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The effect of cutting process on surface microstructure and hardness of pure and Al 6061 aluminium alloy

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ABSTRACT

In this study pure aluminium and Al 6061 aluminium alloy material had been cut with saw, milling, submerged plasma, plasma, laser, wire electric discharge machining, oxyfuel and Abrasive water jet. Microstructures and hardness variations of cut surfaces which obtained with different processes have been investigated. Results of the study show that the hardness and surface quality of the cut surface is affected from the kind of cutting process. Microstructure of cut surfaces is affected from the kind of cutting process. Microstructural changes during cutting of the materials are observed with all of the cutting process other than Abrasive water jet. Abrasive water jet method can be effectively used in industrial applications where no microstructural changes and hardness reduction is essential.

1. Introduction

The quality of cutting process which has been obtained with any method can be determined by measuring of surface properties such as surface roughness. The new cutting methods are needed to obtain better surface quality. Non traditional cutting methods are developed and used for newly developed engineering materials. The cutting methods which based on jet principle are preferred for hard to cut materials. Microfeatures of surfaces show variations depending on cutting methods. The machined surfaces which obtained by jet based cutting processes show parallel straight surface features. In the jet method which is based on jet flow the quality of surface can be developed by using the increased power for per unit of cutting length of material. To get better surface quality the jet pressure is increased and the lateral movement of jet is decreased [1]. Cut surface features; when it examines to assign the quality of cut surface features, it is seen that there are similarity of the surfaces cut by jet based cutting applications. The surface roughness of the workpiece is related to diameter of the jet [2]. There are some cutting methods for the plate shaped materials. Abrasive water jet (AWJ) method has been compared with other cutting methods in Fig. 1 by Hashish [3]. In the figure power levels and conventional chip removing ratio have been compared for different machining methods. Hashish stated that AWJ consume less energy level during cutting applications when compared with other cutting methods [3]. In AWJ method it is possible to cut with too narrow kerf. AWJ does not have any thermal effect on the materials to be cut. The water jet (WJ) and the AWJ also have limitations [3,6] besides their advantages. Powel et al., have studied the economic point of view of laser and AWJ [7]. They investigated the technical and commercial advantages and disadvantages of the processes. Ohlsson et al., investigated the effects of cutting pressure, abrasive amount in the jet, lateral speed on the cutting depth and surface features for grey cast iron and steel [7–9] In Hashish and Schreiber's studied they had reported that the laser and abrasive water jet methods have unique cutting capabilities [10–12]. In Fig. 2 AWJ is compared with common alternative cutting methods the comparison of most common cutting methods is seen in Fig. 2. Maximum cutting thickness of the processes is given in Table 1. Material applications of some machining methods is shown in Table 2. A general comparison of cutting methods depending on material is shown in Table 3 [12–18].

The previous study focus abrasive Waterjet process or other cutting process but none of them compare the all process with each other. The present study, compare all cutting process and fill the literature the gaps.

In this study pure aluminium and Al 6061 aluminium alloy material had been cut with saw, milling, submerged plasma,

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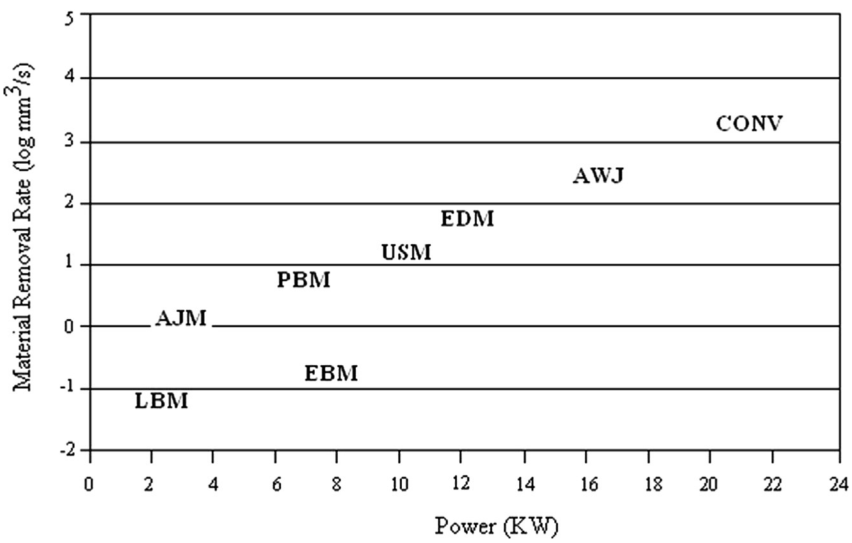

