LOGIC
Journal of Engineering Design and Technology
Vol. 21 No. 3 November 2021; p. 172 - 178

p-ISSN : 1412-114X
e-ISSN : 2580-5649
http://ojs2.pnb.ac.id/index.php/LOGIC

EXPERIMENTAL STUDY OF THE EFFECT OF PLASMA CUTTING ON THE TENSILE STRENGTH OF MATERIALS "FE"

I Wayan Suma Wibawa [1)], I Ketut Suherman [2)]

1,2) Lecturer at Jurusan Teknik Mesin, Politeknik Negeri Bali, Indonesia. Jalan Kampus Bukit Jimbaran, Kuta Selatan, Kabupaten Badung, Bali – 80364., Telp. (0361) 701981 (hunting) Fax. 701128

Correponding email [1,2)]:
sumawibawa@pnb.ac.id
ketutsuherman@pnb.ac.id

Abstract. The cutting process in plasma cutting begins with the formation of a pilot arc between the electrode and the workpiece as a result of the electrical ionization reaction of the highly conductive cutting gas. The gas is heated by the pilot arc until its temperature rises very high then the gas will be ionized and become a conductor of electricity. When the gas stream leaves the nozzle, the gas expands rapidly carrying the molten metal so that the cutting process continues. This plasma temperature can reach 33,000°C, approximately 10 times the temperature produced by the reaction of oxygen and acetylene. If this is related to the mechanical properties of the material, where the material has been heated it will result in changes in the mechanical properties of the material in the heating area/around the cutting plane. Tensile testing is the most widely used type of test because it is able to provide representative information on the mechanical behavior of the material. Seeing an incident like this, it is necessary to test the Effect of Plasma Cutting on the Tensile Strength of 'Fe' Materials through a tensile test. Several studies have shown that torch height, amperage and cutting speed can affect material properties. The best tool parameter settings are obtained at a travel speed of 500 mm/min, 75 amperes and a torch-material distance of 3 mm, so that these settings are used as a reference in this study. In analyzing the data, the authors compare the results of plasma cutting testing with conventional cutting, in order to know the changes in mechanical properties that occur.

Keywords: plasma cutting, tensile test, strength of material

1. INTRODUCTION

The lower the torch distance used, the smaller the value of the kerf width and the resulting surface roughness [1][2]. The results show that the lower the rate of decline, the higher the hardness value and vice versa [3]. This process uses a concentrated electrical arc which melts the material through a high-temperature plasma beam. All conductive materials can be cut. Plasma cutting units with cutting currents from 20 to 1000 amperes to cut plates with inert gas, 5 to 160 mm thicknesses. Plasma gases are compressed air, nitrogen, oxygen or argon/ hydrogen to cut mild and high alloy steels, aluminum, copper and other metals and alloys [4][5]. The quality characteristics that were assessed included the surface roughness, the heat affected zone and the conicity of the cut geometry. Using design of experiments and analysis of variance, it was found that the surface roughness and the conicity are mainly affected by the cutting height, whereas the heat affected zone is mainly influenced by the cutting current [6].

The PAC parameters studied were how to have setting for the parameter such as Gas Pressure, Current flow, Cutting Speed and Arc gap of machine [7]. The plasma process is suitable for electrically conducting materials of thickness from 1 to 600 mm. The plasma cutting process may be used to cut any conductive material, including carbon steel, stainless steel, aluminum, cooper, brass, cast metals and exotic alloys [8]. The quality characteristics that were assessed included the surface roughness, the heat affected zone and the conicity of the cut geometry. Using design of experiments and analysis of variance, it was found that the surface roughness and the conicity are mainly affected by the cutting height, whereas the heat affected zone is mainly influenced by the cutting current [9]. Plasma cutting, whether conventional or precision, is a fast, economical way to produce parts. Manufacturers should first understand the process, and then determine if this or another process produces the parts more effectively [10]. The term for advisable state of plasma arc is called stability of arc too. The stability of arc is keeping the plasma jet in desired form. It is possible to be provided by: shape of plasma torch; streaming jet; water. We must monitor these parameters: temperature and electrical conducting; density of plasma jet; diameter of plasma beam; degree of the plasma beam focusing in out put from nozzle [11]. Plasma is a thermally highly heated up, electrically conductive gas, which consists of positive and negative ions, electrons as well as of excited and neutral atoms and molecules. At the physics they often speak of the 4th state of aggregation [12]. For the cutting process first of all a pilot arc ignition by high voltage between nozzle and cathode takes place. This low-energy pilot arc prepares by ionization in parts the way between plasma torch and workpiece. When the pilot arc touches the workpiece (flying cutting, flying piercing), the main arc will start by an automatic increase in power [13].

