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Novel Approach For The Analysis Of Self-Propelled Rotary Tool Wear During Turning Of En31 Alloy Steel

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Abstract: The primary objective of designing and developing the self-propelled rotary circular tool holder is to explore the impact of circular tool and self-propelled rotational techniques on turning operations, utilizing the developed holder. Several considerations were taken into account during the design and fabrication process of the self-propelled rotary circular tool holder. These include ensuring the rigidity of the circular tool holder, allowing free rotation, accommodating different inclination angles for the circular tool, and selecting appropriate bearings to minimize frictional energy during rotation. With these criteria in mind, a self-propelled rotary circular tool holder was designed and constructed for potential application in the turning of En31 steel.

An extensive experimental investigation is underway using the developed self-propelled rotary tooling system. The study aims to analyze the influence of machining parameters on flank wear and surface finish during turning operations on En31 alloy steel using the rotary tool.

Keywords: En31 alloy steel, rotary tool, surface finish.

1. Introduction

Better and economic machining of hard material requires application of special tooling and techniques in machining. For utilization of the special technique in turning of E0300 alloy steel and En31 steel a self-propelled rotary circular tool holder has been designed and fabricated. A specially designed circular insert is mounted in such a way in the self-propelled rotary circular tool holder that it rotates counter clockwise motion due to the clockwise rotational motion of the work-piece during turning. This system of machining is one of the good alternatives to the stationary tooling in continuous turning of E0300 alloy steel and En31 steel.

The main advantages of the developed self-propelled rotary circular tooling system during turning of hard material are the distribution of heat generation over the entire cutting edge and intermittent cooling of the cutting edges during turning and the distributions of tool wear all over the entire cutting edge. It gives less cutting tool wear due to the relative rotational motion between tool and the work-piece material. Chance of formation of built-up edge even at low cutting speed during turning is very less. Rigorous sliding friction between the chip and cutting tool is less during turning and reduces chip and tool rubbing, which may reduce the cutting forces, temperature and tool wear. The self-propelled rotary circular tooling system increases the tool life.

From the review of the past research work, as it was dealt with the study of wear during the turning which is summarized as Astakhov Viktor P. et al. [1] studied the effect of a cutting speed on the flank wear of carbide P10 insert during turning of AISI 52100 steel. Author concluded that tool wear is minimum at optimum cutting speed. Ezugwu E. O. et al. [2] presented the test results during turning of titanium alloy by self-propelled rotary tool. Authors concluded that the circular insert exhibited superior wear resistance as compared to conventional rhomboid shaped carbides tool. Kishawy H. A. et al. [3] presented a performance assessment of rotary tool during machining of hardened steel. The investigation includes an analysis of chip morphology and modes of tool wear. The effect of cutting tool geometry and type of cutting tool material on the tool self-propelled motion are also investigated. Lian et al. [4] developed a self-organizing fuzzy controller (SOFC) for constant cutting force control and to control performance of the turning system. Authors concluded that the SOFC has a better control performance in constant cutting force control over traditional fuzzy controller (TFC). Schnffer C. et al. [5] studied to develop a monitoring system for hard turning by using dynamic artificial intelligence (AI) technique. Authors concluded that AI could be utilizing to monitor crater and flank wear during hard turning.

2. Planning for Experimentation

2.1 Machine tools, cutting tools, work-piece materials and measuring instruments

The different sets of experiments have been performed by turning operation on a HMT-LB20 Center Lathe with and without use of cutting fluid. Table 2.1 represents the details of cutting tool used for the experimentation. Machined surfaces have been measured at different positions along the machined surface and average value is taken utilizing TSK SURFCOM-130 A surface texture measuring instrument. The stopwatch is also utilized for determination of actual setup time and machining time for turning operation. Tool life is to be estimated on the basis of cutting tool flank wear considering 0.3mm of flank wear as a tool life. The flank wear is to be measured using toolmakers microscope of resolution 0.01mm. En31 steel are selected as work-piece materials. Table 1 represents the chemical composition of the work-piece materials obtained by Spectro analysis used for experimental investigations.

