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ANALYSIS OF THE EFFECT OF CUTTING SPEED AND CURRENT ON SURFACE ROUGHNESS WITH CNC PLASMA CUTTING ON STEEL PLATES SS400

Gunawan Budi Susilo[1], Beni Tri Sasongko[2], Prabuditya Bhisma Wisnu Wardhana[3]
[1] Industrial Engineering Study Program, Faculty of Science and Technology, State Islamic University Sunan Kalijaga Yogyakarta, Indonesia
[2] Manufacturing Engineering Study Program, Faculty of Engineering, Yogyakarta State University, Indonesia
[3] Applied Undergraduate Study Program in Manufacturing Engineering Technology, Banyuwangi State Polytechnic, Indonesia

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ABSTRACT

Surface roughness characteristics are very important data in the machining process. This study aims to determine how much influence the cutting speed and current variation with air pressure of 1 MPa on surface roughness of SS 400 steel plate cutting using CNC plasma cutting on roughness. The independent variables of the research are variations in cutting speed and current. Testing the cutting speed of the material removal rate (MMR) using the method of reducing the mass of the workpiece and calculating the empirical formula, testing the surface roughness using the surface roughness tester TR 1200. The data are presented in the form of tables and graphs. The results of the material removal rate test for reducing the mass of the workpiece, the lowest value obtained in this study was 378 mm/min^3 with a cutting current of 110 A and the highest was 1890 mm/min^3 with a cutting current of 100 A, while at the melting point at a current of 90, 100, 110 Ampere get a value of 0.444, 0.494, 0.543 cm/min^3.baSe The results of the roughness test, which should be that the higher the melting point value, the higher the roughness level, at 90 Ampere cutting currents get an average value of 12,502 µm, 100 Ampere currents have an average value of 8.653 µm and, 110 Ampere currents have an average value of 7.56 µm . Cutting speed affects the cutting current, the results of calculations using the mass weighing method and using calculations, the results of testing the measurement of the roughness value are getting smaller.

Corresponding Author:

Gunawan Budi Susilo
Industrial Engineering Study Program, Faculty of Science and Technology, State Islamic University Sunan Kalijaga Yogyakarta, Indonesia
Email: gunawanbudisusilo@gmail.com

INTRODUCTION

Along with the development of an increasingly advanced industrial world, it encourages industry players to increase the need for more effective and efficient use of tools. More sophisticated tools will encourage industry players to get maximum results. Plasma cutting is one of the tools that will encourage industry players to get maximum results (Agnitias 2019). Plasma cutting is a process used to cut metal using plasma. In the process compressed air is blown at high speed from the nozzle and at the same time an electric arc is formed through the gas from the nozzle to the surface that has been cut and converts some of the gas into plasma (Riyadi 2019) . By using plasma, the cutting method becomes very efficient and offers great advantages in terms of cutting speed and initial cost when compared to oxy-fuel cutting and water jet cutting. (Dedy 2020).

Plasma cutting is a process used in cutting metal which utilizes plasma energy coming out of the plasma torch which is pressed out at high speed. Plasma cutting is a process where steel and other metals are cut using a plasma torch (Hamid, 2018). Current strength and gas pressure are two cutting parameters in adjusting the use of plasma cutting tools when operating. Parameters that must be considered in plasma cutting include electrical polarity, current magnitude, gas rate speed, cutting speed and so on (Hidayat 2021).

Non-conventional plasma cutting has become a lifeline in the industrial world, of course it will be very helpful to get maximum final results, especially in cutting accuracy. (Malik 2021). Industry players demand that the tools used must help in their work. In the process of cutting plates, precision is needed so that later it does not cause kerfs that are too wide and precision will also be achieved (Saiful 2019). What is meant by kerf is the cutting gap that arises from cutting the material, kerf varies in size depending on the influencing factors. To get a precise kerf, there are several factors that must be met including current strength, air pressure, torch height, cutting speed (Hamid, 2019)

Medium carbon steel is steel with a carbon content of 0.25 - 0.55%. The cutting process begins with the formation of an arc between the electrode and the workpiece from the reaction of electrical ionization to the cutting gas. The gas is heated by the arc so that the temperature increases and then the gas will be ionized to become electrically conductive. The ionized gas under these conditions is called plasma. Plasma is flowed through the nozzle to cut the workpiece (Akhmad, 2009). Parameters that affect the quality of the cutting material and processing time using a plasma arc are: cutting speed, current strength, torch height to the cutting surface, gas pressure and plasma gas flow (Salonitis & Vatousianos, 2012).