The PAC process uses this high temperature, constricted, high velocity jet of ionized gas exiting from the constricting orifice of the torch tip to melt a much localized area and remove the molten material from the metal being cut by the force of the plasma jet. The force of the arc pushes the molten metal through the work piece and severs the material. Extremely clean and accurate cuts are possible with PAC. Because of the tightly focused heat energy, there's very little warping, even when cutting thin gauge sheet metal thickness. PAC also offers quality gouging and piercing capabilities [14].

"Torch stand-off" is the distance the outer face of the torch tip or constricting orifice nozzle is to the base metal surface. This standoff distance will be determined by the thickness of material being cut and the amperage required. Low heat build-up while cutting with less than 40 amperes may allow dragging the torch tip on the material. If a high build-up of heat is expected, a standoff distance of 1/16" to 1/8" will be required. This is easily accomplished with a Miller ICE torch with a "Drag Shield". The "Drag Shield" works with the flow dynamics of the torch to provide better cooling of the consumable parts for longer parts life. This permits the operator to drag the torch on the work piece while cutting at full output, which increases operator comfort and makes template cutting easier [15]. The treatment of the nozzle is physical condition checking, cleaning and proper testing. This test is done by Plasma temperatures can reach 33,000°C, approximately 10 times the temperature produced by the reaction of oxygen and acetylene [1]. If this is related to the mechanical properties of the material, where the material has been heated it will result in changes in the mechanical properties of the material in the heating area/around the cutting plane. Tensile testing is the most widely used type of test because it is able to provide representative information on the mechanical behavior of the material. Seeing an incident like this, it is necessary to test the Effect of Plasma Cutting on the Tensile Strength of 'Fe' Materials through a tensile test.

2. METHODS

Material with a length of 500 mm, a width of 200 mm and a thickness of 8 mm, as shown in the picture then cut with plasma cutting and manually (bandsaw) with a cut size of 200 mm long, 20 mm wide and 8 mm thick.

