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Studying The Effect of a New Mixed Cutting Fluid on Surface Roughness

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K E Y W O R D S

Surface Roughness, Turning, Cutting Fluids, Soluble Oil.

A B S T R A C T

This research studied the influence of cutting fluids and cutting parameters on the surface roughness for stainless steel worked by turning machine in dry and wet cutting cases. The work was done with different cutting speeds, and feed rates with a fixed depth of cutting. During the machining process, heat was generated and effects of higher surface roughness of work material. In this study, the effects of some cutting fluids, and dry cutting on surface roughness have been examined in turning of AISI316 stainless steel material. Sodium Lauryl Ether Sulfate (SLES) instead of other soluble oils has been used and compared to dry machining processes. Experiments have been performed at four cutting speeds (60, 95, 155, 240) m/min, feed rates (0.065, 0.08, 0.096, 0.114) mm/rev. and constant depth of cut (0.5) mm. The amount of decrease in Ra after the used suggested mixture arrived at (0.21μm), while Ra exceeded (1μm) in case of soluble oils This means the suggested mixture gave the best results of lubricating properties than other cases.

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1. Introduction

Cutting fluids are commonly used to enhance machining operations such as turning. During the machining process, friction between the cutting tool and work piece causes a rise in temperature generation. As result, the generated heat effects on both the work piece and cutting tool, thereby some problems include: difficulty controlling in work piece dimensions, formation of built-up edge on the cutting tool that increases surface roughness of the work piece, and reduces the tool life [1]. Cutting fluid is utilized for machining of metal due to several causes such as to improve surface roughness. In metal manufacturing processes, costs of cutting fluid are about (7-17%) of the total manufacturing costs, while the costs of cutting tool amount are (2-4%) [2]. Cutting fluid is utilized for machining of metal due to several causes such as to improve surface roughness. In metal manufacturing processes, costs of cutting fluid are about (7-17%) of the total manufacturing costs, while the costs of cutting tool amount are (2-4%) [2]. Several studies have been written in recent time are given below:

Ebbrell, et al. examined the contact zone between cutting tool during the use of high cutting speeds. Cutting fluids with water based will reduce the effect of generated heat on the tool. The type of work piece material is the other factor for selection of adequate cutting fluids in machining processes. High pressure additive cutting oils are preferred for brass machining. The other parameter for selection of cutting fluid in cutting processes is the tool material, and waterless cutting fluids are more suitable when difficult-to-cut materials are machined [3]. Liu, et al. concluded that the lower surface roughness can be produce by spraying (oil / water) emulsion on the flank face, when vegetable oil molecules has been sprayed into tool chip area. Cutting fluid is utilized for machining by cooling the work piece tool region, reducing the material deformation at the cutting area, and reduced the bonding degree between chip and tool rake, and become the lowest value of Ra. The cutting fluid also enhance ability of chip-breaking, and prevent winding of the chips around the work piece [4]. Obi, et al. compared the using of many kinds of vegetable oil (palm, groundnut, shear butter and cotton seed oils) as lubricating fluids within the turning operating, with conventional cutting fluid. They concluded the properties of vegetable oils enhanced their performance in machining operations include the presence of fatty acids, surface active agents such as stearic acid and halogens such as chlorine, that helps to reduce surface energy and increases its wetting power or oiliness. A slight decrease of chip compression by speed, followed by a small amount rise and a decrease again, where chip thickness reduced first reaching a minimum. The Ra ranges were gated (0.5-3.2 μm), the palm oil gave better value of Ra reached (0.5 μm) during feed rate (0.09 mm/rev), while the largest value of Ra arrived (4.4 μm) at depth of cut (2.9 mm) while using groundnut oil [5]. Hussein had machined a brass alloy as wok piece and studied the effect of using different cutting fluids with different cutting speeds at constant cutting parameters (feeding and depth of cut) on Ra, and discussed the application of cutting fluids as an alternative for choosing coated cutting tools, and used different cooling conditions that are started with dry machining, wet condition (water, soluble with water, water and soap solution, sun flower oil and standard coolant). The Ra for dry, water, oil, soluble water, air, and standard coolant was revealed that in every condition decreases in surface roughness with increase in cutting speed, the best surface roughness appear when the standard coolant used as a cutting fluid followed by sun flower oil, and the best of surface roughness Ra after using standard coolant was (0.125μm) at (70 m/min) [6].