Fig. 1. The volume chip removing ratio of machining related to power levels [3].

plasma, laser, wire electric discharge machining (EDM), oxyfuel and abrasive water jet. Microstructures and hardness variations of cut surfaces which obtained with different processes had been investigated. Results of the study show that the hardness and surface quality of the cut surface is affected from the kind of cutting process.

2. Experimental study

In this study aluminium alloy plate material which has 20 mm thickness have prepared and cut by conventional (oxygen flame, hydraulic saw, and milling machine) and 8 non-traditional (AWJ, Laser, Plasma arc, Water plasma, wire erosion) cutting methods. Microstructure and hardness variations of the cut surface based on the kind of cutting process had been investigated. In the experimental study commercial pure aluminium and Al 6061 aluminium alloy material were used. The chemical composition of aluminium plate materials is given in Table 4. Technical details of the AWJ system that are used in experimental study is given in Table 5. The hardness of the pure and Al 6061 aluminium alloy plates were 41.05 and 53.08 HV_{30}

Base material and cut surface microstructures have imaged (X280) by using "PANASONIC WV-CP410 Model Type N334" microscope. The specimens had been polished with aluminium powder and diamond paste. Then the specimens were etched with 2 ml HNO_3 98 ml for 20 min before taking images. INSTRON WOLPERT TESTOR were used to measure hardness values of base materials and cut surfaces at HV_{30} condition. Hardness values of the every point in the figures represent the average of 5 measurements on the same linear line on the cut section. After this stage images and hardness values of the cut surfaces that were obtained with cutting process had been evaluated.

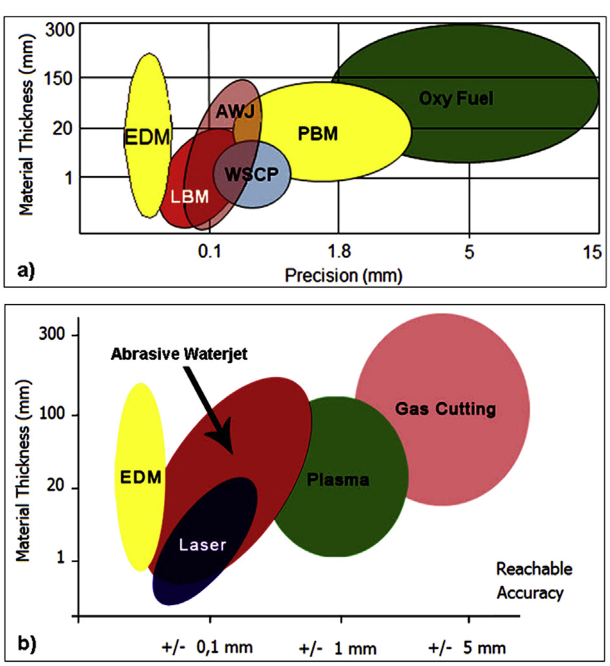

Fig. 2. Comparison of cutting abilities of different cutting methods by using single orifice jet beam [13].

3. Results and discussion

The effect of cutting process on microstructure of the studied materials is given in Fig. 3. In Microstructure of pure and Al6061 aluminium alloy it is seen that α-Al intermetallic compounds have dispersed homogenously. To investigate the microstructure of cut surface and the structural deformation, the photographs

Table 1
The comparison of cutting methods depending on material thickness [12].

Cutting methods	Maximum material thickness (mm)				
	Stainless steel	Alloyed steel	Carbon steels	Composites	Stone, granite marble
AWJ cutting	100	100	100	140	140
Laser cutting	10	5	16	–	5
Plasma cutting	20	20	20	–	–
Oxygen cutting	–	–	160	–	–