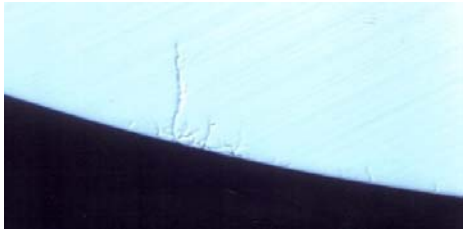
CONTOUR
FINE TOOLING

Diamond Tool wear during cutting of plastics.

The wear of monocristalline diamond tools when cutting polymers, generally is 5 to 10 times higher than when cutting copper with the same parameters. This phenomenon cannot be explained by the difference in hardness between diamond and plastic. It is presumed that an important role in wear of the tool is due to electrostatic charging. Recent investigations by the University Eindhoven together with industrial partners have attempted to get a clearer picture of this phenomenon.

Several investigations in the past have already proven that electrostatic charging is a result of:

1. Friction between diamond and synthetic material.
2. Scission of the polymer chains during the cutting process.



The electrostatic charging affects the cutting of polymers in several ways:

- It creates an opposite polarity between work piece and diamond tool. This results in adhesion and, therefore, chips and swarf will stick around the cutting edge. This has an immediate negative effect on the quality of the surface being cut.
- The electrical fields around the cutting edge result in local ionization of air which might induce plasma of radicals that will degrade the diamond. This process sometimes can be observed by the smell of ozone or visual luminescence around the cutting edge.
- Finally, the electrostatic charging can become so high that discharging takes place. This means that a spark emission occurs which will damage the diamond cutting edge (see picture).

Tests have shown that the amount of electrostatic charging depends on the type of polymer. Polymers with high density of polymeric chains have a higher electrostatic charge, which will result in more diamond tool wear.

The experiments also have shown that Relative Humidity (RH) has a very big influence on the electrostatic charging and, therefore, on tool life. Below RH 60% strong electrostatic charging occurs, between RH 60% and 70% is a transition area and above RH 70% no electrostatic charging is observed.

The lack of electrostatic charging has two positive effects on the cutting process:

- No local ionization of air, so no discharge and no inducement of plasma with radicals will occur.
- Much better chip flow because there is no longer any adhesive force.

These factors are confirmed by industry where experience has shown that above RH 65% the tool life increases considerably.

Due to above mentioned investigations, the following recommendations can be made:

- When possible cut in an environnement with RH 70% or higher, because this will result in:
  - Longer tool life due to the absence of plasma with radicals which degrades the diamond.
  - Better surface finish because of better chipflow. Absence of adhesion between tool and work piece limits sticking of chips around the edge of the diamond.
- Same results can be achieved by using water as a cutting mist or spray. The cooling function of the water has no effect but electrostatic charging is removed effectively.
- When possible choose materials with low polymeric chain density to minimize electrostatic charging.

In situations where a high RH value or the use of water as cutting spray are not advisable because of possible hydrating of the work piece material, it is recommended to use an ioniser in the air blast to reduce the electrostatic fields as much as possible. When this option is not available it is recommended that the diamond cutting edge is regularly cleaned. Because of opposite polarity, sticking of material on the cutting edge can not be avoided, so adequate and regular cleaning is necessary to optimize surface finish.

To get a better understanding of what is happening in the production area, it is recommended that the tool life (number of lenses), the type of work piece material and the daily RH value are recorded. After a period of time, a possible relationship between RH value and tool life can be established in the production area. Experiments have shown that there is a relationship, but only experience in industry can really determine if these observations have an impact on tool life.
Unfortunately tool wear can never be eliminated, but being aware of the existence of electrical charging during cutting of polymers, will give a better understanding of what is occurring and also possibilities to optimize the production process.

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