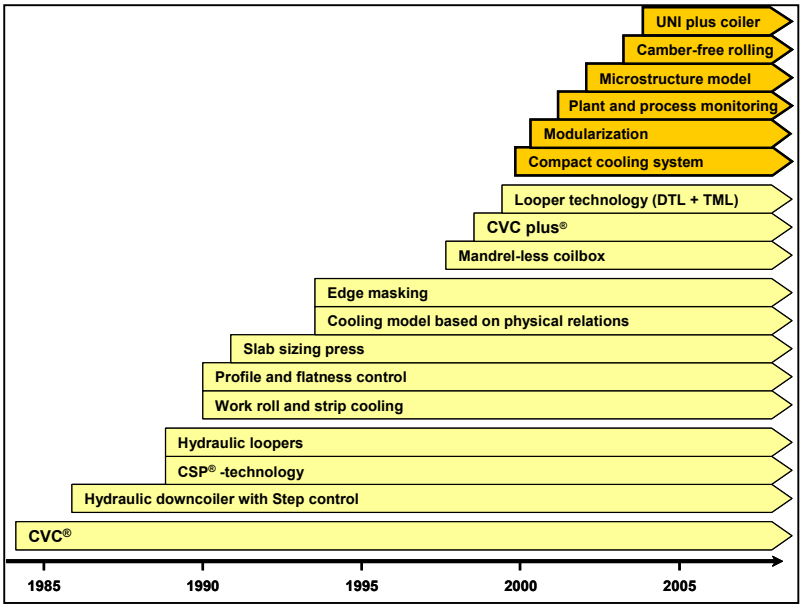

Figure 3: Important innovations in hot strip production by SMS Demag.

Characteristic of the most recent innovations is an optimized, well tuned rating of mechanics, electrics and automation. This is the prerequisite for further developments in process control as well as a more efficient plant rating. Another advantage of a close linking between mechanics, electrics and automation as supplied by SMS Demag is that for every problem the most efficient solution can by found by a combination of the mechanical design and the automation technology.

NEW HOT ROLLING TECHNOLOGIES

Camber-free rolling

An example of such a solution is camber-free rolling which was successfully introduced by SMS Demag. Camber in the transfer bar resulting from asymmetric heating or thickness wedges in the slab is one of the main causes for reduced stability of the rolling process in the finishing mill.
The combination of strong hydraulic side guides and the automated Roll Alignment Control (RAC) largely avoids the formation of camber. Heavy side guides actively counteract the formation of strip camber. The contact between side guides and rolling stock results in an asymmetric distribution of stresses in the material. The RAC ensures that the roll gap remains parallel and thereby enforces a mass flow crosswise to the direction of rolling in the stock.

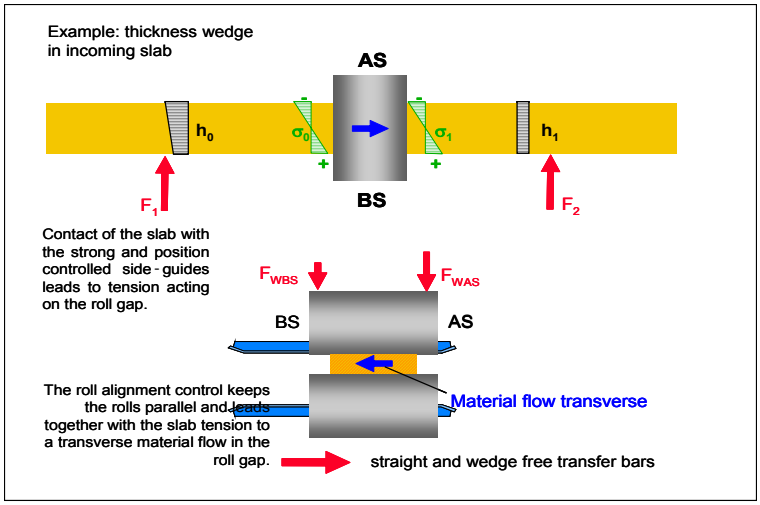

Figure 4: Principle of camber free rolling.

Figure 5 shows the elimination of camber in a transfer bar and an exemplary measurement of transfer-bar camber.

