The Wheel and Creep Feed Grinding

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It is widely accepted that grinding wheels with a high percentage of porosity are an absolute necessity for Creep Feed grinding. It is the purpose of this paper to understand why and to, highlight possible areas for thought when selecting the appropriate wheel.

There's no "Buzz Word" in the grinding industry today that sparks the interest and excitement of "CREEP FEED".

It is impossible to attend a seminar on Creep Feed without hearing the phrase "very soft very open" when referring to the grinding wheel without any real explanation of why or compared to what? Compared to conventional grinding, and what is actually going on. In contrast to conventional reciprocating grinding, Creep Feed is characterized by increased depths of cut and much slower table speeds.

Increasing the depth of cut or infeed is an easily observable change to any grinding system. Increasing the depth of cut also increases the length of arc of contact. In this example "length of arc" will refer to the distance an abrasive particle must follow while in contact with the work piece. For our example we will be using a 16" diameter grinding wheel. Setting the machine for a depth of cut of .001", will generate an arc of contact between the wheel and the work piece of .126". Increasing the depth of cut to .110" will increase this arc of contact from .126 to 1.266". (Figure #1).

Using the same 16" diameter grinding wheel of any given width and depth of cut .001" we have a given area of contact. By "area of contact" we mean that portion of the wheel actually in contact with the work piece during the grind. (Length of arc x width of wheel) (Figure #2). Within this area, based on abrasive size and structure there will be a given amount of abrasive particles. Increasing the depth of cut (Figure #3) will proportionately increase this area of contact. Again, keeping abrasive size and structure constant, we can expect an increase in the amount of active abrasive particles in contact with the material.

Applying a given force of the same amount to both areas results in the amount of force per individual abrasive particle within the larger area to decrease (Figure #4). This decrease in unit pressure per abrasive particle is the same principle we see in conventional grinding. One should be able to visualize at this time that changing the depth of cut directly effects the area of contact between the wheel and the work piece. Changing the area of contact in turn effects the unit pressure per abrasive particle causing the grinding wheel to act harder or softer.

As in conventional reciprocating grinding it is an accepted f act that as you increase the area of contact, you must adjust the grade to maintain the same performance. Changing the depth of cut although very obvious is not the only element to influence the number of active abrasive particles in relation to area. Form must also be taken into consideration.

Unlike conventional surface grinding where form has a less noticeable effect on the number of active abrasive grinding particles, Creep Feed with full depth grinding has a much more pronounced affect. For example, a straight faced grinding wheel has a fixed number of active abrasive particles for a given horsepower (Figure #9A), unless Figure B has a depth of cut greater than that of the formed area, the effect is the same as removing 1/4 the amount of material with the same horsepower. A wheel that might work well with the given horsepower in 9A could possibly grind unsatisfactory in condition 9B. Another thing to remember here is that the sides of the form sections are not actively grinding, but rather have a polishing effect. Keeping horsepower constant from form 9A to 9B would result in more force per active abrasive particle, or we would expect the wheel to act softer than in 9A.

The extreme example of a forms affect on the active abrasives grinding particles is represented in Figure 9C. In this case only <u>1/2</u> the material is now being removed by <u>twice</u> the active abrasive particles. Again maintaining the same horsepower as in 9A would result in a much lower force per active abrasive particle and in this instance we would expect the wheel to act harder. From these examples it becomes easier to visualize that when we say very soft it is relative to performing the same operation by conventional reciprocation with it's greatly reduce area of contact. And that a wheel that works very well on a particular material with set machine parameters would possibly require readjusting these parameters, as the depth of cut or form on the grinding wheel is changed to optimize results.

When referring to the cavities or porosity within a grinding wheel what we are actually referring to is the wheels structure. Structure is the relationship of abrasive grain and bonding material to the voids or spaces within the wheel Figure #5. For each grit size and grade combination there is an optimum structure. In creep feed it is confirmed that increased porosity is absolutely necessary. Testing has also indicated that it is beneficial if the cavities have a size relatively close to the size of the abrasive particles. Extremely large pore size is undesirable because the number of active abrasive particles at the interface of the grinding wheel and workpiece becomes extremely erratic which can have a direct result on performance and wheel wear. As pore size increases, uniform distribution throughout the grinding wheel also becomes extremely difficult to control (Figure #6).

As pore size decrease control of distribution increases and improved bond to pore relationships are possible. Unduly small pore sizes are also not highly desirable. If the pore size becomes too fine relative to the abrasive particle-size the wheels will not transport sufficient coolant or allow for ample chip clearance and grindability will decrease.

Pore size also has a direct bearing on the grinding wheels form holding capabilities. As pore size increases without regard for abrasive size it becomes increasingly difficult to maintain form. Although bond posts between individual abrasive particles strengthen, the large honeycomb matrix of the wheel oftentimes will leave the truing device trying to impart a form into air (Figure #7). This is especially observable on the edges of the wheels where large chunks of abrasive material may separate from the grinding wheel. Smaller cavities reduce the size of the honeycomb matrix and bond posts between individual abrasive particles becomes less random. This finer more uniformly distributed matrix means that the truing device will have an increased probability of imparting the form into the grinding wheel. The wheel will also accept more intricate forms and tend to maintain the form longer.

