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Research Paper

Investigation of cutting parameters on hard turning of 90CrSi steel under dry condition

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Abstract
The paper content presents an experimental investigation on hard turning process of 90CrSi steel (60-62 HRC) under dry environment. The factorial experimental design was applied to evaluate the influences of cutting speed, feed rate and depth of cut on surface roughness R_a. The obtained results show that feed rate has the strongest influence on R_a, followed by the depth of cut and cutting speed. The interaction effect of feed rate and depth of cut presents the significant effect on R_a. Moreover, the proper values for cutting speed, feed rate and depth of cut are provided to achieve the smaller surface roughness values.

Keywords: *Hard turning, cutting speed, feed rate, depth of cut, surface roughness.*

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I. INTRODUCTION

In recent years, hard machining technology has been developed and applied more and more widely in the metal cutting industry. The traditional solution for finishing hardened steels is grinding. The use of cutting tools with geometrically defined cutting edges for direct cutting of heat-treated steels offers outstanding advantages such as high productivity and high production flexibility [1]. Besides, the hard machining technique gives high dimensional and surface accuracy, equivalent to grinding [2].

Along with the development of material technology and machine tools, it is now easier to implement hard machining on machine tools, helping production facilities to save money on machine investment costs. Among hard machining processes, hard turning is an increasingly widely used method and has demonstrated outstanding advantages when compared to grinding in terms of productivity. Moreover, hard turning under dry condition, which eliminates the use ofcooling lubricants, has contributed to reduce the cost of using and treating these types of used coolants, so dry hard turning is classified in the group of environmentally friendly machining methods [3].

However, when cutting in dry condition, the cutting force and heat generated from the cutting area are very large, so this technology often requires very strict requirements on the selection and materials of cutting tools. The types of cutting tools commonly used in hard machining technology are: Polycrystalline Diamond (PCD), Cubic Boron Nitride (CBN), ceramics, and coated carbides. Another factor that also plays an important role is the use of a reasonable cutting condition for each type of workpiece and cutting tool material. Therefore, investigating the influence of cutting mode on the hard turning process has high scientific and practical significance.

There have been many studies on the influence of cutting parameters when using CBN inserts[4,5], ceramic tool, carbide inserts[6,7]. The experimental results show that the surface quality is high in hard turning. However, studies on the effect of cutting condition on the hard turning process of 90CrSi steel are still very limited. Therefore, the authors studied the effects of cutting speed, feed amount, and depth of cut on surface roughness in hard turning of 90CrSi steel (60-62 HRC).

II. MATERIAL AND METHODS

The experimental set up was shown in Figure 1.The coated carbide inserts wereused. Surface roughness values were measured byMITUTOYO SJ-210 Portable Surface Roughness Tester.The 90CrSi steel samples have the hardness of 60-62 HRC and thediameter is 40 mm with the chemical composition (Table 1).

Table 1 – Chemical composition in % of 90CrSi steel

Element	C	Si	Mn	Ni	S	P	Cr	Mo	W	V	Ti	Cu
Weight (%)	0.85-0.95	1.20-1.60	0.30-0.60	Max 0.40	Max 0.03	Max 0.03	0.95-1.25	Max 0.20	Max 0.20	Max 0.15	Max 0.03	Max 0.3

