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Turning process on en47 spring steel with different tool nose radii using OFAT approach

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ABSTRACT

EN47 spring steel samples are machined using coated tungsten carbide tools of different nose radii and the results are compared with each other. Cutting parameters are considered using one factor at a time (OFAT) approach. Input parameters are cutting speed (V_c), feed rate (f) and depth of cut (a_p) varies from 256 rpm to 572 rpm, 0.043 mm/rev to 0.117 mm/rev and 0.25 mm to 0.75mm respectively. The corresponding output performance are cutting force, surface roughness and tool tip temperature have been analyzed. The result reveals that the lower cutting force and better surface roughness obtained with 1.2 mm nose radius similarly for minimum tool tip temperature obtained with 0.8 mm nose radius.

1. INTRODUCTION

Manufacturing is the backbone of any industrialized nation. Its importance is emphasized by the fact that, as an economic activity, it comprises approximately 20–30% of the value of all goods and services produced. Manufacturing can be defined as the application of mechanical, physical, and chemical processes to convert the geometry, properties, and appearance of a given starting material to make finished parts or products. The ability to produce this conversion efficiently determines the success of the company. Manufacturing is an important commercial activity carried out by the companies that sell products to customers [1-2].

In the modern sense, manufacturing involves interrelated activities that include product design and documentation, material selection, process planning, production, quality assurance, management and marketing of products. In machining process proper selection of cutting condition as well as work material, cutting tool is necessary. Cutting tool performance can be evaluated considering some of the output performance such as surface roughness, tool wear, etc. So many researches have done on machining process some of the literature helps to identify the method and techniques. P Shivaiah and D Chakradar investigate the machinability characteristics of 17-4PH stainless steel during wet and cryogenic machining. Performance characteristics are tool wear, surface roughness, cutting temperature and cutting force. Comparison done with wet and cryogenic machining. The results reveal that cryogenic machining performs better than wet machining [3]. S Paul et al attempt had been done with turning process on AISI 1060 with two types of carbide inserts during cryogenic machining on tool wear and surface roughness. Obtained results have been compared with dry machining and machining with soluble oil as coolant. From this experiment they conclude that cryogenic machining substantially benefits for tool wear and surface roughness [4]. M Y Noordin et al illustrate the experimental work on AISI-1010 steel with three different cementite carbide tool materials (i. uncoated ii. coated with Al_2O_3 iii. coated with TiN). The experiments performed with varying cutting speed and feed rate, constant depth of cut during dry condition. Cutting forces and surface roughness were measured during experiment. Comparative study has been done on three different cutting tool inserts, in that coated with TiN performs better result achieve low cutting force and very good surface finish could be obtained [5]. Ibrahim et al performed turning process on AISI 304 and AISI 316 austenitic stainless steel using CVD-multilayer coated cemented carbide tools (i. TiCN/TiC/Al_2O_3 ii. TiC/TiCN/TiN). Turning process performed with varying cutting speed while depth of cut and feed rate kept constant, output responses are cutting force and surface roughness. The result reveals that cutting speed significantly affected the machined surface, higher cutting speed leads better surface finish [6]. Sreeram reddy et al investigates the flank wear of the cutting tool insert, main cutting force and surface finish of the machined workpiece. Turning operation carried out on C45 workpiece material with coated tungsten carbide and this were subjected to deep cryogenic treatment (-179˚C). He concludes that the flank wear of deep cryogenic treatment of tool insert is lower than the untreated tool inserts on machining of C45. The machining force is lower with the treated carbide compared to untreated tool insert, similarly surface finish good at the treated tool insert [7]. V Sivaraman et al investigates the machinability characteristics of multiphase (ferrite-bainite-martensite) micro-alloyed steel was carried out with uncoated tungsten carbide. Influence of machining parameters such as speed, feed and depth of cut. Output response is surface roughness and cutting force. He concludes that feed rate and depth of cut influence more on cutting force and surface is the only influencing parameters is feed rate [8]. Satish chinchanikar et al in his research work he investigates different machinability aspects such as cutting force, tool life, surface roughness and chip morphology during turning of AISI 4340 with CVD applied multilayer coated carbide tool and PVD coated single layer carbide tool. He concludes that the better tool life obtained by CVD coated tool, Al_2O_3 oxide layer protected the tool from severe abrasion at elevated temperature and also the cutting speed and depth of cut influencing the tool life [9]. Several researchers worked on machinability characteristics on steel using conventional technique and optimization technique for cutting force, surface roughness, tool wear, chip morphology, white recast layer [10-12].

