METABK 52(1) 235-238 (2013)
UDC – UDK 669.14.018:672.7:621-4:620.178.1=111

COMPARISON OF HEAT EFFECTS ASSOCIATED WITH METAL CUTTING METHOD ON ST 37 ALLOY STEEL

Received – Prispjelo: 2013-01-24
Accepted – Prihvaćeno: 2013-09-09
Preliminary note – Prethodno priopćenje

In this study, by examining effects of the heat on the cut surface of material formed by the processes, such as Plasma, Laser, Wire Erosion applied on St 37 alloy steel material, it has been determined that minimum cutting damage occurs in wire erosion process.

Keywords: steel St 37, cutting, surface damage, hardness

INTRODUCTION

As well as gaining time in manufacturing, problems created in external and internal structure of processed material by today's technology used in metal processing, have a non-ignorable importance. Cutting effects associated with used technological method have been examined.

In the optimization study made for the selection of processing parameters of wire erosion, important factors affecting processing performance were determined by using Taguchi experiment design method and analysis of variance [1]. Processing with wire erosion allows mould members to be processed in high measurement precision, after being exposed to heat treatment, because hard materials, which are manufactured very difficult according to classic processing methods, could be processed provided that being conductive [2]. In wire erosion, generally, a hard layer and hair cracks occur on the surface of work piece depending on performed processing conditions and thermal features of material [3]. With wire erosion, chip is removed from work piece through electro thermal energy, for this reason, machining ratio depends on electrical conductivity and heat of melting of work piece [4]. Gas parameters, power supply parameters and cutting speed are important parameters for plasma cut [5]. An surface roughness that increases depending on cutting depth is inevitable likewise laser cutting, plasma, underwater plasma and oxygen flame [6]. While laser cutting and plasma cut, structural alterations, which possessed high hardness degree and processed with difficulty, occur on cutting surfaces because of the used thermal energy [7].

Purpose of this study is to examine hardness and micro structure alteration which occur on cutting edge of the material because of the heat formed by the method used in metal cutting process and to determine the most productive cutting method.

MATERIALS AND METHODS

In experimental studies done, St 37 alloy steel sample, which is commonly used in many phases about manufacturing in heavy industry, was used. As it is illustrated on Figure 1, size of sample is been 20 x 20 x 15 mm and its chemical properties are given onTable 1. Prepared sample was cut by plasma, laser, wire erosion methods of advanced cutting technologies.

Table 1. **Chemical properties of the material used in experiment**

Material	Chemical Composition / %					
	C	Si	Mn	P	S	N
St 37	0,17	0,40	0,50	0,04	0,05	0,007

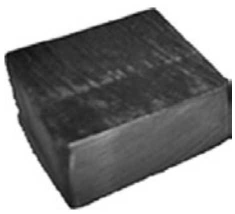


Figure 1 Untreated sample

The Cutting with Plasma

Method of plasma cut is a thermal cutting method used in cutting of conductive metals. Cutting is performed, in simple terms, by ionizing (transforming in plasma) partially the gas flowing in torc by giving energy, by heading of formed plasma with high temperature from nozzle block towards the material is positive pole by effect of gas flow, and by melting the material and then removing the melted material through pushing

L. Dahil, IstanbulAydın University, Department of Mechanical andMetal Technologies, Turkey, İ. Dahil, Ministry of Education, Istanbul Provincial Administration of Education, Turkey

by jet ef fect of fl owing gas. Today's sensitive plasma systems can make cutting with 1-12 mm sensibility.

For sample cutting, Ajan CNC and Plasma Cutting Loom of Öz Emek Metal Company was used. State of the sample cut by plasma, is shown on Figure 2.

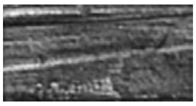


Figure 2 Photo of surface of shear of the sample cut by plasma

The Cutting with Laser

Laser beam is formed by giving electric current to carbon dioxide gas on the laser looms. Cutting process carried out by obtained laser beam is called Laser Cutting.

For laser cutting of the material, Bystar L 600 W CNC Laser Cutting Loom of Yünsel Laser Machine Company, was used. State of the sample cut by laser, is shown on Figure 3.