Table 1 Chemical composition of En 31 steel

Specification	%C	%Mn	%P	%S	%Ni	%Cr	%V	%Mo	%Cu	%Ti	%W
En31 steel	1.07	0.53	0.08	0.07	0.04	1.12	0.02	0.04	0.08	0.01	0.16

2.2 Details of the developed self-propelled rotary circular tool holder

The main feature of the rotary circular tooling system is to increase the tool life through reduction of tool wears. A self-propelled rotary tool holder has been designed and fabricated for the purpose.

In self-propelled rotary tooling, a circular insert is to be rotated due to the action of the rotational motion of the work-piece during turning. Here, the circular insert rotates in opposite direction with respect to the rotational motion of the work-piece. The cutting action is generated during turning operation by the obliquity of the cutting edge of the round insert.

2.3 Design and fabrication of the developed rotary circular tooling system

The basic aim of the design and development of the self-propelled rotary circular tool holder is to study the effect of circular tool and self-propelled rotational techniques in turning by utilization the developed holder. However, few points have been considered during design and fabrication of the self-propelled rotary circular tool holder such as circular tool holder should be rigid, rotate freely, circular tool can be hold with different inclination angles, bearing should be selected properly so that minimum frictional energy requires during rotation. Keeping the points as mentioned above, a self-propelled rotary circular tool holder has been designed and fabricated for potential application of rotary technique in the turning of E0300 alloy steel and En31 steel.

An in-depth study is being carried out during experimental investigation using developed self-propelled rotary tooling system.

Figure 1 Fabricated rotary circular tool holder

Fig. 1 shows fabricated self-propelled rotary circular tool holder. The major components, which have been exhibited in Fig.1, are indexing holder (6 holes, 15^0 apart), tool holder, for holding round insert of specification RCMT-10 T3-MO-4025, M-12 Bolt and Nut, M-6 Bolt and Nut.

2.4 Scheme of experiments

The scheme of experimentations have been setup to perform the experimental studies on the machining parameters and suitability of round RCMT-10 T3-MO-4025 insert during machining of En31 steel respectively by turning operation. The experiments have been carried out on HMT centre Lathe with and without use of coolant. The cutting speed range has been selected between 40 m/min to 160 m/min for machining of En31 steel during turning. The experimental investigation was carried out considering feed rate range 0.16 mm/rev to 0.48 mm/rev with constant depth of cut 1.25 mm. The cutting tool flank wear to predict the life of the tool with continuous machining time considering o.3 mm flank wear width as a parameter for assessing the tool life. The flank wear widths have been measured after each individual experiment by a Tool makers Microscope of resolution 0.01 mm. The machined surface finish also measured by Surface roughness measuring machine Surfcom 130A. A self-propelled circular tool holder was designed and fabricated in such as way so that tool can be hold with different inclination angle. The range of variation of the inclination angle was 15^0 - 60^0 for rotary circular tool used for experimental investigation.

3. Results and discussion

3.1 Influence of continuous machining time on tool wear

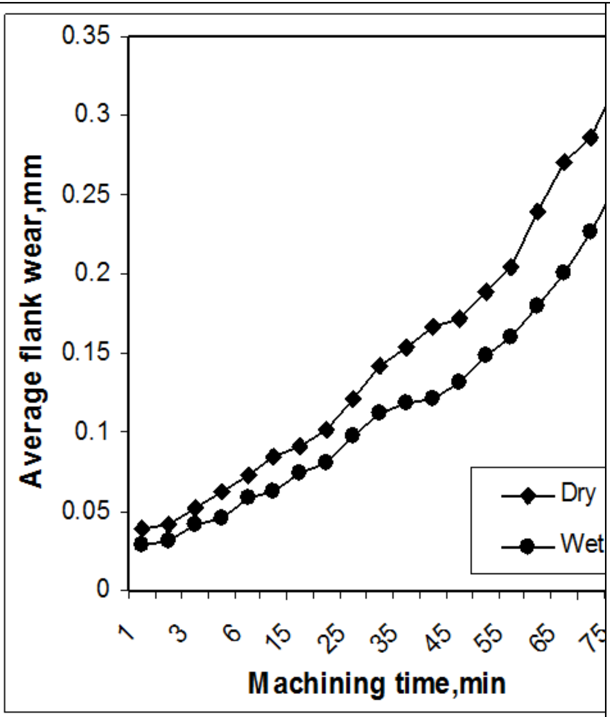

Figure 2 (a) Growth of average flank wear in mm observed while turning En31 steel by RCMT-10 T3-MO-4025 insert under dry and wet environments respectively.

