HIGHLY FLEXIBLE DEBURRING GRINDING SOLUTIONS FOR SLABS, BLOOMS AND BILLETS FOR CONTINUOUS PRODUCTION*

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Abstract
Depending on the product or the material grade, conventional deburring machines, such as e.g. with rotating hammers, are in many cases not capable to reliably or completely remove burrs from the edges of a continuously cast product. Burr, however, is generated at the front and/or tail ends of a slab, bloom or billet as a result from torch cutting. Likewise, traversal grinding of the slab's rolling surfaces can also cause burr at the long side edges of the slab whereby such burr can even be more difficult to remove. Based on their experience and know-how with abrasive machining processes (abrasive cutting, high-pressure grinding) over a period of more than 50 years up to now, BRAUN has developed a highly flexible deburring grinding machine for applications which are too difficult for conventional deburring techniques. BRAUN's deburring grinding machines were successfully introduced to the steel industry and have proven their worth under normal production conditions already. The subject paper describes the key features and advantages of BRAUN's machine design and the operational results from the first already completed projects.
Keywords: deburring grinding, slabs, reliable burr removal, continuous production

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1 INTRODUCTION

During the continuous casting process, molten metal is solidified and formed into slabs, blooms or billets for subsequent rolling in the finishing mills. Since the 1950´s, it has evolved into the most frequently used casting process for steel (in terms of tonnage). Its advantages are an improved yield, a reliable quality, a high productivity and an excellent cost efficiency. Continuous casting produces metal sections at lower costs with better quality, due to its inherently lower costs.
At the end of the continuous casting process, it is required to shorten the cast products or to carry out a secondary cutting for the next production steps whereby the cutting is performed by mechanical or thermal methods.
Continuous cast products must be cut to length for the next production steps using mechanical or thermal methods. The most common method is torch cutting, which leaves slag deposits, known as burrs or beards, on the upper and, in particular, the lower edge of the cut end. This burr (or beard) must be removed before the down-stream rolling process in order to prevent considerable damage to the rolls and to avoid rolled-in defects.
Conventional deburring methods, e.g., rotating hammers or shear knives, do not reliably remove the burr reliably from the front and tail ends of the product. BRAUN has therefore developed a highly flexible deburr-grinding solution (patent pending). Based on BRAUN’s proven HP (high-pressure/high-performance) grinding technology, this solution provides rapid and reliable deburring.
Traverse surface grinding of slab rolling surfaces by certain types of slab grinding machines can also leave burrs at the longitudinal slab edges. Such burrs can be particularly difficult to remove. BRAUN’s automated deburr-grinder offers a reliable, practically proven solution for that task.

2 BASIC PRINCIPLES OF DEBURRING BY MEANS OF HP GRINDING

Depending on the actual steel grade, more or less heavy, strong-adhering burr at the head and tail ends of the product has to be removed reliably in order to achieve fault-free surfaces. BRAUN’s HP (high-pressure/high-performance) grinding technology has already proven its worth as the most reliable and most effective, thereby also highly flexible and environmentally friendly way to achieve fault-free product surfaces.
Hot-pressed grinding wheels (see Figure 1) are tools, used with high contact pressure and high drive power for the deburring grinding process. In order to meet the require-ments of the deburring application with regards to highest removal rates, fully auto-matic control to reduce labor costs, high reliability and optimum safety, etc., the sele-ction of the proper grinding wheel specification is as important as the utilization of a superior grinding machine.

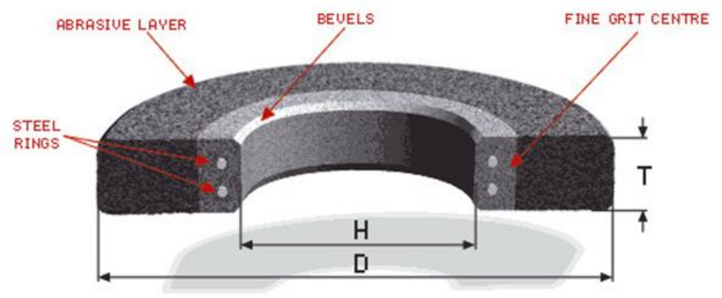

Figure 1. Basic Structure of a Hot-pressed Grinding Wheel

The abrasive layer of the resin-bond grinding wheel, compressed under high temperature and high pressure, consists of grain and binder. Both components have to be adjusted in the right proportion to each other. The binder, based on phenolic resins, ensures the greatest distances between grains and thus the lowest grain surface density, which contribute to the formation of very large chips compared to the grinding wheel size.

Hot-pressed grinding wheels operate at working speeds of 80 m/s and are thus exposed to high centrifugal forces. Safe machine and process design and compliance with safety regulations are important.

3 REQUIREMENTS FOR THE DEBURRING PROCESS

The torch cutting process required during and after continuous casting results in firing slag deposits on the upper and especially the lower cut face edges, and on the cross-sectional surface of the cast product.

In addition to burner settings, burr and beards formation are strongly dependent on the steel alloy and are particularly noticeable in the case of stainless steel alloys, since steel powder is added during the torch cutting process to reduce material losses. Steel powder residues adhere to the slab surface after torch cutting.

