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Influence of Spindle Speed on Aluminum Surface Alliance in Conventional and CNC Lathe Machine

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Abstract

The level of surface roughness of a metal in the lathe process depends on the process; spindle rotation, cutting speed, feed speed, cutting tool material, cooling process and machine condition. The objective of this research is to know spindle rotation relationship to aluminum surface roughness on the conventional lathe and CNC lathe. The test specimens amounted to 36 for the conventional lathe and 36 for the CNC lathe. Spindle rotation varied at 9 levels of rotation ie 90 rpm, 100 rpm, 155 rpm, 190 rpm, 260 rpm, 320 rpm, 440 rpm, 540 rpm and, 740 rpm. Each spindle level rotates four specimens. The measurement results show that on the conventional lathe the higher the spindle spin the higher the level of surface roughness, while on the CNC lathe the higher the spindle spin the lower the surface roughness level.

Keywords: spindle rotation, surface roughness, CNC, rpm

1 Introduction

Now a day's turning process is a widely used metal removal process in manufacturing industry that involves generation of high cutting forces and temperature (Sudheerkumar *et al.* 2015; Butola *et al.* 2017; Miyake *et al.* 2018). The surface roughness of a metal depends on the process of work experienced by the metal before (Figure 1). Under certain conditions of surface roughness needs to be known for certain. The roughness of metal surfaces for machine parts and also metal scrapings is a critical factor in ensuring component quality. The lathe process is one of the processes experienced by the metal used to support a machine construction. In the process of roughening the desired surface roughness level can be achieved by considering factors such as machine condition and machining process. Vadgeri *et al.* (2017) adds that the effect of approach angle, feed, depth of cut and nose radius on cutting force components in lathe also affect the quality of product results.