The present work deals with a turning process on EN-47 spring steel [13-15] using coted different nose radii (0.4, 0.8 & 1.2mm) during dry condition. Cutting parameters are considered using one factor at a time (OFAT) approach. In OFAT varying one factor and keep constant for other two factors. Output responses cutting force, surface roughness and tool tip temperature are analyzed with three different nose radii.

2. EXPERIMENTAL WORK

A conventional lathe self-center 3 jaw chuck, PANTHER lathe machine used to conduct the experiments. Lathe machine having spindle speed ranges from 30 rpm to 1250 rpm, based on literature survey cutting conditions are chosen, and machining condition are mentioned in the Table 1.

Table 1. Input parameters

SL No	a_p (mm)	V_c (rpm)	f (mm/rev)
1	0.25	256	0.046
2	0.50	384	0.093
3	0.75	572	0.117

In the present work EN47 spring steel having dimension of 150 mm length and 30 mm diameter. For avoiding chatter and vibration the length/diameter ratio should maintain within 10 (ISO 3685). Chemical composition is mentioned in the Table 2. Commercially available SNMG120404, SNMG120408 & SNMG120412 coated tungsten carbide tool insert having nose radius 0.4, 0.8 and 1.2mm during, which is attached in DSSNR2020K12 right handed tool holder. Experiments conducted based on one factor at a time (OFAT) approach.

Table 2. Composition of spring steel

Elements	C	Mn	Si	S	Cr	P	Fe
% Composition	0.45-0.55	0.50-0.80	0.50 max	0.04	0.80-1.20	0.04	Rest

Cutting forces and tool tip temperature are measured by piezo-electric based three component lathe tool dynamometers (Kistler type 9257 B) [16-17] and infrared thermal heat gun respectively. Surface roughness measured by Mitutoyo Talysurf S301 roughness tester [18-19]. For avoiding errors experiments are repeated for thrice and average value was considered for final analysis and validation.

3. RESULTS AND DISCUSSION

In this experimental work total nine experiments are conducted based on one factor at a time (OFAT) approach. OFAT is a method of conducting experiments varying one factor at a time and other two factors keep it as constant of middle level.

3.1 Varying cutting speed (V_c)

From the experimental work varying cutting speed, which influences on cutting force, tool tip temperature and surface roughness for different nose radii 0.4, 0.8 & 1.2mm.

From the Figure 1 (a) cutting speed increases with increasing tool tip temperature this due to contact between tool-chip interface, extraction of chip is more when increase the cutting speed during machining which leads higher temperature of the tool tip. In lower cutting speed, there existed some adhesion material in the cutting edge and tool rake face. The formed adhesion material are very hard nose shaped lumps, due to this built up edge (BUE) formed in the tool insert. Formation of BUE, the contact volume between tool nose radius and workpiece constantly changed, thereby the peak spacing and the peaks height of the machined surface changed. Cutting Forces: the main force is the tangential force which acts on the rake face of the tool. The two other forces, which are numerically smaller, are the feed force which resist the feed of the tool and the radial force which tends to push the tool away from the work. From the Figure 1 (b) it is observed that cutting speed increases with decreasing cutting force this is due to higher cutting speed tends high temperature which is softens the work material and this will reduce the shear angle which cause reduction in cutting force [9].

From the Figure 1 (c) it is observed that cutting speed increases with decreasing surface roughness this is due to thermal softening of the work material and increase of cutting speed which leads better surface finish [20].

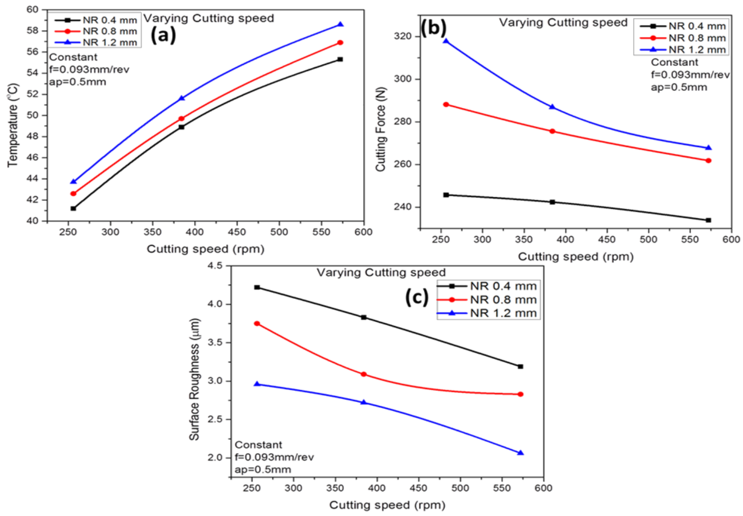

Figure 1. (a-c) Varying cutting speed on temperature, cutting force and surface roughness

3.2 Varying feed rate (f)

From the Figure 2 (a) Feed rate increases with increasing tool tip temperature this is due to increased contact length of tool-chip leads to higher temperature.

