Production of

Coated Abrasives

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General
A large proportion of grinding tasks in craft or industrial production are performed by the machining of workpieces with coated abrasives. These tasks cover a wide-range of application extending from rough grinding to finishing and polishing. In addition to pre-grinding, intermediate grinding and re-grinding to produce defined shapes and dimensions with given surface qualities, production of the surface finish is an important application.

Grinding tools are used, among other things, for machining of metal, wood, plastic, paint, ceramics, stone, rubber and leather. The large number of possible applications necessitates numerous tool shapes and dimensions as well as tool characteristics adapted to the specific grinding task. These characteristics are achieved by using a wide variety of raw materials in various combinations. The most important structural components of grinding tools are the abrasive, the bonding material and the backing. Abrasive rolls in production width of up to 1620 mm can be produced from these components at large manufacturing installations.

Abrasives
Abrasives can basically be divided into natural (e.g. diamond, natural corundum, garnet, emery, flint, quartz, pumice) and synthetic (e.g. synthetic diamond, cubic boron nitride, fused corundum, zirconic corundum, silicon carbide) abrasives.

Today, synthetic abrasive grain types such as fused corundum, silicon carbide, zirconia alumina, cubic boron nitride and diamond are practically the only types of technical importance.

Grinding grit developments have become known recently, in which microcrystalline aluminum oxide is manufactured and through a liquid phase by calcinating and sintering. The advantage of such ceramic grits is an increase in thoughness whilst maintaining a high degree of hardness. Because of its characteristic light blue colour, the new grit developed in Hermes Research has the name "Sapphire Blue".

Fused corundums differ with respect to their degree of purity. Depending on the degree of contamination, there is black corundum (70 to 75 % AL_2O_3), medium quality corundum (94 to 97% AL_2O_3), semi-noble corundum (97 to 98% AL_2O_3) and noble corundum (over 99 % AL_2O_3), whose colours are black, brown, pink and white. The pink colour of noble corundum is due to a 0,5 to 2,0 % component of chromium dioxide.

The chemical composition influences the hardness and toughness of the grain material, thus noble corundum is harder than medium quality corundum but is easier to fracture (not as tough). Of the conventional abrasives, silicon carbide achieves the greatest degree of hardness. Its toughness also depends on its purity. Consequently, the black SiC (98,3%) normally used for abrasives on backing is tougher than the green version (99,7%). However, both are considerably more brittle than noble corundum.

Zirconia alumina has markedly better toughness properties, when compared with fused corundum. This compound, consisting of AL_2O_3 and approx. 40% Zr0, achieves hardness values comparable with corundum.

Cubic boron nitride (CBN) and diamond are the hardest abrasive grain types in this list. However, they have not yet achieved any significance for abrasives on backings. Garnet, on the other hand has a limited application field in woodworking due to its sharp grain edges. Its hardness is below that of fused corundums.

Bonding Materials
Abrasive bonding materials have the task of securing the grain to the backing until the end of the abrasives service life. Natural glues, synthetic resins and lacquers are used predominantly. Natural glues (hide glues) include top quality animal glues, for example, which are extracted from water-enlarged collagen in animal hides. Synthethic resins, phenolic resins, alkyd resins, aminoaldehyde resins and aminoaldehyde furan resins, epoxy resins and polyurethane resins are all utilized, depending on application.

In accordance with the type of bonding, we distinguish between pure glue or synthetic resin bonding as base or top bonding and partial synthetic resin bonding with glue priming and synthetic resin top bonding.

The advantages of the hide glues are good workability, good adhesion to the backing material, simple drying and good elasticity.

Synthetic resin bonding materials offer advantages for higher grinding demands, such as good grip, high impact resistance, excellent adhesion properties, heat resistance and insensitivity to water.

Backings
A characteristic feature of coated abrasives in the elasticity and flexibility of the backing material, whereby materials with a wide variety of properties can be used. Sodium and sulphate wood pulp craft papers with different base weights are generally used for paper backings. Vulcanized fibre backings consist of several layers of parchment papers which are combined to the required thickness in rolling presses under high pressure.

If increased demands are placed on the strength and flexibility of the tools, backing made of cotton, synthetic fibre (polyester) or mixed fabrics in linen, twill ore sateen weave are used. In addition, knit fabrics, synthetic non-woven web and polyester film are available as other backing systems.