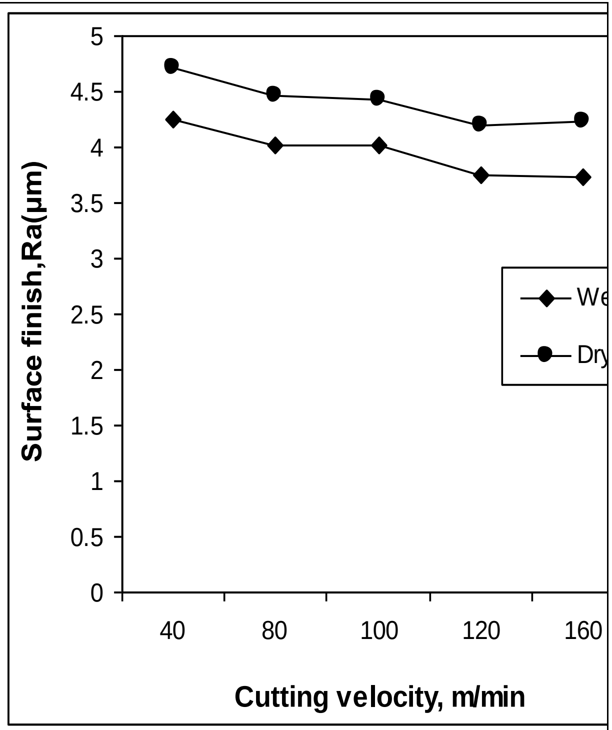

Figure 2 (b) Variation in surface finish, Ra (µm) with that of cutting speed in turning of En31 steel by RCMT-10 T3-MO-4025 insert under dry and wet environment respectively.

Similarly, Fig. 2 (a) shows the influence of continuous machining time on the average flank wear width during turning of En31 steel under dry and wet environments RCMT-10 T3-MO-4025 insert. From the Fig 2 (a), it is observed that average flank wear increases with increase in machining time. In dry turning, average flank wear are 0.321 µm and 0.039 µm after 75 min and 1 min of continuous machining respectively. But in wet turning average flank wear are 0.258 µm and 0.030 µm only even after 75 min and 1 min of continuous machining.

Similarly, Fig. 2 (b) shows the influence of continuous machining time on the average flank wear width during turning of En31 steel under dry and wet environments RCMT-10 T3-MO-4025 insert. From the Fig 2 (b), it is observed that average flank wear increases with increase in machining time. In dry turning, average flank wear are 0.321 µm and 0.039 µm after 75 min and 1 min of continuous machining respectively. But in wet turning average flank wear are 0.258 µm and 0.030 µm only even after 75 min and 1 min of continuous machining.

3.2 Influence of machining parameters on surface finish

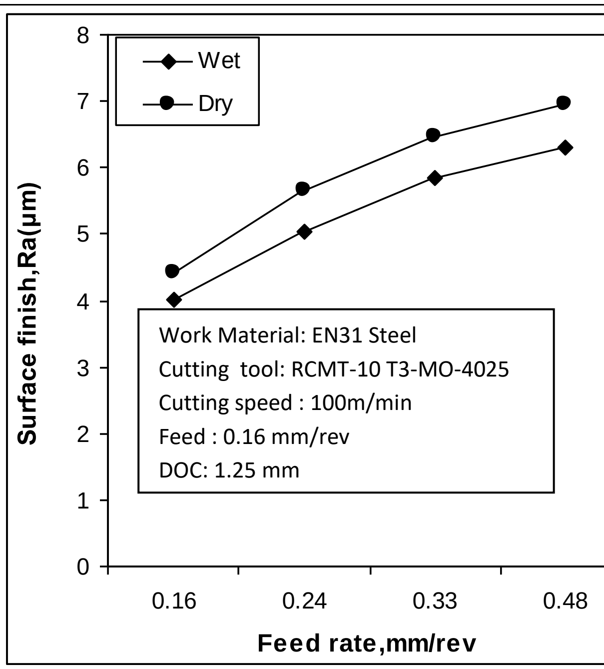

Figure 3 (a) Variation in surface finish, Ra (µm) with that of feed rate(mm/rev) in turning En31 alloy steel and En31 steel by RCMT-10 T3-MO-4025 insert under dry and wet environment respectively.

