The effect of twist drill angle and spindle speed on surface roughness in S45C steel drilling process

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R D A Saputro[1], T Sukardi[2], Y E Wibowo[2], R A P Hardiyanta[2]
[1]Graduate Program of Technology and Vocational Education, Universitas Negeri Yogyakarta, Yogyakarta, Indonesia.
[2]Department Mechanical Engineering Education, Universitas Negeri Yogyakarta, Indonesia.

Email: riansaputro96@gmail.com

Abstract. The purpose of this research is to determine the effect of twist drill angle variations and spindle rotational speed on the surface roughness of S45C steel in the drilling process. The method used in this research is the experimental method. The independent variables used in this study are variations in twist drill angle (118°, 122°, 125°) and spindle rotational speed variations (1036 rpm, 1340 rpm, 1630 rpm). The dependent variable used is the result of surface roughness in S45C steel. While the control variable used is a feed rate of 0.18 mm/round. The results showed the highest surface roughness was obtained at 125° twist drill angle variation and spindle rotational speed of 1630 rpm with a roughness value of 8.590 µm, while the lowest surface roughness value was obtained at 118° twist drill angle variation and spindle rotational speed of 1036 rpm with a roughness value of 2.898 µm. This research can be developed to find standards from other aspects that affect the results of the drilling process.

1. Introduction

Manufacturing technology is growing rapidly, almost all components in the field of engineering are produced through the manufacturing process, both with conventional and unconventional machining processes. One manufacturing process that is often done is drilling. In simple terms, drilling can be said as the process of making holes using a twist drill.

Smooth surface of the hole resulting from the drilling process is needed. Holes with a smooth surface will reduce the coefficient of friction of these components and are easier to pair with other components. The quality of the surface of the hole is smooth or commonly called the roughness value can be produced by drilling the process using the right method. Each machining process has certain roughness value standards. The hole produced in the drilling process has a roughness value between N7 to N10 or 1.6 µm -12.5 µm [1].

In the drilling process there are several factors that can affect product quality (surface roughness). These factors are cutting method and twist drill geometry. The intended cutting method is the spindle rotational speed and feeding motion. In the drilling process, the selection of spindle rotational speed will affect the occurrence of vibrations that happen so that it will indirectly affect the surface roughness value of the product [2]. While the twist drill geometry in question is the twist drill angle, different twist drill angles will affect the drilling results, the greater the twist drill tool angle will cause a large vibration effect, so the product is not smooth or the surface roughness value is high and the twist drill tool is blunt quickly [3].

From the explanation, there are several factors in the drilling process that affect the surface roughness value, so that the idea of the twist drill angle (point angle) and spindle rotational speed can influence the surface roughness value. Based on this, the research needs to be done.

2. Method

This research is using experimental method. This research was done for determine the effect of twist drill angle variations and spindle rotational speed on the S45C steel surface roughness value in the drilling process. The data analysis technique used is descriptive analysis technique. The research diagram is illustrated in figure 1.

