“Analysis of Tool Life, MRR and Surface roughness during turning of D2 steel by using CERMET insert”

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TABLE OF CONTENTS

Title Page	I
Certificate	ii
Compliance Certificate	iii
Paper Publication Certificate	iv
Thesis Approval Certificate	v
Declaration of Originality	vi
Acknowledgements	vii
Table of Contents	viii
List of Figures	xi
List of Tables	xii
Nomenclature	xiii
Abstract	xiv
CHAPTER 1: INTRODUCTION	**1-8**
1.1 Introduction to manufacturing process	1
1.2 Classification of manufacturing process	1
1.3 Classification of machining process	3
1.4 Turning Process	3
1.5 Classification of Turning Process	4
1.6 Dynamics of turning	5
1.7 Workpiece Introduction	6
1.7.1 Properties of D2 steel	6
1.7.2 Chemical Composition of D2 steel	6
1.7.3 Application of D2 steel	7

1.8	Tool insert	7
1.8.1	Introduction of cermet insert	7
1.8.2	Application of cermet insert	8
CHAPTER 2: LITERATURE SURVEY		**9-20**
2.1	Problem Identification	9
2.2	Literature Review	10
2.3	Literature Mapping	18
2.4	Literature Summary	19
2.5	Objectives	20
CHAPTER 3: METHDOLOGY		**21-23**
CHAPTER 4: DESIGN OF EXPERIMENT		**24-25**
CHAPTER 5: EXPERIMENTAL SETUP AND WORK		**26-46**
5.1	CNC Machine	26
5.2	Tool insert	28
5.3	Selection of workpiece for turning	29
5.4	Analytical Calculation for Turning Operation	30
5.5	Surface Roughness Tester	31
5.6	Experimental Setup	32
5.7	CNC Program	32
5.8	Experimental Procedure	35
5.9	Material Removal Rate	36
5.10	Tool life	38
5.11	Surface Roughness	43
CHAPTER 6: RESULT AND DISCUSSIONS		**47-48**
CHAPTER 7: CONCLUSIONS AND FUTURE SCOPE		**49-50**
7.1	Conclusions	49

7.2 Future Scope 50

REFERENCES **51-54**

APPENDIX A: Review Card **55**

APPENDIX B: Compliance Report **61**

APPENDIX C: Acceptance Letters **62**

APPENDIX D: Standard **63**

APPENDIX E: Standard Result **65**

APPENDIX F: Plagiarism Report **68**

LIST OF FIGURES

FIG. NO.	TITLE	PAGE NO.
1.1	Schematic Representation of Turning Operation	4
2.1	Year Wise No. of Literature	18
2.2	Publication Wise % of Literature	19
2.3	Domain wise % of literature	19
3.1	Flow Chart for followed methodology	22
5.1	DX 150 CNC Machine	26
5.2	Cermet Insert	28
5.3	Surface roughness tester	30
5.4	Workpiece Setup	31
5.5	Turning operation	34
5.6	Workpiece after Machining	35
5.7	Flank Wear at different Cutting Speed	39
5.8	Flank wear vs Machining Time	40
5.9	Logarithmic Scales	41
5.10	Surface Roughness Setup	42
5.11	Close view of tip touch of roughness tester	43
5.12	Checking Surface roughness Value	43

LIST OF TABLES

TABLE NO.	TITLE	PAGE NO.
1.1	Classification of manufacturing process	2
1.2	Classification of Machining Process	3
1.3	Composition of D2 steel in %	7
4.1	Process Parameters	23
4.2	Process parameters and its range	23
4.3	Design of Experiment	24
5.1	Specifications of DX150 CNC Machine	26
5.2	Specification of Cermet insert	27
5.3	Size of workpiece	28
5.4	Analytical Calculations for cutting speed 100m/min and time interval 25min	29
5.5	Specification of MITUTOYO SJ/210	31
5.6	Material Removal Rate Calculations	37
5.7	Maximum Flank wear width observed	39
5.8	Logarithmic Values	41
5.9	Average Surface Roughness	45
6.1	Effects of input parameters on output parameters	46

NOMENCLATURE

MRR	Material Removal Rate
R_a	Surface Roughness
v	Cutting Speed
f	Feed Rate
ASTM	American Society for Testing and Materials
DOC	Depth of Cut

"Analysis of Tool Life, MRR and Surface Roughness during Turning of D2 Steel by Using Cermet Insert"

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ABSTRACT

The use of engineering materials has increased to a great extent in industries. So it is required to find the optimum parameters in order to have easy and economical machining. Turning operation is most important in the machining process. Especially of hard materials it is difficult sometimes to do so. For better results, the selection of proper process parameters is very important. This dissertation work presents, the effect of process parameters on various materials while performing turning operation and been validated by various methodology techniques. It also highlights on the effect of input controllable parameters over the required output values. According to ISO 3685 design of experiment was carried out. Tool life was calculated according to different cutting speed and machining time keeping feed rate and depth of cut constant. Optimum values were obtained and the effect of cutting speed on tool life was studied.

Keywords: Turning operations, Cermet, Tool life, MRR, Surface roughness, ISO 3685

CHAPTER 1

INTRODUCTION

1.1 Introduction to manufacturing process:

As we can see in the manufacturing process raw materials or semi-finished products is been converted into final finished product. It is basically the process of converting raw material into finish product. For these different types of tools, machines, equipment are used to produce the finished goods. It is the important steps in production process. It mainly focuses with the change of form of material or the dimensions being produced. When manufacturing process is carried out, there is a change in its physical properties of work material. In today's competitive market manufactured parts should be carried out at lowest possible cost having best possible quality and customer requirement.

The primary aim of manufacturing process is to produce a product that have a useful form. In the production process, manufacturing process is important. The steps like transportation, handling or storage are not the part of manufacturing process because they are not involved in the change of the shape or size of the workpiece by which required dimensional accuracy and surface finish is achieved.

Workpiece of various shapes and dimensions are being produced in the manufacturing industry. Manufacturing process is classified basically into two groups, the group of cutting and that of non-cutting.

1.2 Classification of manufacturing process:

In industry many of the materials are fabricated in the desired shape by any one of the following methods viz: casting, forming, machining and welding. The selection for a particular technique depends upon the different factors which may be include the shape and size of the component, required precision, material, cost and also on its availability. Sometimes one specific process can be used to achieve the desired object. However, more often it's possible to have choice between the processes available for making end product.

Among available options economy plays the important decisive role in making the final choice.

Table 1.1: Classification of manufacturing process [31]

Sr. No.	Based on function of process	Sub classification of manufacturing process
1.	Machining Process	Turning, drilling, milling, grinding, etc.
2.	Casting Process	Sand casting, Permanent mold casting, Die casting, Centrifugal casting
3.	Shearing and forming process	Punching, Blanking, Drawing, bending, forming
4.	Metal working process	Rolling, forging, extrusion, wire drawing, etc.
5.	Joining Process	Welding, brazing, soldering, joining
6.	Surface finishing process	Lapping, honing, super finishing

1) **Machining process:**

   With single or multiple cutting edges the excess material over a workpiece is removed in the form of chips by forcing a cutting tool into the workpiece.

2) **Casting process:**

   It is the one type of process in which a solid is been heated up to an appropriate temperature so that it gets dissolved into a liquid and it is been added to mould cavity.

3) **Shearing and forming process:**

   They are used for sheet metal work. Products manufactured by this process is pots and pans, door and window hardware, metal cabinets and automobile bodies.

4) **Metal working process:**

   It is the process in which the deformation of the material takes place due to the flow of material under the condition of strain rate and temperature.

5) **Joining process:**

This process defines as joining of two or more metals which are joint to each other or repair the broken parts. The joints made may be permanent like welding or may be temporary like soldering, riveting, soldering, etc.

6) **Surface finishing process:**

This processes are used to improve appearance or to manufacture smooth surface or to provide a protective coating.

1.3 Classification of machining process:

Machining process are classified into two main parts as shown in table below:

Table 1.2: Classification of machining process [31]

Conventional Machining	Non-Conventional Machining
Conventional machining processes are done by shearing action between workpiece and cutting tool by direct contact.	Non-conventional machining processes are carried out by abrasion, corrosion, melting of material in small amount without contact of work piece and cutting tool.
The conventional machining processes are listed below: • Turning • Drilling • Boring • Planning • Slotting • Milling	The non-conventional machining processes are listed below: • Ultrasonic machining • Abrasive jet machining • Water jet machining • Electro discharge machining • Laser beam machining • Plasma Arc Machining

There are various types of conventional machining processes used as of now a days. From which turning process is taken into consideration for the dissertation work.

1.4 Turning process:

In the operation of machine shop, CNC turning process are used to make cylindrical parts, where cutting tool is moved in a linear fashion while the work piece rotates. The rotation is performed basically using a lathe, in which turning process reduces diameter of workpiece, typically for specifying dimension and for producing a smooth surface finish. This process generally uses single point cutting tools. The material removed or the bits of waste metal while turning operations is known as chips (North America) or swarf (Britain).

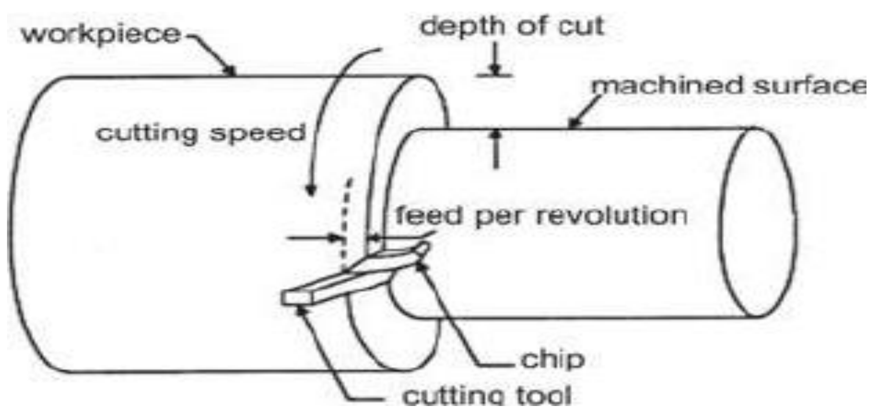


Figure 1.1: Schematic Representation of Turning Operations [31]

Turning process is widely used process. It is useful for basic change in form or dimensions being produced. It helps the product to get in required shape or for making surface smooth before any other process. This turning process was considered as important aspect in this dissertation work because of its importance in today's manufacturing arena.

1.5 Classification of Turning process:

The general process of turning process involves rotation of workpiece/part while a single point cutting tool is moved parallel to the axis of rotation. This process can be done on external surface of part as well as on the internal surface (process known as boring). The starting material is generally a workpiece generated by other processes such as extrusion, forging, casting or drawing.

Turning process specific operations include:

- **Tapered turning:**

  This operation produces a cylindrical shape that gradually show decrease in diameter from one end to the other.

- **Spherical Generation:**

  This operation generally produces a spherical finished surface by turning a form around a fixed axis of revolution.

- **Hard turning:**

  This process is intended to replace or limit traditional grinding operations. Hard turning when is applied for purely stock removal purposes, competes favorably with rough grinding. However, when it is being applied for finishing where dimension and form is critical, grinding is superior.

- **Facing:**

  Facing in the context of turning work involves moving the cutting tool at right angles to the axis of the rotation of the rotating workpiece. It can be performed by the operation of the cross slide, if one is fitted, as the distinct from the longitudinal feed (turning). It is basically the first operation performed in the production of the workpiece, and often the last hence the phrase "ending up".

- **Parting:**

  Parting also called as parting off or cutoff, is usually used to create deep grooves which will remove a part complete or completed component from its parent stock.

- **Grooving:**

  Grooving is like parting, except that grooves are cut to a specific depth of instead of serving a completed/part-complete component from the stock. It can be performed on external/internal surfaces, as well as on the face part (trepanning or face grooving).

1.6 Dynamics of turning:

- **Forces:**
  - The forces in turning operation is important in the design of machine tools.
  - The tools and components must be able to withstand these forces without causing significant vibrations, deflections or chatter during the operation. Mainly three principle forces in turning process.

- The cutting or tangential forces acts downwards on the tool tip allowing deflection of the workpiece upward. This force supplies the energy required for cutting operation. This force depends on the materials.
- The feed or axial force acts in the longitudinal direction. Its also called feed force because it acts in the direction of feed by the tool. It tends to push away the tool from the chuck.
- The radial or thrust force acts in the radial direction and tends to push the tool away from the workpiece.

➢ **Speed:**

Speed for turning is chosen purely based on work piece material, cutter material, setup rigidity, machine tool rigidity, and coolant choice and spindle power.