2. CLASSIFICATION OF CUTTING FLUIDS

There are many ways of classification cutting fluids, one of these ways the classification that are based on their origins, as shown in Figure 1 [7].

I. Selection of suitable cutting fluids

The selection of cutting fluid in machining process depends on different factors which are carried out according to the following [9]:

1) Type of machining processes.
2) Type of work piece materials.
3) Type of cutting tool material.

II. Work piece type, Machine, and cutting tool

The work piece material used in this experimentation was a stainless steel bar (316) of length (170mm) divided to five equal parts (25mm) the original outer diameter of (58mm) was machined and changed to (52mm), as shown in Figure 2. The chemical composition of stainless steel (316) alloy was referred in Table I. The turning used was a manually 330mm swing Centre lathe (Harrison M300). The tungsten carbide (WC) cutting tool was used, and the promotional tungsten carbide insert used is (DCMT DCMT070204/ DCMT0702 DCMT11T304), as shown in Figure 3.

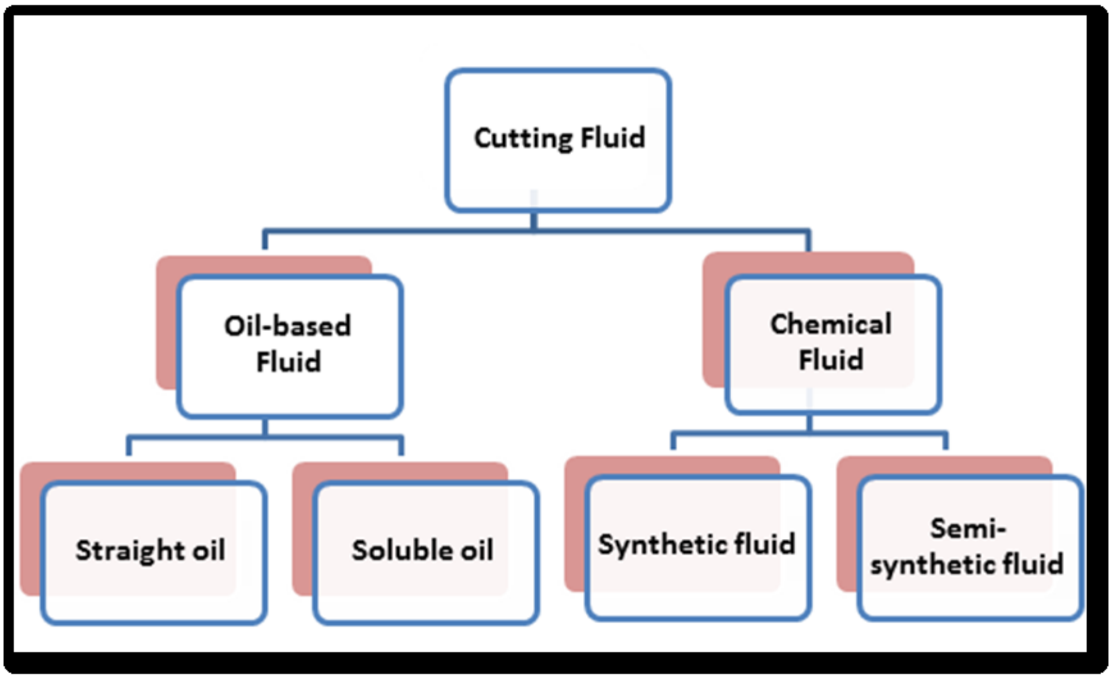

Figure 1: Classifications of cutting fluids [8].

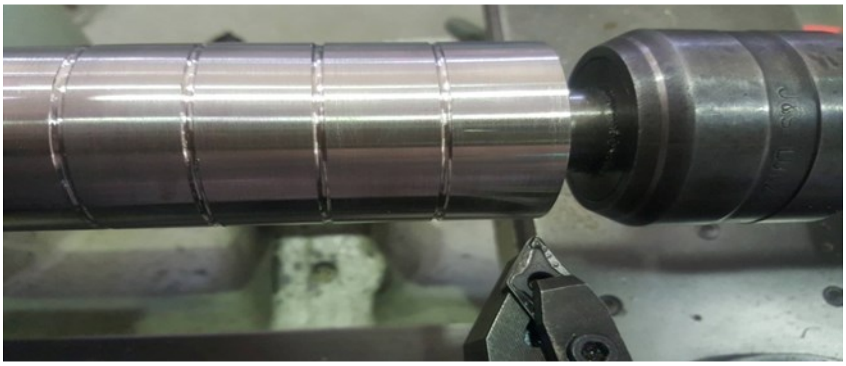

Figure 2: Stainless steel bar (Work piece).