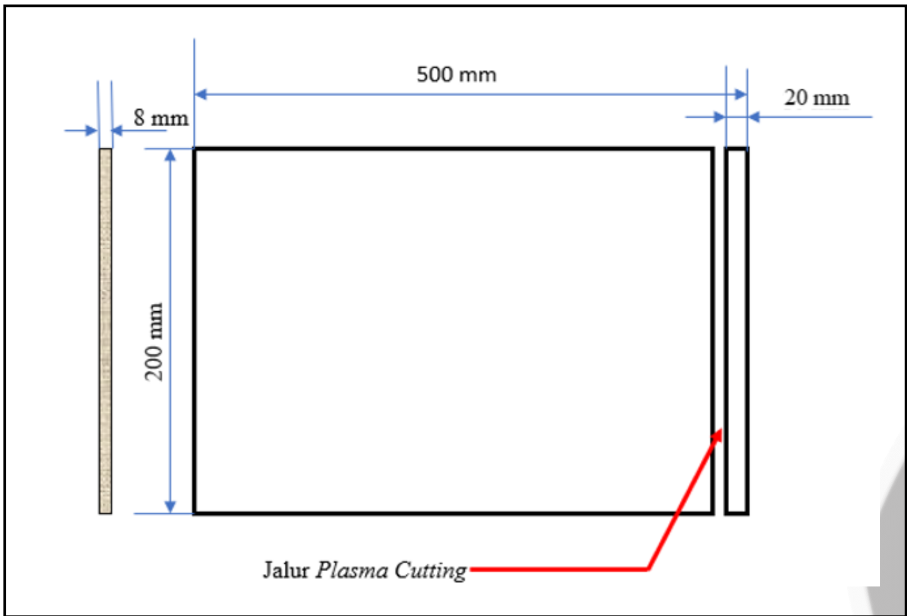

Figure 1. Test material design

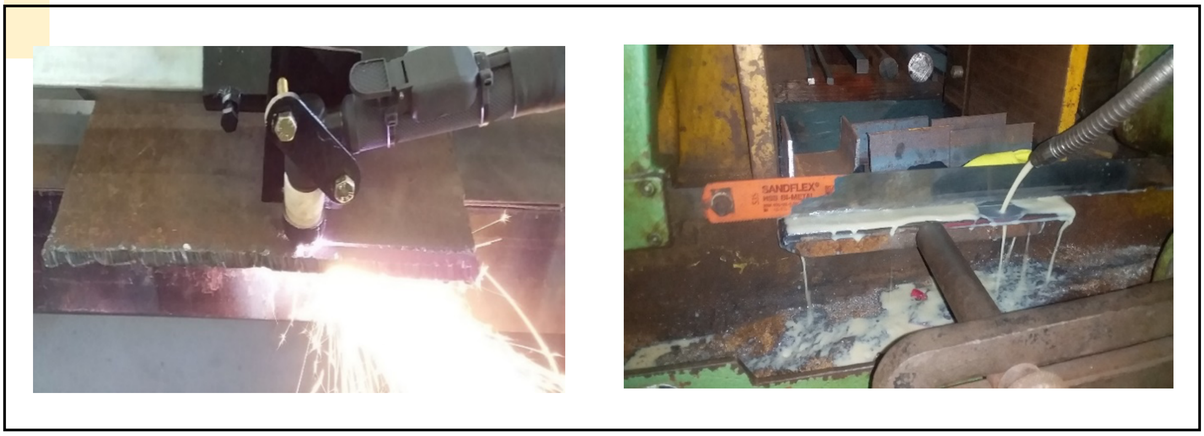

Figure 2. Plasma cutter and manual cutter

Figure 3. Cutting result

After the plasma cutting process is carried out, the test object is prepared in such a way according to the test method, to fit the clamp on the tensile test equipment, then the test material is tested for tensile strength to obtain the required data. The dimensions of the test object are made 200 mm X 20 mm X 8 mm then a notch is made on the cutting results to be tested as shown in Figure 4.

