Improved Life for Cutting and Forming Tools by CVD Coating

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As basic characteristics of cutting and forming tools, hardness and toughness are required, but it has been difficult to increase both at the same time with conventional tool material alone. Coating is a means of satisfying both of these characteristics simultaneously.

Indexable cutting inserts coated with thin surface layers of hard materials such as titanium carbide (TiC), titanium nitride (TiN), aluminum oxide (Al_2O_3) up to a few microns thick are today firmly established on the market and their importance is steadily increasing. (Fig. 1)

Coated carbide tips are principally used for turning and milling of steel and cast iron. Two main advantages arise from the use of coated tips: the increase in tool life, which can be several times that of uncoated inserts, and the possibility of using increased cutting speeds and thereby reducing machining time.

The majority are coated by Chemical Vapor Deposition (CVD) process, Figure 2. The coating temperatures range from 800°C to 1100°C. A hard coat is formed at the surface of the tool by chemical reaction as shown here.

$$TiCl_4 + CH_4 \rightarrow TiC + 4HCl$$
$$TiCl_4 + 2H_2 + 1/2N_2 \rightarrow TiN + 4HCl$$
$$2AlCl_3 + 3H_2 + 3CO_2 \rightarrow Al_2O_3 + 3CO + 6HCl$$

The performance of carbide cutting tools is substantially increased by TiC coatings produced by CVD. These coatings have been commercially available for ten some years.

During these years of coatings, there have been significant improvements made in the quality and performance of coated cutting tools. Improvements have also been made in the control of metallurgy of the coating-substrate interface, resulting improved coating adhesion and suppression of strength degrading interface reactions, such as the formation of brittle η phase. Additional improvements have been obtained by use of the cemented carbide substrate compositions designed to optimize the two most important substrate properties, namely, breakage resistance and thermal deformation resistance. Fig. 3 shows the effect of coating thickness on transverse rupture strength (TRS). TRS of a CVD coated carbide is greatly affected by coating thickness and reduced to about 55% of uncoated at 5um. Therefore, special carbides have been developed for the substrate.