

A Critical Approach to Usage of Diamond Segmented Frame Saws

F. Bayram, S. Kulaksız & Y. Özçelik

Department of Mining Engineering, Hacettepe University, Ankara, Turkey

ABSTRACT: Marble is an industrial material with a very high commercial potential in Turkey. At present, one of the machines used for production of slab from marble blocks in marble processing plants is a diamond segmented frame saw. Frame saws are important machines in processing plant due to high production efficiency, production of large slabs and also high installation cost. There are many parameters affects the sawing efficiency during sawing operation with diamond segmented frame saws. These parameters are unchangeable parameters related with stone characteristics, semi-changeable or changeable parameters related with machine and environmental conditions. In addition to these parameters, the industrial usages of frame saws have an important effect on efficiency. In this study, mistakes on industrial usage of diamond segmented frame saws were determined and some suggestions to eliminate these mistakes and consequently suggestions to increase the general machine efficiency were revealed.

INTRODUCTION

Since old periods marble has been used for making of important construction and decoration materials. Marble is preferred as a construction and decoration material due to its sufficient strength, having attractive colors, figures and usefulness. Marble blocks extracted from marble quarry should be subjected to series of processes for usage of human.

Marble processing plant can be defined as a plant in which marble blocks are processed for finish product. The purpose in these plants is the production of required goods according to market demand at possible lowest cost. It is necessary for this purpose that the processes should be carried out efficiently. Marble processing plants consist of various machines having high investment cost. Efficient and conscious utilization of these machines satisfy and increment in efficiency while decrease the production cost of marble.

In scope of this study, revelation of mistakes in industrial usage of diamond segmented frame saws that are important machines having a highest investment cost was aimed. Besides, requirements were considered for eliminating these mistakes and increasing machine efficiency. The mistakes in usage of diamond segmented frame saws and suggestions for elimination of these mistakes were depended on scientific data and observations.

2 MATERIALS AND METHODS

2. / *Diamond segmented flame saws*

Different methods and machines suitable to these methods are used in processing plants for slab production from marble blocks. In marble processing, physical conditions of raw marble blocks such as shapes, dimensions, fracture mechanisms of blocks are considered in determination and selection of processing method.

Diamond segmented frame saws are used to produce the slabs from carbonate originated blocks in marble processing plants. Diamond segments welded on a blade perform sawing process. Sawing process can be carried out in two ways depending on machine structure. In the first way, block is fixed and blades are moved downwards besides forward-backward strokes. In the other way, block on table moves upwards with hydraulic system and blades perform only forward-backward strokes at horizontal plane. The general appearance of diamond segmented frame saw is given in Figure I (Bayram 2002. Kulaksız et. al. 2002).

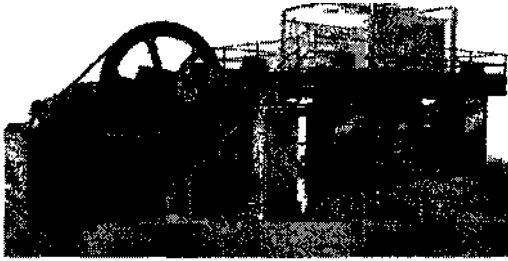


Figure 1 General appearance of diamond segmented frame saw

Sawing processes in diamond segmented frame saws consist of different steps. These steps affect the number of slab and consequently sawing efficiency. The steps in Figure 2 are generally followed in sawing process. In the first step, block is installed on timber beams on table. The sides of block must be parallel to the side of table. After this step, table is settled to the frame saw. When the block is under the blades completely, block side and blade must be parallel each other. Then, water is supplied to the sawing area. Main motor is run and the forward-backward stroke of blades is realized. Sawing process is performed by downward movement of blade or upward hydraulic movement of block according to the frame saw type. Entrance sawing speed of blade is low. After penetration of blades into block, normal sawing speed is applied. When the blades close to the underside of the block approximately 20-25 cm, the main motor is stopped and water supply is closed. Timber wedges are

installed between half-sawed slabs. Using support elements of table presses slabs. Then slabs are mounted by chain tightly. Water is given to the sawing area again and main motor is run. Sawing process is continued at low speed and block is sawed completely. Then, chain and timber wedges are taken out. Slabs on table are installed to stock area by using portal crane.

