Webology (ISSN: 1735-188X)
Volume 16, Number 1, 2019

Evaluation Of Surface Roughness Characteristics (Ra) Of E0300 Alloy Steel By Using CCMT09T308PM4225 And DNMX150608WM1525 Inserts Under Dry And Wet Cutting Environment

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Abstract This study explore into the assessment of surface roughness characteristics exhibited during turning operations on E0300 alloy steel. The investigation employs CCMT09T308PM4225 and DNMX150608WM1525 inserts and compares the outcomes under both dry and wet cutting conditions. Surface roughness plays a pivotal role in determining the quality and functionality of machined components, particularly in manufacturing contexts. The research aims to scrutinize the impact of different cutting environments on surface roughness in E0300 alloy steel. Experimental trials were conducted using a lathe machine, with surface roughness measurements collected across varied cutting parameters. Influence of dominant cutting parameters which affects surface finish during turning E-0300 alloy steel were investigated. Results reveal notable distinctions in surface roughness profiles between dry and wet cutting conditions, as well as among the two insert types. These findings offer valuable insights for optimizing machining processes to attain the desired surface finish quality in E0300 alloy steel components.

Key words: E0300, Surface roughness, Dry and wet cutting

1. INTRODUCTIONS

Surface roughness is a critical parameter in machining processes, significantly impacting the quality and functionality of machined components. Achieving the desired surface finish is crucial across various industrial sectors, particularly in manufacturing where precision and reliability are essential. E0300 alloy steel, known for its excellent mechanical properties, finds extensive use in engineering applications, emphasizing the importance of understanding and optimizing machining processes for this material.

Recent advancements in cutting tool technology have provided manufacturers with a range of options to enhance machining efficiency and surface finish quality. Inserts such as CCMT09T308PM4225 and DNMX150608WM1525 have gained recognition for their performance in turning operations on challenging materials like E0300 alloy steel. However, the choice between dry and wet cutting environments can significantly influence machining outcomes, including surface roughness. While dry cutting offers benefits such as reduced coolant costs and environmental impact, it may lead to higher tool wear and poorer surface finish compared to wet cutting, which provides effective cooling and lubrication.

Therefore, this research aims to evaluate the surface roughness characteristics of E0300 alloy steel during turning operations using CCMT09T308PM4225 and DNMX150608WM1525 inserts under both dry and wet cutting conditions. By systematically examining the effects of cutting environment and insert type on surface roughness, valuable insights can be gained to optimize machining processes for E0300 alloy steel components. Such optimizations are crucial for enhancing product quality, reducing production costs, and improving overall manufacturing efficiency.

Lee, S. W., Che Haron, C. H., & Ghani, J. A [1]. conducted a study on surface roughness during end milling of Al/SiC-MMC, employing response surface methodology to analyze the impact of cutting parameters and tool geometry on surface quality. Sadeghi, M. H., & Rostam, S. [2] conducted experimental investigations on turning AISI 304L stainless steel to assess the effects of cutting parameters and tool geometry on surface roughness, aiming to optimize machining parameters for improved surface finish. Mhamdi, F., Yallese, M. A., Mabrouki, T., & Rigal, J. F. [3] developed predictive models for surface roughness and cutting force in hard turning operations using regression and neural networks, contributing valuable insights for process optimization. Karpat, Y., & Özel, T. [4] also developed predictive models for surface roughness and tool wear in hard turning processes using regression and neural networks, enhancing the understanding and optimization of hard turning operations. Palanikumar, K., & Lenka, S. K. [5] optimized machining parameters for turning AISI 304 austenitic stainless steel utilizing the Taguchi method, with the aim of improving surface finish while minimizing machining time and cost. Elmunafi, M. H., & Khidhir, B. A. [6] conducted experiments to optimize surface roughness and cutting forces in end milling of Inconel 718 using PVD–TiAlN coated carbide inserts, seeking to enhance machining efficiency and surface quality. Altintas, Y., & Eynian, M.[7] investigated the mechanics and dynamics of serrated chip formation in metal cutting processes, providing valuable insights into fundamental mechanisms underlying metal cutting phenomena. Gaitonde, V. N., Karnik, S. R., & Davim, J. P [.8] optimized machining parameters for Al/SiC metal matrix composites using the Taguchi method and response surface methodology, aiming to enhance machining efficiency and surface integrity Ho, S. S., Newman, S. T., & Rahimifard, S. [9] focused on environmentally conscious machining practices for difficult-to-machine materials, aiming to reduce environmental impact while maintaining machining performance. Sarikaya, M., Ozkaya, E., & Cetin, A. [10] optimized cutting parameters during turning of AISI 304 austenitic stainless steel rods with coated carbide tools to improve surface finish and minimize tool wear.