Normally the warp yarns are interlaced for the woven fabrics. In the case of knit fabrics the longitudinal and cross threads are sewn with a third thread at the knotted points. This results in high strength and less elongation in the longitudinal direction.

Non-woven webs are crosslinked textile fabrics consisting of synthetic fibres where the abrasive grain is anchored on the fibre surfaces by bonding agent droplets.

Because of their extreme uniformity, polyester film substrates are used primarily with applications in final sanding with fine grits.

In addition to the abrasive and bonding materials, grinding tools may also contain different types of additives in varying quantities and compositions which act as active grinding components to improve the grinding characteristics.

Preparation for Manufacture

Production of coated abrasives is generally a continuous process. Raw materials are selected and prepared as required for each production run. Woven and knitted backings are provided with a filler so the required physical characteristics can be realized. Flexibility and adherability of the bonding material for the abrasive grain, sliding and adhesive properties of the backing for use with fixed support elements, energy transfer to the drive rollers and resistance to coolants are all examples of these characterics. The processed raw backing products are then available as roll goods in production width for the basic production process.

The abrasives are prepared on a job-specific basis with respect to type, grain size, composition and quantity. An important characteristic is the grain size classification. A distinction is made here between macro and micro grains, whereby the macro range lies between P 12 and P 220 and the micro range between P 240 and P 2500 for abrasives on backings. Grain size classification takes place in sieve machines (macro grains) or sedimentation (micro grains). Sieving or sedimentation is performed in accordance with DIN 69 176 or FEPA 43-D (F, GB)-1984 in the Federal Republic of Germany and many European countries, – while ANSI/ASC B 74.18-1984 is used in the USA. Careful monitoring ensures uniform grain quality.

The bonding agents are produced in a bonding compound preparation. Here, we must distinguish between the base bond (make coat) and top bond (size coat). In principle, pure hide glue, partial synthetic resin or full synthetic resin bonding agents are possible. Pure hide g lue bonding agents are frequently used when lower loads are involved in the grinding process. The preferred backings used in this process are paper and woven fabrics.

Partially synthetic resin-bond coated abrasives are provided with hide glue as a base bond and synthetic resin as a top bond. These grinding tools are generally suitable for medium-duty grinding tasks. If the demands placed by the grinding process are high (high metal removal volume, high grinding forces), then the abrasives are exclusively bonded in synthetic resin. The relatively hard bonding creates strong cohesion between the backing and abrasive grain.

Manufacturing Procedure

The backing, or processed roll, is now placed on the unwinding station of the production installation and is fed to the stamping machine by means of deflection rollers. The backing then passes through the printing unit where it is stamped over the entire width of the rear side with information concerning the manufacturer, type, grain and the production number or additionally required safety information (DSA No., maximum working speed).

The first bonding agent is applied in the base coating machine. The base coat bonding agent is stored in a supply tank into which a rubber-coated roller is immersed. This roller then applies the bonding agent uniformly to the grain-side of the backing when it rotates. A spring-loaded metering roller (counter- roller, squeezing roller) controls the coated quantity by means of an adjustable gap distance.

Tank filling and agent removal are monitored by automated weighing devices. An oscillating spreading brush positioned transversely with respect to the backing additionally improves the homogeneity of the bonding agent coating.

The roll goods then pass through the spreading machine for abrasive grain coating. Two coating methods are possible. In the case of mechanical coating, the abrasive grain is applied to the backing by free fall. If this method is used, the grains generally have a flat slope with respect to the backing surface. The required grain coating quantity is adjusted by varying the gap distance in the spreading hopper and by changing the backing speed. Loose, non-adhering abrasive grains fall into a collection hopper.

In the case of improved electrostatic coating, the abrasive grains are accelerated by conveyor belt from the bottom to top backing in an electric force field. Here, they align themselves in accordance with their geometric longitudinal axis and stand on the base coating with their sharp cutting edges perpendicular to the backing. The advantages of this spreading method are a uniformly and easily reproducible distribution of the abrasive grains, improved grain engagement properties during grinding and longer tool life.

