Hardness

The hardness of a grinding disc is the resistance that the binding of the disc exerts against grain shedding.

The bond hardness of a cutting-off wheel or grinding disc can be influenced and adjusted by the resin used as well as by the added filler materials. According to DIN ISO 525 the bond hardness of cutting-off wheels and grinding discs is identified by letters of the alphabet that are added to the type designation. The identifiers range from "A" (extremely soft) to "Z" (extremely hard), i.e. the harder the bond, the higher the position of the corresponding letter in the alphabet.

As a general rule, the selection of a cutting-off wheel / grinding disc that is ideal for a particular application requires that the softness of the bond of the abrasive used increase with the hardness of the material to be processed.

If the bond selected by the user is too hard, worn and dull grains will not be shed from the backing during the work process, resulting in a rapid decrease in aggressiveness of the disc. This may cause the cutting edge to overheat, resulting in the "vitrification" of the disc and the total loss of its cutting performance.

If the bond selected by the user is extremely soft, the abrasive tool affords the user a high level of aggressiveness as the grain used is always fresh, resulting in shorter processing times. At the same time, an extremely soft bond will result in increased wear of the tool and, consequently, decreased service life.

Cutting speed

The cutting speed refers to the speed at which a tool moves during grinding. On a belt grinder, for example, it is the circumferential speed of the belt. On an angle grinder, it is the rotational speed of the grinding or cutting-off wheel. This is also referred to as the maximum operating speed.

The cutting speed during grinding is calculated based on the following formula:

$$V_c = d \cdot \pi \cdot n/60000$$

Vc = cutting speed [m/s]
D = tool diameter [mm]
n = rotational speed [1/min.]

The cutting speed, along with the feed speed have a decisive influence on the processing speed during machining and, thus, the output/production volume per unit of time and the achieved surface finish. As the temperature of the blade increases with the cutting speed, any increase in cutting speed also translates to an increase in tool wear and, therefore, a shorter service life. The selection of the optimum cutting speed during grinding depends primarily on the substance/material to be processed.

For safety reasons, applicable standards mandate that the maximum permissible cutting speed of rotating abrasive tools be equal to the maximum operating speed in most cases.

Passive layer

The so-called passive layer is a thin oxide film that forms on the surface on non-corrosive steel when it comes into contact with oxygen. The chromium atoms of the steel subsequently form a thin and inert (hence, the name "passive layer") oxide film that prevents the oxidation from proceeding, thereby preventing the steel from corroding. The characteristic and durability of the passive layer depends primarily on the alloy composition of the steel.

Stainless steels react to oxide and form an oxide film to the same degree as normal steel. In normal steel, the oxygen reacts with the iron atoms existing in the steel; this reaction produces a porous surface that allows the reaction to proceed. This process can result in the complete "rusting out" of the work piece.

In non-corrosive steel, the oxygen reacts with chromium atoms, which are contained in the steel at a relatively high concentration, to form the passive layer on the surface.
There are two reasons for the formation of rust on "non-corrosive" stainless steels:

- the passive layer could not form, or
- the passive layer was damaged

The inability of the passive layer to form can only be prevented by a high degree of cleanliness. All processed surfaces must be thoroughly cleaned of all residue. This applies, in particular, to any residue left behind by abrasives. For this reason, all abrasives suitable for processing stainless steel are free (mass portion < 0.01 per cent) of chloride, iron and sulphur.

Rotational speed

The rotational speed indicates how many revolutions per unit of time a tool completes and is given in revolutions per second or per minute. In rotating abrasives, the maximum permissible rotational speed is a factor of key importance that results from the maximum operating speed specified in the applicable standards as a function of the tool diameter and is given in revolutions per minute (1/min. or min.-1).

All rotating abrasive tools have information on the maximum rotational speed at which the tool may be operated imprinted or engraved directly on the tool. The following product groups included in Klingspor's product line contain information on rotational speed:

- fibre discs, fibre disc backing pads
- Kronenflex cutting-off wheels and grinding discs; Kronenflex cup grinding wheels
- abrasive mop discs SMT, cleaning wheel NCD 200
- abrasive mop wheels, small abrasive and finishing mops
- abrasive cleaning disc Power Wheel PW 2000
- compressed non-woven discs MFW 600
- quick-change disc (backing plate)
- diamond cutting blades and diamond sanding pads
- R-Flex wheels with elastic bonding, mounted points, mottling points
- carbide burrs

For safety reasons, the user must never exceed the specified maximum rotational speed while using this tool (see also Maximum operating speed) as centrifugal forces and vibrations may otherwise destroy the abrasive, and split-off parts may result in severe injury.

