University of Jordan

Department of Industrial Engineering

Manufacturing Engineering Lab

Luna Tadros	0183639
Leen Sakijha	0185566
Asma’a Ibrahim	0188427

Date: 25 /12/2021

Effect of Cutting Conditions on Surface Roughness of Metals; EXPERIMENT 4&5

DR. Mohamad Al-Tahat

Abstract:

This experiment was conducted to mainly investigate the effect of cutting conditions on surface roughness of metals. These cutting conditions include the cutting speed (N), feed rate(f) and the depth of cut (d). Moreover, cutting operations are done using several machine tools depending on the process required, these include lathe machines, grinding machines, milling machines, drills and many more. Finally, cutting tools are classified either single point like those used in turning operations, or multipoint tools used in milling and drilling and are made of one of the following: -1) insert carbide 2) High speed steels 3) synthetic diamond 4) ceramics, to withstand heavy cutting forces.

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1 Introduction:

In many industries, it is necessary to achieve high quality surfaces for components with complex shape surfaces, so surface roughness is one of the most significant surface quality indicators and is affected by the choice of cutting conditions mentioned before (feed rate, cutting speed and depth of cut).When the correct combination of cutting conditions is selected, it’s possible to achieve the required surface quality , depending on the material of the specimen machined and the material of the cutting tool itself too.

As we said before, good quality surface roughness is necessary for many reasons, not only because of the dimensional accuracy, but also the properties of the material itself such as the expected service life, fatigue strength and resistance to corrosion. Now, there are many reasons behind the surface roughness varieties occurring in products, one of them is the cutting conditions mentioned before, the temperature generated during machining processes that results in residual stresses, defects such as cracks and inclusions, and many more.

Finally, in this experiment, surface roughness of three groups of cylindrical Aluminum specimens (each group consists of three units of 100 mm length and 25 mm diameter) is evaluated, and the relationship between cutting conditions and surface roughness is maintained.

2 Methodology:

Surface roughness is an important characteristic in evaluating surface quality of the machined components and is usually related to the correct performance of a part. Hence, obtaining good surface quality is essential in most machining applications, so that it has a vital role in influencing the customer satisfaction in manufacturing. However machined surface quality demands significantly affect production cost and increase the price of a product. Machined components during their useful life are significantly influenced by surface roughness which affects several properties mentioned before such as corrosion resistance and fatigue strength, wear resistance as well as the coefficient of friction, ability of distributing and holding a lubricant, load bearing capacity and heat transmission. For the previous reasons, control of the machined surface roughness is essential, and appropriate processes parameters (cutting conditions) must be selected to reach the desired surface quality machined parts.

This experiment focuses on evaluating the surface roughness of 9 aluminum specimens-previously machined-. These specimens were processed and machined by turning, with changing the cutting conditions (feed rate, cutting speed, depth of cut) each time, so relationships between the cutting conditions and the surface roughness could be observed. Turning process could be achieved by using an ancient cutting machine called lathe machine (shown in *Figure 1*), which is known as the mother of machine tools, as it led to the invention of other machine tools.

Figure 1 Lathe machine

It is obvious that it is practically impossible to produce a component that is free from surface irregularities. Imperfections on a surface are in the form of succession of hills and valleys varying in both spacing and height. So, in order to distinguish one surface from another, we need to quantify surface roughness. For this reason, parameters such as height and surface roughness of surface irregularities are considered.

Now, the normal roughness generated by any operation under normal manufacturing conditions is measured by 3 methods: - 1) arithmetic mean value (Ra) 2) root mean square average (RMS, Rq) 3) maximum roughness height (Rt).