If this method is used, excessive abrasive grains are also brought into the electrostatic field. The strength of the force field and the speed of the backing again determines the quantity of grain applied. A downstream knocking roller causes the loose abrasive grains to fall off in both coating methods. After coating the backing passes through the drying section. The abrasive backings are moved forward slowly in this predrying section while hanging in loops. The length and spacing of the loops depends on the backing quantity and the transport speed. The temperatures in the drying section are between 30 and 45°C for hide glue products and between 90 and 130°C for synthetic resin products.

After pre-drying, the abrasive backings are transported into the coating machine for the top bonding agent coating. The bonding material is coated in the same way as for the base coat. Rubber rollers are used so grain edges are not damaged during coating.

The bonding agent and grain coating operations are constantly monitored. The coating values at the measurement using the irradiation method is used.

Both the process backings and the coating layers are measured; the values are then compared in the computer with the standards and corrected in the event of deviations. This ensures a homogenous and reproducible production process over the entire abrasive surface and guarantees uniform product quality.

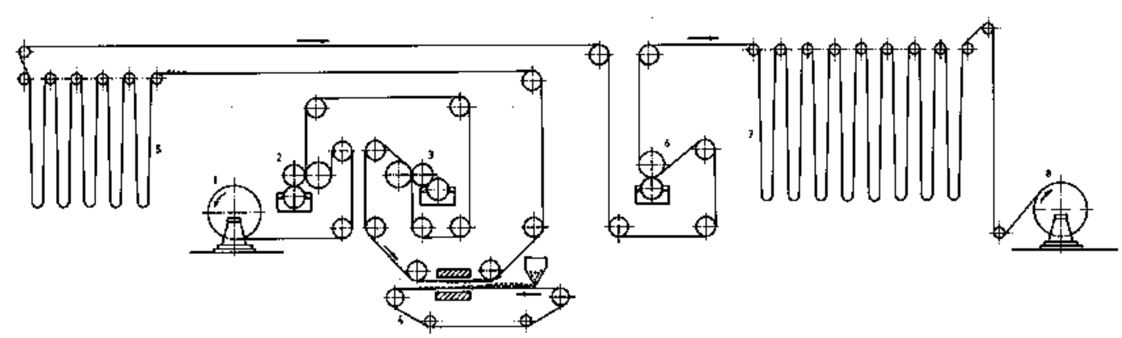
Final hardening of the product emerging from the post-glueing machine takes place in a similar way to pre-drying in a drying section which is 4 to 5 times as long as the predrying and intermediate sections. Like the intermediate drying section, the material enters the section in loops. The spacing and length of the loops, dwell time in the drying section (which is divided into individual and conditioning zones), drying temperature and transport speed are adjusted in accordance with product requirements. Towards the end of the hardening process, the moisture of the abrasive backing which has evaporated as a result of the heating process must be re-supplied by means of a conditioning process in order to ensure a supple, flexible finished basic product.

The wind-up-machine is located at the drying section exit. The basic coated abrasive material is rolled up over its entire width, wereby seams and defects are identified by tickets. When a roll diameter of 800 to 1000 mm has heen reached, the roll ("Jumbo") is taken from the roll-up machine and is supplied to the flexing department or held for further processing depending on the planned application. If necessary, additional drying is also possible in chamber ovens.

In order to achieve the required and uniform flexibility of the basic product, the next operation is the jumbo roll flexing. Here, the hardened and rigid bond is partically broken in a controlled manner in small area sections. In these sections, the abrasive grain remains firmly anchored, so that premature breaking out of the abrasive grains is avoided as a result of changing loads in the grinding process. During this process (flexing), the abrasive backing is guided diagonally and/or transversely over cylindrical flexing rods of small diameter or over flexing knives and can be deflected a number of times. The degree of flexibility of the abrasives depends on the diameter, width and shape of the flexing tool, tension and flexing angle.

Further processing of the abrasive products to produce endless wide and narrow belts, rolls, drum covers, discs, sheets, flap wheels and other design forms is performed on special machines in the conversion departments. In addition to manual devices, state of the art semi- and fully-automatic machines and installations are utilized in the conversion department.

Overview of a Production Installation



1. Unwinding machine
2. Printing machine
3. Base coat application machine
4. Electrostatic coating machine
5. Drying section
6. Glueing machine (top coating)
7. Main drying section
8. Winding up station