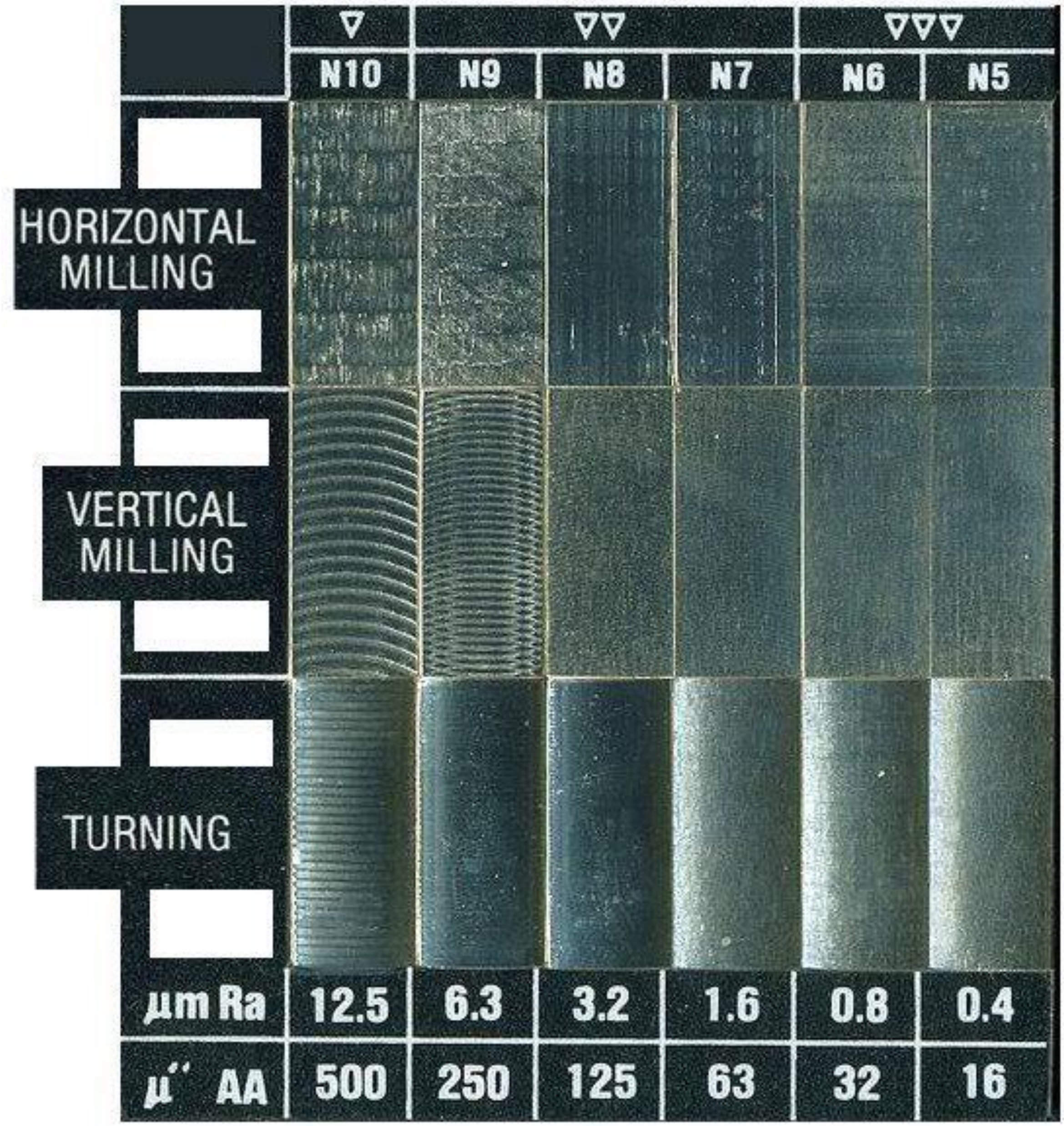

Figure 1 The photos of surface finish comparator for milling, turning

Processes that affect the roughness of metal surfaces namely; spindle rotation, feed speed, cutting speed, a material cutting tool used and cooling process. Spindle rotation as the main axis on the lathe will change as the workload changes. Variations in the size of the workpiece affect the spindle rotation. This rotational change due to the load factor affects the output of the workpiece done with the lathe. This study aims to determine the relationship between spindle rotation on aluminum metal surface roughness on conventional lathes and CNC Lathes.

2 Literatur Review

2.1 Surface Roughness

The surface roughness (**Error! Reference source not found.**) of a lathe workmanship is a very important factor in the field of production. For that process must be done properly and accurately to ensure the quality, accuracy, and precision of the resulting product. Surface roughness needs to be considered especially for moving machine components or friction components such as bearings.

2.2 Lathe Machine

Lathes (Figure 2) is one of the production process machines used to form cylindrical workpieces. Establish here is doing the process of cutting or reduction of workpiece dimensions to reach the desired size. The workpiece is first mounted on the chuck on the engine spindle and then the spindle and workpiece are rotated at high speed. The knife used to form the workpiece will be worn on a rotating workpiece where the blade is still. In high rotational speed, the knife easily cuts the workpiece so that the workpiece is easily formed. Yang *et al.* (2017) also adds that, the lathe bed characteristics are directly effect on the machining accuracy.

By rotating the arm on the lathe's head, the main axle spin can be adjusted. For lathe with variable motor rotation, or with variable transmission system, the main shaft rotation speed is no longer stratified but continuous. The feeding motion available on a lathe varies and according to standardized levels, eg: 0.1, 0.112, 0.125, 0.14 etc. (mnii / (r)).

Figure 2 Emco Maximat V13 conventional Lathe

2.3 CNC Machine

CNC machine (Figure 3) is a machine that uses the computer as a controller of every movement of the machine. CNC lathes require software (program) in operation such as operating system, utility program and special application program on the controller computer. Compared to conventional equivalent machines and similar to CNC machines can be said to be more precise, more precise, more flexible and more productive. The method leads to more efficient machining on CNC lathes (Kelova *et al.* 2015). Mori *et al.* (2009) also adds that, An efficient design and optimization method is proposed for a headstock structure design of NC lathes to minimize the thermal displacement of the spindle center position.

2.4 Aluminum

Aluminum is a light metal that has good corrosion resistance and good electrical conductivity as well as other properties as metal properties. To increase its mechanical strength and other special properties it is made alloy by adding elements such as copper, nickel, silica and so on. Aluminum is one of the most important ingredients because of its properties and its characteristics and its wide use in the industrial world. Pure aluminum has a tensile strength of 49 (MPa) of up to 700 MPa when combined with other elements.

