

THE IMPLEMENTATION OF THE HIGH TECHNOLOGY METHODS OF CUTTING ON St 50 ALLOYED STEEL AND THE EXAMINATION OF THE EFFECTS OF CUTTING OPERATION AT THE SURFACE OF MATERIAL

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Preliminary note – Prethodno priopćenje

Since competition has risen in the manufacturing methods of present conditions, the chance of competition has lost in the situations which new or high technologies aren't exactly known. The proper selection is important for competing in the market conditions. In this study, the aim is to present the most advantaged cutting method for obtaining quality products by using high technology for gaining a better chance of competition. In the test, St 50 alloyed steel is used as sample. This sample is cut with the methods of laser, erosion and abrasive water jet (AWJ) among the cutting operations made with the high technology. The micro structure photograph of surface of sample, which is cut, are taken and the effects of different methods of cutting on the metallurgical structure of material are compared. Also, changes are examined by performing the measurement of rigidity to the core from the edge of cutting. The most advantaged cutting method is presented by considering these examinations.

Key words: steel St50, cutting, wire, laser, water jet

INTRODUCTION

Traditional methods have different disadvantages. In the last years, there are the manufacturing methods called as the high technology cutting techniques.

In the optimization study carried out for the selection of processing parameters in wire erosion, important factors, which affect to the operation performance, by the design method of Taguchi test and the analysis of variance [1]. A hard layer and hair cracks occur on the surface of the work piece depending on the operation conditions, which are generally carried out in the wire erosion, the thermal properties of material [2].

It is presented with studies which are carried out that when the feed rate of jet is decreased, the sharpness of abrasive particles is partially lost in the region of deformation abrasion and the particles which rupture from the materials cut increase the depth of hole by contacting the surface[3]. Since the water jet hasn't the thermal properties on especially material which is cut, it becomes more effective than other methods which it competes with[4]. Depending on the depths of cutting, an increased roughness of surface is inevitable like laser, plasma, underwater plasma and the cutting with oxyacetylene flame [5]. Since the cutting operation with the water jet is provided with water, it is absolutely proper

to the health conditions which the food sector needs[6]. The water jet is never abraded, doesn't become clear its rotations, doesn't leave burrs on the corners, doesn't form forces to deform materials during the cutting, hasn't the effect of heat and so, it is a cutting set in which is not seen the structural defect, obscuration, distortion, deliquation, the formation of spotting and the burning problems. Also, the most complicated types of it can even cut with the high sensibility and very clear surface properties [7].

In the study, the sample is subjected to laser, the wire erosion and the cutting operations. The micro structure photographs of surfaces of sample which is cut and the micro structure photographs of the original photographs are compared and the effects of different high technology cutting methods on the metallurgic structure of material are evaluated.

Also, in the samples cut with different methods, the hardness measurement to the core from the edge of cutting are carried out and the effects of hardness changes are examined on the graphics which are obtained.

MATERIALS AND METHODS

St 50 alloyed steel, which is commonly used, is used as sample. As seen in Figure 1, the sample which is used has 20x20x20 mm. Its chemical properties are given in Table 1. The sample, which is prepared, is cut with laser, the wire erosion and abrasive water jet (AWJ) among the high technology cutting.

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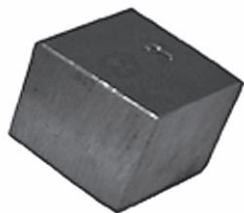


Figure 1 Nontreated sample

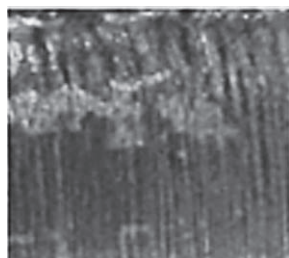


Figure 2 The sample cut with laser

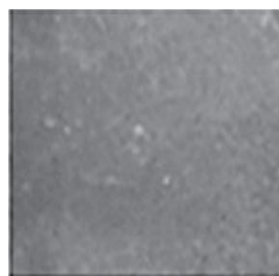


Figure 3 The sample cut with erosion

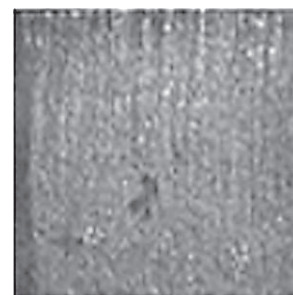


Figure 4 The sample cut with abrasive water jet

Table 1 The chemical properties of St 50 material which is used in the test / wt %

C	Si	Mn	P	S	N
0,17	0,40	0,50	0,040	0,050	0,007

Cutting with Laser

The method of cutting with laser can be defined as the transmittal of the photon energy to the part to be operated with thermal or photochemical ways, the operation of “atom-atom” of the material to be operated with melting and evaporation way and the remove of the dilution material from the cutting region with the help of gases which are used [8].