➢ **Feed:**

The distance, the tool advances into material in one revolution is called as "Feed". Unit of feed is mm per revolution (mm/rev).

1.7 Workpiece:

D2 steel development coincides with the part with the inventions of stainless steel as well as high speed steel. This steel is a part of tool steel category known as "High Carbon, High Chromium" steels.

1.7.1 Properties of D2 steel:

➢ D2 steel is an air hardening, high carbon, high chromium, tool steel.

➢ It has high wear and abrasion resistant properties. It is heat treatable and will offer a hardness in the range 55-62 HRC, and is machinable in the annealed conditions.

➢ D2 steel gives little distortion on correct hardening.

➢ D2 steels high chromium content gives it mild corrosion resisting properties in the hardened condition.

1.7.2 Chemical Composition of D2 steel:

According to standard specification for tool steel alloy chemical requirements of D2 steel in % are shown in table below:

Table 1.3: Composition of D2 steel in % [29]

Composition	% requirement
Carbon	1.40-1.60
Manganese	0.10-0.60
Phosphorous	0.030
Sulfur	0.030
Silicon	0.10-0.60
Chromium	11.00-13.00
Vanadium	0.50-1.10
Molybdenum	0.70-1.20

1.7.3 Application of D2 steel:

Typical applications for D2 steel are as follows:

- Stamping or Forming Dies
- Punches
- Forming Rolls
- Knives, slitters, shear blades
- Tools
- Scrap choppers
- Tyre shredders

1.8 Tool insert:

1.8.1 Introduction to Cermet Insert:

A cermet is a composite material made of ceramic (cer) and metal (met) materials. It is ideally designed to have optimal properties of both metal, such as the ability to undergo plastic deformation and that of ceramic, such as high temperature resistance and hardness. The metal is used as a binder for an oxide, carbide or boride. The metallic elements used are nickel, molybdenum, and cobalt. Depend on the physical structure of material, cermet can be metal matrix composites, but cermets are usually less than 20% metal by volume.

1.8.2 Applications of cermet insert:

- Cermets are used in machining on cutting tools.
- Cermets are used as ring material in high quality line guides for fishing rods.
- Cermets are used in dentistry as a material for fillings.

CHAPTER 2

LITERATURE SURVEY

This chapter includes the identification of problem and the objectives settled after referring to various research papers. Literature survey includes the basic idea of overall dissertation base idea that from where data is been collected and according to it is standardized value or not. According to literature we got information that the most affecting cutting parameters while turning operations are cutting peed, feed rate and depth of cut. The parameters range was selected according to standard ASM Specialty handbook: Tool materials. The various journals referred during this dissertation are as follows:

1. Journals of Materials Processing Technology: Elsevier.
2. Material & Design: Elsevier.
3. Materials and Manufacturing Process: Taylor & Francis.
4. Journal of Manufacturing Process & Alloys & compounds: Elsevier.
5. International J Advance Manufacturing Technology: Springer.
6. Standard Specification for tool steel Alloy: ASTM A681 international Standard, 2015.
7. ASM Specialty Handbook: Tool materials, 1995.
8. Standard STN ISO 3685: Tool life testing with single point cutting tools, 1993.

2.1 Problem Identification:

- The main aim of this research project has been to study the machinability on D2 steel with hard turning process.
- On referring more research paper it was noted that turning operation on D2 steel was not been reported by using cermet inserts. And it has been studied that improper parameters can lead to poor surface roughness quality.
- To maximize material removal rate with compromise in roughness up to an acceptable level in order to increase production rate. The selection of optimum

process parameters is very important with determining the values of these parameters.

- MRR and surface roughness are dependent on cutting parameters like speed, feed, and depth of cut.

2.2 Literature Review:

Tugul Ozel, Yigit Karpat, J. Paulo Davim [1] investigated that tool nose design has effect on surface finish and productivity in finish hard turning process. Experimental result indicated that surface roughness R_a values as low as 0.18-0.20 µm is achievable with wiper tools. Surface roughness and tool flank wear was carried out and was compared with a non-training experimental data.

J. Paulo Davim, Luı´s Figueira [2] mentioned that the hard turning is generally performed without a coolant.The results of the test showed that with a appropriate cutting parameters choice is possible to obtain a surface roughness that allows to elimite cylindrial grinding operations.

R. Ferreira, D. Carou, C. H. Lauro & J. P. Davim [3] investigated in the Hard Turning of Steel by using Ceramic Tools, Materials and Manufacturing Processes. The input parameters were considered as cutting speed, feed rate, and the type of tool. The experiment allowed recognition of the influence of feed rate and type of tool on the surface quality.

Wenbin Ji, Bin Zoua, Shuai Zhang et .al [4] evaluated the cutting performance of gradient cermet composite cutting inserts, effects of cutting speeds on the tool life and surface roughness was investigated during dry turning continuously. The developed cermet composite cutting inserts showed longer tool life and better machining quality than Ti cermet inserts under the same cutting conditions. Cutting speed plays a important effect on both tool life. It contributed to high surface hardness, good wear resistance of surface layer.

Sarmad Ali Khan, Muhmmad Umar et. al [5] to evaluate the effect of wiper inserts micro geometry for critical hardness regime of D2 steel material. Work piece hardness plays an important role for tool life whereas for surface roughness, and feed rate is found to be more dominant. At highest feed and depth of cut combination, material pull-out was revealed as the major microstructural damage.

N. López-Luiz, O. Jiménez Alemán et. al [6] stated that signal to noise ratios and the response surface methodology had been used to optimize maximum flank wear and surface roughness of cutting tool when turning a hardened steel AISI D2. And by employing regression models, cutting speed, cutting depth and feed rate, which optimized maximum flank wear and surface roughness, they concluded that the depth of cut was the main parameter that affected on the surface roughness, where the feed rate was the most influential parameter on the flank wear.

Ashok Kumar Sahoo, Bidyadhar Sahoo [7] it deals with a comparative study on flank wear, tool life and surface roughness in turning high carbon high chromium AISI D2 steel with coated and uncoated carbide inserts under dry cutting environment. And concluded that carbide tools is capable of reducing machining costs and performs better that uncoated carbide inserts in machining steel.

Bin Zou, Huijun Zhou et. al.; [8] developed $Ti(C_7N_3)$/WC/TaC cermet cutting tool using a hot pressed technology. A standard orthogonal array was considered to investigate the cutting performance of this newly developed insert in the high-speed turning of 17-4PH martensitic and 321 austenitic stainless steels. The effects of the cutting parameters on the tool life and surface quality were analysed to examine the performance of the inserts based on Taguchi method. The mechanisms of tool damage and machined-surface generation and their relationships were also thoroughly discussed to understand the machinability of different stainless steels. The considered cutting parameters are as follows: a cutting speed, feed and a depth of cut which is considered to be a notably efficient parameter for machining stainless steel. They experimented and found the longest tool life which exceeded 46 min and the best surface roughness of 0.58µm.

XU Kaitaio, Zou Bin et. al.; [9] studied the cutting performance of C-276 nickel based alloy machines by newly developed $Ti(C_7N_3)$ based cermet insert manufactured by hot-pressing method. Based on orthogonal experiment method, the influence of cutting parameters on tool life, MRR and surface roughness was investigated. Notch wear, flank wear, chipping at the tool nose, built-up edge (BUE) and micro-cracks are found when $Ti(C_7 N_3)$-based cermet insert turned Haste alloy C-276. They also concluded that Flank wear, chipping and cracking was the dominant tool failure modes when machining Haste alloy C-276 with $Ti(C_7 N_3)$-15(WC+TaC) cermet tools at the lower cutting speed. With increase in the cutting speed, the notch and catastrophic fracture of the edge occurred to decrease the tool life. The adhesion/attrition, abrasive, oxidation and diffusion were the main wear mechanisms of $Ti(C_7 N_3)$-based cermet tools.

Anshuman Das, Saroj Kumar Patel et. al.; [10] described the experimental and statistical analysis of flank wear, material removal rate, tool tip temperature, surface roughness parameters, chip morphology, chip thickness and dimensional deviations. For experimental design taguchi's L_{27} orthogonal array was elected whereas to study the significance of cutting parameters of the responses ANOVA was been used. For each response, mathematical model was been developed with regression analysis. The optimal combination of machining parameters has been obtained using neuro-genetic algorithm.

Anshuman Das, Nirmal Tirkey et. al.; [11] evaluated mist cooling and dry cutting effects on cutting force, chip morphology, flank wear, crater wear, surface roughness and micro hardness of chip during hard turning operation of EN-24 grade steel having hardness of 48 HRC. Water-soluble oil is applied for cooling and lubricating purposes in mist cooling, and a comprehensive comparative analysis was performed with dry machining environment. They concluded good surface finish in mist cooled turning as compared to dry turning.

Raman Kumar, Paramjit Singh Bilga et. al.; [12] optimized the active power consumed by the machine for rough and finish turning of EN 353 alloy steel. The Taguchi L_{27} orthogonal array was used for design of experiments and the effect of cutting speed, feed rate, depth of cut and nose radius along with their interactions has been studied. The multi-layer coated tungsten carbide inserts are used for rough turning operation and cermet inserts are used for finish turning operation. The regression models have been developed with RSM. The results also reveal that the machine tools for finish turning operation with lower nominal power motors can be used for batch/mass production. It can reduce the installation and operating cost of the new machine tools.

Prafulla B. Pawar, Uday A. Dabade; [13] investigated the experimental study related to the optimization of cutting parameters in turning of AISI D2 steel by coated carbide inserts using Response surface methodology (RSM). The relationship between cutting parameters i.e. cutting speed (m/min), feed (mm/rev) and depth of cut (mm) and the response parameter i.e. surface roughness (µm) is analyzed using the contour plots. The influence of each parameter is studied through ANOVA. Cutting speed and depth of cut are found to be significant parameters for surface roughness.

Murat Tolga Ozkan et. al.; [14] carried out experiment in which 50CrV4 (SAE 6150) steel was subjected to machining tests with coated carbide and cermet cutting tool in turning operation. They carried out tests at various cutting speeds, feed rates and cutting depths. In the light of these parameters, cutting forces were surface roughness values were determined. Components of cutting forces were measured during the tests using a dynamometer, while the machined surface-roughness values were determined using a surface roughness measuring unit. The relations between the cutting force and the surface-roughness values were also defined. The forces were higher when machining the softer steel.

T. Sreenivasa Murthy et. al.; [15] investigated the optimal setting of process parameters which influences the surface roughness during the machining operation of EN41B alloy steel with cermet tool. Experiments were carried out by using taguchi design. They said that the surface roughness is considered as quality characteristics while the process parameters considered are speed, feed and depth of cut. The results of the machining experiments was used to characterize the main factors affecting surface roughness by ANOVA. A regression model was developed for surface roughness. The developed model is reasonably accurate and can be used of prediction within limits.

M. Aruna and V. Dhanlakshmi; [16] carried out turning operation on Inconel 718, a nickel based super alloy using cermet inserts. This paper was concerned with the optimization of the surface roughness. The approach is based on Response surface method (RSM). They developed second-order quadratic models for surface roughness, considering the cutting speed, feed and depth of cut as the cutting parameters, using central composite design. The machining parameters were optimized and been validated experimentally, and it was observed that the response values are in reasonable agreement with the predicted values. They concluded that cutting speed has the strongest effect on the surface roughness among the selected parameters and it is inversely proportional to response. They also found out that the surface roughness could be controlled in the design stage which is the most effective and inexpensive way.

Anshuman Das, S. K. Patel et. al.; [17] compared the performances of coated carbide and coated cermet inserts for varied machinability aspects throughout the machining of hardened steel (AISI 4340, 48 HRC) in the dry cutting surroundings. Cutting speed, feed, and depth of cut were thought of as major governing parameters. Work piece surface temperature, machining forces, and tool flank wear were taken as measures to check the performance estimation of various cutting inserts during this work. ANOVA, regression analysis, and main effect plots were accomplished using the MINITAB-16 software. Flank wear of both carbides and cermets was mainly influenced by cutting speed and feed. The coating helps in improvement of the performance of the cermet inserts. And also concluded that tool wear, cutting force, and temperature are less when coated cermets are used instead of uncoated carbides.

Anshuman Das, Saroj Kumar Patel et. al.; [18] investigated machinability and estimated cost during the finish dry turning of AISI 4340 steel with untreated and cryo treated cermet inserts. The input variables were optimized using response surface methodology (RSM) to evaluate the tool life for the economic analysis. Machining with optimal input parameters reduced the cost effectively.