Diamond segmented frame saws are commonly used in marble processing plant because of their high production capacity and low production cost. The important point on efficient usage of diamond segmented frame saws is to produce slabs at minimum cost by adjusting the effective sawing parameters adequately. The parameters affecting on sawing efficiency can be classified in 3 groups as given in Table 1 (Bayram 2002. Kulaksız et. al. 2002):

- Unchangeable parameters
- Semi-changeable or changeable parameters
- Environmental conditions

Unchangeable parameters affecting on sawing efficiency are related with stone characteristics. Semi-changeable or changeable parameters are related with diamond segmented frame saws. Environmental conditions are the conditions at sawing area. It is necessary that these parameters should be considered carefully for efficient usage of frame saws before the sawing operation. The effects of these parameters on sawing might be evaluated by users in detail. Effective parameters should be adjusted adequately for increasing the product efficiency on diamond segmented frame saws.

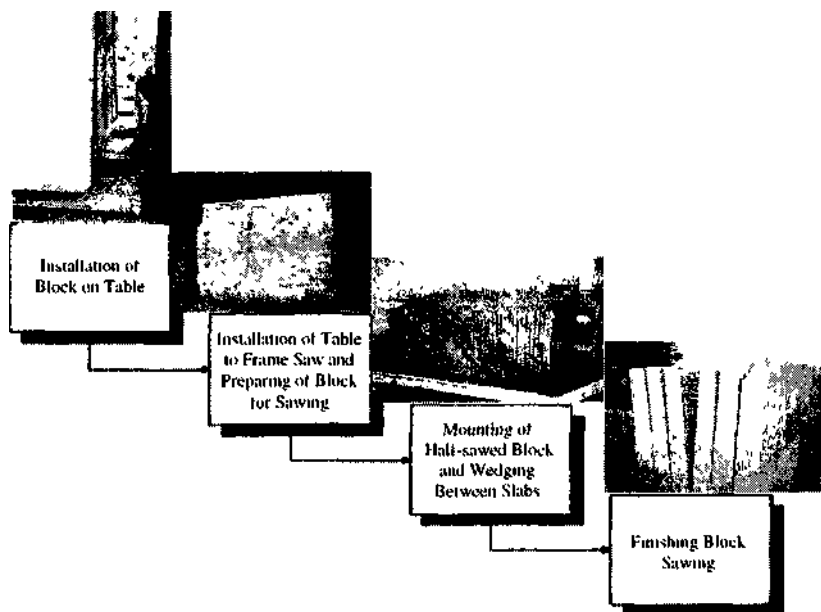


Figure 2 Steps of sawing process in name sawing

Table I. Parameters affect sawing efficiency un frame saw (Bayram 2002. Kulaksız et al 2002)

1. Unchangeable parameters related with stone characteristics
 - Physical and mechanical properties
 - Chemical properties
 - Mineralogical properties
 - Petrographical properties
 - Discontinuities
 - Textural properties
 - « Structural properties

2. Semi-changeable or changeable parameters related with diamond segmented frame saw
 - Sawing speed
 - Interval between segments
 - Structure of segments
 - Water amount and pressure
 - Water purity and pH
 - Dimensions of block
 - Machine structure and motor power
 - Dimensions of blade, blade structure and number

3. Environmental conditions
 - Technical personal
 - Vibration
 - Pressure distribution on blades
 - » Forces between diamond grains and stone

