ISSN 1983-4764

LAMINAÇÃO
Rolling
51º SEMINÁRIO DE LAMINAÇÃO - PROCESSOS E PRODUTOS LAMINADOS E REVESTIDOS - INTERNACIONAL
51st ROLLING SEMINAR - PROCESSES, ROLLED AND COATED PRODUCTS - INTERNATIONAL

# HIGH PERFORMANCE ABRASIVE CUT-OFF MACHINES TO IMPROVE OPERATION OF HOT ROLLING MILLS*

*Norbert Asamer* [1]

**Abstract**
At various stages during the hot rolling process, the different rolled products – blooms, billets, bars, respectively sections, but also slabs or plates – need to be cut. While the cross sections of these products are being reduced during each rolling pass, the lengths are being increased accordingly. Thus, it becomes necessary to cut the products to shorter lengths suitable for the next steps of production by state-of-the-art designed dry abrasive cut-off machines.
**Keywords:** Hot-rolling mills; Abrasive cutting; Billets; Slabs.

[1] *Dipl.-Wirtsch.-Ing. (FH), Sales and Project Manager - Steel Cutting & Grinding Machines, BRAUN Maschinenfabrik GmbH, Vöcklabruck, Austria.*

* *Technical contribution to the 51st Rolling Seminar – Processes, Rolled and Coated Products, October 28th to 31st, 2014, Foz do Iguaçu, PR, Brazil.*

ISSN 1983-4764



## 1 INTRODUCTION

In order to respond to the increasingly demanding requirements of their customers and to remain competitive on the market, the steel mills have been facing pressure to adapt their operation procedures and production facilities to meet the most stringent criteria regarding product costs (to be as low as possible), production flexibility (as high as possible), product quality (as high and reliable as possible), payback of improvements (as high as possible), etc. This also concerns the hot rolling operations as one of the key processes in the steel industry.
At various stages during the hot rolling process, the different rolled products – blooms, billets, bars or rods, respectively sections, but also slabs, plates or sheets – need to be cut. While the cross sections of these products are being reduced during each rolling pass, the lengths are being increased accordingly. Thus, it becomes necessary to cut the products to shorter lengths suitable for the next steps of production or eventually for packing and shipping. Furthermore, it might also become necessary to cut off the front and tail ends in the ideal length, as the excess material in may cause problems when rolled or to take short sample pieces for material analyses.
Shears, flame cutters (plasma cutters) and friction saws (with metallic saw blades), are conventional techniques to perform these cutting jobs. In light of the aforementioned developments in the steel industry, the disadvantages associated with these cutting methods - poor cutting quality requiring deburring or even additional cutting afterwards, need for extensive maintenance, high energy consumption, noise, low flexibility regarding changes in the product mix of the mill, etc. - have become less and less tolerable.

## 2 KEY FEATURES & ADVANTAGES OF THE ABRASIVE CUTTING TECHNOLOGY

In contrast to the conventional techniques, abrasive cutting has become the state-of-the-art cutting technology. It meets the requirements of the market and the needs of the steel industry to the largest extent. In particular, abrasive cutting features the following substantial advantages:

- Excellent quality of the cut surface can be reliably achieved (thanks to the consistent self-sharpening of the cutting wheel): the bar ends cut are straight, precise, clean, without hardening of the cut surface. Thus, subsequent machining processes to adjust the material ends (eg. deburring, edge trimming, etc.) can be eliminated.

* *Technical contribution to the 51st Rolling Seminar – Processes, Rolled and Coated Products, October 28th to 31st, 2014, Foz do Iguaçu, PR, Brazil.*