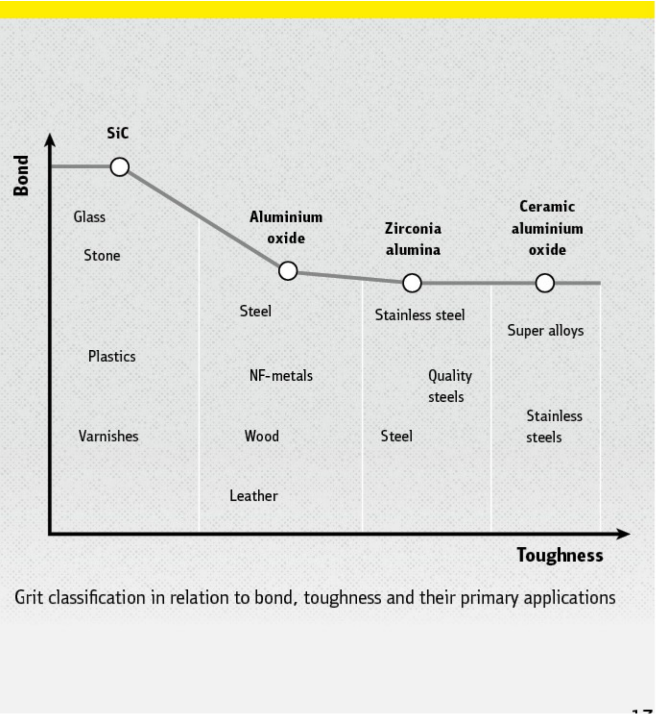
From a standpoint of application efficiency, operating abrasive tools at maximum speed is often not advisable as this type of use will lead to, for instance, increased wear or the generation of high temperatures. This is why Klingspor prints information on the maximum permissible rotational speed along with information on the recommended speed on the label of some abrasives (e.g. SMT 800, SMT 850+, MFW 600, KM 613). When operated at this recommended speed, the abrasive tool allows the user to achieve the best possible results with regard to grinding performance, wear and service life.

Grain types

The term grain types in the area of abrasives signifies the different types of minerals used during the manufacture of abrasive tools. Since the essential portion of the grinding process, namely the machining of the material to be processed, is performed by these minerals, the grain type used has a major impact on the suitability range and performance of a abrasive.

An overview of the different grain properties and the typical wear characteristics of the most commonly used grain types is given in the diagram below.

Grit



Grit classification in relation to bond, toughness and their primary applications

Grit is responsible for stock removal. When selecting the correct grit two properties are particularly important:

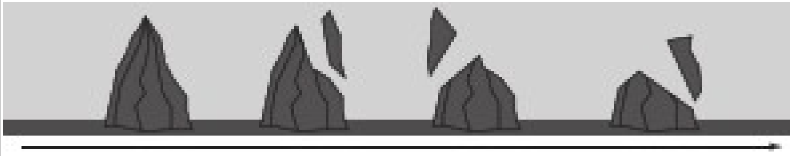
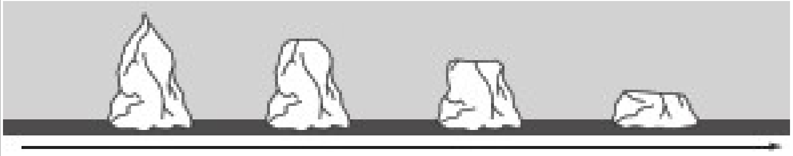
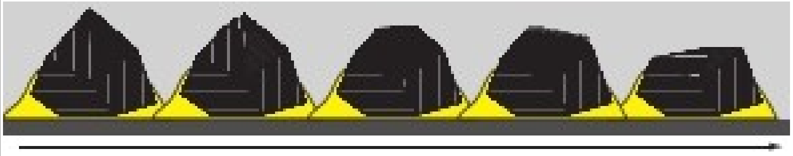
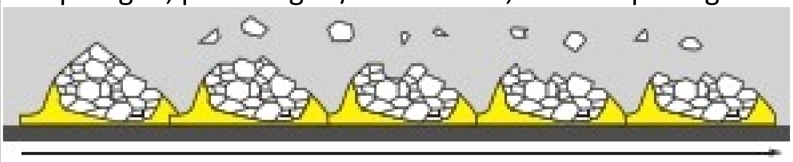
- Bond
- Toughness