Different investigators have performed different studies related with effective parameters on frame sawing up to now. Bayram (2002) and Kulaksız et. al. (2002).summarized these studies as given follow. Löns (1970) measured sawing forces and diamond wear of single segment under some sawing conditions. Gerlach (1981) found that properties of stone and feed rate affected the sawing forces. Meding (1993) found that on a model frame sawing machine, the cutting forces and the segment wear were affected by the feed rate and the sawing times. Wiemann (1968) measured the tensile stress of the frame sawing blades. Jansen (1977) found that the friction among the tension elements reduced the tension acting on the saw blade. Clausen (1992) investigated the method of tool assessment work for frame sawing in the laboratory. In this study, the

contact conditions, the sawing forces and the segment patterns were analyzed. Wang and Clausen (2002) performed sawing processes at different parameters and observed the stone surface. In this study, the contact condition between stone and diamond grit was analyzed All these studies are related with specific parameter affected on sawing efficiency, operating conditions and machine structure. But, studies related with efficient usage of frame saw have not been realized. Effects of applications and all parameters in sawing processes have not been investigated. In this study, not only elimination of this lack of frame sawing is aimed but also lime and money consuming due to the wrong usage of machines will be prevented.

2.2 Methodology

Methodology of this study is given in Figure 3. Investigations for this study were performed in a marble processing plant at Afyon-İscehisar Marble Industry Zone. In this plant, 20 marble blocks were sawed with different two types of domestic and imported segments on diamond segmented frame saw which is very well designed according to present technological conditions. The sawed marble blocks are Afyon Violet (A1, A4, A6 and A7), Afyon Sugar (A2, A3, A8, A9, A10 and A11), Afyon White (A5), Kütahya Violet (K2, K4, K6 and K7) Kütahya Green (K1, K3 and K5), Akhisar Onyx (O) and Diyarbakır Beige (D) type marbles. The important mechanical properties of these rocks are given in Table 2. Wearing on diamond segments and average sawing speeds were investigated and interpreted on machine efficiency. After all sawing processes with domestic segments, some segment samples were taken and microscopic investigations was performed for the investigation of suitability of segment usage according to the stone. Furthermore, applications of sawing processes on diamond segmented frame saws in marble processing plant were observed and mistakes in applications were determined. Suggestions for eliminating of these mistakes were revealed.

Table 2 Laboratory test results of investigated rocks (Bağram 200; Kulaksız, al. 2002)

Rock Type	Average Uniaxial Compression Strength (MPa)	Average Tensile Strength (MPa)	Average Stroke Strength (MPa)	Average Shore Scleroscope Hardness	Average Schmidt Hammer Hardness
Afyon Violet	63	6.8	• 3.3	46	54
Afyon Sugar	58	7.2	3.6	47	55
Afyon White	47	5.7	2	40	51
Kütahya Violet	63.5	6.8	3.6	50	56
Kütahya Green	64	7.5	3.6	46	53
Akhisar Onyx	49	4.2	3	45	55
Diyarbakır Beige	55	4.2	2	46	54

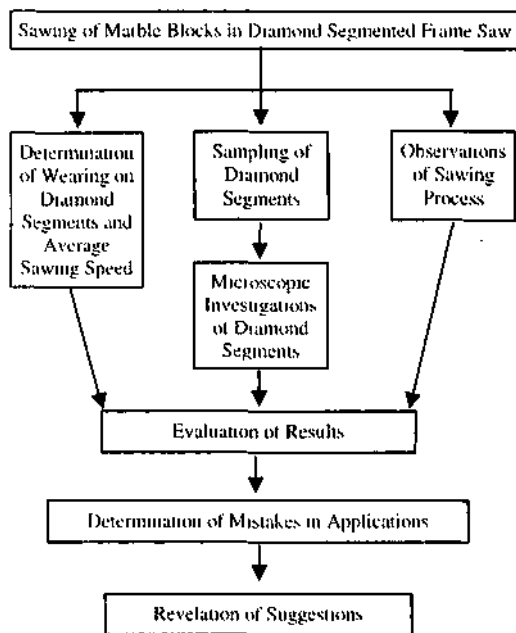


Figure 4 Methodology of study

3 SOME IMPORTANT MISTAKES IN INDUSTRIAL USAGE AND SUGGESTIONS

Diamond segmented frame saws that are the important parts of marble processing should be used very efficiently. Mistakes in usage of diamond segmented frame saws prevent the effective and efficient usage of these machines. The observations in this study revealed that, these mistakes in a sawing process have no major effect on the production cost and machine efficiency one by one but their repetition increases the production costs and decreases maintenance and usage period of machine in a long time. In this study, some mistakes were determined in the utilization of frame saws. The mistakes and possible solutions are discussed in below:

- There have been many mistakes in the selection of diamond segments as in the selection of all diamond cutting tools (disc segments, diamond bead etc.) in marble industry. Selection of optimum diamond segments that are using in diamond segmented frame saws is an important factor in efficient usage of frame saws. The production and selection of diamond segments in Turkey are not depended on any scientific data by marble companies. Selection of diamond segments has been carried out without asking the question of "how a diamond segments should be?" based on rock parameters. This selection has been mostly performed with depend on suggestions of some user, persuasion ability of seller and seller-customer

satisfaction. Suitability of selected diamond segments can be determined different sawing efficiency and customer (user) satisfaction according to every marble company. However, it is a fact that physical, mechanical and mineralogical properties of marble are related with technical parameters of diamond segments.

Microscopic investigations with the fact of wearing types have showed that, the diamond segments used in this study were not suitable to sawing rock. Diamond segment is exposed to wear in sawing operation. As a consequence of matrix wear, the hunchback structure occurred at the front and back of the diamond grits. This hunchback formation is called as comet structure. This structure supports the diamond grit and increases the diamond strength and give information about the sawing quality. The formation of comet structure reveals a better sawing, otherwise it emphasizes that the diamond grits are not properly active in sawing. Various types of grooves can be formed between these hunchbacks based on the location of diamond grits. The formation of comet and groove are seen in Figure 4. The formation of groove is very important in sawing because by the aid of these grooves, worn diamond, matrix particles and water can be removed out. The main reason of the absence of any groove is that the matrix hardness is higher than the rock. When swarf and water are not removed from environment, the material wears the diamond and especially matrix and as a result of this situation the segment life decreases (Bayram 2002, Kulaksız et al. 2002). The comet and groove formation were not seen mostly on diamond segments (Fig. 5). This situation affects the sawing efficiency of diamond segments directly.



Figure 4. Appearance of comet and groove on diamond segment (Bayram 2002 Kulaksız et al. 2002)



Figure 5 Appearance of diamond segment structure with groove formations (Bavram 2002). Kulaksız et al. 2002)



Figure 6 Grooves occurring on the diamond segment surface (Bayram 2002). Kulaksız et al. 2002)

Selection of diamond segments on diamond segmented frame saws must be suitable to physical, mechanical and mineralogical properties of rock. After the evaluation of rock properties such as grain size, hardness, texture and mineralogical composition together, result of this evaluation diamond segment should be selected. The classification system related with sawability should be formed for rocks and then technical structure, diamond contents and diamond grain size of diamond segments should be determined by this classification system.

- Some wearing was encountered at the out of sawing process in microscopic investigations (Fig. 6). Especially, when blades dislodged between sawed slabs, grooves on diamond segment perpendicular to forward-backward movement of blade occur. The reason of these grooves is that some diamond grits on segment surface pull out and wear the matrix surface with effect of abrasion between diamond segments and sawed slabs at dislodging of slabs. This wearing should be prevented by pulling of timber wedge that are installed between slabs for easy movement of blades as possible as late. So that, the performance of diamond segment can be increased. Furthermore, these grooves can be occurred from swarf of rock. Swarf can cause to grooves as similar the pulled out diamond grits. The important reason of this problem is the lack of sufficient cooling water supply to the sawing zone and swarf cannot be removed from environment. Therefore, amount and purity of cooling water must be adjusted carefully (Bayram 2002, Kulaksız et al. 2002).

- One of the most important parameters that can affect the sawing efficiency on diamond segmented frame saws is the sawing speed. In these machines, same type of diamond segments saw different type marble blocks. Due to this characteristic, sawing speed affects the wearing on diamond segments mostly. The wearing on diamond segments is high because of high sawing speed. In the opposite situation, when the sawing process is performed slowly, machine runs more than necessary besides, energy consumption for sawing increases. All these situations can negatively affect the sawing and production cost to a great extent. As a result of sawing processes performed in this study, the high relationships between average sawing speed and wearing on diamond segments were determined for both domestic and imported segments (Bayram 2002, Kulaksız et al. 2002). These relationships are seen in Figure 7a and Figure 7b. Determination of optimum sawing speed with respect to the rock type is essential for efficient usage of frame saws.