Aminollah Mohammadi et. al.; [19] investigated the effects of cutting speed, feed rate, hardness and cutting tool material on cutting region temperature and surface finish in hard turning process. A L36 Taguchi's standard orthogonal array was applied as experimental design. Machining tests were conducted under controlled conditions. AISI 4340 alloy steel which has numerous industrial applications was used to perform machining experiments. Main effects of the factors and their interactions are considered in this study using ANOVA (Analysis of variance) method. Also predictive models are derived by regression. Furthermore, optimal factor levels are obtained through S/N (signal to noise) ratio analysis in order to increase the machining efficiency. Workpiece hardness and other interactions do not exhibit significant effects on surface finish. They concluded that all factors and two-way interactions have significant effect on the cutting region temperature. Confirmation tests were conducted to verify the adequacy of predictive models. Optimal amount of factors were obtained through "signal to noise ratio (S/N) analysis. Plot of main effects showed that tool material and workpiece hardness dramatically influence the sensitivity of the system to noise in relationship to surface finish. Verification tests were conducted to confirm the validation of optimization process for surface roughness and cutting temperature.

R. Suresh, S. Basavarajappa et. al.; [20] investigated machinability on hardened AISI 4340 steel using coated carbide insert. An attempt has been made to analyze the influence of cutting speed, feed rate, depth of cut and machining time on machinability characteristics such as machining force, surface roughness and tool wear using response surface methodology(RSM) based second order mathematical models during turning of AISI 4340 high strength low alloy steel using coated carbide inserts. The experiments were planned as per full factorial design (FFD). The interaction plots suggest that employing lower cutting speed with lower feed rate can reduce tool wear. Chip morphology study indicates the formation of various types of chips operating under several cut-ting conditions. Analysis of variance has been carried out to check the adequacy of the proposed machinability models. They concluded that Based on the operating cutting conditions, various chips such as short broken irregular shaped, loose arc, continuous, long continuous tubular structured coiled and short saw toothed loose arc thick types are formed. The chip breaking is observed at high cutting speeds.

Ramanuj kumar, Ashok kumar Sahoo et. al.; [21] focused on investigation of flank wear, average roughness of surface and chip-tool interface temperature in the machine turning of heat treated AISI D2 grade tool steel using indexable multi-layer coated carbide inserts. Response surface methodology (RSM) based models and Artificial-Neural-Network (ANN) models are implemented for forecasting the responses in hard-turning. Comparative assessment between actual and predicted results has been carried. ANN model for flank wear generated more accurate results compare to RSM Model whereas for surface finish and chip-tool interface temperature, the accuracy of RSM based prediction is more precise compared to ANN. They concluded that RSM based empirical relations have been made for responses flank wear, surface roughness and chip-tool interface temperature.

E. Aslan; **[22]** carried out experimental investigation of cutting tool performance in high speed cutting of hardened X210 Cr12 cold-work tool steel. The study explored the performance and wear behavior of different cutting tools in end milling of X210 Cr12 cold-work tool steel hardened to 62 HRC. The purpose of the experiments reported in this paper is to investigate the wear of TiCN coated tungsten carbide, TiCN + TiAlN coated tungsten carbide, and TiAlN coated cermet, mixed ceramic with Al2O3+ TiCN and cubic boron nitride (CBN) tools. Tool performance evaluation was based on the surface finish and tool flank wear. The highest volume of metal removal was obtained with CBN tool. The best cutting performance was obtained with CBN tool. Ceramic tool was not as good as CBN.

Manu Garg Munish Kainth et. al.; **[23]** determined the optimum process parameters during turning of CNC lathe of EN8 and EN24 steels using taguchi method and ANOVA. Cemented carbide coated tool insert was used in the dry condition and the combination of the optimal levels of the parameters was obtained. In study MRR and machining time is also analyze by using Taguchi approach. In order to study the performance characteristics in turning operation the Signal-to-Noise ratio and Analysis of Variance (ANOVA) were employed.

H. Aouici, H. Bouchelaghem et. al.; **[24]** investigated machinability in hard turning of AISI D3 cold work steel with ceramic tool using response surface methodology. The effects of cutting speed, feed rate, and depth of cut on surface roughness, cutting force, specific cutting force, and power in the hard turning were experimentally investigated. Analysis of variance is used to check the validity of the model. Experimental observations show that higher cutting forces are required for machining harder work material. This cutting force gets affected mostly by feed rate followed by depth of cut. Feed rate is the most influencing factor on surface roughness. Optimum cutting conditions are determined using response surface methodology (RSM) and the desirability function approach. Verification experiments carried out show that the empirical models developed can be used for machining of AISID3 steel.

Ranganatih M. S., Vipin Harshit; [25] predicted surface roughness model for CNC turning of EN8 steel using response surface methodology. Manufacturing requires highly reliable models and methods for the prediction of output performance (surface roughness) in the machining process. The model was developed in the form of multiple regression equations correlating dependent parameter surface roughness, with cutting speed, feed rate and depth of cut, in a turning process. The box behnken design was used to plan the experiment.

A. V. N. L. Sharma, K. Venkatasuibbaiah et. al.; [26] discussed an investigation into the use of taguchi parameter design and regression analysis to predict and optimize the surface roughness and material removal rate in turning operation using CVD cutting tool. A set of experiments are conducted on the workpiece EN353 with CVD and PVD cutting tools to evaluate the effect of machining parameters such as speed, feed and depth of cut on surface roughness and material removal rate. Regression model is able to predict values for responses in comparison with experimental values within reasonable limits and Taguchi approach is used to obtain the optimal settings of these process parameters, finally ANOVA is used to analyze the influence of these cutting parameters during machining.

R. K. Suresh, P. Venkataramaiah et. al.; [27] experimentally investigated on turning of AISI 8620 alloy steel using PVD coated cemented carbide CNMG insert. The main focus of experimentation was to optimize the process parameters namely spindle speed, feed and depth of cut for desired response characteristics i.e. surface roughness, VMRR, and interface temperature. To study the performance characteristics orthogonal array, ANOVA and analysis of means (ANOM) were employed. The experiment was carried out on AISI 8620 alloy steel. Taguchi design is an effective way in finding optimal process parameters.

2.3 Literature Mapping:

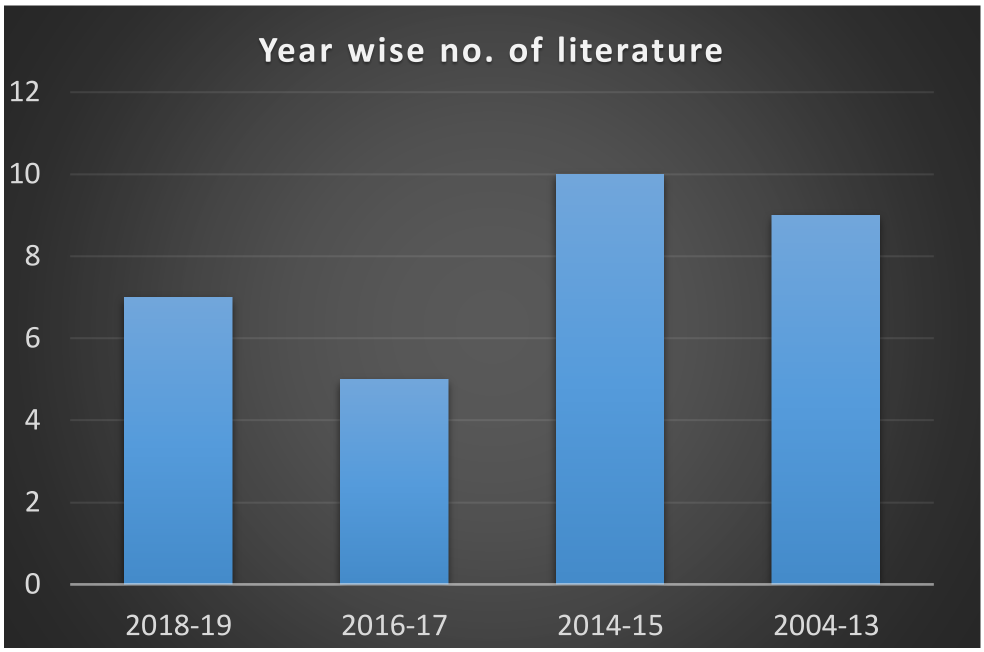


Figure 2.1: Year Wise No. of literature

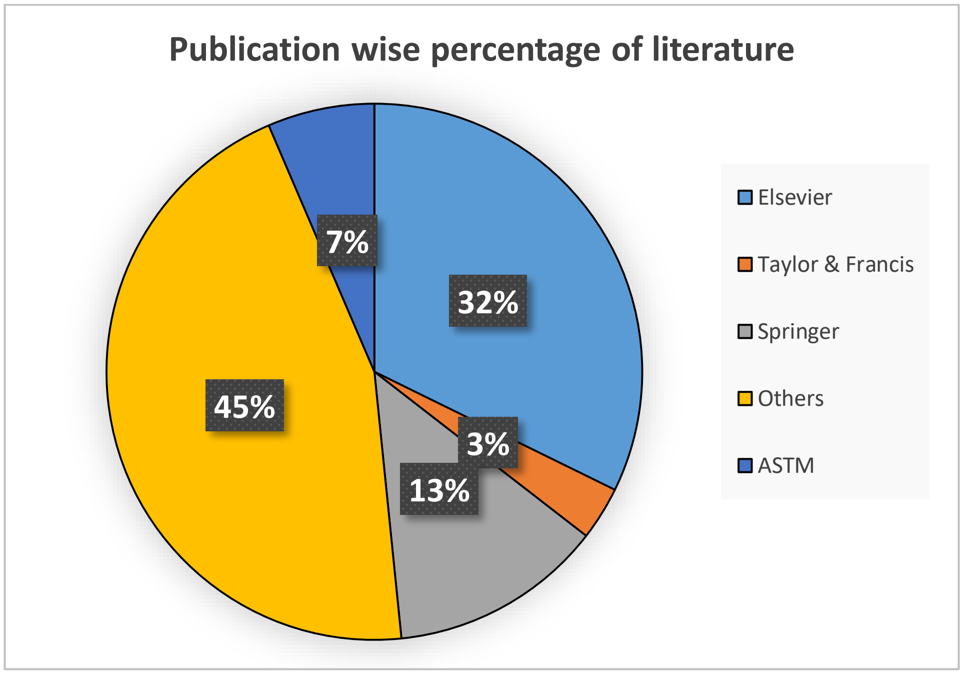


Figure 2.2: Publication Wise % of literature

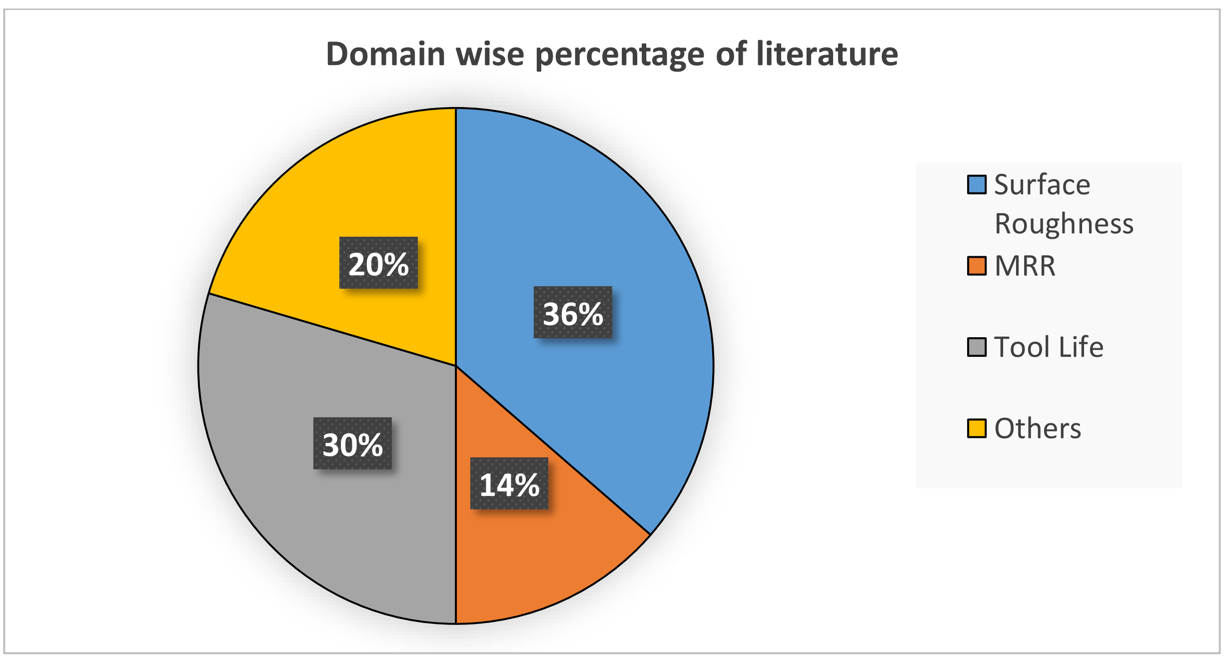


Figure 2.3: Domain Wise % of literature

2.4 Literature Summary:

From the above referred literature review, literature summary is described below:

- Turning operation is done on various types of materials like SS304, carbon steel, D2, D3, OHNS, H11, etc.
- With priority analysis most affecting parameters on Material Removal Rate (MRR), and surface roughness are cutting speed, feed rate, and depth of cut (DOC).
- Minimum surface roughness is obtained at low feed rate, high cutting speed and low depth of cut.
- The cutting speed has the most dominant effect on the tool life during machining.
- Machining with optimal input parameters reduced the cost effectively.
- Surface roughness is inversely proportional to depth of cut.

