EXPERIMENTAL INVESTIGATION OF AL_2O_3 AND MUSTARD OIL AMALGAMATION NANOFLUIDS EFFECT ON MACHINING PROCESS OF EN8 MATERIAL ON LATHE

A Project report submitted in partial fulfillment of the requirement for the award of the degree of

BACHELOR OF ENGINEERING

IN

MECHANICAL ENGINEERING

Submitted by

K Manohar (314126520082)

M Mohan N D M Chandra Raj (314126520100)

K Jagadeesh (314126520083)

N Sudhakar (314126520104)

P Venkata Prasad (314126520125)

Under the guidance of

Mr. B. PRADEEP KUMAR,

Assistant professor

DEPARTMENT OF MECHANICAL ENGINEERING

ANIL NEERUKONDA INSTITUTE OF TECHNOLOGY & SCIENCES (Permanently Affiliated to Andhra University, Approved by AICTE, Accredited by NBA & NAAC with 'A' grade)Sangivalasa - 531162, Bheemunipatnam (Mandal), Visakhapatnam (Dist.), Andhra Pradesh, India.

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(Permanently Affiliated to Andhra University, Approved by AICTE, Accredited by NBA & NAAC with 'A' grade)
Sangivalasa, Bheemunipatnam, Visakhapatnam, A.P.

PRAGNANAM BRAHMA
ANITS

CERTIFICATE

This is to certify that this project report entitled "**EXPERIMENTAL INVESTIGATION OF AL_2O_3 AND MUSTARD OIL AMALGAMATION NANOFLUIDS EFFECT ON MACHINING PROCESS OF EN8 MATERIAL ON LATHE**" has been carried out by K Manohar (314126520082), M Mohan N D M Chandra Sai (314126520100), K Jagadeesh (314126520083), N Sudhakar (314126520104),P Venkata Prasad (314126520125) under the esteemed guidance of **SRI. B. PRADEEP KUMAR,** in partial fulfillment of the requirements for the award of "**Bachelor of Engineering**" in **Mechanical Engineering** of **Andhra University**, Visakhapatnam.

APPROVED BY:	**PROJECT GUIDE:**
(Prof. B Naga Raju) **Head of the Department** **Dept. of Mechanical Engineering** **ANITS, Sangivalasa** **Visakhapatnam.**	**(Sri. B. Pradeep Kumar)** **Asst. Professor** **Dept. of Mechanical Engineering** **ANITS, Sangivalasa** **Visakhapatnam.**
Signature of HOD	Signature of Internal Guide

PROFESSOR & HEAD
Department of Mechanical Engineering
ANIL NEERUKONDA INSTITUTE OF TECHNOLOGY & SCIENCE
Sangivalasa 531 162 VISAKHAPATNAM Dist A P

THIS PROJECT IS APPROVED BY THE BOARD OF EXAMINERS

INTERNAL EXAMINER:

Dr. B. Naga Raju
M.Tech,M.E.,Ph.d
Professor & HOD
Dept of Mechanical Engineering
ANITS, Sangivalasa,
Visakhapatnam-531 162.

EXTERNAL EXAMINER:

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We express our sincere thanks to the non-teaching staff of Mechanical Engineering for their kind co-operation and support to carry on work.

Last but not the least, we like to convey our thanks to all who have contributed directly or indirectly for the completion of this project work.

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ABSTRACT

In metal cutting industries it is essential to study the chip morphology during machining process. The chip formation is not only depending upon the work piece material but even on the cutting fluids and grain structure of the materials. Cutting fluids have seen extensive use and have commonly been viewed as a required addition to high productivity and high quality machining operations. The development of lubricants like, cutting fluids was traditionally based on vegetable oil as a base Fluid. This fact is related to the technical properties and the reasonable price of vegetable oils. Cutting fluids are used widely to reduce the negative effects of the heat and friction on both tool and work piece. The cutting fluids generally produces three positive effects in the process such as heat removal, lubrication on the chip–tool interface and chip removal. Issues of using fluids in machining related to environment, health, and manufacturing cost that need to be solved and options to reduce their use has to be accomplished for this new trend lubricant cutting fluid prepared in this work with combination of mustard oil and at various weight percentages of Al_2O_3 which is used in this work as a coolant/lubricant.

