

Trends in the modernisation of conventional hot-strip mills

Modernising hot-strip mills can be an effective way to adapt to market requirements and decrease conversion costs. Approaches range from incremental improvements through to a full revamp in one stage.

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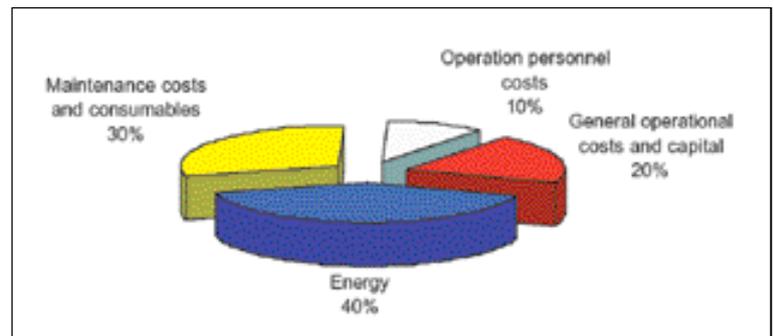
Continually increasing demands on product quality and lower cost production force hot strip producers to constantly seek for equipment improvements and more efficient rolling operations. A detailed knowledge of the mill condition, the hot strip quality produced and the connection to costs lead to different measures being required, and often de-bottlenecking studies help define the right measures to increase productivity. Other important items are the return on investment and the payback period. Today, modernisation measures increasingly target profitability instead of the more quality-oriented measures observed about 10 years ago.

For special measures, which require a major shutdown it is useful to cooperate with an external partner such as a mill builder who will bring expertise on the technical solution, evaluation of investment costs, and planning of the revamp and shutdown. Moreover, an external supplier shares the risk with the steel company.

Three examples will be described to show the different approaches and philosophies of mill modernisation.

Introduction

Considering the major investment expenditures necessary for new hot-strip mills, it is well worth first investigating the hidden potentials of existing facilities. For maximum benefit modernisation projects and improvements should not significantly affect ongoing production operations, must be rapidly implemented and should assure a short



● **Figure 1** Typical cost distribution in a European hot-strip mill

payback period. For a successful project, in-depth knowledge about both the strong and weak points of the mill and processes is necessary, and the close cooperation with an experienced engineering and plant-building partner is vitally important.

General remarks on targets of modernisation

In general, the targets of modernisation projects and improvements can be divided into two groups:

- Decrease of conversion costs (\$/t)
- Adaptation of the hot-rolled strip products to market requirements

Target group: Decrease of conversion costs

The major cost elements (see Figure 1) for a decrease of conversion costs are:

- Costs for energy (deformation, reheating and energy for other mill equipment like pump stations)
- Costs for maintenance and consumables (maintenance personnel, rolls, general wear parts, spares, lubrication oil, grease and so on)
- Costs for operation personnel

Depending on specific cost structures and internal interfaces, some producers also consider the costs for slab and coil transport as conversion costs.

For the evaluation of modernisation projects it is also useful to look at the conversion costs of specific products, for example, work roll wear is much higher when rolling thin gauges (<1.7mm) than for thicker gauges, and reheating of HSLA grades will be more expensive than for structural steel grades due to different heating times.

Characteristic numbers for benchmarking

Productivity, availability and yield describe the production capability of a mill and are often used for benchmarking. This benchmarking has to be done very carefully, that is, the current product mix, layout, market, equipment, and so on, have to be considered, since the productivity will not be comparable, for instance, if one mill has a share of thin gauges of 5% and the other 20%. Today, the availability of conventional hot-strip mills (actual net rolling time related to planned net rolling time including scheduled roll changes) is more than 80%, the yield (weight of coiled strips related to weight of charged slabs) is typically 98%.

Target group: Adaptation of the hot rolled strip products to the market requirements

This target deals with the product itself and can be divided into three areas:

- Improvement of product quality (thickness, crown, surface, flatness, and so on)
- Extension of the dimensional range of the product mix (wider, thinner, and so on)
- Extension of the steel grades mix such as dual phase steel or transformation induced plasticity (TRIP) steel

Evaluation aspects of modernisation projects

The variety of measures to reach these targets affects improvement potentials in the hot rolling process itself, such as logistics, mechanical and hydraulic equipment, and automation systems. The decisions about which measure, when, and to what extent they will be implemented, depends on the pay-back period and the sustainable positive effect on competitiveness.

The evaluation of modernisation projects requires a continuous and detailed reporting and data logging of costs, consumption figures, maintenance, process data, product quality data and detailed knowledge about the different dependencies of all these aspects. It will be pointless to justify measures for improvement of yield if the weighing device for the charged slab is partly out of operation or has big deviations when it is calibrated.