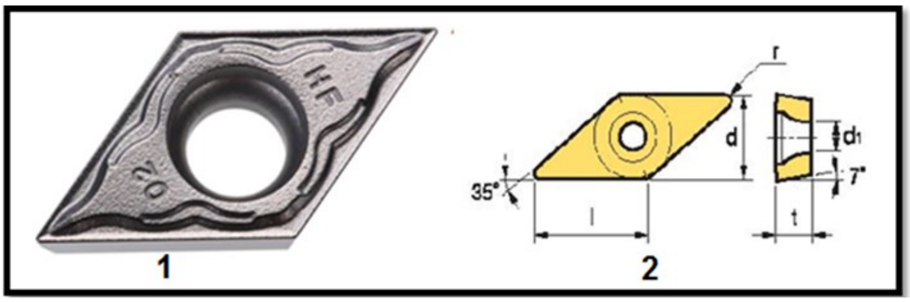

Figure 3: Tungsten carbide cutting tool.

TABLE I: The chemical compositions of Work piece material, stainless steel (AISI 316L).

No.	Element	Percent	No.	Element	Percent
1	C	0.0813	*8*	Al	0.001

2	Si	0.401	***9***	Ni	8.91
3	Mn	1.39	***10***	Cu	0.34
4	P	0.036	***11***	V	0.0997
5	S	0.0005	***12***	W	0.0501
6	Cr	17.62	***13***	Fe	Residual
7	Mo	0.052			

III. Cutting fluids

Experiments included using of different types of cutting fluids in addition to variable cutting conditions. The flash point was tested by pensky martens closed cup tester ASTMD93, PH by tested using PH meter, and specific gravity was tested by Hydrometer Method (ASTM D 1298). The cutting fluids used in this study were: Soluble oil Code No. (7201), Soluble oil Code No. (7208), were sourced from Al-Doura refinery, and the tests were conducted there, and the proposed cutting fluid. In order to get a liquid meet with a low surface roughness. The proposed cutting fluid mixture was suggested, that consists of:

1. Sodium Lauryl Ether Sulfate (SLES): The common name is (Texapon) and chemical formula: CH3(CH2)11(OCH2CH2)nOSO3Na mixed with water in the rate of: (1:10).
2. Tri Ethanol amine (N(CH2 CH2 OH)3) as a chemical bond in the rate of (2%) with a mixture of Texapon and water.
3. Anti foam: as auxiliary additive, to prevent foam with small amount ranges (80) gm into the amount of 20 liters of the above mentioned. All ratios were selected after several tests of different ratios to obtain good specifications of viscosity, density, and moderate PH rate. The specifications of this mixture is shown in Table II.

TABLE II: Specifications of the proposed cutting fluid mixture

	Specification	Result
1	Viscosity (cst) at 31 C	3.2419
2	Sp. Gravity	1.02
3	Flash point(c.o.c) C	Up to 250
4	Emulsion (7 days)	Pass
5	Corrosion (24 hr.)	Ok
6	PH	7.0

IV. Experimental Procedure

In this research, four samples with 50 mm diameter and 180mm length were used from stainless steel (316). The chemical composition of work piece alloy was indicated in Table III. Samples were machining in dry and wet cutting conditions (by using cutting fluids). The cutting conditions were: cutting speeds (60, 95, 155, 240 m/min), feed rates (0.065, 0.08, 0.096, 0.114 mm/rev), at constant depth of cut. Portable surface roughness device used to measure surface roughness (Ra), which produced by (MAHR FEDRAL INC, USA) with a range (0.03 µm to 6.35 µm).

3. RESULTS AND DISCUSSION

During each turning operation the surface roughness Ra were measured. The readings for each measured value are repeated three times, and the average was taken.

