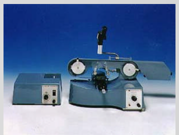
Characterizing the Model 850 Wire Saw



1.0: Purpose

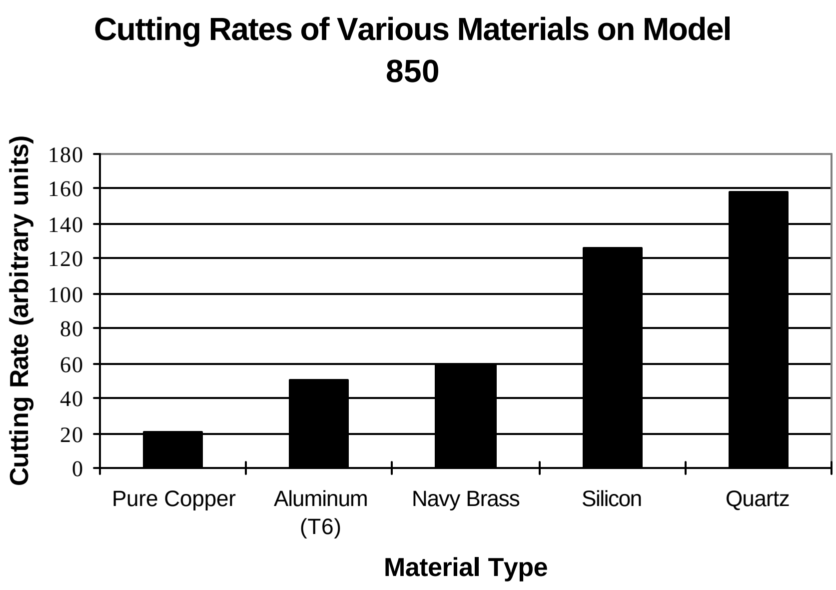
To characterize and clearly outline the various parameters which affect cutting times and quality and provide basic guidelines for cutting and slicing of materials. Investigation into the parameters which affect cutting such as load, wire speed, wire type, slurry type and viscosity, and grit size will be done to provide some insight as to what the optimal conditions for cutting are.

2.0: Procedures

Several tests were run on the Model 850 Wire Saw to properly investigate all of those parameters which affect cutting. Each test will be discussed in detail to outline the results of each test and an overall evaluation of the optimal parameters for cutting will be discussed.

2.1: Specimen Composition

One of the most obvious factors that affect cutting times of the Model 850 is specimen composition. This perhaps is the main limiting factor in the cutting times of the specimen. Depending upon the mechanical properties of the specimen such as hardness and toughness, certain specimen types will cut more efficiently than others. The following chart shows the cutting rates of certain material types based upon the cutting time and total area of the specimen cut.



As can be seen in the graph above, ductile materials cut at much slower rates than do the brittle, hard materials. Ductile materials present slight problems when cutting with the Model 850, primarily due to the removal mechanism involved. Material is removed in a shearing fashion, whereas with hard or brittle materials, material is removed through chip formation or brittle fracture.