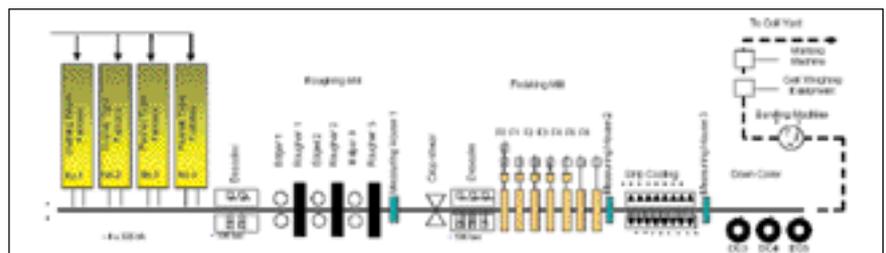
All measures to improve productivity, availability and yield increase the potential output of the mill and will therefore decrease the specific conversion costs directly. For evaluation it has to be determined whether the HSM itself is the bottleneck (earnings from

Company	Short description
Jiangsu Shagang Group Co. Ltd, China	Second hand hot strip mill transferred to China, modernisation during erection to penetrate the flat product market
Ispat Annaba, Algeria	Full revamp in one stage to increase productivity, availability and product quality
voestalpine Stahl GmbH, Austria	Continuously upgrading of equipment, continuous investigation of cost savings and hidden potentials

● **Table 1** Examples of modernisation projects

	Reduction of operation cost				Adaption to market requirements		
	Energy	Utilities	Productivity	Yield	Product quality	Extension strip dimension	Extension product mix
Descaler: Primary, rougher no. 1+2, finishing mill, F1					X		
F1 – F6: HAGC, new back-up roll change			X		X		
F0 – F6: New wear plates, piping, hydraulic systems		X			X		
F4 – F6: Work roll bending, work roll shifting, SmartCrown, modernisation work roll change			X		X		
New laminar cooling					X		
New level 1+2 automation	X	X	X	X	X	X	
VAIQ Strip					X		X
Metallurgical and operational know-how			X		X		X

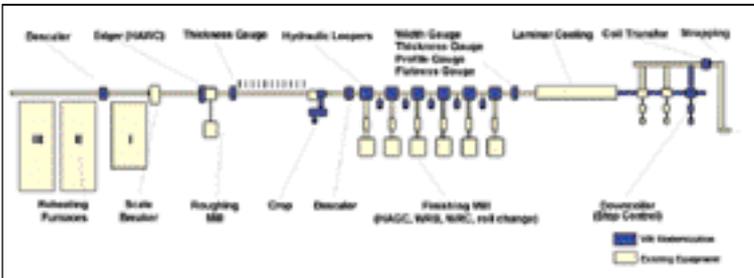
● **Table 2** Modernisation activities at Shagang HSM



● **Figure 2** Layout of the reassembled mill of Shagang

additional production), and also which individual part of the mill is the bottleneck. This can be valid for the total production or only parts of the product mix.

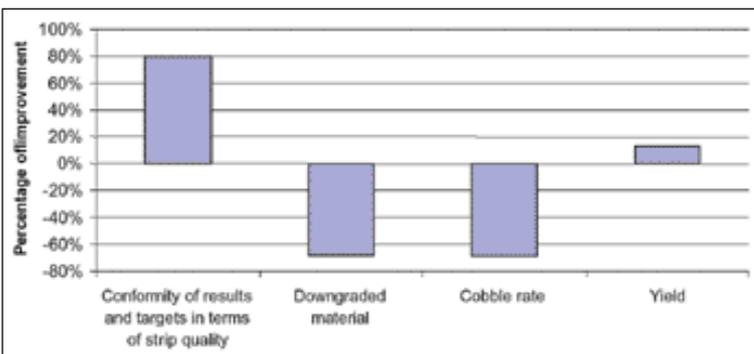
The evaluation of the measures for the target group ‘adaptation to market requirements’, is much more difficult, except maybe for the valuation of downgraded, rejected or scrapped material. The improvement of the thickness tolerance will affect neither productivity or yield. If the hot-strip mill is only producing for an internal customer, the investment is ‘just to fulfill the internal requirements’, and the



● Figure 3 Layout of Ispat Annaba HSM



● Figure 4 Ispat Annaba HSM



● Figure 5 Improvements after the modernisation of the Ispat-Annaba HSM

invested money will pay back indirectly via the earnings of, for example, cold-rolled products. It is difficult to estimate lost earnings or lost market share because of inferior product quality in comparison with the competition. Similar conditions exist for evaluating extensions to the dimensional range and range of steel grades.

