TRIBOLOGICAL STUDIES OF LASER TEXTURED TOOL INSERTS IN TURNING PROCESS

A dissertation
Submitted in partial fulfilment of the requirements for the
award of the degree
of

BACHELOR OF TECHNOLOGY

in

MECHANICAL ENGINEERING

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CERTIFICATE

This is to certify that Project Report entitled "**Tribological Studies of Laser Textured Tool Inserts in Turning Operation**" which is submitted by **P. Deepak Kumar, Prashant Kumar Rajput** and **Ashish Bhatt** in partial fulfilment of the requirement for the award of degree **Bachelor of Technology** in **Department of Mechanical Engineering** of Dr. A.P.J. Abdul Kalam Technical University, Lucknow is a record of the candidates own work carried out by them under my supervision. The matter embodied in this thesis is original and has not been submitted for the award of any other degree.

Supervisor **Project Coordinator** **HOD**

External Viva

Name of Examiner **Signature with date**

DECLARATION

I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person nor material which to a substantial extent has been accepted for the award of any other degree or diploma of the university or other institute of higher learning, except where due acknowledgment has been made in the text.

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ABSTRACT

Metal forming and machining processes are used for converting the raw materials into the products in the industries. During these processes large amount is energy is consumed in the form of friction energy. In order to conserve this energy and prevent wear of tools, there is a need of green manufacturing. In this project work, an attempt has been made in order to increase the tool life and conserve energy. The comparative study has been done by taking conventional tungsten carbide tool inserts and textured tungsten carbide tool inserts. Turning process has been done on mild steel rod (C-20) with these carbide tool inserts at various parameters like spindle speed, depth of cut and feed rate.

Keywords: *Laser texture, friction, wears, dry condition and conventional tool insert*

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Manufacturing is a very important component of any engineering realization. It involves providing the different shapes, sizes and cross sections to the components of the products/systems. It is worth noting that high percentage of GDP of many nations comes from the manufacturing sector. Manufacturing sector also provides maximum jobs to the people. This is also one of the reasons for launching the “Make in India” programme by our prime minister in 2014. For large scale manufacturing in any country, there is a requirement for efficient and quality machining for its sustainability. Thus, there is need for in-depth research in manufacturing processes for making it more energy efficient with better finished quality. It is worth noting here that setting up of large manufacturing industries for boosting the GDP and providing the employment can harm the nature through its emissions and effluent disposals. Thus a need arises for development of energy efficient green manufacturing for protecting the environment. However the increasing price of energy and the current trend of sustainability have created thrust on the manufacturing sector for reducing the energy consumption keeping in the mind both cost saving and environmental issues. Therefore in the current scenario, the objectives of manufacturing are to reduce the cost, time, and energy consumption without sacrificing the quality of products. Thus, there is a need for sustainable manufacturing, which involves environmental, economic and social issues. The sustainable manufacturing is also termed as “green manufacturing”. It must be noted here that there is growing demand in industries for green manufacturing strategies due to depletion of natural resources that is causing the rise of cost of raw materials and energy involved. In order to achieve a better energy efficiency associated with a manufacturing process, the tribological studies at the tool (or tool insert) and work piece interface are essential for exploring the improvement of tool (or tool insert) life (low wear) and reduction of friction (which is reflected in terms of reduction in temperature rise). It is worth mentioning here that the surface modifications of tool insert by heat treatment, profiling, and texturing, are being used for improving the tribological performances at the insert and work piece interface. Therefore, it is worth exploring the turning process of carbon steels for assessing, improving and comparing the tribological performance behaviours at the tool insert and work piece interface with conventional and textured tool inserts. It is essential to mention here that the combination of turning operation (manufacturing) and carbon steel work piece is proposed for investigation due to their extensive use in industries.

1.2 Types of Cutting tool

Cutting tools have been used in metal machine shops since the late 19th century and manufacturers are continuing to evolve these mechanisms to become more efficient within the industry. Cutting tools come into contact with the raw material, cutes, removes debris and chips from the material. Cutting tools may be classified according to the number of major cutting edges involved as follows:

- Single point: e.g., turning tools, shaping, planning and slotting tools and boring tools
- Double (two) point: e.g., drills
- Multipoint (more than two): e.g., milling cutters, broaching tools, hobs, gear shaping cutters etc.

1.3 Material of Cutting tool

To produce quality product, a cutting tool must have three characteristics:

- Hardness: hardness and strength at high temperatures.
- Toughness: so that tools do not fracture.
- Wear resistance: having acceptable tool life before needing to be replaced.

Cutting tool materials can be divided into two main categories: stable and unstable. Unstable materials are substances that start at a relatively low hardness point and are then heat treated to promote the growth of hard particles which increases the overall hardness of the material at the expense of some its original toughness. Since heat is the mechanism to alter the structure of the substance and at the same time the cutting action produces a lot of heats, such substances are inherently unstable under machining conditions.

Stable materials are substances that remain relatively stable under the heat produced by most machining conditions, as they don't attain their hardness through heat. They wear down due to abrasion, but generally don't change their properties much during use. Most stable materials are hard enough to break before flexing, which makes them very fragile. Unstable materials being softer and tough can stand a bit of flexing without breaking, which makes them much more suitable for unfavourable machining conditions.

Table 1.1 Tool insert material with their properties

Tool material	Properties
Carbon tool steels	It is unstable and also not very inexpensive. These are extremely sensitive to heat.
High speed steel (HSS)	These are unstable and inexpensive. HSS retains its hardness at moderate temperatures. They are most commonly cutting tool material used today.
HSS cobalt	These are unstable and moderately expensive. The high cobalt versions of high speed steel are very resistant to heat and thus excellent for machining abrasive and/or work hardening materials such as titanium and stainless steel.
Cast cobalt alloys	It is stable, expensive and somewhat fragile material. Despite its stability it doesn't allow for high machining speed due to low hardness.
Cemented carbide	It is stable and moderately expensive material. It is the most common material used in the industry today.
Ceramics	Ceramics are stable and not very expensive. These are chemically inert and extremely resistant to heat, ceramics are usually desirable in high speed applications, the only drawback being their high fragility. The most common ceramic materials are based on alumina (aluminium oxide), silicon nitride and silicon carbide.
Cermets	This is stable and expensive material. It provides higher abrasion resistance compared to tungsten carbide at the expense of some toughness.
Cubic boron nitride (CBN)	CBN is stable and expensive tool material. It offers extremely high resistance to abrasion at the expense of much toughness. It is generally used for hard machining.

Diamond	It is most stable and very expensive tool material. Superior resistance to abrasion but also high chemical affinity to iron which results in being unsuitable for steel machining. It is used where abrasive materials would wear anything else. It is extremely fragile.

1.4 Tool Geometry

Material and geometry of the cutting tools are important in achieving effectiveness, efficiency and overall economy of machining.

(i) Concept of rake angle and clearance angle of cutting tool

The word tool geometry is basically referred to some specific angles or slope of the salient faces and edges of the tools at their cutting point. Rake angle and clearance angle are the most significant for all the cutting tools. The rake angle and clearance angle will be clear from turning operation shown in Fig. 1.1.

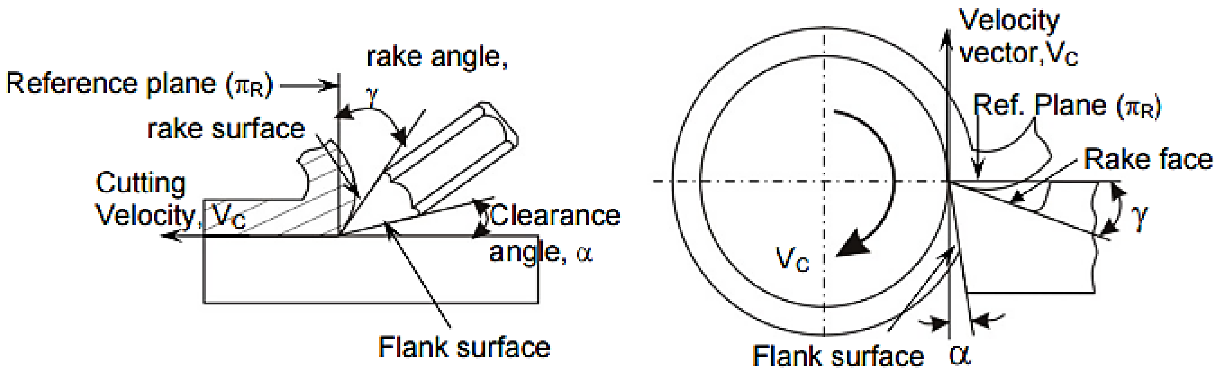


Fig. 1.1 Rake and clearance angle of cutting tools (www.doubtpoint.com)

- Rake angle (γ): Angle of inclination of rake surface from reference plane. Rake angle may be positive, or negative or even zero. Relative advantages of such rake angles are:
- Positive rake – helps reduce cutting force and thus cutting power requirement.
- Negative rake – to increase edge-strength and life of the tool
- Zero rake – to simplify design and manufacture of the form tools.
- Clearance angle (α): Angle of inclination of clearance or flank surface from the finished surface Rake angle is provided for ease of chip flow and overall machining. Clearance

angle is provided to avoid rubbing of the tool (flank) with the machined surface which causes loss of energy and damages both the tool and the job surface.

(ii) Tool geometry systems

- Tool-in-Hand System – where only the salient features of the cutting tool point are identified or visualized. There is no quantitative information, i.e., value of the angles.
- Machine Reference System – ASA system
- Tool Reference Systems ∗ Orthogonal Rake System – ORS ∗ Normal Rake System – NRS
- Work Reference System – WRS

(iii) Expression of tool geometry in ASA system:

ASA stands for American Standards Association. Geometry of a cutting tool is related to its angles or slope of working surfaces and cutting edges. Those angles are expressed with respect to some planes of reference. In ASA system, three planes of reference and the coordinates are chosen based on the configuration and axes of the machine tool. The planes and axes used for expressing tool geometry in ASA system for turning operation are shown in Fig. 1.2.

