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Development of a Copper Based Tool for Drilling Flat Glasses

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Abstract: *Today, the use of flat glass is increasingly preferred in many industrial areas. Therefore, it is becoming more and more important to reduce the cost of machining of flat glass to internationally competitive levels. In this study, a new composite material drill was prepared and tested to investigate the effect of microstructure and chemical mixture on the life of drilling tools. Experimental studies were carried out with glass drilling machine in a flat glass factory. Microstructure analysis of the drill material was performed using Scanning Electron Microscope (SEM) and Energy Dispenser X-Ray Analyzer (EDX). The lifetime of this drill made of diamond particle reinforced copper alloy was calculated. The drill life value of the new drill was measured as 2465 min.*

Keywords *- Flat glass, drilling, MMC, tool life*

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I. Introduction

Glass industry is used in many industries such as automotive, space, white goods, energy, food, medicine, furniture, construction, electricity and electronics [1,2 and 3]. The glass industry in the world has a size of approximately 140 billion USD and has a total production capacity of 180 million tons [4].

With the development of technology, the use of glass has been increasing over the years. When the glasses used today are examined, it is seen that flat glasses are preferred most in terms of tonnage. The actual glass production in Turkey is approximately 3.5 million tons'/year level. In other words, a large part of the production capacity is flat glass product group. The size of the glass industry in Turkey is approximately 2.3 billion US dollars. According to the data of 2013, the exports of glass and glass products in our country amounted to 993.4 million dollars and the imports amounted to 816.9 million dollars. The majority of flat glass produced in Turkey is preferred in kitchen decoration, white goods and furniture sectors [4]. In the process of converting glass to final product, drilling and grinding are mostly used. As the white goods and automobile industries grow, so does the use of glass. Therefore, the importance of low production cost and product quality is increasing day by day [5, 6].

In previous research, it has been stated that costs can be reduced by studying tool properties, shear strength and process temperatures [3]. The location of the drilling is important in the drilling process. During drilling, there are many undesirable conditions such as excessive surface roughness, axial misalignment, tool wear, burr formation and circularity. Many analysis methods have been used to optimize the parameters used for glass processing and experimental design. Experimental design of the Taguchi method is one of the methods used in the planning of experiments [7-11]. The fact that glass materials have some superior mechanical properties and the increasing use of glass in many engineering fields has led to many investigations especially in the fields of glass processing parameters and machinability [12-15]. Glass processing, strength, cutting parameters, acceptable roughness and performance of glass processing tools and similar issues have been examined and some useful results have been obtained [16-19]. Machining methods are generally used in order to process many glass materials that we use in industry and bring them to the desired size. In general, drilling is the most commonly used machining method especially in the white goods sector. Because many glass used in the white goods sector needs to drill holes in certain sizes.

In order to reduce production costs, it is necessary to reduce production times. For this, it is necessary to accelerate the drilling process and increase the life of the drilling tools. The design of tools used for drilling flat glass is important in terms of tool life and production speed. Since the tools are subjected to a lot of force and impact, diamond abrasives should be used with the bonding matrix material at the tip of the drill. In the cutting part of the drill bit, the diamond abrasives are used together with the binding matrix material. In composite materials used in drilling tools, some elements act as binders (matrix), while some elements give hardness and high temperature resistance and increase tool life. Since the tools are subjected to a lot of force and impact, diamond abrasives are used with the bonding matrix alloy as reinforcing elements at the end of the drills. The cutting tools and cutting parameters used in drilling affect the surface quality of the workpiece.

However, there is an important relationship between the tool life and the drilling tool material. In this study, a new composite material punching tool was produced and drilling process of flat glasses was made with this tool. The flat glass drilled in the experiments is mostly used in ovens, stoves and refrigerators manufactured for the white goods sector. The tool life of this drill was measured and its internal structure (Scanning Electron Microscope) was examined by SEM.

II. Material And Methods

Glasses with a thickness of 4 mm and dimensions of 100x500 mm were used in the experiments. The experiments were carried out in the factory producing flat glass for the white goods sector in the industrial environment. Drilling of flat glasses was performed on Retatek CDH 6060 type machine. Flat glasses are drilled with Ø37.4 mm diameter drills. In the cutting tool production, CuSnCo alloy was used as matrix alloy and 15 % diamond particle size of 60-80 mμ was used as reinforcing element. Drill bits are manufactured by powder metallurgy technique. In the drilling tests, the selected speed is 3000 rpm and the feedrate is 1.5 mm / s. The machine used for glass drilling is shown in Figure 1. The machine has four head assemblies capable of drilling.