The following characteristics of burrs and beards have been noticed in practice by different customers (see Figure 2):

- Moderately adhering burrs on the top and bottom of the slab with a slurry of approximately 25 to 50 mm and a length up to the respective slab width.
- Strongly adhering metal powder incenses at the slab top side over entire slab width
- Strongly adhering slag reflow at the slab top and bottom over the entire slab width
- Strongly adherent local slag baths, usually occurring at the entry and exit points of the cutting burners, at the slab top and bottom

Burr Strips

Metal Powder Incenses

Slag Reflow

Local Slag Baths

Figure 2: Beard and Burr Formation on Slabs

The methods used so far for deburring slabs, billets, and ingots, are either the shearing-off of the burr by means of a shear knife or the removal of the burr by a de-burring machine with rotating hammers. Deburring shears machines only remove the bottom side burr, leaving the top side burr to be manually removed. The disadvantages of rotating hammers deburring machines are especially evident for stainless steel alloys, where strongly adherent burrs are not removed and are instead deeply fused into the slab substrate.

4 KEY DESIGN FEATURES OF BRAUN'S DEBURRING GRINDING MACHINE

BRAUN's main goal was the development of a deburr grinding solution to rapidly and reliably remove burrs from the front and the rear ends of the slabs at both the lower and upper edges, or, if necessary, to grind the cut end surfaces. Furthermore, customers also expressed the desire to grind up to 70 mm in length direction of the slab on the upper and lower rolling surfaces (see Figure 3).
The limited space conditions in the outlet area of a continuous casting plant, the requirement for easy retrofitting of the system between two consecutive outlet table rolls, and the requirement for a 360° rotatable grinding head (see Figure 4) were the reasons for a gantry-type design of the deburr grinding machine.

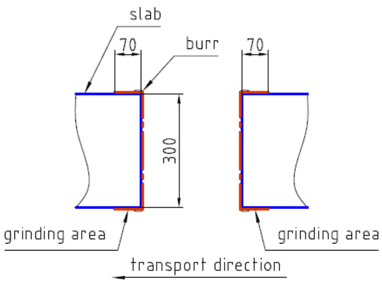

Figure 3: Deburring Area

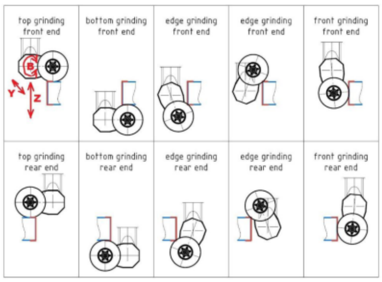

Figure 4: 360° Rotatable Grinding Head for Different Deburring Tasks

Slab surface temperatures up to 900°C in the deburring area necessitate heat shielding (F) for the gantry frame (A) above the roller table (see Figure 5). The vertical slide (C), into which the grinding spindle motor is integrated and the horizontal slide (B) move on a linear guide system. At the lower end of the vertical slide, the swivel-mounted grinding head (E) is positioned on a swivel drive (D), which allows the required continuous and endless rotation.

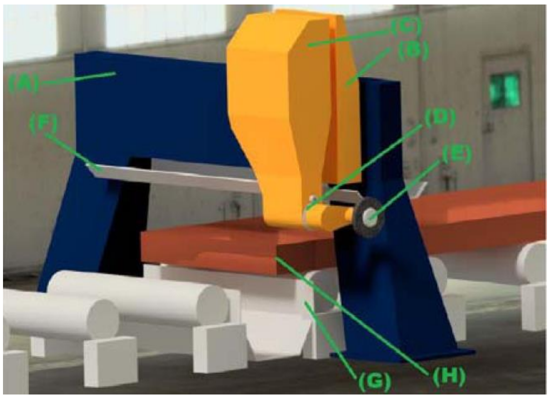

Figure 5. Schematic drawing of a deburring grinding machine

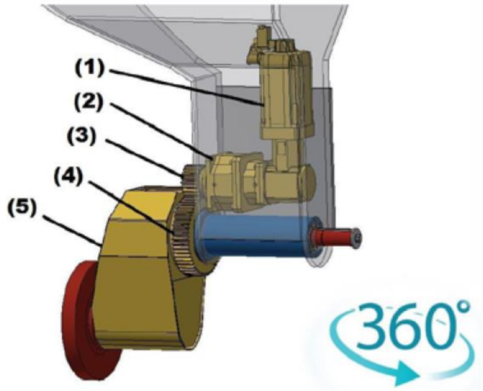

Figure 6. Schematic drawing of swivel-mounted grinding head

The slab positioning and recognition system (H) locates and positions the slab on the roller table. The chip discharge (G) below the slab ensures a reliable discharge of the abraded material.

5 PROCESS DESCRIPTION AND TECHNICAL DATA

Deburring grinding of the slabs after the continuous casting can take place either inline or offline.

When the slab is arriving into the area of the deburring machine, the slab head face is recognized by a laser measuring system. Next, the slab is slowed down and positioned via the roller table control. After the slab has been stopped, the position of the slab on the roller table, its thickness and width, as well as its lateral position are automatically determined before the deburring cycle starts.

