ISSN 1983-4764

MODERN WORK ROLL GRADES FOR ROUGHING STANDS IN HOT ROLLING MILLS[1]

Weiguo Ji[2]
Bernd-H. Beuter[3]

Abstract

Over the past few years, many modern hot rolling mills have been built worldwide for hot strip production. In both new and existing mills, it is necessary to use optimally suitable roll grades. This paper analyses the specific features of two-high and four-high roll stands in hot rolling mills and presents optimum work roll grades. These include rolls with a working layer of hot-working steel and high-speed steel. Experience has shown that using such roll grades not only substantially reduces wear, but can also significantly extend roll life. The consequences of mill accidents and stickers are made substantially less severe. This leads to a reduction in non-productive roll consumption and an increase in economic efficiency.
Keywords: Roughing stands; Work roll grades; Roll wear

1 *Technical contribution to the 47th Rolling Seminar – Processes, Rolled and Coated Products, October, 26th-29th, 2010, Belo Horizonte, MG, Brazil.*
2 *Chief R&D, Gontermann-Peipers GmbH, Germany*
3 *Sales Manager, Gontermann-Peipers GmbH, Germany*

ISSN 1983-4764

Introduction

With both continuous rolling lines and steckel rolling lines, in the roughing stands of hot strip rolling mills, an effort is made to structure the production process as efficiently as possible. To this end, the metal is formed in a few passes with maximum height reduction per pass. This is complicated by a relatively slow rolling speed and the high temperatures of the material being rolled, which result in extreme heating of the surface of the roll. Before this background, roll manufacturer Gontermann-Peipers carried out many research and development projects in the area of roughing stand work rolls with the objective of developing suitable grades for the various stands, rolled products and rolling conditions.

Work Roll Grades for Four-High Roughing Stands

For many years now, an established grade for work rolls in four-high roughing stands has been so-called "high-chrome steel" with a core material of ductile iron and an alloy content of more than 10% chrome and other alloying elements in the working layer. Besides increasing wear resistance, these also increase the thermal resistance of the material, which reduces susceptibility to fire cracking.
The carbides in high-chrome steel take the form of M_3C and M_7C_3 carbides. However, the basic hardness of these carbides is relatively low, thus the rolls are not very wear resistant. At high rolling temperatures, this grade forms a dense, hard oxide layer on the surface of the roll. However, this results in a significant reduction in the friction coefficient, so that a high pass reduction is no longer possible.
This is why, some twenty years ago, Gontermann-Peipers began developing a roll with a working layer material similar to high-speed steel and a core made of spheroidal graphite iron. On various occasions, GP employees have presented this grade as semi-HSS, namely, because of the lower alloy content in comparison with HSS.[1-3] Gontermann-Peipers still produces work rolls made of this material today using a vertical centrifugal casting machine.
In the meantime, experience has shown that this grade is especially suitable for rolling carbon steel.
Similarly to high speed steel, semi-HSS is alloyed with the alloying elements chrome, molybdenum, tungsten and vanadium, but the total quantity of alloying elements is slightly lower than with classic high-speed steel. The carbon content is also lower. The special carbide forms and material characteristics, however, are similar to those of high-speed steel, namely:

- Special carbides such as MC, M_2C und M_6C are formed, which substantially increases basic hardness and wear resistance;
- The thermal resistance and tempering resistance of the working layer material are greatly increased by the alloying elements. Susceptibility to fire cracking is significantly reduced, even in the event of stickers;
- The total carbide content is only 5%. In many cases, this lower carbide concentration in comparison with high-speed steel makes it possible to increase pass reduction.

In the beginning, semi-HSS was very difficult to manufacture. The main problems were micropores, microcracks, poor transition between working layer and core and higher residual compressive stress. Many roll manufacturers abandoned production of semi-HSS rolls because of the high scrap rate. Meanwhile, after some time, it was

ISSN 1983-4764

possible to solve the manufacturing problems on the basis of protracted investigations.
Semi-HSS has the following advantages in comparison with traditional high-chrome steel:

- In many cases, roll performance is increased by 50%;
- This makes it possible to extend roll life substantially;
- The risk of slipping is reduced. In some cases, it is possible to raise the height reduction per pass and reduce the number of passes;
- Fire cracks are no longer so deep, thus reducing unproductive losses.

