ECONOMICAL PRODUCTION ON WIRE ROD AND BAR MILLS[1]

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Abstract

The new technologies described above exceed today's quality and productivity requirements in high capacity rebar mills as well as in high-speed wire rod mills. As the markets become more competitive mills need to control inventory, while at the same time increasing the rolled tonnage in order to achieve the best return on assets and to increase profitability.

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Introduction

Steel producers worldwide are searching for improvements in output, utilization and yield as well as for final products from the rolling heat. Suitable developments are available from SMS Meer.

Highlights in wire rod mills for quality steel are the Multiline Loop technology in combination with the 8-stand block and the FRS® sizing mill. Very high mill utilization in excess of 90% is possible with this concept. Thermomechanical rolling can be applied for the complete size range from 5 to 25 mm. The related CCT® software system is available for both wire rod and bar mills.

For SBQ bar mills the 3-roll sizing mill PSM was developed. The PSM has the unique features of roll setting with hydraulic AGC resulting in many operational advantages including very close bar tolerances.

For rebars, the H.S.D.® High Speed Delivery system has reached speeds of 41 m/s. The latest generation is built for operating speeds of 46 m/s with a design speed of 50 m/s.

For compact coils, the VCC® Vertical Compact Coiler is available for twist-free coiling, speeds up to 35 m/s and sizes 6 – 32 mm rebar, rounds, squares, hexagon and flats.

High Speed Wire Rod Mills – 550,000 to 700,000 tons per year

Mills for quality steel and small lot sizes

In all fields of steel production there is the goal of best possible mill availability even with changing market conditions. Especially for mills producing quality steel, small lot sizes are required. This in turn necessitates frequent mill changes with the associated increased down time. In view of this, SMS Meer has developed the Multiline Loop concept allowing mill utilization in excess of 90-% for mills producing quality wire rod with small lot sizes. Thus a quick response to market needs is possible and inventories can be reduced.

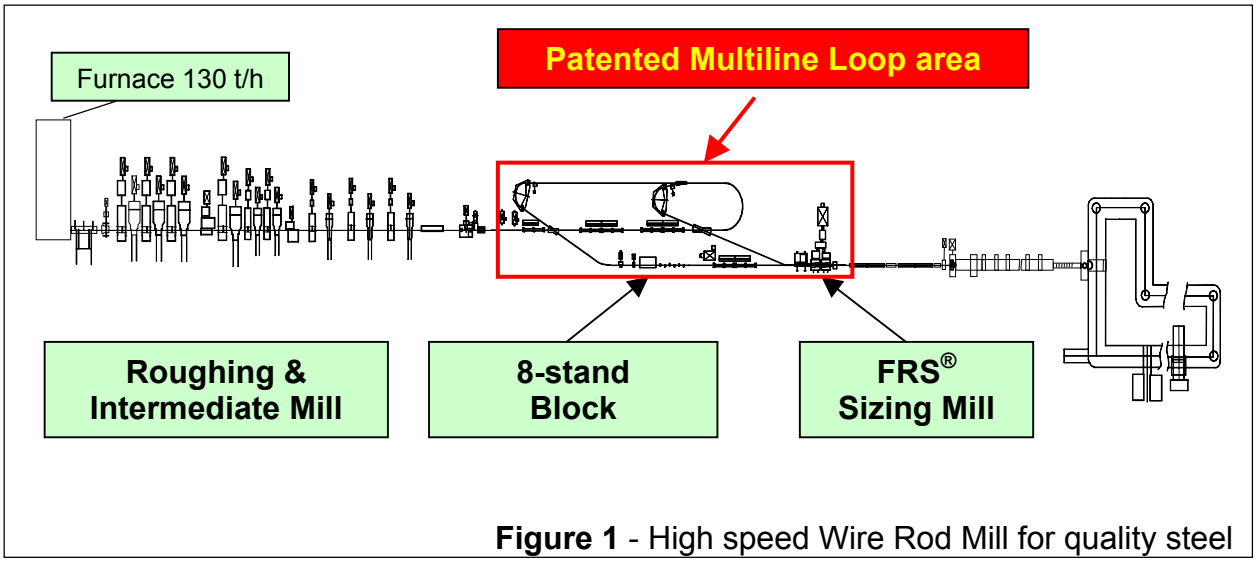

Figure 1 - High speed Wire Rod Mill for quality steel

Figure 1 shows the layout of a typical mill with all features for the production of quality steel. A mill of this type can produce 550,000 to 700,000 tons per year, depending on the product mix.