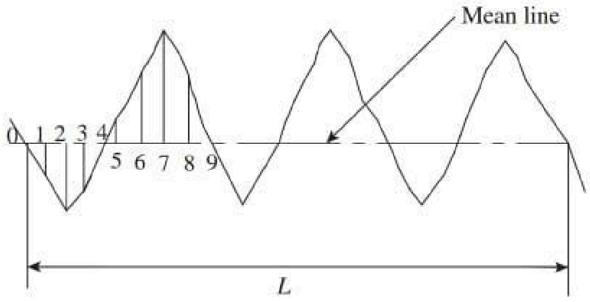


Figure 2 Coordinates used for surface roughness measurement

$$Ra=\frac{y1+y2+y3+\ldots\ldots+yn}{n}$$

$$Rq=\sqrt[2]{\frac{y1^2+y2^2+y3^2+\ldots+yn^2}{n}}=1.1*Ra \text{ for cutting}$$

or =1.2* Ra for grinding

or =1.4* Ra for lapping and honing

Rt=the height from the deepest valley to the highest peak.

-Materials and Equipment:

1) Lathe machine.

2) Three groups of cylindrical Aluminum specimens (each group consists of three units of 100 mm length and 25 mm diameter)

3) Roughness assessment device (Surface Roughness Gage Comparator shown in *Figure 3*) for previously machined products (specifically turning).

4) Papers, pencils, working table.

-Procedure:

1. Make sure that all test equipment is present.

2. Split the three groups of specimens so the cutting condition that varies in each group is known (either the cutting speed or the feed rate or the depth of cut)

3. Each group of students took a specimen with three units that differ in roughness according to varying one single cutting condition and remaining the other two constant.

4. The roughness of these 9 specimens were tactically compared to the roughness gage comparator.

5. Values were taken from the gage comparator and filled in the tables (refer to Results and discussion).

6) plots were graphically drawn to construct the required relationships (refer to Results and discussion).

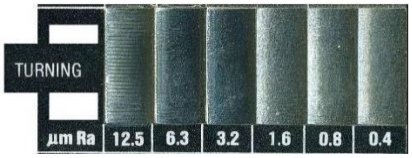
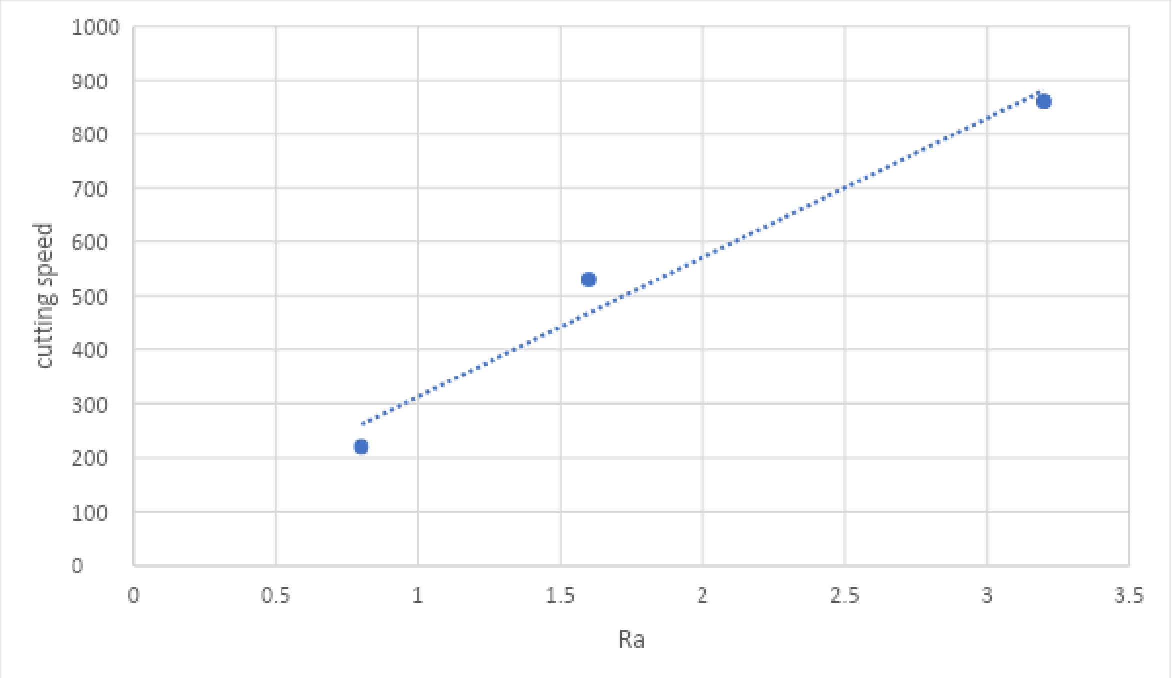