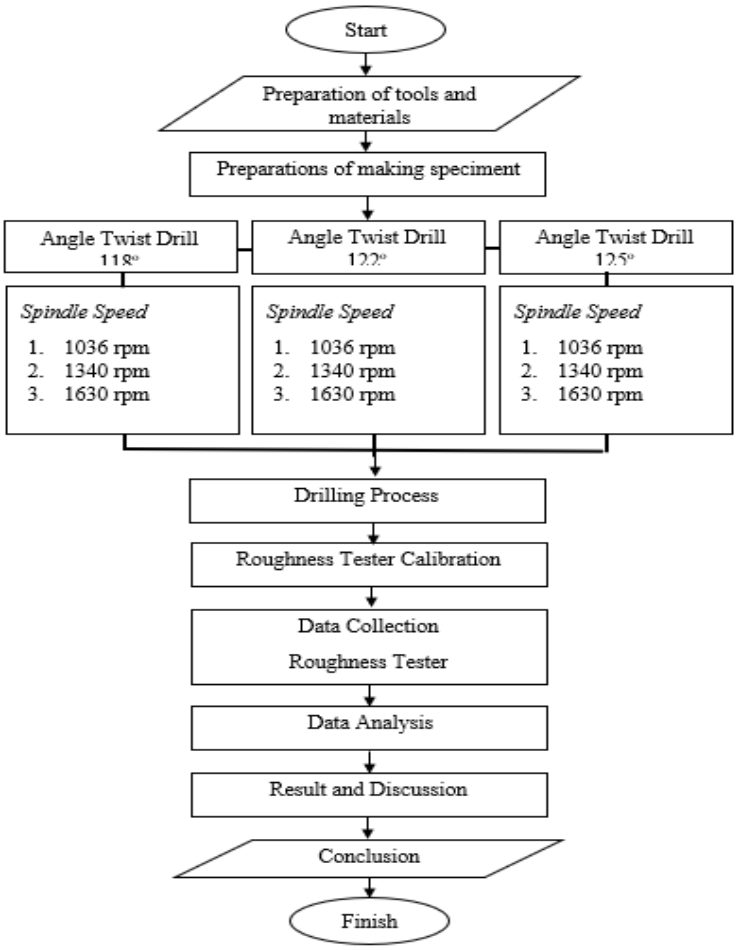

Figure 1. Research diagram

Before conducting the drilling process, for the first prepare the tools and materials and determine the parameters to be used. Materials that will be used in this research are S45C steel with a diameter of 30 mm and a length of 35 mm, and HSS twist drill with a diameter of 10 mm with variations in the angle of twist drill 118°, 122° and 125°. While the tools that will be used include milling machine type X6376, SAE 40 cutting fluid, KW1500768 angle grinder, brush, and surface roughness tester.

Steel S45C was chosen because it's one of the raw materials for making component in the engineering field. In general, S45C steel material is used to manufacture engine components or structures such as piston rods, transmision shafts, axle shafts, crank shafts, and boilers. This material is a type of medium carbon steel with a carbon element content of 0.3-0.5% C [4]. Because the material used in this study is S45C steel which is classified as medium carbon steel, the variation of twist drill angle that can be used is between 118°-125° [5]. Spindle rotational speed variations used are 1036 rpm, 1340 rpm and 1630 rpm. While the feeding speed used is 0.18 mm/rotation [6].

After drilling the specimen was carried out S45C steel. The next process is to test the surface roughness of the results of the drilling process using a surface roughness tester. Part of the specimens tested in this study is shown in figure 2.

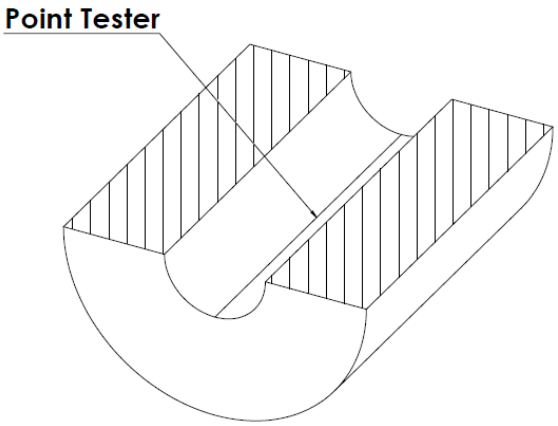

Figure 2. Roughness testing point on specimens

Surface roughness testing is carried out using a tool of surface roughness tester in the area of the hole resulting from the drilling process, testing is done by placing the dial indicator of the surface roughness tester in a position that is stable to the surface of the measurement object. Before the test tool is turned on, first enter the test parameters such as the surface length of the object to be tested and the standard to be used (Ra, Rq, Rz, Rmax, and other parameters). At the time of data collection, the position of the dial indicator must move constantly in accordance with the horizontal axis and parallel to the test specimen. Data is taken once in one specimen, after testing is done the test results can be printed directly from the surface roughness tester (figure 3).

Figure 3. Testing Process

3. Result and Discussion

Roughness testing using the Surf 300 SE300 roughness test tool, the data obtained in the form of numbers (values). This study involved two factors that can be symbolized by the letters A and B. The surface roughness results that are influenced by factor A are twist drill angles (118°, 122°, 125°), while factor of B consists by variations of the spindle rotational speed (1036 rpm, 1340 rpm, 1630 rpm). The surface test results were summarized in table 1.

