

TRENDS IN DIAMOND TOOLS FOR STONE PROCESSING

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Abstract: The paper presents a platform to discuss the trends in diamond tools used for stone processing. It gives selection criteria for the composition of matrix and diamond for the stones in Andhra Pradesh. The trend of developing iron and copper based matrix powders is discussed. Recent developments in stone cutting wires and segments, technical and commercial effect of Chinese diamond tools in India are discussed.

Introduction:

The dominance of cobalt powder in diamond tools is about to be over due to the cost and availability, but it cannot be replaced totally because of its acceptable chemical compatibility with diamond at the processing temperature and good wear resistance for a number of cutting operations. The trend is set to develop the iron or copper based matrix powders with lower percentage of cobalt. The diamond tool companies are trying to use these matrices because of cost and performance issue. In addition, they are putting lot of money to develop their own bond material suitable for the specific stones. Table 1 shows recent pre-alloyed powders, which are in the market developed by mainly European companies and being used as a matrix material for stone cutting diamond tools.

i. NEXT Powders

Cu, Co and Fe in predetermined ratios have been produced and launched by a powder producer under the name NEXT. The pre-alloyed powders have certain advantages over cobalt powder as a matrix material for diamond tools.

ii. Cobalite HDR

Cobalite HDR is widely used pre-alloyed powder for hot pressed diamond tool segment. The use of HDR for free sintering is restricted by the lower percentage of Copper.

iii. Powder developed in P/M lab, IIT Bombay

The powder developed in the laboratory is premixed-pre-alloyed powder. Nitrates of copper, cobalt and iron were mixed in the water and heated to dryness. The dried mixture of salts was reduced in hydrogen atmosphere to get Cu-Co-Fe pre-alloyed powder. The reduction temperature, heating rate and holding time were varied to obtain the pre-alloyed powder of higher purity and smaller grain size. {1-4}

Diamond segments:

The segment area of diamond tool is susceptible to fluctuation in the market cost and requirements of the user due to intrusion of Chinese circular saw segments. The logical way to cope with the Chinese invasion is by developing low cost-stable quality bonds. It is wrong to conclude that the Chinese do not have quality. There are few companies, which are having top quality products with lower prices. However, there are few points to consider while competing with Chinese companies as follows:

1. Primary studies suggest that Chinese segments have basically iron-based premixed/pre-alloyed powder bonds.
2. The geometry of the segments (grooved, multilayered) is the important point to be considered.
3. Also, the stone material has to take into consideration.
4. Increasing the height is one option to tackle the balance between free cutting and high wear resistance bond.

Table 2 shows the cutting performance of the stone material usually found in south India against gang saw cutting.

Diamond Wires:

Despite loss in the profit margins in segment area, the diamond wires are still popular in diamond tool manufacturing companies. During this period, development in wire technology is seen as crucial as a long-term goal and vital development to diamond tool industry. R&D groups of various diamond tool companies are trying to replace the inevitability of pre-alloyed powder and cobalt content from the bond material. Currently, wires are being manufactured on the basis of their use in stone cutting and type of stone and thinner, more flexible, multistone cutting wires are the latest in wire technology for stone cutting. It has found out that Chinese companies are still not much into this part of diamond tool division.

Globalization in Diamond Tool Manufacturing:

In the words of Friedman, the world has become flat. Like USA, India is outsourcing the manufacturing jobs to cheap labor sites in another countries. Due to free trade policies of other countries, it is easy to transport powders from other countries to country of manufacturing plant instead of getting the powders to India. It's the international exposure that also matters in this case. Like for instance, the product is sold in India as an imported one, which has its effect on consumers. However, the communication gap between head office and manufacturing plant is a big problem. Although, electronic media helps to connect, online observations are of little help to effectively change or improve the production. There is also problem with quality control and performance evaluation, which affects production time.

Effect of Stone Material on The Wires of Same Composition:

One of the important points is the selection of right bond for right stone material. Most of the time it is falling outside the area of R&D manager to check the stone cutting response against the designed bond material. The selection of the composition partly depends on the stone material's composition, hardness and microstructure. The usual method is to prepare wires and segment sets and send it to the different distributors and so different users. The observation data, which includes the life of cutting and wear of the segments, is sent to the R&D manager for performance evaluation.

Table3 shows the stone materials at Ongole-Gurujapalli area of Andhra Pradesh. At the area of Coral Rocks, the stone material is stone 2 (softer material), which shows 30% more wire life when compared to stone 1. Another material found in the area, stone 3 has slightly different composition than that of stone1 and 2 leading to different performance of wires. Stone 3 proves to be harder material with respect to Stone 1 in terms of cutting. For, this kind of stones, the prices for the 50m wires are usually between 1Lakhs to 2.5 Lakhs depending on user's preference on the performance-cost balance and the type of cutting. However, it should be known as the general experience of the other quarry supervisors. Also, it is observed that most of the quarries do not have any subsequent accounting of the parametric details of cutting, which leads no written proof of wire performance.

Conclusions:

1. The trend is set to develop the iron or copper based matrix powders with lower percentage of cobalt.
2. The selection of composition of matrix and diamond is based on stone composition and microstructure.
3. Chinese segments have taken large share of Indian market due to low prices-stable quality performance.
4. Diamond wire saw is still the area where the Indian companies get more margins in profit as compared to segments.

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Table 1: Pre-alloyed powders

1. NEXT Powders			
Element	NEXT100	NEXT200	Cobalite HDR
	Wt %	Wt %	Wt %
C	0.039	0.039	2.42
O	1.07	1.04	0.76
Fe	25.2	14.7	63.96
Co	24.1	22.6	27.89
Cu	49.5	61.7	4.98
Total	100	100	100

2. Powder developed in P/M lab, IIT Bombay	
Element	Wt %
C	4.31
O	0.83
Fe	26.45
Co	24.31
Cu	44.1
Total	100

Table 2 : Stone Response to gang sawing

Stone cutting	Response to sawing
Sapphire Brown	Hard
Sapphire blue	Hard
Black galaxy	Soft
Black	Hard
Tan brown	Hard
Red multicolor	Hard
Madurai (6-7 colors)	Soft
Paradise	Medium

Table 3 Stone Materials at Ongole-Gurujapalli Area of Andhra Pradesh

	Stone 1	Stone 2	Stone 3
SiO ₂ (%)	59.72	6.4	51.22
Al ₂ O ₃ (%)	14.17	12.24	12.14
Fe ₂ O ₃ (%)	3.34	6.97	14.37
Hardness (Mohr' s scale)	6.5	6.5	7
Fe (%)	2.4	4.9	10