ISSN 1983-4764



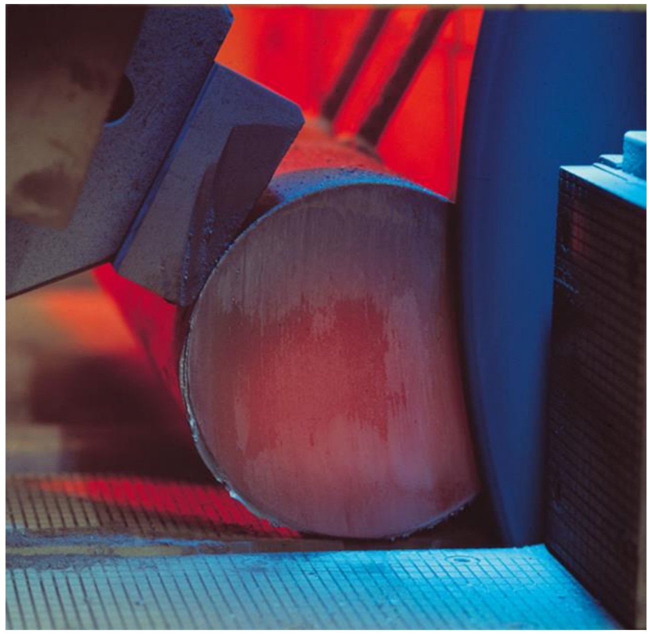


**Figure 1.** Hot abrasive cutting

**Figure 2.** Bar ends cut with friction saw.

**Figure 3.** Abrasive cut bar ends.

- Abrasive cutting is suitable for an extremely wide range of different kinds and grades of materials, from unalloyed carbon steels up to high-alloyed, high-carbon steels, titanium and nickel alloys, as well as special alloyed steels and non-ferrous alloys.

* *Technical contribution to the 51st Rolling Seminar – Processes, Rolled and Coated Products, October 28th to 31st, 2014, Foz do Iguaçu, PR, Brazil.*

ISSN 1983-4764



**Table 1.** Classification of materials typically cut by means of abrasive cut-off machines

| Material group | Properties | Examples | Typical material grades |
|---|---|---|---|
| 1 | unalloyed, medium to high carbon content | carbon steels, construction steels | St 52-3, Ck35 |
| 2 | low-alloyed, low carbon content | engineering steels, railway steels, hardenable steels | 16MnCr5 |
| 3 | low-alloyed, medium carbon content | heat-treated steels | 34CrNiMo6 |
| 4 | low-alloyed, high carbon content | bearing steels | 90MnV8 |
| 5 | high-alloyed, medium carbon content | stainless steels | X2CrNi189 |
| 6 | high-alloyed, high carbon content | tool steels | X210Cr12 |
| 7 | high-temperature resistant light metal alloy | titanium alloys | LT31 |
| 8 | high-temperature resistant hard metals | nickel alloys | NiCr5Fe |
| 9 | other non-ferrous metal alloys | brass, bronze | CuZn20Al |

Whereas a friction saw has its limitations at higher material temperatures and at higher alloyed, harder materials, a shear is of no use for cutting of cooled down materials or for cutting material with bigger cross sections.
Abrasive cutting, however, is equally suitable for cutting cold, warm or hot materials and represents a real universal cutting process. This is of special importance for hot rolling mills where interruptions in the operation of the mill with the rolled products cooling down are likely to happen.

- Abrasive cutting is a high-performance stock removal process. Thanks to a high abrasion rate, abrasive cutting enable rapid cutting times. Only shearing is faster - but has the significant disadvantages indicated above.
  Since well designed abrasive cut-off machines allow to change worn cutting wheels against new ones within 3 to 5 minutes with a BRAUN machine, they are ideal cutting facilities for continuous production processes in a hot rolling mill while by achieving a very throughput capacity.
  Depending on the temperature and on the size of the material to be cut, a state-of-the-art abrasive cut-of machine allows to achieve specific cutting rates of 40cm²/second or higher for hot cutting. In this context, the material grade does actually play a minor role only, i.e. also higher alloyed, respectively harder materials can be cut with maximum cutting speed.

** Technical contribution to the 51st Rolling Seminar – Processes, Rolled and Coated Products, October 28th to 31st, 2014, Foz do Iguaçu, PR, Brazil.*