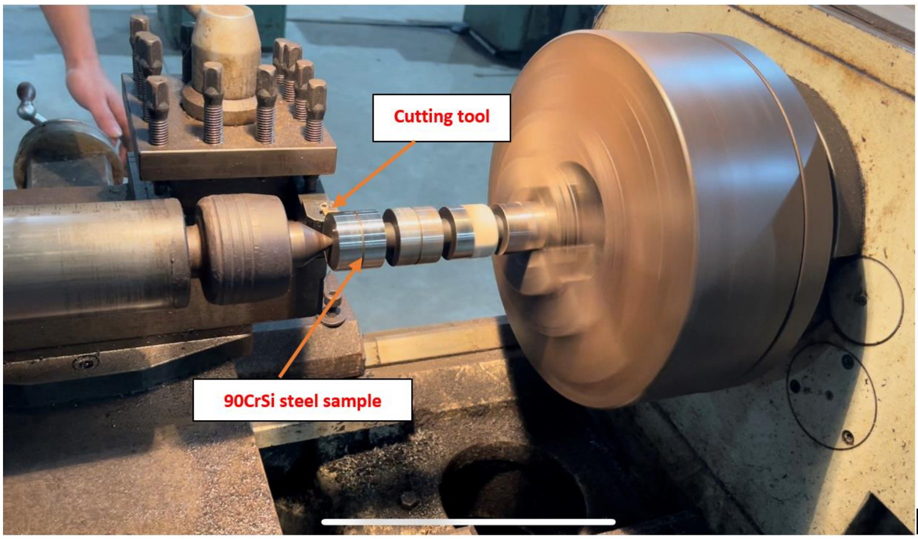

Figure 1. The experimental set up

The factorial design of three factors and their levels is given by Table 2. Each experimental trialiscarried out be following the factorial design and is repeated by three times under the same cutting parameters. The measured surface roughness values were taken by the average values.

Table 2. Factorial design of three factors and their levels

Input machining parameters	**Low level**	**High level**
Cutting speed, V (*rpm*)	650	950
Feed rate, f (*mm/rev.*)	0.05	0.15
Depth of cut, a_p (*mm*)	0.1	0.2

III. RESULTS AND DISCUSSION

The experiments were conducted by following the factorial experimental design, and the data were collected and processed. The main effectsand interaction effects of the input parameters on the surface roughness R_a are shown in figures 2, 3. The regression equation for surface roughness R_a is given below:

R_a (µm) =3.113 - 0.003500*V - 20.89*f - 19.74*a_p + 0.02607*V*f + 0.02477 V*a_p+ 174.3*f*a_p - 0.1933*V*f *a_p (1)

From Figure 2, it can be seen that with increasing cutting speed, the surface roughness decreases, while the surface roughness values go up rapidly when feedrate and depth of cut increase. Among them, feed rate has the greatest influence on surface roughness. The interaction effect between feed rate and depth of cut has the greatest influence on surface roughness, while the interaction effects between cutting speed and feed rate and cutting speed with depth of cut has little influences (Figure 3).