2. PLANNING FOR EXPERIMENTATION

1. Materials and Tools and machining environment:
   - E0300 alloy steel work pieces with standardized dimensions will be employed for consistency.
   - Cutting inserts CCMT09T308PM4225 and DNMX150608WM1525 will be utilized for turning operations.

- A HMT lathe machine suitable for turning operations will be used.
    - Cutting environment (dry, wet)
- Dependent Variable:
    - Surface roughness of the machined E0300 alloy steel surfaces.
- Control Variables:
    - Cutting speed: 40m/min to 160 m/min
    - Feed rate: 0.16,0.24,0.33,0.48 mm/rev
    - Depth of cut: 1.25mm

2. Experimental Procedure:

- Work piece Preparation:
    - Ensure uniform dimensions and surface finish of E0300 alloy steel work pieces.
- Tool Preparation:
    - Mount CCMT09T308PM4225 and DNMX150608WM1525 inserts onto the cutting tool holder.
- Cutting Conditions Setup:
    - Adjust cutting speed 100m/min, feed rate 0.33 mm/rev, and depth of cut 1.25 mm according to predefined parameters for each experimental condition.
- Dry Cutting Environment:
    - Perform turning operations on E0300 alloy steel work pieces without using cutting fluid.
- Wet Cutting Environment:
    - Conduct turning operations on E0300 alloy steel work pieces using an appropriate cutting fluid.
- Surface Roughness Measurement:
    - Utilize a surface roughness measuring instrument to quantify the surface roughness of machined surfaces.
    - Take multiple readings across each work piece to ensure reliability.

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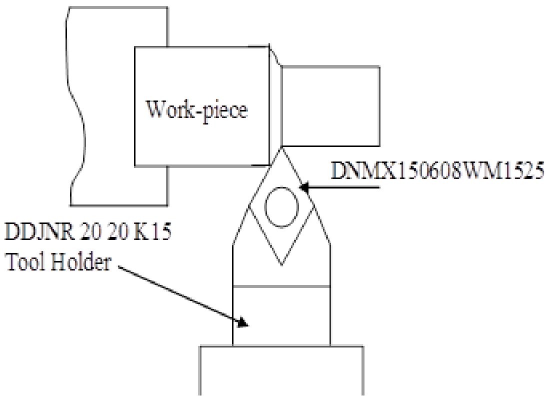

Fig. 1 Experimental Setup

Table 2.1 Details of cutting tool used and environment for turning experiments

Cutting tool used	**Cutting tool specification**	**Rake angle**	**Clear -ance angle**	**Nose radius**	**Cutting edge angle**	**Environment**

T-Max-P Positive insert	CCMT09T308 PM4225	0^0	7^0	0.8 mm	80^0	Wet and dry
T-Max-P Négative insert	DNMX150608 WM1525	-6^0	0^0	0.8 mm	55^0	Wet and dry

Table 2.2 Chemical composition of E0300 alloy steel

Specification	%C	%Mn	%P	%S	%Ni	%Cr	%V	%Mo	%Co	%Ti	%W
E0300 alloy steel	0.87	0.76	0.46	0.82	0.028	1.34	0.01	0.03	0.01	0.01	0.25

2. INFLUENCE DOMINANT PARAMETERS I.E. CUTTING SPEED AND FEED ON SURFACE ROUGHNESS CHARACTERISTICS (R_a)

Figure 2(a) and 2(b) show the effect of cutting velocity, Vc (m/min) and feed rate (mm/rev) on the surface finish, Ra (µm) during turning of E0300 alloy steel by CCMT09I308PM4225 insert under dry and wet condition respectively. From the figures 2(a) and 2(b), it is clear that surface roughness decreases with increase in cutting velocity and increase of feed rate. In dry turning, the magnitude of surface roughness is 3.68 µm at 40 m/min cutting velocity and 0.48 mm/rev. But surface finish, Ra (µm) is only 1.86 µm when machining is done with the parameters setting at 160 m/min cutting velocity, 0.16 mm/rev feed rate and 1.25 mm depth of cut. Similarly, in wet turning, the magnitudes of surface roughness are 3.26 µm and 1.79 µm respectively when machining undertaken at same parametric combination as mentioned above by CCMT09I308PM4225 insert. Figure 2(c) and 2(d) show the effect of cutting velocity, Vc (m/min) and feed rate, (mm/rev) on the surface finish, Ra (µm) during turning of E0300 alloy steel by DNMX150608WM1525 insert under dry and wet condition respectively. Here also observed similar trends in results i.e. surface roughness decreases with increase in cutting velocity and decrease of feed rate. The magnitudes of surface roughness are 3.28 µm and 1.44 µm in dry turning and 2.76 µm and 1.24 µm in wet turning at same parametric setting for both the cases i.e. 40 m/min cutting velocity, 0.48 mm/rev feed rate, and 160 m/min cutting speed, 0.16 mm/rev feed rate respectively.

