



Sintering Effect on Cutting Tool Material

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Bronze-based Co-Ni-Sn alloy cutting tools used in natural stone cutting processes in our country are produced by powder metallurgy method. By selecting four different sintering temperatures in the production, the effect of the sintering temperature on the surface properties of the marble cutting tools was investigated. Synthetic diamond particles have been incorporated into the metal dust at certain ratios to provide stone cutting properties to the samples. Using the hot pressing technique as a method, the sintering temperature is; 600 °C, 650 °C, 700 °C and 750 °C were selected. The sintering pressure was 30 MPa, the sintering time was 3 minutes and the treatments were carried out in an argon gas atmosphere. Microstructure images of specimens with different sintering temperatures were produced.

Keywords: Powder metallurgy, marble cutting tool, sintering, synthetic diamond.

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1. Introduction

Powder metallurgy is a component production technique that is produced by mixing the metal powders at certain ratios, compressing them at the desired pressure values in sensitive molds at room temperature and sintering them continuously. With this technique, powder production, mixing of powders, pressing and sintering are important in

terms of the quality of the product [1]. Part production steps by powder metallurgy are shown in Figure 1.1.

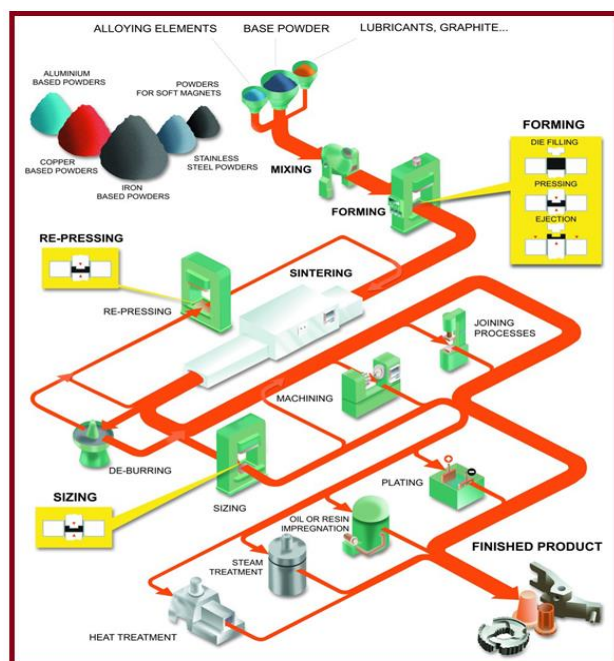


Figure 1. Part production steps using powder metallurgy [1]

Sintering is defined as thermal activation, which reduces the specific surface areas of the powders, increases the particle contact surfaces and consequently changes the pore shape and reduces the volume. In other words, it is the reaction of eliminating the pores after thermal activation, which is the compacted structure that is observed [2].

The marble cutting tools are composed of a combination of metal powders and materials such as cobalt, copper, bronze, nickel, iron and diamond particles. The diamond particles inside the tool are used to carry out the cutting process of the natural stone. Other elements form the part of the matrix in which the diamond particles are located and make an important task, such as holding the diamond particles. The mechanical properties of the matrix phase, usually hardness, are very important in terms of the performance of the cutting tool. If the matrix holding the diamond particles is too hard, it will not wear out during the cutting process, allowing the diamond particles to separate from the holding area and to allow the new particles to participate in the cutting process, which cannot do the complete cutting operation. On the contrary, if the matrix is too soft, it will wear out quickly and cause the diamond particles to come out of their place without performing their tasks, and the tool ends without performing sufficient cutting operations. For these reasons, it is expected that the cutting tool matrix material should be selected very well, very good understanding of diamond particles and optimum results [3].

In our study, an international study was carried out by Buyuksagis and Goktan. In this study, the researchers selected 28 kinds of marbles around a 40 cm disc and

selected seven kinds of marble from the province and investigated their cutability. A block cutting machine was used in the works. The result is that the hardest of the selected marbles causes more energy consumption and tool wear than the other marbles [4].

One of the conclusions of the pitcher's work on the "Factors Affecting Rock Cutting Ability" is the effects of the cutting direction on the cutting diamond life. According to this, in the downward direction, the diamonds have broken more quickly and the tool life has decreased. The researcher concluded that abrasive wear was the most responsible mechanism in the wear of cutting tools during cutting, and also that overload, sudden overload, heat shrinkage and fatigue were among other mechanisms effective in tool wear [5].

Turchetta and colleagues conducted a study on marble cutting tools and investigated the cutting performance of diamond-coated, single-sided tungsten carbide grain compared to uncoated tungsten carbide grain. As a result, they found that the cutting performance of the diamond-coated tool was higher than that of the tungsten-plated jig, that faster cutting was possible and that it was used for a longer time [6].