This experiment is to determining the effect of cutting fluids and cutting parameters on chip formation mode, cutting tool temperature, work piece temperature, tool wear and surface roughness and cycle time in turning of EN 8(AISI 1040) material. The above operation has been carried out in dry cutting condition, Flood application of cutting fluids. Cutting fluids like combination of mustard oil and various percentages of Al_2O_3 used in the present work. The cutting operations were carried out on a conventional lathe machine there by making turning operation with High Speed Stainless Steel cutting tool at different spindle speed(n) of 190 rpm. Also feed (f) of 0.4 rev/min and 0.6 rev/min . Depth of cut is at 1mm and 2 mm. By using the combination of mustard oil and at varying weight percentage of Al_2O_3 (i.e. 0.5, 1, 2, 3, 4 %) from this experimentation examine the optimum Al_2O_3 percentage of oil can improve the surface finish, metal removal rate and to reduce the tool and work piece temperature, tool wear and environmental effects.

CHAPTER-1
INTRODUCTION

The challenge of modern machining industries is mainly focused on the achievement of high quality in terms of work piece, chip formation, surface finish, high production rate, less wear on the cutting tools, economy in machining based on cutting fluids and type of work material. It is necessary to determine optimal cutting ranges like speed, feed rate and depth of cut also tool geometry and type of the cutting fluids. Selection of the cutting parameters and cutting fluids are directly influence on chip morphology and tool chip interface. Cutting fluid is a type of a coolant and lubricant designed especially for metal working and machining processes. Most of the metal working and machining processes can benefit from the use of cutting fluids.

Cutting fluids are employed in machining to reduce friction are employed in machining to reduce friction, cool the workpiece and wash away the chips. With the application of cutting fluid, the tool wear reduces and machined surface quality improves often the cutting fluids also protect the machined surface from corrosion. They also minimize the cutting forces thus saving the energy. The method to be employed for the application of cutting fluids depends upon the type of machining, cutting conditions, tool materials, workpiece materials, accuracy requirements etc. Therefore for reducing cutting tools cost and increased production being achieved through the use of appropriate cutting fluids are highly justified. The cutting fluid should meet the specific requirements of the turning process. In addition to the cooling effects, cutting fluids can lubricate the workpiece, acting decisively to maintain the good quality of the final piece. This fact makes cutting fluids one of the most important parameters in a turning operation process. With regards to the characteristics of cutting fluids, pure oils is believed to have a high lubricating capacity while emulsion has a high cooling capacity.

1.1 Types of Lubricants:

Lubricants generally classified in four categories which are using presently in machining:

i. Straight oils (mineral or petroleum oil):

Straight oils are non-emulsifiable and are used in machining operations in an undiluted form. They are composed of a base mineral or petroleum oil and often contains polar lubricants such as fats, vegetable oils and esters as well as extreme pressure additives such as Chlorine, Sulphur and Phosphorus. Straight oils provide the best lubrication and the poorest cooling characteristics among cutting fluids.

ii. Synthetic fluids (alkaline inorganic compounds):

Synthetic Fluids contain no petroleum or mineral oil base and instead are formulated from alkaline inorganic and organic compounds along with additives for corrosion inhibition. They are generally used in a diluted form (usual consent ration = 3 to 10%). Synthetic fluids often provide the best cooling performance among all cutting fluids**.**

iii. Soluble oils (mineral + water):

Soluble Oil Fluids form an emulsion when mixed with water. The concentrate consists of a base mineral oil and emulsifiers to help produce a stable emulsion. They are used in a diluted form (usual concentration =3 to 10%) and provide good lubrication and heat transfer performance. They are widely used in industry and are the least expensive among all cutting fluids.

iv. Semi synthetic fluids (synthetic +soluble oil):

Semi-synthetic fluids are essentially combination of synthetic and soluble oil fluids and have characteristics common to both types. The cost and heat transfer performance of semi-synthetic fluids lie between those of synthetic and solauble oil fluids**.**