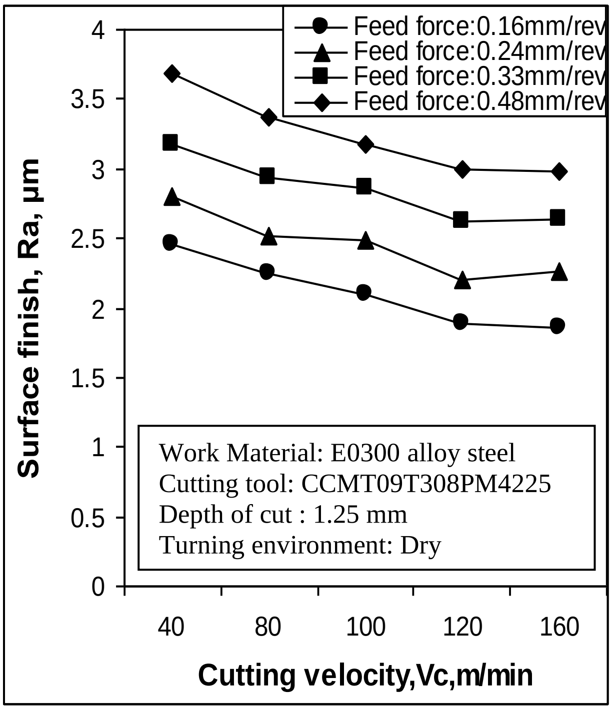

Fig.2(a)

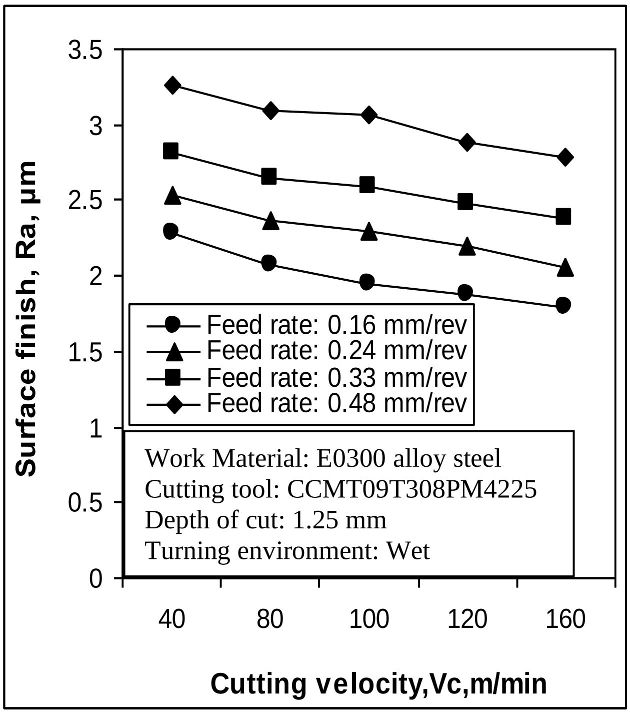

Fig. 2(b)

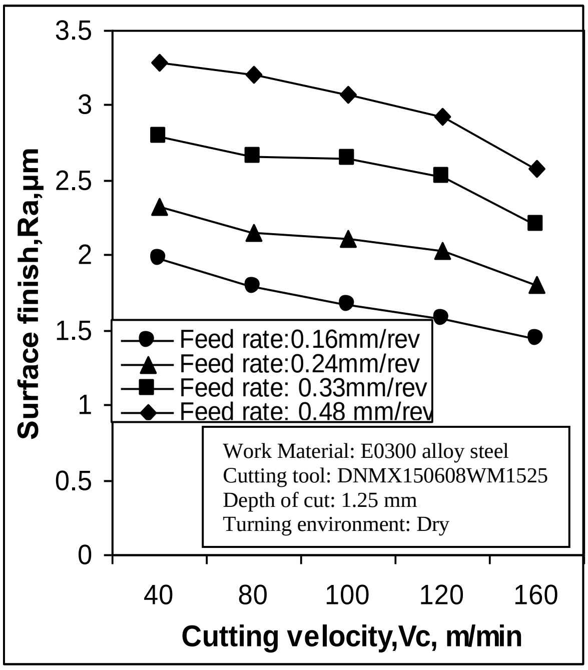

Fig.2(c)