All Klingspor grit types are produced synthetically. This ensures a consistently high quality product. Four different grit types are used with coated abrasives:

- Silicon carbide
- Aluminium oxide
- Zirconia alumina
- Ceramic aluminium oxide

Grit classification in relation to bond, toughness and their primary applications

Grit Types	**Bond/ Toughness**	**Structure**	**Properties / wear properties**
Silicon carbide	very hard / less tough	crystalline	sharp-edged, brittle, highly friable / micro-wear

			
Aluminium oxide	hard / tough	crystalline, irregular	wedge-shaped, block grain, even wear 
Zirconia alumina	hard / very tough	crystalline, even	wedge-shaped, block, drop formed grit / micro-wear, self-sharpening 
Ceramic aluminium oxide	hard / very tough	micro-crystalline	sharp-edged, pointed grit / micro-wear, self-sharpening 

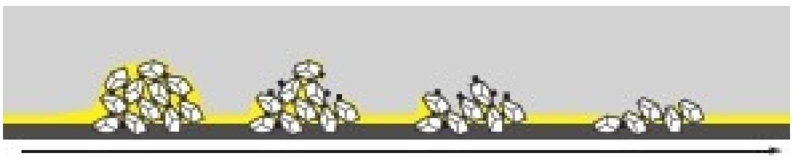
Grit type properties and their specific wear properties

In addition, there are also so-called grit agglomerates. This is not an independent grit type, rather it is a grit agglomeration, which is comprised of many individual aluminium-oxide or SIC-grits mixed with a resin bonding agent, which together form a large grit. Agglomerates are used almost exclusively on abrasive belts. The advantage of agglomerates is that they provide an even finish from the first use to the last. Dull grit breaks off from the agglomerate and creates space for new, sharp grit. The objective is to attain an even finish through continual stock removal and an extremely long service life.

Coating

Moreover, the coated abrasives are coated with different grit coverage densities. The term “grit density” describes the grit coverage density distributed on the backing. One differentiates between:

- close coating
- semi-open coating
- open coating



Open coated grit has a large space between the individual grits, such that the stock removal and the grinding dust can be extracted
more easily from the grinding surface. This prevents premature
clogging when working on long-chipping materials, such as wood.
The decision as to which grit density to use is primarily dependent
upon how great the likelihood is that the grinding dust will clog the
space between the grits.

Historically, grain types fall into the two major groups of natural and synthetic grains. Subsumed in the category of natural grain types are, in particular, flint, garnet and emery; however, these grain types are barely used any more in the production of abrasives. Instead, the abrasives produced today are usually made with synthetic grain types such as aluminium oxide, zirconia alumina, silicon carbide and ceramic aluminium oxide. Compared to their natural siblings, synthetic grain types offer significant advantages in the areas of hardness and toughness; they, furthermore, offer greater uniformity across their properties, which is the defining attribute that qualifies them for demanding industrial applications in the first place.
In order to offer their customers a broad range of possible applications and perfect suitability for their specific purpose, Klingspor sells abrasives (belts, rolls, sheets, discs, strips, fibre discs, resinoid cutting-off wheels and grinding discs, abrasive mop discs, abrasive mop wheels and abrasives with an elastic bond) with different grain types. This approach ensures that customers will always achieve the perfect grinding result by selecting the grain type that is right for the material and work piece they need to process and the result they wish to accomplish.

Stainless steel

Stainless steel is an umbrella term for all steel grades that have been manufactured in a special process, possess a high level of purity and react uniformly to designated thermal treatments. According to this definition, stainless steels do not necessarily have to be alloy or high-alloyed steels. The description from here on will, however, be confined to high-alloy stainless steels with a chromium content of at least 10.5%.

Categorisation of high-alloy stainless steels

Based on their structure, high-alloy stainless steels can be grouped into the following categories:

- ferritic stainless steels
- martensitic stainless steels
- austenitic stainless steels
- ferritic-austenitic stainless steels (duplex steels)

Ferritic stainless steels

Ferritic stainless steels fall, again, into two groups:

- containing approx. 11% to 13% of chromium
- containing approx. 17% of chromium (Cr)

Stainless steels with a chromium content of 10.5% to 13% are categorised as inert to corrosion due to their low chromium content. They are used wherever service life, safety and low maintenance requirements are of paramount importance and no specific requirements are made on appearance. Common fields of applications are container, carriage and vehicle construction.

