DEFORM™ Application #354

Pressing and Sintering Carbide Inserts

Background:

Tungsten carbide cutting inserts are manufactured by pressing a powder blended from tungsten carbide with a small amount of cobalt binder into a “green” compact. The green compact is then sintered to obtain a hard, densified insert.

The sintering process causes the insert to shrink, and depending on the density distribution after pressing, may also cause distortion. As this influences the tolerances of the final product, an understanding of the relationship between pressing process parameters and final shape is important.

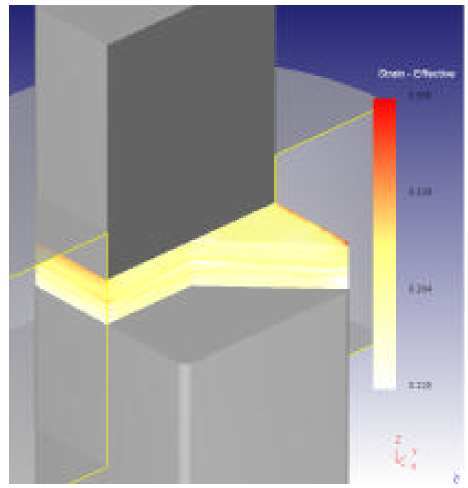

Figure 2: This DEFORM-3D simulation result shows strain distribution in square insert after pressing. Any 3D geometry can be imported from a CAD solid modeling system

Pressing:

The pressing of powder with 35% relative density into green compresses was simulated using DEFORM™. Results are shown for a round insert, in Figure 1, and a square insert in Figure 2. The relative density gradients are clearly visible.

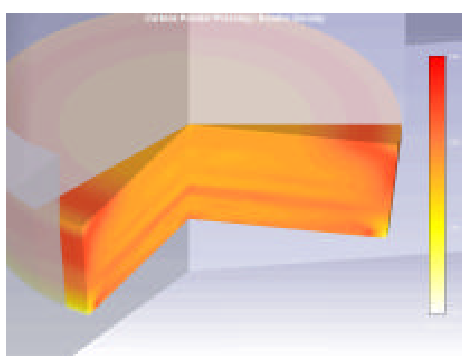

Figure 1: This image shows density distribution after pressing a round insert.

Sintering:

Tungsten carbide inserts are sintered using a liquid phase process. The sintering temperature is above the melting temperature of the cobalt binder phase, but below the melting temperature of the harder tungsten carbide phase.

The shrinkage effects associated with sintering involve:

- Primary rearrangement of the solid particles when the liquid phase is formed
- Grain shape accommodation by contact flattening
- Filling of large pores and grain coarsening in the final stage of sintering.

The model implemented in DEFORM™ accounts for all of these phenomena.

DEFORM™

Design Environment for FORMing

Validation:

Experimental verification of the press and sinter process was performed for two different grades of carbide powder. The tapered round insert shown in Figure 1 and Figure 3 was used as the test part. The green pressed dimensions are shown in Figure 3, and the geometry after sintering is shown in Figure 4.

Table I shows final experimental and predicted shrinkage. As can be observed, the predicted shrinkage ratios show good agreement with experimental results.

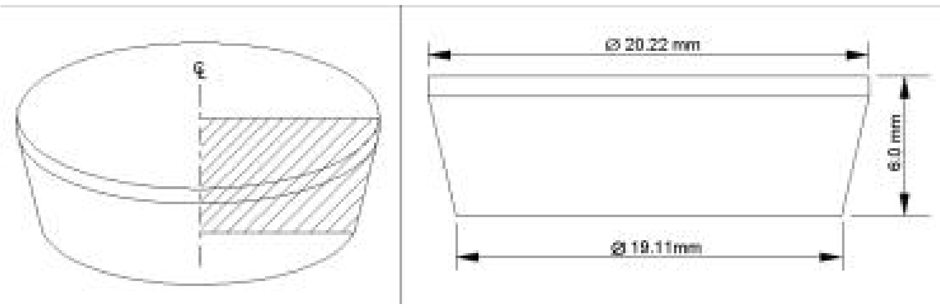

Figure 3: The dimensions of a round insert after pressing are shown.

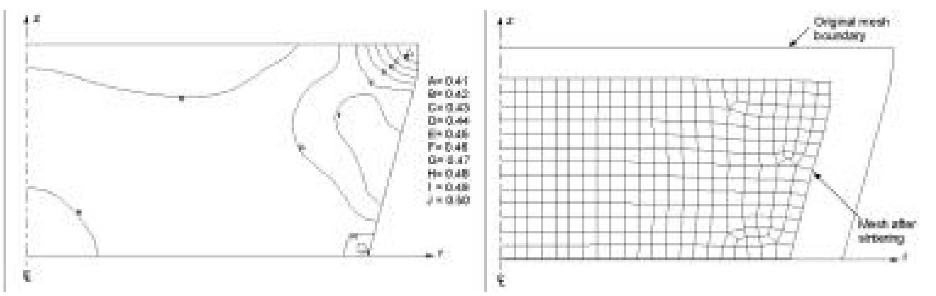

Figure 4: The shrinkage during sintering is a function of density distribution after pressing. Density contours (left) and the shrinkage(right) are shown.

Table I. Comparison of Experimental Results and Model Prediction

Grade	Bottom Diameter mm		Top Diameter mm		Height mm	
	Experimental	Model	Experimental	Model	Experimental	Model
Grade-1	16.36	16.46	18.59	18.64	5.12	5.30
Grade-2	16.37	16.22	18.49	18.51	5.09	5.16

Conclusions:

Computer simulation of the pressing and sintering process for tungsten carbide metal cutting inserts has been demonstrated. Modeling pressing and sintering using DEFORM™ can provide an opportunity for cost savings by improving the performance and reliability of the process.

Further reading:

For more details on the pressing process see the paper:
Shamasundar, M. Siddegowda, P. Chigurupati, R. Raghavan, and Rao, “Modeling Liquid Phase Sintering of Hard Metal Powder Compacts,” PM^2 TEC, Jun 17-21, 2002, World Congress on Powder Metallurgy and Particulate Materials.

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