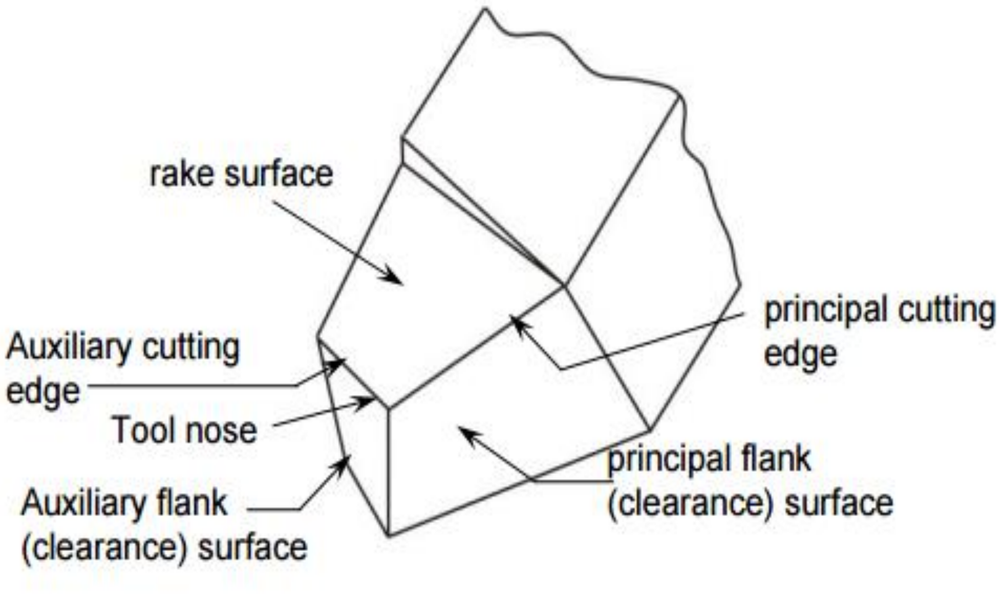


Fig. 1.2 Basic features of single point in turning operation (www.slideshare.net)

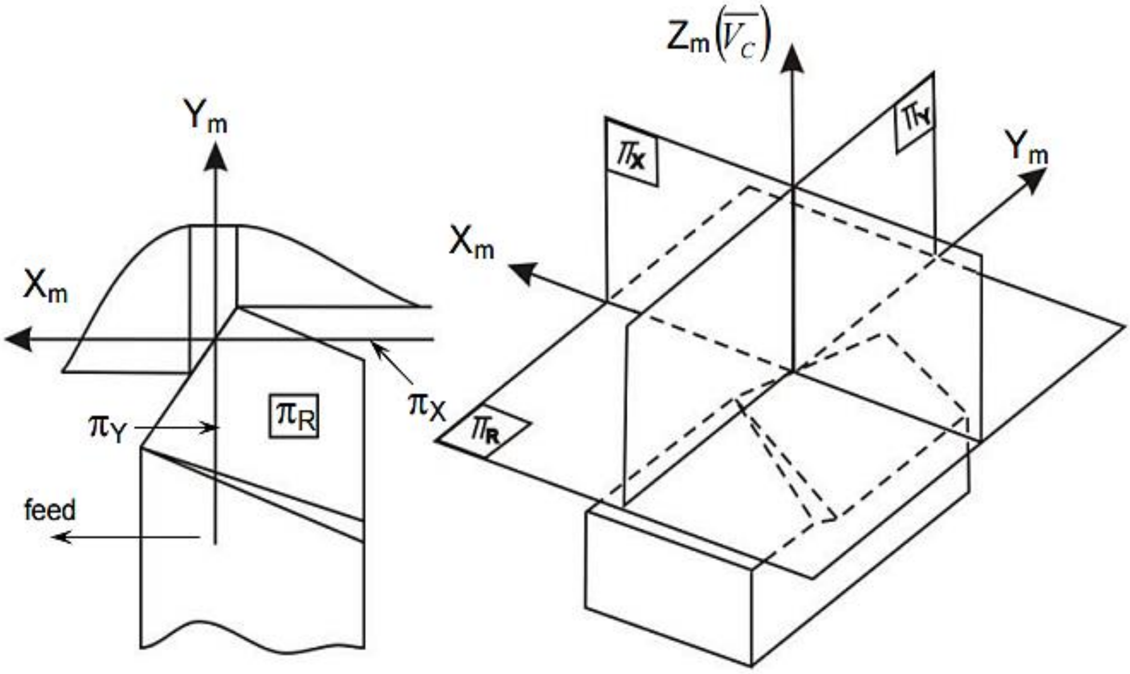


Fig. 1.3 Planes and axes of reference in ASA system (www.nitc.ac.in)

The plane of references and the coordinates used in ASA system for tool geometry are:

$$\pi_R - \pi_X - \pi_Y \text{ and } X_m - Y_m - Z_m$$

Where,

π_R= Reference plane; plane perpendicular to the velocity vector (shown in Fig. 1.3)

π_X= Machine longitudinal plane; plane perpendicular to π_R and taken in the direction of assumed longitudinal feed

π_Y= Machine Transverse plane; plane perpendicular to both π_R and π_X

CHAPTER 2

LITERATURE REVIEW AND PROBLEM DEFINITION

2.1 Literature review

Metal forming and machining processes are used for converting the raw materials into the products in the industries. It is worth mentioning here that 15-20% of gross domestic product (GDP) of industrialised nations comes from the manufacturing sector. Moreover, it is essential to mention here that one third (about 33%) of all the energy consumed in the industries including the energy consumed in the manufacturing processes (forming and machining) goes to overcome the friction. It is worth noting here that high friction yields an energy inefficient industrial process. Therefore, reducing the friction in industrial processes is one of the major challenges toward the attempt to reach a sustainable society with low energy consumption and reduced environmental consequences. Thus, great efforts are being made by the researchers across the globe to explore and develop the friction reduction techniques in every step of the industrial processes where friction presence is not desirable. Due to global warming and resource conservation issues, now great efforts are being made by the engineers/scientists to implement the concept of "Green manufacturing", which mainly involves low friction, reduced wear, and minimum energy consumption. Therefore moving ahead in the direction of green manufacturing, in this project it is planned to explore the possibilities of friction and wear reduction of tool inserts in the turning process of metals without compromising the surface quality of the machined product. It has been proposed herein to improve the tribological performance of tool inserts by mimicking the textures present on the biological surfaces (banana leaf and scorpion skin) over the insert surface. Literature survey in the field of proposed research title has been carried out in the paragraphs to come for understanding the current status of the research and accordingly setting the objectives for study.

In the past, many attempts have been made by the researchers [1-18] for investigating and improving the tribo-performance behaviours involved in the turning process for extending the tool life and improving the surface quality of machined work piece efficiently. Good surface finish is an essential requirement in a machining process, which is very sensitive to the form accuracy of the tool. It is worth noting here that due to the rapid wear of tool (due to poor lubrication and lack of cooling at the tool and work piece interface); the quality of surface finish deteriorates. **Grzesik [1]** has tried in his research work to quantify the surface finish on the turned hardened alloy steel parts in terms of cutting time (leading to tool wear) produced by differently shaped ceramic tool tips. To supress the adhesion during the milling of aluminium alloy at the cutter face, nano/micro textured surfaces of cutter promoted anti-adhesiveness features as said by **Sugihara *et al* [2-3]** in his work. For improving the turning process on lathe machine, **Enomoto *et al* [6]** have used textured WC/Co carbide tools filled with MoS_2 solid lubricants on the rake-face close to the main cutting edge of the tool. Turning operations were performed in dry conditions using the rake-face textured tools and conventional one. It has been reported by the authors that the cutting performance of the rake-face textured tools is significantly improved over that of the conventional one. The studies related to turning of AISI 52100 bearing steel with CBN tool has been reported by **Jianxin *et al* [7]**. The combined effects of process parameters (cutting speed, feed rate, depth of cut and cutting time) on the performance characteristics (tool wear, surface roughness, cutting forces and metal volume removed) are investigated by the authors [7] using ANOVA analysis. The relationship between process parameters and performance characteristics through the response surface methodology (RSM) are modelled. The results show that the cutting speed exhibits maximum influence on abrasive tool wear. The depth of cut affects strongly the cutting forces; however, it has a negligible influence on surface roughness. The cutting time has a considerable effect on all performance characteristics. The power consumption and roughness characteristics of surface generated in turning operation of EN-31 alloy steel (bearing steel) with TiN+Al2O3+TiCN coated tungsten carbide tool under different cutting parameters have been assessed by experimental work of **Neves *et al* [8]**. The study investigated the influences of the spindle speed, depth of cut and feed rate on surface roughness as well as power consumption. The study presents the results for five different spindle speeds (in the range of 700 -1200 rpm) keeping feed rate between 0.4 mm/s to 1.6 mm/s and depth of cut between 0.12 mm to 0.20 mm.

2.2 Motivation

Based on the literature review, it is noticed that there is dearth of research work carried out in turning process for improving the machining efficiency, insert life, and surface quality by employing the biological textures, which nature has created through passes of time for drag reductions.

2.3 Objectives of the study

Based on the literature review, the following objectives for study in the project have been set:

- Tribological (wear by loss of weight and geometric dimension and temperature rise) studies of **conventional tool inserts** employed in the turning process of carbon steel (C-20) at various operating parameters (depth of cut, feed rate, spindle speed) for dry condition.

- Tribological (wear by loss of weight and geometric dimension and temperature rise) studies of **textured (with biological surface patterns) tool inserts** employed in the turning process of carbon steel (C-20) at various operating parameters (depth of cut, feed rate, spindle speed) for dry condition.

- Comparisons of tribological parameters achieved with conventional and textured inserts.

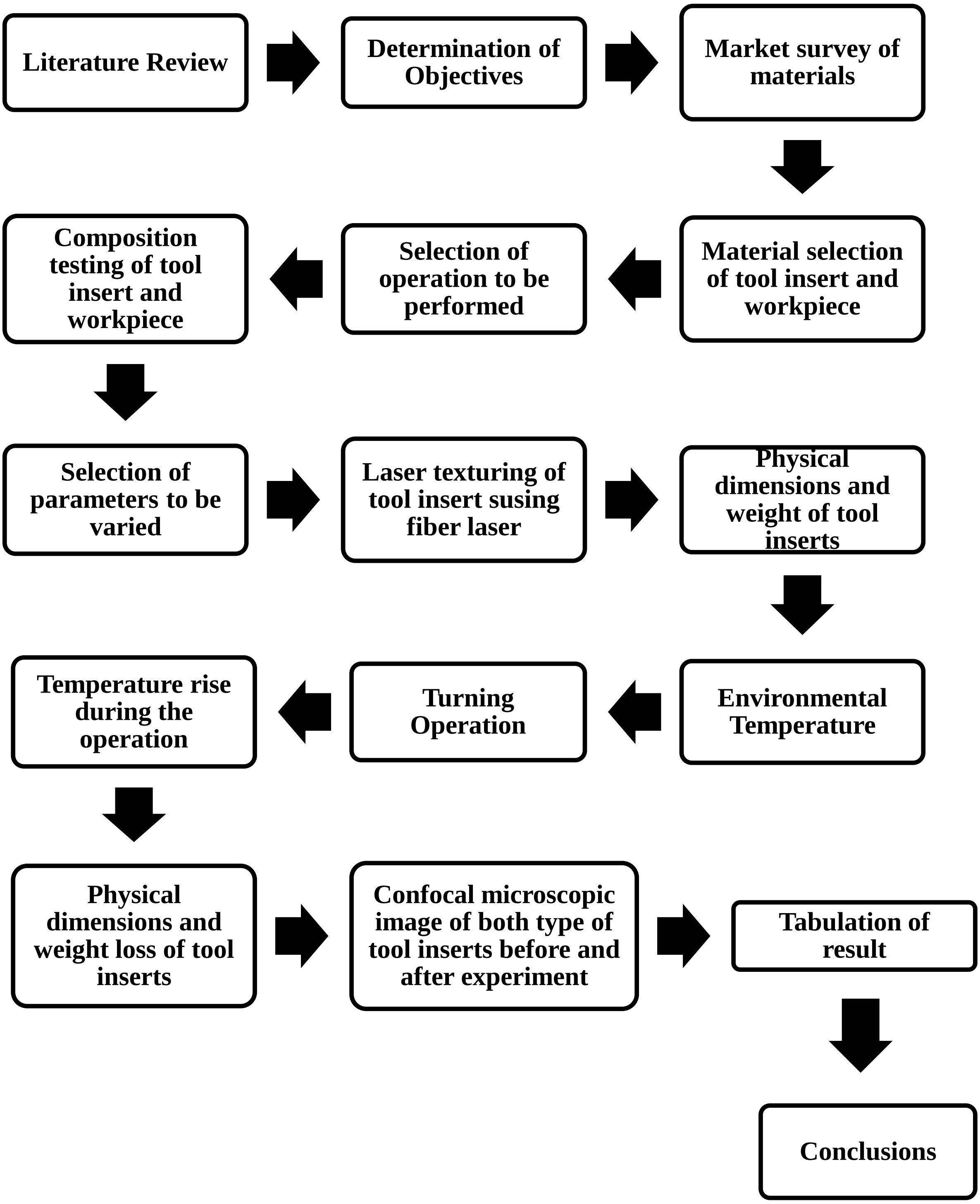
CHAPTER 3

METHODOLOGY

To accomplish the objectives of the project, the following steps have been planned for the investigation:

- Identification of lathe machine and work piece material (C-20) for conducting the experiments as turning process.
- Selection of tool insert material (Carbon carbide) for employing in the turning of carbon steel (C-20) material.
- Operating parameters in turning process: Three different spindle speeds (in the range of 300 -1200 rpm), three feed rates (0.12 and 0.20 mm/s), four depth of cuts (0.4 and 1.6 mm), dry condition machining
- Understanding the 2-D and 3-D topographies of scorpion skin, scanning electron microscope (SEM) for copying the biological textures on the tool inserts using fiber laser textures.
- Lapping of tool inserts for cleaning the surface and taking scanning electron microscopic image of that textured insert surface.
- Wear investigation: by measuring/assessing the weight, physical dimensions, confocal microscopic image of tool inserts before and after the turning operations of C-20 material.
- Friction investigation: Due to unavailability of dynamometer with the lathe machine on which experiments have been planned, it is thought to measure the temperature rise at the interface of tool insert and work piece using non-contacting thermometer. Less temperature will indicate low presence of friction at the interface during the turning process.