One of the parameters that affect cutting using plasma arc cutting is current strength. Current strength is a parameter that directly affects the penetration and speed of metal melting (Susilo 2024). If the current strength used is higher, the temperature in the plasma arc increases which makes the cutting process faster (Pawar S, 2017). The highly focused heat energy during metal cutting using plasma arc cutting can increase the value of the cutting width and changes in the hardness of the metal material. The effect of cutting width and hardness on the cutting process using plasma arc cutting is disadvantageous because, if the cutting width is too large, the wasted material will increase. The increase in wasted material causes the accuracy of the size of the cutting results to decrease so that the cutting results are not in accordance with the design or drawing (Tiyan 2022). Changes in hardness of the cut material will cause the length of the process for the next work step. If one of the production processes is hampered, it will cause a decrease in production results which will cause losses (Pambudi 2022).

The quality of the cut using CNC Plasma affects several aspects. Among them are the bevel angle, the width of the cut, and the roughness level of the cut. When the plate is cut with CNC Plasma, the heating process affects the metal structure. Metal hardness is influenced by gas pressure factors, the shape of the cutting tool and metal conditions at the time of cutting. Another study conducted showed the results of the impact of variations in current strength and rate of gas flow on the width of the cutting groove gap using plasma arc cutting techniques on 5083 aluminum material (Hamid 2019). In this study using the Taguchi method as an effort to optimize the parameters in the cnc plasma cutting process produces a bevel angle factor, the width of the cut, and the roughness of the cut. From the results of previous studies, it can be seen that cutting speed and current strength have a significant effect on cutting results.

METHOD

The research method used is an experimental study using variable cutting speed variations of 20, 25, 30 mm/min, and current strength of 90, 100, 110 Amperes. Adjusting the current strength aims to achieve optimal cutting results for cutting width and surface roughness. The cutting process using CNC Plasma Ultron Orion. Kompressor is used to supply air to the torch in the cutting process. The gas pressure during the cutting process is 1 MPa.

Research Tools

In this research using CNC Plasma Ultron Orion

Figure 1 CNC Plasma Arc Cutting Machine

Surface Roughness Tester is a tool used to measure the surface roughness of materials or products that can be seen in Figure 2.

Figure 2 Measuring Instrument Sourface Roughness Tester TR 1200

This vernier is to measure the workpiece resulting from the cutting process. The term used can be seen in Figure 3.

Figure 3 Measuring Instrument of the Vernier Caliper

To find out whether the weight of the workpiece before and after cutting can be seen in Figure 4.

Figure 4. Measuring Instrument Scales

Research Materials

The material used in this study is SS 400 steel which will be machined with a CNC plasma arc cutting process with the following specifications: (PxLxT) = (100x50x10) mm with a total of 9 workpieces in this experiment, which can be seen in Figure 5.

Figure 5. Workpiece Size

The cutting process using computer programming with Y 25 X 0 coordinates and the occurrence of the plasma arc life cut straight as far as 100 mm, with the cutting parameters used as follows:

Table 1. Parameter Testing Methods

Parameter	Description
Current	90, 100, 110 Ampere
Cutting speed	20 mm/min, 25 mm/min., 30 mm/min
Air Pressure	1 Mpa
Cutting Length	100 mm
Size After Cutting	10 mm x 25 mm x 100mm
Material	SS 400
Hole diameter Nozzel	1.5 Mm

RESULTS AND DISCUSSION

In the SS400 steel plate with a size of 100x50x10 mm used in this experiment to obtain the density of the workpiece specimen, by weighing the initial weight of the experiment before the workpiece cutting process and the final weight of the experiment after the workpiece cutting process. It can be seen in table 2 from the results of the MMR workpiece weighing value and after the EDM factor as follows:

Table 2. workpiece weight

Spesimen	Sebelum di potong (kg)	Sesudah dipotong (kg)
A1	0.375	0.370
A2	0.386	0.372
A3	0.382	0.379
B1	0.380	0.374
B2	0.388	0.379
B3	0.379	0.367
C1	0.381	0.373
C2	0.400	0.390
C3	0.400	0.385

Workpiece specimen cutting speed calculation

Table 3. Grouping against Cutting Speed against Cutting current

Spesimen	C S	Arus Pemotongan	MMR
A1		90 A	631
A2	20 mm/min	100 A	1760
A3		110 A	378
B1		90 A	757
B2	25 mm/min	100 A	1130
B3		110 A	1510
C1		90 A	1010
C2	30 mm/min	100 A	1260
C3		110 A	1890

Description:

C S: is the cutting speed parameter of the plasma CNC machine

MMR: the removal rate of a workpiece material

Melting point material removal rate (MMR) in EDM factor

The EDM (electric discharge machine) process is an electric discharge (discharge) in the form of plasma cutting the workpiece produced by the electrode with air pressure, because it will become ionized in the plasma cutting gap between the electrode and the workpiece (Riska 2019). In SS400 steel material has a carbon content below 0.3%, so SS400 steel is classified as low carbon steel. The melting point of SS400 steel reaches 1500^{o}C.

$$MMR : \frac{KI}{T_m^{\ 1,23}}$$

Where:

MMR = Material release rate, (cm3/min)

K = Personality costante, 5.08 in US units, 39.86 in SI units

I = Discharge current. (Ampere)

T = Melting temperature of the workpiece. (^{o}F or ^{o}C)

Ampere 90 = 0.444 cm^3/min

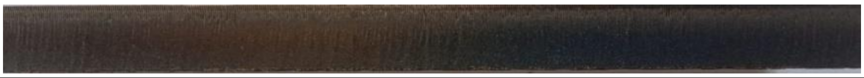
Ampere 100 = 0.494 cm^3/min

Ampere 110 = 0.543 cm^3/min

Workpiece surface roughness test results

Surface roughness is the most important thing needed in the industrial world in the field of manufacturing of course, because it is used as a reference parameter to determine a product specification desired by engineering to get roughness. This image of the results of CNC plasma cutting Art cutting of several specimens and different parameters when cutting, obtained from a cellphone camera can be seen in table 4.

Table 4. Plasma cutting results

Specimen	CNC Plasma Cutting Experiment Picture
A1	
A2	
A3	
B1	
B2	
B3	
C1	
C2	
C3	

Workpiece cutting on MMR

From the test results of cutting speed on material removal rate (MMR) using the method of weighing the workpiece before and after use in the CNC plasma cutting process Art cutting can be made a graph to get a comparison of the results of workpiece material removal. The graph of the effect of cutting speed on MMR) of each type of workpiece can be seen in Figure 6.

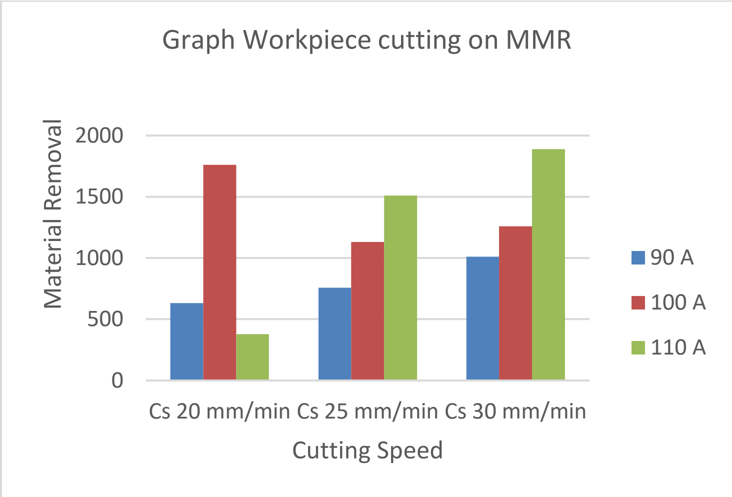


Figure 6. Graph of workpiece cutting at MMR)