ISSN 1983-4764



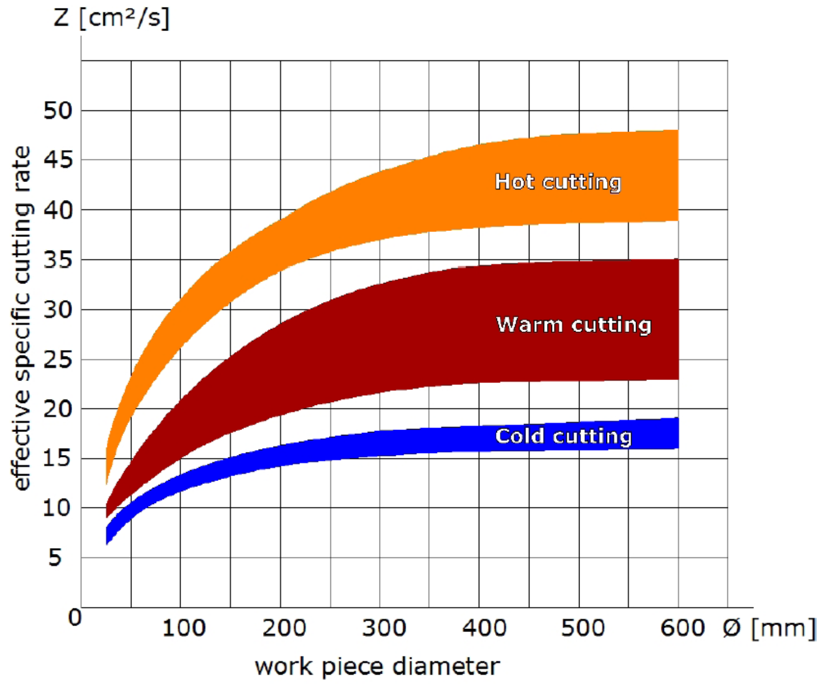



**Figure 4.** Efficient cutting rates in relation to material temperature and work piece dimension

- Compared to a friction saw, the noise level of an abrasive cut-off machine is substantially lower. Usually, the average noise level of an abrasive cut-off machine, measured during a normal production shift is between 80 and 85 dB(A) - even without a soundproof booth. The peak noise during certain cuts can be over 90 dB(A) – still significantly lower than the noise levels of a friction saw which are well above 100 dB(A). For these reasons, it is not necessary to install an abrasive cut-off machine inside a sound-proof booth [1].
- Thanks to its fully automated operation, the abrasive cut-off machine does perfectly match to the operational requirements of continuous production processes such as hot rolling. Specific cutting programs are stored in the cut-off machine's PLC which is interfaced with the control system of the rolling mill. By this means, all necessary product data, as well as the cutting requirements is automatically provided to the PLC of the cut-off machine and the proper cutting program is also be selected automatically.
- As far as the consumption of electric energy and other utilities is concerned, abrasive cutting is highly efficient. Unlike sawing, abrasive cutting is a dry process that does not require the application of liquid coolant during cutting. Thus, also collecting, cleaning or disposal of used, polluted coolant is not necessary.

  Whereas flame cutting consumes huge amounts of gas (usually the burners are on at all times when the rolling mill is operating), abrasive cut-off machines consume the bulk of electric energy during the short times of cutting only – immediately after completion of a cut, the power drops to a no-load condition.

ISSN 1983-4764



## 3 BASIC TECHNOLOGICAL CONCEPT

The tools utilized for abrasive cut-off machines are the cutting wheels. These high-performance tools are produced in a multi-stage manufacturing process. Individual raw material components forming the wheels are the synthetic abrasive grain - regular aluminium oxide, silicon carbide, zirconium alumina or ceramic aluminium oxide - the bonding and fibre glass fabric used for reinforcing the wheels [2,3].