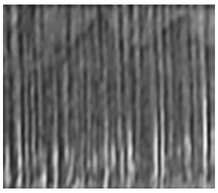


Figure 3 Photo of surface of shear of the sample cut by laser

The Cutting with Wire Erosion

Wire erosion is the method of cutting by the help of a wire on which high-density fl ow is passed. On these looms, when wire electrode connected to different electrical poles is approximated to work piece, high temperature occurs with high dischar ges and chip is removed by local metal defrosting way [8].

While cutting the material by wire erosion, Sodick AQ 535 L 550 x 350 x 300 (z) mm CNC Wire Erosion cutting loom of Kalıpsan Sheet-Metal Diesinking Company, was used. State of the sample cut by plasma, is shown on Figure 4.

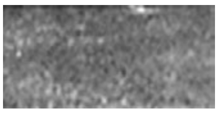


Figure 4 Photo of surface of shear of the sample cut by wire erosion

Hardness of the cut surfaces was measured by "HV0.5" value in "Shumazu" hardness measuring instrument. Photos of cut surfaces were taken by zooming their micro structures 500 times by the help of "Olympus BX-60 Model" microscope and TV tuner and software on "Inter Core 2 Duo PC".

In order to examine variable hardness values of materials cut by dif ferent cutting methods and structural defect and alterations in microstructures and on surface caused by cutting method, edges neighboring on surface of shear of cut samples were cleaned by sandpapers consisting of dif ferent granule sizes. The reason why cleaning and polishing operations are applied on edges neighboring on surface of shear is to examine hardness alteration from the border of surface of shear to inward. The process was carried out until the base is parallel to the surface on which examinations will be made.

For polishing process, aluminum powder and diamond paste were used as abrasive. After pouring these abrasives on baizes glued on disk, polishing process was practiced in a way to generate circular rings reverse to direction of rotation of disk or by moving forward and backwards from central of disk to its environment and by pressing slightly. After providing the gloss completely, the surface to be seared and examined was cleaned by washing with water and alcohol.

These operations were carried out until the desired surface is obtained for metallurgical examinations. Each polished material was seared by 3 % nital for 6 seconds in order to find out surface structures. After searing operation, the surface to be examined was cleaned by washing pure water and alcohol. Seared materials were zoomed 500 times by examining under optical microscope and then their micro structure photos were taken.

The micro structure is at a point, which is non-affected by cutting method, and the structure is formed at cutting edge were examined comparatively in order to observe alterations in micro structures of material.

In order to find differences resulted in examination, a lar ge number of photos were taken three dif ferent points from material surface, and deformation in the structure of material caused by cutting method and hardness alterations were determined as a result of examining all of these photos.

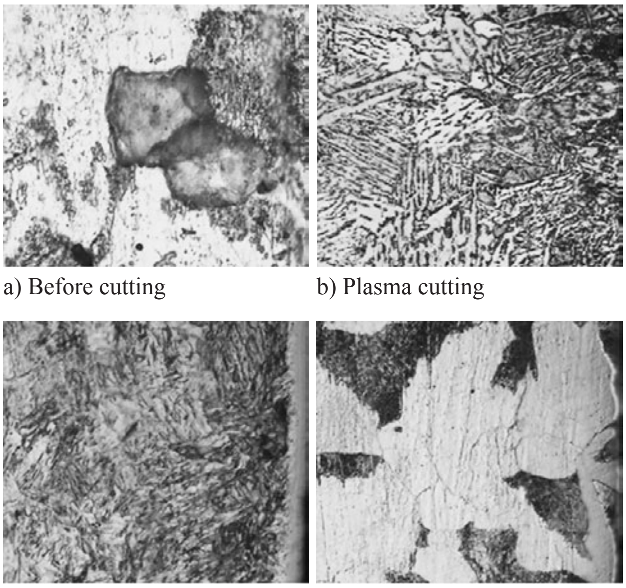
Hardness measurements of materials, which their micro structures were examined, were carried out by Vickers hardness measuring device and the obtained results were transmitted on graphics. On the same sample, by measuring hardness at intervals of two each millimeters from cutting border to core, hardness alterations were determined from cutting border towards core and effects of dif ferent methods were evaluated depending on these alterations.