TABLE III: The results of measured Ra values

No.	V_c **(m/min)**	***f*** **(mm/rev)**	**Ra (µm)**

			Dry	*SO.1*	*SO.2*	*CF mixture*
1	60	0.065	1.82	0.90	0.45	**0.50**
2	60	0.08	2.6	1.06	0.58	**0.62**
3	60	0.096	2.72	1.25	0.72	**0.74**
4	60	0.114	2.81	1.49	1.21	**0.93**
5	95	0.065	1.21	0.58	0.46	**0.40**
6	95	0.08	1.68	0.74	0.52	**0.51**
7	95	0.096	1.72	0.88	0.62	**0.62**
8	95	0.114	1.8	0.96	1.02	**0.76**
9	155	0.065	0.9	0.32	0.36	**0.28**
10	155	0.08	1.01	0.40	0.48	**0.38**
11	155	0.096	1.21	0.52	0.57	**0.45**
12	155	0.114	1.32	0.68	0.78	**0.56**
13	240	0.065	0.38	0.32	0.26	**0.21**
14	240	0.08	0.66	0.38	0.32	**0.32**
15	240	0.096	0.80	0.45	0.43	**0.37**
16	240	0.114	0.96	0.50	0.61	**0.44**

Figures 4, 5, 6 and 7 explain the relationship between feed rates and surface roughness. They show any increase in feed rate in ranges of (0.065-0.114 mm/rev) will increase the surface roughness accordingly for different values of cutting speeds. In dry machining, the Ra was reduced by (25%) with increase in cutting speed, while the percentage of decrease was (35%) at low cutting speeds, because of increase in chip area which causes an increase in surface roughness, as shown in Figure 4. The Ra values after using cutting fluids are less than that in the dry machining, because a low coefficient of friction for fluids. Figure 5 shows that machining at soluble oil (7201), there are a lot of convergence in Ra values at high cutting speeds (155-240 m/min) that can be caused by a slight effect of this fluid in these conditions, which confirms the low physical properties such as viscosity and gravity.

A close values of surface roughness in case of soluble oil (7201) shown clear in Figure 6, beyond to good effect of soluble oil on surface roughness, viscosity is high compared with soluble oil (7201). Figure 7 indicates a significant reduction in surface roughness, especially at high cutting speed values, due to stability of cutting fluid mixture when the heat rises. The best value of surface roughness was (0.21 µm) at cutting speed (240 m/min), and feed rate (0.065 mm/rev) under the proposed cutting fluid mixture.

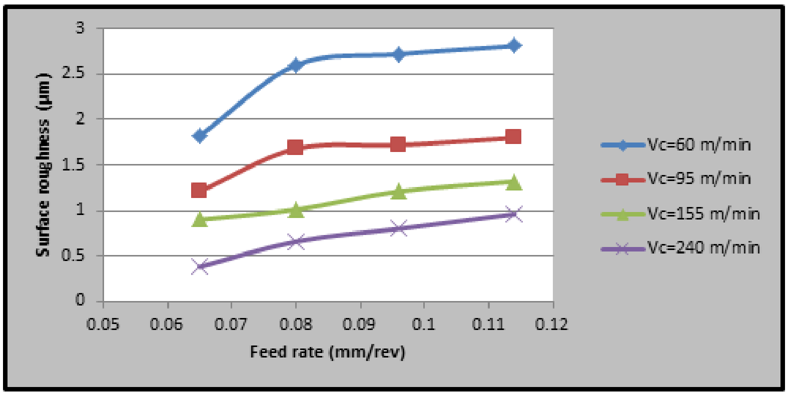

Figure 4: The relationship between feed rate and Ra for dry machining.

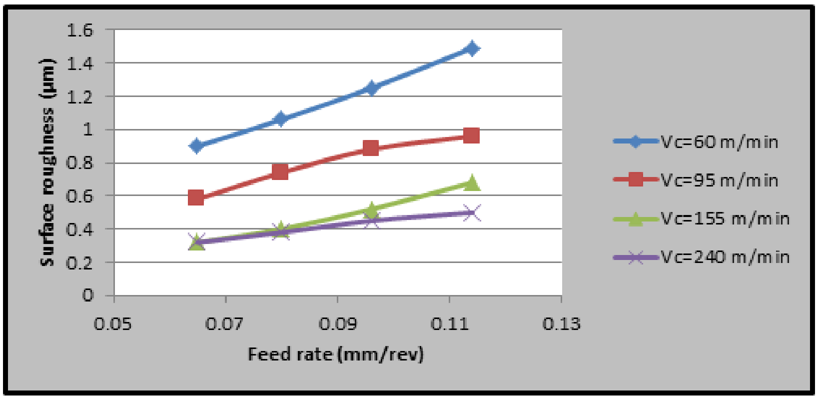

Figure 5: The relationship between feed rate and Ra for soluble oil cod No.(7201) machining.