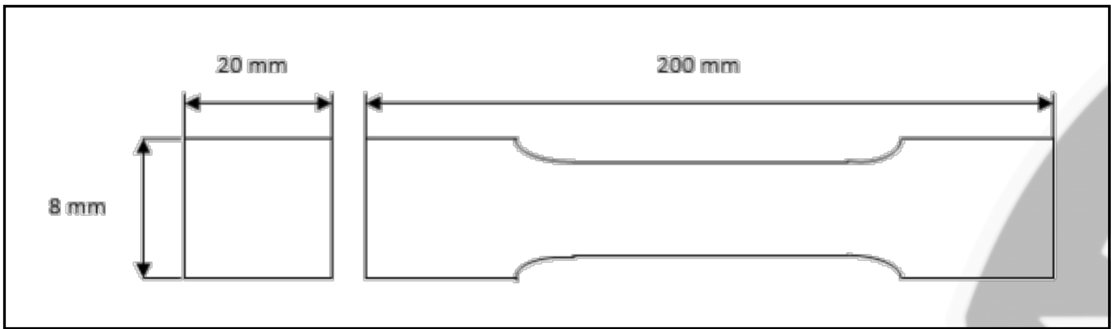

Figure 4. Tensile test object

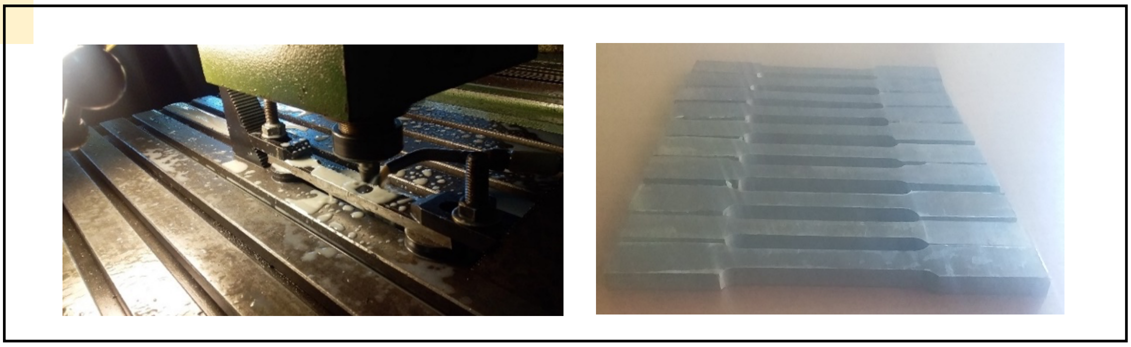

Figure 5. Formation of test object and specimens ready for test

Figure 6. Tensile strength testing process

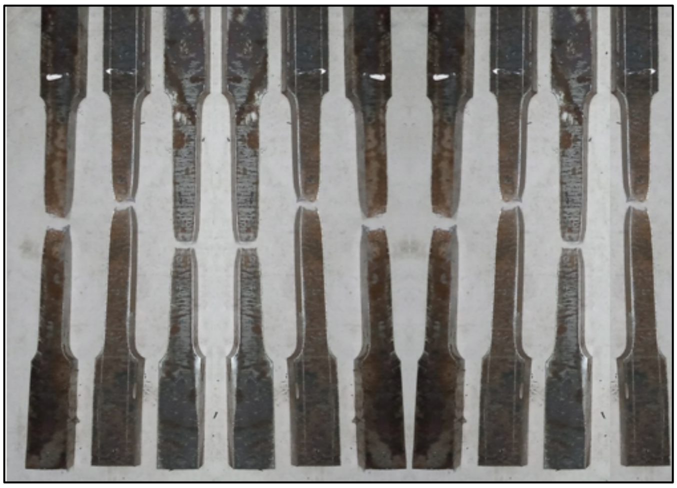

Figure 7. Tensile strength testing process

3. RESULTS AND DISCUSSION

3.1. Research data

To find out the properties of the material above, a test or evaluation must be carried out with the aim of obtaining a material that is in accordance with its classification. Tests on materials in general can be divided into two parts, namely [5]:

1.) Destructive Test This test is destructive to the workpiece, so in this test a test specimen is needed (test specimens are duplicates of workpieces derived from the same material).
    Tensile Test
    The purpose of conducting a mechanical test is to determine the material response of a construction, component or fabricated assembly when subjected to external loads or deformations.
2.) Non-Destructive Test This test does not damage the workpiece, so no test specimen is needed and can be directly tested on the workpiece. This is done with the aim of seeing surface defects and below the surface of the workpiece.

The process of testing the specimens was carried out at the Bali State Polytechnic Material Testing Laboratory. The test carried out is a destructive test to determine the tensile strength of the welding results. The number of samples is 10 for each variable. The test results can be seen in Table 1 below.

Table 1. Research data

Sample	Material Tensile Strength (kgf/mm²)			
	Manual cutting		Plasma Cutting	
	ST 42	Used materials	ST 42	Used materials
1	36.48	33.576	37.734	33.79
2	36.97	33.624	37.612	33.766
3	36.508	33.398	37.704	33.804
4	36.564	33.502	37.504	33.998
5	36.85	33.56	37.48	33.82
6	36.75	33.6	37.552	33.852
7	36.624	33.486	37.652	33.902
8	36.86	33.442	37.802	33.798
9	36.716	33.492	37.588	33.832
10	36.54	33.546	37.732	33.786
Average	36.69	33.52	37.64	33.83

The tendency of the material to fracture or crack more quickly if given the same stress is the brass material followed by a mixture of steel and iron. This is related to the strength of the material, where brass has a very low tensile strength when compared to alloy steel and iron. Factors that cause fracture, due to the rate of deformation and the origin of the material formed [16].