Figures 1 and 2 show a wear profile comparison between conventional high-chrome steel and semi-HSS. After a roll life of approx. 25,000 t, both top and bottom rolls evidence significantly less wear than with high-chrome steel.

Wear of Bottom Rolls in Chrome Steel and Semi-HSS Grade

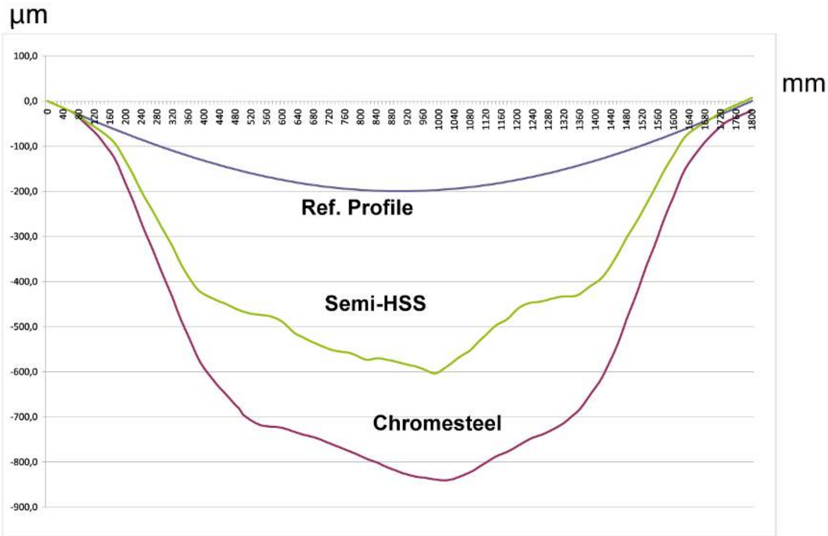

Figure 1: Wear profile for bottom rolls after approx. 25,000 t.

Wear of Top Rolls in Chrome Steel and Semi-HSS Grade

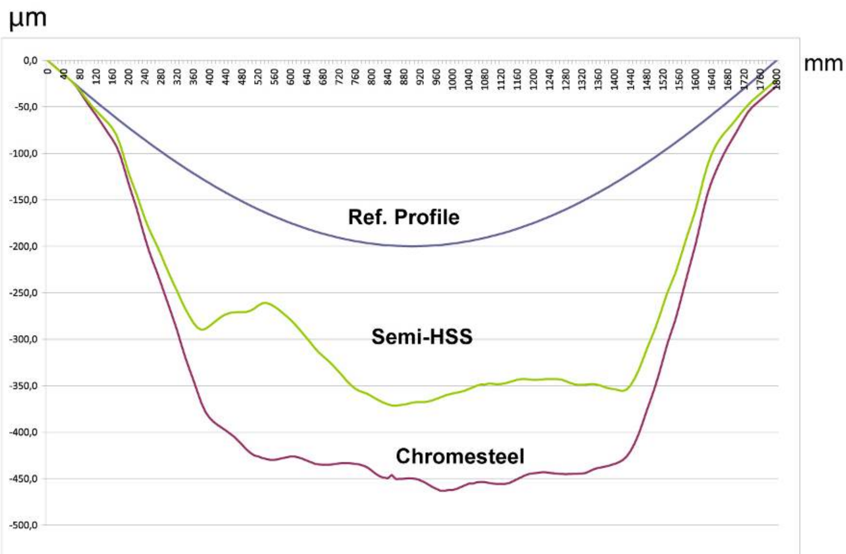

Figure 2: Wear profile for top rolls after approx. 25,000 t.