For the cutting of material with laser, triaxial CNC Laser Cutting Table with 3015 brand in Zinox Company is used Figure 2.

The Cutting with the Wire Erosion

The wire erosion is the cutting method with the help of a wire on which a high flux is conducted. In these tables, when the wire electrode which is connected to different electrical poles is closed to the work piece, the high temperature occurs with the electrical discharges and rasping is removed with the local way of metal melting [9].

In the cutting of the material with the wire erosion, Sodick AQ 535 L 550 x 350 x 300 mm CNC Wire Erosion Cutting Table of Kalıpsan sheet-metal diesinking company is used. The state in which the sample is cut with the wire erosion is presented in Figure 3.

The Cutting with Abrasive Water Jet

The base of the cutting of water jet is that the beam of high speed water jet obtained by the passing of water, whose pressure is increased (4000 bar), from a narrow gap abrades particles from the material with the effect of strike and so, the material is processed [10]. QMAX Abrasive Water Jet Table of Majet Company is used in the cutting of materials with abrasive water jet. In this study, GMA Gamete is used among GMA Gamete, Barton, Gamete and Power Gamete which are commonly used in the systems of abrasive water jet. The state in which the sample is cut with abrasive water jet is presented in Figure 4.

The hardness of surface cut is measured with the value of “HV0.5” in the “SHUMAZU” hardness measuring machine. The photographs of surfaces which are cut are taken by magnifying 200 times of their micro surfaces with the help of the microscope of “OLYMPUS BX-60 MODEL” and “Intel core 2 Duo PC”.

Since the changed hardness value of the sample which is cut with different cutting methods and the structural deterioration and changes which are originated from the cutting method in their internal structure and their surfaces are intended to examine, the edges which are adjacent to the cutting surface of samples which are cut are cleaned with 240-360-400-600-800-1000-1200 swingers which are located at the rotating disk and contain SIC particles in the different extents. The reason of the implementation of the operations of cleaning and polishing on the adjacent surface to the cutting surface is to examine the hardness change belonging to the cutting surface from the edge to the core. The operation is carried out until the base and the surface on which the examinations would be made parallel to each other. These operations are repeated until the intended surface would be obtained for the metallographic examinations. Each material which is polished is subjected to etching with 3 % nital in 6 seconds with the aim of showing the surface structures. After the etching, the surface to be subjected to thinning is cleaned by washing pure water and alcohol. The photographs of etching materials are taken by magnifying 200 times by examining with optic microscope.

For observing the changes in the micro structure of the material, the structure which doesn't affect from the cutting method and form in the edge of cutting and the micro structure in one point is comparatively examined.

For finding differences in the end of examination, many photographs are taken with magnification of 200 times from three different parts of material surface and the changes of deformation and hardness which the cutting method creates in the material structure is determined in the examinations of all photographs.

The hardness measurements of materials, whose micro structures are examined, are made with Vickers hardness measurement device and the results obtained are transferred into graphics. In the same sample, the hardness with two each mm intervals from the edge to the core are measured and the changes of hardness from the edge to the core are determined. Depending on these changes, the effects of different methods are evaluated.

FINDINGS

The Evaluation of Changes Occurring in the Internal Structure of Sample

What changes would be created by the changes of temperature on the external structure of the part during the different cutting operation on the prepared sample is examined and the findings obtained are compared with the micro measurements. The adjacent surfaces of surfaces obtained in the end of cutting are subjected to the examination of internal structure by polishing. After micro film and the hardness measurement, the hardness and the structural changes occurring depending on the cutting methods in the material are evaluated. The photographs of micro structure of cutting edges and surfaces of the sample which is cut with different cutting method are presented in Figure 5(a), 5(b), 5(c), and 5(d).

Changes occurring in the end of these comparisons are shown in Table 2. As seen in Table 2, there are no significant changes in the cutting edge and the internal structure of material surface in only water jet among the cutting methods which are used.

