Implementation of a new 3-roll Reducing & Sizing block in a wire rod and bar mill

The use of 3-roll Reducing & Sizing blocks in rod and bar mills improves product quality, profitability and mill flexibility. The significant economic advantages lead to a quick return on investment. Easy installation during the annual mill shut down, followed by a rapid learning curve quickly leads to increased capacity.

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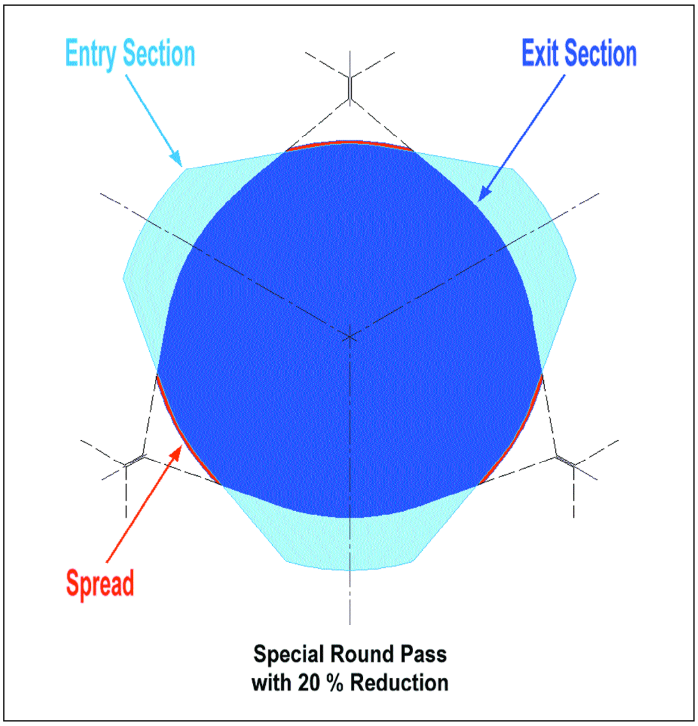
A constantly growing demand for high-quality steel bars (tolerances, surfaces quality and metallurgical properties) to be produced with high flexibility (any size and grade at any time to reduce inventory), and at the same time showing best operational economy (maximum yield, high mill utilisation, low operating costs), has considerably influenced the development of modern rod and bar mills.

Since the mid-1980s there has been a growing application of 3-roll Reducing & Sizing Blocks (RSBs) in the finishing area of bar mills, which often act as prefinishing mills in combination wire rod and bar mills. This has led to the current impressive number of 52 references at 41 customers in 16 countries, representing an annual capacity of more than 19Mt. No other comparable system or technology can show such a record of installations, in spite of the higher initial investment cost involved.

Advantages of 3-roll technology

The main reasons for the success of this technology are its benefits compared to conventional 2-high systems and its operational philosophy.

Figure 1 shows a 3-roll pass with 20% reduction, and the very low spread illustrated results in much higher deformation efficiency with less material heat-up during rolling, which is ideal for thermo-mechanical rolling (TMR). Another important feature is the automatic compensation of different entering bar parameters related to different material grades (spread), changing rolling temperatures (head to tail and/or bar to bar) and cross-sectional variations (heavy ends). Also, thanks to the homogeneous deformation across the section of the bar, very homogeneous structural properties (grain sizes) result.