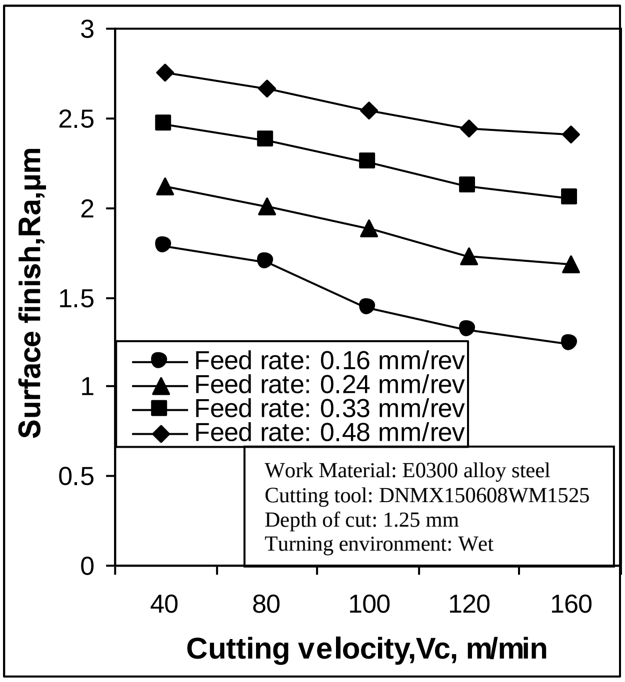

Fig.(2d)

Figure 2 (a) to 2 (d) Variation in surface finish, Ra (µm) with that of cutting speed and feed in turning E0300 alloy steel by CCMT09T308PM4225 and DNMX150608WM1525 inserts under dry and wet environment

4. INFUENCE OF DOMINANT CUTTING PARAMETERS WHICH AFFECTS SURFACE FINISH DURING TURNING E0300 ALLOY STEEL

A) Dry Cutting**:**

- Dry cutting involves machining without the use of coolant or cutting fluid.

- When turning E-0300 material with CCMT09T308PM4225 and DNMX150608WM1525 inserts under dry cutting conditions, the following surface finish effects may arise:
- Increased tool wear: Dry cutting often generates higher temperatures due to friction, leading to accelerated tool wear. This can result in reduced tool life and diminished surface finish quality over time.
- Higher cutting forces: Dry cutting typically results in elevated cutting forces compared to wet cutting, potentially causing increased vibration and chatter. These effects can contribute to surface irregularities and a decrease in surface finish quality.
- Elevated temperatures: Absence of coolant in dry cutting can lead to higher temperatures In the cutting zone, potentially causing thermal expansion of the work piece material and the tool. This can result in dimensional inaccuracies and surface finish deterioration.
- Chip evacuation challenges: Dry cutting may lead to chip accumulation, which can interfere with the cutting process and contribute to surface defects such as built-up edge (BUE) formation, impacting surface finish negatively.

B) Wet Cutting**:**

- Wet cutting involves the use of cutting fluid or coolant to lubricate the cutting zone and dissipate heat.
- When turning E-0300 material with CCMT09T308PM4225 and DNMX150608WM1525 inserts under wet cutting conditions, the following surface finish effects may be observed:
- Reduced tool wear: Wet cutting lubricates the cutting zone and helps dissipate heat, resulting in lower tool wear rates compared to dry cutting. This can lead to prolonged tool life and improved surface finish consistency.
- Lower cutting forces: Coolant in wet cutting reduces friction between the tool and work piece, resulting in decreased cutting forces. This can minimize vibration and chatter, contributing to a smoother surface finish.
- Controlled temperatures: Coolant application in wet cutting helps maintain lower temperatures at the cutting interface, reducing the risk of thermal damage to the work piece and tool. This can lead to better dimensional accuracy and surface finish quality.
- Effective chip evacuation: Wet cutting facilitates better chip evacuation by flushing away chips and debris from the cutting zone, preventing re-cutting and surface defects. This can result in enhanced surface finish and a reduced risk of chip-related issues.

In summary, wet cutting generally offers advantages over dry cutting in terms of tool wear, cutting forces, temperature control, and chip evacuation when turning E-0300 material with CCMT09T308PM4225 and DNMX150608WM1525 inserts. However, the specific effects may vary depending on factors such as cutting parameters, tool geometry, and coolant application method.

5. CONCLUSIONS:

The examination of surface roughness characteristics of E0300 alloy steel utilizing CCMT09T308PM4225 and DNMX150608WM1525 inserts under both dry and wet cutting conditions has yielded significant insights into the machining behavior of this material. Through systematic experimentation and analysis, several pivotal findings have emerged.

1. The selection of cutting environment exerts a substantial impact on surface roughness outcomes. Our investigation revealed that wet cutting environments generally result in smoother surface finishes compared to dry cutting conditions.
2. The choice of cutting insert demonstrates notable influence on surface roughness. While both CCMT09T308PM4225 and DNMX150608WM1525 inserts demonstrated competence in machining E0300 alloy steel, distinctions in surface finish were evident.
3. It is observed that the surface finish decreases with the increase in cutting velocity for both CCMT09T308PM4225 and DNMX150608WM1525 inserts under dry and wet cutting condition.

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