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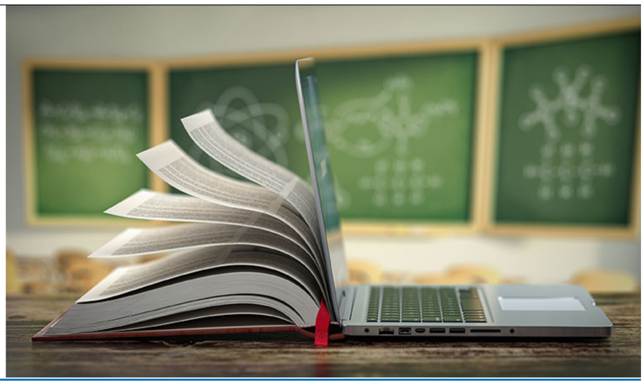

Water jet characteristics in SS400 steel cutting process on surface roughness

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Abstract. The metal cutting process is the first step before the machining process is carried out so that the raw material in the form of sheet plates is designed according to the size planned for the manufacturing process. This cutting process is a high-speed type that takes into account the type of coolant at each parameter setting. So it is necessary to cut the sheet according to the drawing by adjusting the variation of the flow rate of water, pump pressure, nozzle cross-sectional area, and the type of water quality. The parameter setting of the cutting process is carried out to obtain various surface roughness results. By using a water jet cutting machine for the cutting process SS400 steel with a thickness of 12 mm in the cold process reduces the thermal effect and reduces the conductivity, HAZ in the cutting process with parameter settings. By using different types of water quality (mineral water and clean water) to get optimal surface roughness, avoid overheating, minimize waste chips and at the same time be environmentally friendly. With water jet technology, you can get good surface roughness for mineral water and clean water. Variations of stand-off-distance 8, 10, 12 mm, (clean water) fluid velocity of 300 m s^{-1} and pump pressure of 50,000 psi on the turbulent flow Re 4000 gets the optimum results on the surface roughness test, which is 3.45 µm. For the variation of stand-off-distance 8 mm,10 mm and 12 mm, (mineral water) fluid velocity of 300 m s^{-1} get the optimum result on the surface roughness test which is 3.69 µm.

Keywords: cutting, nozzle, water jet, turbulent, surface roughness

1. Introduction

The metal cutting process is the first step before the machining process is carried out so that the raw material in the form of sheet plates is designed according to the size planned for the manufacturing process. Cutting plates before working (pre-cutting) is needed to ensure the machining process runs well until quality components [1]. Cutting the sheet plate will set variations in the speed of water out of the nozzle, the cross-sectional area of the nozzle and the type of water quality. This cutting process is a high-speed type that takes into account the type of coolant at each parameter setting. The parameter setting of the cutting process is carried out to get the optimum variety of surface roughness results.

The metal cutting process will result in the release of the chip material or cuttings between the cutting edge and the workpiece along with the thermal conductivity process [2-5]. Metal cutting is a fundamental process in manufacturing, using a water jet with the better cut quality and less wasted materials. The water jet is a (cutting tool) used to cut soft and hard materials, ductile, tough very well. The use of this water jet has been carried out in many applications in the automotive industry, manufacturing, paper products, food and fruit, and so on [6].

Non-conventional cutting processes such as water jet machining (WJM) and electrical discharge machining (EDM) were developed to obtain optimum, economical and environmentally friendly results [7]. So it can be used for non-metals such as composites with a variety of materials to minimize stress due to deformation and thermal effects on the material. To increase the effectiveness of cutting, use abrasive particles as a fluid mixture that is sprayed through a nozzle and this method is called Abrasive Water Jet Cutting using a stand-off-distance (SOD) [8].

WJM is a water erosion process with high pressure and speed to release small pieces of material (chips). In detail, this principle converts the pressure energy and transmits it continuously to the velocity of water (jet velocity) through a nozzle made of diamonds of various diameters and SOD. Water from the pump is pressed up to 50,000 psi-60,000 psi which is directed through the nozzle hole resulting in very thin water flow and has a high/turbulent speed. With the high-pressure pump, it is expected that water continuity in the cutting process will run smoothly while minimizing maintenance [9,10]

Many studies have been carried out by varying the pump pressure, the average velocity profile, the higher the pump pressure, the less the speed dependence on the nozzle diameter which will affect the water jet characteristics [11]. However, to vary the types of coolants such as clean water and flow types, it can still be developed by paying attention to SOD. The water temperature parameters in the orifice exit process and the cutting process are always considered to maintain the quality of the surface roughness of a material.