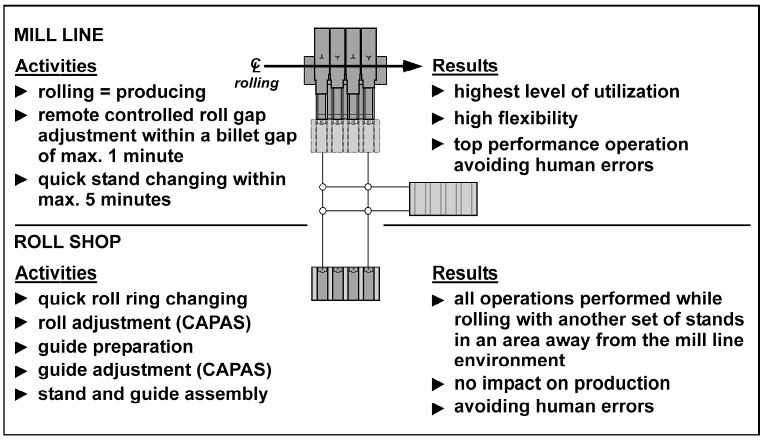


● **Figure 1** ***Typical 3-roll reduction pass***

A very decisive factor is the significant 'free-size' range of 3-roll stands compared to 2-high stands, which allows the operator to roll a large diameter range with diameters varying in very fine increments by roll gap adjustment only, while enjoying the 'first bar in tolerance' feature. Furthermore, a lower pass wear also reduces the roll costs for the respective mill area.

Operating philosophy

The basic target of the RSB operating philosophy is to minimise mill down time by transferring all operations that interrupt production from the mill line to the roll shop. *Figure 2* shows the activities in the mill line and the roll shop, together with the corresponding results. The most important effects of this operating philosophy are significantly increased mill flexibility (rolling different finished sizes at any



● **Figure 2** ***RSB operating philosophy***

time) and the highest level of mill utilisation (almost no down time).

Comparable 2-high or 4-roll systems have not been able to attain the success achieved by 3-roll technology due, among other reasons, to their deformation characteristics, in combination with design and operation-related problems. Although some features of 2-high and 4-roll systems do sometimes show a slight advantage, the overall performance and optimal combination of process, design and operation characteristics of the 3-roll technology lead it to be the prevailing application.

The latest RSB generation

The ever-changing market demands have nourished the steady development of RSBs and, based on the operating philosophy described above, the following features were introduced, characterising today's RSBs:

Design of machinery

- Adjustable stands with 3 input drive shafts
- 'C-module' drive system
- Quick stand-changing system (in mill line)
- Quick roll-changing system (in roll shop)