Martensitic stainless steels

Martensitic stainless steels with a chromium content of 12% to 18% and a carbon content exceeding 0.1% turn austenitic at temperatures above 950 - 1,050°C. Rapid chilling (quenching) leads to the formation of a martensitic structure. This structure, especially when hardened and tempered, offers outstanding strength, which increases even further with a rising carbon concentration. Martensitic stainless steels are used, for example, for the production of razor blades, knives or scissors.

Austenitic stainless steels

Austenitic stainless steels (also known as: chromium-nickel steels) with nickel concentrations above 8% represent the most favourable combination for practical use when in comes to workability, corrosion resistance and mechanical properties. The foremost characteristic of this grade of stainless steel is its high resistance to corrosion. For this reason, austenitic stainless steels are used in areas with exposure to abrasive media, e.g. contact with seawater containing chloride and in the chemical and food industry.

Austenitic-ferritic stainless steel

Austenitic-ferritic stainless steels are often referred to as duplex steels on account of the two structures of which they are composed. As they offer exceptional ductility and improve corrosion resistance at the same time, these steels are particularly well suited for use in off-shore engineering.

Grinding of stainless steels

Many components made of stainless steel are ground at the end of the machining process. Klingspor's product range offers a host of abrasives that are specifically designed for processing this material. Nonetheless, the machining of stainless steel requires that peculiarities specific to the material be observed in order to achieve consistently satisfying results.
The surface finish produced at the factory, i.e. the rolled, stained and/or subsequently heat-treated material, should be selected in such a way that the original surface resembles the desired surface

at the end of machining as closely as possible.
The corrosion resistance of stainless steel work pieces requires that the material be properly stored and transported before it is even processed.

Things that need to be avoided in particular:

- Any kind of contact with other types of steel (steel brushes, wire cables).
- Damage to surfaces and edges as well as chafe marks.
- The storage of materials in processing areas or storage together with other types of steel (e.g. rolled steel).

Another rule that applies to corrosion resistance: the finer the surface the greater the resistance to corrosion

Grinding

There is a multitude of parameters that affect the roughness and visual appearance of ground surfaces:

- The grinder including the contact elements fitted on it and the machining parameters (cutting speeds and feed rates)
- The use of grinding fluids (oils and emulsions)
- The quality of the grinding fluid

Due to the framework conditions dictated by the grinding process, it is not possible to make a statement about the finished surface and the used grinding fluid that applies in all cases. To avoid any misinterpretations regarding the agreed finished surfaces, it is advisable to define a boundary sample and roughness averages (Ra) before machining commences.

Grinding and corrosion

Regardless of the stainless steel used, it is recommended to strictly observe the measures listed below prior to grinding non-corroding steel:

- Never use abrasive tools on normal steel first before using the same tools on stainless steel!
- Clean all surfaces thoroughly of grinding dust!
- Never spray stainless steel surfaces with fountains of red hot sparks!
- The machining temperatures must be low enough to prevent the formation of chromium carbides and of subsequent intercrystalline corrosion. If the metal tarnishes it has be to reworked!

This is the only way to ensure that the passive layer in the processed areas rebuilds and the other surfaces are prevented from sustaining damage from pitting corrosion or intercrystalline corrosion.

Fibre disc

Vulcanised fibre discs (commonly known as: fibre discs) are round grinding wheels with a backing made of vulcanised fibre that is coated on one side with resin and abrasive grain. Fibre discs are fitted to suitable backing pads and used on angle grinders, predominantly for machining metal. The safety requirements applicable to fibre discs and their backing pads are laid down in the EN 13743 standard. The maximum surface speed (maximum operating speed) for fibre discs is 80 m/s.

As they can be combined with a wide range of grain types and backing pad versions, fibre discs have a extensive scope of applications ranging from rough machining to finish grinding of surfaces. The benefits fibre discs offer over abrasive mop discs and grinding discs are the elasticity of the backing, resulting in excellent adaptability, a fine and uniform scratch pattern (compared to grinding discs) and, first and foremost, their more affordable price.

Their downsides in contrast with abrasive mop discs lie in their inferior service life and their relatively high sensitivity to moisture and temperature.