3.1 Block Diagram of work process



CHAPTER 4

EXPERIMENTAL SETUP

In the beginning of this experiment the equipment's that are required for successfully completing the project are discussed in this chapter. The experimental setup for the conduction of this experiment includes lathe machine, non-contact thermometer, tool holder, tool inserts (Tungsten carbide tool insert), work piece (mild steel rod C-20), weighing machine, confocal microscopy machine, lapping machine and fiber laser machine.

4.1 Equipment's

4.1.1 Lathe Machine

Pioneer-175 lathe machine (shown in fig.4.1) was identified for turning operation. This machine has speed variation from 54 rpm to 1200 rpm, with least feed rate as 0.2 mm/rev and least depth of cut as 0.04 mm.

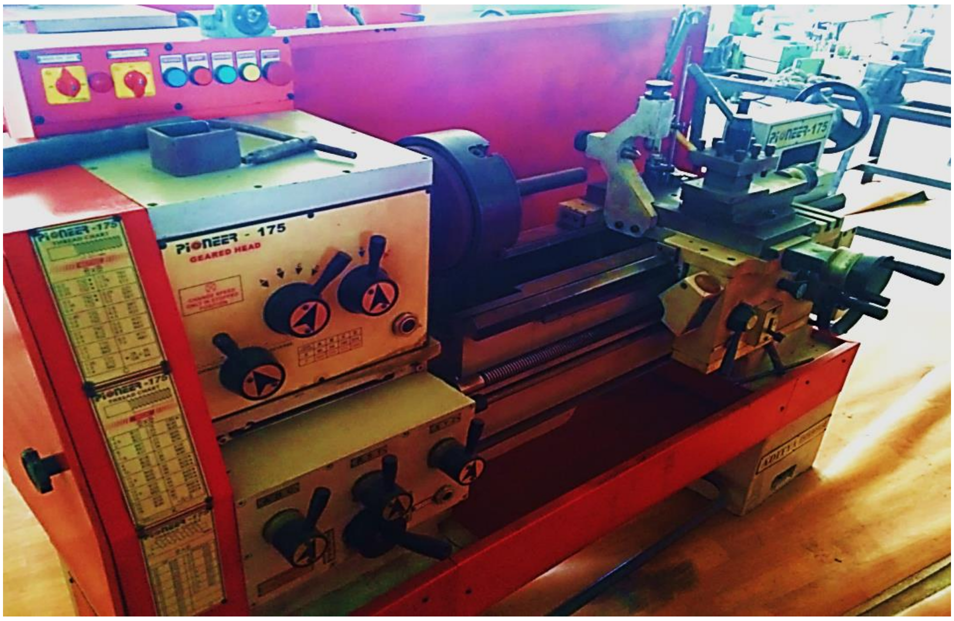


Fig.4.1 Pioneer-175 lathe machine

4.1.2 Non-Contact Thermometer

The non-contact thermometer of Work Zome (as shown in fig. 4.2) is used for measuring the temperature rise (first measuring the temperature of the tool insert tip before the turning operation and then after the turning operation). The temperature range of this thermometer is from -50^{o}C to 1100^{o}C. The validation of this equipment has been done. The temperature shown by this thermometer is 2^{o}C more than the actual temperature. So the temperature has been noted by taking this error in consideration.

Fig.4.2 Non-Contact thermometer of Work Zome

4.1.3 Tungsten carbide tool insert

The carbide tool inserts which are shown in fig.4.3 are used for the turning operation are triangular in shape. The dimensions of the tool inserts have been noted down along with the weight of each carbide tool insert. The dimensions are measured using Vernier calliper and protector. The length of tool insert is 15.148 mm and width is 6.128 mm. The angle formed by sides of tool insert is 60^{o}. The rake angle is 0^{o} during turning operation.

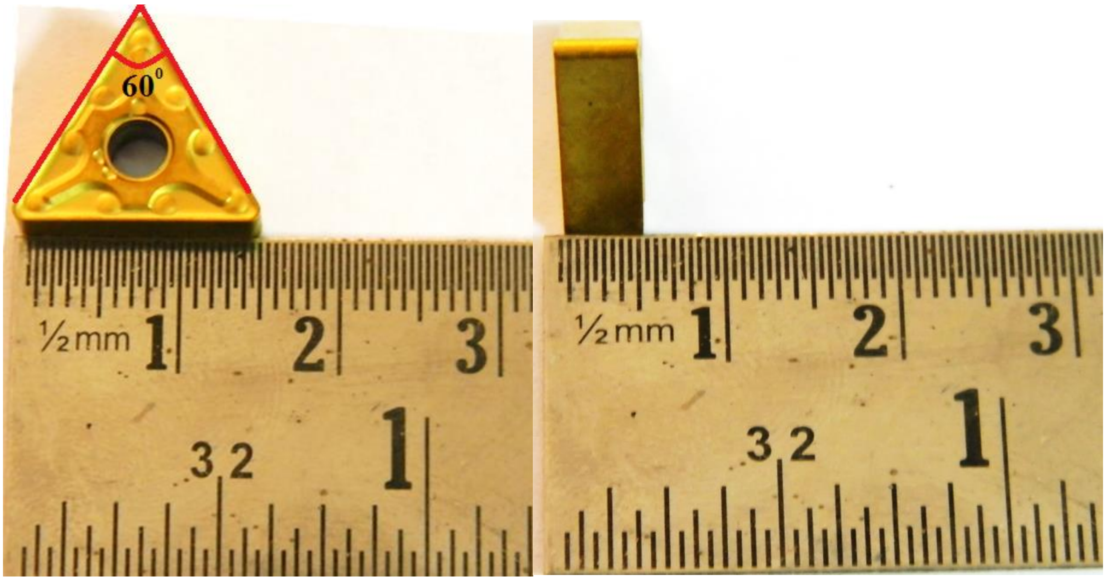


Fig. 4.3 Carbide tool inserts

4.1.4 Tool Holder

Tool holder shown in fig.4.4 is used for holding the tool inserts. This tool holder is mounted on the tool post of the lathe machine. Tool holder is made of cast iron as it has high compressive strength. The length of tool holder which is outside the tool post also contributes in force which acts on the workpiece. Same length of tool holder is outside the tool post so that same force is applied on every workpiece.

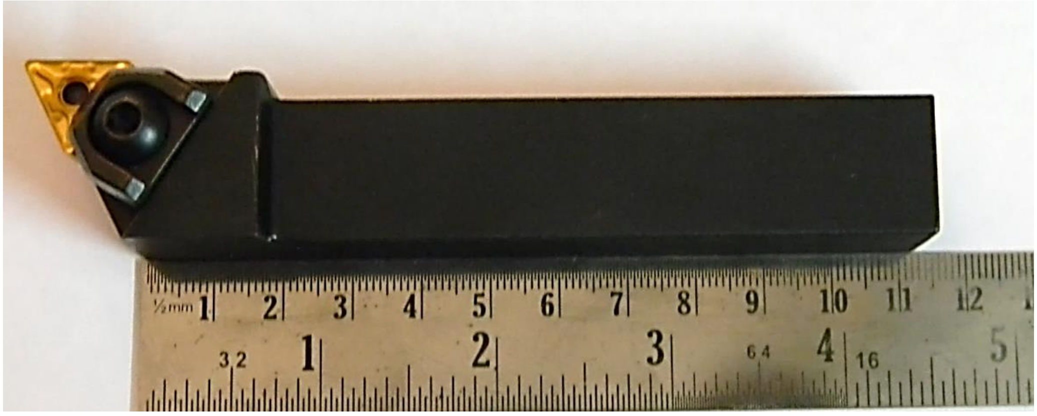


Fig.4.4 Tool holder

4.1.5 Workpiece

Mild steel rod (C-20) is used as workpiece which around 20 cm in length. The turning has been done up to 12.5 cm in the length as shown in fig.4.5.

Fig.4.5 Mild steel rod and turning has been done up to 12.5 cm

4.1.6 Fiber laser machine

The texturing of the specified dimensions on the surface of tungsten carbide tool insert has been done from Noida (Uttar Pradesh). For this project work, fiber laser (shown in fig.4.6) was used to generate the texture and the parameters are given in table 4.1.

Preliminary trials were performed to correlate the laser parameters like frequency of laser pulse, power of laser, scanning speed, and distance between two grooves. Varying these parameters allows optimization of the dimensions and the quality of shape produced.

Table 4.1 Parameters of Fiber Laser Machine for Texturing

S. No.	LASER Parameters	Values
1.	Crystal used for LASER	Nd:YAG (Neodymium: Yttrium-Aluminium-Garnet)
2.	Laser Power (W)	20
3.	Wavelength (nm)	1064
4.	Pulse Frequency (kHz)	2
5.	Distance between two grooves (mm)	0.2
6.	Scanning speed (mm/s)	5

Fig. 4.6 Fiber laser cutting machine

4.1.7 Lapping machine

The laser texturing was done on the surface of tool insert. Lapping machine (as shown in fig.4.7) is used to do lapping operation on the tool surface to clean it from the particles of the tool material which are there on the surface after the texturing. Lapping machine is similar to polishing machine. First the diamond paste is applied on the surface to be cleaned and then surface is kept on the rotating disc. The disc rotates and removes the dirt particles.

Fig.4.7 EFCO Lapping machine

4.1.8 Confocal Microscopy Machine

Confocal microscopy machine is based on optical imaging technique which is used to increase optical resolution and contrast. It eliminates the out of focus light by using spatial pinhole placed at confocal plane of the lens. It reconstructs the 3-D structures from the obtained images.

Fig.4.8 Confocal microscopy machine

4.2 Procedure of the experiment

The experiment was performed by a sequence of steps.

1. First the dimension and weight of the tool inserts are taken before the experiment.
2. We mount the rod in chuck of lathe machine and mount the tool holder on tool post.
3. The tool insert is mounted on tool holder and the temperature at the tip of tool insert is measured and noted down.
4. The parameters are set on the lathe machine and turning operation is performed. The turning operation is performed 15 times for both textured tool insert and conventional tool insert but the temperature is taken when first turning operation is performed.
5. After the turning process the temperature at the tip of the tool insert is measured.
6. Same above steps are repeated for the rest of the conventional tool tip and laser textured tool inserts.
7. After the turning operation the dimensions and weight of the tool inserts are measured.