Luciano and his colleagues also studied marble cutting tools and investigated the performance of cutting tools using a Fe-Cu-based metal matrix instead of a Co-based metal matrix. Silicon carbide is added at certain ratios such as %1-2 to ensure later wear of the matrix. In order to ensure that the abrasive grains are well adhered to the metal matrix, both the surface of the diamond grains and the matrix copper have been added. As a result of this work, it has been proved that marble cutting can be done by using Fe-Cu based matrix. The same researchers have also calculated the wear resistance of a diamond cutting tool, which they achieved by carrying out wear tests, according to the weight loss method. A standard test machine has been used for these operations [7].

In his doctoral thesis titled "Alternative Binders in Diamond Cutting Tools", Celik produced diamond-based cutting tools with Fe-based and Cu-Ni-Mo additives with no cobalt in their matrix and investigated their microstructure and mechanical properties. It also tried to determine the optimum sintering temperature in terms of cutting tool characteristics by using different sintering temperatures during production. The researcher has performed fractured surface analyzes of the diamond-doped samples and determined that the matrix was strong and well retained in the Ni-doped alloys because some of the diamond particles remained on the fractured surface during fracture. According to this, in contrast to the fact that the diamond particles do not easily break off during the fracture of the tools, while the diamond particle remains in place, the

particle itself is broken and it is determined that some of the particles remain in the matrix. As a result of the hardness tests, the highest values were obtained as a result of Ni and Mo-assisted samples [8].

As a domestic study, Karagoz and Zeren conducted a research on the microstructural design of diamond cutting tools used in the cutting of natural stones. They have reached the conclusion that although diamond-milled cutters are expensive in cost, they have very high cutting performance and very smooth cutting surfaces. It has also been determined that the sintering time, sintering temperature and sintering pressure applied during the production of the cutting tool are very effective on the tool quality [9].

Nitkiewicz and Swierzy investigated the effect of tin on the hot stamped diamond-metal matrix cutting tool used for natural stone cutting. They increased the tin ratio up to %12 in the matrix and examined a number of cutting tools, including various types of compositions. Depending on the hot pressing period and tin content, four types of tools were identified in different composites and then four different types of tinned tools were produced in the same composite by adding tin to them in specific proportions. Tin-free and tinned tools compared to each other resulted in tin-containing tools having higher hardness values and better cutting performance [10].

Di Ilio and Togna have done a theoretical work of cutting natural stone with diamond cutters. In these studies, theoretical models for diamond cutting tools have been developed, taking into account various factors. They compared their results with experimental studies in practice and, according to them, made some suggestions [11].

Carrino and colleagues conducted a study on marble processing and investigated the extent to which marble could be processed with a form tool. A numerical controlled (NC) bench was used in the studies and wear tests were carried out on this bench. First, the diamond cutting tool was mounted on a shaft to obtain a tool milling type, and then the tool was machined by joining an NC bench. The results of the abrasion were calculated in terms of the diameter loss of the fingers corresponding to the unit volume of the cut marble. These studies in the research were carried out as part of artistic processing [12].

The effect of the sintering temperature of the Bronze-based Co-Ni-Sn alloy powders used in natural stone cutting processes on the surface properties of the marble cutting tools produced in our country was investigated. To produce marble cutting tool powder with bronze based Co-Ni-Sn alloy by powder metallurgy method, synthetic diamond beads are added to the metal powder at certain ratios in order to obtain cutting stone cutting ability. Produced marble cutting tools were photographed with optical

microscope. The sintering parameters during the production that directly affect the performance of the cutting tool will be examined. In other words, the sintering temperature is changed during tool production and the most suitable values for the tool quality will be tried to be obtained. This is because the sintering temperature directly affects the quality of the tool while achieving a perfect cutting tool.

2. Experimental Studies

2.1 Materials

Bronze, cobalt, nickel and tin powders, synthetic diamond particles, liquid paraffin, graphite mold lubricant are used.

2.2 Marble cutter tool production

The mixture of two different Bronze based Co-Ni-Sn alloys in Table 1 was weighed in synthetic ratios at specific ratios and mixed with an eccentric stirrer for 20 minutes. Mixtures with specific ranges were observed, and steel balls were added in different sizes in order to make the mixture more homogeneous by adding 1% liquid paraffin if the powders were agglomerated. Table 2.1. shows the production parameters of marble cutting tools. In Figure 2.1., there is a three-dimensional rotating powder mixing mixer.