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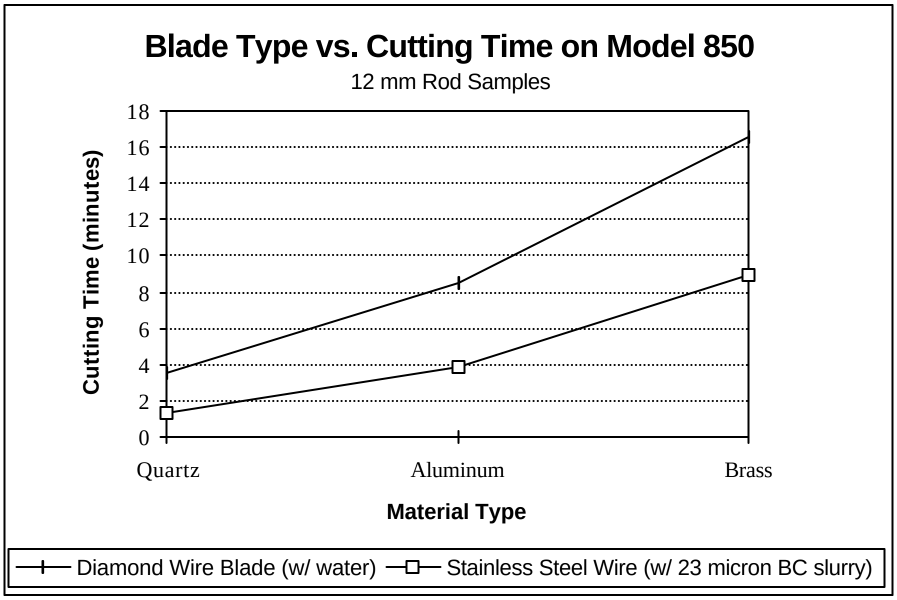
2.2: Wire Blade Type

Another important factor which affects cutting is the type of blade being used. There several different diameter wires available for use on the Model 850, with two different types offered: Stainless steel wires or Diamond Impregnated Wires. Stainless steel wires are designed to be used with an abrasive slurry and the diamond wires are used with water. The following chart shows the differences in cutting times as compared with the type of wire used.



As can be seen in this graph, diamond wire blades tend to take longer to cut specimens as opposed to stainless steel wires. Although the grit size of the diamond wire is approximately 45µ (almost twice that of the slurry used in this experiment), cutting times are still longer primarily due to the slow pullout of the dimonds impregnated within the wire. The abrasive slurry is a more effective way of cutting materials due to the constant recycling of the abrasive particles onto the cutting surface, providing an efficient lapping and cutting action from the wire.

2.3: Slurry Type

Slurry type also plays a major role in determining the cutting efficiency and speed of a cut on the specimen. As in all cutting and sectioning methods, the hardness of the abrasive must be at least equal to that of the material being cut, ideally being harder than the specimen material. In this experiment three slurry types were used: Boron Carbide, Silicon Carbide, and Aluminum Oxide. Boron Carbide is the hardest of the three, with a Mohs Hardness of 9.7, closely followed by Silicon Carbide with 9.5, and finally Aluminum Oxide with a hardness of 9.The slurry ratio mixture was kept constant for all three slurries to maintain consistency and the results are shown in the graph below.