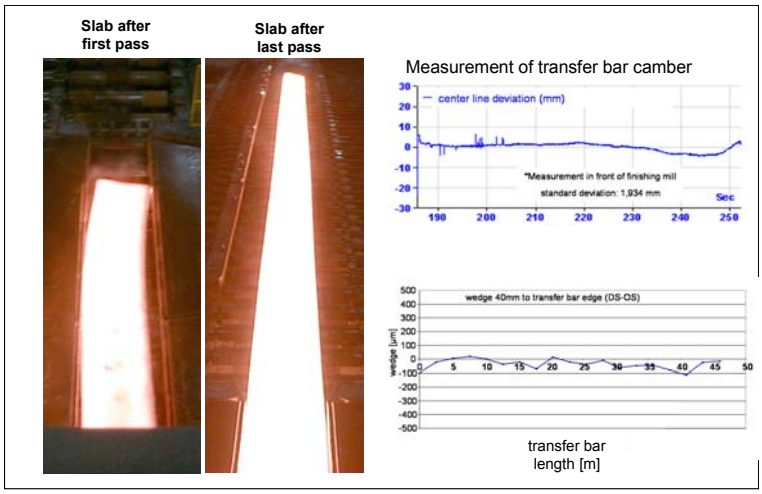

Figure 5: Results of camber free rolling.

Microstructure models

Another development focus is on the modeling of microstructure characteristics. Powerful microstructure models were developed, considering the temperature and deformation curves and the recrystallization behavior which allow a precise prediction of the material properties. This enables monitoring and influencing of the mechanical product characteristics and an optimization of the process control for steel grades difficult to roll. Moreover, the microstructure models cut the development times for new products.

The benefit of the microstructure models becomes apparent for example in rolling microalloyed steels. They are characterized by a highly complex, temperature-dependent recrystallization behavior in longitudinal and crosswise directions. If the work hardening and softening fronts relocate from the interstand area into the roll gap, the rolling behavior becomes instable and often results in cobbles. The microstructure model can be used to optimize the reduction distribution and temperature control in such a way that the critical work hardening and softening fronts are under the common scatter of the process conditions always between the stands.

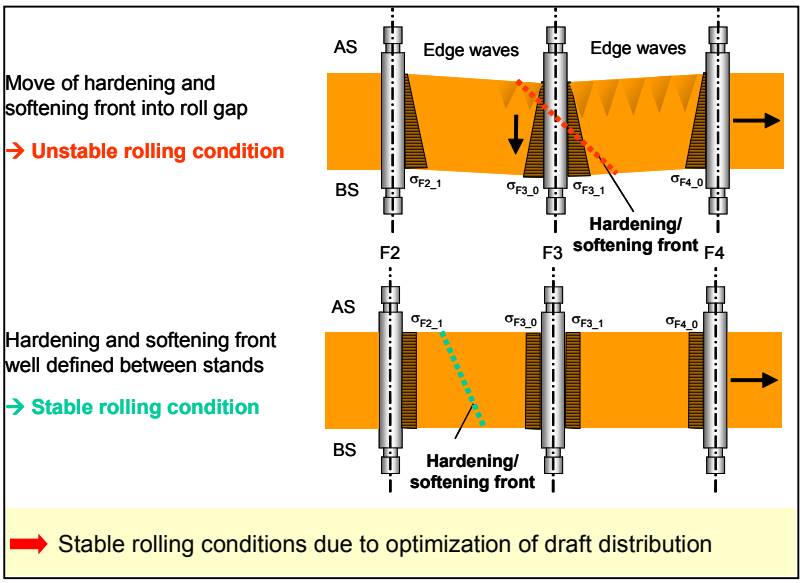

Figure 6: Strain hardening and softening of micro-alloyed steel.

Compact cooling system

The development of innovative steel grades creates further demands on the cooling section. High-strength steels like pipe grades must be cooled with a steep ramp, whereas dual-phase and multi-phase steels are cooled in several steps from finish rolling temperature to less than 200°C to 300°C.
Our compact cooling system implements high cooling rates by applying large amounts of water at high pressure over a short distance. Depending on the application, the cooling units are installed ahead of the laminar cooling line or just before the coiler. The installation of an edge masking system prevents excessive cooling of strip edges. Thereby, stress differences over the strip width are reduced and cold strip flatness improved.

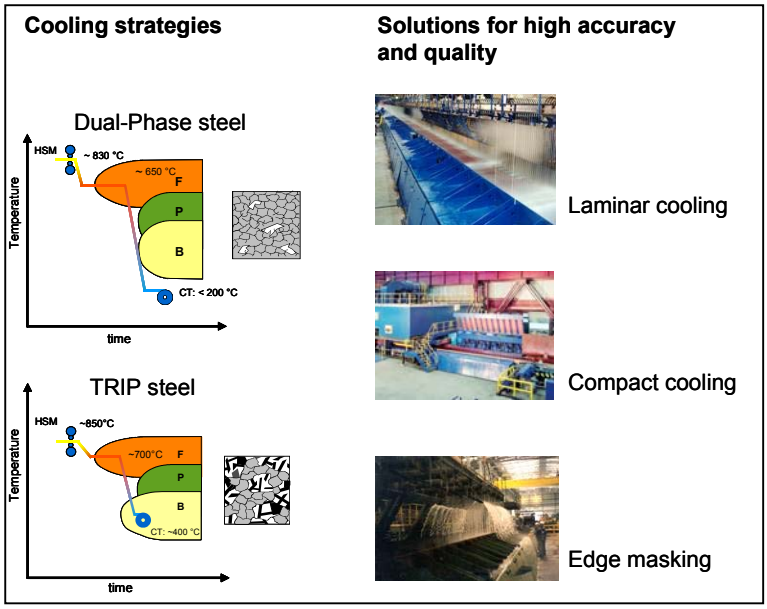

Figure 7: Cooling strategies and cooling equipment.

