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ANALYSIS OF INFLUENCE OF MACHINING TIME AND TOOL WEAR ON SURFACE ROUGHNESS IN TURNING AISI-1060 STEEL

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ABSTRACT

In this work, a surface roughness analysis versus machining time of AISI 1060 steel obtained by turning process has been selected. The effect of tool wear on the surface quality is also analyzed. The parameter selected to define the surface quality has been the arithmetic average roughness, Ra and average flank wear VB is used to define tool wear. Ra values have been analyzed for a series of test pieces obtained under different cutting condition and inserts. The obtained results allow affirming the Ra values, in general, has tendency to increase with machining time and tool wear. Within this general tendency, Ra values are higher for wet machining than dry machining.

Keywords: Turning, Steel, Roughness, Tool wear and Machining time.

1. INTRODUCTION

Surface roughness is a widely used index of product quality and in most cases a technical requirement for mechanical products. Achieving the desired surface attributes is of great importance for functional behaviour of parts that are in motion, fit with other products or needs to retain lubrication. So, the surface roughness of machined parts is a significant design specification that is known to have considerable influence on properties such as wear resistance and fatigue strength. It is one of the most important measures in finish cutting (turning, milling, drilling, etc.) operations .Consequently, it is important to achieve a consistent tolerance and surface finish[1]. For engineers, providing desired surface quality is an integral element of design conformation. So, it is important to understand the influencing factors affecting surface roughness.

In the competitive environment, production cost and volume play a vital role for economic & sustainable manufacturing activity. The natural response for high volume economic production is machining resulting high material removal rate for which machining activities needs to be pushed to the limits of machining parameters like machining speed, feed and depth of cut. Again, care should be taken that such extreme machining condition does not lead to quality compromise. This new situation makes necessary to look for combinations of cutting parameters and cutting tool variants that optimize machining in these extreme work conditions with the purpose of obtaining a quality level in products according to the demand specifications and with a cost as low as possible[2].

However, the process dependent nature of surface roughness formation along with numerous uncontrollable factors that influence pertinent phenomena, make almost impossible a straight forward solution. In order to establish selection criterion of tool and values that allow obtaining pieces in a functional and competitive way, it is necessary to carry out systematic studies about the behaviour of tools and pieces for different combinations of materials, cutting parameters and machining process.

The first study on surface roughness was performed in Germany in 1931 [3]. As a result of this study, the surface qualities were arranged as the standard DIN 140. Surfaces are expressed as “machined or not machined surfaces”. In all machined pieces, the examinations performed by hands and eyes are taken into consideration. The surfaces are classified according to tactile feeling and the naked eye. Surface qualities are designated in 4 different forms: coarse, rough, medium and fine.

Kopac and Bahor [4], who studied the changes in surface roughness depending on the process conditions in tempered AISI 1060 and 4140 steels, found speed to be the most dominant factor if the operating parameters were chosen randomly. They also reported that, for both steel types, the cutting tools with greater radius cause smaller surface roughness values. Similar studies were published by Yuan et al. [5] and Eriksen [6] and Ozses [7].

Gökkaya et al. [8] investigated the effect of cutting tool coating material, cutting speed and feed rate on the surface roughness of AISI 1040 steel. In their study, the lowest average surface roughness was obtained using cutting tool with coated TiN. A 176% improvement in surface roughness was provided by reducing feed rate by

80% and a 13% improvement in surface roughness was provided by increasing the cutting speed by 200%.

Lin and Lee [9] formulized the experimental results of surface roughness and cutting forces by regression analysis, and modeled the effects of them using S55C steel. Similar investigations were conducted by Risbood and Dixit [10], Ghani and Choudhury [11], Petropoulos et al. [12], Feng and Wang [13], Sekulic [14] and Gadelmavla and Koura [15].

This study was conducted because sufficiently in depth studies have not been carried out about the effects of length of machining time on surface roughness. In this context, the results presented in this work are part of a study focused to analyse the machinability of AISI-1060 steel under dry and wet cutting conditions. In particular, the main objective of this work is to analyse the surface roughness evolution versus the machining time and to establish the relations between gradual tool wear (average flank wear, VB) and surface roughness development using two different types of uncoated carbide inserts. The parameter selected to define the surface quality has been the arithmetic average roughness, Ra; the most extended parameter in literature for the determination of the superficial quality of the machined pieces [16].