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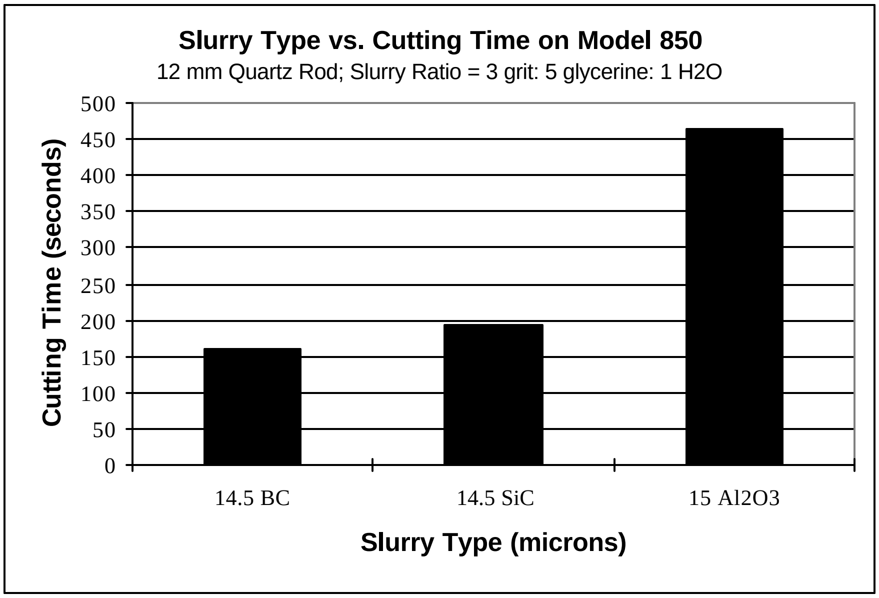
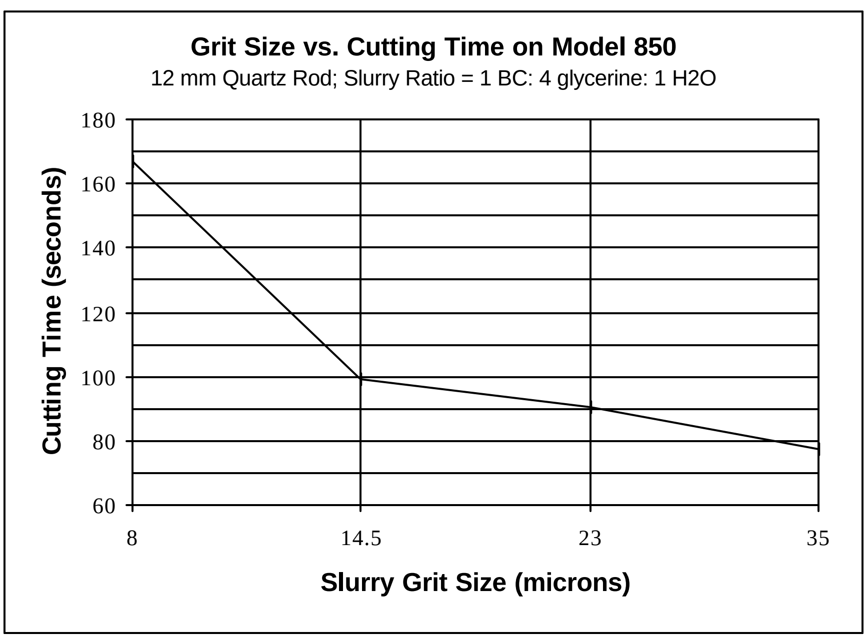


As can be seen from the graph above, the BC slurry cuts the fastest followed by SiC and then Al_2O_3. This correlates well with the hardness values given and the fact that the cutting time is directly dependent upon the hardness of the slurry abrasive used. For samples of equal or higher hardness than BC, diamond abrasive slurries should be used as diamond is the hardest known material.

2.4: Slurry Grit Size

Not only does the slurry type affect cutting times but the slurry grit size also affects this as well. This is logical in that a particle of smaller nominal diameter will cut and remove less material as oppossed to a larger particle. The following graph shows the relationship between cutting time and abrasive particle size.



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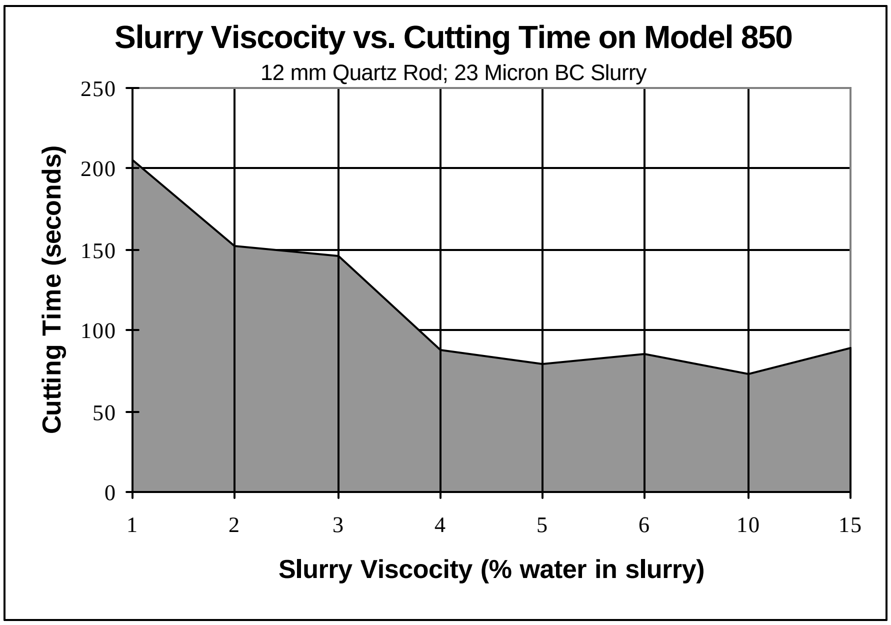
As can be seen in the graph, cutting time will decrease as the abrasive particle size is increased. There is a large difference in the cutting time from the 8µ size to the 14.5µ size, but levels off slightly at the larger grit sizes. If surface finish and roughness are of concern, the smaller abrasive sizes will produce higher quality finishes and require less subsequent grinding and polishing to produce polished surfaces. Therefore it may be a tradeoff between cutting time and surface finish to produce the optimum specimen.