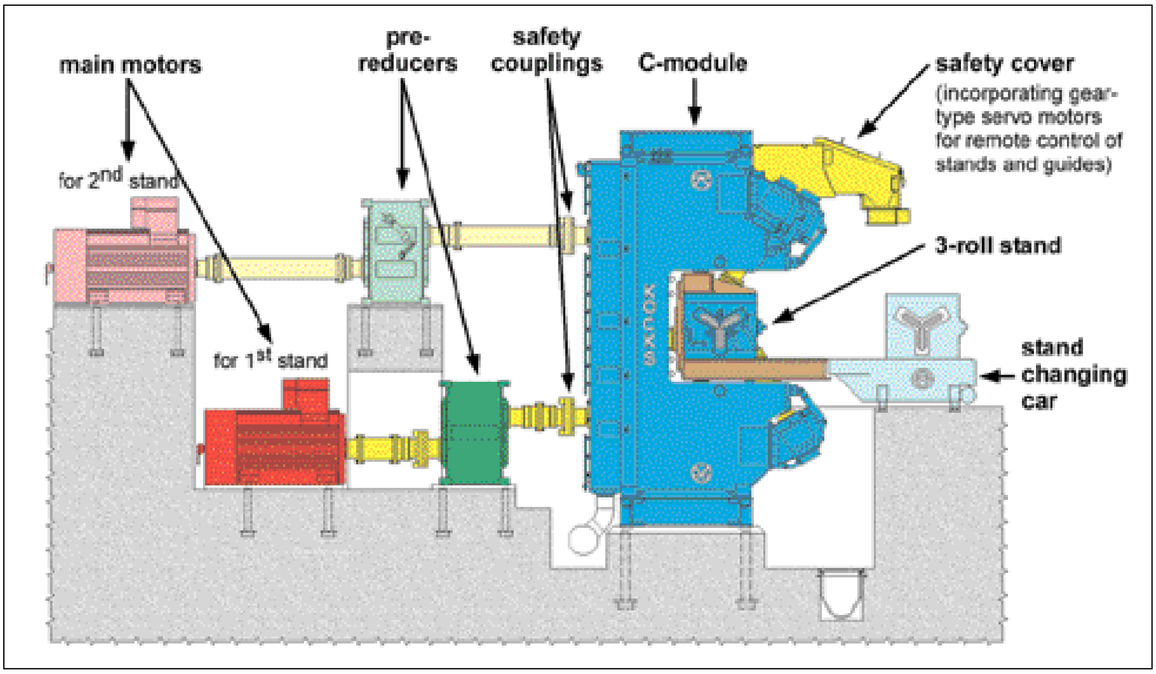
Processes

- Pass design with combination of reducing & sizing in one RSB
- 1-pass family rolling throughout the roughing and intermediate mill
- 'Free-size' pass design
- Remote control adjustment of rolls and guides in the mill line
- Computer-aided adjustment system for stands and guides in roll shop

Figure 3 shows the arrangement of the 3-roll stand, the C-module drive system, the pre-reducers and main motors and the quick-change stand car.

RSBs are not only applied in newly constructed rod and bar mills but also to a very significant extent as an effective way of modernising existing plants. In many cases, this offers companies the only chance to cope with quality and economy related requirements in order to survive in today's tough markets. A characteristic example will demonstrate

● **Figure 3** ***Equipment arrangement of RSB***



the planning, erection and commissioning of an RSB installation, together with the timely execution and the start-up results after completion of the modernisation project.

Layout and pass schedule of a 5-stand RSB project

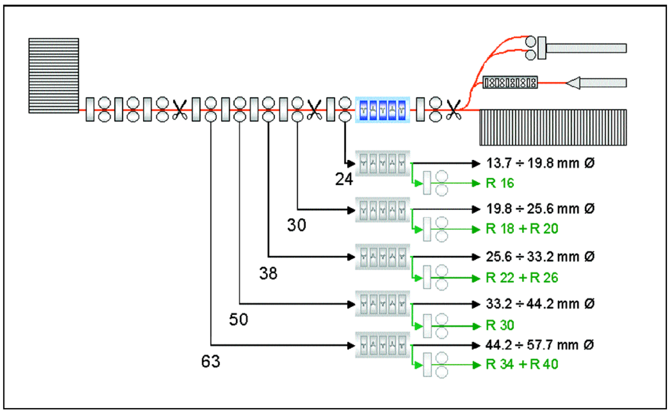
The example chosen is the replacement of two 2-high stands by a 5-stand RSB in a combination wire rod and bar mill. *Figure 4* shows the layout of the mill where the RSB was positioned in the area of stands 17 and 18, while stands 19 and 20 remained for the production of special rebar. This means that the RSB is replacing the four horizontal/vertical (HV) stands acting as the finishing block for bars between 13.7 and 57.7mm diameter, while at the same time, pre-finishing the feed bars for the wire rod finishing mill and the two rebar stands. The rolling schedule in the lower part of *Figure 4* indicates the advantage of feeding just five pre-rounds from the roughing and intermediate mill (stands 8, 10, 12, 14 and 16) out of a 1-pass family. The operational advantages for the roughing and intermediate mill are obvious.

All finished diameters or pre-sections for the wire rod block or rebar stands 19 and 20 are rolled in the RSB, either by remote control adjustment within the respective 3mm free-size ranges during a billet gap of one minute maximum, or by rapid stand changing from one free-size range to another free-size range within five minutes maximum.