This fully continuous mill is suitable for a maximum billet size of 150 to 160 mm square, depending on the steel grades to be rolled. In this case the entry speed still achieves an acceptable level. Furthermore, a billet-welding machine can be installed, provided there is adequate space between the furnace and stand no.1.

If larger billets were to be used, the layout would be as shown in **Figure 1a** since a free run out of the product is required behind the roughing mill. Four stands are installed in the roughing mill. This allows a favourable box pass design in the first 2 stands followed by an oval / round sequence. In any case the intermediate roller table must be covered in order to avoid undesirable heat losses of the product.

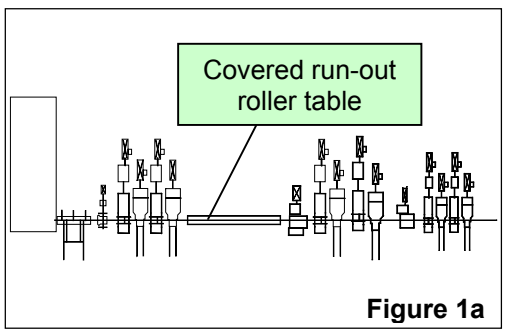

Figure 1a

Using the concept with the 8-stand block and the 4-stand FRS® (Flexible Reducing Sizing) mill in the finishing part of the mill, single family rolling is used from stand 1 up to the block exit. The complete finished product size range from 5 to 25 mm is rolled

on the FRS®. Quick changing facilities are available in 2 different alternatives. The most economical solution is a quick roll change allowing a complete size change within 15 to 20 minutes. The other possibility would be to change the complete 4-stand FRS® within 5 minutes requiring an additional unit.

Tolerances are within ± 0.1 mm for the complete size range. The design speed is 120 metres per second with dressed rolls.

In addition to the above, there is the patented **Multiline Loop** in combination with the 8-stand block and the 4-stand FRS® offering advantages that cannot be achieved with any other mill concept.

First there is the very high utilization of the mill. **Figure 2** shows the outstanding and exceptional flexibility of this concept. The basic idea is that the mill can continue to roll even when the block has to be changed for reasons of roll life. In this case – and this applies to all sizes above 11 mm – the products bypass the block during its changing time. Block change may take between 40 to 60 minutes, depending on the number of workers available and the number of stands to be changed.

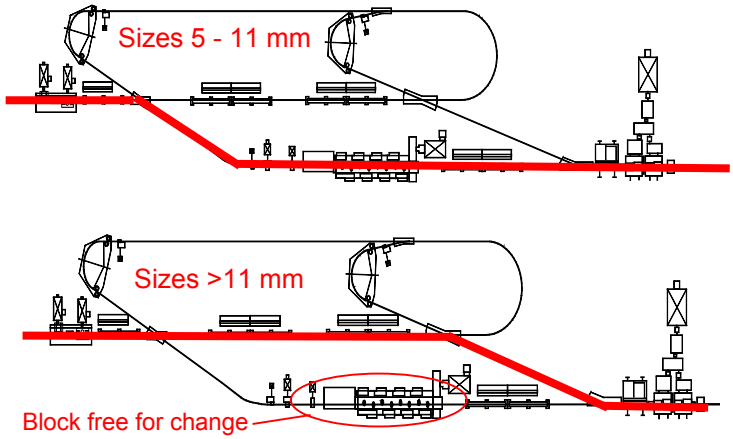

Figure 2 – Rolling at elevated temperatures

While Figure 2 represents the rolling method for normal rolling (rolling at elevated temperatures) **Figure 3** shows the incorporation of the Loop Technology with low temperature rolling. In this case, too, the block is bypassed for sizes above 11 mm, offering the same advantages in mill flexibility as for normal rolling.