2.5 Objectives:

1) To identify the most affecting cutting parameters on surface roughness and material removal rate of turning operation of D2 steel while using cermet insert.
2) To identify process parameters which gives maximum tool life.
3) To investigate the tool life of cermet insert by turning operation on D2 steel.
4) To evaluate MRR and surface roughness value of cermet insert by turning on D2 steel.

CHAPTER 3

METHODOLOGY

The Showcased below are the step followed during the entire dissertation:

1. **Selection of proper work material and checking the feasibility of it during turning on it:**
   Before carrying out turning operation selection of proper workpiece is an important criteria that should be fulfill. Workpiece was selected on the basis of chemical requirements mentioned in Standard Specification for tool steel Alloy.
2. **Selection of input and output process parameters for getting easiness in manufacturing and reducing the cost of product:**
   Based on various literature papers referred we got idea about the most affecting input parameters over various output parameters.
3. **Selection of process parameters range:**
   After selection of process parameters its range is to be identified. According to ASM specialty handbook the cutting parameters range was identified accordingly.
4. **Create design of experiment for the checking of input parameters:**
   Based on input parameters and output parameters and the range selected for machining design of experiment is to be done. With the help of ISO 3685:1993 the design of experiment was carried out accordingly to the requirement.
5. **Creating programming for turning operation:**
   After all the parameters being set and after the design of experiment. Programming is to be done with necessary outcome results and appropriate programming is to be done for machining to carry out turning operation based on the input parameters selected.
6. **Perform the experiments respectively using the selected values of input parameters:**
   Next step after creating programming turning operation is to carry out machining over the selected values and for different time intervals. All the time intervals is been noted

to check it with analytical calculation carried out and to check for actual difference in time intervals.

7. **Testing for tool wear:**

   After turning operation is been finished and machining is been done. The corners of insert is been tested in optical microscope for finding out the width of flank wear generated due to machining over the surface of the insert.

8. **Checking for surface roughness value:**

   After tool wear is been calculated, its surface is to be checked and it was required as an output parameter. Surface roughness was measured using surface roughness tester SJ-210.

9. **Calculating material removal rate after machining:**

   This is the required output parameter which is to be calculated mathematically. Based on the mathematical formula available for calculating MRR, for every different set of parameters it is been calculated.

10. **Check for the optimum value satisfying material removal rate and surface roughness:**

    After getting all the output values based on calculations and testing facilities carried out. All the values are compared with each other to find the best suitable input parameter for getting required output value.

The figure 3.1 shows the flowchart of the entire work done during the entire dissertation project study respectively.

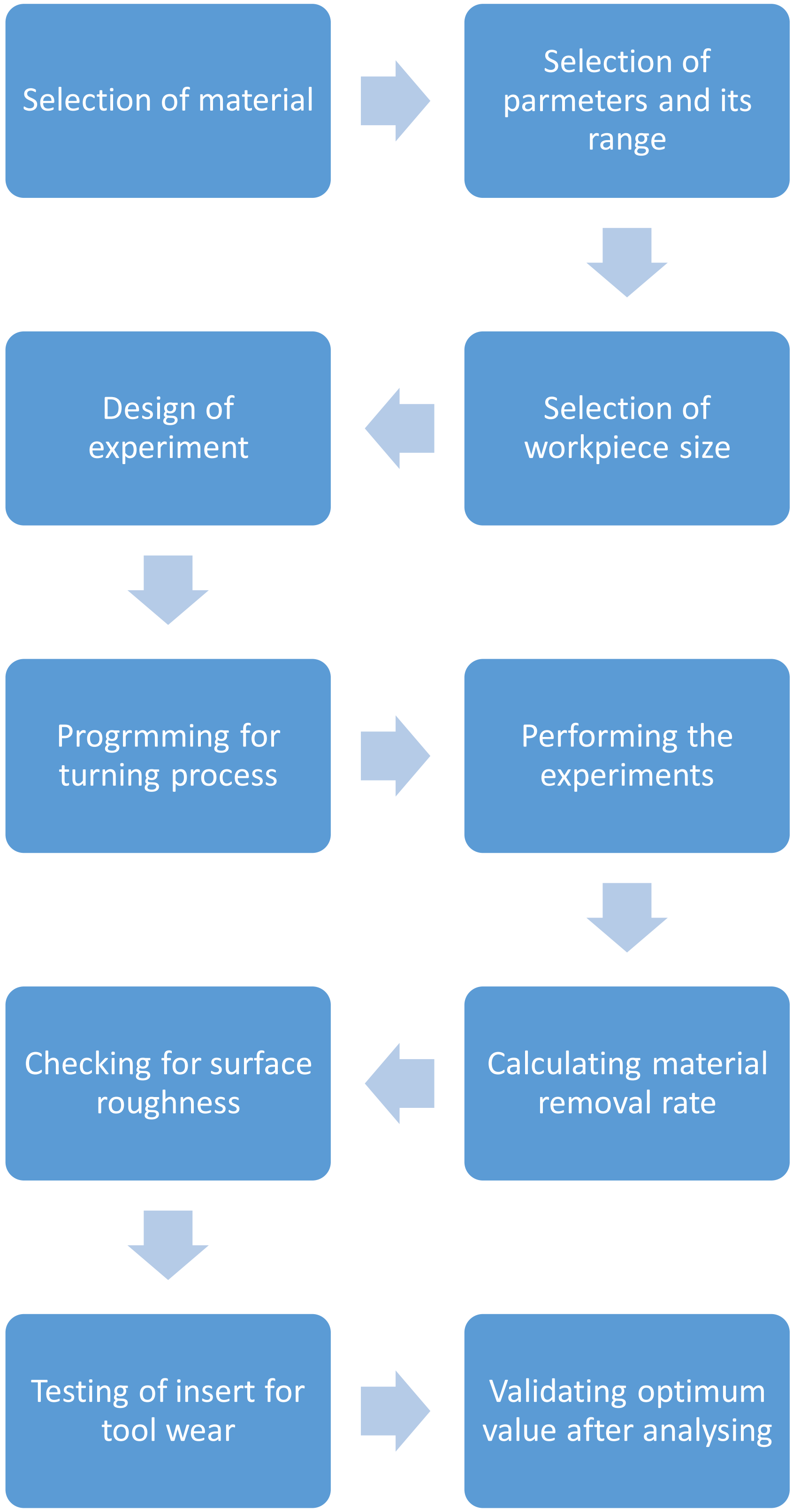


Figure 3.1 Flow chart of followed methodology

CHAPTER 4

DESIGN OF EXPERIMENT

After analyzing the literature and establishing the most dominant affecting parameter are shown in table below:

Table 4.1: Process Parameters

Input Parameters	Output Parameters
• Cutting Speed • Feed Rate • Machining time • Depth of cut	• Tool life • Surface roughness • Material Removal Rate

After selection of process parameters, range is to be identified for experimentation. Based on ASM Specialty handbook for tool material range of process parameters is selected.

Table 4.2: Process Parameters and its range [28]

Level Factors	Selected parameters	Range			
1.	Cutting Speed	100m/min	150m/min	200m/min	
2.	Feed Rate	0.2mm/rev			
3.	Depth of Cut	0.5mm max.			
4.	Machining Time	9min	15min	20min	25min

Based on range of parameter been selected design of experiment was carried out according to ISO3685:1993.

Experimental design is shown in table as follows:

Table 4.3: Design of experiment [26, 28]

Sr. No.	Cutting Speed (m/min)	Feed Rate (mm/rev)	Depth of cut (mm)	Machining time (min)
1.	100	0.2	0.5	25
2.	100	0.2	0.5	20
3.	100	0.2	0.5	15
4.	150	0.2	0.5	25
5.	150	0.2	0.5	20
6.	150	0.2	0.5	15
7.	200	0.2	0.5	25
8.	200	0.2	0.5	20
9.	200	0.2	0.5	9

CHAPTER 5

EXPERIMENTAL SETUP AND WORK

5.1 CNC Machine:

CNC machine is the automated control of machining tools. A CNC machine processes a piece of material to meet the required specifications by following a coded programmed instructions and without a manual operator. It is a motorized maneuverable tool and mostly a motorized maneuverable platform, which are controlled by computer, according to the specific input applied instructions.

Instructions are delivered to a CNC machine in the form of a sequential program of machine control instructions followed by G-code and M-code, and then it is executed. The program can be written by a person or far, mostly generated by graphical CAD software.

Experiment is to be conducted on DX 150 computerized numerical control machine. DX 150 is high performance machine suitable for varied application, with rigid headstock and spindle, hydraulic chucking, and with 90^{o} vertical unique structure.

Figure 5.1: DX 150 CNC M/c

- Specifications of DX150 CNC machine:

  The specification of DX150 CNC machine are shown below:

Table 5.1: Specifications of DX150 CNC machine

Description	Units	Values
Weight	Kg	3000
Dimension length	Mm	1950
Width	Mm	1375
Height	Mm	1950
Tailstock		
Quill diameter	Mm	75
Quill stroke	Mm	100
Thrust adjustable	Kgf	300
Turret		

No. of Station		8
Max. boring bar diameter	Mm	32
Tool size	Mm	20*20
Slides		
X axis travel	Mm	150
Z axis travel	Mm	350
Rapid feed rate (X&Z axis)	m/min	24
Main Spindle		
Spindle motor power	Kw	10.5/7
Spindle bore	Mm	50
Spindle nose		A2 5
Max bar capacity	Mm	38
Spindle speed range	Rpm	50-4500

5.2 Tool insert:

Insert used for performing the experiment is of Kyocera Company.

Specification of Cermet insert:

Table 5.2: Specification of cermet insert

Part Number	TNMG160408HQ
Material type	TN6020

- Part No specification:

  T – Triangle

  N - Relief angle 0 degree

  M - Corner height, thickness

  G – Hole (Yes), two sides

  16 – Edge length symbol

  04 – Thickness symbol

  08 – Corner symbol

HQ – Manufacturers option

Figure 5.2: Cermet insert

5.3 Selection of workpiece for turning:

Size of workpiece is selected that it should maintain L/D ratio as per ISO3685:1993 (As per ISO3685:1993 – The length/Diameter ratio greater than 10 is not recommended) Different sizes of workpiece material selected are as follows:

Table 5.3: Sizes of workpiece

Sr. No.	Cutting Speed (m/min)	Size of workpiece (Diameter X Length in mm)	Quantity (Nos.)
1.	100	50 x 250	1
2.	150	60 x 250	1
3.	200	60 x 250	1

5.4 Analytical Calculation for turning operation:

After workpiece material dimensions was selected. Calculations has to done according to given parameters for carrying out turning operations. Based on this analytic calculations was carried out to calculate rpm required while machining and to check for no. of pass it will occur while machining workpiece for over a time interval of 25min, 20min, 15min and 9min.