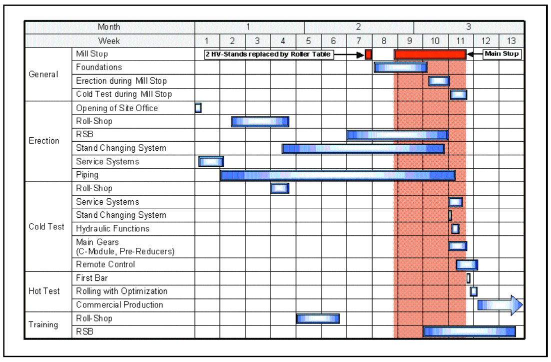
It also becomes possible to roll bars into pouring reels or onto the cooling bed while setting up the wire rod block, and to change from one production line to the other as required ('chance free' rolling). In the intermediate mill the passes are only changed when they are worn, or dummied where bigger feed material is needed for the RSB. This leads to a smoother overall operation, greatly reduces roll and guide inventory, shortens changing procedures and results in a considerably higher mill utilisation with fewer cobbles.

Timing of erection and commissioning

Figure 5 represents the time schedule for the 5-stand RSB described above. It took approximately 11 weeks, from opening the site office until rolling the first bar via the RSB. After a design and manufacturing period of 12–13 months, the equipment was delivered to the site in accordance with the erection needs. Mill stoppages due to the installation were just two days, one week before the annual summer shutdown and the three weeks of the actual summer shutdown. The first two days were used to dismantle the two HV stands and replace them with a roller table. Thus it became possible to continue the production of bigger sizes for one week while dismantling the existing foundations in that area and preparing for the RSB foundations.



● **Figure 4** ***Layout and rolling schedule of a wire rod and bar mill with 5-stand RSB***



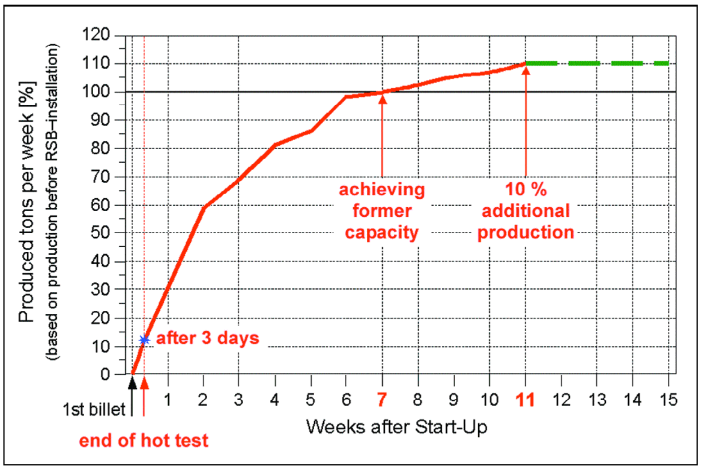
● **Figure 5** ***Erection and commissioning schedule for a 5-stand 370-type RSB***

Erection of certain equipment was done before the shutdown, such as in the roll shop, the service systems, the main scope of the stand changing system and parts of the RSB (see *Figure 5*).

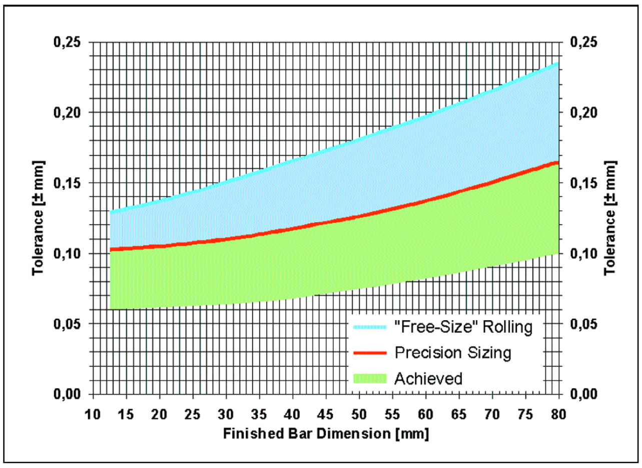
The RSB foundations were ready 9 days after the beginning of the main shutdown so that the balance of the RSB erection in the mill area took place approximately one week later, followed by cold tests during the main shutdown. Cold tests and optimisation of the remote control system were also done during the first days of testing. The hot tests, ie, rolling of finished products with respective fine tuning and optimisation measures, required three days, after which commercial production started.

