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EFFECT OF COOLANT ON TOOL LIFE DURING LATHE TURNING OPERATIONS: AN EXPERIMENTAL APPROACH

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ABSTRACT :

Tool longevity plays a critical role in the effectiveness of metal cutting processes, influencing factors such as operational cost, product quality, and manufacturing efficiency. This research explores how the application of coolant impacts the lifespan of cutting tools during turning processes on a traditional lathe. The study involved two experimental scenarios—machining with no lubrication (dry turning) and machining with an appropriate cooling fluid. Key machining variables, including feed rate, spindle speed, depth of cut, and material properties, were kept constant to maintain experimental accuracy. Tool wear progression was systematically monitored and evaluated using recognized measurement techniques. Results revealed that the use of coolant led to a marked enhancement in tool durability, attributed to improved heat dissipation and lower friction at the contact zone. Furthermore, machining with coolant produced smoother surfaces and more precise dimensions. The outcomes underline the practical advantages of incorporating coolant in turning operations for better tool utilization and cost-effectiveness.

Keywords- Lathe Machine, Coolant, Tool Life, Turning operation

1. INTRODUCTION

Turning operations, performed predominantly on lathe machines, are among the most essential and frequently employed techniques in modern machining. The success and precision of these operations are heavily dependent on the durability and performance of the cutting tool. As the tool engages repeatedly with the workpiece, it experiences gradual wear, particularly under conditions of elevated temperature and high cutting speed, which can significantly impact surface finish, accuracy, production time, and overall machining costs. To mitigate such issues, the use of cutting fluids—or coolants—has become a standard approach. These fluids play a multifaceted role in the machining process by reducing heat generation, decreasing tool-workpiece friction, removing chips from the cutting zone, and improving the quality of the machined surface. However, with increasing concerns over sustainability and cost-effectiveness, there has been a renewed focus on evaluating when and how coolant application is most beneficial. This study presents an experimental comparison of tool life during turning processes conducted with and without the use of coolant. By maintaining uniform machining conditions and systematically measuring tool wear, the research aims to assess the effectiveness of coolant in extending tool longevity and enhancing machining performance, thereby offering valuable insights for improving industrial practices.

2. PROBLEM IDENTIFICATION

In metal cutting processes, particularly in turning operations conducted on lathe machines, the degradation of cutting tools over time poses a major challenge. This wear not only shortens the effective lifespan of the tool but also hampers the precision, surface integrity, and overall productivity of the machining process. Accelerated tool wear often results from intense heat and friction generated at the interface between the tool and the workpiece. While the application of cutting fluids is widely recognized for its ability to lower machining temperatures and extend tool life, comprehensive studies comparing tool performance in dry versus lubricated conditions remain relatively scarce. This is especially true when considering varying material types and process parameters. Additionally, in many small-scale and cost-sensitive manufacturing setups, the use of coolants is often minimized or excluded entirely due to financial, maintenance, or environmental limitations. This research seeks to bridge this knowledge gap by conducting a comparative analysis of tool wear behavior in turning operations carried out with and without coolant. The outcomes are expected to guide machinists, process engineers, and decision-makers in evaluating the practical benefits of coolant usage and optimizing machining strategies for better performance and cost efficiency.

3. OBJECTIVES OF THE RESEARCH WORK

The primary aim of this research is to explore the impact of coolant application on tool life during turning operations. To achieve this, the following objectives have been formulated:

- To examine the influence of cutting tool degradation during lathe-based turning processes.
- To analyze how varying machining parameters—such as cutting speed, depth of cut, and lubrication conditions (dry vs. coolant-assisted)—affect tool wear in relation to applied forces and thermal loads.
- To explore the relationship between cutting zone temperature and the operational lifespan of the tool.
- To evaluate the impact of mechanical forces generated during the turning operation on the structural integrity and performance of the cutting tool.