2. SURFACE ROUGHNESS

The surface parameter used to evaluate surface roughness, in this study, is the roughness average, Ra. This parameter is also known as the arithmetic mean roughness value, arithmetic average (AA) or centerline average (CLA). Ra is recognized universally as the most common international measure of roughness [17]. The average roughness (Ra) is the area between the roughness profile and its center line, or the integral of the absolute value of the roughness profile height over the evaluation length (Fig.1) [18]. Therefore, the Ra is specified by the following equation:

$$R_a = \frac{1}{L}\int_0^L |Y(x)|dx \quad \text{................................(1)}$$

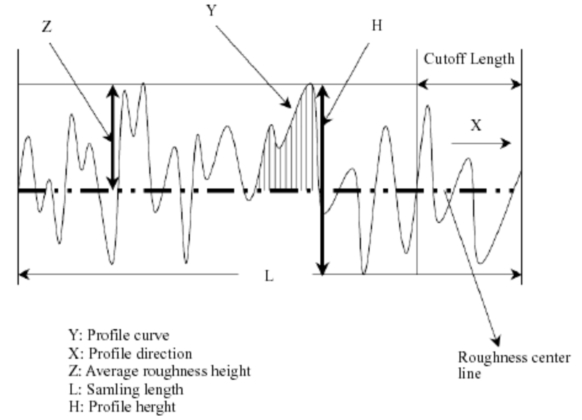


Fig 1: Surface roughness profile

When evaluated from digital data, the integral is normally approximated by the trapezoidal rule:

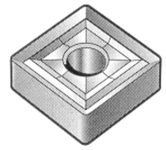
$$R_a = \frac{1}{n}\sum_{i=1}^{n} |Y_i| \quad \text{................................(2)}$$

where, R_a is the arithmetic average deviation from the mean line, L is the sampling length and Y represents the ordinate of the profile curve.

3. EXPERIMENTAL ARRANGEMENT

The machining tests have been carried out by straight turning of AISI 1060 steel on a lathe under dry and wet condition using two different types of uncoated carbide insert at a definite combination of machining parameters. The machining conditions are given in Table 1.

Table 1: Experimental conditions

Machine tool	**:** Lathe Machine (France) 15hp
Work material	**:** AISI 1060 steel (φ173 X 710 mm)
Cutting tool	
Cutting insert	**:**   SNMM 120408 SNMG 120408
Tool holder	**:** PSBNR 2525M12
Working geometry	**:** -6°,-6°,6°, 15°, 75°, 0.8 (mm)
Process parameters	
Cutting velocity	**:** 100 m/min
Feed rate	**:** 0.22 mm/rev
Depth of cut	**:** 2.0 mm
Environments	**:** Dry and Wet

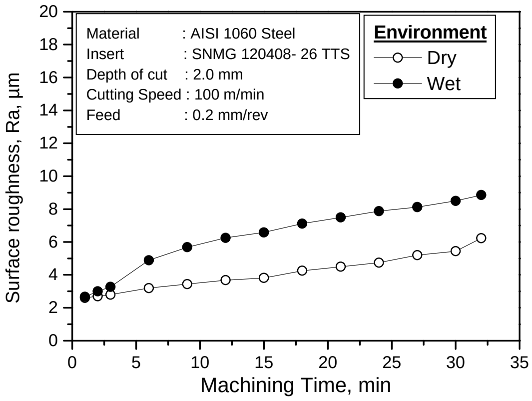
During machining, the cutting insert was withdrawn at regular intervals and then VB is measured under metallurgical microscope (Carl Zesis, 351396, Germany) fitted with micrometer of least count 1µm. The readings were taken until tool life criterion was reached.

Fig 2: Photographic view of the surface roughness measuring technique

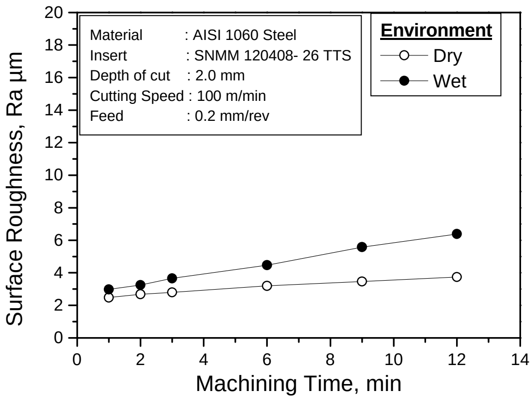
Surface roughness was measured respectively by a Talysurf (Surtronic 3+ Roughness Checker, Taylor Hobson, UK) using a cut-off length of 0.8 mm. The photographic view of the surface roughness technique for measuring surface roughness is shown in Fig. 2.

4. RESULTS AND DISCUSSION

Fig.3 shows the variation in roughness with machining time for a cutting speed of 100 m/min, feed 0.22 mm/rev and 2.0 mm depth of cut for both wet and dry machining using SNMG and SNMM insert respectively. Looking at this figure, it can be observed as Ra values present a certain tendency to increase with the machining time for both the conditions and both the inserts. Within this general tendency, Ra values are found to larger in wet condition than dry condition.