1.2 Importance of Nanolubricants over the Normal fluids

Where as nanolubricant is better than the normal fluid because nanofluid is a fluid containing nanometre-sized particles, called nanoparticles. These fluids are engineered colloidal suspensions of nanoparticles in a base fluid. The nanoparticles used in nanofluids are typically made of metals, oxides, carbides, or carbon nanotubes. Nanofluids have novel properties that make them potentially useful in many applications in heat transfer, including microelectronics, fuel cells, pharmaceutical processes, and hybrid-powered engines, engine cooling/vehicle thermal management, domestic refrigerator, chiller, heat exchanger,in grinding, machining and in boiler flue gas temperature reduction. They exhibit enhanced thermalconductivity and the convective heat transfer coefficient compared to the base fluid. In analysis such as computational fluid dynamics (CFD), nanofluids can be assumed to be single phase fluids. However, almost all of new academic paper uses two-phase assumption. Classical theory of single phase fluids can be applied, where physical properties of nanofluid are taken as a function of properties of both constituents and their concentrations. An alternative approach simulates nanofluids using a two-component model.

Nanofluids are primarily used for their enhanced thermal properties as coolants in heat transfer equipment such as heat exchangers, electronic cooling system (such as flat plate) and radiators.

The fluids which are taken for the study considerations are silicon oxide (SiO_2), alumina (Al_20_3), copper oxide (CuO). Further, out of the two fluids, solution of Al_2O_3-H_2O is used at two different concentrations. In the solution of nanofluids, various concentrations of nanoparticles in the water is taken as per requirements or required cooling performance. Concentration of the nano-particles in the water plays a vital role in the heat carrying capacity of the nano fluid. As the quantity of nano particles in the water increases it leads to the more heat carrying capacity of the fluid. Also, distilled water also have been used as heat carrying medium in the process to have variety of results which help us to analyze the problem more accurately. Making of the solution of nano particles with base fluids or distilled water is generally done at the chemistry laboratory. Nano sized particles of nanoparticles has been used in the powder form to get the required solution. Prescribed amount of quantity of the powder is been used to get the solution of relative concentration. Certain procedures are also followed to get the distilled water in the laboratory as a base fluid.

1.3 Methods for Nanofluid Preparation

In the past few decades importance of nanofluids are improved in the manufacturing and industries because of its novel parameters such as best cooling effect, machining quality and surface finish etc., by these reasons research on preparation of nanofluids has been conducting at various research centres. Basically preparation of nanofluids are followed by these methods, such as

1.3.1 One-Step Method

To reduce the agglomeration of nanoparticles, Eastman et al. developed a one-step physical vapour condensation method to prepare Cu/ethylene glycol nanofluids. The one-step process consists of simultaneously making and dispersing the particles in the fluid. In this method, the processes of drying, storage, transportation, and dispersion of nanoparticles are avoided, so the agglomeration of nanoparticles is minimized, and the stability of fluids is increased. The one-step processes can prepare uniformly dispersed nanoparticles, and the particles can be stably suspended in the base fluid. The vacuum-SANSS (submerged arc nanoparticle synthesis system) is another efficient method to prepare nanofluids using different dielectric liquids. The different morphologies are mainly influenced and determined by various thermal conductivity properties of the dielectric liquids. The nanoparticles prepared exhibit needle-like, polygonal, square, and circular morphological shapes. The method avoids the undesired particle aggregation fairly well.

One-step physical method cannot synthesize nanofluids in large scale, and the cost is also high, so the one-step chemical method is developing rapidly. Well-dispersed and stably suspended copper nanofluids were obtained. Mineral oil-based nanofluids containing silver nanoparticles with a narrow-size distribution were also prepared by this method.

However, there are some disadvantages for one-step method. The most important one is that the residual reactants are left in the nanofluids due to incomplete reaction or stabilization. It is difficult to elucidate the nanoparticle effect without eliminating this impurity effect.

1.3.2 Two-Step Method

Two-step method is the most widely used method for preparing Nanofluids. Nanoparticles, Nanofibers, Nanotubes, or other Nanomaterials used in this method are first produced as dry powders by chemical or physical methods. Then, the nanosized powder will be dispersed into a fluid in the second processing step with the help of intensive magnetic force agitation, ultrasonic agitation, high-shear mixing, homogenizing, and ball milling. Two-step method is the most economic method to produce nanofluids in large scale, because nanopowder synthesis techniques have already been scaled up to industrial production levels. Due to the high surface area and surface activity, nanoparticles have the tendency to aggregate. The important technique to enhance the stability of nanoparticles in fluids is the use of surfactants. However, the functionality of the surfactants under high temperature is also a big concern, especially for high-temperature applications. Due to the difficulty in preparing stable nanofluids by two-step method, several advanced techniques are developed to produce nanofluids, including one-step method. In the following part, we will introduce one-step method in detail.