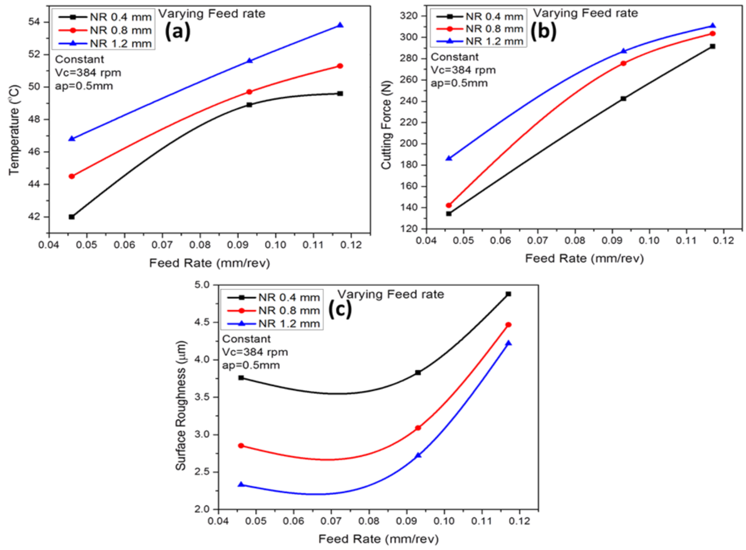

Figure 2. (a-c) Varying feed rate on temperature, cutting force and surface roughness

From Figure 2(b) Feed rate increases with increasing cutting force this is due to the increase in cross section of the chip leads higher cutting force [21]. From Figure 2(c) Feed rate increases with increasing surface roughness this is due to higher feed rate generates helicoids furrows and these furrows are wider and deeper which tends higher surface roughness [22].

3.2 Varying depth of cut (a_p)

From Figure 3(a) depth of cut increases, tool tip temperature also increases this is due to more energy is require to remove higher amount of material which leads a higher temperature. From Figure 3(b) depth of cut increases cutting force also increases this is due to the cross section of the removed chip becomes very large, which causes an increase in the volume of deformed material and requires significant cutting forces [22]. From Figure 3(c) depth of cut increases surface roughness also increases this is due to the friction between tool and workpiece are more, this leads higher surface roughness.

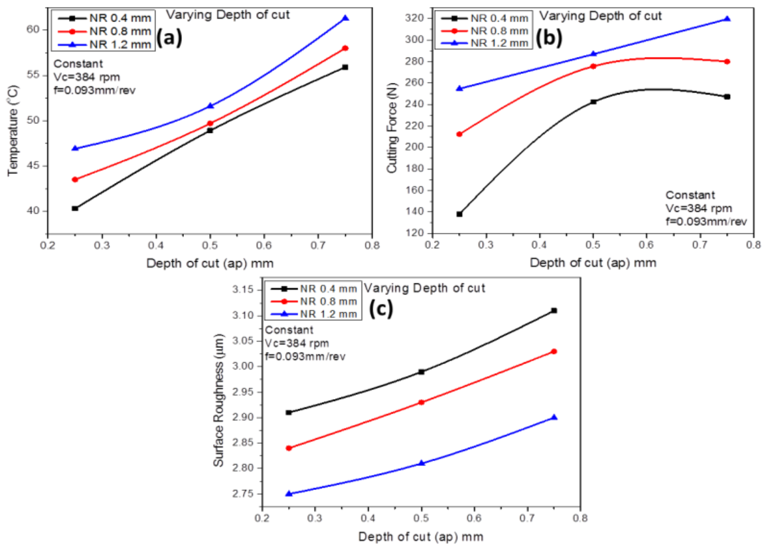

Figure 3. (a-c) Varying depth of cut on temperature, cutting force and surface roughness

4. CONCLUSIONS

The present experimental investigation was successfully conducted turning process on EN47 spring steel with different nose radii (0.4, 0.8 & 1.2mm) of tool insert. One factor at a time (OFAT) approach are applied to conduct the experiments and comparison have been studied. The effect of turning parameters of cutting speed, feed rate and depth of cut on turning operation was studied under dry condition and some of the conclusions are drawn:

- Cutting speed increases with tool tip temperature also increases but cutting force and surface roughness decreases.

- Feed rate and depth of cut increases with all the output performances are increased.
- Surface roughness decreases with increasing nose radius, 1.2mm nose radius tool insert exhibits better performance.
- Lower cutting force and tool tip temperature achieved with 0.4mm nose radius.
- In all the cases 0.8 mm NR exhibits nominal performance.

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