*Figure SEQ Figure * ARABIC 3 Surface Roughness Gage Comparator*

4 Results and discussion:

Table 1 Group 1 of specimens, effect of Cutting Speed on roughness

Specimen#	Cutting speed (N) RPM	Feed Rate (f) mm	Depth of cut (d) mm	Surface roughness		Roughness grade number	Roughness grade symbol
				Ra	Rq		
1	860	0.176	0.5	3.2	1.1*3=3.3	N8	▽ ▽
2	530	0.176	0.5	1.6	1.1*1.6=1.76	N7	▽ ▽
3	220	0.176	0.5	0.8	1.1*0.8=0.88	N6	▽ ▽ ▽

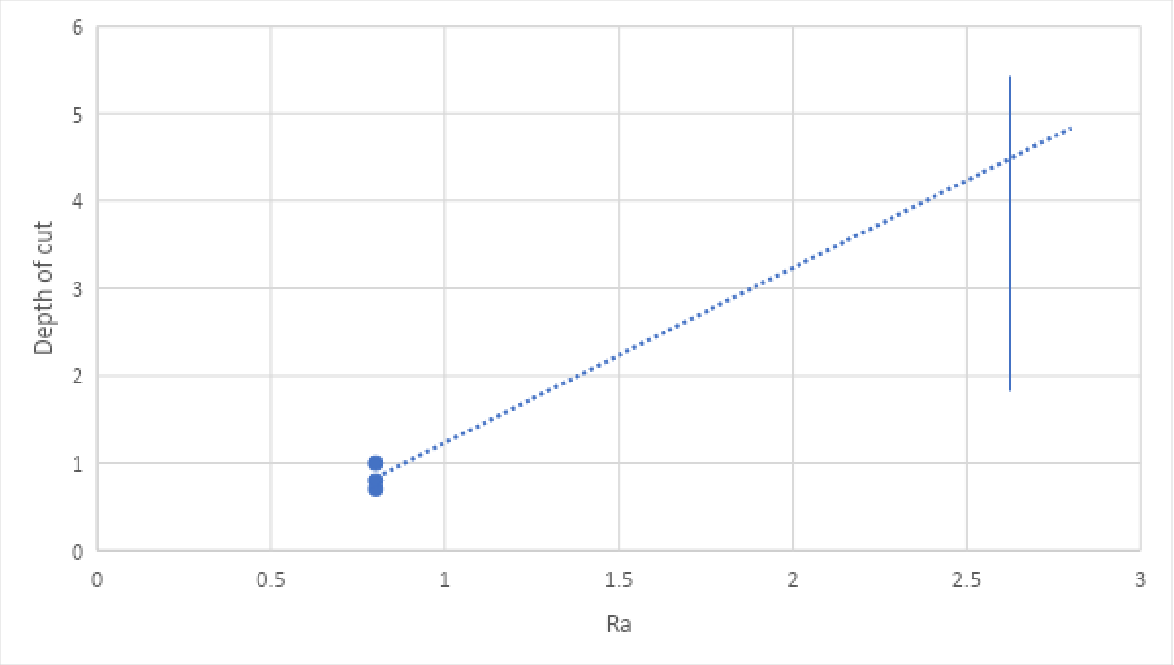


From the table above,we concluded that the cutting speed is proportional to the surface roughness Ra. (When N increases, Ra increases and the surface becomes rough).