Figure 3 CNC Lathe TU-2A Type

3 Methodology

The material used in this research is Aluminum rod with diameter 36 mm, length 53 mm as many as 72 pieces. The machines used are conventional EMCO lathe, CNC lathe (TU-2A) and Surface Roughness Tester.

3.1 Research Procedures

The research procedure performed is as follows:

1. Specimen preparation. The size of the specimen diameter is based on what is obtained in the market, while the length of the specimen is adjusted to the efficiency at work.
2. Specimen specimen. The specimen is divided into 2 parts. The first part is worked with conventional lathes and parts again with CNC lathes. In the process the variation of the spindle spinning speed that is; 90 rpm, 110 rpm, 155 rpm, 190 rpm, 2160 rpm, 320 rpm, 440 rpm, 540 rpm, and 740

rpm. Each spindle rotation level is done 4 repetitions. The cutting speed at work is based on the calculation results. While the depth of the food is set at 0.5 mm (Vadgeri *et al.* (2017). The chisel eye used is the HSS chisel, while cooling is cooling the air.

3. Measurement of surface roughness. Surface roughness measurements use a roughness surface tester TR200 digital roughness gauge system (Figure 4).

Figure 4 Roughness surface tester TR200 digital

4 Results and Discussion

The use of aluminum and aluminum alloys as raw materials has been increasing in the last decades due to their several excellent mechanical properties (such as tensile strength, hardness or corrosion resistance) and technological properties (such as excellent castability or finish turning) (Horvath and Agota 2015). Therefore, surface roughness measurement data for specimens performed with conventional lathe are presented in Table 1.

Table 1 Surface roughness measurement data using conventional lathe

Spindle speed (rpm)	**Repetition**	**Surface roughness (μm)**	**Average (μm)**
90	1	0.607	0.656
	2	0.630	
	3	0.707	

	4	0.680	
110	1	0.742	0.848
	2	0.689	
	3	0.863	
	4	1.100	
155	1	0.601	0.690
	2	0.757	
	3	0.663	
	4	0.740	
190	1	1.956	1.165
	2	0.888	
	3	0.974	
	4	0.841	
260	1	0.778	0.717
	2	0.672	
	3	0.660	
	4	0.760	
320	1	3.379	4.036
	2	4.835	
	3	2.725	
	4	5.204	
440	1	4.095	3.384
	2	3.534	
	3	2.039	
	4	3.870	
540	1	6.541	5.433
	2	5.414	
	3	3.839	
	4	5.940	
740	1	3.452	3.250

	2	2.793	
	3	3.884	
	4	2.869	

Table 2 Surface roughness measurement data of CNC machines

Spindle speed (rpm)	**Repetition**	**Surface roughness (μm)**	**Average (μm)**
90	1	3.018	2.976
	2	3.159	
	3	2.836	
	4	2.889	
110	1	2.374	2.400
	2	2.736	
	3	2.019	
	4	2.472	
155	1	0.953	1.104
	2	0.842	
	3	1.145	
	4	1.475	
190	1	0.886	0.963
	2	0.900	
	3	0.847	
	4	1.220	
260	1	1.148	1.197
	2	1.132	
	3	0.803	
	4	1.705	
320	1	0.953	0.955
	2	1.172	

	3	1.003	
	4	0.691	
440	1	0.705	0.964
	2	1.514	
	3	0.630	
	4	1.007	
540	1	0.677	0.633
	2	0.682	
	3	0.774	
	4	0.397	
740	1	0.957	0.938
	2	1.447	
	3	0.776	
	4	0.571	

Surface roughness measurement data for specimens worked with CNC lathes as in Table 1. Furthermore, from the data obtained can be seen the relationship between spindle spin to surface roughness for a conventional machine in Figure 5. From the graph, it is read that the larger the spindle spin the higher the resulting surface roughness value. This means that the higher the spindle spins the rougher the resulting metal surface. In the graph seen for the lowest rotation of 90 rpm resulted from surface roughness of 0.656 μm, while at the highest round of 740 rpm produced surface roughness of 3.250 μm. This means that the higher the spindle spin the lower the smoothness of the metal surface. These results indicate the need to conduct further research on the effect of engine vibration on aluminum surface roughness. This is in line with the results of research Zhang *et al.* (2015) which states that, the general factors are summarized as machine tool, cutting conditions, tool geometry, environmental conditions, material property, chip formation, tool wear, vibration etc.