2. Method and materials

Parameters in the cutting process include abrasive particles, mixing, and fluid mechanics, and hydraulics. Specifically for fluid mechanics and hydraulics, it is a combination of pump pressure and coolant speed to cut metal in the form of clean water and mineral water (coolant) mixed with abrasive particles. The use of water fluid and the turbulent flow type allows the abrasive particle velocity to reach 300-600 m s^{-1} with a pressure of 400 MPa to flow into the sapphire orifice so as to produce a coherent flow with a high-speed water jet. A Cutting the workpiece material using an inward orifice with a hole into the mixing tube. The jets of water enter through the abrasive port and the mixing tube and mix and then exit the nozzle in the form of a mixture of water and high speed abrasive with a turbulent thin flow type. The cutting process is very flexible, with minimum thermal conductivity, temperature and minimal cutting waste [12,13]. Figure 1 below shows the nozzle position with the turbulent flow type cutting the workpiece with variations in SOD, pressure, and velocity of the water fluid.

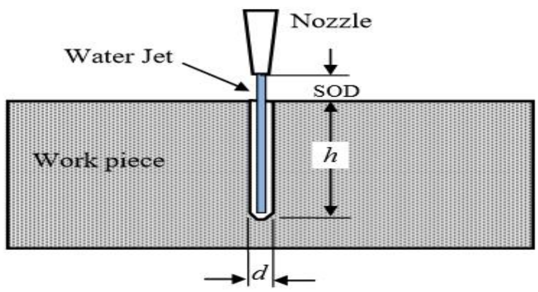

Figure 1. Cutting process illustration [8]

One of the ideal geometric characteristics in the cutting process is the surface roughness of the part and the component is a smooth surface. To achieve this goal, it requires setting the water pressure and velocity parameters adjusted to the workpiece and selecting the cooling media [11]. The use of coolant with a predetermined quality is able to form the surface of parts and components with good surface roughness. To achieve a good level of surface roughness, setting accuracy, minimizing operator error, minimizing friction, wear, and resistance to fatigue by using lubrication. Surface roughness characteristics are designed from the off-line to ensure component quality characteristics are protected from deviations from component part quality [14,15]. This surface roughness quality characteristic can be controlled in the manufacturing process or the on-line cutting process by observing shifts and deviations from the surface roughness quality standard that has been set in the off-line process. Microscopic inspection, (surface photograph) and Mechanical Roughness Instrument (MECRIN) methods are needed to ensure the surface roughness of the components is maintained with the quality setting at the off-line [16,17].

3. Result and discussion

3.1 Fluid mechanics and hydraulics parameters

The surface roughness of the workpiece component parts in this study can be seen from the changes in the variation of pump pressure and the various feeding fluid velocities, the Reynolds number, which is mostly turbulent flow, shows a smooth surface of the workpiece. Changes in pump pressure variations and fluid velocity variations as well as the coolant quality of clean water and minerals in the abrasive mixture.

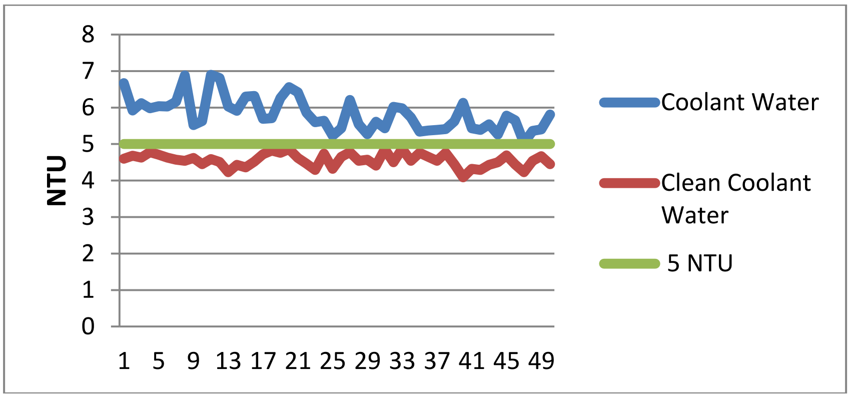

Figure 2. Coolant and clean water

In Figure 2 above, it can be seen that the results of the clean water test produce the turbidity threshold value for Nephelometric Turbidity Units (NTU). This clean water is taken after processing in the clean water industry with the addition of coagulant chemical compounds. With variations in SOD at the 8 mm, 10 mm and 12 mm positions, it can be seen that this variation affects the surface roughness value.