Table 2 Group 2 of specimens, effect of Cutting Speed on roughness

Specimen#	Cutting speed (N) RPM	Feed Rate (f) mm	Depth of cut (d) mm	Surface roughness		Roughness grade number	Roughness grade symbol
				Ra	Rq		
4	860	0.176	1	0.8	1.1*0.8=0.88	N6	▽ ▽ ▽
				0.8	1.1*0.8=0.88		
				0.8	1.1*0.8=0.88		

5	860	0.176	0.7		N6	∇ ∇ ∇
6	860	0.176	0.4		N6	∇ ∇ ∇

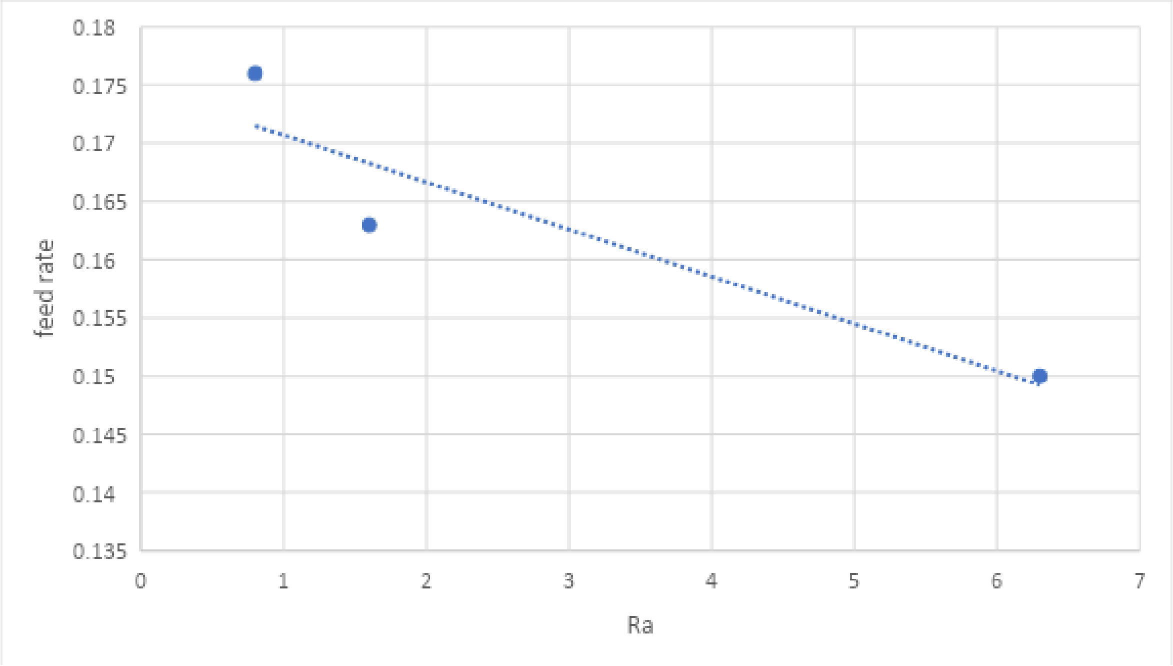


From the table above,we concluded that when changing the depth of cut (increasing or decreasing) ,the surface roughness Ra will remain the same .

Table 3 Group 3 of specimens, effect of Cutting Speed on roughness

Specimen#	Cutting speed (N) RPM	Feed Rate (f) mm	Depth of cut (d) mm	Surface roughness		Roughness grade number	Roughness grade symbol
				Ra	Rq		

7	860	0.176	0.5	0.8	1.1*0.8=0.88	N6	▽ ▽ ▽
8	860	0.163	0.5	1.6	1.1*1.6=1.76	N7	▽ ▽
9	860	0.150	0.5	6.3	1.1*6.3=6.93	N9	▽ ▽