1.4 Lubricants functions on the machining process (lathe operations)

- Keep moving parts apart.
- Reduce friction.
- Transfer heat.
- Carry away contaminants and debris
- Transmit power.
- Protect against wear.
- Prevent against wear.
- Seal for gases.
- Stop the risk of smoke and fire of objects

The primary functions of cutting fluids in machining are:

- Lubricating the cutting process primarily at low cutting speeds.

- Cooling the workpiece primarily at high cutting speeds.
- Flushing chips away from the cutting zone.

Secondary functions include:

- Corrosion protection of the machined surface.
- Enabling part handling by cooling the hot surface.

Process effects of using cutting fluids in machining include:

- Longer Tool Life.
- Reduced Thermal Deformation of Workpiece.
- Better Surface Finish (in some applications).
- Ease of Chip and Swarf handling.
-

1.5 Criteria for Selection of Lubricant for machining process:

The principal criteria for selection of a cutting fluid for a given machining operation are:

Process performance :
Heat transfer performance
Lubrication performance
Chip flushing
Fluid mist generation
Fluid carry-off in chips
Corrosion inhibition
Fluid stability (for emulsions)
Cost Performance
Environmental Performance
Health Hazard Performance

1.6 Reason for choosing Nanofluids as coolant:

One of the reason for choosing nanofluid for heat carrying medium is it's better heat carrying capacity compare to other ordinary fluids. As the particles used in the nano fluids are solid so the surface area is more in case of solids than the fluid molecules hence the better heat carrying capacity of the same. Also as per study, these nano fluids are more efficient in carr1ying away heat along with them due to the previously described reasons

1.7 Influence of Nanoparticle Properties on Lubricant Performance:

In the industry, most of the surfaces in mutual contact (i.e., bearings, seals and gears) are lubricated with specific oils in order to control friction and wear. Many scientific researches have been published on the tribological properties of nanoparticles-based lubricants and the phenomena regarding any mechanical system in relation to friction and wear, strongly depends upon the characteristics of the nanoparticles, such as shape, size and concentration within the lubricant. Even a small concentration of nanoparticles (a few tenths of a percent by weight) could be sufficient to improve the tribological properties of the system. When the load between the sliding parts is small (low load conditions), friction reduction is mainly ascribable to the bearing-like behaviour of nanoparticles, that roll between the contact surfaces, keeping their shape intact; for high load conditions, a coating, induced by the presence of nanoparticles, is deposited on the crests of surface roughness and it can reduce direct contact between the asperities, thus, minimize wear. Since solid materials have much higher thermal conductivities than fluids, it is then a straightforward logic to increase the thermal conductivity and viscosity of fluids by adding solids on lubricants. However, if solid particles of micrometer, even millimetre magnitudes are added into the base lubricants to make slurries, the increase in thermal conductivity and viscosity of the slurries is insignificant even at high particle loading.

Because of the nature (inorganic and refractory) of the nanoparticles generally used as filler, the optimal performances achieved by the nanolubricant can also be maintained in the working conditions at high temperature, thus avoiding the typical degradation of the traditional organic additives. A major challenge to face, in order to scale up the use of nanoparticles as filler for lubricants, is related to their dispersion within fluids that is often not uniform. Their small size, in fact, causes the attractive forces to rule over the other types of forces. This phenomenon generally causes aggregation and precipitation of nanoparticles. This issue shows that nanoparticles in lubricants need to be dispersed with other methods in order to optimize their stability, most likely they need to be surface-functionalized with organic treatments. Due to these disadvantages of the liquid suspension of large particles, the method of enhancing the thermal conductivity and viscosity by adding solid particles was not a preferred one until the emergence of nanolubricants. Modern material process and synthesis technologies provide us an opportunity to explore the dimensional bottoms of materials.

A variety of nanostructured materials has been produced possessing quite different mechanical, optical, thermal and electrical properties from the corresponding bulk materials. Several outstanding features of nanoparticles, such as the small size, large specific surface area, less particle momentum, and high mobility make nanoparticles perfect candidates as the dispersed phases in liquid suspensions.