ISSN 1983-4764

Figure 3 shows a semi-HSS roll after a five-day campaign of approx. 80,000 t.

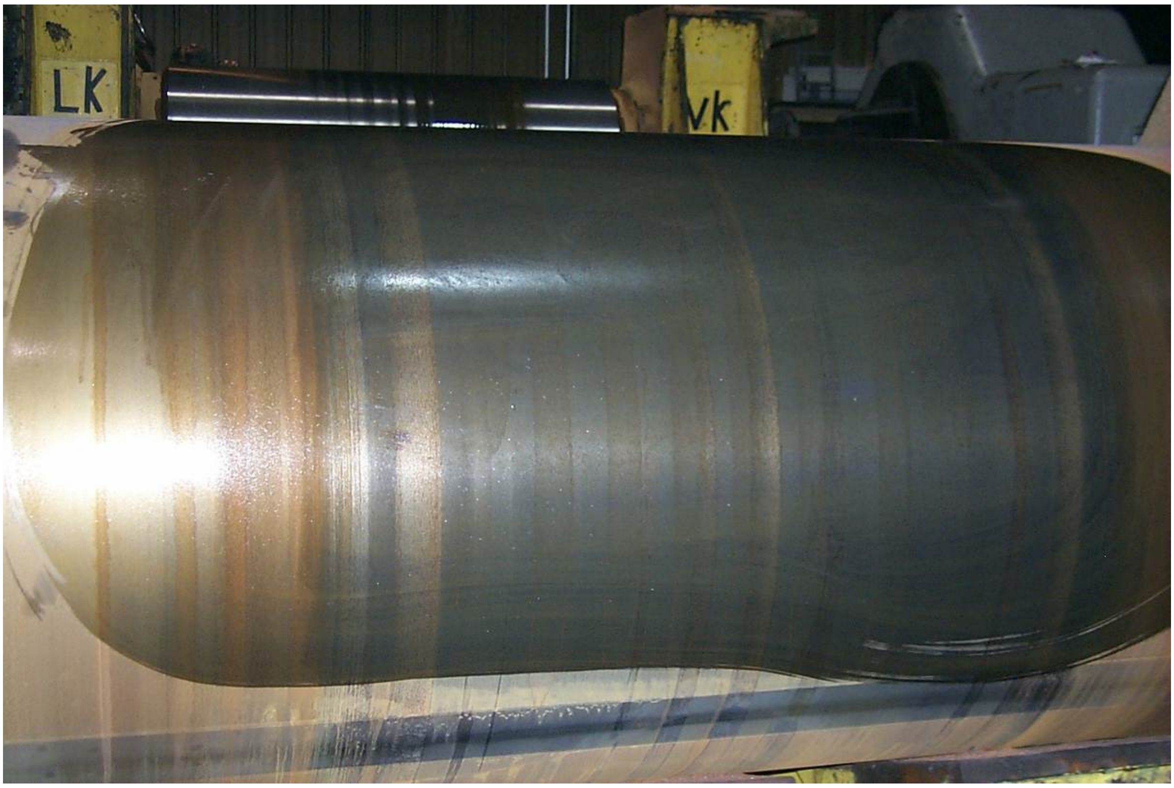

Figure 3: Semi-HSS roll in a European rolling mill after approx. 80,000 t.

It is not necessary to modify the rolling conditions in order to use semi-HSS rolls. At least no negative phenomena have been reported in connection with the use of the rolls supplied by GP.
Parallel to the semi-HSS grade, HSS grades for roughing stands were also developed at GP. Some characteristics are substantially improved specifically for rolling austenitic stainless steel by additional alloying of special elements such as tungsten, molybdenum and vanadium.
The results of the rolls delivered show that semi-HSS and HSS roles usually evidence similar performance when rolling normal carbon steel, also in comparison with other suppliers.
Nevertheless, with HSS rolls by all manufacturers, it has been ascertained that using HSS makes the rolling process somewhat more difficult to control. Because of a larger expansion coefficient, a crown tends to form in the middle of the body of HSS rolls due to heat absorption during the rolling process. This crown is not compensated for by normal wear due to the extremely high wear resistance. For this reason, the role profile should be adapted accordingly during grinding. Otherwise a phenomenon known as "strip sabre" can easily occur. Hence, there are customers who use HSS rolls only for rolling austenitic stainless steel. However, in this case, too, the boost in performance is many times greater than that of high-chrome steel.

