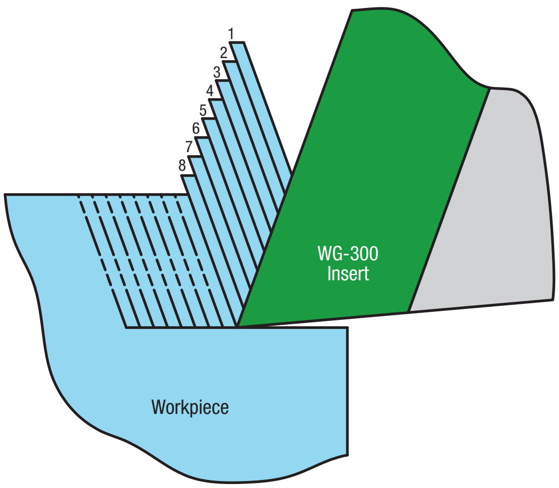
# How to Use the Properties of WG-300

During the metal-removal operation, material is displaced ahead of the tool by being forced through a "shear zone" and subsequently sliding over the rake face of the tool as a chip. This action has been studied by numerous researchers including "Piispanen and Merchant," who demonstrated the mechanism of chip formation, likening it to the sideways slide of a deck of cards, caused by the rake face of the tool. *(Figure 3)*

***Figure 3 – Deck-of-Cards Principle***

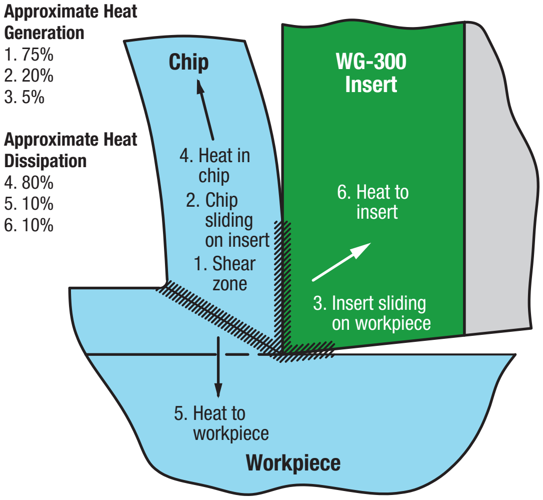


The chip is formed first by grain boundary distortion in front and below the shear plane, followed by grain boundary dislocation. This results in a chip which is always thicker than the layer of material being removed.

A large amount of shear stress is required to cause plastic deformation and shear to occur in the "shear zone"; and this results in the generation of significant quantities of heat. In fact, as much as 75% of the heat generated during cutting is produced in this way. The other 25% comes from the sliding of the chip over the tool rake face and the contact of the flank of the tool with the workpiece. *(Figure 4)*

Most of the heat generated during metal cutting is dissipated by the chip carrying it away. As cutting speeds increase, the metal-cutting process becomes more adiabatic. In other words, the heat generated in the "shear zone" cannot be conducted away during the very short time in which the metal passes through this zone. We can benefit from the heat generation, temperature rise and softening effects in the "shear zone."

***Figure 4 – Heat Dissipation in Ceramic Machining***



The heat generated in the "shear zone" has been traditionally thought of as a negative factor since it is also associated with heat-related failure of cemented carbide cutting tools. This often leads to the need to slow down the cutting operation to a point where carbide inserts will give acceptable life.

WG-300 is able to withstand high temperatures while maintaining strength and hardness, and it has been shown that contrary to traditional methods of machining, we can, in fact, use the heat generated in the shear zone ahead of the tool to our advantage. There is an optimum speed outside the range of carbide tools where the heat generated lessens the cutting forces by softening the metal and aiding in the grain boundary dislocation.

This advantage can be very dramatic, sometimes moving the possible metal-cutting speeds from a few hundred feet per minute to thousands of feet per minute!

Such is the case with Greenleaf WG-300 whisker-reinforced ceramic when applied to most forged Nickel-based alloys. Optimum speeds can be achieved with temperatures exceeding 1000° Celsius.

The excellent thermal shock resistance of WG-300 results in a cutting material which can be used either dry, wet or even intermittently cooled without fear of catastrophic tool failure from thermal cracking.

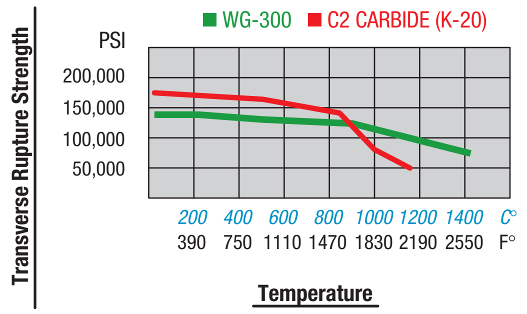
The outstanding hardness of WG-300 inserts, combined with the high strength imparted by the reinforcing silicon-carbide whiskers, makes possible the machining of many materials previously workable only by grinding. Heat-treated alloy steels, die steels, weld overlays, and hard irons with interrupted cuts are just a few of the successful applications of WG-300.

If your job is in the 45Rc to 65Rc range, chances are that Greenleaf WG-300 can increase productivity and cut machining costs substantially.

## Relative Strength at Elevated Temperatures

It is important to recognize that laboratory hardness and strength tests are conducted at room temperatures. Under actual cutting conditions where temperatures at the tool/chip interface may reach over 1000° C, Greenleaf WG-300 will retain high strength and hardness well beyond the point at which a tungsten-carbide material has softened, deformed or failed completely. We need to take advantage of that area when using WG-300.

***Figure 5 – Relative Strength at Elevated Temperatures***



## Ceramic Application Guidelines

### *Rethink the process*

The correct application of ceramic tooling on a CNC machine necessitates reprogramming of the part. Since we are doing this, we might just as well re-examine the entire process. Are we using the best geometry, the largest radius, thickest insert, best tool path, etc.?

When you have studied this application guide, you will be more aware of the variables and best approaches to the job using ceramic cutting tools.

Integrate the following tested methods into your programs, the guidelines are:

***Figure 6 – Ceramic Application Guidelines***

1. Use a toolholder system designed for ceramic inserts.
2. Use the strongest insert shape possible.
3. Use the largest corner radius possible.
4. Use the correct edge preparation for the application.
5. Use the thickest inserts available for roughing.
6. Use a toolholder or boring bar with the largest possible cross section.
7. Consider heavy metal or carbide bars for boring applications.
8. Prechamfer on entry and exit whenever possible.
9. Keep toolholder overhang to a minimum.
10. ***Rethink the process***