Optimizing Cutting Conditions for Polymeric Materials

1.0: Purpose

To properly characterize and optimize cutting conditions for a polymeric material. The specimen to be cut is a hydroxyethyl methacrylate of 13mm diameter which is extremely hydrophilic, that is, it has a strong affinity for water. If water is allowed to absorb into the polymer this may change it's physical characteristics and will make relation of the microstructure and it's properties very difficult and misleading.

For cutting these methacrylate polymer materials, several different requirements need to be fullfilled to successfully and efficiently cut these materials for analysis. They are as follows:

1) Reduce cutting times to a minimum.
2) Avoid the use of any lubricants, water or oil based.
3) Easy mounting of specimens for maximum number of cuts from each sample.
4) Smooth cut surface.

Standard metallographic cutting using a slow speed diamond wheel saw, such as the Model L650, traditionally uses a fair amount of coolant during cutting. Cooling the specimen during cutting helps reduce possible heat damage which may result in microstructural changes during processing. This coupled with the very nature of low speed cutting both help prevent heat damage and other crystallographic defects from forming. In the case of polymeric materials, however, the presence of a water-based coolant may cause unwanted structural changes in the specimen. Therefore to prevent this from occurring the specimen can be cut dry without coolant. However, this will somewhat hinder the cutting time as coolant helps to lubricate the cutting area, reducing frictional effects. Also, polymers by nature are soft and pliable compared to metallic specimens and therefore lack of a cooling fluid may be problematic.

2.0: Procedure

To avoid the problems associated with cutting polymeric materials, several different parameters can be optimized to ensure the highest quality cut with the maximum amount of efficiency. Cutting force, wheel selection, wheel speed, and specimen mounting are all factors which can affect the specimen outcome. Below each is described in detail as to how the cutting was optimized.

<u>Cutting Force (Load):</u> The applied load to the specimen was kept to a minimum, around 25-50 grams during cutting. These small loads are enough to maintain constant contact with the diamond wheel yet small enough to prevent wheel binding with the soft polymer.

<u>Wheel Speed:</u> The wheel speed was kept at a maximum (300 rpm) to ensure the most efficient and timely cutting action.

<u>Specimen Mounting:</u> The specimens were mounted using a double clamp holder (Model L65003). This allowed efficient mounting without the need for waxes or special adhesives compatible with polymeric materials.

<u>Wheel Selection:</u> LDWH 4121: High concentration, coarse diamond
LDWH 4122: High concentration, medium diamond
LDWH 4123: High concentration, fine diamond

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Cutting Arrangement

Below is an illustration of the mounting procedure used for cutting these polymers. The specimen was placed into the double clamp holder and held into place during cutting. Thin sections were then taken serially along the specimen, advancing the specimen towards the cutting blade using a precision micrometer.

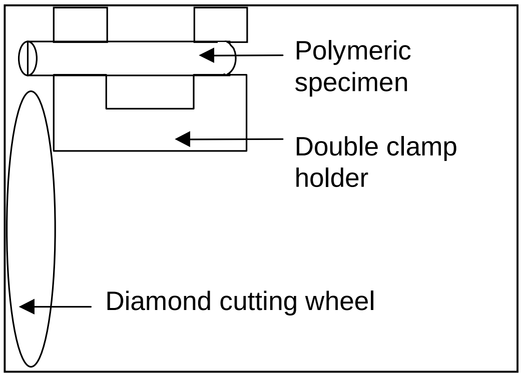
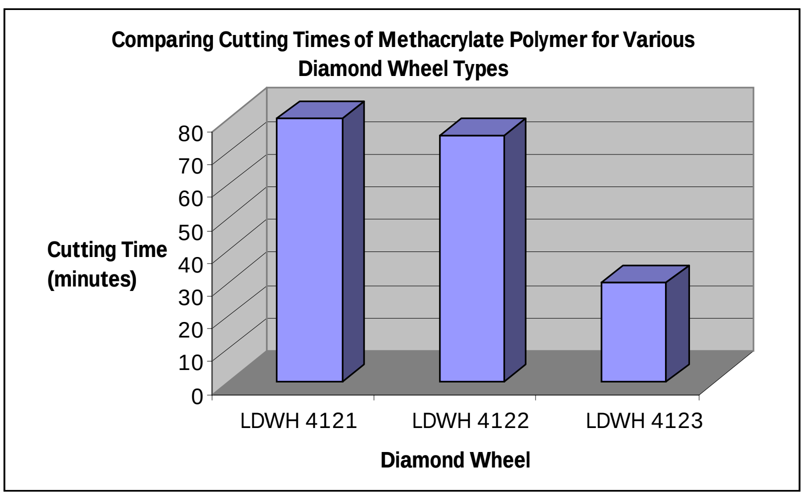


Figure 1: Illustration of the cutting arrangement used for sectioning the polymeric material. The sample was clamped onto the machine using a Model L65003 Double Clamping Holder and sectioned using a diamond wheel.

3.0: Results

Below is a graph illustrating the various cutting times obtained with the different diamond wheel types. As can be seen in the graph, the fine diamond wheel performed most efficiently due to the small diamond particles and the reduction in wheel loading effects.



Graph 1: Illustration of the various cutting times obtained using different diamond wheel types. As can be seen from the graph, the coarser the diamond wheel is, the longer the cutting time. This is due to the highly pliable nature of the polymeric specimen. Larger pieces of material are removed using coarse wheels, however these large pieces also clog the diamond particles, a phenomenon known as "wheel loading". This is especially difficult to overcome when cutting without a fluid. The fine diamond wheels are much more efficient and cut much faster.

4.0: Conclusion

Although cutting polymeric materials without a lubricant can be somewhat difficult, it has been shown that cutting times as low as 25-35 minutes can be achieved coupled with excellent surface quality following cutting. By selecting the proper diamond wheel along with the optimization of the other parameters affecting cutting, high quality specimens in a short amount of time can be produce