Based on the all the parameters considered analytical calculation for cutting speed 100m/min and for time internal 25min is as follows:

Table 5.4: Analytical Calculations for cutting Speed 100m/min and time interval 25min

Pass a	L b	Length c	Diameter d	Rpm e	Feed (mm/min) (f=0.2*e)	Time (g=b/f)	time (sec) (h=g*60)	Cumulative time
1	240	240	58.5	1088.239	217.6478	1.102699	66.16194	1.102699
2	240	480	58	1097.62	219.5241	1.093274	65.59645	2.195973
3	240	720	57.5	1107.165	221.433	1.083849	65.03097	3.279823
4	240	960	57	1116.877	223.3754	1.074425	64.46548	4.354247
5	240	1200	56.5	1126.761	225.3521	1.065	63.89999	5.419247
6	240	1440	56	1136.821	227.3642	1.055575	63.33451	6.474822
7	240	1680	55.5	1147.063	229.4125	1.04615	62.76902	7.520973
8	240	1920	55	1157.49	231.4981	1.036726	62.20353	8.557698
9	240	2160	54.5	1168.11	233.6219	1.027301	61.63805	9.584999
10	240	2400	54	1178.926	235.7851	1.017876	61.07256	10.60288
11	240	2640	53.5	1189.943	237.9887	1.008451	60.50707	11.61133
12	240	2880	53	1201.169	240.2339	0.999026	59.94159	12.61035
13	240	3120	52.5	1212.609	242.5218	0.989602	59.3761	13.59995
14	240	3360	52	1224.269	244.8538	0.980177	58.81061	14.58013
15	240	3600	51.5	1236.155	247.231	0.970752	58.24513	15.55088
16	240	3840	51	1248.274	249.6548	0.961327	57.67964	16.51221

17	240	4080	50.5	1260.633	252.1266	0.951903	57.11415	17.46411
18	240	4320	50	1273.24	254.6479	0.942478	56.54867	18.40659
19	240	4560	49.5	1286.101	257.2201	0.933053	55.98318	19.33964
20	240	4800	49	1299.224	259.8448	0.923628	55.41769	20.26327
21	240	5040	48.5	1312.618	262.5236	0.914203	54.85221	21.17748
22	240	5280	48	1326.291	265.2582	0.904779	54.28672	22.08225
23	240	5520	47.5	1340.252	268.0504	0.895354	53.72123	22.97761
24	240	5760	47	1354.51	270.902	0.885929	53.15575	23.86354
25	240	6000	46.5	1369.075	273.815	0.876504	52.59026	24.74004
26	240	6240	46	1383.956	276.7912	0.86708	52.02477	25.60712

As we can see from above table no of passes to achieve time interval of 25mins is 26 and it will require an rpm of 1385 for machining.

Similarly for different time interval and different cutting speed analytical calculations was carried out before experimentation.

5.5 Surface roughness tester:

Surface roughness tester was used for measurement of surface of workpiece after machining by MITUTOYO SJ-210 Company.

Surface roughness was carried out in host institute.

Figure 5.3 Surface roughness Tester [32]

Table 5.5: Specifications of Surface Roughness Tester

Specifications	
Model	**MITUTOYO SJ-210**
Measuring Motion	Start measuring from detector retracted state
Measuring Range	200 µm to 150 µm
Stylus Tip Radius	2 µm
Measuring Force	0.75 MN
Stylus Tip Material	Diamond

5.6 Experimental Setup:

Figure 5.4: Workpiece setup

5.7 CNC Program:

- Below shown programming is of a flat round D2 steel material bar which is being machined on CNC m/c having length of 240 mm and outer diameter of 48mm and is being machined for 25 minutes till inner diameter 41mm having cutting speed of 100 m/min and spindle speed having 1384 rpm.

- CNC program for experimental work having cutting speed 100m/min and time interval 25mins. Is as follows:
- N10 G90 G53 G64 G71 G95;
  N20 M03;
  N30 G96 S100 LIMS=1384 M03;
  N40 T1;
  N50 M16 D1;
  N60 M08;
  N70 G00 X50.5 Z2;
  N80 X48;
  N90 G01 Z-240 F0.2;
  N100 G00 X50 Z2;
  N110 X47.5;
  N120 G01 Z-240;
  N130 G00 X49.5 Z2;
  N140 X47;
  N150 G01 Z-240;
  N160 G00 X49 Z2;
  N170 X46.5;
  N180 G01 Z-240;
  N190 G00 X48.5 Z2;
  N200 X46;
  N210 G01 Z-240;
  N220 G00 X48 Z2;
  N230 X45.5;
  N240 G01 Z-240;
  N250 G00 X47.5 Z2;
  N260 X45;
  N270 G01 Z-240;
  N280 G00 X47 Z2;
  N290 X44.5;

```
N300 G01 Z-240;
N310 G00 X46.5 Z2;
N320 X44;
N330 G01 Z-240;
N340 G00 X46 Z2;
N350 X43.5;
N360 G01 Z-240;
N370 G00 X45.5 Z2;
N380 X43;
N390 G01 Z-240;
N400 G00 X45 Z2;
N410 X42.5;
N420 G01 Z-240;
N430 G00 X44.5 Z2;
N440 X42;
N450 G01 Z-240;
N460 G00 X44 Z2;
N470 X41.5;
N480 G01 Z-240;
N490 G00 X43.5 Z2;
N500 X41;
N510 G01 Z-240;
N520 G00 X43 Z2;
N530 X200 Z150;
N540 M05;
N550 M30;
```

- Experiments are performed with turning of D2 steel at 100m/min cutting speed, 0.2mm/rev feed rate and 0.5mm depth of cut.
- This experiment is repeated for every time intervals using different corners of cermet insert.

Figure 5.5: Turning Operation

5.8 Experimental procedure for different cutting speed:

- Every workpiece was reduced by 1.5mm for smooth surface and through rotation.
- For cutting speed 100 m/min:
    - Size of workpiece diameter 48.5mm X 250mm length.
    - Initially turning process is carried out for 25 min and upto 240 mm length.
    - Next operation is performed for 20 min and upto 220mm length.
- Now time is reduced to 15 min and upto 200mm length.
- For cutting speed 150 m/min:
    - Size of workpiece diameter 58.5mm X 250mm length.
    - Initially turning process is carried out for 25 min and upto 240 mm length.
    - Next operation is performed for 20 min and upto 220mm length.
- Now time is reduced to 15 min and upto 200mm length.
- For cutting speed 200 m/min:
    - Size of workpiece diameter 58.5mm X 250mm length.
    - Initially turning process is carried out for 25 min and upto 240 mm length.
    - Next operation is performed for 20 min and upto 220mm length.
    - Now time is reduced to 9 min and upto 200mm length.
- Figure 5.6 shown is of workpiece after machining.

- First round bar shows machining at 100m/min cutting speed, second of 150m/min cutting speed whereas third round bar indicates machining at 200m/min cutting speed.

Figure 5.6: Workpiece after Machining

5.9 Material Removal Rate:

MRR is the amount of material removed in the form of swarf (chips in North America) from the workpiece per unit of time.

MRR denotes the cutting speed of machining of workpiece.

High machining rate is always required because it is directly related to productivity.

Unit of Material removal rate is mm^3/min.

Mathematically MRR can be shown as,

$$MRR = vfd$$ [31]

Where, v = Cutting Speed

f = Feed Rate

d = Depth of Cut

Depth of Cut (d) is given by,

$$d = \frac{do - di}{2}$$

Where, d_o = Outer Diameter

d_i = Inner diameter

Here, considering process parameters selected for calculating MRR,

For e.g. consider cutting speed 100m/min, feed rate as 0.2mm whereas diameter before and after machining as 48.5 mm and 41 mm respectively.

MRR can be calculated as,

$$MRR = vfd$$

$$= 100 \text{ X } 0.2 \text{ X } (48.5\text{-}41)/2$$

$$= \mathbf{75 \text{ X } 10^3 \ mm^3/min} \qquad [1m= 1000mm]$$

Based on above calculation, MRR can be calculated for every process parameters selected

We calculated MRR for all the dimensions listed in table 5.6.

Table 5.6: Material Removal Rate Calculations

Machining Time	Cutting Speed, v (m/min)	Feed Rate, f (mm/rev)	Outer Diameter, d_o (mm)	Inner diameter, d_i (mm)	Depth of cut, $d=(d_o-d_i)/2$ (mm)	MRR (mm^3/min)
25 min	100	0.2	48.5	41	3.75	$75X10^3$
20 min	100	0.2	41	33	4	$80X10^3$
15 min	100	0.2	33	24.5	4.25	$85X10^3$
25 min	150	0.2	58.5	49	4.75	$142.5X10^3$
20 min	150	0.2	49	39	5	$150X10^3$
15 min	150	0.2	39	28	5.5	$165X10^3$
25 min	200	0.2	58	46.5	5.75	$230X10^3$
20 min	200	0.2	46.5	31.5	7.5	$300X10^3$
9 min	200	0.2	31.5	20	5.75	$230X10^3$

As we can see from above table that MRR continuously increases with increase in cutting speed.

Also Maximum MRR for different speed is attained at cutting speed of 200 m/min for every time interval.

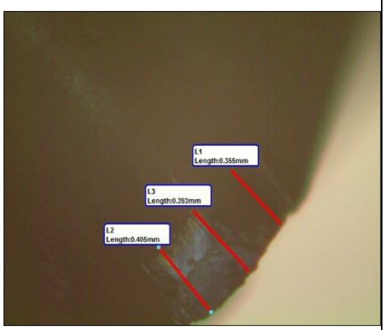
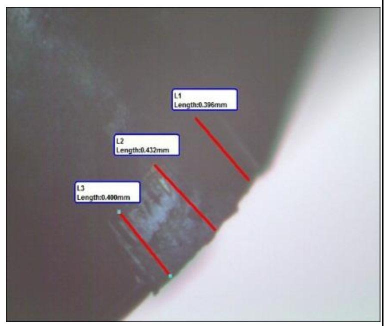
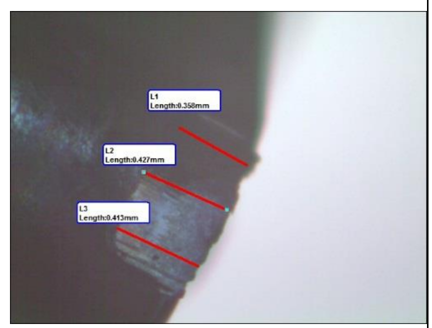
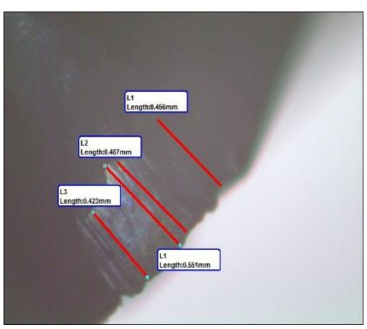
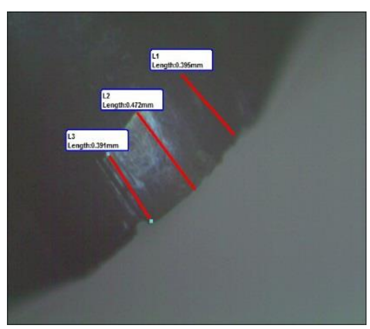
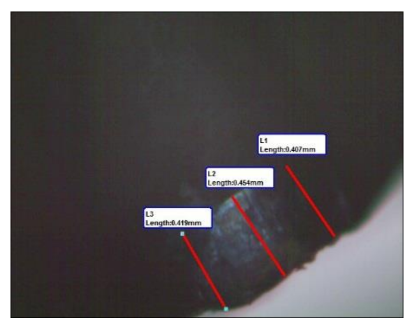
5.10 Tool life:

For analyzing tool life, tool wear has to be found out by using testing instrument.

Tool wear was captured by using optical microscope available in testing laboratory. They had lenses ranging from 5x to 1000x.

According to ISO 3685:1993 for calculating tool life graph of flank wear (V_b) is to be plotted against machining time as shown in figure 5.7.

Flank wear of different cutting speed at different machining time is shown in figure 5.7.

<table>
<tr><td colspan="3">Cutting Speed = 100m/min</td></tr>
<tr>
<td>Wear at 25min

</td>
<td>Wear at 20min

</td>
<td>Wear at 15min

</td>
</tr>
<tr><td colspan="3">Cutting Speed = 150m/min</td></tr>
<tr>
<td>Wear at 25min

</td>
<td>Wear at 20min

</td>
<td>Wear at 15min

</td>
</tr>
<tr><td></td><td>Cutting Speed 200m/min</td><td></td></tr>
</table>

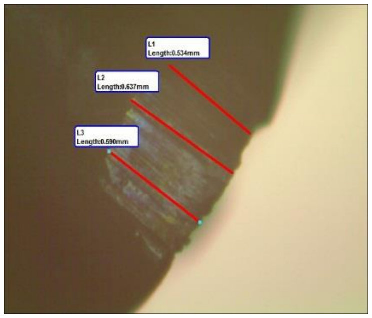
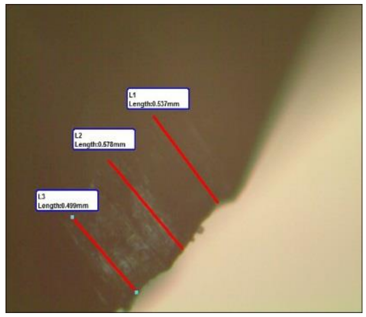
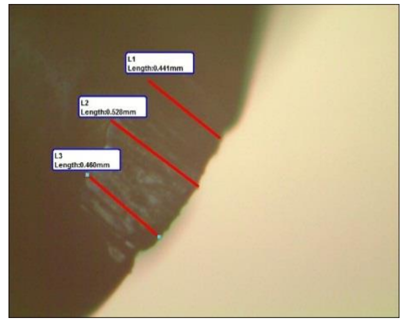
Wear at 25 min	Wear at 20 min	Wear at 9 min
		

Figure 5.7: Flank Wear at Different Cutting Speed

As captured with the help of optical microscope, tool distant points were taken one at the edge and other till the wear occurred over insert.