Investors use different valuation models, depending on the structure of costs and markets and the company or shareholder philosophy. It can be assumed that many measures, which are published under the title of

	Before modernisation at Dortmund	After relocation and modernisation
Capacity	3.6Mt/yr	4.5mtpa
Thickness range	1.5–16 (20)mm	1.5–20mm
Width range	600–1,550mm	900–1,550mm
Max. coil weight		32t
Steel grades	Structural steel HSLA grades Pipe grades	Low carbon steel Structural steel HSLA grades Pipe grades (X70) Ferritic stainless Austenitic stainless Silicon grades

● Table 3 Product data of Shagang HSM before and after modernisation

quality improvement, are combined measures and the valuation is mainly justified by the increase of production, yield and availability, or decrease of other costs such as energy, at the same time.

Planning of projects

Another aspect is the implementation of a modernisation project itself. If the duration of the planned shutdown is exceeded even by only a few days, or the productivity is low for a long period because of a weak start-up or learning curve, the financial and market consequences can be severe. The accurate estimation of the duration of a shutdown requires a detailed investigation and description of the work to be carried out. To avoid additional risks, the detailed technical solution has to be prepared in advance. Often it is recommended to involve an external partner in a study, who is experienced in modernisation projects. This partner provides specialists, brings new ideas and, if given the contract, takes over guarantees and shares risks.

Hidden potentials

These are measures, which require almost no or only minor investment. They are typically improvements which could be reached by continuous and critical investigation of the metallurgical and deformation processes or the working procedures. The base is again an in-depth knowledge of processes, a detailed data logging exercise, and reporting system. Examples of hidden potentials are:

- Hot charging and direct charging
- Optimisation of slab length (hearth coverage)
- Investigation of gap times
- Energy consumption of, for example, pump stations
- Scheduling of rolling campaigns
- Reheat times of slabs
- Sampling costs

These potentials may differ between plants and locations and have to be evaluated individually.

Examples of hot-strip mill modernisation projects

Table 1 shows examples of three different approaches.

HSM modernisation at Jiangsu Shagang Group Co. Ltd, China

Jiangsu Shagang Group Co. Ltd purchased a hot-strip mill from ThyssenKrupp Stahl, Westfalenhütte in Dortmund, which was shut down in March 2001. The equipment has been dismantled and subsequently shipped to China to be reassembled by the end of 2004 under the direction of Shagang. Shagang is a producer of long products and is utilising this investment to enter the flat products market. In July 2002, Shagang contracted VAI and ABB (as electric supplier) for the modernisation of the equipment in the hot rolling mill (see Figure 2).

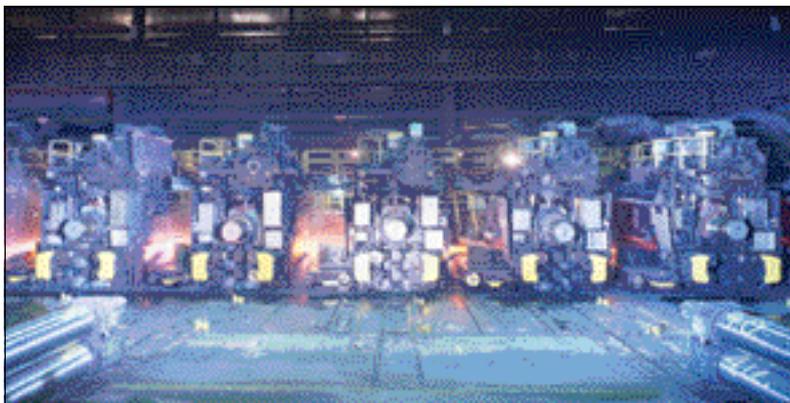
The mill modernisation activities are shown in Table 2, where the improvements are categorised in the two target groups, reduction of operating costs and adaptation to market requirements.

By carrying out these measures Shagang will achieve the following objectives:

- Improvement of the strip quality
 - Dimensional tolerances
 - Surface quality
 - Mechanical properties
- Higher level of plant availability
- Increased production

(See also Table 3.)