1.7.1 Challenges in Nanofluids

i) There is an influence of many factors on the thermal conductivity of the nanofluid. So it is a challenge to keep the nanofluid mixture balanced. The influences are:

a) Influence of nano-particles
b) Influence of base fluid
c) Influence of solid-liquid interface

ii) From the previous studies, specific heat of the nanofluid has found to be lower than that of base fluids. But for an ideal coolant, it is important to possess the higher value of specific heat to carry away or remove more heat when compared to the base fluid.

iii) From the previous researches, viscosity of the nanofluid has found to be higher than that of base fluids. It was dependent on both the concentration of the nanofluid and their type of particles.

iv) Increased pressure drop is also a type of challenge during the flow of nanofluid through the heat exchanger or some other cooling system.

v) Production of the nanofluid is a costly process as it require one step method & two step method to be produced and it may lead to hinder the application of the nanofluid in the industries. Both the methods require advanced and sophisticated equipments.

1.8 Properties of Cutting Fluids

The desirable properties of cutting fluids in general are (Boston, 1952):

High thermal conductivity for cooling,
Good lubricating qualities,
High flash point, should not entail a fire hazard,
Must not produce a gummy or solid precipitate at ordinary working temperatures,
Be stable against oxidation,
Must not promote corrosion or discoloration of the work material,
Must afford some corrosion protection to newly formed surfaces,
The components of the lubricant must not become rancid easily,
No unpleasant odour must develop from continued use,
Must not cause skin irritation or contamination,
A viscosity that will permit free flow from the work and dripping from the chips.

1.9 Selection of suitable Cutting Fluid:

The selection of a cutting fluid depends on many related factors. The primary concerns are machinability of the material, compatibility and acceptability. The selection of the type of cutting fluid as follows

a) Type of machining processes
b) Type of machined workpiece material
c) Type of cutting tool material

(a) Type of Machining Processes

One of the most important factors in selecting a cutting fluid is the nature of machining operation. The various machining operations naturally differ in metal removal characteristics. The most difficult machining process will need to use more cutting fluid. Selection is, therefore a matter of assessing the severity of the machining operation and marrying it to the appropriate cutting fluid. The cooling effect of cutting fluid is more important in drilling process because of its cutting speed which is generally low due to two cutting edges of drill tool. In conventional drilling operation, emulsion oils and sulphur or chlorine additive mineral oils should be selected.

(b) Workpiece materials.

The second parameter for selection of suitable cutting fluids in machining processes is the type of workpiece material. The application of cutting fluids should provide easy machining operation in all materials. In steel machining operation, generally the high pressure containing and additive cutting fluids are used therefore high pressure cutting oils should be selected.

(c) Cutting tool materials

The third important factor for selection of cutting fluid in machining processes is the cutting tool material. Varieties of cutting tool materials are commercially available for all kind of machining processes, however high speed steel cutting tools can be used with all type of cutting fluids. High-speed steel (HSS) tools are so named because they were developed to cut at higher speeds. First produces in early 1900‟s, high speed steels are the most highly alloyed of the tool steel. However there are three possible modes by which a cutting tool can fail in machining as explained by Groover:

(a) Fracture failure: This mode of failure occurs when the cutting force at the tool point becomes excessive, causing it to fail suddenly by brittle fracture.

(b) Temperature failure: This failure occurs when the cutting temperature is too high for the tool material, causing the material at the tool point to soften, which leads to plastic deformation and loss of the sharp edge.

(c) Gradual wear: Gradual wearing of the cutting edge causes loss of tool shape, reduction in cutting efficiency, an acceleration of wearing as the tool becomes heavily worn, and finally tool failure in a manner similar to a temperature failure.

1.10 Tool Life:

Tool life is defined as the length of cutting time that the tool can be used. Operating the tool until final catastrophic failure is one way of defining tool life. Tool life is the time a tool will cut satisfactorily; it is expressed as the minutes between changes of the cutting tool. The significant of tool life in drilling cannot be over emphasized because substantial time is lost either at the replacement or resetting of tools. However, in production, it is often a disadvantage to use the tool until this failure occurs because of difficulties in re sharpening the tool and problems with work surface quality.