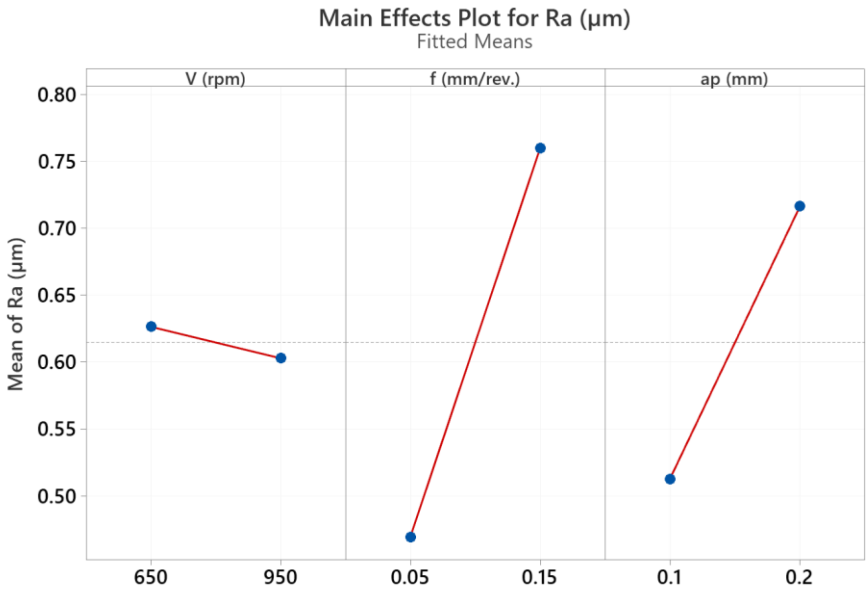

Figure 2. Main effects of input variables on surface roughnessR_a

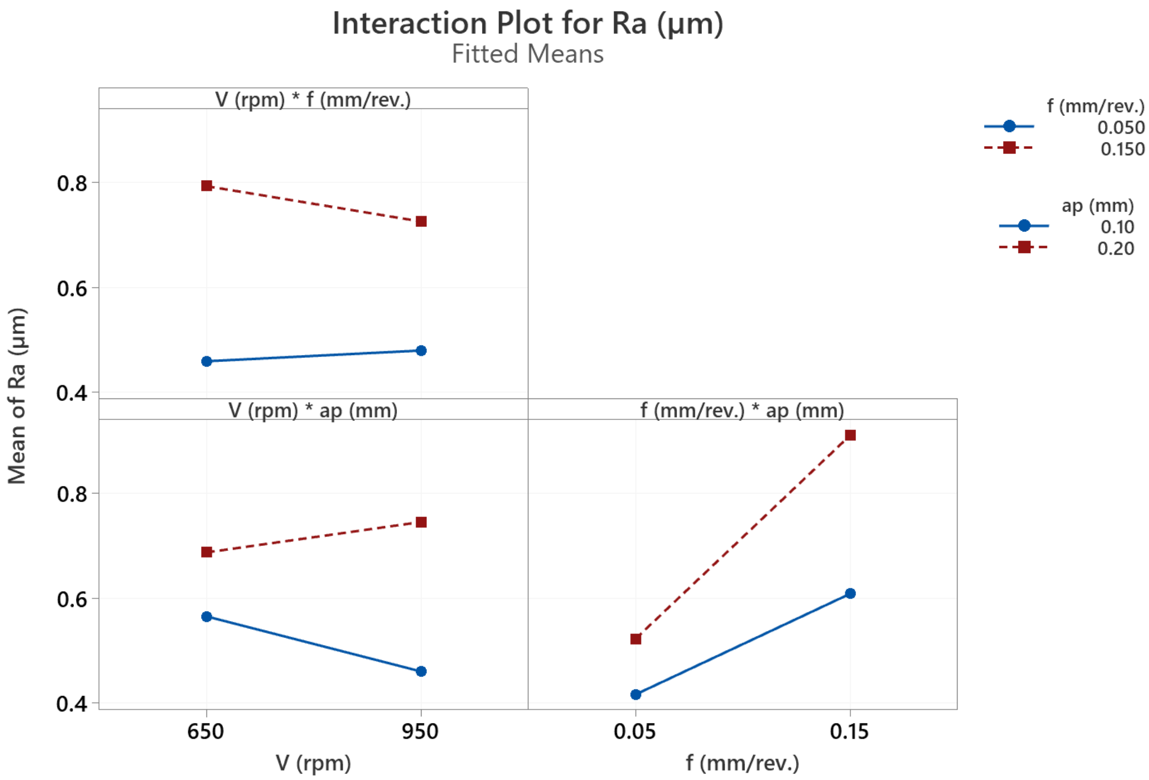

Figure 3. Interaction effects of input variables on surface roughnessR_a

From the surface plots showing the interaction effects between the cutting speed and feed rate on surface roughnessR_a by fixing depth of cut at 0.15 mm, cutting speed and feed rate should be selected with the low levels to bring out the smaller R_a (Figure 4). In the case when feed rate is fixed at 0.1 mm/rev., it is recommended to choose the high level of cutting speed combined with the low level of depth of cut (Figure 5). In the case when cutting speed is fixed at 800 rpm, the low levels of feed rate and depth of cut should be selected (Figure 6).