RESULTS

Evaluation of Changes in Internal Structure

During different cutting operations applied on prepared sample, it was observed that temperature changes would cause what kind of changes in micro structure of piece and then the results were compared with micro measurements.

After micro film and hardness measurement operations, hardness and structural changes that occur depending on cutting methods on material, were evaluated. On Figures 5(a), 5(b), 5(c), and 5(d) illustrate micro structure photos of cutting border and surfaces of the sample cut by different cutting methods.



a) Before cutting b) Plasma cutting

c) Laser cutting d) Wire erosion cutting

Figure 5 Figures of cutting magnify 500 times micro structure of cutting edges and surfaces of sample which is cut with different cutting methods.

Beginning from the surface of shear of sample, after analyzing micro structure photos and hardness values obtained backwards at 2, 4, 6 mm distances, they have been made into graphic. By examining hardness values with images obtained from micro photos, micro structural alterations of the samples depending on dif ferent cutting methods and dif ferences of current hardness, were examined – Table 2..

Table 2. **Evaluation for effects of different cutting methods on metallurgical structure of cutting border of cut material.**

Cutting Method	St 37
Uncut Material	Micro structure of non-processed material is in loose and low hardness. Rates of alloying element are low.
Plasma Cut	There are structural defects on cutting zone because of overheating and a very hard tissue formed in micro structure of material.
Laser Cutting	Structural defect formed on cutting zone because of overheating. Needled tissue formed and its harness increased.
Wire Erosion Cutting	There are structural defects caused by heating and cooling on cutting zone. Hardness increased partially.

Hardness Changes of the Sample caused by the Method used in Cutting Operation

In order to determine these changes coming into existence on these cut materials, original hardness value of the sample that was not subjected to cutting operation was determined primarily. In order to carry out determination and comparison of the changes after cutting operations, hardness values in Vickers (HV) were measured at 2, 4, 6 mm distances on neighboring surface from cutting edges towards centre.

Graphics, which have been formed to fi gure out what kind of a change is presented to wards inside of material by hardness values on the cut surfaces of the sample subjected to dif ferent cutting methods and to make comparison to before and after the operation, are given on Figures 6, 7, 8.