ISSN 1983-4764

Work Roll Grades for Two-High Roughing Stands

In two-high roughing stands, slabs can be rolled in one or three passes and the pass reduction can exceed 50 mm.
During the long holding time in the preheating furnace at more than 1200°C, as a rule, a thick primary oxidation layer forms on the surface of the slab. This layer is removed by the scale breaker or scale washer before the slab is rolled. However, usually, some scale particle residue still adheres to the slab, which, because of its hardness, leads to increased roll wear in the first roughing stand. The surface of the roll is also subject to high stress because of the rolling temperature and the low rolling speed. Moreover, the roll is subject to high mechanical stress because of the high pass reductions.
While in a four-high stand the backup rolls are normally exposed to bending stress and the working rolls are predominantly exposed to torsion, in a two-high stand, the drive side is exposed not only to torsion due to torque, but also to bending stress due to the rolling force. This is depicted in Figure 4. The spheroidal graphite iron core material otherwise normally used for work rolls is highly resistant to torsion because the shear strength of this material is roughly equivalent to its bending strength. However, because bending stress predominates in two-high stands, this material is not very suitable. In this case, a material consisting of steel with a higher bending strength evidences significantly higher reliability in use.

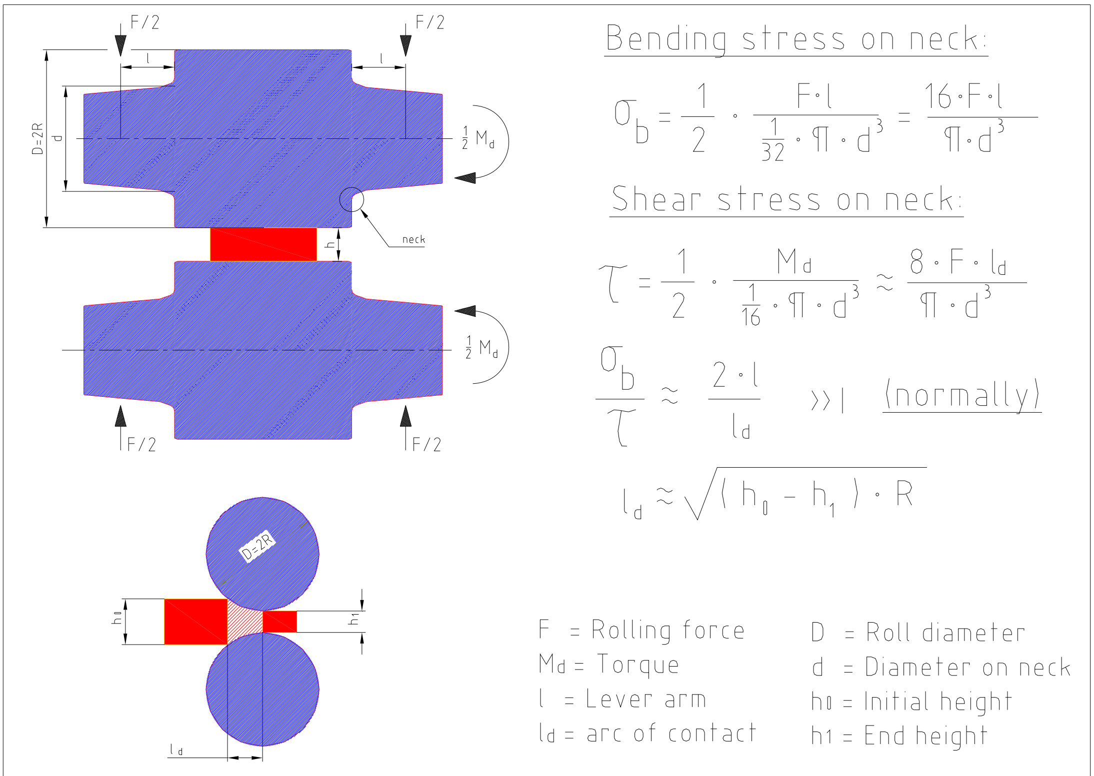

Figure 4: Stress analysis for a two-high rolling stand.