A powerful cooling model is a necessity to realize different cooling strategies for well-defined mechanical properties. The cooling model is based on mathematical-physical relationships and considers detailed conditions of heat flow within the strip as well as on the outside. As well, γ-phase transformation with its related energy is included.

UNI plus coiler

Currently the modernization of coiler systems is on the agenda of many owners of hot strip mills. This is due to the growing requirements for coiling high-strength tube grades in ever increasing thicknesses and widths which are more and more demanded by the power suppliers. To meet these demands, many well-known mill owners count on the UNI plus coiler. It is based on a coiler design which has proven its worth in over 100 applications. The further development to the UNI plus coiler is characterized by the reinforced mandrel for a long service life and the highly dynamic and precise setting of the position and the pressing forces of the wrapper rolls. The UNI plus coiler thus ensures an excellent coiling quality also for higher-strength materials in large widths and thicknesses.
An example of this trend is the new UNI plus coiler for Arcelor Bremen which went into service in 2007 and is one of the most powerful coilers in the world. It is rated for coiling tube grades with a maximum thickness of 25.4 mm and a strip width of 2,100 mm at low strip head-end temperatures.

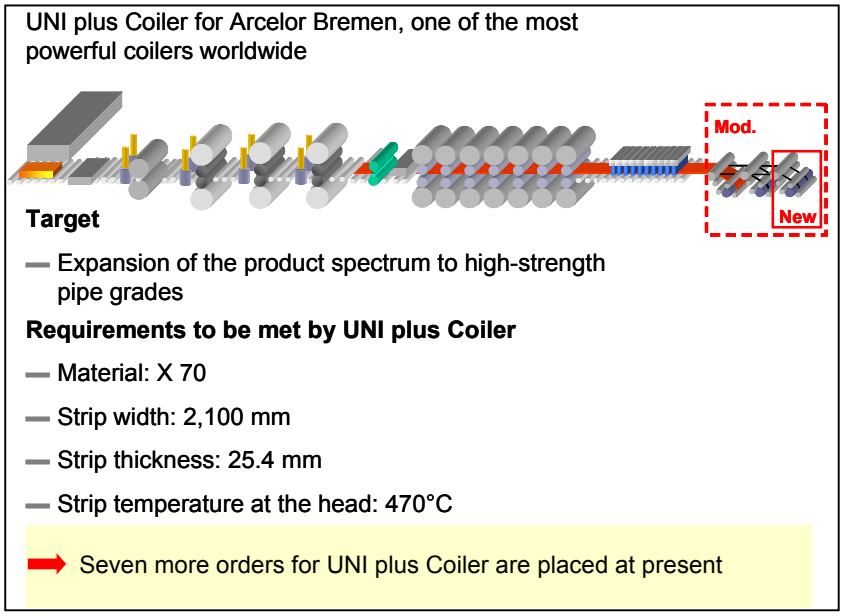

Figure 8: Main features of UNI plus coiler for Arcelor Bremen.

Modularization

For improving the economic efficiency in any phase of a plant's life cycle, SMS Demag implemented modularization of the hot strip mill to a large degree. This concept is able to cut the investment costs, speed up commissioning and simplify maintenance.
An example of this development is the modularization of the mill-stand hydraulics. All hydraulic controls are located in a media platform on the stand and connected via pre-fabricated pipework modules with the hydraulic actuators. Here each hydraulic function (e.g. hydraulic adjustment systems, work roll bending) is implemented in a

dedicated module. The different modules are combined in a compact column design and accommodated in the media platform separately for the drive and operator sides.