In testing iron, brass and mixed steel with a tensile test, if each material is pulled, there will be an elongation of the original length and this will cause a shrinkage of the width from the original width. This means that the percentage effect of the width shrinkage will be proportional to the percentage of the elongation of the material. This comparison is known as the Poisson ratio. The Poisson ratio for each material used is different from one another, where the Poisson ratio for iron is msteel = 0.106±0.002, brass is mbrass = 0.104±0.002 and manneal alloy steel = 0.103±0.005. The Poisson ratio for iron is greater than the Poisson ratio for brass and alloy steels. This means that the elasticity of the iron material is greater than that of brass and mixed steel, and besides that, the composition of the formation or composition of the material is also different when the tensile treatment is carried out by the force distributed to the material which also affects the strain [16].

3.2. Data processing

The test results show:

1. There is a difference in tensile strength from the results of the cuts made, where there is a change/increase in the tensile strength of both the ST 42 plate and the used plate. For the New plate with manual cutting after averaged it has a tensile strength of 36.69 kgf/mm2 and with plasma cutting after averaging the

tensile strength increases to 37.64kgf/mm2. While the used plate with manual cutting after averaged has a tensile strength of 33.52 kgf/mm2 and with plasma cutting after averaging the tensile strength increases to 33.83 kgf/mm2

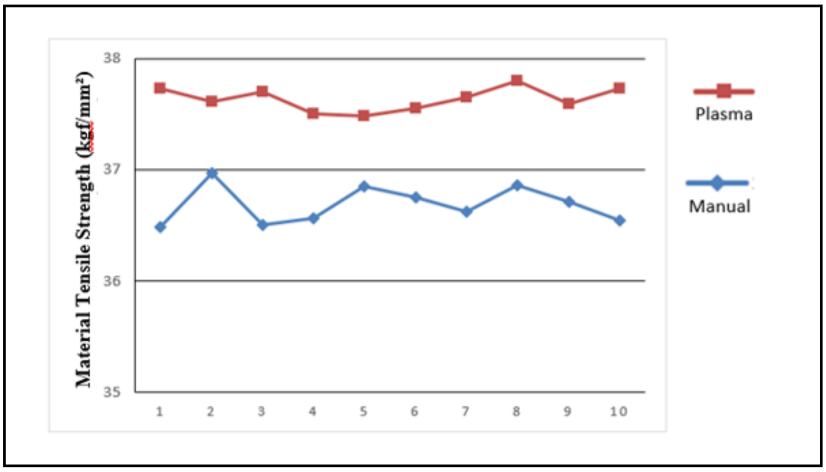

Figure 8 Graph of manual and plasma cutting results the new Plate

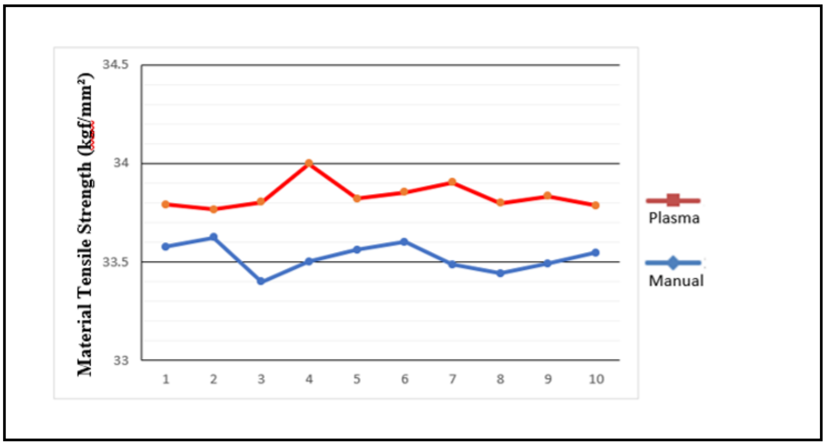

Figure 9 Graph of manual and plasma cutting results the used Plate

The increase in tensile strength is the result of the influence of cutting temperatures with high plasma cutting making structural changes in the metal so that hardening occurs. On the one hand, these changes have both good and bad effects, the good being that the material becomes stronger in accepting the load, while the bad thing is that in the next processing stage, the material requires harder tools/equipment for processing; Another effect is that with increasing hardness, it will automatically become more brittle/breakable in other words the material will have a lack of receiving vibrations.