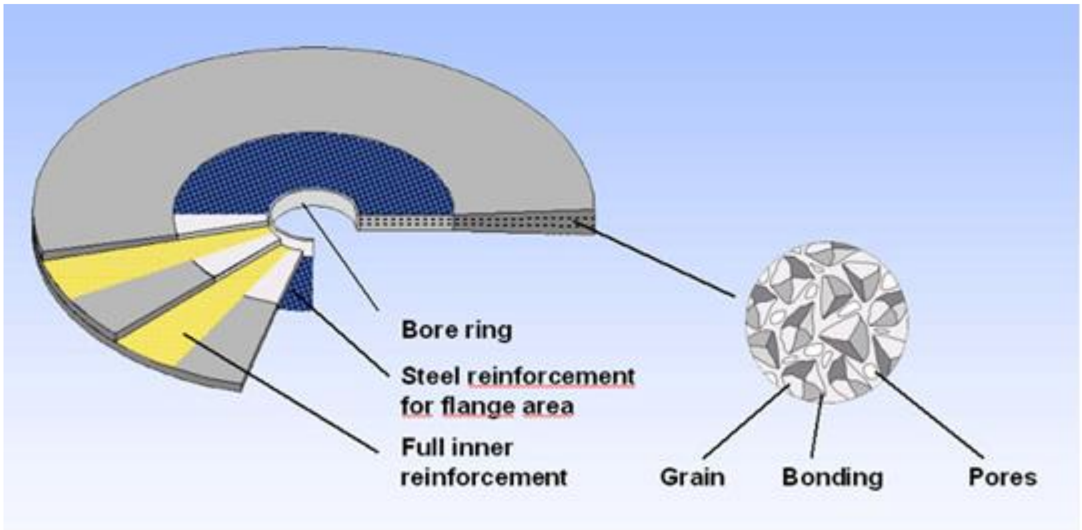



**Figure 5.** Basic structure of a cutting wheel

The actual composition of the cutting wheel depends on the specific application. Certain criteria such as material temperature, material shape and size, type and grade of material, etc. play a dominant role. At any rate, the cutting wheel must ensure high stability, high bursting speed, an excellent cutting quality and a maximum performance over its entire service life.

To achieve this goal, the manufacturing process is highly sophisticated and comprises the following stages: raw material analysis, weighing and mixing, filling and adjusting, pressing, curing under temperature, machining/balancing, as well as final quality checking. In order to be able to offer cutting wheels specifically tailored for particular applications, thereby keeping the end user's overall costs to a minimum, the leading cutting wheel manufacturers – all of them partners of BRAUN – focus on continuous research and development.

For the abrasive cutting process, it is vital to keep the peripheral speed of the cutting wheel constant. Depending on the cutting requirements and the specification of the cutting wheel, peripheral speeds between 80 and 100 m/s are used [2,3].

Since the diameter of the cutting wheel reduces during the cutting process, the rotating speed of the cutting shaft must be adjusted (increased) accordingly. BRAUN cut-off machines are equipped with an automatic wheel wear compensation system that measures the actual diameter of the cutting wheel after each cut. Subsequently, the speed of the frequency-controlled drive motor is adjusted automatically.

* *Technical contribution to the 51st Rolling Seminar – Processes, Rolled and Coated Products, October 28th to 31st, 2014, Foz do Iguaçu, PR, Brazil.*

ISSN 1983-4764

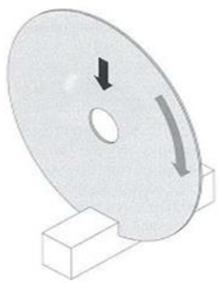


This special wheel wear compensation system also allows to automatically position the edge of the cutting wheel always in the shortest-possible distance to the material, thereby contributing to fast cutting cycles. Furthermore, the number of cuts still possible for a certain material size with the actual wheel diameter is automatically calculated; this allows to prepare in time for changing the worn cutting wheel against a new one.
Depending on the temperature of the material to be cut, abrasive cutting can be distinguished between:

- cold cutting: material temperatures up to abt. 200°C
- warm cutting: material temperatures from abt. 200°C up to abt. 700°C
- hot cutting: material temperatures from abt. 700°C up to abt. 1150°C

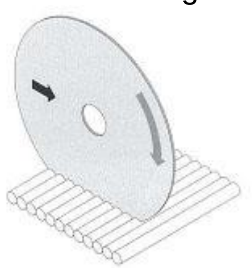
As shown in Figure 4 above, higher material temperatures allow higher specific cutting rates, this shortens the cutting cycles further.
Depending on the cutting application in the rolling mill, the following cutting principles are typically applied:

- chop stroke cutting:



The cutting wheel is moved to the material in a chopping motion with a radial infeed into the work piece. Generally, this principle is used for cutting of single round, squared or nearly squared cross sections.
With a properly designed cut-off machine, also rectangular parts or narrow layers of round or squared work pieces can be cut.

- traverse cutting:



The cutting wheel is moved horizontally across the material to be cut, in a single cutting-off stroke. This principle is generally used for cutting wider layers of round, squared and nearly squared cross sections, but also for cutting flat products such as rectangular slabs, plates or sheets.