2.5: Slurry Viscosity

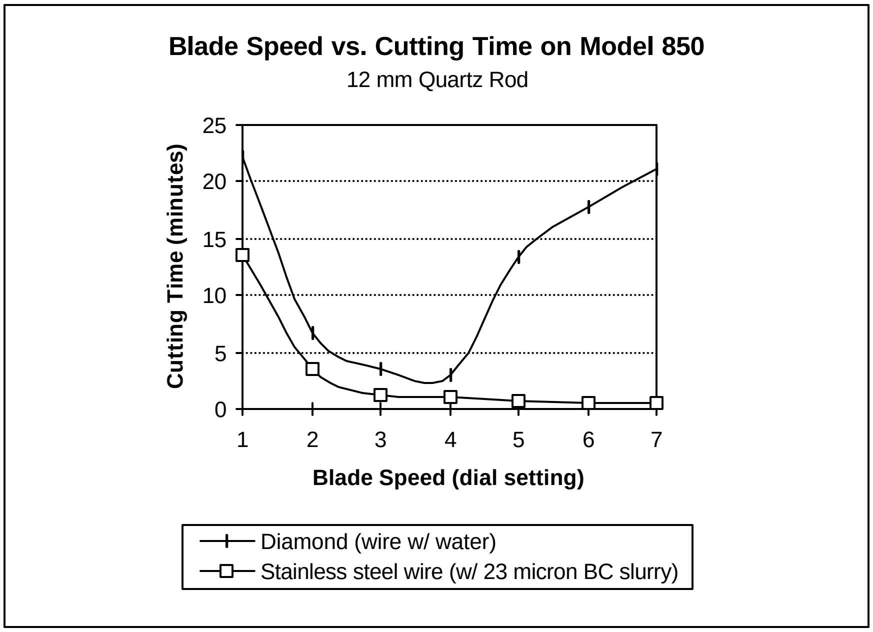
A final factor when dealing with the abrasive slurry must be considered for optimum cutting operations. The viscocity of the slurry used, or the amount of water contained in the slurry plays another role in the efficiency and time of cutting. As the water content is increased, the abrasive slurrry viscocity begins to decrease, which allows the slurry to flow at higher rates. This is important since optimum cutting is produced when the maximum amount of slurry is allowed into the area being cut, which is limited by the diameter of the wire blade. Therefore an optimum viscocity must be known to allow the most efficient use of the abrasive slurry. The graph below shows a plot of the cutting time as compared with the slurry viscocity.



As can be seen in the graph above, cutting time is dependent upon the slurry viscocity. As viscocity is decreased (water content being increased) the cutting time also decreases. However, if the slurry viscocity is not viscous enough, there is an insufficient amount of abrasive being utilized and the cutting time will begin to increase again, as indicated at the 15% water viscocity. Therefore an optimum value of viscocity must be used to provide the most efficient use of abrasive as possible. From the graph, the optimum value of viscocity is around 10%.