Three to four different wear length was marked to calculate the maximum flank wear occurred.

Maximum flank wear occurred over different insert is shown in table below:

Table 5.7: Maximum Flank wear width observed

Sr. No.	Cutting Speed (m/min)	Machining Time (min)	Flank Wear V_b (mm)
1.	100	25	0.445
2.		20	0.432
3.		15	0.427
4.	150	25	0.551
5.		20	0.472
6.		15	0.454

7.	200	25	0.637
8.		20	0.578
9.		9	0.460

According to ISO 3685:1993 graph of width of flank wear with respect to machining time was plotted as shown in figure below:

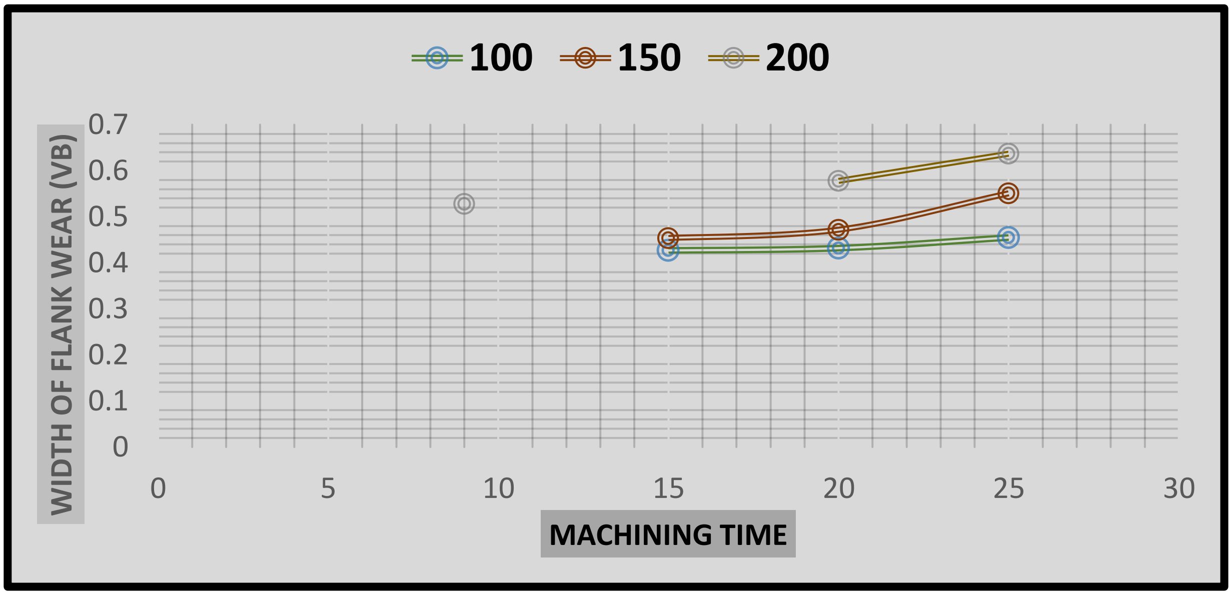


Figure 5.8: Flank Wear Vs Machining Time

- Tool life criterion for cermet insert is 0.6.
- So, the line which crosses or touches the 0.6 criterion point gives us the tool life for this insert.
- As we see from figure that 200m/min touches the criterion point at 22.5 minutes.
- Whereas, if we go increasing the machining time for cutting speed 100m/min as well as for 150m/min it will touch the criterion point.
- As on extending line it touches the criterion line at 53.5 min and 26 min respectively.
- According to Taylor's tool life equation $VT^n = C$, to find the values of constant "n" and constant "C" logarithmic chart is to be plotted to calculate values of n and C.

- As we calculated tool life for cermet insert and we also had different cutting speed, logarithmic values of it are taken to plot values in chart as shown in figure 5.9.
- Table below shows the calculated logarithmic values of cutting speed and tool life.

Table 5.8: Logarithmic Values

Cutting Speed (v)	Tool life (T)	Log(v)	Log(T)
100	53.5	2	1.7284
150	26	2.1761	1.415
200	22.5	2.301	1.3522

- Based on logarithmic values of cutting speed and tool life, logarithmic scale chart is been plotted according to ISO3685:1993

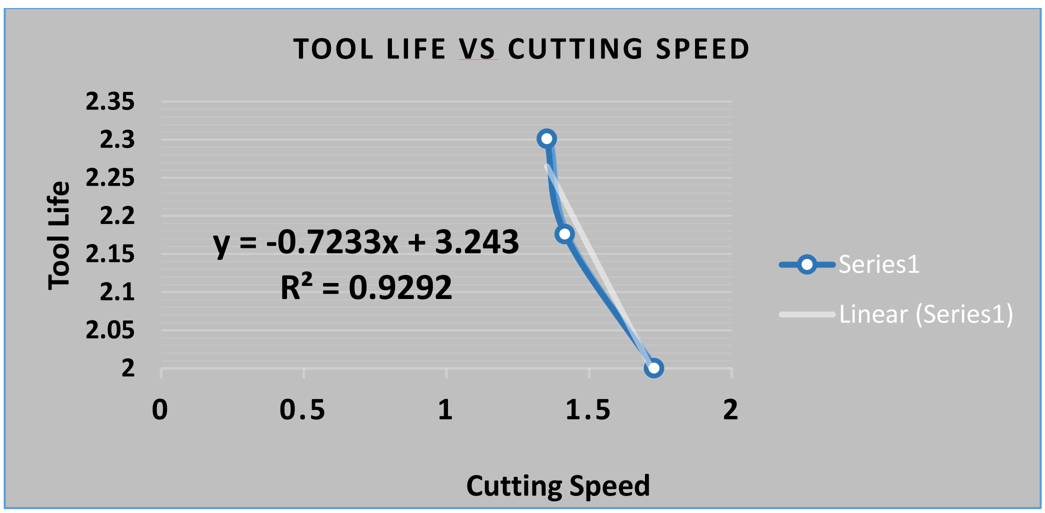


Figure 5.9: Logarithmic scales (Tool life vs Cutting Speed)

- As we can see from figure 5.9 slope of line denotes the value of constant “n” whereas the value of constant “C” is given by the point at which it touches Y axis.
- We can conclude from figure 5.9 that values of constant “n” and “C” are 0.723 and 1749.85 respectively.

5.11 Surface Roughness:

- Surface roughness is usually referred to as roughness, and is also a component of surface texture.
- Surface roughness can be quantified by the direction of the normal vector of real surface from its original ideal form.
- If the deviations are small, then we can say that the surface is smooth, whereas if the deviations are high then we can say that the surface is rough.
- Surface roughness plays major role in prediction of how a real object will interact with its surrounding environment.
- Roughness is always a good predictor of performance of mechanical component.
- High roughness value is always undesirable because it may be costly to control surface roughness from manufactured parts.
- Decreasing the surface roughness, usually increases manufacturing cost.
- Surface roughness was measured using instrument Surface roughness tester of Mitutoyo company model SJ 210.
- Surface roughness tester setup is shown in figure 5.10

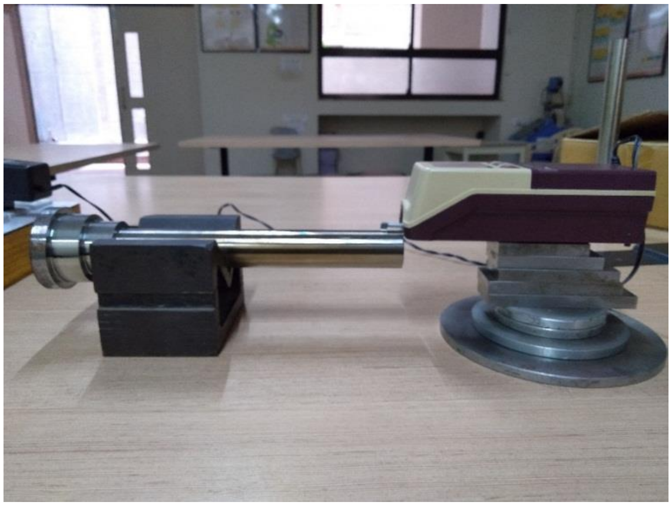


Figure 5.10: Surface roughness Setup

- Below shown figure was captured with close view of tip touch to the workpiece.

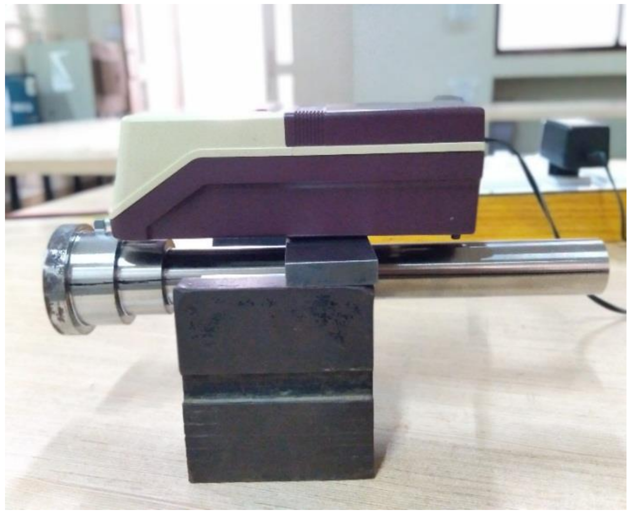


Figure 5.11: Close view of tip touch of roughness tester

- Figure was captured while taking noting down and taking readings from surface roughness tester while measuring surface roughness.

Figure 5.12: Checking and noticing Surface roughness value

- Below shown table are the results obtained while measuring surface roughness using roughness tester:

Table 5.9: Average Surface Roughness

Cutting Speed = 100 m/min	
15 min	2.1225 μm
20 min	2.835 μm
25 min	3.1525 μm
Cutting Speed = 150 m/min	
15 min	1.98 μm
20 min	2.4775 μm
25 min	3.04 μm
Cutting Speed = 200 m/min	
9 min	1.6925 μm
20 min	3.875 μm
25 min	2.315 μm

- As we can see from above table that average surface roughness value we obtained for cutting speed 100m/min and for machining time intervals 15min, 20min and 25min are 2.1225 μm, 2.835 μm and 3.1525 μm respectively.
- For cutting speed 150m/min average surface roughness value we obtained for machining time intervals 15min, 20min and 25min is 1.98 μm, 2.4775 μm and 3.04 μm respectively.

- At last for cutting speed 200m/min average surface roughness value we obtained for machining time intervals of 9min, 20min and 25min is 1.6925 μm, 3.875 μm and 2.315 μm respectively.

CHAPTER 6

RESULTS AND DISCUSSION

- All the output parameters was calculated as shown in chapter 5.
- Below shown table 6.1 shows the effect of input parameters over output parameters.

Table 6.1: Effects of input parameters over output Parameters

Cutting speed (m/min)	Feed (mm/rev)	Depth of cut (mm)	Machining time (min)	Tool life (minutes)	Average Surface Roughness (µm)	MRR (mm^3/min)
100	0.2	0.5	25	53.5	3.1525	$75X10^3$
	0.2	0.5	20		2.835	$80X10^3$
	0.2	0.5	15		2.1225	$85X10^3$
150	**0.2**	**0.5**	**25**	**26min**	**3.04**	**$142.5X10^3$**
	0.2	**0.5**	**20**		**2.4775**	**$150X10^3$**
	0.2	**0.5**	**15**		**1.98**	**$165X10^3$**
200	0.2	0.5	25	22.5min	2.315	$230X10^3$
	0.2	0.5	20		3.875	$300X10^3$
	0.2	0.5	9		1.6925	$230X10^3$

- As we calculated tool wear on results we can say tool life at considered cutting speed.
- Tool life obtained for cutting speed 100m/min, 150m/min, 200m/min is 53.5min, 26min and 22.5min respectively.

- According to Taylor life equation we obtained value for n and C as 0.723 and 1749.85 respectively.
- As we can notice from obtained results that optimum value for good surface finish is obtained at cutting speed 150m/min.
- Obtained surface roughness value for different machining time is for 25 min, 20 min, and 15 min is 3.04µm, 2.475µm, 1.98µm respectively.
- MRR continuously increases wit increase in cutting speed and we can indicate that MRR is directly proportional to cutting speed. Higher the cutting speed, higher is the MRR, and vice versa.
- Good surface requirement is majorly concerned in now a day's arena. We observe hat optimum surface finish is obtained at cutting speed 150m/min, followed by MRR142.5X10^3, 150X10^3 & 165X10^3, respectively for machining time having surface finish of 3.04µm, 2.475µm, and 1.98µm.