1.11 Metal Cutting Parameters:

Conventional metal-cutting is the outwardly simple process of removing metal on a work piece in order to get a desired shape by relative movement of the work piece and tool, either by rotating the workpiece (as in a lathe). Some parameters involved in the metal-cutting process are in fact closely related with some other parameters in the metal-cutting process; playing with one will have an influencing effect on another. These are the basic parameters of metal cutting processes.

i. Material mach inability:

The mach inability of a material decides how easy or difficult it is to cut. The material's hardness is one factor that has a strong influence on the machinability. Though a general statement like "a soft material is easier to cut than a harder material" is true to a large extent, it is not as simple as that. The ductility of a material also plays a huge role.

ii. Cutting tool material:

In metal-cutting, High Speed steel and Carbide are two major tool materials widely used. Ceramic tools and CBN (Cubic Boron Nitride) are the other tool materials used for machining very tough and hard materials. A tool's hardness, strength, wear resistance, and thermal stability are the characteristics that decide how fast the tool can cut efficiently on a job.

iii. Cutting speed and spindle speed:

Cutting speed is the relative speed at which the tool passes through the work material and removes metal. It is normally expressed in meters per minute (or feet per inch in British units). It has to do with the speed of rotation of the workpiece or the tool, as the case may be. The higher the cutting speed, the better the productivity. For every work material and tool material component, there is always an ideal cutting speed available, and the tool manufacturers generally give the guidelines for it. Spindle speed is expressed in RPM (revolutions per minute). It is derived based on thecutting speed and the work diameter cut (in case of turning/ boring) or tool diameter (in caseofdrilling/ milling etc).

iv. Depth of cut:

It indicates how much the tool digs into the component (in mm) to remove material in the current pass. The depth of cut in drilling is equal to one half of the drill diameter.

v. Feed rate:

The relative speed at which the tool is linearly traversed over the workpiece to remove the material. In case of rotating tools with multiple cutting teeth (like a milling cutter), the feed rate is first reckoned in terms of "feed per tooth," expressed in millimeters (mm/tooth). At the next stage, it is "feed per revolution" (mm/rev). In case of lathe operations, it is feed per revolution that states how much a tool advances in one revolution of workpiece. Incase of milling, feed per revolution is the feed per tooth multiplied by the number of teeth in the cutter.

To calculate the time taken for cutting a job, it is "feed per minute" (in mm/min) that is useful. Feed per minute is the feed per revolution multiplied by RPM of the spindle. The feed of a drill is the distance the drill moves into the job at each revolution of the spindle. This can be expressed as feed per minutes, and this defined as the axial distance moved by the drill into the work per minute

vi. Tool geometry:

For the tool to effectively dig into the component to remove material most efficiently without rubbing, the cutting tool tip is normally ground to different angles (known as rake angle, clearance angles, relief angle, approach angle, etc). The role played by these angles in tool geometry is a vast subject in itself.

vii. Coolant:

To take away the heat produced in cutting and also to act as a lubricant in cutting to reduce tool wear, coolants are used in metal-cutting. Coolants can range from cutting oils, water-soluble oils, oil-water spray, and so on.

viii. Machine/ spindle power:

In the metal-cutting machine, adequate power should be available to provide the drives to the spindles and to provide feed movement to the tool to remove the material. The power required for cutting is based on the metal removal rate, the rate of metal removed in a given time, generally expressed in cubic centimeters per minute, which depends on work material, tool material, the cutting speed, depth of cut, and feed rate.

ix. Rigidity of machine:

The rigidity of the machine is based on the design and construction of the machine, the age and extent of usage of the machine, the types of bearings used, the type of construction of slide ways, and the type of drive provided to the slides. All play a role in the machining of components and getting the desired accuracy, finish, and speed of production. Thus, in getting a component finished out of a metal-cutting machine at the best possible time within the desired levels of accuracy, tolerances, and surface finish, some or all the above parameters play their roles.

1.12 Advantages of the Nanofluids:

i) They are potential heat transfer fluids with enhanced heat transfer performance and can be implemented in many devices.

ii) They are the fluids with improved thermo-physical properties and can be used in various electronic devices for the better performances.

iii) Based upon the previous studies, it is strongly observed that the nanofluids have higher thermal conductivity which make them a capable cooling medium in the various cooling systems.

iv) They possess temperature-dependent thermal conductivity at a very low particle concentration.