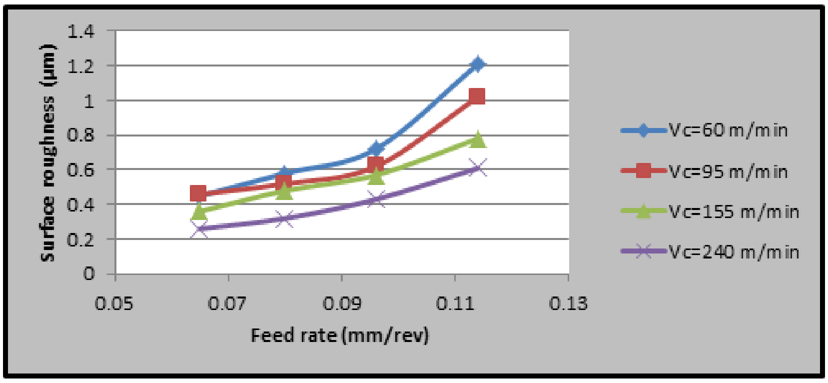

Figure 6: The relationship between feed rate and Ra for soluble oil cod No. (7208) machining.

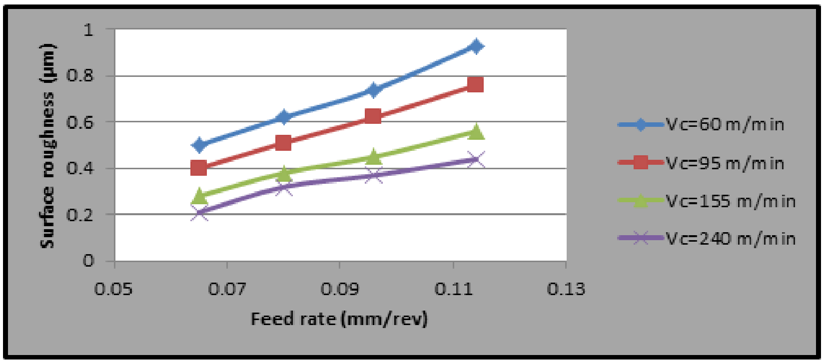

Figure 7: The relationship between feed rate and Ra for the proposed cutting fluid mixture machining.

Figures 8, 9, 10 and 11 explain the relationship between cutting speed and Ra will be shown. Any increase in cutting speed in the ranges of (60-240 m/min) will reduce Ra accordingly for different values of feed rate ranges (0.065 to 0.114 mm/rev) at all cutting conditions, since any increase in cutting speed will reduce the cutting force, and vibrations, due to Merchants circle relations and the reduction in formation of Build Up Edge (BUE) at high cutting speed.

Figure 8 shows the relationship between Ra, and cutting speed for dry machining. They indicate a significant difference between Ra values during the change in cutting speed, due to the absence of cutting fluids. Figure (9) shows soluble oil (1) machining, there is a slight change in Ra, where the percentage of decreasing reaches (79%), and a close Ra vales at (Vc =240 m/min), due to low effect of soluble oil No.(1) on Ra at high cutting speed during feed rate ranges (0.065-0.114 mm/rev). In Figure 10 for soluble oil (2) machining, the results shows same trend as in case of fluid No. (1) machining, but with lower values of Ra, where the maximum Ra measured was (1.21 µm) compared with previous machining was (1.49 µm).

The best result of Ra was observed during the proposed cutting fluid mixture machining, as shown in Figure 11, which refers to this mixture gave better lubricating properties than other conventional soluble oils, the average of percentage for decreasing in Ra reached (53%).