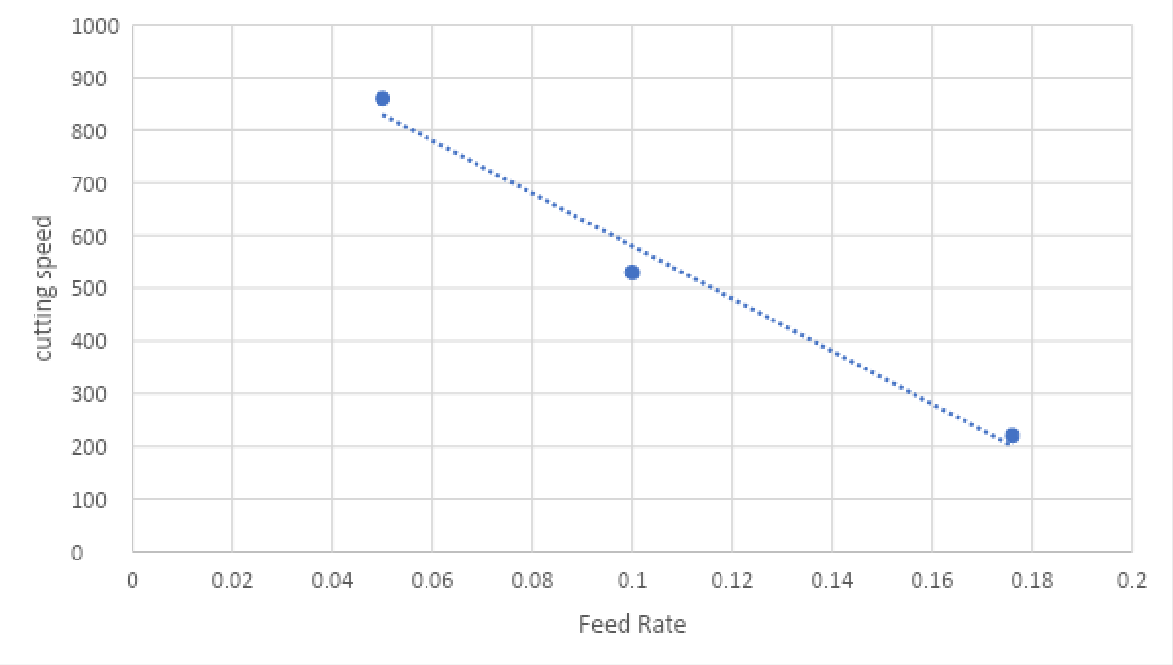


From the table above,we concluded that the feed rate is inversely proportional to the surface roughness Ra .(When f increases ,Ra decreases and the surface becomes smooth).

To construct the relationship between the feed rate and cutting speed, we assumed the following: -

Table 4 Group 4 of specimens, effect of Cutting Speed on roughness

Specimen#	Cutting speed (N) RPM	Feed Rate (f) mm	Depth of cut (d) mm	Surface roughness		Roughness grade number	Roughness grade symbol
				Ra	Rq		
1*	220	0.176	0.5	0.8	1.1*0.8=0.88	N6	▽ ▽ ▽
2*	530	0.1	0.5	0.8	1.1*0.8=0.88	N6	▽ ▽ ▽
3*	860	0.05	0.5	0.8	1.1*0.8=0.88	N6	▽ ▽ ▽



From the table above,we concluded that the feed rate is inversely proportional to cutting speed.In other words, high cutting speed with low feed rate or high feed rate with low cutting speed will both yield to good surface quality.

5 Conclusions and recommendations

1- We were able to successfully perform the roughness test on pre-machined Al-specimens.

2- We were able to take a look on machines used to perform cutting operations such as the lathe machine, drilling machine, milling machine.

3- Relationships between the surface roughness and cutting conditions were constructed as follows: -

- The cutting speed is proportional to the surface roughness Ra. (When N increases, Ra increases and the surface becomes rough).
- When changing the depth of cut (increasing or decreasing) ,the surface roughness Ra will remain the same.
- The feed rate is inversely proportional to the surface roughness Ra. (When f increases ,Ra decreases and the surface becomes smooth).
- The feed rate is inversely proportional to cutting speed.In other words, high cutting speed with low feed rate or high feed rate with low cutting speed will both yield to good surface quality.

6 Acknowledgements:

The majority of information was directly presented by Dr.Mohammad Al-Tahat -Thanks to him-and done experimentally by our mentor Eng. Amer AlZenat-Thanks to him too-.

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