2. Based on the data obtained, the increase in tensile strength for new materials is 2.58% while for used materials it is 0.93%, it should be noted that this value is not absolute. Corrosion due to the environment is also human error during the cutting process and specimen making.

4. CONCLUSION

There is an increase in tensile strength in the new material by 2.58% while in the used material by 0.93%.

5. ACKNOWLEDGEMENT

Finally, I would like to thank everybody who was important to the successful realization of this paper. This paper is far from perfect, but it is expected that it will be useful not only for the researcher, but also for the readers. For this reason, constructive thoughtfull suggestion and critics are welcomed.

6. REFERENCES

[1] Akhmad, Al. Antoni. 2009. Pemesinan nonkonvensional *plasma arc cutting*. Palembang : Jurnal Rekayasa Mesin. Vol. 9, No.2 : 51–55;

[2] Fathony Nada Saputro dan Wirawan Sumbodo. 2019. Pengaruh ketinggian *torch* terhadap lebar *kerf* dan kekasaran permukaan pada pemotongan *cnc plasma arc cutting* dengan bahan baja ST 37. Semarang : Jurnal Kompetensi Teknik Vol. 11, No.2, November 2019;

[3] Ami Rima Rahmawati dkk. 2019. Pengaruh kecepatan pemotongan dan ketebalan bahan terhadap kekerasan dan kekasaran permukaan baja AISI 1045 menggunakan *cnc plasma arc cutting*. Semarang : Jurnal Dinamika Vokasional Teknik Mesin. Volume 4 Nomor 2 Oktober 2019 Hal 93-98;

[4] Azian Diki dkk . 2021. Identifikasi Hasil Pemotongan Plasma Cutting Dengan Variasi Travel Speed : Jurnal Politeknik Negeri Batam;

[5] Jeffus, Larry. 2011. *Welding And Metal Fabrication. 1nd ed. England: Cengage Learning.*

[6] K. Salonitis and S. Vatousianos,(2012). *Experimental investigation of the plasma arc cutting process, Manufacturing and Materials Department*, Cranfield University.

[7] V. Singh, (2011). Analysis of process parameters of Plasma arc cutting using design of experiment, Thesis National Institute of Technology

[8] *Experimental Results Concerning The Variation Of Surface Roughness Parameter (Ra) At Plasma Arc Cutting Of A Stainless Steel Workpiece* Sanda-Maria Ilii

[9] Asiabanpour Bahram (2009) *Optimising the automated plasma cutting process by design of experiments. Int. J. Rapid Manufacturing,* Vol. 1, No. 1, 2009.

[10] Hatala Michal Faculty of Manufacturing Technologies of the Technical University of Košice Štúrova *The Principle of Plasma Cutting Technology and Six Fold Plasma Cutting*. 5 th International Multidisciplinary Conference

[11] Sommer, C.: *Non-traditional machining handbook. Advance publishing*, Houston, 2000, 432 p. ISBN 1-57537-325-4

[12] Maňková, I.: Progressive Technologies. Vienala Košice, 2000, pp. 225-240 (in Slovak).

[13] Zajac, J. - Miškovičová, M. - Miškovič, V: *Cutting facilities of new type of came cutting material. In: Proceedings of the conference PPTO*, Košice, 1995, pp. 138-139.

[14] *Parweld Plasma Process Synopsis September 2001 Release,* England (books)

[15] *Plasma Arc Cutting Theory, Miller Electric Mfg. Co. Publication*. (books)

[16] Souisa Matheus, 2011, Analisis Modulus Elastisitas Dan Angka Poisson Bahan Dengan Uji TariK, Jurnal Barekeng Unpatti, Poka-Ambon Vol. 5 No. 2 Hal. 9 – 14 (2011)