1.13 Cutting Tool Temperature and Tool wear:

In metal cutting, the heat generated on the cutting tool is important for the performance of the tool and quality of the workpiece. Maximum heat is generated on the tool-chip interface during machining. The machining can be improved by the knowledge of cutting temperature on the tool. The cutting temperature is a key factor which directly affects tool wear, work piece surface integrity and machining precision according to the relative motion between the tool and workpiece. The amount of heat generated varies the type of material being machined. The cutting parameters especially cutting speed, feed rate and depth of cut influence on the chip-tool interface temperature, Temperature in the cutting zone depends on contact length between tool and chip, cutting forces and friction between tool and work piece material. A considerable amount of heat generated during machining is transferred into the cutting tool and work piece. The remaining heat is removed with the chips. The highest temperature is generated in the flow zone. Therefore, contact length between the tool and the chip affects cutting conditions and performance of the tool and tool life. In a single point cutting, heat is generated at three different zones during metal cutting as shown in Figure 1.1

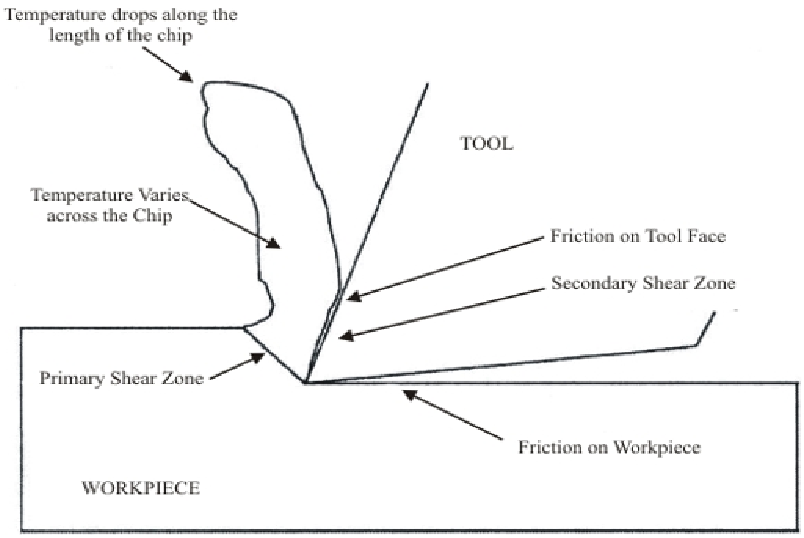


Figure 1.1 Heat generated by chip formation

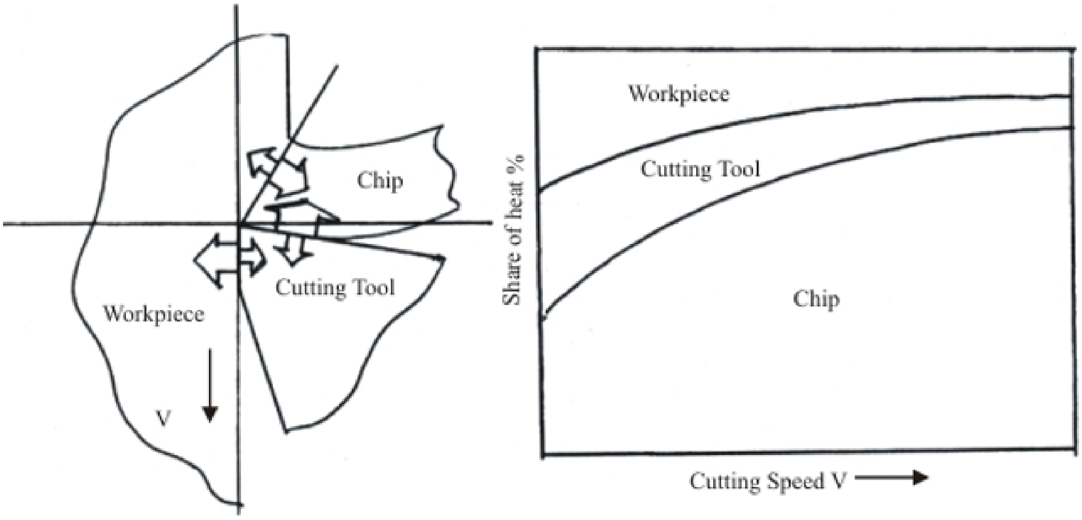


Figure 1.2 Apportionment of heat amongst chip, tool and work piece

1) Heat is produced in the primary shear zone as the workpiece is subjected to large irreversible plastic deformation.