The following grinding cycles are possible with the deburring grinding machine (see Figure 7):

- Two grinding passes on the slab bottom side, adjacent to the cut face
- One chamfering pass at the lower cut face edge, across the entire width
- Two grinding passes on the slab top side, adjacent to the cut face
- One chamfering pass at the upper cut face edge, across the entire width

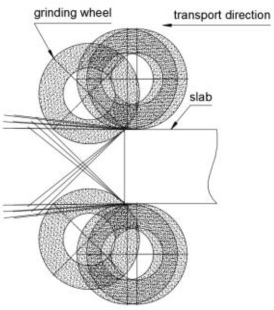

Figure 7. Possible Grinding Positions

Deburring process:	dry, hot
Motor power:	50 kW, 1 500 to 3 000 rpm
Wheel position	90° to grinding direction
Wheel diameter:	406 mm
Grinding pressure:	up to 4 kN
Infeed Speed:	80 m/s
Grinding depth:	abt. 1 mm
Total cycle time:	4 min for lower and upper edge

Figure 8. Deburring Grinding Machine Technical Specifications

6 SOLUTION FOR LONGITUDINALDEBURRING GRINDING OF SLABS

Torch cutting is not the only source of burrs on continuously cast products. Traverse grinding of slab rolling surfaces by certain types of slab grinding machines can cause burrs at the longitudinal slab edge. These strongly adhering burrs can be particularly difficult to remove. For their reliable removal from longitudinal slab corners, BRAUN has developed a different deburr grinding unit comprising two grinding robots (Figure 9) situated at the slab surface grinding machine exit.
As soon as the head end of the slab is detected by a roller table light barrier, two robots equipped with grinding wheels (one robot located on each side of the roller table) automatically grind upper and lower longitudinal edges of the slab alternately while the slab continuously moves forward on the roller table (see Figure 10). Preset grinding pressure is automatically maintained throughout the process. The abraded burr (swarf) removed from the longitudinal edges (corners) of the slab is collected in a moveable spark box. The slab transport speed is supervised by a laser measurement system, which provides the information required for control of the robots. When the tail end of the slab passes the light barrier, the two grinding robots are automatically retracted.
The required grinding wheels for the two robots are stored in a vertical chain conveyor-type tool magazine with an automatic tool changing device. This ensures that all four longitudinal edges (corners) of the slab can be ground with interruptions for tool changes. The unloading of the worn grinding disc and loading of the new grinding disc will be safely done by an operator in a separate loading area without disrupting the deburring process.

Figure 9: Industrial Robot with Grinding Wheel

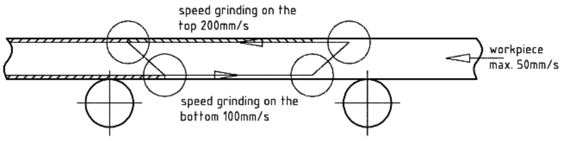

Figure 10: Grinding Processes on Lower and Upper Edges

Figure 11: Industrial Robot in Operation

Figure 12: Longitudinal Deburring Grinding Results

7 SOLUTION FOR DEBURRING/CHAMFERING OF ROUND ELECTRODES AND REMELT INGOTS

The electrodes and remelt ingots used for manufacturing special steel products are in most cases separated by means of an abrasive cut-off machine in chop-stroke or index cutting processes.

Even though almost no - or only a very light burr - remains at the edge at the end of the product after abrasive cutting, some customers require an additional chamfer of 45° in order to ensure perfectly burr-free product ends. For these requirements BRAUN developed a deburr grinding unit, which can be retrofitted on existing abrasive cut-off machines. This deburr grinding unit consists of a grinding robot, which is mounted on the abrasive cut-off machine (see Figure 13). Depending on whether the edge of the front or the rear end of the product is to be deburred/chamfered, the grinding robot is situated either on the left or right side of the abrasive cut-off machine spark box. This deburr/chamfering grinding machine is equipped with a tool magazine with automatic tool changing device.

After cutting off the head or the tail crop, the electrodes or ingots are rotated with by means of a material turning device which is integrated in the transport roller table and lifts the round product off the roller table. At the same time, the grinding wheel mounted

on the robot arm is positioned at an angle of 45° from above and the chamfer is ground on the edge (Figure 14). The deburring process is completed after one revolution of the electrode or ingot.

By means of a special force control, grinding wheel contact pressure is automatically adjusted in real time.

Figure 13: grinding robot in operation

Figure 14: electrode with a 45° chamfer

8 CONCLUSION

The deburring solutions as described for semi-finished slabs, blooms, billets, and electrodes are feasible and adaptable to specific products requirements. Based on flexible design concepts, deburr grinders can be retrofitted on existing continuous casting lines, hot grinding plants, or abrasive cut-off machines, with relatively low investment costs.

Building on the company’s specific know-how and experience in grinding, and coupled with targeted R&D of flexible, integrated solutions for deburring slabs, blooms, billets, or electrodes, BRAUN has developed robust new abrasive deburring and chamfering solutions for the metals industry.

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