After conducting research on various specimens, then from Figure 6 the test results of cutting the workpiece at MMR with the method of reducing the mass of the workpiece from cutting speed 20 mm/min, 25 mm/min, 30 mm/min, showing an average value of 1147.33 mm^3 /min material removal during the cutting process, each material removal rate shows that at a cutting speed of 20 mm/min experiencing up and down graphs with the highest value at a current of 100 A reaching a value of 1890 mm^3 /min, at a current of 110 A there is a decrease in the value of 378 mm^3 /min and also shows the most lace of the graph. From each cutting speed of 25 mm/min and cutting speed of 30 mm/min, the greater the cutting current value, the higher the MMR). From the results of the MMR) analysis that the effect of cutting current produced affects the MMR) resulting from CNC plasma Arc cutting.

Figure 6 shows that the average effect of cutting current with a cutting speed of 20 mm/min shows a result of 939.66 mm^3 /min, at a cutting speed of 25 mm/min shows a result of 1155.33 mm^3 /min, and a cutting speed of 30 mm/min shows a result of 1378.66 mm^3 /min. So it is concluded that the average value obtained from the calculation of the graph increases. This is influenced by the release of material on the cutting current of the workpiece during the CNC plasma Arc cutting process using a cutting time of 1 minute with a cutting current of 90 A, 110 A, 110 A.

Melting point in MMR is affected by EDM

From the results of the melting point test on the MMR) which is influenced by the electric discharge machine (EDM) using the empirical calculation method that has been used previously, in the CNC plasma cutting process Art cutting. There are several parameters listed on the machine that can be made a graph to get a comparison of the results of the removal of workpiece material against EDM using the formula. The melting point graph on the (MMR) affected by the EDM) for each machine parameter listed can be seen in Figure 7.

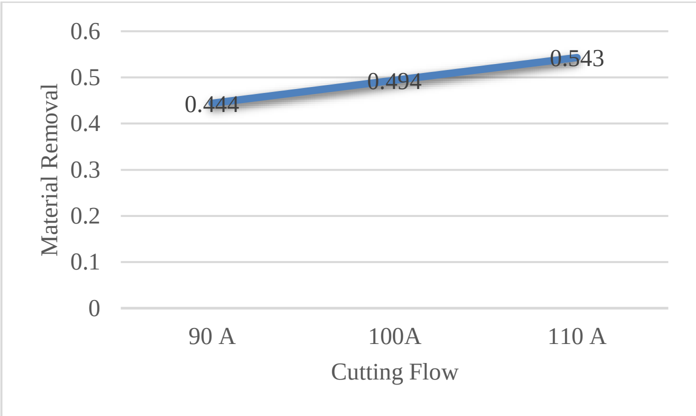


Figure 7 MMR to EDM graph

Based on the strong cutting current and the value of material removal, the calculation can be made as illustrated in Figure 7 above, from the graph it is concluded that the value obtained from the calculation of the graph increases. from each material removal rate (MMR) influenced by EDM) shows that the greater the cutting current value, the higher the level of influence of MMR on EDM.

Effect of current variation and cutting speed parameter of CNC plasma on workpiece roughness

From the results of testing the surface roughness of the workpiece, a comparison graph can be made between the effect of current variation and cutting speed on the surface roughness value of the workpiece in the CNC plasma Art cutting machine process. The graph of the surface roughness of the workpiece can be seen in Figure 8.