CHAPTER 7

CONCLUSION AND FUTURE SCOPE

7.1 Conclusions:

- From the above dissertation work we can concluded some that suggestions were given to the industry about the selection of input parameters range for doing the analyzation of tool life. The following conclusions can be made listed below:
- The most affecting parameter or we can say the influence parameters while turning operation which has been used in manufacturing department are cutting speed (v) which affects tool life.
- All the project work is carried out according to ISO 3685:1993, Standard specifications of tool steel alloy and ASM specialty handbook for tool materials.
- With the help of ISO 3685:1993 tool life was calculated and been validated by optical microscope.
- Tool life obtained for various cutting speed is 53.5min, 26min and 22.5min respectively
- Obtained surface roughness value for different machining time is for 25 min, 20 min, and 15 min is 3.04µm, 2.475µm, 1.98µm respectively.
- MRR continuously increases with increase in cutting speed and we can indicate that MRR is directly proportional to cutting speed. Higher the cutting speed, higher is the MRR, and vice versa.
- Good surface requirement is majorly concerned in now a day’s arena. We observe hat optimum surface finish is obtained at cutting speed 150m/min, followed by MRR142.5X10^3, 150X10^3 & 165X10^3, respectively for machining time having surface finish of 3.04µm, 2.475µm, and 1.98µm.

- We can conclude at cutting speed 100m/min MRR and surface finish can be achieved and their values also can be recommended for usage.

7.2 Future Scope:

- Various inserts like CBN, ceramic, etc. can be used.
- Input parameters like temperature, cutting force, tool nose radius can be considered for machining.
- Tool life of different insert can be compared with each other while turning operation of workpiece material.
- Coated cermet can be compared for validation of tool life with uncoated cermet.
- Instead of machining under dry conditions, coolant can be used.

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Appendix A: Review Card

ATMIYA UNIVERSITY
FACULTY OF ENGINEERING & TECHNOLOGY

ATMIYA UNIVERSITY
सुहृदं सर्वभूतानाम्

Master of Technology

(Dissertation Review Card)

Name of Student : Daji Amit N

Enrollment No. : | 1 | 8 | 0 | 0 | 4 | 4 | 0 | 0 | 1. |

Student's Mail ID:- amitdarji362@gmail.com

Student's Contact No. : 8347479427.

College Name : Atmiya University, Rajkot

College Code :

Branch Name : M.TECH Mechanical (Production)

Theme of Title :

Title of Thesis : "Analysis of tool life, MRR, & Surface Roughness during turning of D2 Steel by using CERMET insert"

Supervisor's Detail	Co-supervisor's Detail
Name : Keyur. V. Parmar.	Name :
Institute : FOET	Institute :
Institute Code :	Institute Code :
Mail Id : kvparmar@aits.edu.in	Mail Id :
Mobile No. : 9909915700.	Mobile No. :

~ 1 ~

❖ **Comments For Internal Review ( )** **(Semester 3)**

Exam Date : 25/09/'19

Sr. No.	Comments given by Internal review panel (Please write specific comments)	Modification done based on Comments
1.	Study fandamentals of CNC turning process.	done
2.	Exhaustive literature review is needed.	Doing it in regular interval.
3.	Refer standard Journals and Data book for process parameters and material properties.	ASTM and ASM standards used for his study.
		(Guide Sign.)

Particulars	Internal Review Panel	
	Expert 1	Expert 2
Name :	Shivang . S. Jani	Pratik . P. Kikani
Institute :	FOET	FOET.
Institute Code :	–	–
Mobile No. :	8000322128	9879858594
Sign :		

Particulars	Internal Guide Details	
	Expert 1	Expert 2
Name :	Keyur. V. Parmar.	
Institute :	FOET.	
Institute Code :		
Mobile No. :	9909915700.	
Sign :		

~ 2 ~

Enrollment No. of Student : 1 8 0 0 4 4 0 0 1

❖ **Comments of Dissertation Phase-1 (** 18MMEPdC305 **(Semester 3)**

Exam Date : 12 / 10/ '19

Title : "Analysis of tool life, MRR & Surface Roughness during turning of D2 steel by using CERMET insert"

1. Appropriateness of title with proposal. (Yes/ No) Yes
2. Whether the selected theme is appropriate according to the title ? (Yes / No) Yes
3. Justify rational of proposed research. (Yes/ No) Yes
4. Clarity of objectives. (Yes/ No) Yes.

~3~

Enrollment No. of Student : 1 8 0 0 4 4 0 0 1

Exam Date : 12/10/19

Sr. No.	Comments given by External Examiners (DP-I) : (Please write specific comments)	Modification done based on Comments
–	To Identify the research parameters as per standard experiment	Research parameters Identified.
–	Literature review is to be ~~reviewed~~ improve.	– done.

5/3/20.

(Internal Guide Sign.)

- *Approved* ☐
- *Approved with suggested recommended changes* ☑
- *Not Approved* ☐

Please tick on any on.

If approved/approved with suggession then put marks ≥ 50 %.

➢ ***Details of External Examiners :***

Particulars	*Full Name*	*University / College Name & Code*	*Mobile No.*	*Sign.*
Expert 1	Hitesh Virani	SLTIET (089)	8866740201	
Expert 2				

~ 4 ~

Enrollment No. of Student : 1 8 0 0 4 4 0 0 1

❖ **Comments of Mid Sem Review (**18MMEPCC401 **(Semester 4)**

Exam Date : 07/03/2020 .

Sr. No.	**Comments given by External Examiners :** i) The appropriateness of the major highlights of work done; State here itself if work can be approved with some additional changes. ii) Main reasons for approving the work. iii) Main reasons if work is not approved.	**Modification done based on Comments**
	- Experiment work is pending	- done -
	- Results are to be derived.	
	-	
		Internal Guide Sign.

- *Approved* ☐
- *Approved with suggested recommended changes* ☑
- *Not Approved* ☐

Please tick on any on. If approved/approved with suggession then put marks ≥ 50 %.

➢ ***Details of External Examiners :***

Particulars	*Full Name*	*University / College Name & Code*	*Mobile No.*	*Sign.*
Expert 1	Hitesh Viranni	SLTIET (089)	8866740201	
Expert 2				

~ 5 ~

Enrollment No. of Student : 1 8 0 0 4 4 0 0 1

❖ Comments of DP-II Review (18MMEPCC)403 (Semester 4)

Exam Date : 07/07/2020.

Sr. No.	**Comments given by External Examiners :** i) Main reasons for approving the work. ii) Main reasons if work is not approved.	Modification done based on Comments
	Work is Satisfactory	

- Approved ✓
- Not Approved

Please tick on any one.

If approved then put marks ≥ 50 %.

➢ ***Details of External Examiners :***

Particulars	*Full Name*	*University / College Name & Code*	*Mobile No.*	*Sign.*
Expert 1	Hitesh Virani	SLTIET (089)	8866740201	
Expert 2				

~ 6 ~

Appendix B: Compliance Report

Comments given during Dissertation Phase-1 and Mid-Semester Review are given below with required actions taken for their fulfilment:

- **Comments for Dissertation Phase-1:**

Sr. No.	Comments Given	Actions
1	To identify the research parameters as per standard experiment	Research parameter identified.
2	Literature Review is to be improve	Done

- **Comments for Mid-Semester Review:**

Sr. No.	Comments Given	Actions
1	Experiment work is pending	Done
2	Results are to be derived	Done

Appendix C: Paper Publication

STM JOURNALS

Consortium e-Learning Network

Scientific • Technical • Medical

ACCEPTANCE LETTER

Dear Amit Darji,

Greetings from STM Journals!!!

We feel glad to inform you that your manuscript entitled **"Evaluation of process paramters of various materials by turning operation using different methodology techniques-A review"** has been accepted for publication in the **"Trends in Mechanical Engineering & Technology", ISSN: 2231-1793, Volume 10 Issue 3, 2020.**

Have A Great Future Ahead.

Thanking you with best regards

Archana Mehrotra

Dr. Archana Mehrotra
Director
Publication Management Team –
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Appendix D: Standard

INTERNATIONAL STANDARD

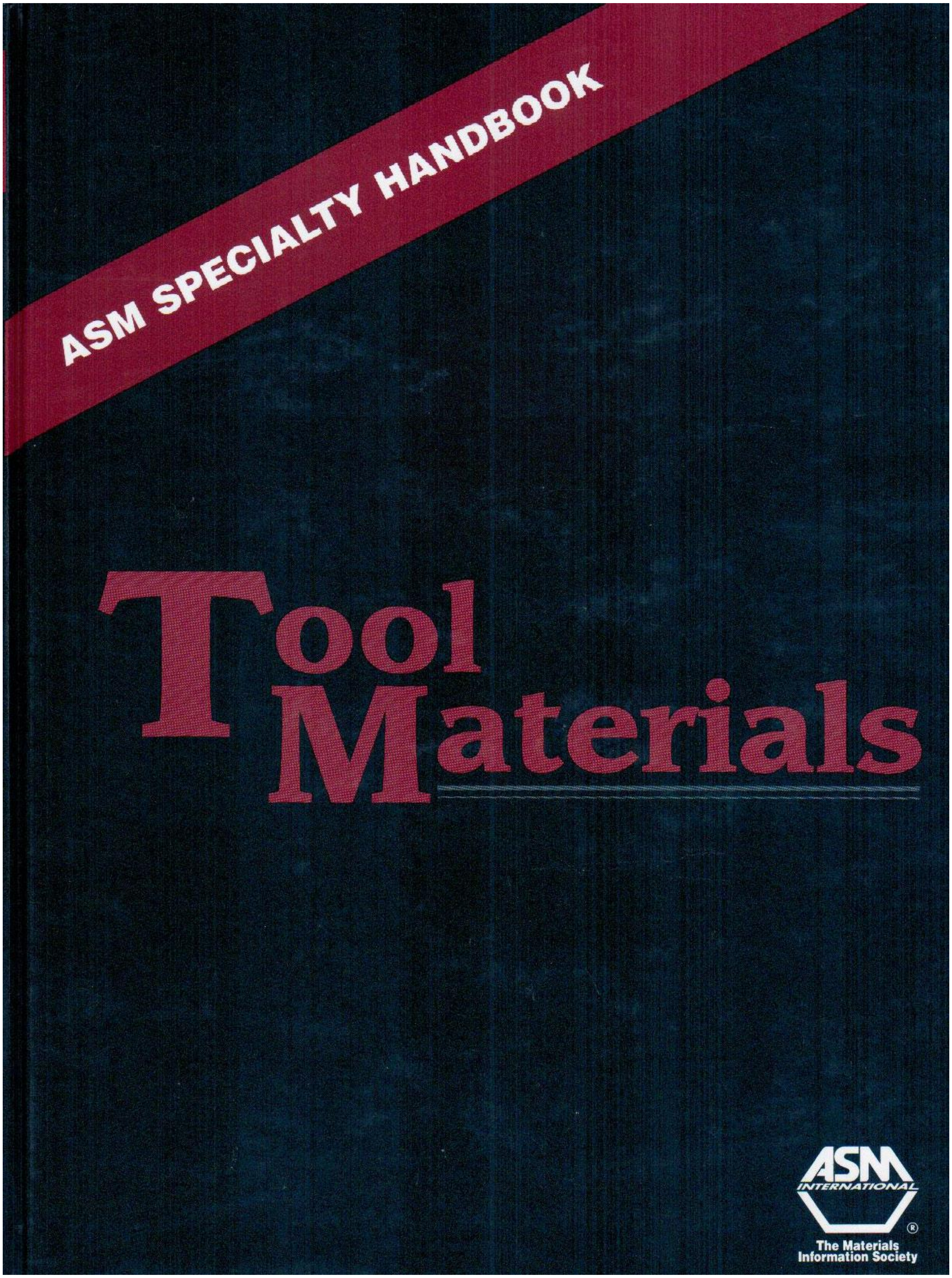
ISO 3685

Second edition
1993-11-15

Tool-life testing with single-point turning tools

Essais de durée de vie des outils de tournage à partie active unique

Reference number
ISO 3685:1993(E)


ASM SPECIALTY HANDBOOK
Tool Materials
ASM INTERNATIONAL
The Materials Information Society

Appendix E: Standard Result

NABL Accredited
Approved by Govt. of India Dept. of Science & Technology for Mechanical & Chemical Testing
TC-5212

RAJKOT METLAB SERVICES
METALLURGICAL TESTING LABORATORY
Testing Today, Protecting Tomorrow