The Hardness Changes of the Sample Which Is Cut with the High Technology Cutting Methods

For determining these changes occurring in the materials which are cut, the original hardness value of the sample which is not primarily subjected to the cutting operation is determined. For making the determination and comparison of changes in the following the cutting operations, the hardness values of Vickers (HV) type in 2,4,6 intervals on the adjacent surfaces to the core from the cutting edges are measured.

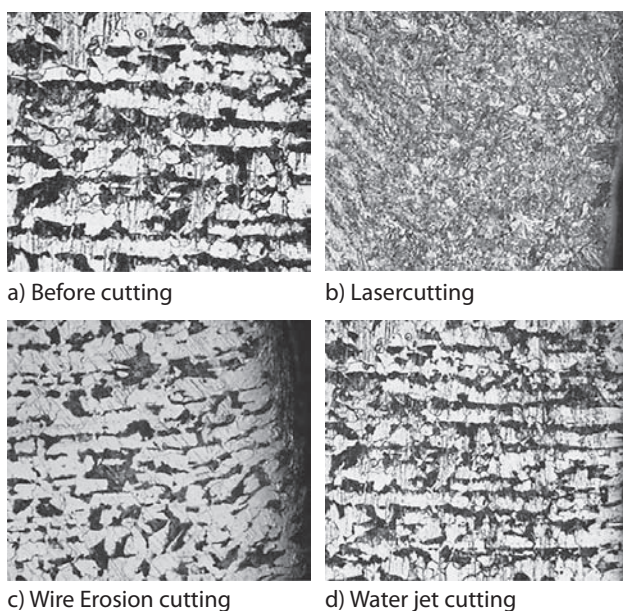


Figure 5 The photographs of cutting magnify 200 times micro structure of cutting edges and surfaces of sample which is cut with different cutting methods

Table 2 The evaluation of effects of material which is cut with different cutting methods on the metallurgical structure in the cutting edge

Cutting Method	St 50
Untreated Sample	Intermediate level hardness of the internal structure of the material. High impact strength.
Laser Cutting	The cutting edge of structural deterioration occurred due to overheating. Carbon were lost.
Wire Erosion Cutting	Structural distortions caused by heat has been on the cutting edge. Increased hardness.
Abrasive Water Jet	No structural changes in the cutting zone. No change in hardness.

Graphics which are formed for understanding how the sample, which is subjected to different cutting methods, shows changes of the hardness values in the surfaces, which are cut, towards the interval part of the material and comparing after and before the operation are presented to Figures 6, 7 and 8.