Figure 1 Glass drilling machine

The drills used for drilling flat glass generally consist of two parts, the first is the metal body and the other is the diamond + binding zone at the cutting end. Figure 2 shows the drill bit and metal body. The wall thickness of the drills used for drilling flat glass is approximately 1 mm.

Figure 2 Drill used for glass drilling

III. Results And Discussion

After drilling, sample pieces were taken from the drill surface by cutting. These samples were imaged with SEM and EDS (Energy DispersiveSpectroscopy) and their chemical compositions were obtained.

The lifetime values of the drills used in the drilling of flat glass were first recorded. Then, microstructure investigations of this tool material were performed. Fig. 3 shows an image of the drill bit taken at SEM at 500 magnifications. When the figure is examined, it is seen that the structure of the drill is regular and the outer surface of the diamond grain is bright.

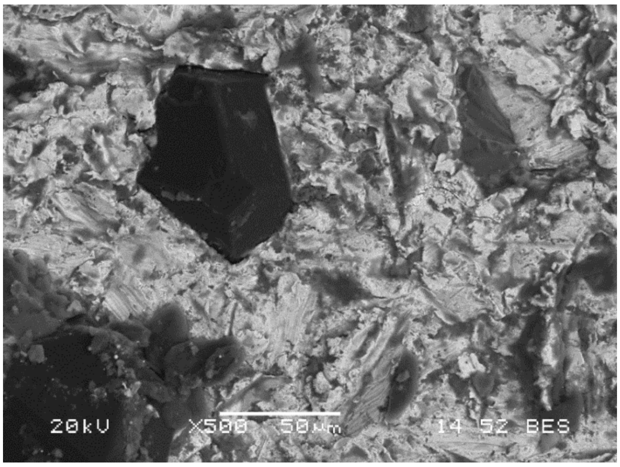

Figure 3 SEM image of the drill bit material at 500 magnifications

For microstructure analysis in the drill, EDS was also examined. Three regions were selected for EDS analysis as shown in Figure 4. Since the content of the first and second regions is completely carbon, it is clearly understood to be diamond.

The result of the EDS analysis for the third region is shown in Figure 5. When the EDS analysis is examined, it can be seen from Table 1 that the copper and cobalt ratios are 77% and 2.7%, respectively. The preferred element as binder in the drill is cobalt. In addition, a small amount of tin is present in the structure for strength.