The cutting principle applied for a certain application is also reflected in the basic design of the abrasive cut-off machine. Altogether, BRAUN has developed five different basic machine designs. Three of them are widely used in rolling mills, for the three major applications described in the following.

*Technical contribution to the 51st Rolling Seminar – Processes, Rolled and Coated Products, October 28th to 31st, 2014, Foz do Iguaçu, PR, Brazil.*

ISSN 1983-4764



## 4 ABRASIVE CUTTING OF SLABS, BLOOMS OR BILLETS

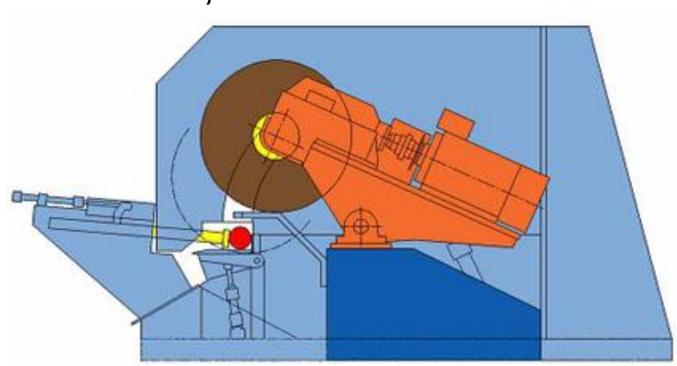


**Figure 6.** Principle of BRAUN chop-stroke cut-off machine, type W (with horizontal rocker)

In primary rolling mills, the blooms or billets are cut in hot condition. Predominantly, the cross sections of the work pieces are still quite large. Therefore, chop-stroke cutting is the preferred method for cutting these materials as single pieces with cutting wheel diameters typically in a range from 1000 to 1600 mm. The abrasive cut-off machine is equipped with a horizontal rocker, like BRAUN's machine type W. The infeed motion of the cutting wheel goes downwards which has the significant advantage that also rectangular work pieces can be cut with an optimum utilization of the cutting wheel. Somewhat smaller billets can be cut as narrow layers of 2 or 3 pieces. This allows keeping the throughput capacity at a high level also for smaller cross sections. To prevent round work pieces from overlapping, vertical blankholders are added to the material clamping system.

**Figure 7.** BRAUN abrasive cut-off machine, type TS 16 W (for 1600 mm cutting wheel diameter), for hot cutting of blooms in primary mill (TATA Engineering Steels, Rotherham, UK).

For downstream processes, abrasive cutting of the hot materials provide clear advantages. Thanks to the smooth, clean cutting surface, stamping or labelling of the material faces are eased. Also billet grinding can be done with less problems since abrasive cutting avoids the thick burrs resulting from sawing or flame cutting, as well as the deformations of the material ends ("noses") resulting from shearing. In the recent years, various blooming or billet mills were upgraded and modernised by replacing shears with abrasive cut-off machines associated equipment for automated length positioning, crop and sample cutting, etc.

---

* *Technical contribution to the 51$^{st}$ Rolling Seminar – Processes, Rolled and Coated Products, October 28$^{th}$ to 31$^{st}$, 2014, Foz do Iguaçu, PR, Brazil.*

ISSN 1983-4764

LAMINAÇÃO
Rolling
51º SEMINÁRIO DE LAMINAÇÃO - PROCESSOS E PRODUTOS LAMINADOS E REVESTIDOS - INTERNACIONAL
51st ROLLING SEMINAR - PROCESSES, ROLLED AND COATED PRODUCTS - INTERNATIONAL