Table 1. Surface roughness test results

Angle Twist Drill Variation	Spindle Speed Variation (*rpm*)	Roughness Tester per Point					Mean Ra	Mean per Variation
		1	2	3	4	5		
118°	1036	2.646	3.040	3.195	3.031	2.578	2.898	4.818
	1340	4.639	4.792	4.911	4.605	3.966	4.583	
	1630	6.711	6.802	6.835	7.566	6.946	6.972	
122°	1036	3.897	3.471	3.427	3.763	3.396	3.591	5.538
	1340	4.583	5.877	5.806	5.514	5.675	5.491	
	1630	7.130	7.381	7.080	7.937	8.139	7.533	
125°	1036	4.412	5.388	5.985	4.556	5.436	5.155	6.691
	1340	6.778	6.945	5.370	6.468	6.081	6.328	
	1630	8.454	8.935	8.055	8.956	8.551	8.590	

From the data analysis, it is known that the angle parameter especially the angle of twist drill affects the value of the result of surface roughness. It can be seen in figure 4 about that the average roughness in the drilling process using S45C steel material producing an average value of 5.682 µm. The highest at an angle of 125° at 6.691 µm and the lowest at an angle of 118° at 4.818 µm.

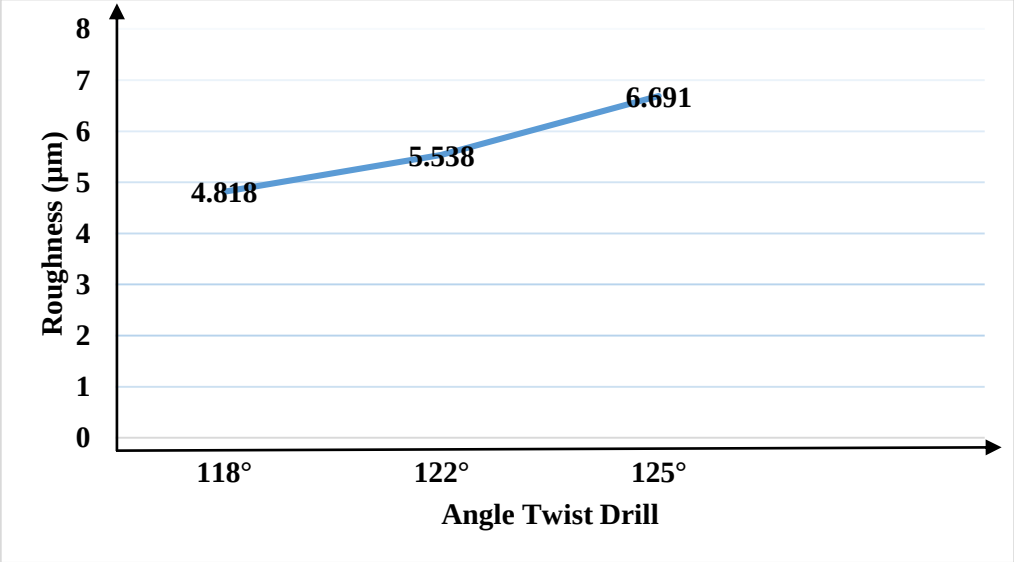

Figure 4. Average roughness value of the drill twist angle

Judging from the results it can be seen that the greater the angle of twist drill the greater the roughness value, this because the twist drill angle had a role in determining the level of roughness. Different twist

drill angle will affect the surface roughness in the drilling process, the greater the twist drill angle will produce a large surface roughness value, so that the product is not smooth (surface roughness) and blunt twist drill is fast [7].

In addition to the twist drill angle, drilling process parameters such as spindle speed also have a large influence on the surface roughness value. The graph of the average roughness value of the spindle speed is depicted in figure 5. With a speed of 1036 rpm the resulting roughness value of 3.881 µm, at a speed of 1340 rpm the roughness value of 5.467 µm and at a speed of 1630 rpm the roughness value of 7.698 µm.