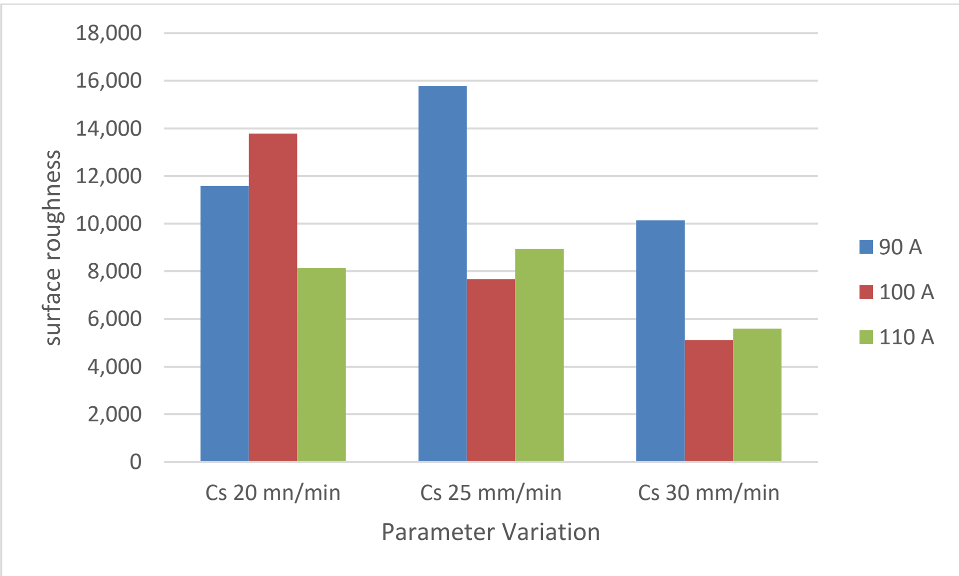


Figure 8. Graph of the effect of variation on the surface of the workpiece

The test results in Figure 10 are the results of testing the surface roughness of the workpiece from cutting the workpiece with variations in current and cutting speed using 1 MPa air pressure, namely with Cs 20 mm/min, Cs 25 mm/min and Cs 30 mm/min. Shows the average roughness value of 12.502, 8.653, and 7.56. This is due to the fact that the variation of parameters carried out (A, B, C) has an effect on the lower value of the surface roughness of the workpiece from the results of the CNC plasma cutting process. Cutting speed variations greatly affect the surface roughness value of the workpiece as a result of the straight cutting process. The higher the cutting current value, the lower the surface roughness (smoother). At 1 MPa air pressure to perform straight cutting affects the kerfh value (cutting slag) which is getting smaller if the air pressure value is increased so that the kerfh is clean. But in the roughness test results obtained results that are inversely proportional due to the influence of the MMR value.The test results in Figure 10 are the results of testing the surface roughness of the workpiece from cutting the workpiece with variations in current and cutting speed using 1 MPa air pressure, namely with Cs 20 mm/min, Cs 25 mm/min and Cs 30 mm/min. Shows the average roughness value of 12.502, 8.653, and 7.56. This is due to the fact that the variation of parameters carried out (A, B, C) has an effect on the lower value of the surface roughness of the workpiece from the results of the CNC plasma cutting process. Cutting speed variations greatly affect the surface roughness value of the workpiece as a result of the straight cutting process. The higher the cutting current value, the lower the surface roughness (smoother). At 1 MPa air pressure to perform straight cutting affects the kerfh value (cutting slag) which is getting smaller if the air pressure value is increased so that the kerfh is clean. But in the roughness test results obtained results that are inversely proportional due to the influence of the MMR value.

CONCLUSION

From the results and discussion of the research, it can be concluded that the effect of cutting speed and current variation with 1Mpa air pressure on SS400 steel plate using CNC plasma Arc cutting machine on roughness is as follows:

1. Cutting speed affects the cutting current, from the results of calculations using the workpiece mass weighing method and using empirical formula calculations. On the effect of cutting speed with a reduction in the density of the workpiece at a cutting speed of 30 mm/min indicates the highest material removal value of 1829 mm3/min, with a material removal rate (MMR) of 0.543 cm3/min, if the cutting speed is increased, it also affects the value of the current strength..
2. Variations in current and cutting speed affect the surface roughness of SS400 steel in the CNC plasma Arc cutting process, with Cs 20 mm/min, Cs 25 mm/min and Cs 30 mm/min based on the results of the test data the average roughness value of the workpiece surface is obtained:
   a. The average roughness value in straight cutting with a cutting current of 90 A is 12.502μm
   b. The average roughness value in straight cutting with a cutting current of 100 A is 8.653μm.
   c. The average roughness value in straight cutting with a cutting current of 110 A is 7.56 μm.

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