Aufbau und Bindungsmatrix hochbeanspruchter keramisch gebundener Zuspannwerkzeuge

Bindungsmatrix entscheidet über Arbeitssicherheit, Sinter- oder Schmelzbindung? [Sinterkorund ist "selbstschärfend".]

H. J. Pedasad


1 Aufbau und Rezeptursystematik von Schleifwerkzeugen

1.1 Dreistoff-System-Darstellung


1.2 Struktur und Gefüge


1.3 Bestimmung der Bindungsmatrix


Neben dieser anwendungsbedingten sogenannten "effektiven" Verfü- lung kennt man noch die sogenannte "notwendige" Verfüllung, die ab einem bestimmten Porenvolumen eintritt, um die Druckfestigkeit und Dimensionenstabilität des betreffenden Schleifkörpers zu gewährleisten.

2 Bindungsmatrix keramisch gebundener Schleifwerkzeuge

2.1 Eigenschafts- und Anforderungprofil

Die Verbandsstruktur des hochfesten Vitrifizierten Bonded-Cutings

1. Charakteristika und Spezifikationen der Gliederung

Eitrige Bondings bestehen aus Klyasen, Kaolinen, Feldspar, Frits und anderen Additiven. Der Bindungstyp, die Schmelzmasse und das chemische Bindungsschema sind dabei entscheidend. Der Eitrige Bonding ist robuster und kann bei Temperaturen bis zu 1000 °C stabil bleiben. Dadurch ist er ideal für die Herstellung von hochfesten Bauteilen.

2. Die Struktur des Vitrifizierten Bonded Cutings

Die Vitrifizierung des Bondings ist ein Prozess, bei dem die Bindungsubstanzen unter Druck und Temperaturen bis zu 1500 °C in ein glasartiges Produkt umgewandelt werden. Dies ermöglicht eine verbesserte mechanische Stabilität und ein besseres Verarbeitungsvermögen.

3. Bindungs-Matrix


4. Vergleich von Vitrifizierten Bonded Cutings

Vitrifizierten Bonded Cutings unterscheiden sich von herkömmlichen Bondings in Bezug auf ihre mechanischen Eigenschaften und ihre Stabilität bei hohen Temperaturen.

5. Literatur


**Bild 6** Mikroskopische Untersuchung von Vitrifizierten Bonded Cutings

**Bild 7** Prozessablauf der Vitrifizierung von Bonded Cutings

**Bild 8** Schneidwerkzeug mit Vitrifiziertem Bonded Cutting
The bond characteristics were tested by means of both physical and chemical methods. The thermal behaviour of the respective bond was determined by heating microscope analysis and adjusted by means of fluxing agents (fluxes) or shortening materials (e.g. alumina) to comply with the firing temperature set by the production processes. Following this the thermal expansion coefficients were measured with a dilatometer and the endo- and exothermic reactions were recorded by means of differential thermal analysis (DTA). The more symmetrical the DTA and DTA curves are, that is the lower exothermic or endothermic reactions taking place, the higher the safety of the bonds. Sudden changes in the expansion behaviour of the grinding wheel while it is heated lead to stresses and consequently to decreases in strength and, in certain cases, to the formation of cracks.

Table 1: Zieja-Mackensen hardness and the modulus of elasticity of grinding wheels (KV = 8885V - 105) fired at different temperatures

<table>
<thead>
<tr>
<th>Temperature [°C]</th>
<th>Zieja-Mackensen Hardness [1000 bar]</th>
<th>Young's Modulus [GPa]</th>
</tr>
</thead>
<tbody>
<tr>
<td>600</td>
<td>400</td>
<td>5,6</td>
</tr>
<tr>
<td>700</td>
<td>500</td>
<td>22,4</td>
</tr>
<tr>
<td>1000</td>
<td>200</td>
<td>34,9</td>
</tr>
<tr>
<td>1300</td>
<td>200</td>
<td>34,2</td>
</tr>
</tbody>
</table>

Table 2: Changes in the SP and HKP values by altering the proportions of the individual components

<table>
<thead>
<tr>
<th>Variant</th>
<th>SP [°C]</th>
<th>HKP [°C]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic Batch</td>
<td>600</td>
<td>900</td>
</tr>
<tr>
<td>Exchange of Frt</td>
<td>1000</td>
<td>1200</td>
</tr>
<tr>
<td>Exchange of Clay</td>
<td>750</td>
<td>900</td>
</tr>
<tr>
<td>Exchange of Feldsp</td>
<td>750</td>
<td>1000</td>
</tr>
</tbody>
</table>

The most important values for the characteristics of the bond are the sintering point (SP) and the melting point (HKP) determined by heating microscope analysis. Fig. 6 shows images made by a heating microscope of typical fused and sintered bonds. While the optimal firing temperature for sintered bond lies above 1250°C, it is possible to use the fused bond from 800°C (SP). As Table 1 shows, different firing temperatures can result in considerable differences in the hardness and strength of the grinding wheel. The Table shows the Zieja-Mackensen penetration hardness and the E-module of a grinding wheel with KV = 48% and PV = 10%. These differences may be exploited according to specific requirements. Fig. 8 shows the SP and HKP values of vitrified bonds as a function of the glass phase content. The type and proportions of the starting materials selected determine the SP and HKP values, and respectively the bond type. The most important components are those responsible for the formation of the glass phase, i.e. the fluxes, since they have an extensive influence on the thermal behaviour of the bond. Table 2 shows how the SP and HKP values can be adjusted simply by altering the flux content (35%) maintaining an otherwise identical composition. Altering the proportions of the other components, e.g. the clays and fieldspars, results in noticeably small modifying effects.