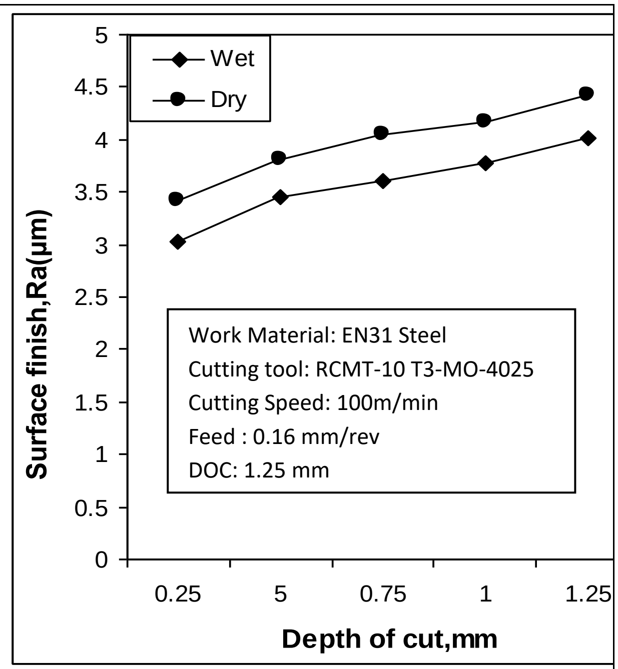

Figure 3 (b) Variation in surface finish, Ra (µm) with that of depth of cut (mm) in turning En31 alloy steel and En31 steel by RCMT-10 T3-MO-4025 insert under dry and wet environment respectively.

The variation of surface finish, Ra (µm) with feed rate (mm/rev) during turning of E0300 alloy steel and En31 steel by RCMT-10 T3-MO-4025 insert under dry and wet environments are shown in Fig. 3 (a). From the Fig 3 (a), it is observed that the surface roughness, Ra (µm) increases with increase in feed rate (mm/rev). In dry turning, surface roughness values, Ra (µm) are 4.43 µm and

6.92 µm when machining operations were performed at 0.16 (mm/rev) and 0.48 (mm/rev) feed rate respectively. But in wet turning surface roughness, Ra (µm) values are 4.02 µm and 6.3 µm at 0.16 (mm/rev) and 0.48 (mm/rev) of feed rate respectively.

The variation of surface finish, Ra (µm) with depth of cut (mm) during turning of En31 steel by RCMT-10 T3-MO-4025 insert under dry and wet environments. is shown in Fig. 3 (b) show the effect of depth of cut (mm) on surface finish, Ra (µm) during turning of En31 alloy steel by RCMT-10 T3-MO-4025 insert under dry and wet environments respectively. From the Fig 3 (b), it is observed that the surface roughness, Ra (µm) value increases with increase in depth of cut (mm). In dry turning, surface roughness, Ra (µm) values are 3.41 µm and 4.43 µm when machining were done at 0.25 mm and 1.25mm depth of cut respectively but in wet turning, surface roughness, Ra (µm) values are 3.03 µm and 4.02 µm at 0.25mm and 1.25mm of depth of cut.

4. Conclusions

1. The developed self-propelled rotary circular tooling system exhibits a tremendous potential for rough and high metal removal rate turning of En31 steel. This tool has more life, less flank wear as compared to the other tools but poor surface finish.
2. Self-propelled rotary tool gives less cutting tool wear due to the relative rotational motion between tool and the work-piece material and the chance of formation of built-up edge even at low cutting speed during turning is very less.
3. During actual machining, it is found that the rigorous sliding friction between the chip and cutting tool is less during turning and reduces chip and tool rubbing, which may reduce the cutting forces, temperature and tool wear.
4. It is observed that the surface roughness, Ra (µm) increases with increase in feed rate (mm/rev) during turning of En31 steel under dry and wet environments using RCMT-10 T3-MO-4025 insert.
5. It is observed that average flank wear increases with increase in machining time during turning of En31 steel under dry and wet environments using RCMT-10 T3-MO-4025 insert.
6. It is observed that the surface roughness, Ra (µm) value increases with increase in depth of cut (mm) during turning of En31 steel under dry and wet environments using RCMT-10 T3-MO-4025 insert.

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