Table 1. Production parameters of marble cutting tools

Team Name	Diamond Concentration	Matrix Composition (Weight %)			
		Co	Bronz	Ni	Sn
N1	Synthetic Diamond	5	91	2	2
N2	Synthetic Diamond	5	84	2	2
N3	Synthetic Diamond	5	91	2	2
N4	Synthetic Diamond	5	84	2	2
Sintering Conditions					
Temperature (°C)	Time (Min.)	Pressure (MPa)			
600	3	30			
650	3	30			
700	3	30			
750	3	30			

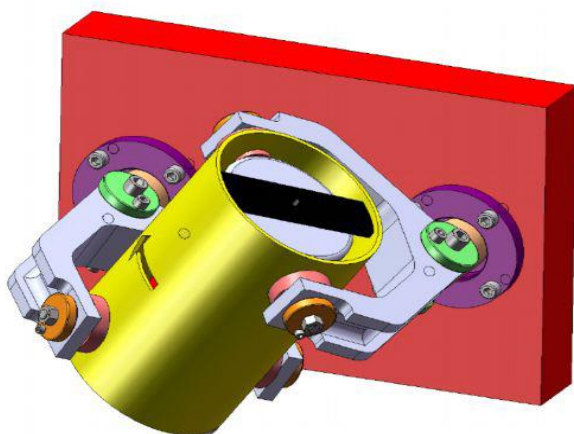


Figure 2. Three-dimensional rotating powder mixing mixer [3]

Physical compaction was performed by filling 2 g of the obtained mixture into the press bowl. After pressing, the samples were placed in the hot pressing machine by arranging the graphite mold. Four different sintering temperatures and fixed sintering pressures and duration were applied to the graphite material. After sintering, the graphite mold is removed and the mold is cooled. After 15 minutes the cooled mold is removed and the sintered cutting tools are removed. The burrs on the edges of the cutting tools from the production are cleaned and welded to the saws with the help of a machine. The burrs of the welded areas of the obtained cutting tool are removed and cleaned.

2.3 Marble cutter tool characterization

The produced cutting tools were cut with abrasive cutting disc and bakelite was taken. Then, sanding and polishing operations are performed at different magnifications. Finally, the image is acquired by optical microscopy. Optical microscopy images were taken at different magnifications of the cutting tools.

3. Result and Discussion

3.2 Morphological analysis

When the optical microscope results are examined; when the sections of the marble cutting tools sintered with four different sintering temperatures are examined, we have shown that the white areas are homogeneously distributed between the Bronze-based Co-Ni-Sn alloys in the Bronze-based synthetic diamond particles homogeneously. In

optical microscope images at 600 °C, 650 °C and 700 °C,

synthetic diamonds are not distributed homogeneously in Bronze based alloys. Make impurities in this irregular structure, inhomogeneities affect hardness and abrasion resistance negatively. Figure 3.1. (a) shows optical microscope images of marble cutting tools sintered at 600 °C, (b): 650 °C, (c): 700 °C and (d): 750 °C.

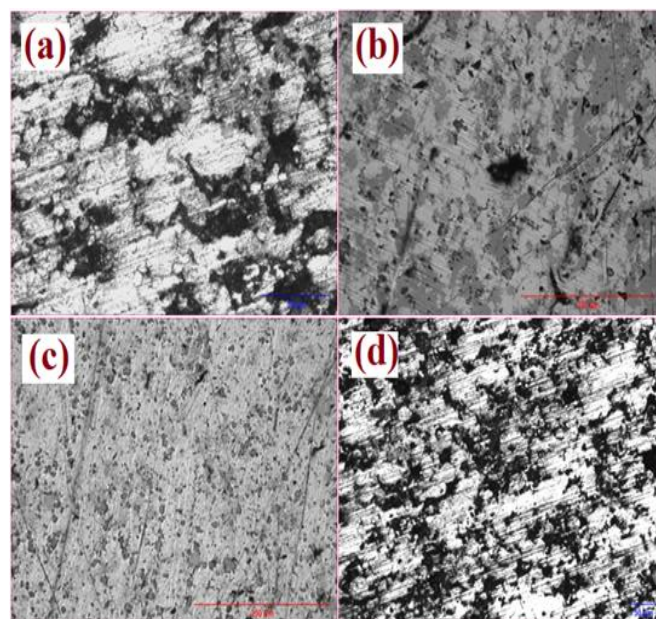


Figure 3. (a): 600 °C, (b): 650 °C, (c): 700 °C, (d): 750 °C marble cutting tools of sintered in optical microscope images

4. Conclusion

Four different sintering temperatures of synthetic diamond reinforced bronze based Co-Ni-Sn alloys. According to the results of research; Co-Ni-Sn alloy is uniformly distributed in the bronze-based alloy. As a continuation of our work, we have been working on the cutting process, which can be done in our country. As a result, more economical and marginal processing costs are attracted to a team inferior to production will be performed. Domestic resources are converted to the value added in this area in such a way that the most perfect of our country's competitiveness can be increased, a certain amount of imports and exports, by stopping. In addition, the Eastern and Southeastern Anatolia Region will be equipped with processing technology and improved knowledge and skills of local people and facilities will be provided.

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