In addition, the client also ordered



● Figure 6 Hot strip mill voestalpine Stahl, Austria

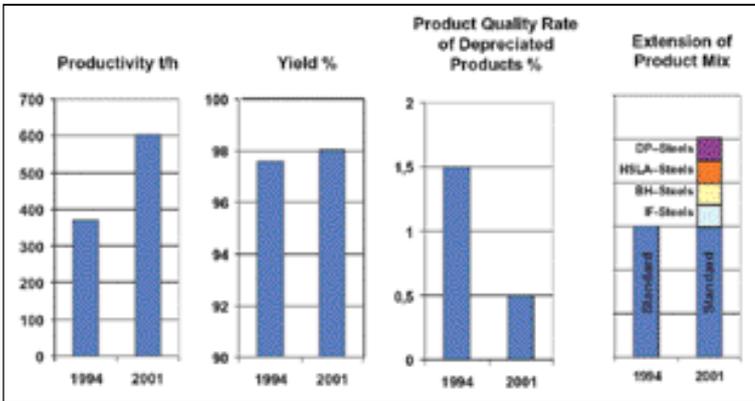
	Reduction of operating cost				Adaptation to market requirement		
	Energy	Utilities	Productivity	Yield	Product quality	Extension strip dimension	Extension product mix
Furnace area							
• New measurement system, level 1+2 automation	X			X	X		
Roughing area							
• Modernisation of scale breaker					X		
• Modernisation of descaler					X		
• New hydraulic edger for width control				X	X		
Finishing mill area							
• New crop shear				X			
• Work roll bending F1 – F6					X		
• Hydraulic F1 – F6					X		
• Hydraulic looper					X		
• New laminar cooling					X		
• Improved work roll change				X	X		
• Automation L1 + L2				X	X		
• New measurement systems					X		
Downcoiler area							
• Hydraulic side guides					X		
• 1 new hydraulic downcoiler			X		X		
• Strapping machine					X		
• Hydraulic system for coil handling							
• Automation L1 + L2			X	X	X		
Additional supply							
• Training, operational assistance							
• Spare parts							
• Local mill stand machining							
• Engineering for erection and turn-key parts							
• Air condition systems for hydraulic and PLC rooms							

● Table 4 Details of modernisation activities at Ispat Annaba HSM

essential metallurgical and operational knowhow. This kind of additional investment will be a key factor for successful and rapid entry into the market for flat-rolled products.

HSM modernisation at Ispat Annaba, Algeria

Although the managers of the previous owner of the HSM at Alfasid had considered modernisation since the early 1990s, nothing was done, and since then the condition of



● **Figure 7** Improvements at voestalpine Stahl HSM between 1994 and 2001

	Reduction of operating cost				Adaptation to market requirement			
	Energy	Utilities/environment	Productivity	Personnel	Yield	Product quality	Extension strip dimension	Extension product mix
Descaler						X		
Skids, low-NOx burner for pusher type furnaces no. 6 and 7	X					X		
New laminar cooling						X		X
New level 1+2 automation systems			X			X		
2 new thickness gauges						X		
Dust exhaust hoods for stands F4, F6		X						
New crop shear			X			X		
Finishing mill edger			X		X	X		
Flatness gauge					X	X		
Water systems		X						
Surface inspection system				X		X		
Work roll shifting for finishing mill stands						X		X
Work roll lubrication	X	X				X		
New edger, new rougher			X			X	X	
New drives for rougher and finishing stands			X				X	
New coil handling system					X	X		
Revamp of downcoilers (hydraulic pinch roll unit and wrapper rolls)			X			X		

● **Table 5** Modernisation steps at voestalpine Stahl, Linz, Austria

the mill worsened such that modernisation of the entire mill became necessary. This commenced under the new ownership, Ispat Annaba (see

Figure 3). The objective of this project was to improve strip tolerances, mill productivity and availability. Installation of the supplied equipment commenced in January 2002 and the revamped hot-strip mill was successfully commissioned in June 2002 (see Figure 4).

For the execution of this project the operation and maintenance management required a strong plant building partner. This partner needed to be experienced in this type of project due to the fact that no established manufacturing and erection companies were available in this region of Algeria. Besides the engineering erection and start-up of the mill (see Table 4), VAI supplied numerous assistance activities in the form of operational personnel to support the mill start-up and to optimise the new equipment and automation systems. Figure 5 shows some of the key improvements achieved.

HSM modernisation at voestalpine Stahl GmbH, Austria (see Figure 6)

At the beginning of the 1990s, voestalpine Stahl GmbH started to change its philosophy on how to improve hot-strip production, considering both target groups; decreasing costs and improving product quality. It increased the number of specialists in the rolling process and maintenance, and started to investigate the weak and strong points in detail. Additional reporting systems were installed and assessments of the rolling process, scheduling, metallurgy, maintenance and so on, were carried out. The result is a continuous upgrade of the mill as described in Table 5.

The continuous improvement steps resulted in a productivity increase of approximately 60%, a yield improvement of 0.44%, and a reduction in the depreciation rate of 1%. Additionally, the product mix was enlarged by those steel grades which were requested by the market and for which the highest profits could be expected. The improvements from 1994 to 2001 are depicted in Figure 7.

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