Already in the past, various steel materials were used, for example, adamite, graphitised steel, low alloy cast steel or forged steel. These steel materials had good gripping capacity on the surface of the roll body and high neck strength. However, materials of this type evidenced low thermal resistance and a low level of hardness. For this reason, the rolls displayed very deep fire cracks after use. Wear was also

ISSN 1983-4764

quite high, and it was necessary to remove more than three millimetres of material during roll turning.
With lower rolling forces, later, high-chrome steel rolls with a ductile iron core and higher body hardness were also used. Under high thermal stress as a result of the high rolling temperature, however, the surface also evidences prominent fire cracking with this roll grade (Figure 5).

Figure 5: High-chrome steel roll after 3 weeks of use in a two-high stand.

This is why, several years ago, Gontermann-Peipers began using a composite roll grade with a working layer made of hot-work tool steel and a core consisting of low alloy carbon steel. This grade is manufactured using a composite steel casting process developed by GP. The difference in carbon content between the working layer material and the core material is so slight that the bond between the two materials is practically perfect. The main alloying elements in the working layer material are molybdenum and chrome. By virtue of its chemical composition and complex heat treatment, this material has enough thermal resistance to minimise the fire cracking that occurs at high rolling temperatures.
The rolls are specifically engineered to have a hardness between 68° and 75° ShC for maximum wear resistance. However, because of the lower carbide concentration in the working layer material, the friction coefficient remains sufficient to grip the material being rolled despite the high hardness. Experience gained to date shows that there are no problems with slipping even with pass reductions of up to 50 mm.
To counteract the bending and torsional stress, a low alloy, high tensile cast steel with a tensile strength exceeding 600 N / mm² and a fatigue strength exceeding 240 N / mm² is used as the core and neck material. This level of strength is sufficient to protect the necks against breakage even when subjected to high stresses.
One can replace the rolls according to a three-week cycle with one as well as three passes. Figures 6 and 7 show the rolls after a three-week campaign. After removal, there are no obvious open fire cracks visible on the surface of the roll. This leads to a drastic reduction in non-productive roll consumption. As a rule, only two to three millimetres of material have to be removed after each use.

ISSN 1983-4764


Figure 6: Hot-work tool steel roll in a European rolling mill after 150,000 t.


Figure 7: Hot-work tool steel roll in an Asian continuous stand after 300,000 t.

No adjustments with regard to the rolling parameters are required when using this grade. To date, no negative influence on the quality of the rolled metal sheets has been ascertained either. The experience gained indicates that this grade is currently the best choice for a two-high roughing stand with high rolling force in a conventional hot rolling line. Thus far, all of the customers supplied have been satisfied with the results.

SUMMARY

Modern, optimally suitable roll grades for the various roughing stands in hot rolling mills can substantially increase roll performance and thus the economic efficiency of hot strip production.

REFERENCES

1 Frank Martiny. The Roughing Work Roll for Hot Strip Mills. Proceedings “rolls 2000+”, Conference Birmingham, England, 1999
2 Frank Martiny & Mario Sinnaeve. Improved Roughing Work Rolls for the Hot Rolling of Low Carbon and Stainless Steel Grades”. Abrasion 2002, Conference Fukuoka, Japan, 2002
3 Weiguo Ji. Safe Production of Rolls of Semi-HSS Quality for Hot Rolling Mills and Their Rational Application China International Steel Mill Rolls Conference, Shanghai, China, 2008.