Depending on the product mix, savings in changing time may be in the range of 3 to 5% of the total mill operating time. This time can be used for additional production. With a mill otherwise producing 600,000 tons, an additional production of 18,000 to 30,000 tons is possible.

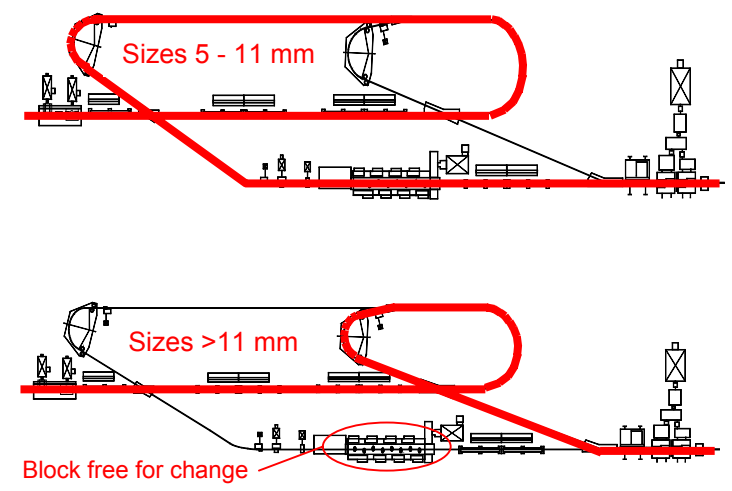

Figure 3 – Low temperature rolling

With an assumed gross margin of 60 euros per ton, this results in an additional margin of 1.1 to 1.8 million euros per year, thanks to the patented Multiline Loop technology.

Experience gained in many applications of high capacity wire rod mills has proved that there is no other reasonable alternative for reducing the product temperature to the desired value of 750° C with the also desired temperature gradient of around 50° to 80° C between surface and core. Even so the speed is so high 5.5 mm does not represent the most critical condition since the hourly production is around 70 tons per hour only. **Figure 4** shows the temperature chart for round 8 mm at a speed of 100 metres per second, corresponding to 130 tons per hour which is the determining size for the loop length.

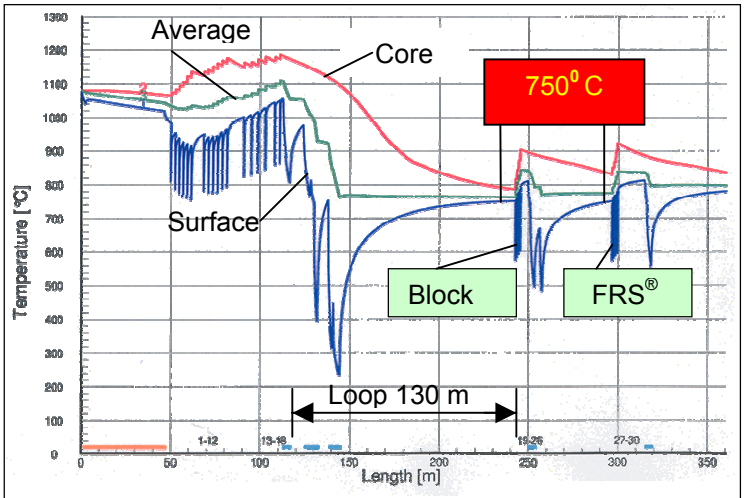

Figure 4 - Cold heading grade 8 mm, 130 t/h

Figure 5 shows the Multiline Loop at Acominas in Brazil. Many of the world's leading wire rod producers are using the Loop technology. Among those is Masteel, China, which employs low-temperature rolling for many of its products. 80% of these products are cold heading steels, most of which are used in downstream processes without any further heat treatment.

Figure 5 – Multiline Loop in Brazil

For a many cold heading grades further heat treatment can be completely omitted in which case the benefits are 15 to 17 euros per ton. For other grades such as ball bearing-, spring steels and other cold heading grades the annealing time can be remarkably reduced resulting in benefits of 5 to 8 Euros per ton. The major contribution to this advantage is based on the Loop technology that allows first class grain size distributions over the product cross-section.

Other features of quality steel wire rod mills are quick changing water boxes and a laying head with tail end control by worm unit. The LCC (Loop Cooling Conveyor) both with high capacity fan cooling as well as insulated covers for retarded cooling further contributes to the desired properties of the final product. A ring distributor assures excellent coil shape.