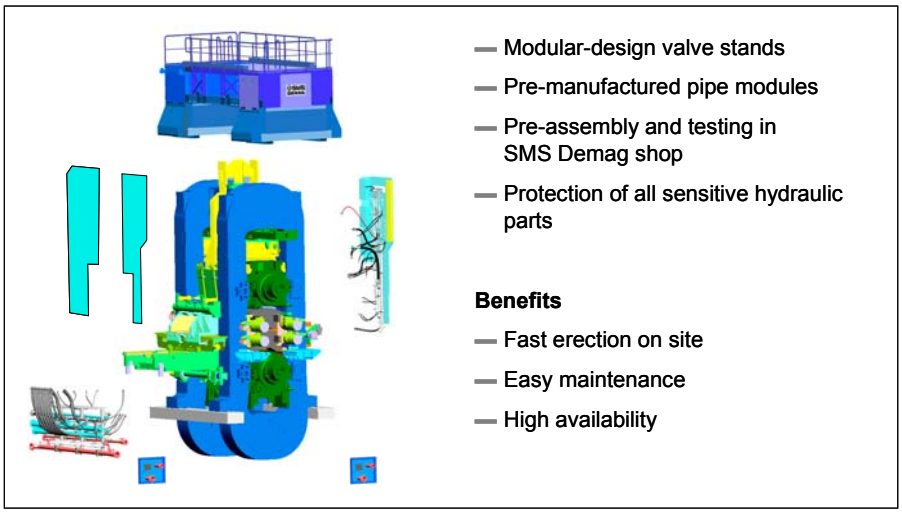

Figure 9: Modularization of hydraulic system.

The advantage of this design is that the system's susceptibility to failure is very low due to protected installation of all elements. The hydraulic supply is easy to service and accessible even in ongoing operation. Moreover, the complete hydraulic system is pre-assembled in our shops and tested before installation which results in shorter commissioning periods.

Plant and process monitoring

The Plant and Process Monitoring System (PPMS) is focused on maintenance optimization and avoiding production losses. It enables a state-orientated maintenance which is a function of the plant's actual condition and is therefore the most cost-effective kind of maintenance.
The PPMS system is based on three main modules: control circuit monitoring, drive monitoring and alarm analysis. The control loop monitoring uses simple characteristic variables for monitoring the performance of the control loop and makes tools available for a detailed analysis of performance deviations. In the field of drive monitoring, the PPMS includes systems for measuring and analyzing torque, bearing temperature and frequency. The alarm analysis evaluates the warning signals of the automation system. In that way it points out weak points and operating errors at an early date and enables successively improving plant operation.

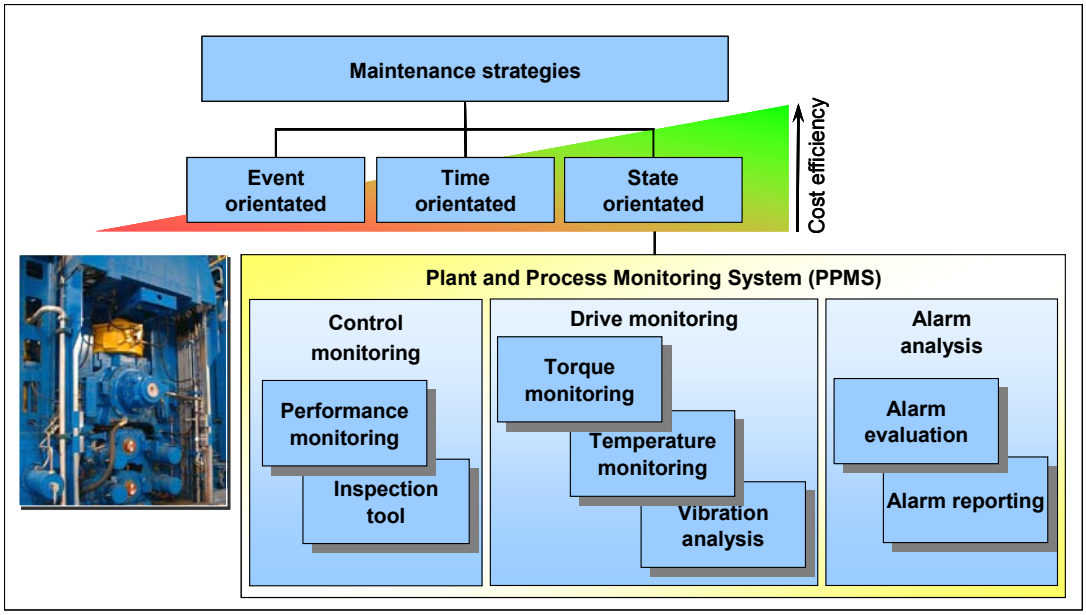

Figure 10: Configuration of PPMS.

CONCLUSION

These examples show how the proven concept of the conventional hot rolling mill has been complemented by a large number of technological innovations leading to major improvements of product quality, productivity and economic efficiency. As system supplier, SMS Demag offers technologically and economically optimized overall packages of mechanical equipment, electrical and automation systems which ensure that the hot rolling mill will continue to be one of the most important and powerful tools for producing high-quality hot strip.