2.6: Wire Blade Speed

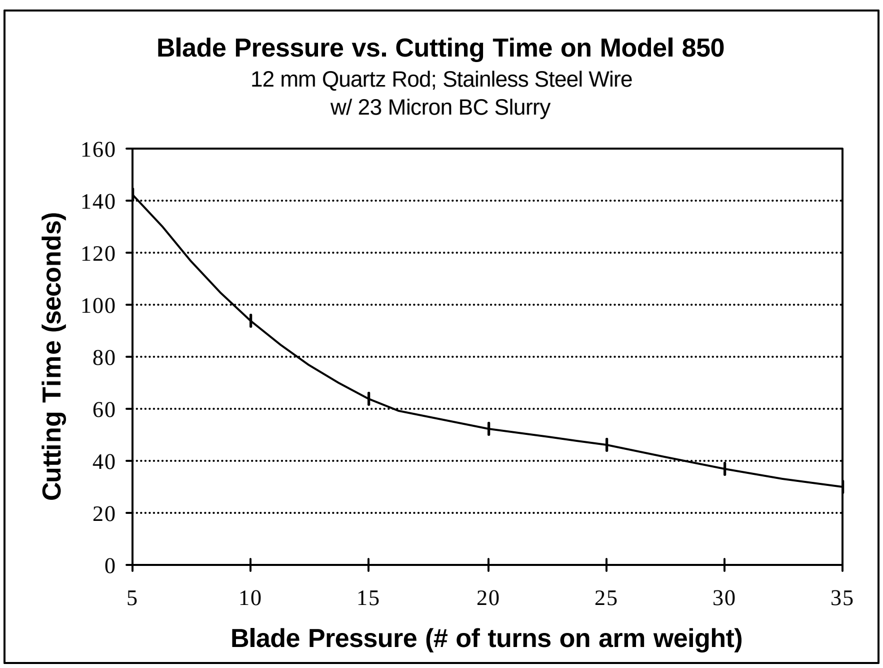
Another major factor in determining cutting time is the speed of the blade, or the motor speed. This is continuously adjustable on the Model 850 and is selected at the users discretion. It can be expected that as the speed of the wire is increased, then the cutting time should begin to decrease. In this experiment, cutting time as a function of wire blade speed is plotted for both the diamond impregnated wires and the stainless steel wires using an abrasive slurry. The following graph shows the results.



As can be seen from the graph above, cutting time with a stainless steel wire blade decreases as the speed of the blade is increased. This follows logically and the relationship appears to be an exponential one. In the case of the diamond wire, however, this relationship does not hold true. Cutting time is decreased for a short time and then suddenly increases past the 4 setting. This can be explained by the diamond abrasive particles being removed from the wire. At higher speeds, the wire loses more diamonds faster, ultimately leaving the wire bare and free of any abrasive to do the cutting. Because of this effect speed of the wire is more critical with the diamond wires as opposed to the stainless steel wires.

2.7: Blade Pressure

A final factor which can affect the cutting time is the blade pressure, or load. The counter-balancing weight on the back of the arm can be adjusted to place larger or smaller loads onto the cutting wire applied to the specimen. The following graph shows the results obtained from this experiment.



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As can be seen in the graph above the cutting time decreases as the blade pressure is increased. This is what was expected and can be used to the advantage of the user. However, a tradeoff exists with respect to the blade pressure. If too great of a load is applied to the arm, the wire lifetime will decrease and cause premature failure. Therefore it is imperative that the correct balance between cutting time and blade pressure be established to ensure proper blade lifetime. Typically the amount of load used is from 5 to 10 turns of the counter-balancing weight after the arm has been balanced and zeroed.

3.0: Results and Conclusions

After completing all of the tests performed on the Model 850, it is well established which parameters affect cutting time and quality. A strong relationship between cutting time and specimen composition has been shown, with softer, ductile materials cutting much slower than harder, brittle specimens.

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