At Acominas, coil transfer is horizontal with a strap-type coil compactor. Depending on the customer's preference, vertical coil transfer or a combination of vertical / horizontal coil transfer are available using a coil compactor for strap or wire tying.

Another important development is the CCT® (Controlled Cooling Technology) software system used in many quality steel wire rod (and bar) mills worldwide. The offline system is capable of calculating the complete temperature setting of the mill from furnace exit until the end of the LCC. Users of the system praise the fact that mill settings can be predicted without loss of rolling time and without consuming expensive trial bars. The extensive rolling programme storage system makes actual results readily available. It is furthermore possible for the user to create new rolling programmes based on the theoretical models stored.

Some of the mills use the online system in which case the offline programme can be used to fully automatically set the mill for the next product. A training of the operators is part of the CCT® package.

Summary – High Speed Wire Rod Mill with Multiline Loop:

- Very high mill utilization of 90% or more even with small lot sizes
- Excellent tolerances of the finished product
- Best layout for low-temperature or thermomechanical rolling
- Many products can be sold without any further heat treatment

Wire rod mills for larger lot sizes

For these types of mills the number of changes required is much less because of the larger lot sizes. Therefore a block only (instead of block and FRS®) is an excellent and economical solution. The block would have 10-stands with normal reduction. Also such mills may be equipped with the loop if low-temperature rolling of quality steel is required. Space can be reserved for the future installation of the FRS® and the Multiline Loop.

Due to the special ultra heavy duty design of the block, product tolerances of $\pm$ 0.1 mm are reliably achieved for the size range 5 – 16 mm. For larger sizes – where only 2 stands in the block are in operation – the tolerance is $\pm$ 0.125 mm.

Wire rod mills for rebar type grades

Especially for rebar grades the HR- (High Reduction) block was developed. Several plants are in successful operation with the HR-block, among those the four-strand mill at Riva Brandenburg, Germany. An 8-stand block is the best choice because of the higher area reduction in each of the stands compared to the block for quality steel. The major components of the block – such as the cassettes – are the same as in the blocks for quality steel.

Due to the reduced number of stands the production costs are lower since fewer rolls, less guides and reduced changing times are required.

PSM – The new generation of 3-roll Sizing Mills for quality steel bar mills

The 3 – roll PSM Sizing Mill for SBQ Special Bar Quality production was developed based on the technological leadership in seamless tube mills for which SMS Meer has built thousands of 3-roll stands.

A contract for the supply of a 6-stand PSM was concluded with EWS, Edelstahlwerke Suedwestfalen in Siegen, Germany. EWS is a pioneer in the production of quality and special steel bars including stainless steel on 3-roll equipment. After modernization the mill will produce bar sizes 22 to 85 mm at a production rate of up to 150 tons per hour. Operation of the PSM will start in the third quarter of 2006.

Figure 6 shows a principle drawing of the 6-stand PSM, which will replace two existing Kocks 3-roll blocks in the EWS mill. The most unique feature of this PSM is the hydraulic roll gap setting with AGC. This technology – in use in hot and cold strip mills worldwide since more than 35 year - has also gained ground in many applications for the production of long products, especially in Heavy and Medium section mills. With the introduction of this superior system an improved level of product tolerances can be now achieved in bar mills also.

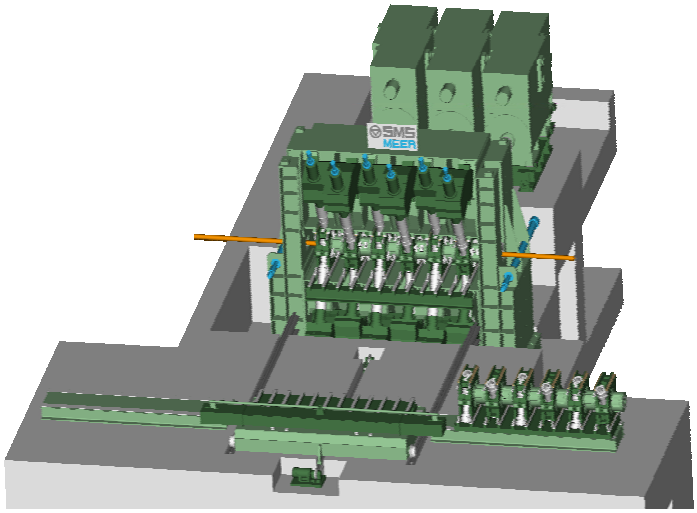

Figure 6 - 6-stand PSM with hydraulic AGC roll setting and quick changing unit

Highlights of the 3-roll PSM for SBQ – Special Bar Quality:

- Tolerance for Precision rolling better than ± 0.1 mm for all steel grades and temperatures
- Tolerance for Free-size rolling better than ¼ DIN, for all steel grades and temperatures
- Full bar length in desired tolerance because of hydraulic roll gap adjustment during rolling with AGC-control
- Automatic compensation for both mill spring and varying entry sizes
- Thermo-mechanical rolling for 800 °C minimum bar entry temperature
- CARTA® process model for automatic and optimised presetting
- No downtime for pass adjustment at free-size rolling because of hydraulic roll gap adjustment and special roller guides
- One Family Rolling upstream of PSM for the whole size range
- Fully automatic quick change for the complete block within 5 minutes only

High-capacity rebar mills

Many steel producers operate mills based on the multi-slit technology. The majority of those mills have a size range of 10 or 12 to 40 mm. Depending on furnace capacity and product size 4-, 3- and 2-slit operation is used. In some applications, 8 mm is also rolled; multi-slitting is again employed. Rolling speeds of those mills are practically 13 – 15 metres per second even so the design speed of these mills may be much higher. The reason for such undesirable low speeds is the fact that operation is sensitive at small sizes and the required mill settings are difficult.

As early as 1971, SMS Meer started with the development of the H.S.D.® system. Since then we have received orders for 50 plants with a total of 68 strands. Speeds have constantly increased from 18 metres per second in the first installation up to 46 metres per second in the latest generation. **Figure 7** shows milestones in the development of those speeds from 1971 to 2005. As can be seen, the design speeds have always been reached. It can therefore be predicted that the design speed of 50 metres per second on the latest H.S.D.® generation will also be achieved in the short-term future.

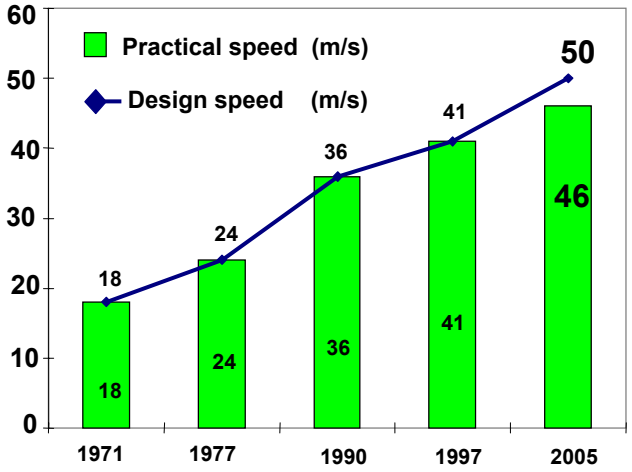

Figure 7 – Milestones of H.S.D® speeds

As a result of these recent developments, we strongly recommend that future rebar mills are built with the H.S.D.® system.

Figure 8 shows a picture of a H.S.D.® reference plant in China with the certified speed of 40 metres per second achieved during the performance test.

Figure 8 - H.S.D® - Plant in China

The explanations below concentrate on the difference between the multislit and the H.S.D.® technology. In both cases other important facts such as inline water quenching and the remaining operation are not described. Billet welding is naturally also possible on these types of mill.

If a continuous caster is installed directly in front of the mill, inline hot charging should definitely be foreseen as grade changes are infrequent in rebar mills and the production capacity of caster and mill is balanced for the majority of the production.

Single strand rebar mill with H.S.D.® - 650,000 tons per year.

Figure 9 shows the layout of this type of mill with a 6-stand block downline of the intermediate mill. Sizes finished from the block are typically 8 – 16 mm, whereas sizes 20 to 40 mm are finished from the intermediate mill. There is no twisting of bar in the whole line!