4. RESULT AND DISCUSSION

In this study, various characteristics are monitored under different operational conditions. The temperatures, forces, and tool weight are recorded using an infrared thermometer, lathe tool dynamometer, and electronic weighing scale, respectively. Based on these measurements, tool wear, resultant force, and volume-to-weight ratio are calculated. The workpiece length is consistently maintained at 75 cm throughout the experiments, with a fixed feed rate of 0.055 mm per revolution. Additionally, constant tool geometry and consistent tool angles are employed across all trials.

The experiment focuses on three key parameters:

1. Temperature of the tool and interference zone
2. Measurement of forces exerted during cutting
3. Tool wear analysis and calculation of volume-to-weight ratio

Table 1.1 Depth of cut V/S Volume weight ratio without coolant at 224 rpm

Speed (rpm)	Depth of cut (mm)	Diameter of w/p (mm)		Volume remove(mm^3)	Tool Wear (mgram)	Ratio (mm^3/ mgram)
		Initial	Final			
224	0.5	35.5	34.5	41249.9981	1.9	21710.5253
224	0.6	32.5	31.3	56129.46173	1.4	32225.5087
224	0.7	31.3	29.8	70714.2825	1.1	49098.2121
224	0.8	29.8	28.2	81763.38914	0.9	60761.9020
224	0.9	28	26.1	88392.85313	0.6	100954.4597

Table 1.2 Depth of cut V/S Volume weight ratio with coolant at 224 rpm

Speed (rpm)	Depth of cut (mm)	Diameter of w/p (mm)		Volume remove(mm^3)	Tool Wear (mgram)	Ratio (mm^3/ mgram)
		Initial	Final			
224	0.5	35	34	40660.71244	1.2	33883.9270
224	0.6	34	32.9	43365.53374	0.9	48183.9264
224	0.7	32.9	31.6	49411.6049	0.5	98823.2098
224	0.8	31.6	30.1	54538.39038	0.3	181794.6346
224	0.9	30.1	28.4	58604.46162	0.2	293022.3081

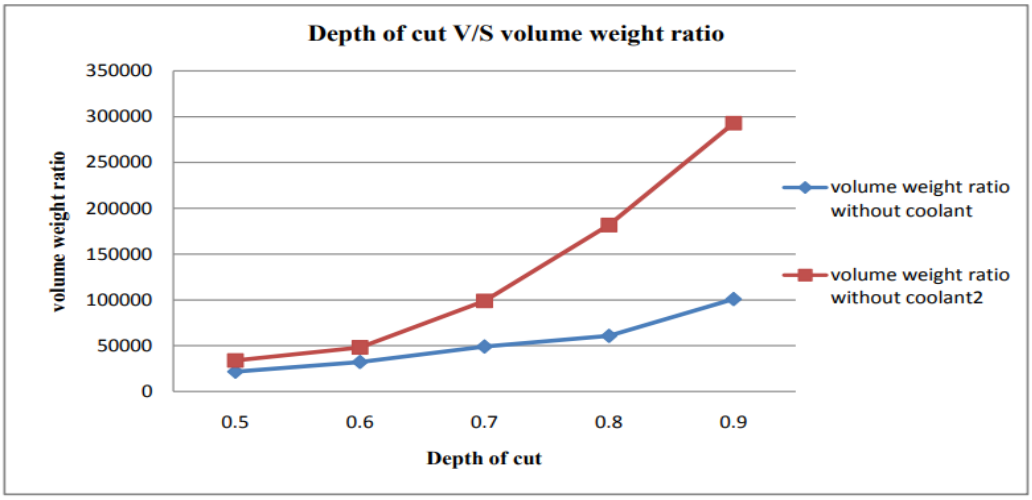

Figure 1.1 Depth of cut V/S volume weight ratio

Table 1.3 Depth of cut V/S Volume weight ratio without coolant

Speed (rpm)	Depth of cut (mm)	Diameter of w/p (mm)		Volume remove(mm^3)	Tool Wear (mgram)	Ratio (mm^3/ mgram)
		Initial	Final			
500	0.5	34.5	33.5	54308.5707	1.8	22261.9045
500	0.6	33.5	32.3	61214.9992	1.6	29081.2496
500	0.7	32.3	30.9	67131.4277	1.3	40107.6918
500	0.8	30.9	29.3	52322.6779	0.9	63066.6658
500	0.9	29.3	27.3	72888.7490	0.8	83383.9274