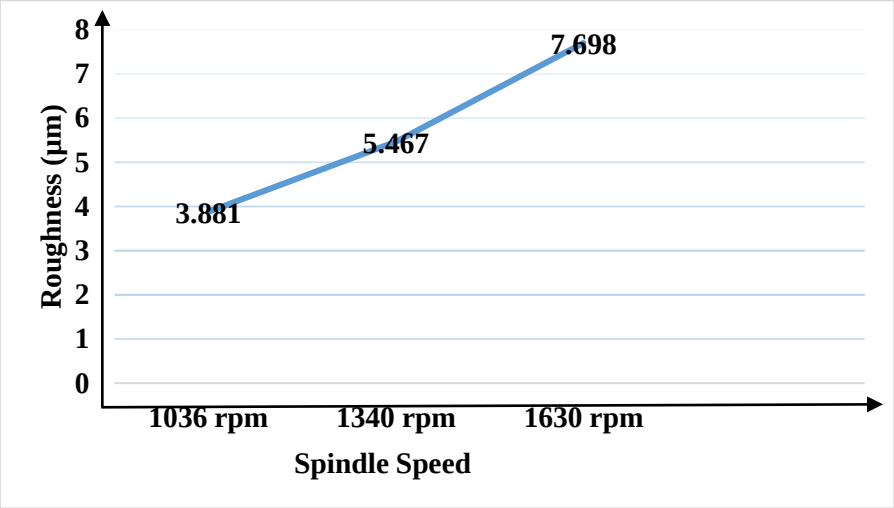

Figure 5. Graph of the average roughness of the spindle speed

The average roughness of the spindle speed is depicted in figure 5. From the result, it can be seen that the greater the spindle speed, the greater the roughness value produced, this is because the high spindle speed will cause a large vibration effect when the drilling process is carried out. This is consistent with the results of research which states that the feed rate and diameter of the twist drill are the most influential factors in the thrust force, while the spindle speed provides the greatest contribution to surface roughness [8].

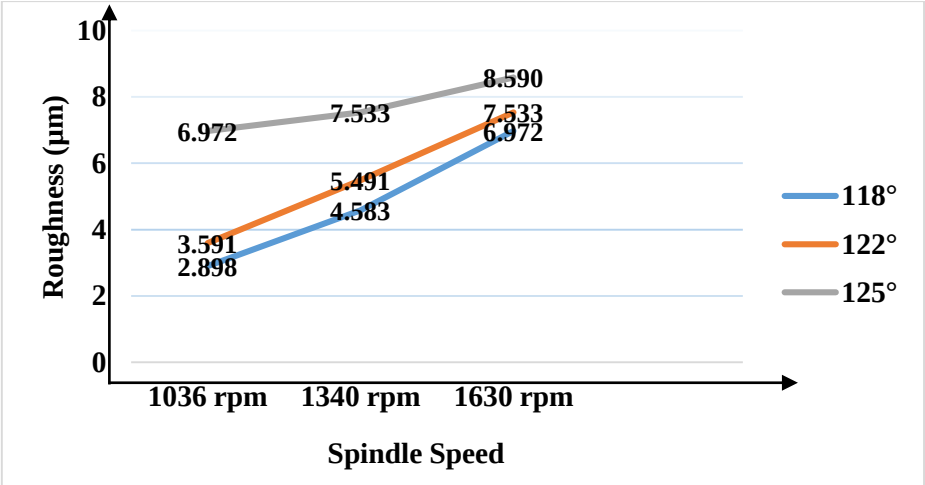

Figure 6. Graph of Relationship Between Twist Drill Chisel Angle and Spindle Speed Against Surface Roughness in Drilling Process with S45C Steel Material

From figure 6 it can be seen that from each variation between the twist drill angle and the spindle speed there are different roughness results. The smallest roughness results obtained at a variation of the angle of twist drill 118º and spindle speed of 1036 rpm with a roughness value of 2.898 µm. The biggest results were obtained at a twist drill angle of 125° and a spindle speed of 1630 rpm with a roughness value of 8.590 µm. This result is because the greater the angle of twist drill and the speed of the spindle, the higher the vibration effect is caused so that the value of roughness in the workpiece is greater.

This is an accordance with research which states that there are four factors that can affect the roughness value in the drilling process, name the type of tool, spindle speed, feed motion, and peck rate, from the study the roughness value of 0.82 µm [9] was generated. The results of the research can be used as a reference in the drilling process to produce quality and standards product. This research can be developed to find standards from other aspects that affect the results of the drilling process.

4. Conclusion

The conclusions that can be obtained from this research is follow:

- The smaller the angle of the twist drill tool are used in the drilling process, the lower the surface roughness value. The greater the angle of the twist drill tool used in the drilling process, the higher the surface roughness value.
- The higher the rotational speed of the spindle used in the drilling process, the higher the surface roughness value. The lower the spindle rotational speed used in the drilling process, the lower the surface roughness value.
- In drilling the S45C steel, it can use 118° twist drill chisel angle and spindle rotational speed of 1036 rpm to get the best surface roughness value.

Akcnowledgments

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