CHAPTER 5

RESULT AND DISCUSSIONS

After conducting the experiments for the conventional tool inserts and textured tool inserts the following results are obtained and is shown in tabulated form. The table includes the condition of tool insert, spindle speed, depth of cut, feed rate, and weight of the tool inserts before and after the experiments, wear and temperature rise at the interface of the tool inert and chip interface.

Table 5.1 Result obtained after the experiment

S. No.	Tool Insert Condition	Spindle Speed (RPM)	Depth of Cut (mm)	Feed Rate (mm/rev)	Weight of the tool inserts before (gm)	Weight of the tool inserts before (gm)	Wear (10^{-4}) (gm)	Temperature rise (^{o}C) at the tool insert-chip interface
1.	Conventional	315	0.12	0.4	5.9506	5.9499	7	1.0
2.	Conventional	315	0.12	0.8	5.9376	5.9371	5	1.1
3.	Conventional	315	0.12	1.2	5.9584	5.9580	4	1.0
4.	Conventional	315	0.12	1.6	5.9589	5.9583	6	1.2
5.	Conventional	500	0.12	0.4	5.8944	5.8944	0	1.0
6.	Conventional	500	0.12	0.8	5.9316	5.9314	2	1.2
7.	Conventional	500	0.12	1.2	5.9496	5.9495	1	1.4
8.	Conventional	500	0.12	1.6	5.9523	5.9520	3	4.4
9.	Conventional	775	0.12	0.4	5.9387	5.9385	2	2.8
10.	Conventional	775	0.12	0.8	5.9091	5.9088	3	2.5
11.	Conventional	775	0.12	1.2	5.9482	5.9480	2	6.2
12.	Conventional	775	0.12	1.6	5.9362	5.9358	4	6.3
13.	Conventional	315	0.16	0.4	5.9552	5.9551	1	0.9
14.	Conventional	315	0.16	0.8	5.9398	5.9398	0	3.4
15.	Conventional	315	0.16	1.2	5.9028	5.9026	2	3.1
16.	Conventional	315	0.16	1.6	5.9510	5.9509	1	2.2
17.	Conventional	500	0.16	0.4	5.9363	5.9361	2	2.7
18.	Conventional	500	0.16	0.8	5.9170	5.9168	2	4.3
19.	Conventional	500	0.16	1.2	5.8974	5.8973	1	2.1
20.	Conventional	500	0.16	1.6	5.9729	5.9729	0	2.0
21.	Conventional	775	0.16	0.4	5.9564	5.9560	4	3.3
22.	Conventional	775	0.16	0.8	5.9263	5.9263	0	3.4
23.	Conventional	775	0.16	1.2	5.9388	5.9390	-2	4.4
24.	Conventional	775	0.16	1.6	5.9558	5.9557	1	4.9
25.	Conventional	315	0.20	0.4	5.9378	5.9380	-2	1.4
26.	Conventional	315	0.20	0.8	5.9539	5.9539	0	2.9
27.	Conventional	315	0.20	1.2	5.9605	5.9605	0	3.5
28.	Conventional	315	0.20	1.6	5.9740	5.9734	6	5.3

29.	Conventional	500	0.20	0.4	5.9376	5.9373	3	2.0
30.	Conventional	500	0.20	0.8	5.9543	5.9540	3	3.8
31.	Conventional	500	0.20	1.2	5.9264	5.9261	3	4.3
32.	Conventional	500	0.20	1.6	5.9336	5.9335	1	4.6
33.	Conventional	775	0.20	0.4	5.9418	5.9416	2	3.7
34.	Conventional	775	0.20	0.8	5.9325	5.9321	4	4.5
35.	Conventional	775	0.20	1.2	5.9323	5.9321	2	5.0
36.	Conventional	775	0.20	1.6	5.9181	5.9179	2	5.2
37.	Scorpion	315	0.12	0.4	5.9360	5.9369	-9	3.8
38.	Scorpion	315	0.12	0.8	5.9296	5.9314	-18	3.3
39.	Scorpion	315	0.12	1.2	5.9054	5.9060	-6	3.0
40.	Scorpion	315	0.12	1.6	5.9482	5.9482	0	2.8
41.	Scorpion	500	0.12	0.4	6.7258	6.7256	-2	1.0
42.	Scorpion	500	0.12	0.8	5.9496	5.9505	-9	1.4
43.	Scorpion	500	0.12	1.2	5.9420	5.9442	-22	1.6
44.	Scorpion	500	0.12	1.6	5.9522	5.9530	-8	2.0
45.	Scorpion	775	0.12	0.4	5.9515	5.9520	-5	1.4
46.	Scorpion	775	0.12	0.8	5.9568	5.9580	-12	3.4
47.	Scorpion	775	0.12	1.2	5.9404	5.9424	-20	2.2
48.	Scorpion	775	0.12	1.6	5.9462	5.9467	-5	2.1
49.	Scorpion	315	0.16	0.4	5.9402	5.9416	-14	3.5
50.	Scorpion	315	0.16	0.8	5.9203	5.9222	-19	4.3
51.	Scorpion	315	0.16	1.2	5.9463	5.9478	-15	4.0
52.	Scorpion	315	0.16	1.6	5.9453	5.9462	-9	3.7
53.	Scorpion	500	0.16	0.4	5.9348	5.9349	-1	0.7
54.	Scorpion	500	0.16	0.8	5.9377	5.9384	-7	1.6
55.	Scorpion	500	0.16	1.2	5.9440	5.9443	-3	1.8
56.	Scorpion	500	0.16	1.6	5.9512	5.9515	-3	3.1
57.	Scorpion	775	0.16	0.4	5.9250	5.9264	-14	5.0
58.	Scorpion	775	0.16	0.8	5.9520	5.9524	-4	2.0
59.	Scorpion	775	0.16	1.2	5.9595	5.9600	-5	2.7
60.	Scorpion	775	0.16	1.6	5.9523	5.9529	-6	2.0
61.	Scorpion	315	0.20	0.4	5.9244	5.9255	-11	2.1
62.	Scorpion	315	0.20	0.8	5.9338	5.9343	-5	2.6
63.	Scorpion	315	0.20	1.2	5.9319	5.9337	-18	2.2
64.	Scorpion	315	0.20	1.6	5.9417	5.9420	-3	2.4
65.	Scorpion	500	0.20	0.4	5.9539	5.9540	-1	2.9
66.	Scorpion	500	0.20	0.8	5.9420	5.9431	-11	2.9
67.	Scorpion	500	0.20	1.2	5.9430	5.9438	-8	3.0
68.	Scorpion	500	0.20	1.6	5.9104	5.9119	-15	3.0
69.	Scorpion	775	0.20	0.4	5.9496	5.9501	-5	2.8
70.	Scorpion	775	0.20	0.8	5.9194	5.9220	-26	2.7
71.	Scorpion	775	0.20	1.2	5.9460	5.9471	-11	3.0
72.	Scorpion	775	0.20	1.6	5.9255	5.9265	-10	2.9

From table 5.1, we can observe that the temperatures and wear of the conventional and textured tool inserts are varying with change in the parameters. We can also observe that for some parameters there is arbitrary change in temperature and wear and this is due to environmental conditions, vibration of the mild steel rod, and manufacturing defect in workpiece like non-uniform cross section and some errors in measuring instruments.

5.1 Result of Temperature rise

In this section we will discuss the temperature rise for textured and conventional tool insert for various parameters. In the end this section, we will come to a conclusion that which type of tool insert is best suited of that set of parameters.

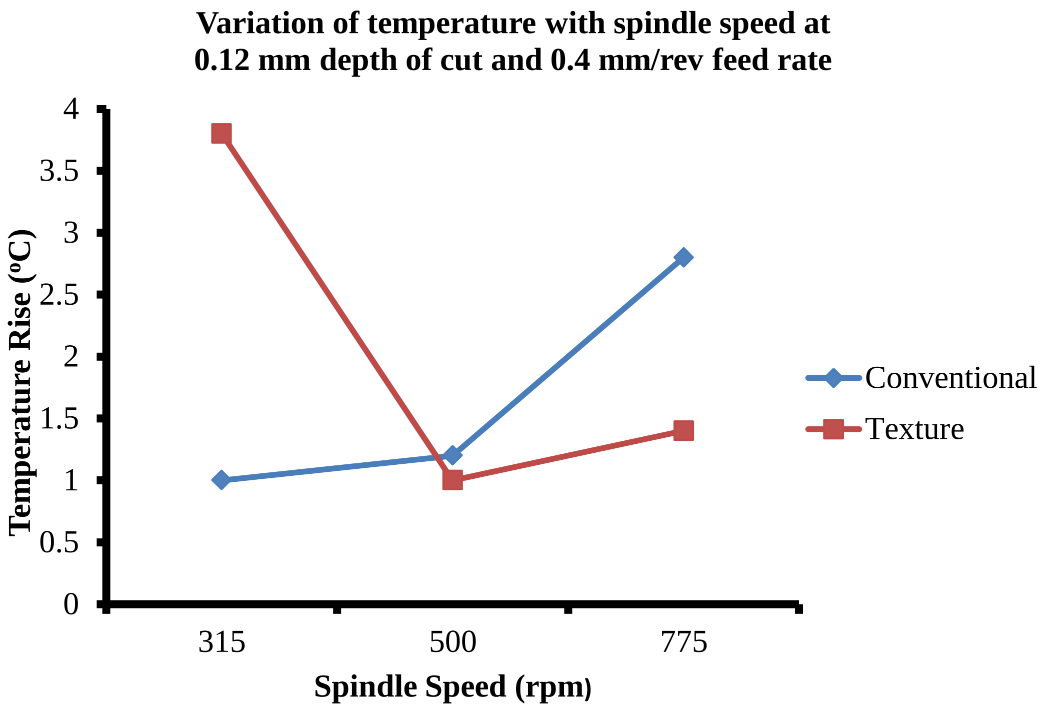


Fig 5.1 Variation of temperature with spindle speeds at 0.12 mm depth of cut and 0.4 mm/rev feed rate

The variation of temperature in relation with various spindle speeds at 0.12 mm depth of cut and 0.4 mm/rev feed rate can be seen in fig. 5.1. The temperature rise is more for texture tool insert at 315 rpm. For spindle speed 500 rpm and 775 rpm the temperature rise of textured tool insert is less than the conventional tool insert. This shows that textured tool insert is better at 500 rpm and 775 rpm.

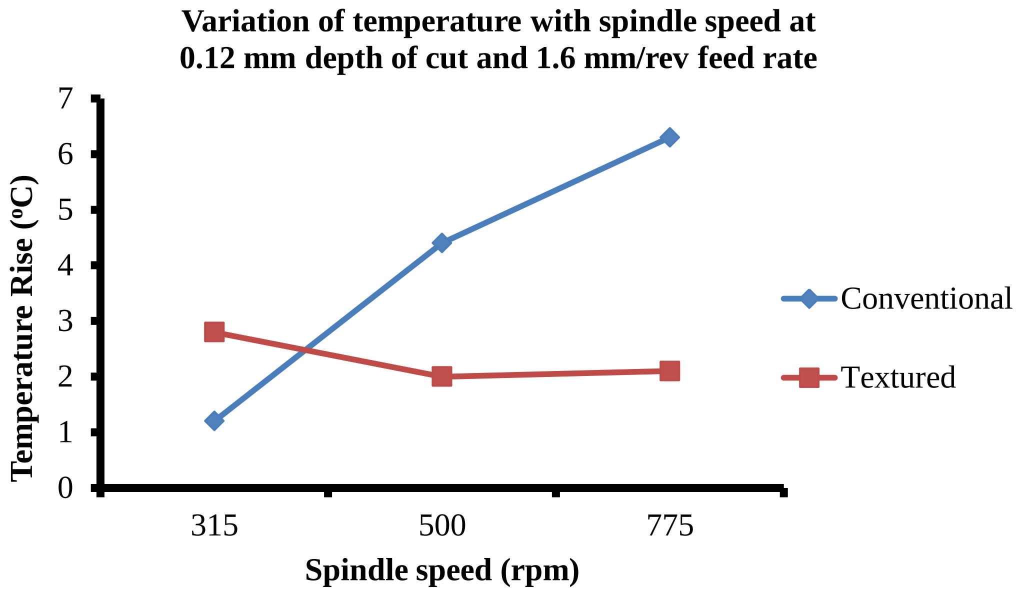


Fig 5.2 Variation of temperature with spindle speeds at 0.12 mm depth of cut and 1.6 mm/rev feed rate

For depth of cut 0.12 mm and feed rate 1.6 mm/rev as shown in fig 5.2, the variation in temperature rise of textured and conventional tool insert for various spindle speed can be observed. The temperature rise of textured tool insert is more than conventional tool insert at 315 rpm. When the spindle speed has increased from 315 rpm to 500 rpm and 775 rpm then the temperature rise for textured tool insert is less in comparison to conventional tool insert.