As a result of detailed investigations it was determined that, suitability of optimum sawing speed according to rock type have not been investigated and sawing speed has been selected randomly. Wearing on diamond segments increases extremely with increasing the sawing speed as seen in Figure 7a and Figure 7b. Sawing speed should be determined by considering the physical, mechanical and mineralogical properties of rock. Owners of marble processing plants should be realized the rock properties and their dependence on scientific data. As far as they concern these studies as unnecessary, they should evaluate them as utmost importance.

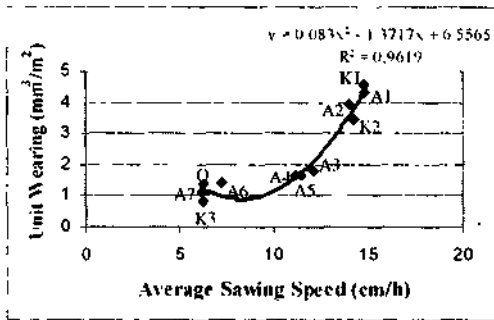


Figure 7a Relationship between unit wearing-average sawing speed in tiame sawing processes with domestic diamond segments (Bavmm 2002. Kulaksız et al 2002)

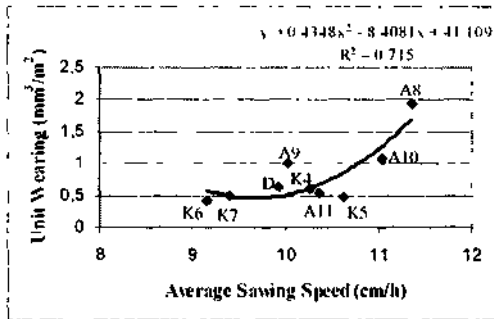


Figure 7b Relationship between unit wearing-average sawing speed in flame sawing processes with imported diamond segments (Bayram 2002. Kulaksız et al 2002)

• One of the most important lack of the marble processing plants is scarcity of qualified personal. Performance of a machine is strongly related with the quality of the technician who is responsible for. Wrong applications of machine operator decrease the production capacity and consequently increase the production cost. In diamond segmented frame saws, operators that are trained and have sufficient skill should be worked. Professional seminars and courses should be organized for personal training.

4 CONCLUSIONS

This study is the small part of a comprehensive study performed on diamond segmented frame saws. Some mistakes in industrial usage of diamond segmented frame saws were determined and suggestions were put forward for eliminating of mistakes affect on sawing efficiency. The main conclusions of this study should be given below:

- Selection of diamond segment and usage of machines are not depended on scientific data in marble processing plant.
- Marble producers evaluate the scientific investigations and conclusions as unnecessary.
- As a result of these conclusions, the followtngs should be mostly recommended:
- Insufficient communication between scientific investigators and marble producers should be eliminated. The most important mission for this should be carried out by owners of marble processing plants.
- The studies should be supported for increasing the machine efficiency, consequently total plant efficiency.
- When the selection of machines and consumption materials (diamond segments, disc-cutter, abrasive head etc.) is carried out according to scientific data, both machines will use more efficiently and production cost will decrease.

ACKNOWLEDGMENTS

The authors would like to thank to Hacettepe University Scientific Research Unit for providing financial support and Res Assist N Hrhan Yaşıtlı. Res Assist Kağan Atasoy for kind help during laboratory studies

REFERENCES

Bayiam. F. 2002. Investigation of Sawing Efficiency on Diamond Segmented Gangsaws *M.Sc Thesis, Hacettepe University Institute of Pute and Applied Silence* 131 p (in Tuikish)

Kulaksız. S. Ö/çelik. Y. Bayram. F. Yaşıtlı. N E and Atasoy. K 2002 Investigation of Sawing Efficiency on Diamond Segmented Gangsaws *Hacettepe Univerinh St teulfic Resean h Unit. Protect No: 01 01 602 024.* 149 p (inTiikish)