The spindle rotation relationship to Aluminum metal surface roughness on CNC lathes (TU-2A) can be seen in Figure 5. On a CNC lathe can be seen, the higher the spindle spin, the lower the surface roughness value. This means that the higher the spindle spins the finer the resulting metal surface. This can be seen at the lowest rotation of 90 rpm to produce a surface roughness value of 2976 μm, on the contrary at the highest spindle spin is 740 rpm obtained surface roughness value 0.938 μm.

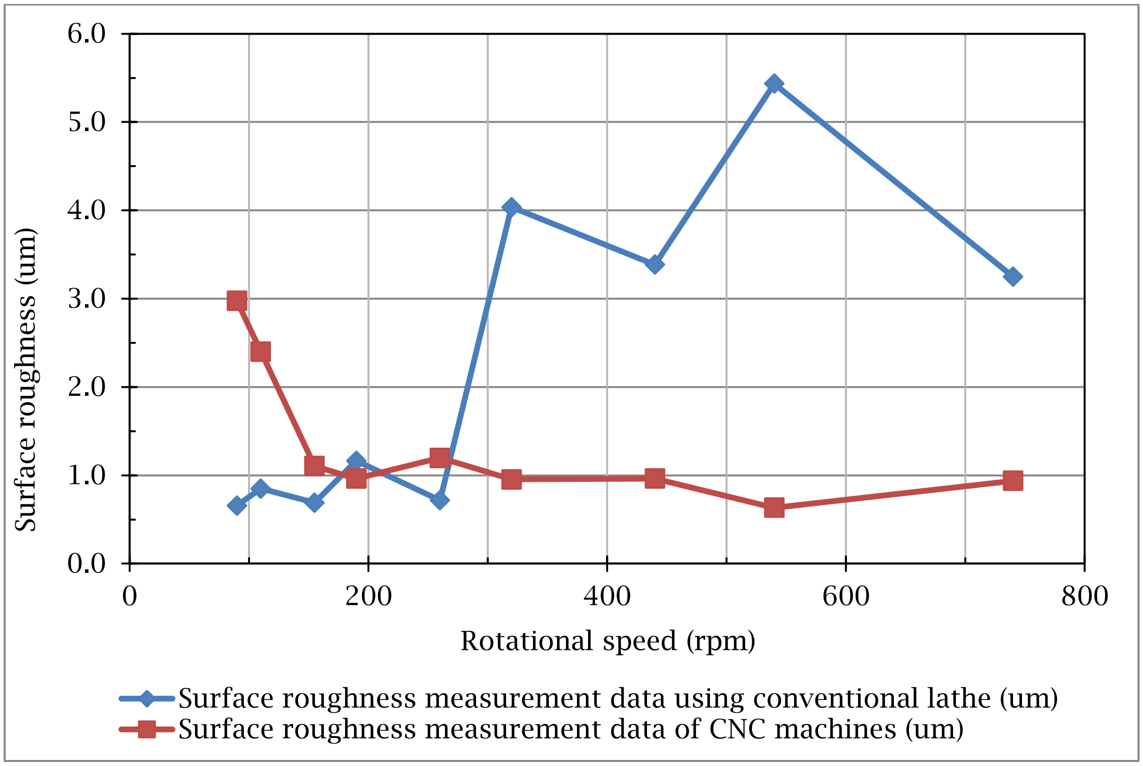

Figure 5 Surface roughness measurement

5 Conclusion

In a conventional lathe, the spindle relationship is the higher the spindle spin the higher the surface roughness value. In CNC lathe, spindle rotation is seen with surface roughness, the higher the spin the smoother the metal surface is worked. High spindle rotation will result in a low surface roughness value. In a conventional lathe, further research on the effect of engine vibration on metal surface roughness is required. Therefore, the vibro-acoustic condition monitoring of the metal lathe machine by the development of predictive models for the detection of probable faults important to investigate.

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