On account of the latter downside, we recommend the following for the use of fibre discs:

- Storage at a medium relative humidity level of 45 – 65%.

  If too high or too low, humidity will cause the discs to buckle.

- Avoid overheating.

Overheating, e.g. by excess pressure of grinding on the spot, may cause burns and blistering on the backing, ultimately resulting in grain shedding.

Klingspor offers an extensive in-stock line of fibre discs with all common diameters (Ø50 – 230 mm) that come either with a single round hole or a star-shaped hole. The available products range from universal corundum discs for universal applications (CS 561) to zirconia alumina discs with or without multibond (CS 565/CS 570) for steel and stainless steel applications to premium discs with ceramic grains with or without multibond (FS 964 ACT/FS 966 ACT) for the machining of stainless steels and high-alloy steels. The product group is completed by matching hard, ribbed backing pads for heavy grinding (ST 358 A) and smooth, flexible pads for predominantly planar applications (ST 358). Applying leading-edge technology for cutting them, Klingspor can produce even custom shapes of their fibre discs, e.g. rosette or multi-corner shapes, or custom sizes for special applications with relative ease.

Maximum operating speed

The maximum operating speed of abrasive tools is the maximum speed at which rotating abrasives can be operated when fitted to the corresponding grinders during application.

It is given in m/s and defined by the applicable standards (for instance, DIN EN 12413, DIN EN 13743 and DIN EN 13236) in an effort to avoid and reduce risks. These standards also designate the different levels of possible maximum operating speeds according to which the abrasives need to be manufactured as well as the identification of these levels and the maximum permissible rotational speeds as a function of the diameter.

While no longer mandatory, the colour coding used to designate the maximum operating speed, which used to be required by regulations until recently, is still frequently used in the form of coloured stripes applied on the abrasive tools (e.g. 50 m/s = blue bar; 63 m/s = yellow bar, 80 m/s = red bar; 100 m/s = green bar,…).

For safety reasons, the user should strictly ensure not to exceed the maximum operating speed specified on the abrasive.

As a founding member of oSa, Klingspor attaches the utmost importance to the safety of their abrasives and to the testing and labelling practices demanded by the applicable standards, thus ensuring strict compliance with the standards DIN EN 12413 (for bonded abrasive products such as cutting-off wheels and grinding discs or R-Flex abrasives), DIN EN 13743 (for coated abrasives such as abrasive mop discs, abrasive mop wheels, mounted wheels, fibre discs and fibre disc backing pads) and DIN EN 13236 (for abrasive tools with diamonds and CBN).

The maximum operating speed is relevant to the following abrasive tools included in Klingspor's product range:

- fibre discs and fibre disc backing pads (80 m/s)
- Kronenflex cutting-off wheels and grinding discs (80 m/s for off-hand applications, 100 m/s for stationary cutting)
- Kronenflex cup grinding wheels (50 m/s)
- abrasive mop discs (80 m/s)
- cleaning wheel NCD 200 (63 m/s)
- compressed non-woven discs MFW 600 (47 / 37 m/s)
- abrasive mop wheels (50 m/s; with the exception of abrasive mop wheels with a width of w>100 mm (30 m/s) and slashed abrasive mop wheels (40 m/s)).
- mounted point/mounted wheel (40 m/s)

- diamond cutting blades (80 m/s for blades fitted to angle grinders; 100 m/s for blades intended for use on petrol saws, joint cutters and table saws)
- diamond sanding pads (80 m/s)
- abrasives with an elastic bond including R-Flex wheels, mounted points and mottling points.

For these tools the maximum operating speed varies with the bond of the abrasive (5 m/s for abrasives with a W-shaped bond; 16 m/s for abrasives with an E-shaped bond; 32 m/s for abrasives with a Z-shaped bond)

Belt joint

The manufacture of an endless abrasive belt from a roll of abrasive paper or abrasive cloth requires that both ends of the previously cut-to-length section of the roll be joint permanently. The so-called belt joint usually runs at a 45° - 80° angle to the running direction of the belt in order to prevent an abrupt transition at the junction.

The abrasive backing (paper, cloth, plastic) used and the application (machine, contact element, work piece) determine the type of the belt joint.