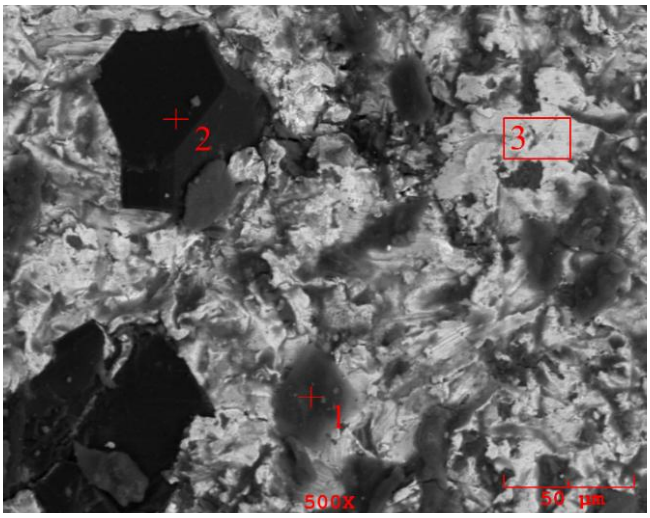

Figure 4 Selected regions for EDS analysis

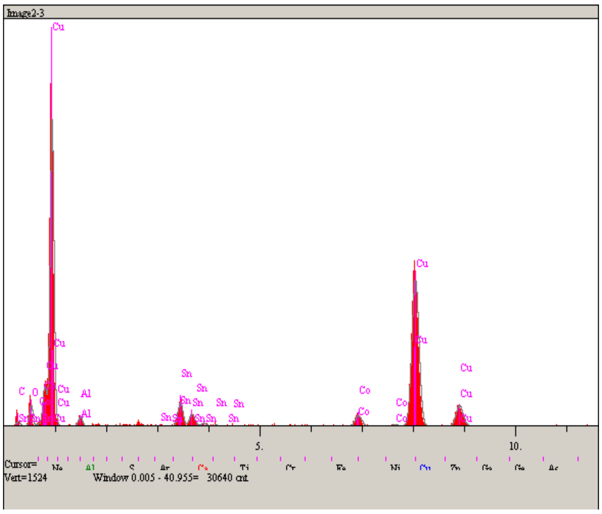

Figure 5 EDS analysis graph

Table 1 Chemical composition of EDS analysis

Elt.	Line	Intensity(c/s)	Error 2-sig	Conc	Units	
C	Ka	5.84	0.882	4.002	wt.%	
O	Ka	22.70	1.739	6.417	wt.%	
Al	Ka	12.16	1.273	1.876	wt.%	
Co	Ka	21.80	1.705	2.681	wt.%	
Cu	Ka	314.90	6.479	77.352	wt.%	
Sn	La	37.29	2.230	7.672	wt.%	
				100.000	wt.%	Total

Diamond particles are understood to increase the hardness and strength of the drill. In addition, no large amount of rupture is observed in the diamond particles of the composite. This shows that the matrix material used as the binder is a sufficient binder. No significant residue was found on the diamond particles. There are diamond particles that do not lose their sharpness. In the SEM photographs of the used tools, it is observed that some of the diamond particles do not fall and remain intact. In other words, this composite tool can be said to have a relatively long life and is suitable for the drilling process.

The drill life value obtained by processing the glass was found to be 2465 min as shown in Figure 6. The strong bonding between the binder matrix alloy and the diamond particles is one of the most important factors that increase the drill life value. This is preferred for drilling drills.

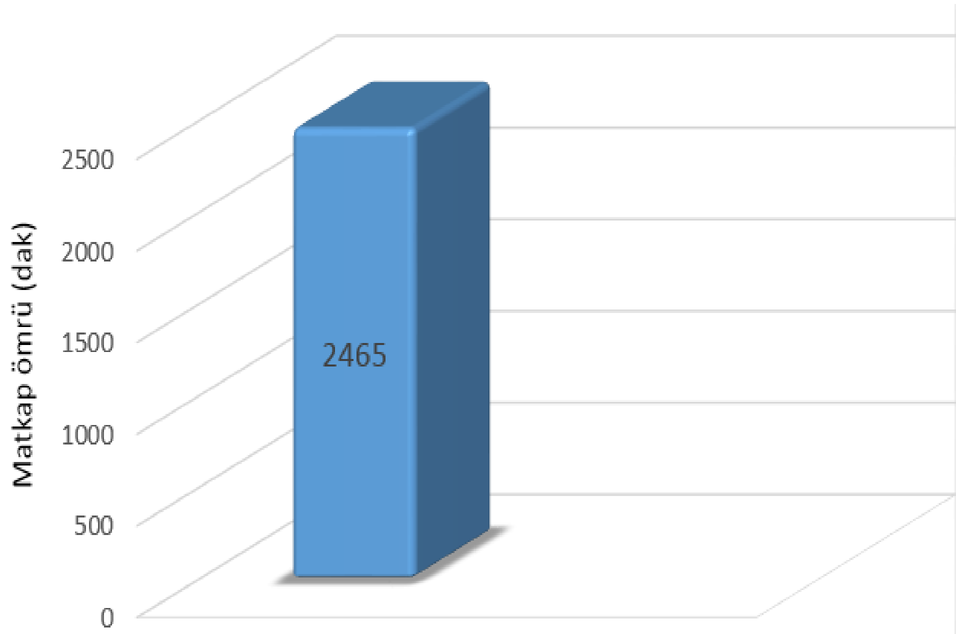

Figure 6 Drill life value

In the drilling process, the cutting and feed is performed by the drill and the resulting forces are high. The ratio of abrasive diamond per unit area is higher than the discs used in glass lapping process. It is seen from previous studies that the chemical composition of the drills affects the axial misalignment of the treated glass holes [20]. However, the chemical structure of the tool also affects drill life.

IV. Conclusion

In this study, the flat glass drilling process used in the white goods sector was examined in detail, the previous studies were taken into consideration and a new drill with suitable chemical composition was formed.

This drill, which is approximately 77% copper, 2.6% cobalt, 7.6% zinc as a matrix alloy and contains diamond particles as a reinforcing element, was started to be used in a glass factory in Bolu and was found to be suitable for life.

In the following studies, the most suitable drilling parameters can be selected with the optimization technique by experimenting with different drilling parameters. New drilling tools can be formed and tested using different matrix materials and different proportions of more homogeneous and approximately the same size diamond particles.

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