Flexible deburring grinding solutions for slabs, blooms and billets for continuous production

BRAUN has developed a cast product deburring grinding solution, based on its well-proven HP (high-pressure/high-performance) grinding machines. The machines are able to rapidly and reliably remove burrs from both ends of the cast products and at both the lower and upper edges or, if necessary, to grind the cut end surfaces. The machines can be retrofitted to existing machines and operate in-or off-line.

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After continuous casting, the cast products are cut to length by 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. The amount and adherence of the burr is both process and steel grade related, but it must be removed before the downstream rolling process in order to prevent damage to the rolls and to avoid rolled-in defects.

Conventional deburring methods, eg, rotating hammers or shear knives, do not reliably remove the burr from the ends of the product, so BRAUN Maschinenfabrik developed a highly flexible deburring 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 on the longitudinal slab edges. Such burrs can be particularly difficult to remove. BRAUN's automated deburr-grinder offers a reliable, practically proven solution for this task.

BASIC PRINCIPLES OF DEBURRING BY HP GRINDING
BRAUN's HP grinding technology has already proven its worth as a most reliable, effective, flexible and environmentally friendly way to achieve fault-free product surfaces.

Hot-pressed grinding wheels (see Figure 1) are the tools used with high contact pressure and high drive power for the deburring grinding process. In order to meet the

Fig 1 Basic structure of a hot-pressed grinding wheel
requirements of the deburring application, namely high removal rates, fully automatic control to reduce labour costs, high reliability and optimum safety etc, the selection of the proper grinding wheel specification is as important as the utilisation of a superior grinding machine.

The abrasive layer of the resin-bond grinding wheel, compressed under high temperature and high pressure, consists of grain and binder in the right proportion. The phenolic resin-based binder ensures the greatest distances between grains and thus the lowest grain surface density, which contributes to the formation of very large chips compared to the grinding wheel size.

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

REQUIREMENTS FOR THE DEBURRING PROCESS

The torch cutting process carried out 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 steels, since steel powder is added during the torch cutting process to reduce material losses and which adheres 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 50mm and a length up to the respective slab width
- Strongly adhering metal powder residues at the slab top side over the entire slab width
- Strongly adhering slag reflow at the slab top and bottom over the entire slab width
- Strongly adhering local slag runs, usually occurring at the entry and exit points of the cutting burners, at the slab top and bottom.

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 deburring 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 hammer deburring machines are especially evident for stainless steel alloys, where strongly adhering burrs are not removed and are instead deeply embedded into the slab substrate.
BRAUN's main goal was the development of a deburr grinding solution to rapidly and reliably remove burrs from both ends of the slabs and at both the lower and upper edges or, if necessary, to grind the cut end surfaces. Furthermore, some customers also expressed the desire to grind up to about 70mm in the length direction of the slab on the upper and lower rolling surfaces (see Figure 3).

The limited space 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. 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 (see E and Figure 6) is positioned on a swivel drive (D), which allows the required continuous and endless rotation.

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.

### PROCESS DESCRIPTION AND TECHNICAL DATA

Deburring grinding of the cast slabs can take place either in-line or off-line. When the slab enters the deburring machine, the slab head face is recognised by a laser measuring system and it is slowed down and positioned via the roller table control. 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. Machine technical data are shown in Table 1.

The following grinding cycles are possible (see Figure 7):

<table>
<thead>
<tr>
<th>Activity</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deburring process</td>
<td>Dry, hot</td>
</tr>
<tr>
<td>Motor power</td>
<td>60hp, 1,500-3,000rpm</td>
</tr>
<tr>
<td>Wheel position</td>
<td>90° to grinding direction</td>
</tr>
<tr>
<td>Wheel diameter</td>
<td>40mm</td>
</tr>
<tr>
<td>Grinding pressure</td>
<td>Up to 400kg</td>
</tr>
<tr>
<td>In-feed speed</td>
<td>7.6mm/sec</td>
</tr>
<tr>
<td>Grinding depth</td>
<td>0.76-163mm</td>
</tr>
<tr>
<td>Total cycle time</td>
<td>4 min for lower and upper edge</td>
</tr>
</tbody>
</table>

### MACHINE FUNDAMENTALS AND KEY DESIGN FEATURES

The following grinding cycles are possible (see Figure 7):

- **Activity**: Deburring process
  - **Details**: Dry, hot
- **Motor power**: 60hp, 1,500-3,000rpm
- **Wheel position**: 90° to grinding direction
- **Wheel diameter**: 40mm
- **Grinding pressure**: Up to 400kg
- **In-feed speed**: 7.6mm/sec
- **Grinding depth**: 0.76-163mm
- **Total cycle time**: 4 min for lower and upper edge

**Table 1 Technical data of deburring grinding machine**
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.

SOLUTION FOR LONGITUDINAL DEBURRING 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 also cause burrs at the longitudinal slab edge and can be particularly difficult to remove. For their reliable removal from the longitudinal slab corners, BRAUN has developed a different deburring grinding unit comprising two grinding robots (see Figures 8 and 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 the 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 and the abraded swarf 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. An example of a ground slab is shown in Figure 11.

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. The unloading of worn grinding discs and reloading of new
ones is safely done by an operator in a separate loading area without disrupting the deburring process.

DEBURRING/CHAMFERING OF ROUND ELECTRODES AND REMELT INGOTS

The electrodes and remelt ingots used for manufacturing special steel products are, in most cases, cut to length by means of an abrasive cut-off machine in chop-stroke or index cutting processes. Although little or no burr remains at the edge at the end of the product after cutting, some customers require an additional chamfer of 45° in order to ensure perfectly burr-free product ends.

For these requirements BRAUN developed a deburring unit, which can be retrofitted to existing abrasive cut-off machines. This deburring unit consists of a grinding robot, which is mounted on the abrasive cut-off machine (see Figure 12). 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 an automatic tool changing device. After cutting off the head or the tail crop, the electrodes or ingots are rotated 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 (see Figure 13). The deburring process is completed in one revolution of the electrode or ingot. By means of a special force control, grinding wheel contact pressure is automatically adjusted in real time.

CONCLUSIONS

The deburring solutions for semi-finished slabs, blooms, billets and electrodes are feasible and adaptable to specific product requirements. Based on flexible design concepts, deburring 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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