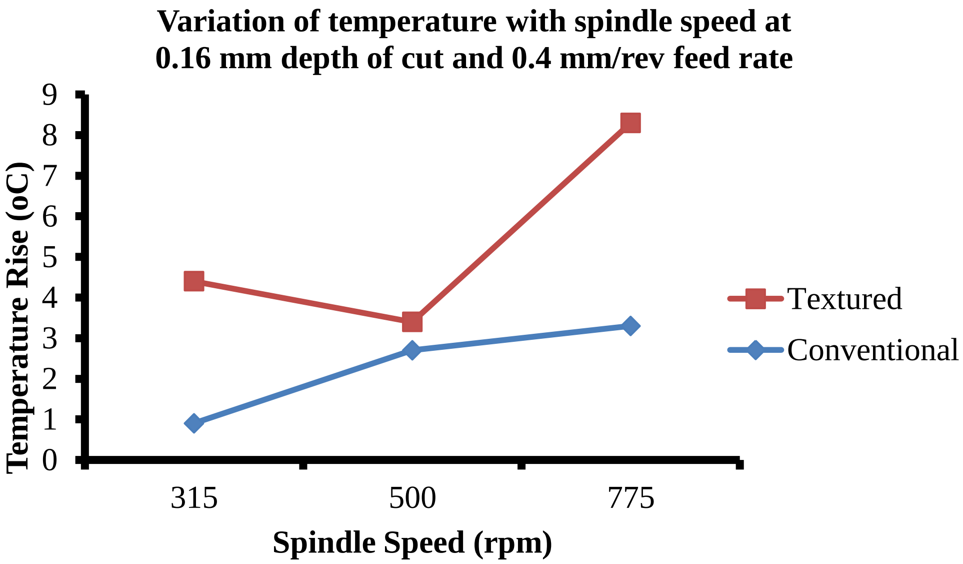


Fig 5.3 Variation of temperature with spindle speed at 0.16 mm depth of cut and 0.4 mm/rev feed rate

The variation of temperature in relation with various spindle speeds at 0.16 mm depth of cut and 0.4 mm/rev feed rate has been shown in fig. 5.3. The temperature rise is more for texture tool insert at all the spindle speeds. Therefore for this parameter conventional tool inserts are better.

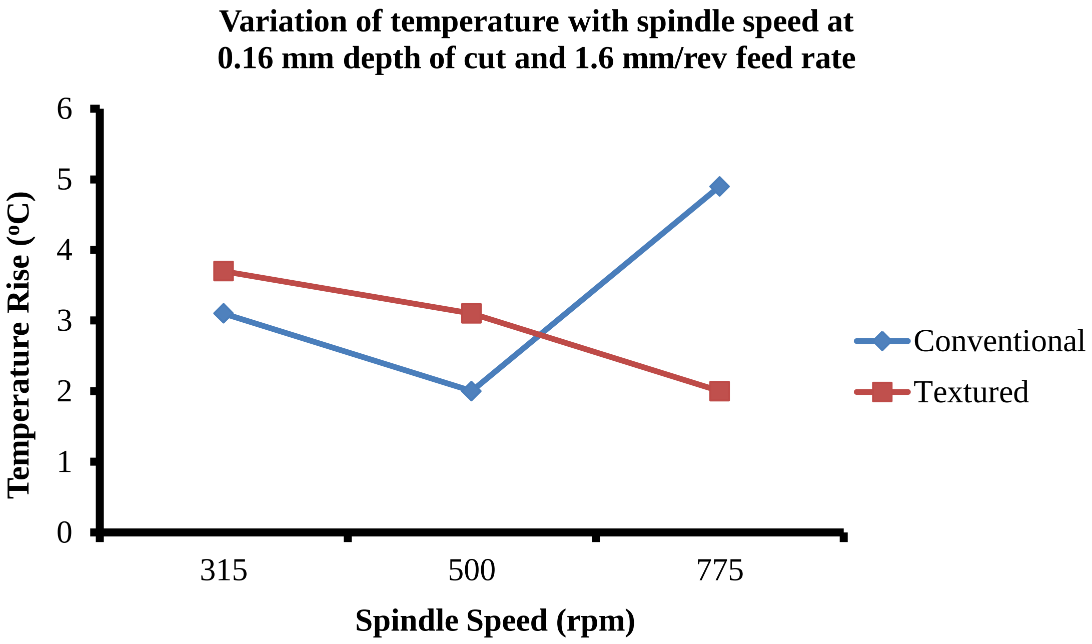


Fig 5.4 Variation of temperature with spindle speed at 0.16 mm depth of cut and 1.6 mm/rev feed rate

The temperature rise for conventional tool insert is less as compared to textured tool insert for 315 rpm and 500 rpm spindle speed, 0.16 mm depth of cut and 1.6 mm/rev feed rate as shown in fig.5.4. When spindle speed increases to 775 rpm, the temperature rise for textured tool insert is less than conventional tool insert.

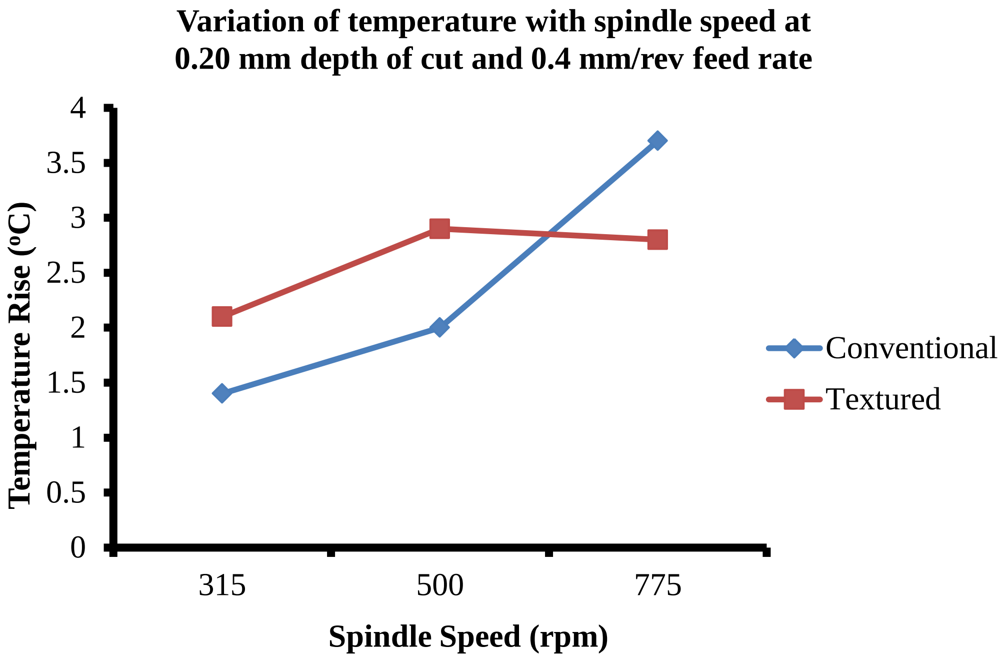


Fig 5.5 Variation of temperature with spindle speed at 0.20 mm depth of cut and 0.4 mm/rev feed rate

The temperature rise for conventional tool insert is less as compared to textured tool insert for 315 rpm and 500 rpm spindle speed, 0.20 mm depth of cut and 0.4 mm/rev feed rate as shown in fig.5.5. When spindle speed increases to 775 rpm, the temperature rise for textured tool insert is less than conventional tool insert.

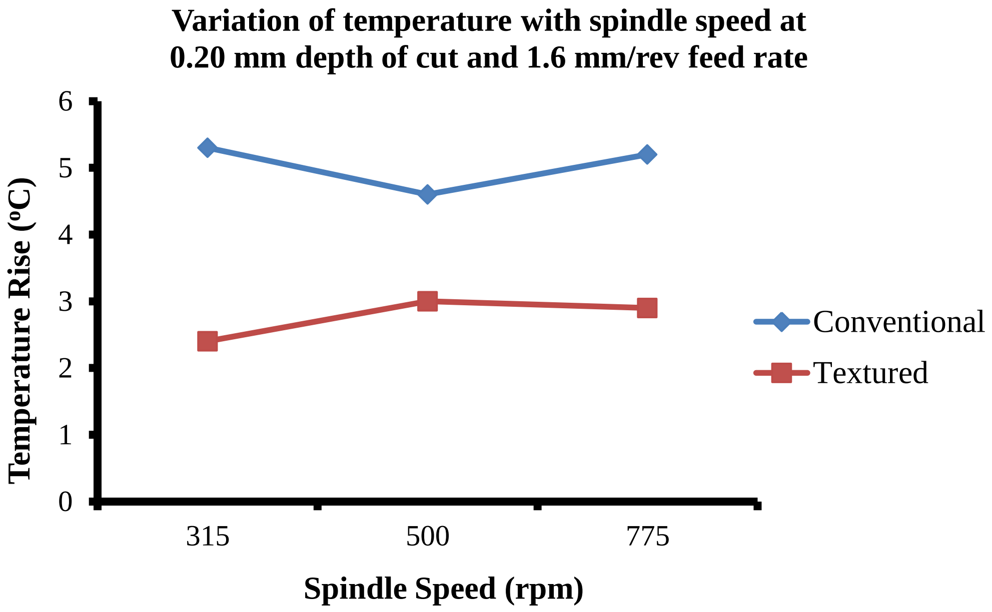


Fig 5.6 Variation of temperature with spindle speed at 0.20 mm depth of cut and 1.6 mm/rev feed rate

The temperature rise of textured tool insert (as shown in fig. 5.6) is less when compared to conventional tool insert for all the spindle speeds at 0.20 mm depth of cut and 1.6 mm/rev feed rate. These are the best parameters for using textured tool insert.

5.2 Confocal microscopic image of conventional and textured tool inserts

In this section the wear pattern can be observed for both conventional and textured tool inserts. The image of both type of tool inserts are shown together for same set of parameters.