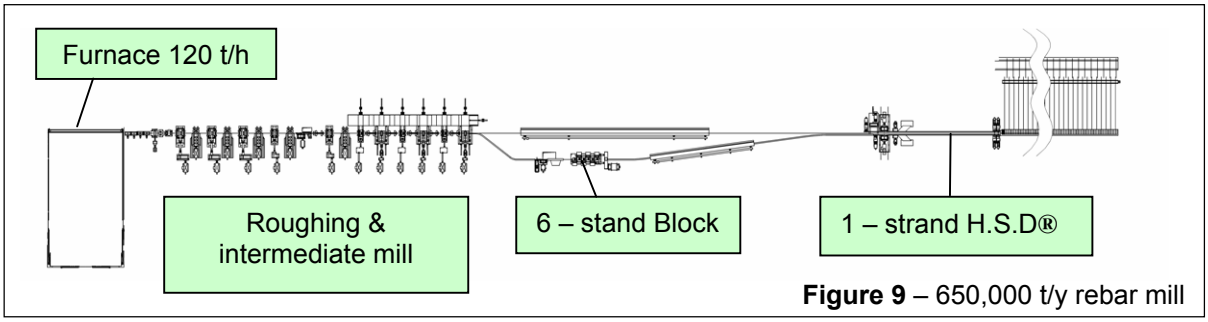

Figure 9 – 650,000 t/y rebar mill

Even there may be a slight advantage in the theoretical production using 4-strand slit rolling for small sizes such as 8 and 10 mm, this is more than recovered by the much higher utilization of a one-strand mill due to the easier operation.

There are a number of additional advantages with one strand H.S.D.® operation. **Figure 10** shows those cost benefits in euros per ton and size. (Explanation as below)

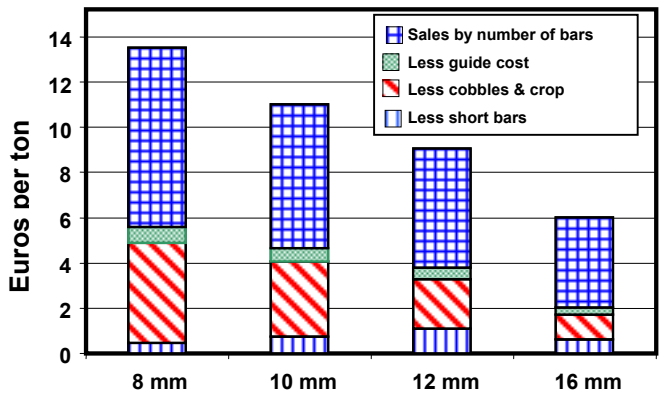

Figure 10 – 1-strand H.S.D.® Benefits for each ton produced

The number of short bars for each billet is 4 with slit rolling compared with only 1 for H.S.D.® operation.

There will definitely be less cobbles and less trial bars with the H.S.D.® concept due to the sensible operation during multi-slitting of small sizes. There is also a difference in guide consumption in favour of H.S.D.® since no slit and twist guides are required.

In many markets rebars are sold by number of bars and not by weight of the bundle. There is no doubt that the control of tolerances is much better with a single strand block operation compared to 4-slit rolling. The cost advantage shown in the chart assumes that the size tolerance is 0.1 mm better with the block, a value definitely achievable.

<u>Summary: Single strand mill with H.S.D.®:</u>

- Consistent operation at high speeds
- Easy to operate
- Best tolerance control of the bar
- Production cost benefit that quickly offsets the additional investment

Single strand rebar mill with two strand H.S.D.® – 1,000,000 tons per year.

It is a known fact that there are rebar mills in operation with an annual production of 1 million tons or even more. However those mills are either not producing the small sizes such as 8, 10 and 12 mm at all or only with a very small production percentage.

Figure 11 shows the layout with two 6-stand blocks downline of the intermediate mill. Sizes 8 – 16 mm (or even 20 mm) are produced with the 2-strand slit mode in the intermediate mill and finished single strand in each of the 2 blocks. Larger sizes are produced in single strand and are finished from the intermediate mill.