To summarize, although grinding wheels with very large pores and obviously open honeycomb structures are very impressive visually, they may not be the best choice for all grinding operations. Quality in a Creep Feed grinding wheel is:

- Proper size relationship between abrasive grains and wheel cavities - for chip clearance and coolant transportation.
- Controlled abrasive and pore distribution - for high dynamic balance.
- Greater bond strength - to accept the higher total forces with higher concentrations of porosity.
- Controlled bond degradation - at the interface of wheel and piece part.
- Reproducibility

References

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4. Lewis,, Kenneth B., "The Grinding Wheel", The Grinding Wheel Institute, Cleveland, Ohio 1960.

Depth of cut versus length of arc

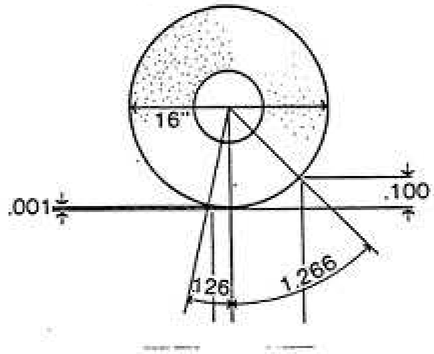

Figure 1

Abrasive versus length of arc

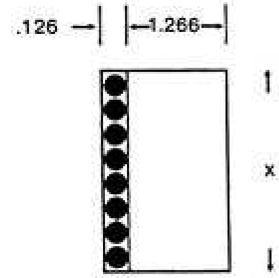

Figure 2

Abrasive versus length of arc

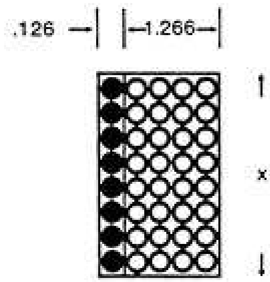

Figure 3

Abrasive versus force

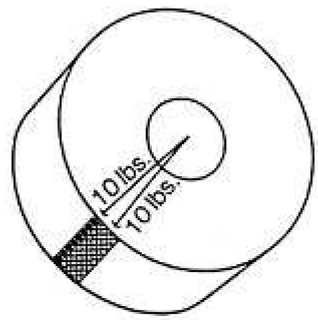

Figure 4

Structure and Bond Posts

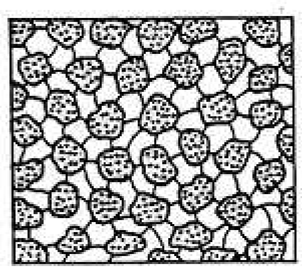

Figure 5

Pore size versus concentration

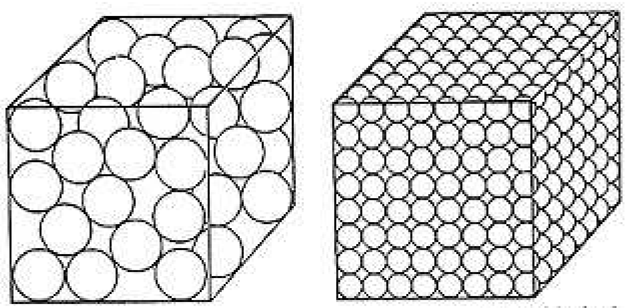

Figure 6

Pore size and truing

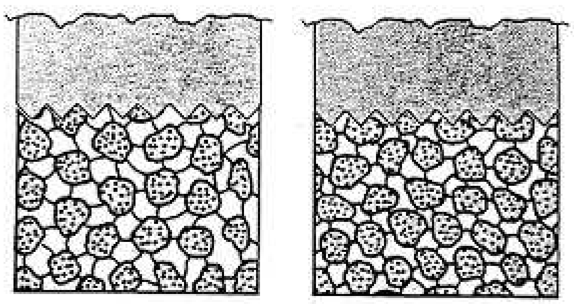

Figure 7

Chip Formation

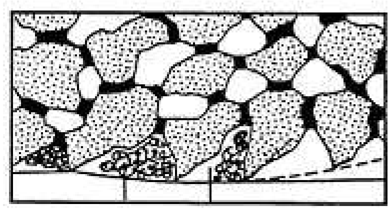

Figure 8

Formed wheels/grade

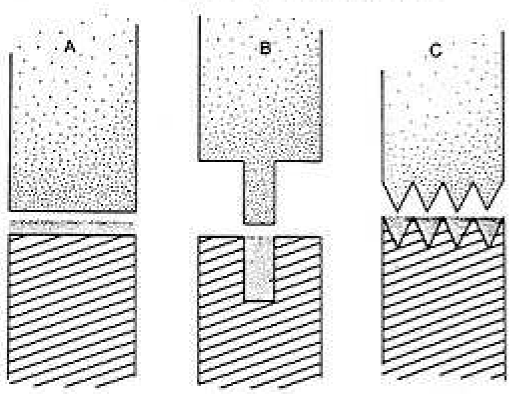

Figure 9