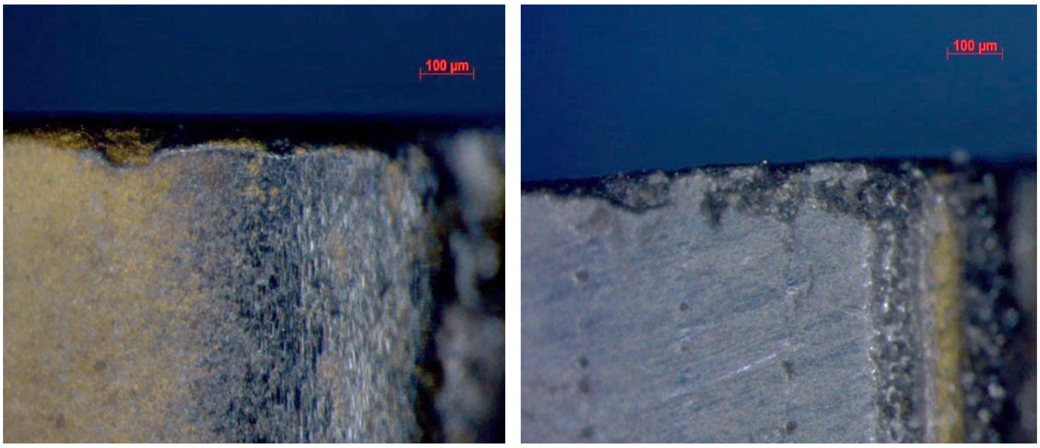


Fig. 5.7 Confocal microscopic image of conventional and textured tool inserts after turning operation at 315 rpm, 0.12 mm depth of cut and 0.4 mm/rev feed rate

The wear pattern can be seen in fig. 5.7, the confocal microscopic image of both conventional and insert after turning operation at 315 rpm, 0.12 mm depth of cut and 0.4 mm/rev feed rate. The images are magnified at 120 times magnified.

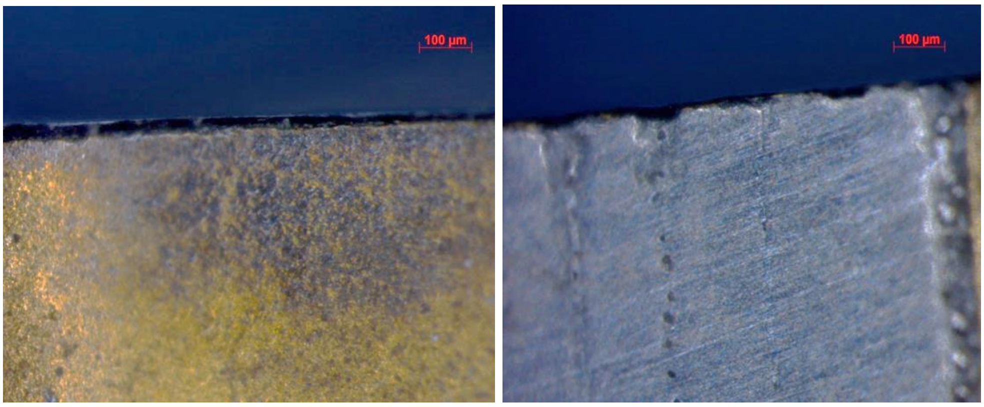


Fig. 5.8 Confocal microscopic image of conventional and textured tool inserts after turning operation at 500 rpm, 0.12 mm depth of cut and 0.8 mm/rev feed rate

As shown in fig. 5.8, the wear pattern can be seen in the confocal microscopic image of conventional and textured tool insert after turning operation at 500 rpm, 0.12 mm depth of cut and 0.8 mm/s feed rate. The images are magnified at 120 times magnified.

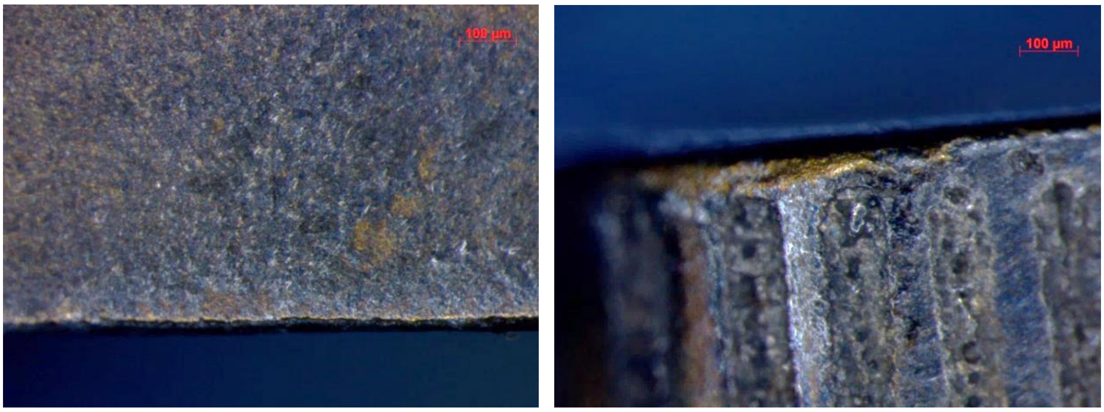


Fig. 5.9 Confocal microscopic image of conventional and textured tool inserts after turning operation at 775 rpm, 0.12 mm depth of cut and 1.6 mm/rev feed rate

Confocal microscopic image of conventional and textured tool insert reveals the wear pattern turning operation at 775 rpm, 0.12 mm depth of cut and 1.6 mm/rev feed rate which is shown in fig. 5.9. The images are magnified at 120 times magnified.

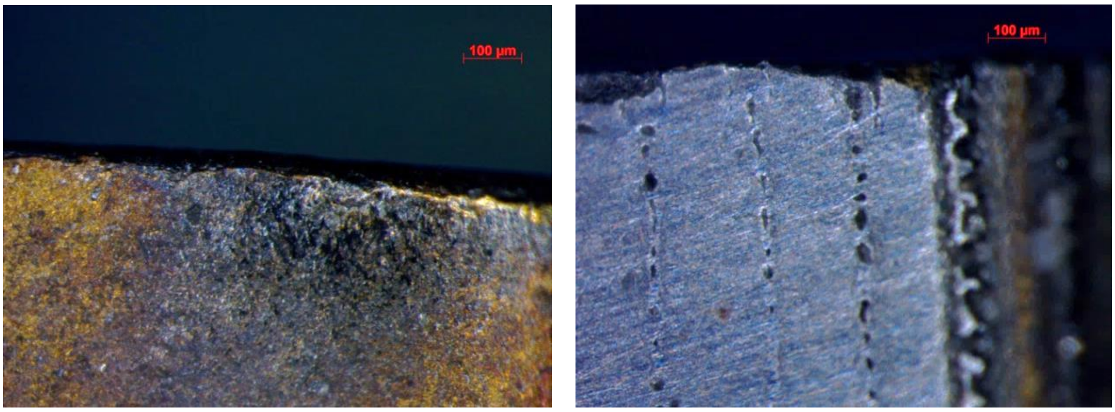


Fig. 5.10 Confocal microscopic image of conventional and textured tool inserts after turning operation at 500 rpm, 0.16 mm depth of cut and 0.8 mm/rev feed rate

Confocal microscopic image of conventional and textured tool insert shows the wear pattern after turning operation at 500 rpm, 0.16 mm depth of cut and 0.8 mm/rev feed rate (as shown in fig. 5.10). The images are magnified at 120 times magnified.

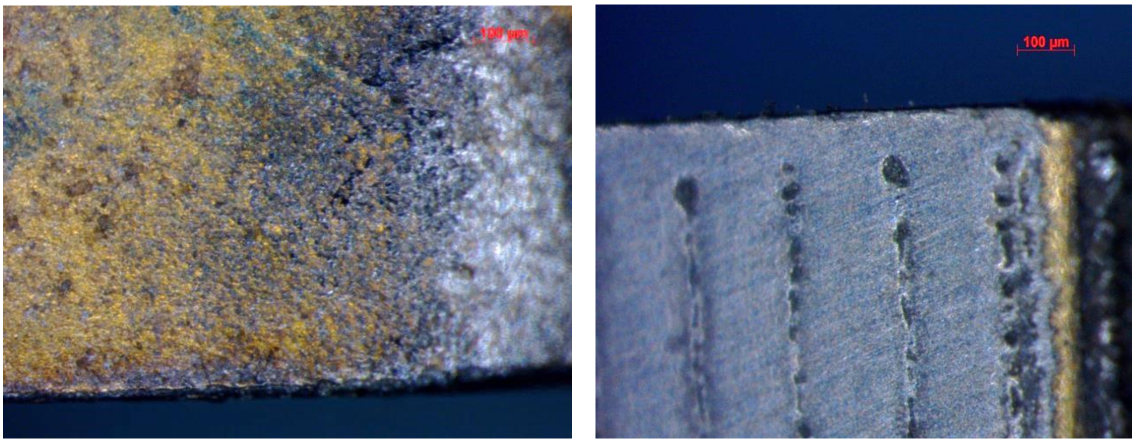


Fig. 5.11 Confocal microscopic image of conventional and textured tool inserts after turning operation at 775 rpm, 0.16 mm depth of cut and 1.6 mm/rev feed rate

Confocal microscopic image of conventional and textured tool insert shows (as shown in fig. 5.11) the wear pattern after turning operation at 775 rpm, 0.16 mm depth of cut and 1.6 mm/rev feed rate. The images are magnified at 120 times magnified.

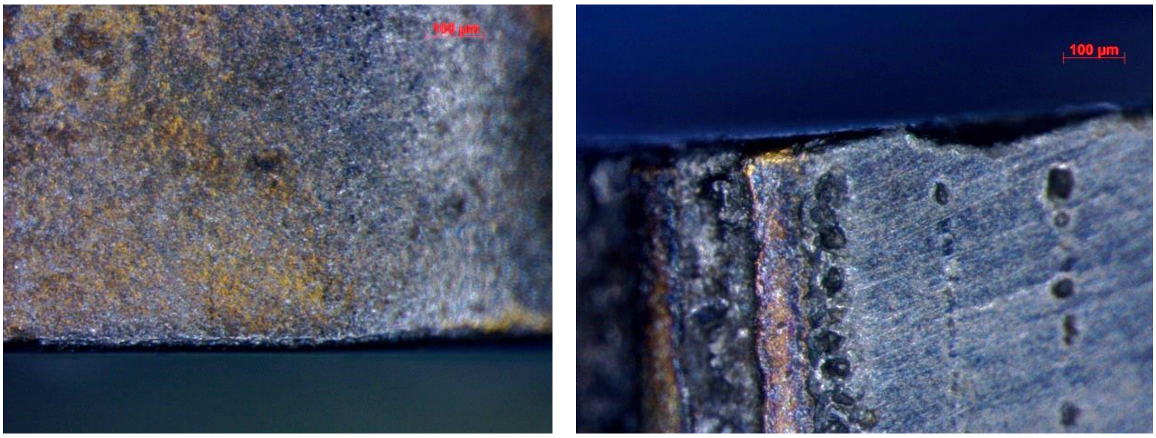


Fig. 5.12 Confocal microscopic image of conventional and textured tool inserts after turning operation at 500 rpm, 0.2 mm depth of cut and 0.8 mm/rev feed rate

Confocal microscopic image of conventional and textured tool insert shows the wear pattern after turning operation at 500 rpm, 0.2 mm depth of cut and 0.8 mm/rev feed rate which is shown in fig. 5.12. The images are magnified at 120 times magnified.

5.3 Wear behaviour of tool inserts

In this section, the wear behaviour of conventional and textured tool inserts for various parameters are shown.

