

# THE MANUFACTURE OF PDC FOR CUTTING TOOLS

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Polycrystalline diamond composite (PDC) for cutting tools has been manufactured using non-diamond carbonaceous material as a starting material. A roughness of  $0.04 \mu\text{m Ra}$  of the workpiece has been obtained with cutting tools made of PDC. The difficulties in making such PDC are how to realize complete conversion of the starting material to diamond and the texture uniformity of the polycrystalline diamond layer. The measures for solving these difficulties are discussed.

## 1. Introduction

For cutting tools, besides the abrasion resistance, impact resistance and thermal stability, the surface finish of the workpiece is an important requirement. In order to get good finish on the workpiece, usually cutting tools made of a single diamond crystal are used, but the strength of the cutters are low due to anisotropism and their cost is high.

There are many approaches to making PDC, for instance, sintering diamond powder with the help of additives and the method of sintering diamond powder by infiltration or the sweep-through technique. Bovenkerk<sup>1)</sup> found that cutting tools made of PDC, the diamond layer of which were synthesized directly from graphite, had good resistance to wear. The purpose of this study is to make PDC consisting of a polycrystalline diamond layer and a tungsten carbide substrate.

## 2. Theoretical

Besides mechanical and thermal properties, the texture of materials for making cutting tools such as polycrystalline diamond compact should be homogeneous. The existence of additives and carbide formed during the sintering process between the diamond particles inevitably damages the homogeneity and causes the bonding between the diamond particles to be weak, so their properties are far inferior to those of diamond. So, the non-diamond phase in the polycrystalline diamond layer should be as little as possible. Diamond-to-

diamond bonding or intergrowth should be realized to obtain PDC of good quality.

## 3. Experimental

Experiments were carried out in a cubic type HP/HT apparatus with one pressure source. The apparatus has good reproducibility. The top faces of the anvils are of  $27 \text{ mm}^2$ ; the pressure was about 6 GPa and temperature 1400–1500°C. A composite material was used as the pressure transmitting medium. Different non-diamond carbonaceous materials were used as the starting materials and various kinds of metal and alloy were used as catalysts. A sintered tungsten carbide was the substrate.

## 4. Results and discussions

It has been found that the difficulties in making PDC using non-diamond carbonaceous material as a starting material are to increase the conversion rate and to realize uniformity of texture. Before these difficulties were solved, the abrasion resistance and impact resistance of the obtained PDC were poor.

It is known that the factors influencing the conversion rate include the pressure, properties of the starting material and the catalyst. To increase the applied tonnage of the press is an effective way to increase the conversion rate, but its disadvantage is severe anvil damage. Because the resultant pressure is decided by the applied tonnage, the effi-

ciency of the pressure-transmitting medium and the pressure change inside the cell due to volume contraction from phase transformation and thermal expansion during the sintering. So, study of the pressure transmitting medium was carried out. As a result, a composite material has been found which can meet the requirements for increasing the pressure inside the cell without increasing the applied tonnage.

The practice of diamond synthesis has shown that different results are obtained with different carbonaceous materials. As far as graphite is concerned, the conversion rate depends on the graphitic structure. So it is desirable to use a starting material having a high conversion rate.

The practice of diamond synthesis has also shown that diamond can be synthesized at different pressures and temperatures with different catalysts; for instance, elements require higher pressure than alloys. If we synthesize diamond at the same pressure, a higher conversion rate can be achieved using an alloy than an element.

The texture of the polycrystalline diamond layer influences the performance of the cutting tools. Experiments have shown that the texture is decided by the structure of the starting material and the relative distribution of the starting material and catalyst, as well as the pressure and temperature. In order to make PDC with uniform texture, attention should be paid to the above-mentioned.

After the measures for increasing the conversion rate and improving the texture were taken, a PDC with good performance was obtained. A roughness of  $0.04 \mu\text{m Ra}$  of the workpiece was achieved.

It is hopeful that PDC cutting tools could partly replace the cutting tools made of single diamond.

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#### REFERENCE

- 1) H. P. Bovenkerk, USP 3850053.