It should be noted that as well as training campaigns before erection, intensive training courses were held on site for the roll shop (roll changing, guide changing, roll and guide adjustment by computer aided pass adjustment system (CAPAS) and stand assembly before the main shutdown). Additionally, two-week training courses on the operation of the RSB were held during the shutdown and the production period.

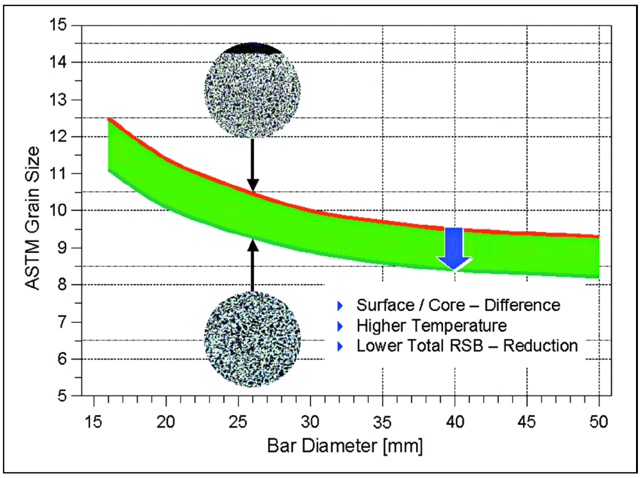
This example illustrates how the upgrading project of integrating an RSB can be done within a



● **Figure 6** ***Example of learning curve after RSB installation***



● **Figure 7** ***RSB tolerances***



● **Figure 8** ***Grain sizes resulting from TMR (medium carbon steel)***

scheduled shutdown period of three weeks, however, in some cases activities have been scheduled within a main shutdown time of just two weeks.

Learning curve

The most important issue of the commissioning stage after revamping projects is the learning curve or production development until reaching the former capacity, so that the market can be served with a better product without delay. *Figure 6* is an example of a learning curve showing the average production per week as a percentage of the average figure before the introduction of the RSB. Including the hot test with fine-tuning and optimisation activities, the productivity of the mill reached approximately 30% of former capacity after one week. After 7 weeks the former capacity was reached, and after 11 weeks production was about 10% higher than before the installation. It should be noted also that, by taking advantage of the specific features of the RSB, many more size changes than before took place during that period, in order to serve customers' needs concerning quick delivery of tailor-made finished sizes with good dimensional tolerances and good metallurgical properties.