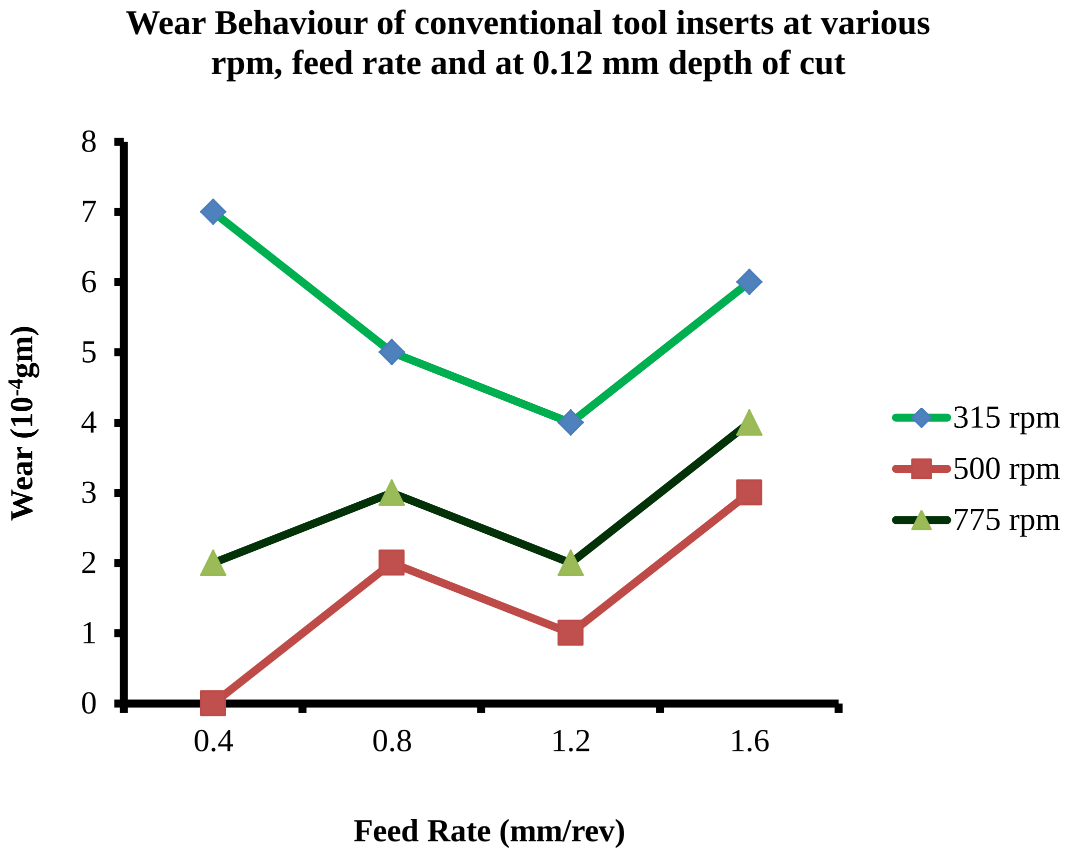


Fig. 5.13 Wear of conventional tool inserts at various rpm, feed rate and at 0.12 mm depth of cut

The graphical representation of wear corresponding to various feed rate for various spindle speed at 0.12 mm depth of cut as shown in fig. 5.13. From the above figure it can be seen that wear of tool insert changes when the feed rate and spindle speed changes. For feed rate 0.4 mm/rev corresponding spindle speed 315 rpm and 500 rpm, the wear is minimum. Wear increases when feed rate changes to 0.8 mm/rev then again it decreases 1.2 mm/rev feed rate and again increases at 1.6 mm/rev feed rate. The wear behaviour is different for spindle speed 775 rpm.

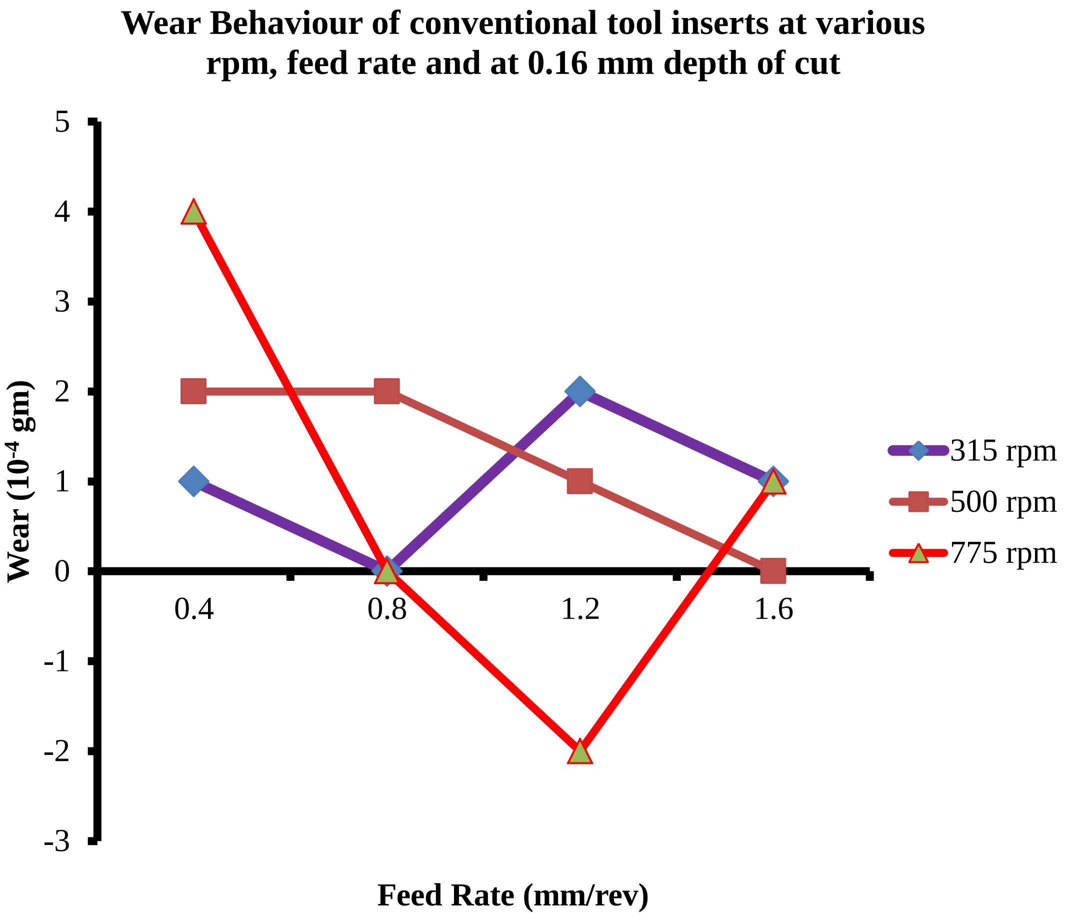


Fig. 5.14 Wear of conventional tool inserts at various rpm, feed rate and at 0.16 mm depth of cut

The graphical representation of wear corresponding to various feed rate at various spindle speed at 0.16 mm depth of cut can be seen in fig. 5.14. From the above figure it can be seen that wear of tool insert changes as the feed rate and the spindle speed changes. For feed rate 0.4 mm/rev, wear is maximum for spindle speed 775 rpm and minimum at 315 rpm. For feed rate 0.8 mm/rev, maximum wear is at 500 rpm and is minimum at 315 and 775 rpm. For feed rate 1.2 mm/rev, unexpected wear behaviour is found. There is addition of material due to heating and weight of tool insert increases.

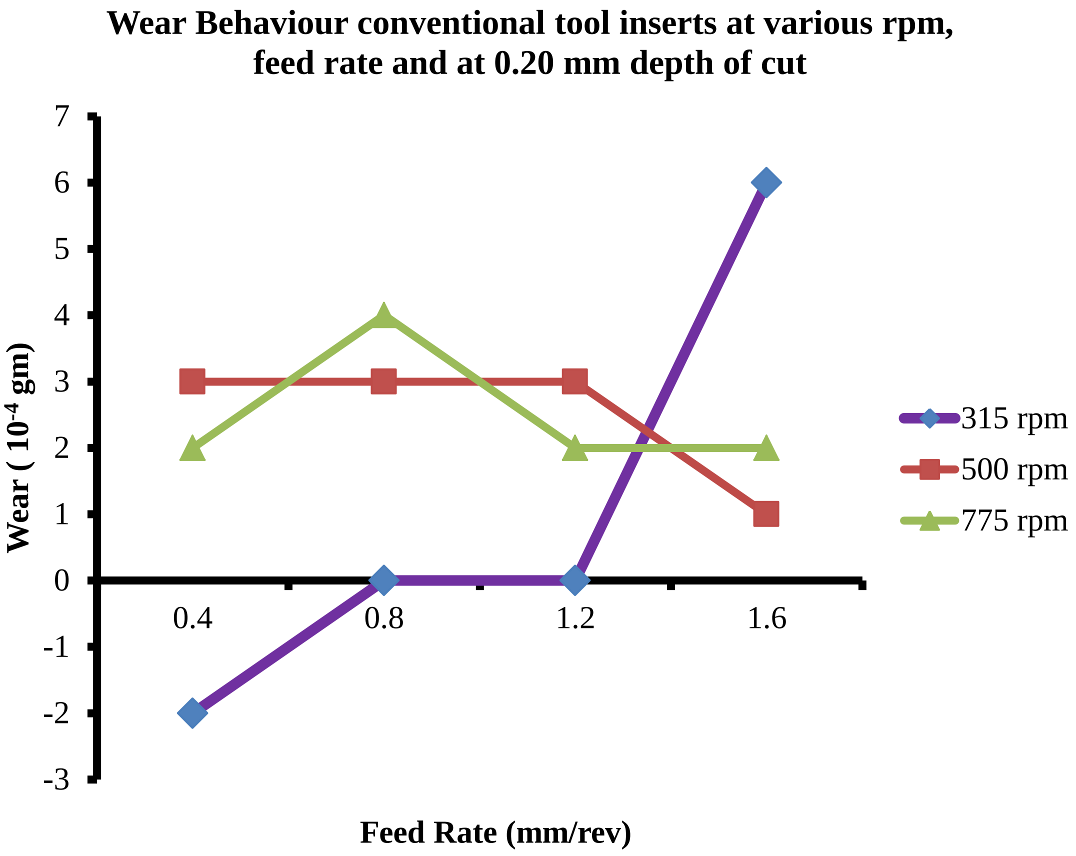


Fig. 5.15 Wear of conventional tool inserts at various rpm, feed rate and at 0.20 mm depth of cut

The graphical representation of wear corresponding to various feed rate at various spindle speed (rpm) at constant depth of cut of 0.20 mm is shown in fig. 5.15. Wear behaviour of various tool inserts changes as the feed rate changes at various spindle speed. For feed rate 0.4 mm/rev, wear changes from minimum at 315 rpm to maximum at 775 rpm. At 315 rpm we can observe that there is addition of material rather than removal and this is due to dirt and impurities getting attached to the tool insert. For feed rate 0.8 mm/rev, maximum wear is at 500 rpm and almost zero wear at 315 rpm. For feed rate 1.2 mm/rev, there is no significant wear of tool insert at 315 rpm and maximum wear is at 500 rpm. For feed rate 1.6 mm/rev, wear of tool insert is maximum at 315 rpm and minimum at 500 rpm.