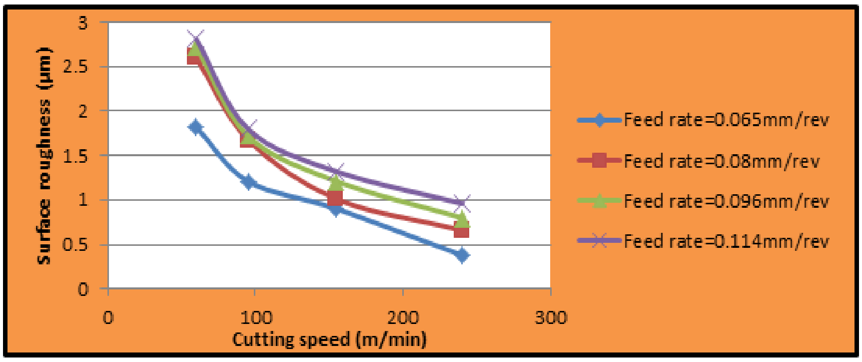

Figure 8: The relationship between cutting speed and Ra at different values of feed rates for dry machining.

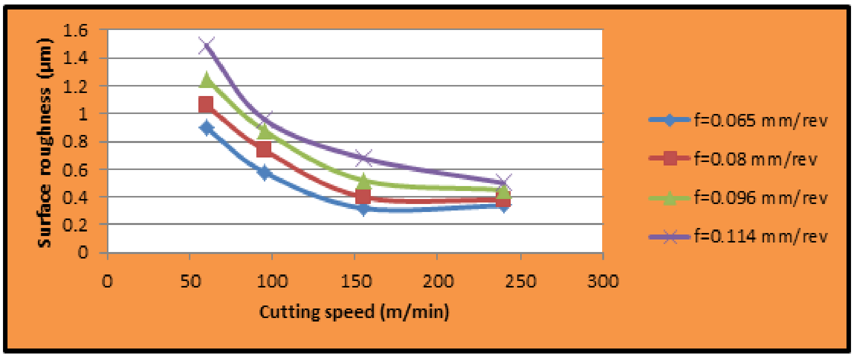

Figure 9: The relationship between cutting speed and Ra at different values of feed rates for soluble oil No. (1) machining.

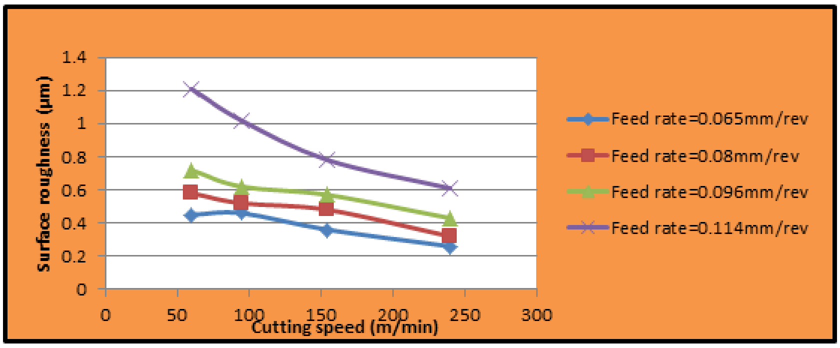

Figure 10: The relationship between cutting speed and Ra at different values of feed rates for soluble oil No. (2) machining.

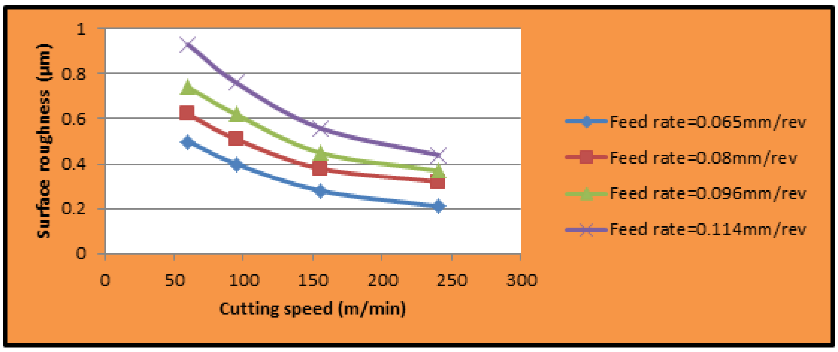

Figure 11: The relationship between cutting speed and Ra at different values of feed rates for the proposed cutting fluid mixture machining.

The different effects of cutting fluids was achieved under many of trials with variety conditions and cutting parameters, and the comparison of relationships for Ra during different cutting fluids shows a cutting fluid mixture having a good performance machining on Ra, especially through cutting speed (155 m/min), as shown in Figure 12.