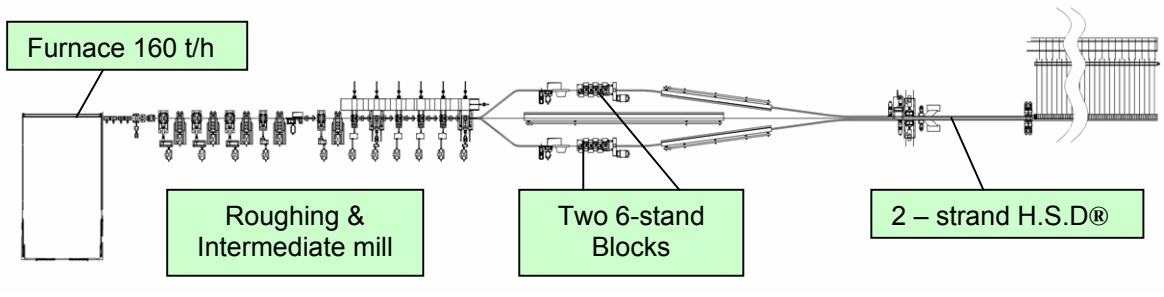

Figure 11 – 1,000,000 t/y rebar mill

Due to the high speed of 46 metres per second for each of the 2 strands, such a mill can produce small sizes also at a high output. **Figure 12** shows the hourly output for each size considering a maximum assumed mill capacity of 160 tons per hour. As can be seen the hourly production for all sizes 10 to 40 mm are at furnace output level of 160 tons per hour, whereas the production for 8 mm is about 115 tons per hour. Even with a 10% share of 8 mm in the product mix such a mill can produce 1 million tons in less than 6,500 rolling hours.

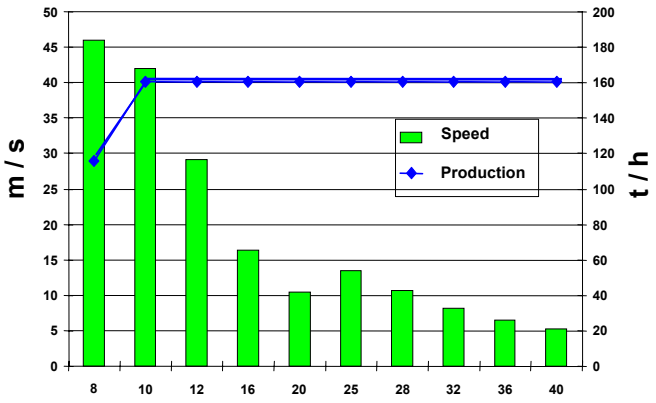

Figure 12 – Two strand H.S.D.® - Speeds & production

The 2 times 46 metres per second on each strand equal to 92 meters per second on the 2 strands might also be of interest by comparison with wire rod mill production of 8 mm rebars. At a comparable production rate, straight bars can be produced directly for those customers who do not request rebars in coils.

As mentioned above 2-strand slitting is required in the intermediate mill. Since the bar size to be slit is relatively large, slitting can be done easy and safely. Two bars with a size of about 16 mm exit from the intermediate mill and are simultaneously sent to the two independent H.S.D.® strands.

The tremendous advantage of two strand H.S.D.® compared to multiple (4-strand) slit operation is the much higher production for the smaller size range **see Figure 13.**

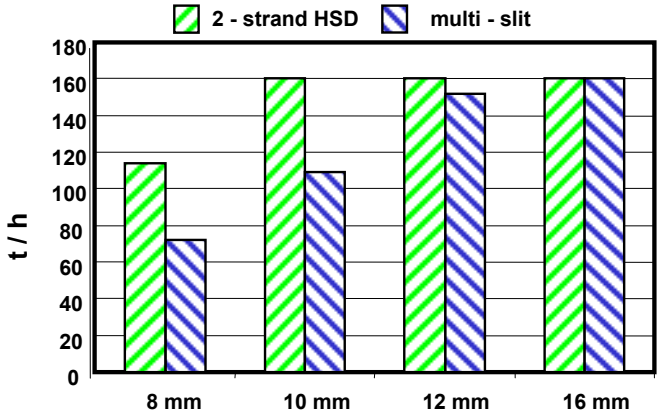

Figure 13 – Two-strand H.S.D® versus 4-strand slit, production on small sizes in t/h

Explanations for the other advantages are as above whereby the individual cost advantages for H.S.D.® are slightly lower since 4 strand slitting has to be compared to 2 strand slitting.