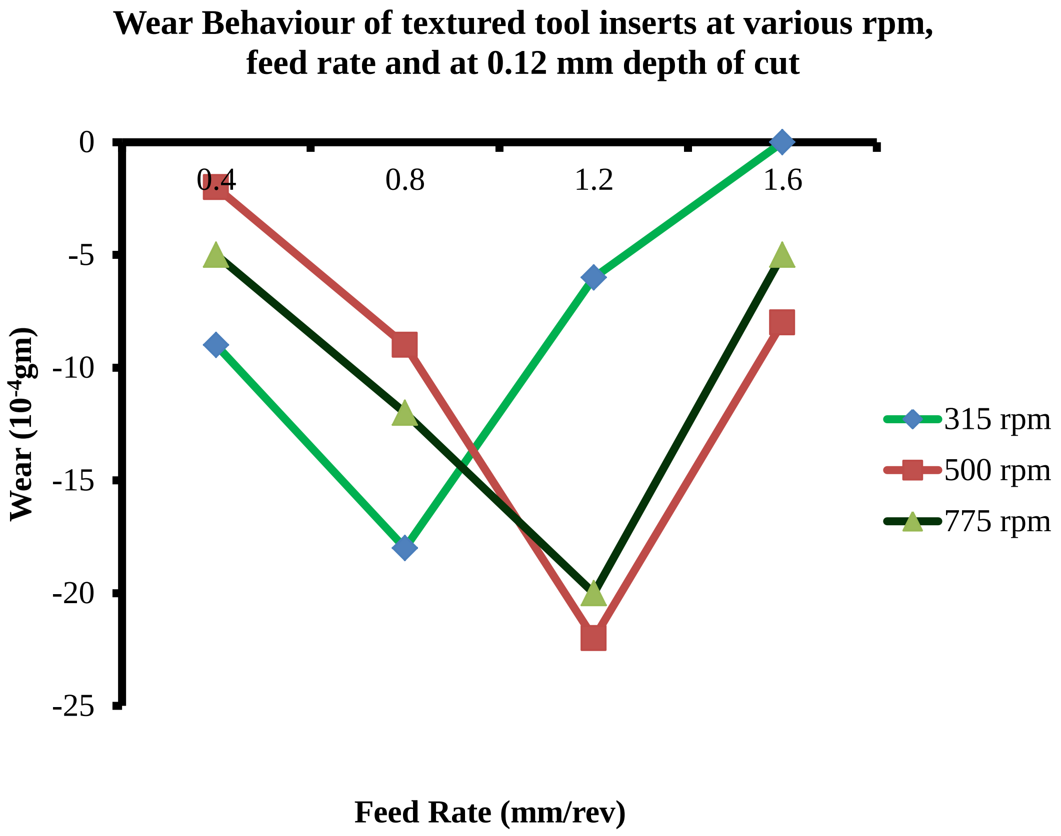


Fig. 5.16 Wear of textured tool inserts at various rpm, feed rate and at 0.12 mm depth of cut

The graphical representation of wear corresponding to various feed rate at various spindle speed (rpm) at 0.12 mm depth of cut is shown in fig. 5.16. From the above figure it can be seen that no wear of textured tool insert takes place with change in the feed rate at various spindle speed instead there is addition of material. This addition has taken place as the chips of workpiece and particles of tool inserts gets trapped inside the texture.

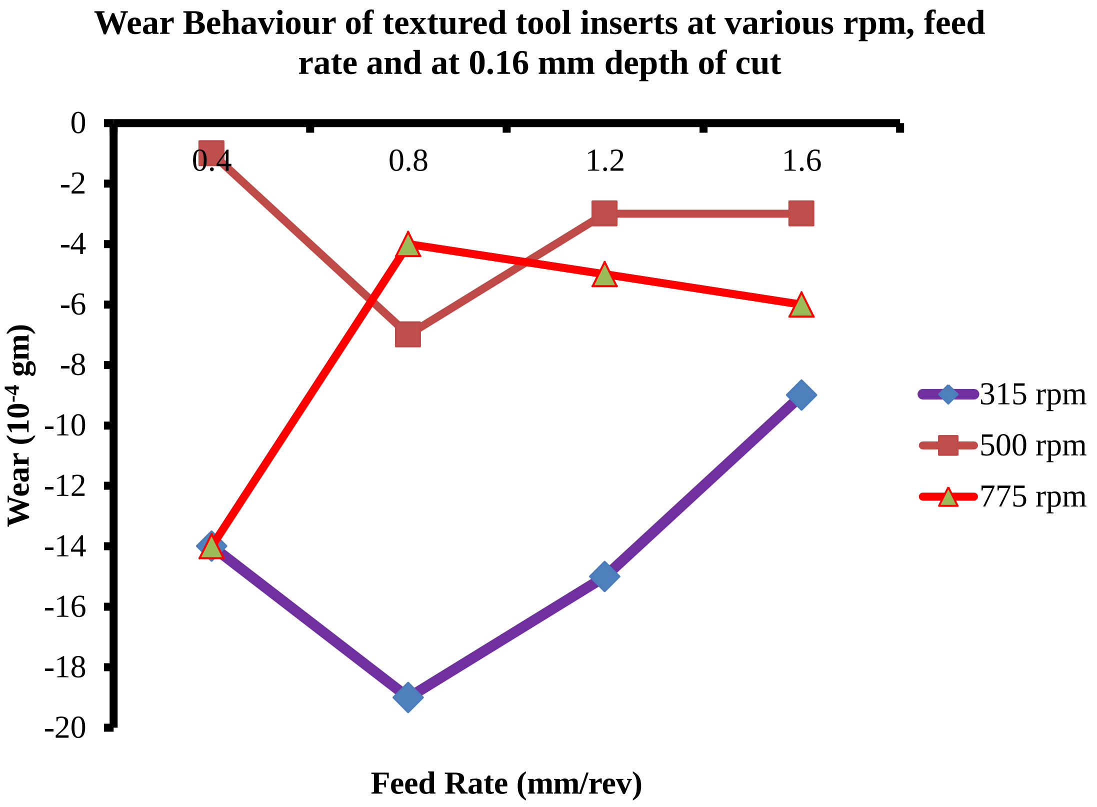


Fig. 5.17 Wear of textured tool inserts at various rpm, feed rate and at 0.16 mm depth of cut

The graphical representation of wear corresponding to various feed rate, spindle speed at 0.16 mm depth of cut can be seen in fig. 5.17. From the above figure it can be seen that no wear of textured tool insert takes place with change in the feed rate at various spindle speed instead there is addition of material. This addition has taken place as the chips of workpiece and particles of tool inserts gets trapped inside the texture. When the spindle speed is 315 rpm the addition of material is more in comparison to 500 rpm and 775 rpm for all the feed rates.

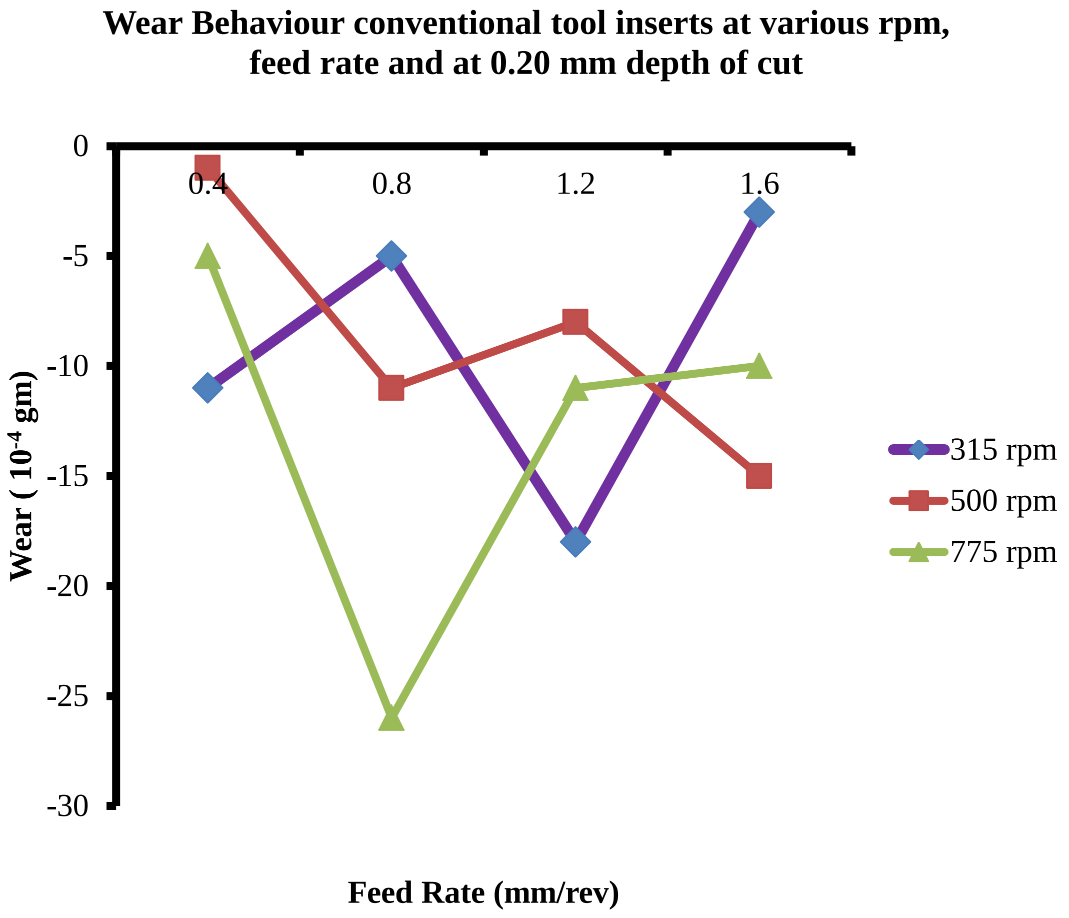


Fig. 5.18 Wear of textured tool inserts at various rpm, feed rate and at 0.20 mm depth of cut

The graphical representation of wear corresponding to various feed rate, spindle speed and at constant depth of cut of 0.20 mm is shown in fig. 5.18. From the above figure it can be seen that no wear of textured tool insert takes place with change in the feed rate at various spindle speed instead there is addition of material. This addition has taken place as the chips of workpiece and particles of tool inserts gets trapped inside the texture. When the spindle speed is 775 rpm the addition of material is more in comparison to 500 rpm and 775 rpm at 0.8 mm/rev feed rate.

CHAPTER 6

CONCLUSIONS AND SCOPE FOR FUTURE WORK

Based on the experimental studies reported in the previous chapters of this report, conclusions drawn are reported herein.

6.1 Conclusions

Based on studies the following conclusions have been drawn:

- Temperature rise is in increasing order when the spindle speed, feed rate and depth of cut is increased for both textured and conventional tool insert. The rise in temperature of textured tool insert is less in comparison to conventional tool insert.
- Weights of conventional tool inserts have decreased after the turning operation. Whereas the weight of textured tool inserts has increased because the chips of workpiece and tool insert articles gets trapped inside the texture.
- Wear of conventional and textured tool inserts changes with change in parameters like spindle speed, feed rate and depth of cut. Wear is more for conventional tool inserts in comparison to textured tool inserts.

6.2 Scope for Future Work

The tribological study on tungsten carbide tool insert has been performed for the first time using this type of texture pattern. In this study various experiments have been carried out with conventional tungsten carbide tool insert and textured tungsten carbide tool insert. In future different materials can be used with different shapes of texture can be studied to improve the tribological behaviour of material. Even different workpiece material can be used to see the tribological effect on the quality of the workpiece.

PROJECT ACTIVITY CHART (GANTT CHART)

S. No.	Activity	Aug.-2015	Sept.-2015	Oct.-2015	Nov.-2015	Dec.-2015	Jan.-2016	Feb.-2016	Mar.-2016	April-2016
1.	**Literature review**	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	
2.	**Identification and purchase of tool inserts and work piece**	🟩								
3.	**Laser surface texturing on tool inserts**		🟩	🟩						
4.	**Conducting experiments on lathe machine**			🟩	🟩					
5.	**Report writing and presentation of project**					🟩				
6.	**Conducting experiments**						🟩	🟩	🟩	
7.	**Final report writing and presentation of project**									🟩

🟦	**Work to do**	🟧	**Work in progress**	🟩	**Work done**

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