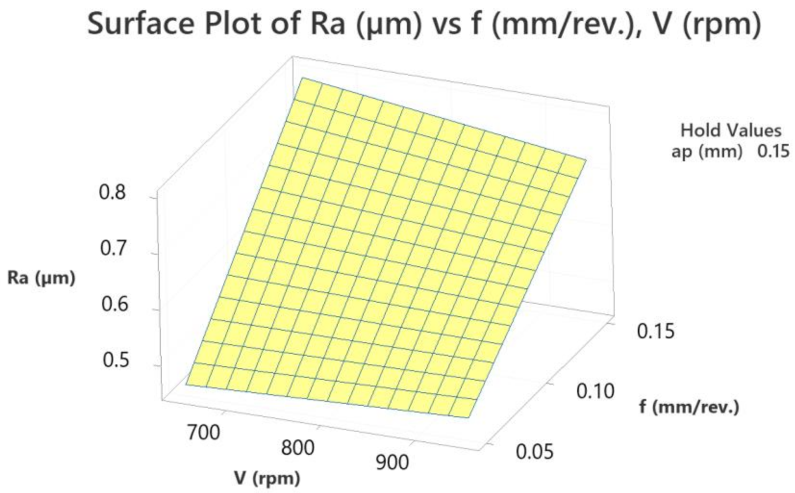

Figure 4. Surface plot of cutting speed and feed rateon surface roughness R_a

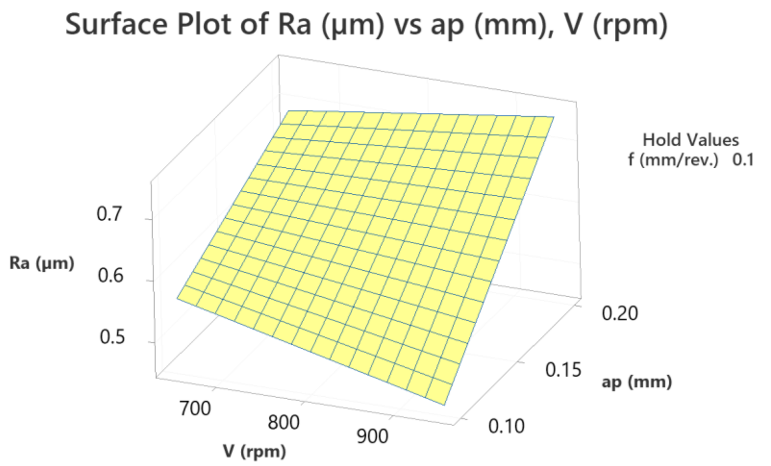

Figure 5. Surface plot of cutting speed and depth of cut on surface roughness R_a

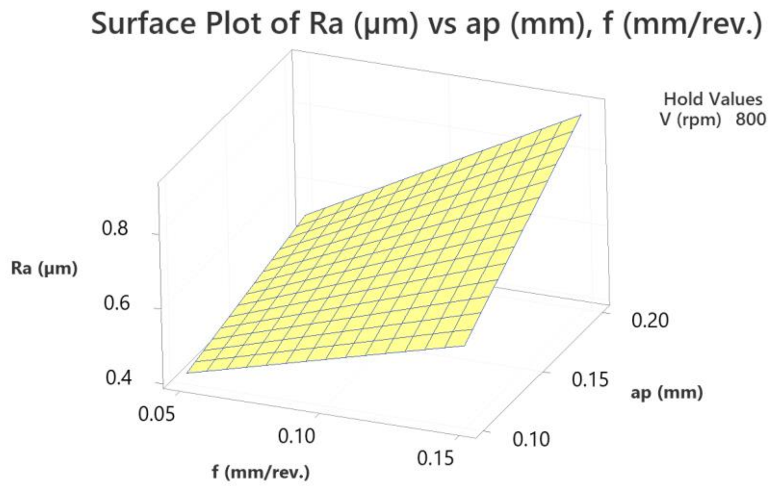

Figure 6. Surface plot of feed rate and depth of cut on surface roughness R_a

IV. CONCLUSION

In this work, dry hard turning of of 90CrSi steel(60-62 HRC) has been successfully implemented. The factorial experiment design with the help of Minitab 19 software was applied to investigate the effects of cutting speed, feed rate and depth of cut on surface roughness R_a. The main effects and interaction effects of input machining parameters were evaluated to reveal that feed rate and the interaction between feed rate and depth of cut have strong influences on R_a. The surface plots can be used to provide the technological guidelines for choosing the appropriate values of input variables suitable for specific machining condition. In further research, more investigationshould be focused on optimizingthe cutting parameters, tool wear and tool life.

Acknowledgments

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