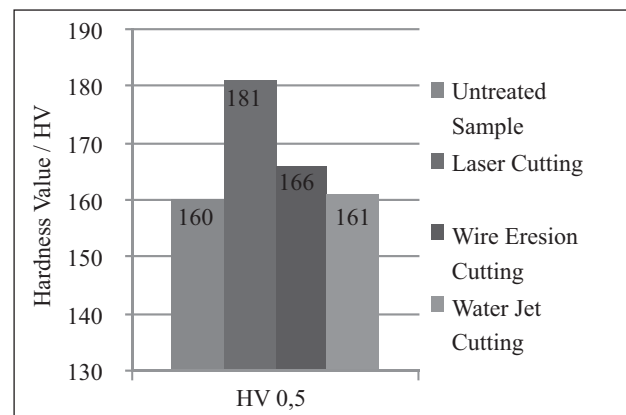


Figure 6 The Hardness Value in 2 mm interval from the cutting edge

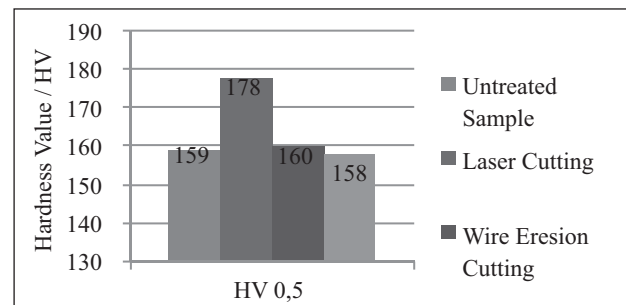


Figure 7 The Hardness Value in 4 mm interval from the cutting edge

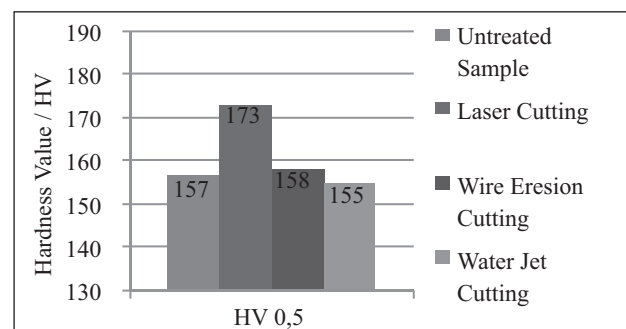


Figure 8 The Hardness Value in 6 mm interval from the cutting edge

When these graphics are examined, it is shown that the hardness values change depending on the internal structure of material in the different cutting methods. This change is shown at most in the laser cutting method and it is shown at least in the water jet cutting method.

It is shown that regarding different hardness values in the material, the operation is completed by having the advantage in the top level without leading to the internal deformation in the materials. The wire erosion and the laser cutting among other cutting methods follow to the water jet in terms of advantage.

The results of these measurements are presented to Table 4. When this table is examined, it is shown that when the original material structure and hardness are compared in terms of the metallurgical features and the changes in the hardness, the best result is obtained from abrasive water jet and the cutting method.

The hardness of surfaces which are cut with abrasive water is approximately viewed in very close values to the original material hardness.

Table 4 % hardness values in the surfaces which are cut with different methods depending on the original hardness values of materials which are cut

CuttingMethod	Hardness / HV	Change / %
Core	160	-
Waterjet	159	0,64
WireEresion	166	3,75
Laser	181	13,13

CONCLUSION

In the study which is carried out with the aim of this study, the results in the following are found.

- In the surfaces which are cut with the cutting method of abrasive water jet, as any thermal operation doesn't occur in the region where the jet ray contacts with, any changes of the internal and the differences of hardness doesn't occur in the materials.
- Depending on the micro structure of the material which is cut, when the region affecting to temperature and the extents of this region are regarded, the high temperature and the shock cooling are impor-

tant for the structural changes which occur in some methods. Depending on the features of cutting methods, the structure of coarse grained in some methods and the structure of fine grained in some methods depending on shock cooling draw attention. In the methods except for the cutting with AWJ, the formation of high temperature and the shock cooling lead to the deformation to the micro structure in the region which is cut.

REFERENCES

- [1] Y. S. Liao, J. T. Huang, H. C. Su, A study on themachining parameter optimization of wire electrical discharge machining. *Journal of Materials Processing Technology*, 71 (1997), 487-493.
 - [2] K. Y. Chou, C. J. Evans, White Layersand Thermal Modeling of Hard Turned Surfaces. *International Journal of Machine Tools and Manufacture*, 39 (1999), 1863-1881.
 - [3] C. Ojmertz, A study on abrasive water milling. Department of Production Engineering, Thessis Degree of Doctor Philosophy, Sweden, 1997.
 - [4] A. Akkurt, Comparision of cut surface properties obtained from aisi 1030 steel by abresive water jet and by other methodologies. *Pamukkale University Journal of Engineering Sciences*, 15 (2009), 142-152.
 - [5] N. S. Guo, H. Louis, H. G. Meier, Recycling capability of abrasive water jet cutting. In: *Lichtarowicz Jet Cutting Technology*, (1992), 503-523.
 - [6] A. Akkurt, Effect of cutting speed on surface roughness in AWJ cutting Applications of comercial püre aluminiumand Al-6061 Aluminiumalloy. *Journal of Polytechnic*, 8 (2005), 69-79.
 - [7] C. Ojmertz, Abrasive water jet machining chalmers tekniska hogskola. *Chalmers Universityof, Goteborg Sweden* (1994), 91-96.
 - [8] H. Y. Zheng, Z. Z. Han, Z. D. Chen, W. L. Chen, S. Yeo, Quality and cost comparisons between laser and water jet cutting. *Journal of Material Processing Technology*, 62 (1996), 294-298.
 - [9] M. Ay, D. Aydođdu, Experimental investigation of the effects of particle size measurement of Wire EDM cutting parameters. *Electronic Journal of Machine Technologies*, (2010), 31-44.
 - [10] N. Geren, T. Tunç, Containing Water-Jet Cutting Systems Structural Differences Determiningthe most appropriate one. *Journal of Engineers and Machine*, 42(2001), 42-49.
- Note:** Theresponsibletranslatorfor English language: Gülsen Bozdemir, Ankara, Turkey

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