National Highway - 27, Opp. Tulip Party Plot, Near JCB Showroom, Rajkot - 360022. Call : +91 - 97252 13600, E~mail : testing@rajkotlab.com, Web. : www.rajkotlab.com

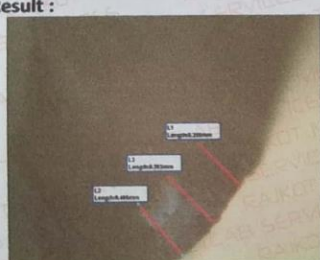
TEST REPORT

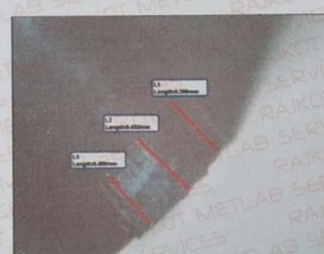
Customer Name : Darji Amit N.
Address : Near, Kalavad Rd, Yogidham, Gurukul, Rajkot- Gujarat India

ULR - TC521220000010775F
Report No : LMF-0876.1
Date of Reporting : 27/06/2020
Sample Received Date : 27/06/2020

Type of Test : Coating Thickness by Microscopic Examination
*Customer's Reference : Nil
*Condition of sample : Test Piece
*Identification of sample : Insert wear-100
*Material Specification : --
Date of Testing : 27/06/2020
Instrument Utilized : Optical Microscope Model: NIM-1000X
Test Method : ASTM B487-85(RA2013)

Result :


100-1


100-2


100-3

Result (mm)		100-1	100-2	100-3
1	:	0.355	0.396	0.358
2	:	0.393	0.432	0.427
3	:	0.405	0.4	0.413
Avg.	:	0.384	0.409	0.399

Remarks: --

Vishal
Tested By

Authorized Signature
Ankur (QM)

Witnessed By

Terms & Conditions :
1) The results relate only to the sample tested, Sample(s) drawn by party.
2) Test certificate shall not be re-produced except in full without the written approval of Laboratory.
3) RMS has made their best endeavors to provide accurate and reliable information, RMS is not responsible for any financial liability due to any act of omission or error made.
4) samples are preserved for 15 days, any ambiguity in test results should be brought forward to the lab mgt within this period.
* Information Provided by Customer

FMT-RPT-006 *** END OF REPORT *** Page 1 of 1

Appendix E: Standard Result

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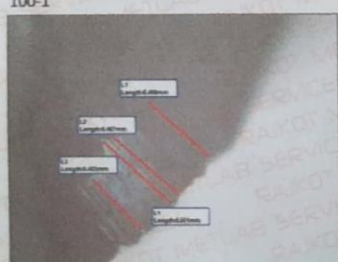
TEST REPORT

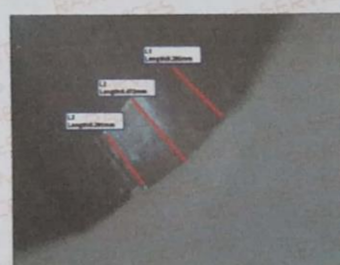
Customer Name : Darji Amit N.	ULR - TC521220000010776F
Address : Near, Kalavad Rd, Yogidham, Gurukul, Rajkot- Gujarat India	Report No : LMF-0877.1
	Date of Reporting : 27/06/2020
	Sample Received Date : 27/06/2020

Type of Test : Coating Thickness by Microscopic Examination
*Customer's Reference : Nil
*Condition of sample : Test Piece
*Identification of sample : Insert wear-150
*Material Specification : –
Date of Testing : 27/06/2020
Instrument Utilized : Optical Microscope Model: NIM-1000X
Test Method : ASTM B487-85(RA2013)

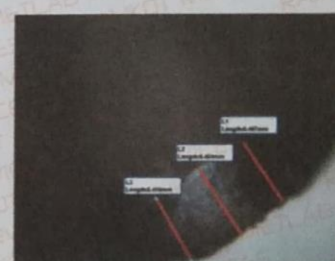
Result :
100-1



150-1



150-2



150-3

Result (mm)		150-1	150-2	150-3
1	:	0.551	0.395	0.407
2	:	0.487	0.472	0.454
3	:	0.423	0.391	0.419
Avg.	:	0.487	0.419	0.427

Remarks: --

RAJKOT METLAB SERVICES

Vishal
Tested By

Authorized Signature
Ankur (QM)

Witnessed By

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3) RMS has made their best endeavors to provide accurate and reliable information,
RMS is not responsible for any financial liability due to any act of omission or error made.
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* Information Provided by Customer

FMT-RPT-006

*** END OF REPORT ***

Appendix E: Standard Result

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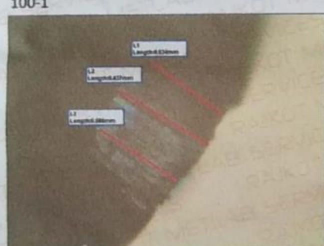
TEST REPORT

Customer Name : Darji Amit N.	**ULR - TC521220000010777F**
Address : Near, Kalavad Rd, Yogidham, Gurukul, Rajkot- Gujarat India	**Report No** : LMF-0878.1
	Date of Reporting : 27/06/2020
	Sample Received Date : 27/06/2020

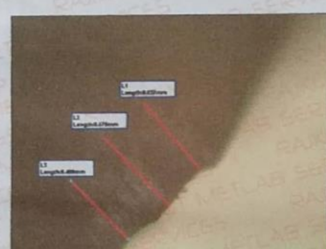
Type of Test : Coating Thickness by Microscopic Examination
***Customer's Reference** : Nil
***Condition of sample** : Test Piece
***Identification of sample** : Insert wear-200
***Material Specification** : --
Date of Testing : 27/06/2020
Instrument Utilized : Optical Microscope Model: NIM-1000X
Test Method : ASTM B487-85(RA2013)

Result :

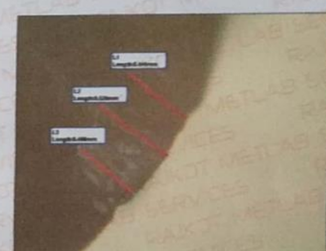
100-1



200-1



200-2



200-3

Result (mm)		200-1	200-2	200-3
1	:	0.534	0.537	0.441
2	:	0.637	0.578	0.528
3	:	0.59	0.499	0.46
Avg.	:	0.587	0.538	0.476

Remarks: --

Vishal
Tested By

Authorized Signature
Ankur (QM)

Witnessed By

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* Information Provided by Customer

FMT-RPT-006 *** END OF REPORT *** Page 1 of 1

Appendix F: Plagiarism

URKUND

Document Information

Analyzed document	Darji Amit_180044001_Thesis_WR.pdf (D76216666)
Submitted	7/10/2020 9:53:00 AM
Submitted by	Dr. Sheetal Tank
Submitter email	librarian@atmiyauni.ac.in
Similarity	17%
Analysis address	librarian.atmiya@analysis.urkund.com

14/7/20.

Sources included in the report

W	URL: https://www.researchgate.net/publication/223217685_Comparison_of_tool_life_between ... Fetched: 10/24/2019 12:30:31 PM	3
SA	**final report ajay.docx** Document final report ajay.docx (D40951752)	2
W	URL: https://www.researchgate.net/publication/322176778_Design_and_fabrication_of_gradi ... Fetched: 7/10/2020 9:56:00 AM	7
SA	**thesis 180180708008.pdf** Document thesis 180180708008.pdf (D74664685)	4
W	URL: https://www.researchgate.net/publication/328359766_TOOL_LIFE_AND_SURFACE_ROUGHNESS ... Fetched: 7/10/2020 9:56:00 AM	3
W	URL: https://www.researchgate.net/publication/235653451_Analysis_of_surface_roughness_a ... Fetched: 11/7/2019 7:13:09 AM	5
W	URL: https://www.researchgate.net/publication/248250990_Modeling_the_surface_roughness_ ... Fetched: 7/10/2020 9:56:00 AM	1
SA	**Ganesan Thesis ANNA UNIV.pdf** Document Ganesan Thesis ANNA UNIV.pdf (D39589942)	4
W	URL: https://www.researchgate.net/publication/229344292_Surface_Roughness_Model_in_Mach ... Fetched: 10/9/2019 12:41:35 PM	5
SA	**THESIS.pdf** Document THESIS.pdf (D50505407)	2
SA	**KARTIK (M.TECH).docx** Document KARTIK (M.TECH).docx (D29755781)	2
W	URL: https://link.springer.com/article/10.1007/s13369-016-2160-0 Fetched: 7/10/2020 9:56:00 AM	4

1/41

URKUND

W	URL: https://www.researchgate.net/publication/313366868_Analysis_of_surface_roughness_i ... Fetched: 10/2/2019 8:42:50 PM	2
W	URL: https://www.scientific.net/AMR.83-86.303 Fetched: 7/10/2020 9:56:00 AM	2
W	URL: https://www.sciencedirect.com/science/article/pii/S2351978918300921 Fetched: 7/10/2020 9:56:00 AM	2
W	URL: https://link.springer.com/article/10.1007/s00170-012-4380-0 Fetched: 7/10/2020 9:56:00 AM	2
SA	**Senthilkumar thesis 9.6.17.pdf** Document Senthilkumar thesis 9.6.17.pdf (D29290209)	4
W	URL: https://link.springer.com/article/10.1007%25252Fs00170-014-5950-0 Fetched: 7/10/2020 9:56:00 AM	1
W	URL: https://www.researchgate.net/publication/317559531_Modelling_and_analysis_of_tool_ ... Fetched: 11/23/2019 11:57:10 AM	2
SA	**final report ajay.docx** Document final report ajay.docx (D40951905)	2
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SA	**71130331008-TS.pdf** Document 71130331008-TS.pdf (D47878647)	1
W	URL: https://hal.archives-ouvertes.fr/hal-01260818/document Fetched: 7/10/2020 9:56:00 AM	1
SA	**Ganesan Plagiarism Thesis report.docx** Document Ganesan Plagiarism Thesis report.docx (D38425164)	1
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W	URL: https://www.semanticscholar.org/paper/Machinability-of-glass-fiber-reinforced-plas ... Fetched: 7/10/2020 9:56:00 AM	1

2/41

URKUND

61/65	SUBMITTED TEXT	33 WORDS	84%	MATCHING TEXT	33 WORDS

Das, A., Mukhopadhyay, A., Patel, S. K., & Biswal, B. B. (2016). Comparative
assessment on machinability aspects of AISI 4340 alloy steel using uncoated carbide and
coated cermet inserts during hard turning.

Das, A., Mukhopadhyay, A., Patel, S.K.   et Comparative Assessment on Machinability Aspects of AISI 4340 Alloy Steel Using Uncoated Carbide and Coated Cermet Inserts During Hard Turning.

W https://link.springer.com/article/10.1007/s13369-016-2160-0

62/65	SUBMITTED TEXT	22 WORDS	100%	MATCHING TEXT	22 WORDS

Machinability Investigation
and Cost Estimation During Finish Dry Hard Turning of AISI 4340 Steel with Untreated
and Cryo Treated Cermet Inserts.

Machinability Investigation and Cost Estimation During Finish Dry Hard Turning of AISI 4340 Steel with Untreated and Cryo Treated Cermet Inserts

W https://www.researchgate.net/publication/313366868_Analysis_of_surface_roughness_in_hard_turning_ ...

63/65	SUBMITTED TEXT	17 WORDS	100%	MATCHING TEXT	17 WORDS

Statistical Analysis of Hard turning Of AISI 4340 Steel on surface finish and Cutting Region Temperature.

Statistical Analysis of Hard Turning of AISI 4340 Steel on Surface Finish and Cutting Region Temperature |

W https://www.scientific.net/AMR.83-86.303

64/65	SUBMITTED TEXT	50 WORDS	92%	MATCHING TEXT	50 WORDS

International
Journal of Refractory Metals and Hard Materials, 33, 75-86.
24. Kumar, R., Sahoo, A. K., Das, R. K., Panda, A., & Mishra, P. C. (2018). Modelling of
flank wear, surface roughness and cutting temperature in sustainable hard turning of
AISI D2 steel. Procedia Manufacturing, 20, 406-413.
25.

SA thesis 180180708008.pdf (D74664685)

40/41

Appendix F: Plagiarism

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65/65	SUBMITTED TEXT	23 WORDS	100% MATCHING TEXT	23 WORDS

Aslan, E. (2005). Experimental investigation of cutting tool performance in high speed
cutting of hardened X210 Cr12 cold-work tool steel (62 HRC).

Aslan E (2005) Experimental investigation of cutting tool performance in high speed cutting of hardened X210 Cr12 cold-work tool steel (62 HRC).

W https://link.springer.com/article/10.1007/s00170-012-4380-0

14/7/20.

41/41