2.3 Plexural Strength Experiments

After the physical tests had been completed, sample grinding wheels were produced at corresponding firing temperatures and cut to form transverse rupture testing rods which were then tested for flexural strength and their modulus of elasticity. According to the studies of Deetjen et al. [8], the modulus of elasticity from this static bending test is comparable to the dynamic E-value obtained with the Grindo Sironic method. From the transverse rupture values the bursting rate which is dependent on composition of the grinding wheel can also be calculated according to Munno's formula [7].

3 Adaption of the Bond Matrix to the Grinding Process

The following examples show how by varying the bond composition it is possible to adapt bond matrix to meet the requirements of the grinding process.

3.1 Adaption to the Abrasive

Silicon carbides and certain sintered alumina are especially sensitive to the bond matrix. For instance, silicon carbides must be fired in an oxidizing atmosphere so that the SiO, SiO2 and carbon impurities are oxidized in order to avoid a weakening of the bond bridges (black core) and a decrease in strength and hardness. For this reason, only sintered bonds without a glass phase may be used, because the fused bonds can easily lead to a premature glazing of the grain and prevent a penetration of the oxygen into the interior of the grinding wheel. The chemical resistance of sintered alumina - especially against alkali silicates - at high temperatures is more critical than in the case of fused alumina. Microscope images of the grain interior of grain type B show in contrast to grain type A clearly penetrated sodium and silicon (Fig. 8). In addition to this chemical reactivity, the firing temperatures also play a significant role. In contrast to the fused alumina, sintered alumina possesses a microcrystalline microstructure, which brings about a very controlled self-sharpening effect of the grinding tool. At higher thermal stresses, however, this results in the growth of the crystals in the jam range and, thus, to uncontrollable self-sharpening. Fused bonds with the lowest possible alkali content and which sinter at low temperatures are the most suitable for sintered alumina.

3.2 Improvement of the Self-Sharpening Effect

The above-mentioned self-sharpening of an abrasive is crucially important for the grinding process [8]. In contrast to sintered alumina, with the fused alumina the self-sharpening usually takes place by the breaking out of larger blunt grain fragments or of the whole blunt grain, leaving new sharp edges. If the remaining grain is held too tightly by the bond matrix, the cutting forces increase rapidly and surface quality of the work piece is thermally damaged. The bond matrix has to be thus adjusted, that when the cutting forces increase, the grain is immediately released so that new sharp cutting grains can replace it. This effect is achieved by adjusting the toughness of the bond matrix.

3.3 Improvement of Strength

The fracture toughness and the resistance to bursting of the grinding wheel is a very important criterion in the development of every bond. During use the probability of fracture has to be reduced to a minimum. The energies, which can be released by a 60 m/s revolving wheel can - apart from injuring the operators - cause extensive and expensive repair damage to the machinery. Grinding wheels for high operating speeds demand particularly strong and safe bonds. The resistance to bursting can be improved by, for example, the addition of lithium and boron compounds. Table 3 shows the resistance to bursting and the modulus of elasticity of grinding wheels with an alkali and a boron containing bond matrix tested in comparable conditions.

Table 3: Comparison of the strength of different bonds

<table>
<thead>
<tr>
<th>Matrix of Binder</th>
<th>Burring Strength [after Munich, ms]</th>
<th>Young's Modulus [GPa m²]</th>
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<tbody>
<tr>
<td>Boron Containing Alkali Contency</td>
<td>120</td>
<td>45.3</td>
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</tbody>
</table>

3.4 Improvement in Profile Durability and Dressing

The machining of new, difficult to cut materials and new grinding processes needs bonds with excellent shape durability and dressing qualities [2]. Increasing the glass phase of the bond results in hard and extremely strong fused bonds, which, because of their low viscosity, bend the individual grain more tightly and thus clearly improve the durability of the shape. Simultaneously, the dressing of grinding wheels has been made easier with the use of diamond tools.

References


"Dr. Horst J. Fiedberg studied chemistry and after completing his degree and receiving his doctorate, he worked as a scientific research assistant and at the Institute of Inorganic Chemistry at the University of Bonn. In 1978 he joined the Feldmühle-Werk Wiesbaden (renamed to CERATIZIT Werk Wiesbaden in July 1995). Since 1981 he has been head of research and development for grinding wheels. Revised post-obliteration contribution from the German Ceramic Society Conference 92 in Bleynew.

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