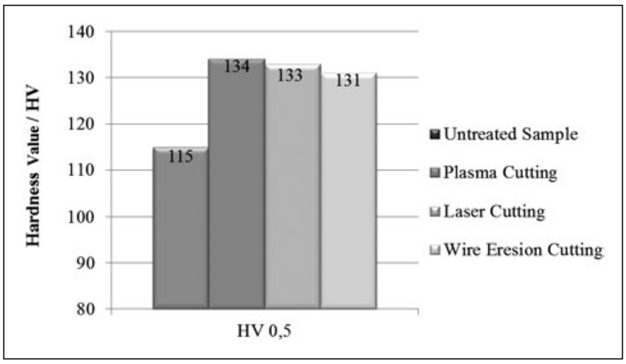


Figure 6 Hardness values at 2 mm distance from cutting edge

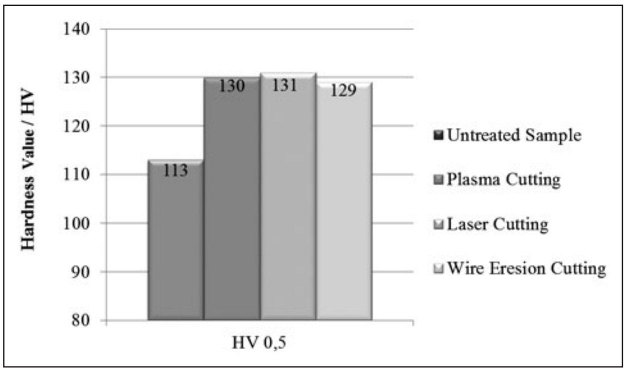


Figure 7 Hardness values at 4 mm distance from cutting edge

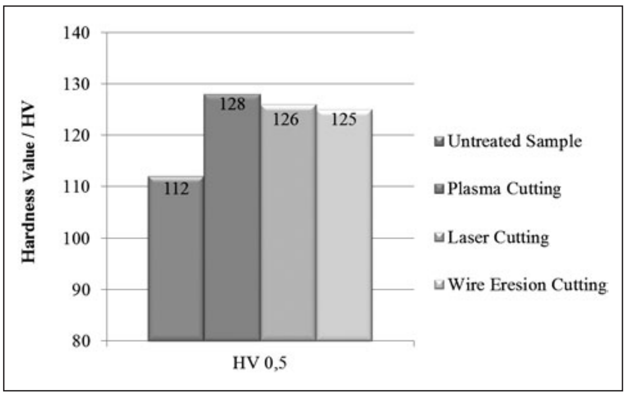


Figure 8 Hardness values at 6 mm distance from cutting edge

When these graphics are examined, you can see how micro structure of material and hardness values change depending on applying cutting methods. It is seen that cutting method with maximum change is plasma, cutting method with minimum change is wire erosion.

By seeing different hardness values of the sample, it has been seen that the most productive cutting method is wire erosion cutting and this method completes the process with minimum cause for internal deformation of material. In other cutting methods, laser and plasma cuttings cause changes for structure of material and therefore they are less advantageous.

CONCLUSIONS

Heat change comes into existence at the surface on which wire erosion cutting method is applied, is smaller than the others, and micro structural and hardness changes depending on cutting in material were minor . For alloyed steel material, it has been observed that other cutting methods apart from wire erosion cutting increase internal stresses and hardness change are higher at the zones closed by cutting edge.

When effects of different cutting methods on metallurgical properties of cut surface are taken into consideration, it is seen that method of wire erosion cutting, which gives the most positive results, comes into prominence. This cutting method has very important advantages, because it doesn' t require quality of surface and additional process, and drives its line to be preferred forward.

While different temperature and cooling effects that occur during metal cutting methods have an important impacts on metallur gical properties of the examined materials, zone af fected by heat is low on the cut surfaces due to effect of temperature is not too high in wire erosion cutting. This situation means that there cannot be a change for mechanic properties depending on the metallurgical properties. This situation means that there will be a little change for mechanic properties depending on the metallurgical properties.

Among three dif ferent method examined in consequence of experiment, if an evaluation is made by taking into consideration micro structural changes of the zone af fected by temperature, it is seen that the most negative method is " Plasma cut" and the most positive method is "Wire erosion cutting".

In different methods, mechanic properties of the material also change depending on the effect of material on metallurgical ef fects after cutting. In consequence of experimental studies conducted, this situation is verified due to hardness values measured on the surfaces cut by dif ferent methods are more dif ferent than original values of the materials.

Since all the applied cutting methods apart from wire erosion contain high heat treatment, they cause a significant change for hardness of material. Hardness changes are been dif ferent depending on the properties of cutting methods. This difference changes depending on heat and temperature formed during cutting and cooling conditions.

REFERENCES

[1] Y.S. Liao, J.T. Huang, H.C. Su, A study on the machining parameter optimization of wire electrical discharge machining. Journal of Materials Processing Technology, 71 (1997), 487-493.

[2] C.Özek, C. Cebeli, Investigation on the Interruption of Gear Steel in Wire EDM Ç8620: Dokuz Eylul University Faculty of Engineering Science and Engineering Journal (2003), 47-52.

[3] K.Y.Chou, C.J. Evans, White Layer sand Thermal Modeling of Hard Turned Surfaces. International Journal of Machine Tools and Manufacture, 39 (1999), 1863-1881.

[4] A.M. Gadalla, Y.M. Cheng, Recent developments in electrical discharge machining. Machining of Advance Composities (1993), 187-205.

[5] A.E. Kutlu, M. Monno, R. Bini, An overview of the method of plasma cutting. Journal Engineers and Machinery (2005), 21-29.

[6] N.S. Guo, H. Louis, G. Meier , Recycling capability of abrasive water jet cutting. In:Lichtarowicz Jet Cutting-Technology (1992), 503-523.

[7] M. Hashish, Optimization factors in abrasive-waterjet machining. Journal of Engineering for Industry (1991), 132-139.

[8] M. Ay, D. Aydoğdu, Experimental investigation of the effects of particle size measurement of Wire EDM cutting parameters. Electronic Journal of Machine Technologies, (2010), 31-44.

Note: The responsible translator for English language: Gülsen Bozdemir, Ankara, Turkey