Table 1.4 Depth of cut V/S Volume weight ratio with coolant

Speed (rpm)	Depth of cut (mm)	Diameter of w/p (mm)		Volume remove(mm^3)	Tool Wear (mgram)	Ratio (mm^3/ mgram)
		Initial	Final			
500	0.5	34	33	58244.9992	0.8	49352.6779
500	0.6	33	31.8	52016.2493	0.6	76371.4275
500	0.7	31.8	30.4	27183.7496	0.6	85524.9988
500	0.8	30.4	28.8	52634.9993	0.3	186057.1403
500	0.9	28.8	27	32616.9638	0.2	295939.2817

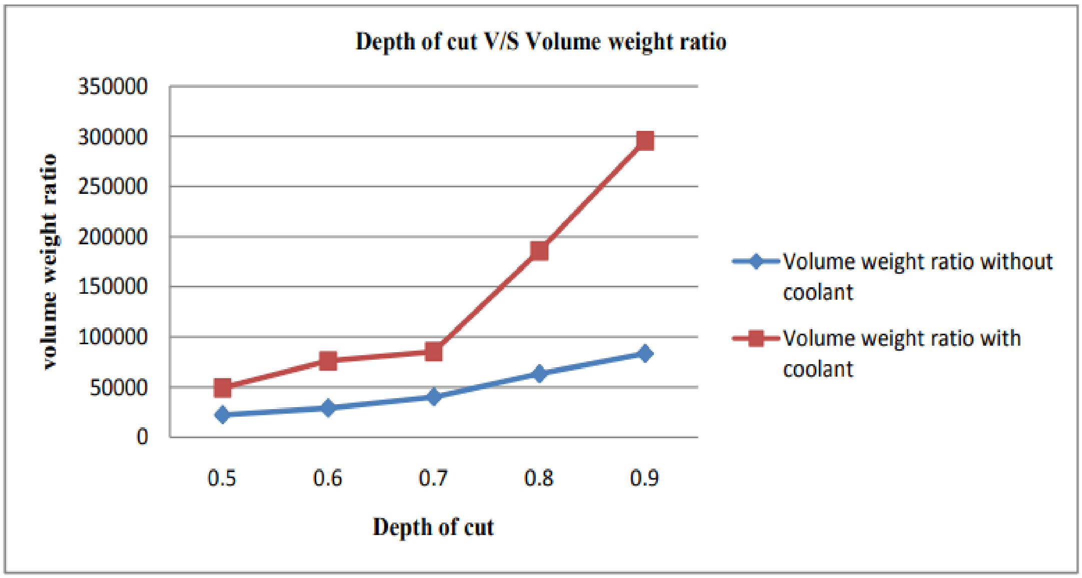

Figure 1.2 Depth of cut V/s Volume weight ratio

5. CONCLUSION

This study investigates the impact of cutting parameters on tool life during high-speed turning operations with and without coolant. The results reveal that increasing the cutting speed, depth of cut, and feed rate enhances productivity, although it also raises tool temperatures, which negatively affects tool longevity. The use of chilled water as a coolant effectively reduces tool temperature by 10-14°C and tool-workpiece interface temperature by 12-18%, thereby extending tool life and boosting productivity.

Moreover, coolant application leads to an increase in cutting and resultant forces as well as power consumption. However, the overall electricity cost remains lower at higher speeds compared to increased depth of cut, as cutting forces decrease and machining time shortens. The material removal rate also improves with higher depths of cut.

The study further demonstrates that coolant significantly reduces tool wear rate, with a 3-4 times reduction compared to dry conditions, while improving the volume-to-weight ratio. This leads to less frequent tool changes and regrinding, thus reducing machining time. Overall, the use of coolant in high-speed turning operations optimizes both productivity and cost-efficiency.

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