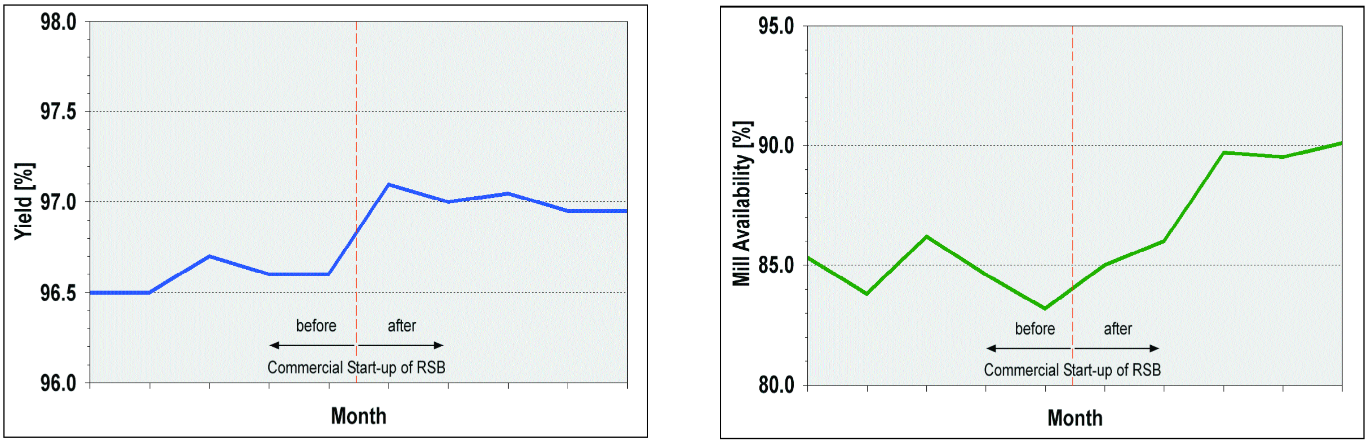
Product quality

Excellent dimensional tolerances, surface quality and adequate mechanical properties are pre-requisites to satisfy customers' requirements for a smooth and cost saving post-processing of the rolled products with high gains in yield and throughput.

Good dimensional control improves the subsequent results in grinding, peeling, drawing, forging and hot and cold heading processes. *Figure 7* shows the tolerance levels achieved directly after commissioning for the precision sizing and the free-size rolling modes, as well as the levels achieved after familiarisation after some months of operation. These dimensional characteristics lead to respective savings in the down stream industry.

It is becoming common practice in modern long product mills to roll at reduced temperatures in the finishing mill in order to improve the metallurgical and mechanical properties of the material, thus simplifying or eliminating subsequent heat treatments, and drastically reducing respective post processing costs. Due to its very uniform deformation, as well as the limited temperature increase during rolling due to the high deformation efficiency, the 3-roll passes are ideally suitable for temperature controlled rolling with a uniform fine grain size, and without any coarse grain formation, which normally occurs in pure sizing systems.

Figure 8 shows the achievable grain sizes depending on finished diameter of the product, as well as surface/core difference, and the influences of rolling temperature and total reduction in the RSB.

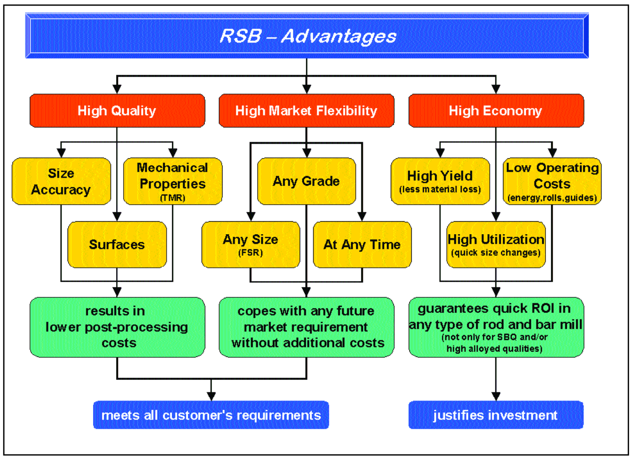


● **Figure 9** ***Influence of RSB installation on yield and mill availability***

Mill economy

Achieving good mill economy is of the utmost importance in today's tough markets. Yield improvement by eliminating heavy ends, second-class quality and cobbles, as well as shorter down times for size and grade changes by remote control and/or quick stand changing, coupled with high mill utilisation, are pre-requisites for reaching that target.

Figure 9 shows an example of yield and mill availability improvement after RSB commercial start-up. In spite of very good figures before the RSB installation there was an improvement of 0.5% in yield from to 97%, as well as an availability increase of 5% to 90%. These figures were reached even when rolling more than 200 sizes a month, many of them up to 3 times a month.



● **Figure 10** ***RSB advantages***

Conclusion

The RSB is the result of many years' experience combined with numerous innovations. As summarised in *Figure 10,* it improves product quality, mill profitability and mill flexibility to serve current and future customer needs. Significant economic advantages lead to a quick return of investment and justify installation. It has been shown that installation can be easily done during the annual mill shutdown followed by a rapid learning curve, leading to an increased capacity within a short period of operation.

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