(a) SNMG insert

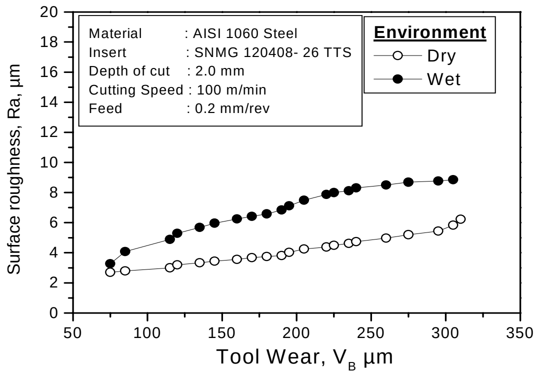


(b) SNMM insert

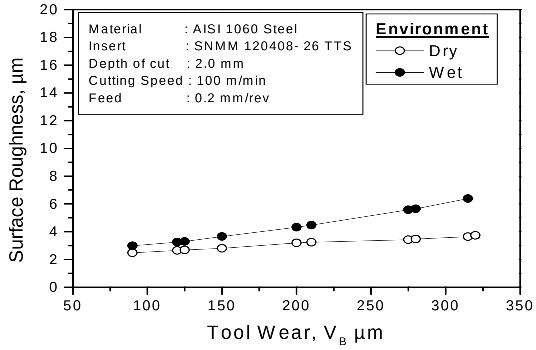
Fig 3: Variation in roughness with machining time for (a) SNMG and (b) SNMM insert

Accumulation of tool wear can be attributed for larger values of Ra as machining time increases as shown in Fig.4. In Fig.5, Ra values versus tool wear is plotted for the aforesaid combination for different inserts and machining condition. With the increase in average flank wear, the principle cutting edge wears out resulting gradual alteration of cutting edge geometry, the roughness of the surface increases.

The Ra values in wet machining is larger compared to dry machining tough tool wears in almost similar fashion in both the cases as shown in Fig.4. Tool wear values versus machining time for different inserts at the specific conditions are plotted in Fig.4. This indicates the application of cutting fluid has a negative impact on the surface generated by machining. The application of cutting fluid resulted in rise in thermal gradient which causes thermal distortion. This thermal distortion contributed to increase in Ra values.



(a) SNMG insert



(b) SNMM insert

Fig 4: Variation in roughness with tool wear for (a) SNMG and (b) SNMM insert

Fig.5 indicates that SNMG insert has a long life than the SNMM insert. Fig. 3 indicates that Ra values for SNMG insert is better than SNMM insert for the duration of the life of SNMM inserts which about 12 min. As the life of SNMG insert is more than SNMM insert, SNMG insert can retain in its shape and size longer.

All these observations can be explained considering alterations of the tool geometry during the turning process. As it can be appreciated, an incorporation of the workpiece materials has taken place during machining process. This incorporation can be located in the cutting edge of the tool known as built-up edge. As machining time increases, built-up edge starts to form and grow and eventually reaches a limiting size to be broken and taken away by the chips. This cycle is repeated time and again with a larger extent resulting in higher values of Ra. Both tool wear and built up edge accumulates along machining time. These two contributes to deterioration of surface roughness.

5. CONCLUSION

Ra values of AISI-1060 steel obtained by turning process have certain tendency to increase with machining time. Within this general tendency, Ra values are larger in wet machining in both SNMG and SNMM inserts though tool wear accumulates more in dry condition than in dry condition.

It is also observed that SNMM insert wear more and result is higher values of Ra than SNMG inserts. This indicates the superiority SNMG inserts as it can retain its shape and size longer and wear less.

In using both SNMG and SNMM inserts, dry machining is superior in improving surface quality. This indicates that application of cutting fluid though has a positive effect on tool wear, it deteriorates surface quality. The deterioration of surface quality in wet machining is perceived to be due to workpiece distortion resulting from quick heat removal by the coolant applied.

The formation and gradual growth of built up edge at the principle cutting edge together with accumulated tool wear along machining time results in gradual worsening of the machined surface.

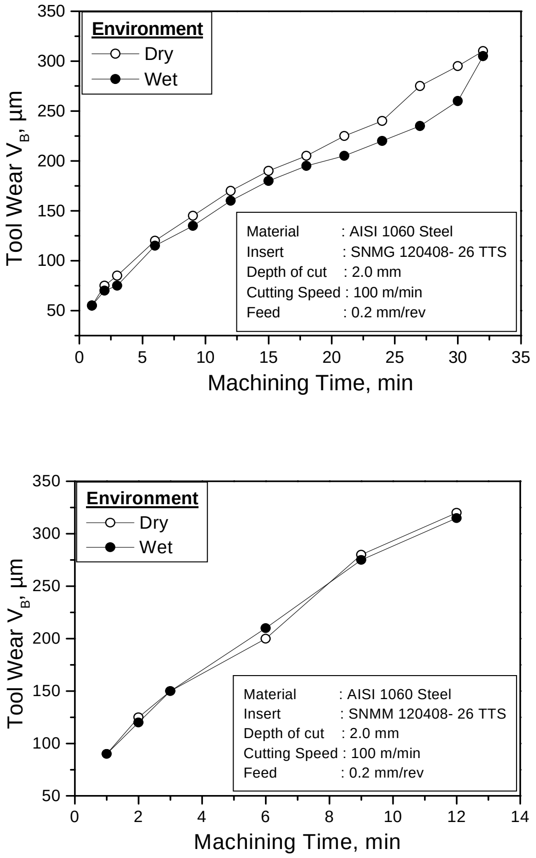


Fig 5: Variation in tool wear with machining time for different inserts

6. ACKNOWLEDGEMENT

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