## 5 ABRASIVE CUTTING OF BARS OR SECTIONS IN LAYERS

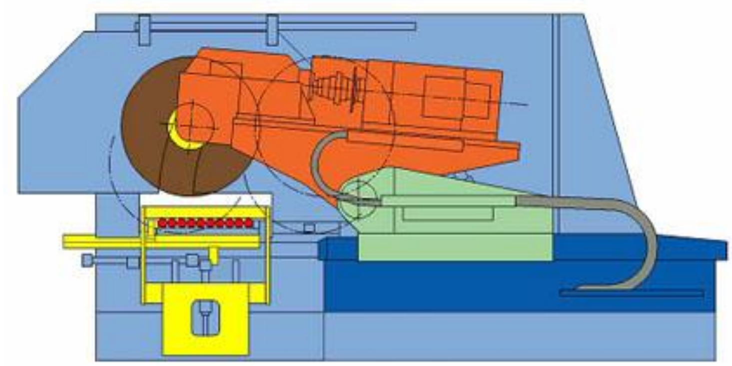


**Figure 8.** Principle of BRAUN traverse cut-off machine, type F

After the last rolling pass, the rolled bars or sections already have the final shape and need to be cut in warm condition to their final lengths before bundling. To meet the throughput requirements of the mill, the products are cut in wider layers by means of traverse cutting. Depending on the actual sizes of the work pieces, typical cutting wheel diameters are between 800 and 1270 mm. For the horizontal cutting motion, the traverse cut-off machine comprises a linear-guided travel slide where the cutting rocker is mounted. The actual cutting infeed is performed by the horizontal slide. The purpose of the rocker is the adjustment of its tilting angle in accordance with the diameter of the cutting wheel getting smaller after each cut, as well as the upswing of the cutting wheel once the traverse cut has been completed so that the travel slide can return to its starting position without blocking the layer of bars on the roller table. BRAUN's machine type F represents the typical design of a traverse abrasive cut-off machine.

**Figure 9.** BRAUN traverse cut-off machine, type TS 12 F for warm cutting of bars in layers. *Source: Jiangyin Cheng Special Steels, Jiangyin City, China*

Especially for this application, it is imperative to achieve a good quality of the cut surface. If the cutting quality is insufficient, as it is mostly the case with a shear, the bar ends must be trimmed or cut once again with a separate cutting facility (a bandsaw for commercial material grades or an abrasive cut-off machine for more special materials, respectively for very wide ranges of material grades) at a later stage – either by the steel mill or by the buyer of the products.

---

** Technical contribution to the 51st Rolling Seminar – Processes, Rolled and Coated Products, October 28th to 31st, 2014, Foz do Iguaçu, PR, Brazil.*

## 6 ABRASIVE CUTTING OF WIDE SLABS, PLATES OR SHEETS

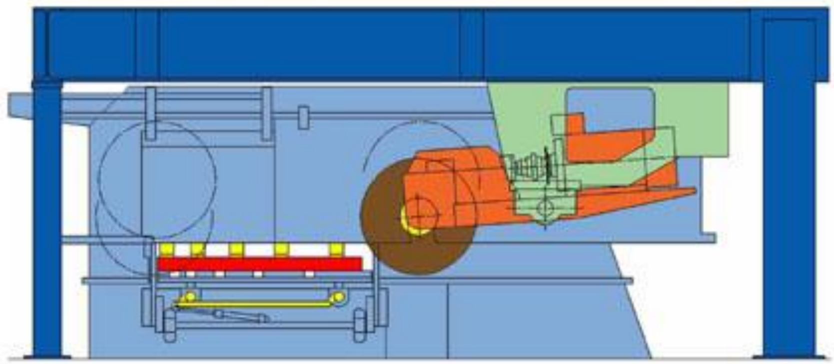


**Figure 10.** Principle of BRAUN gantry-type traverse abrasive cut-off machine, type FP

Traditionally, shears or flame cutters were used for hot cutting of the rolled plates or sheets. Abrasive cutting of these flat products in hot condition, immediately after the last rolling stand, was only introduced a few years ago.

After the installation of 3 new rolling stands in their plate mill, the Austrian special steel producer BÖHLER was searching for the state-of-the-art cutting technology that should replace the existing shear which was a permanent source for problems and also not able any more to meet the increased quality requirements for cutting. In order to avoid additional manipulation of the plates and to cut the costs BÖHLER decided in favour of the abrasive cutting technology.

Due to the widths of the plates and sheets to be cut (up to 2.3 m cutting width), however, BRAUN developed a gantry-type traverse abrasive cut-off machine (type FP). The horizontal travel slide with the rocker is moved overhead, in linear guides mounted onto a sturdy gantry structure. In order to meet one very special request of BÖHLER– cutting of cast slabs in cold condition in certain cases - this cut-off machine also features a specifically designed material clamping device with individually actuated, self-adjusting clamping elements, for safely clamping the slabs despite their slightly rounded surfaces.