Belt joint types generally fall into two different categories:

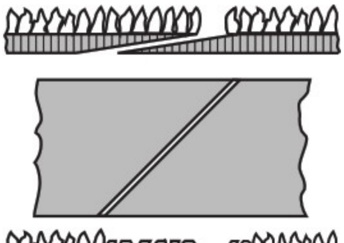
a) the lap joint which is formed by alternately tapered ends that are laid and fused on top of each other and

b) the butt joint which is formed by two ends that abut each other and are joined by means of a narrow strip of (mostly fibre-reinforced) tape either on the front or the reverse side of the belt.

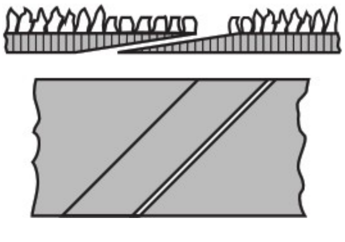
Since there are additional variations within these two types of joint categories, the belt can be perfectly adjusted to the grinding task at hand.
Klingspor uses the following types of belt joints for their abrasive belts:

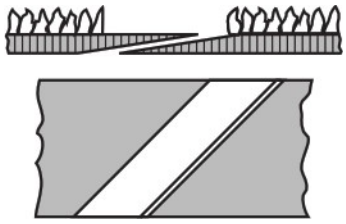
Overlap joint

F1 Standard overlap joint



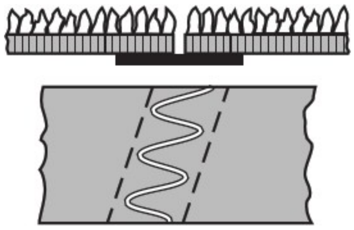
F2 Lap joint with sharpened grain points



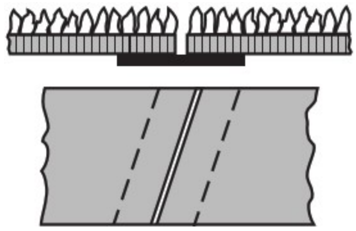


F5 lap joint without resin and abrasive grain in the overlap

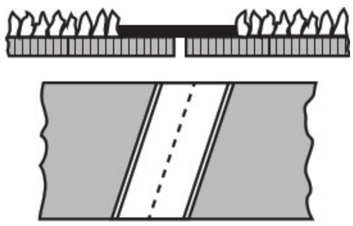
Butt joint



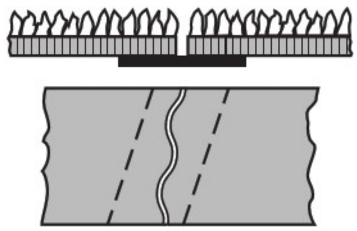
F3G Zig-zag joint with tape on the reverse



F4G straight cut at an angle to the running direction of the belt with tape on the reverse

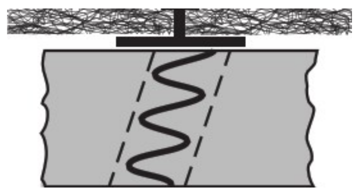


F6G Butt joint with tape inserted on the grain side; grain and resin in the joint area are removed beforehand

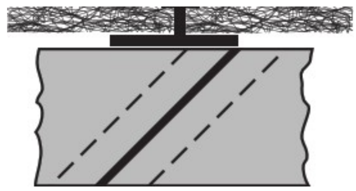


F7G wave joint with tape on the reverse

Joints for non-woven belts



F3W Special belt joint for non-woven web belts. Tape reinforced butt joint with additional frontal adhesion.
mit zusätzlicher stirnseitiger Verklebung.



F4W Bevel cut, butt joint, fabric-reinforced film and bonding on the face side. Special joint for non-woven file belts, product type NBF 800.

Selecting the right type of belt joint plays a key role in the area of abrasives. Klingspor ships all belts of standard dimensions and belts available for order from stock with the type of belt joint that experience has proven to be the best choice for this particular belt type. If required by the customer, Klingspor can also manufacture and deliver other types of belt joints that will be better suited for the customer's specific application.

Wet grinding

Wet grinding describes a grinding process under addition of water, emulsion or oil.

The main tasks of wet grinding are:

- cooling and lubricating the processed surface
- cleaning (removal of the grinding chip)
- protecting the tool against corrosion
- increasing of the processing speed
- improving the surface finish
- protection of the abrasive tool / increase of the tool's service life

End users constantly look for ways to speed up the production process. Wet grinding allows the user to achieve much faster through-feed times as opposed to dry grinding. Klingspor offers waterproof grinding tools that are suitable for all sorts of wet grinding applications.