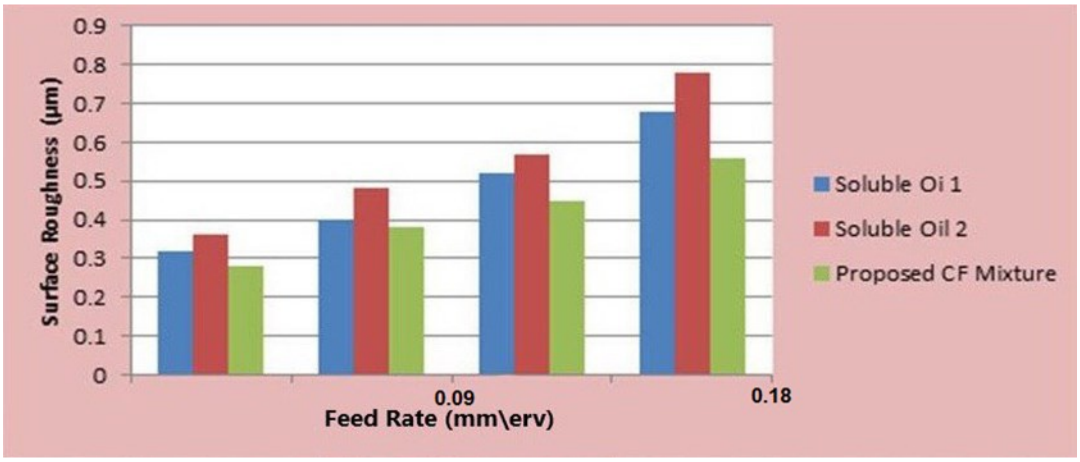

Figure 12: Maximum Ra attained during machining with cutting fluids at the cutting speed (155) m/min.

4. Conclusions

Based on practical experiments and different cutting conditions, the following was concluded:

i. The cutting fluids play an important role and have a great effect on surface roughness (Ra).
ii. The decrease in the values of surface roughness was at the lowest feed rates as expected and with the presence of the proposed mixture that gave the lowest amount of surface roughness after it was proven effective in terms of viscosity and gravity.
iii. An increase in cutting speed during ranges (60-240 m/min), leads to reduction of the Ra value, the proposed mixture helped to reduce friction significantly at most speeds range rates, which did not exceed (0.75 μm), the used speed during machining.
iv. The best value of Ra has been obtained at cutting speed (240 m/min), and the ratio feed (0.065 mm/rev), are (0.21 μm), during the use of the proposed cutting fluid mixture.

References

[1] K. Prasad and S. Chakraborty, "A Quality function deployment-based model for cutting fluid selection," Advances in Tribology (1), pp. 1-10, 2016.

[2] F. Klocke, and G. Eisenblatter, "Dry cutting," Annals of CIRP, Vol. 46(20), pp. 519-526, 1997.

[3] S. Ebbrell, N.H. Woolley, Y.D. Trimidas, and D.R. Allanson, W.B. Rowe, "The Effects of cutting fluid application methods on the grinding process," International Journal of Machine Tools and Manufacture, Vol 40, 209-223, 2000.

[4] Y. Liu, A. Wang, B. Wang, and Z. Liu, "Experimental study on the effects of oil/water emulsion on machining stainless steel," International Technology and Innovation Conference, pp. 1-4, 2009.

[5] A. I. Obi, A.A. Alabi, R. B.O. Suleiman, and F.O. Anafi "Verification of some vegetable oils as cutting fluid for Aluminum," Nigerian Journal of Technological Development, December, 2013.

[6] S. G. Hussein "An Experimental study of the effects of coolant fluid on surface roughness in turning operation for brass alloy," Journal of Engineering, March, 2014.

[7] P.J. Liew, A. Shaaroni, N.A.C. Sidik, J. Yan, "An overview of current status of cutting fluids and cooling techniques of turning hard steel," International Journal of Heat and Mass Transfer 114, pp. 380–394, 2017.

[8] Z. Wank, "The Correlation between the penetration force of cutting fluid and machining stability," A Thesis of the Degree of Master of Science, Worcester Polytechnic Institute, May, 2010.

[9] M.A. El Baradie, "Cutting fluids Part I: Characterization," Journal of Materials Processing Technology 56, pp. 786-797, 1996.