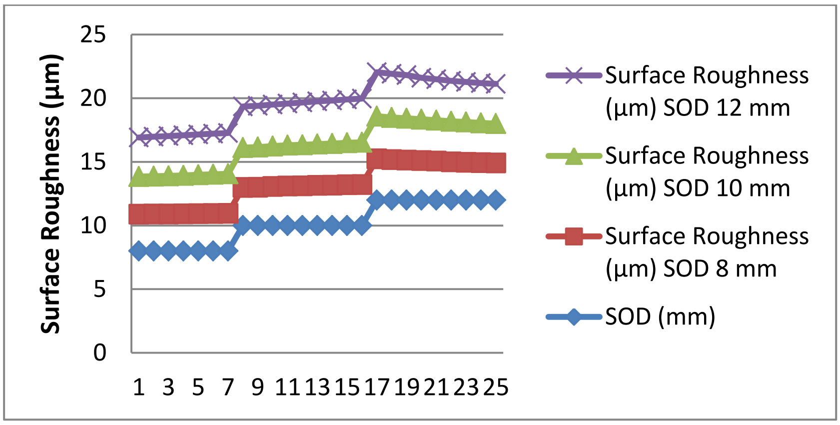

Figure 3. Surface roughness with coolant clean water

In Figure 3 using a clean water coolant, it can be seen that the roughness value is still in the initiation position, then at a speed of 300 m, s-1 with the turbulent flow will increase the high water jets at the nozzle orifice. This effect increases the high roughness value in the cutting period but decreases when approaching the end of the workpiece milling process [7].

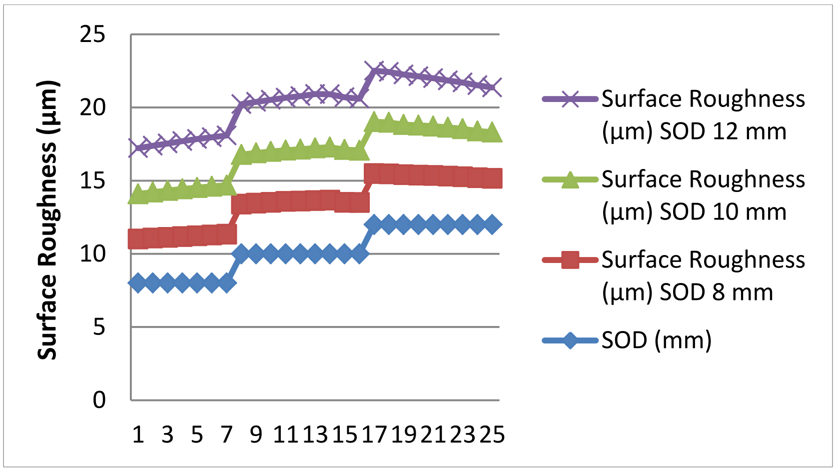

Figure 4. Surface roughness with coolant mineral water

Figure 4 above shows that at 12 mm SOD there is a movement of variation in the roughness value, this is influenced by the nozzle water jet and the direction of the jet is stronger because of the influence of the speed and pressure of the pump and the nozzle valve setting which is influenced by turbulent flow. In addition to the effect of speed and pump pressure, it turns out that the effect of turbulent flow causes changes in the surface roughness of the workpiece. Another effect of turbulent flow is a reduction in the chip cut and the minimization of thermal conductivity when the cutting machine and the workpiece are in contact.

4. Conclusion

This SS400 cutting process uses coolant media of clean water and mineral water to see and compare the surface roughness value, with a speed of 300 m s^{-1} at a pump pressure of 50,000 psi at Reynolds 4000 is a turbulent flow. With the SOD value of 12 mm fluctuating in surface roughness, this is influenced by a high nozzle valve setting and beam direction because the pump pressure is made stable to ensure the minimization of chip cutting processes and a decrease in thermal conductivity. The optimal roughness value is 3.45 µm in clean water and 3.69 µm in mineral water.

In general and specific changes in surface roughness are influenced by changes in coolant, but the basis of this finding is the influence of coolant quality and nozzle valve setting with turbulent flow.

5. References

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