As shown on **Figure 14** the benefits in Euros per each ton produced are as such that there is no doubt on the necessity to incorporate H.S.D.® into a rebar mill producing small sizes with an annual capacity of 1,000,000 tons.

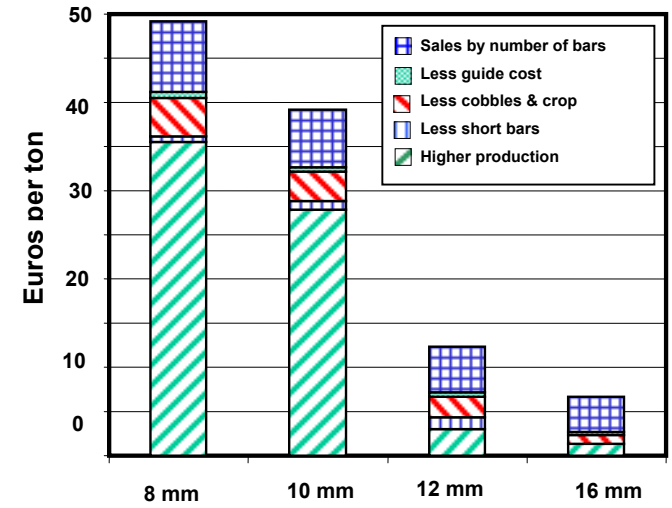

Figure 14 – 2-strand H.S.D.® Benefits for each ton produced

As far as sales by the number of bars and the theoretical weight are concerned the same applies as for the 1 – strand mill since final rolling is performed in a single strand block also in this case.

Summary: Single strand mill with 2 strand H.S.D.®:

- 1 million tons per year possible even with small rebars 8 and 10 mm
- Easy to operate
- Best tolerance control of the bar
- Production cost advantage that very quickly offsets the additional investment

The VCC® - Vertical Compact Coiler

One of the latest developments is the VCC®. This unit makes it possible to achieve excellent coil shapes directly from the rolling mill. **Figure 15** shows a typical coil produced at the VCC®.

The VCC® is capable of producing coils up to 3.5 tons with speeds of up to 35 metres per second. The size range can be 6 to 32 mm for rebars, 6 to 50 mm for rounds as well as flats, squares and hexagons.

Figure 15 - VCC® Coils

The main advantages of coils produced with the VCC® compared to coils from a wire rod mill are the compact coil shape, no twist in the product – as from a wire rod mill – and the very high coil weights possible. Uncoiling is the best possible due the layer-type coiling operation. Benefits comparing VCC® operation with wire rod rolling followed by Re-coiling (at similar hourly production rates from the mill) are in the range of 15 euros per ton.

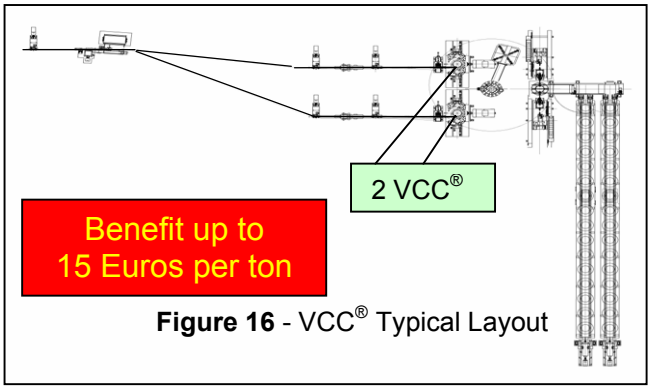

Figure 16 - VCC® Typical Layout

Figure 16 shows a typical layout of the VCC®. Two coilers are used for 1 strand operation. While coiler 1 is in coiling mode, coiler 2 is being unloaded. Due to the vertical coiling operation, tilting of the coil is not required for the transport onto the coil transfer. Automatic coil tying is also performed in the vertical position.