**Figure 11.** BRAUN gantry-type traverse abrasive cut-off machine, type TS 12 FP (BÖHLER /Austria)

Due to the size of the cross sections to be cut, the diameters of the cutting wheels utilized for such applications are at least 1250 mm.

---

** Technical contribution to the 51st Rolling Seminar – Processes, Rolled and Coated Products, October 28th to 31st, 2014, Foz do Iguaçu, PR, Brazil.*

ISSN 1983-4764



## 7 SPECIAL REQUIREMENTS FOR MACHINE DESIGN

As described above, abrasive cutting is the state-of-the-art technology for a wide range of cutting applications in hot rolling mills, both for cutting of long and flat products. Abrasive cut-off machines are also an ideal tool to upgrade existing rolling mills and to improve product quality and mill performance.

In order to achieve optimum results, however, it is essential that the abrasive cut-off machine utilized for a specific application is properly designed. Both, the cut-off machine and the cutting wheel must be matched to the material to be cut. All three elements together – cut-off machine, grinding wheel and material to be cut – form the “cutting system”.

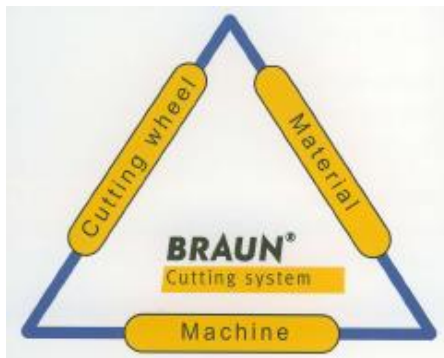



**Figure 12.** The “cutting system”: cut-off machine – cutting wheel – material to be cut [4].

The abrasive cut-off machine is one of BRAUN’s main products. Therefore, it enjoys an extremely high priority within BRAUN’s company policy.

Thanks to more about 50 years experience, ongoing research and development, as well as a close collaboration with the leading manufacturers of cutting wheels, BRAUN has been able to establish an extensive know how of the “cutting system”.

As a result, BRAUN is in a position to offer state-of-the-art machine designs to the customers, perfectly tuned to their specific applications. Furthermore, each abrasive cut-off machine is functionally tested at BRAUN’s workshops before shipment.

These “soft facts” also contribute to the big difference between a state-of-the-art high-performance cut-off machine and a poorly designed cut-off machine. BRAUN already replaced existing cutting machines from other manufacturers by new BRAUN machines – simply due to an inadequate design of the existing machines which were never capable to perform properly.

* *Technical contribution to the 51st Rolling Seminar – Processes, Rolled and Coated Products, October 28th to 31st, 2014, Foz do Iguaçu, PR, Brazil.*

ISSN 1983-4764



**Figure 13.** Pre-assembly of cut-off machines at BRAUN prior to shipment.

**Figure 14.** In-house functional testing of a cut- off machine prior to shipment.

## 8 CONCLUSION

Due to the increasingly competitive market environment, the steel mills will remain under consistent pressure to further improve their production facilities. Even though the various cutting processes at different stages during rolling operations are still widely regarded as minor processes, it has become evident that cutting does indeed have a substantial impact on the performance of the mill, on the quality of the final products and on the overall production costs.

Nowadays, most of the modern hot rolling mills are equipped with abrasive cut-off machines from the very beginning. During recent years, more and more abrasive cut-off machines have also been retrofitted to existing rolling mills.

Due to the many advantages of the abrasive cutting technology versus other, conventional cutting methods (as described in the above paper), this trend will continue. In particular the implementation of an abrasive cut-off machine in an existing mill, however, does require specialist know how.

## REFERENCES

1 3M Winterthur Technology Group, Fast, precise and cost-effective, Available at: http://www.winterthurtechnology.com/en/group/solution-finder/grinding-process/cut-off-grinding.html
2 Pferd - August Rüggeberg GmbH & Co. KG, flyer stationary cut-off wheels, p. 3
3 Braun M, Untersuchung über den Einfluss der Vorschubgeschwindigkeit beim Trennen von Profilen, p. 56, 1977
4 Braun Maschinenfabrik GmbH, High-performance abrasive cut-off machines, p. 3

*Technical contribution to the 51st Rolling Seminar – Processes, Rolled and Coated Products, October 28th to 31st, 2014, Foz do Iguaçu, PR, Brazil.*