2) Heat produced by friction and shear on the tool rake face, or secondary shear zone.

3) Heat produced at the tool-work interface, where the tool flank runs along the workpiece surface and generates heat through friction.

The heat generated is shared by the chip, cutting tool and the work-piece. Figure **1.2** shows the maximum amount of heat is carried away by the flowing chip. From 10% to 20% of the total heat goes into to the tool and some heat is absorbed in the work-piece. With the increase in cutting speed, the chip shares heat increasingly. The effect of cutting temperature, particularly when it is high, is mostly detrimental to both the tool and the job. Due to the high shear and friction energies dissipated during a machining operation the temperature in the primary and secondary shear zones are usually very high, hence affect the shear deformation and tool wear. Total tool wear rate and crater wear on the rake face are strongly influenced by the temperature at chip-tool interface. Therefore, it is desirable to determine the temperatures of the tool and chip interface to analyze or control the process.

Several experimental and analytical techniques have been developed for the measurement of temperatures generated in cutting processes. Due to the nature of metal cutting, it is not possible to measure temperature precisely in the cutting zone and thus it difficult to verify the theoretical results in a precise manner. Because of nature of the metal cutting (elasto-plastic nature of the chip tool contact), tool geometry and variation of thermal properties of tool-work combination with temperature, determinations of internal temperatures on the cutting tool are very difficult. Actual measurements give a true picture of cutting temperatures. For measuring of this temperatures generated in the cutting zone, several methods have been developed. Since at the interface there is a moving contact between the tool and chip, experimental techniques such as standard pre calibrated thermocouples cannot be used to measure the interface temperature. The main techniques used to evaluate the cutting temperature during machining are embedded thermocouple, tool-work thermocouple, calorific method, single wire thermocouple, PVD film method, Infrared thermometers, Infrared cameras etc. Out of these methods the tool-work thermocouple is easy and simple technique for measuring chip-tool interface temperature (average temperature) during metal cutting**.**

1.14 Objectives of the Project:

- Preparation and compare the thermal-physical properties of standard mustard oil lubricants added with various volume concentrations of 50 nm Al_2O_3 by sonication process at various volume Percentages of Alumina oxide Nano powder.
- En8 material is used as work piece and HSS tool is used as cutting tool. Coolant as a pure mustard oil and combination of mustard oil and various weight percentages of Al_2O_3.
- Experimental setup arrangement for effect of nano fluid on the lathe cutting tool with various speed and Depth of cut at constant feed.
- Experimental investigation and comparison of tool and work piece temperatures while machining and surface roughness of the work piece for without lubricant and with Lubricant(Al_2O_3+Mustard oil).
- Evolution and optimize the best lubricant weight percentage of Al_2O_3 through the experimental investigation.

CHAPTER 2

LITERATURE REVIEW

2.1 Influence of Nano fluids on machining

1] Mohamed Kamal Ahamed [2017], reviews the significance nano-lubricants and assesses their effectiveness to provide the most promising approaches to reduce the friction and anti-wear/scuffing over the boundary regime. The main purpose of this review is to summarize the present knowledge about major advantages of the nanomaterials as nanolubricant additives in boundary lubrication. It is very complex regime involving surface topography, metallurgy, physical adsorption and chemical reactions. There is no intent to present an exhaustive survey of the literature, but it presents the main reasons for decreasing the friction and wear based on lubricated by nanolubricants during heavy load and low-speed conditions.

2] A.A.M. Redhwan[2017], has introduced Nanolubricant in compressor might improve the performance of automotive air conditioning system. Prior testing of the nanolubricant enhancement performance, thermal conductivity of Al_2O_3/PAG and SiO_2/PAG nanolubricants has to be investigated and compared. Al_2O_3 and SiO_2 nanoparticles first been dispersed in Polyalkylene Glycol (PAG) for different volume concentrations. KD2 Pro was used in determining the thermal conductivity of the nanolubricant. The experimental results showed that the thermal conductivity of the Al_2O_3/PAG and SiO_2/PAG nanolubricants increased by volume concentration but decreased by temperature. The highest thermal conductivity was observed to be 0.153 W.(m K)-1 and enhancement of 1.04 times higher than the base lubricant for Al_2O_3 with 1.0 volume concentration. Finally regression equations were developed in order to estimate the thermal conductivity for these nanolubricants.

3] Ajay K, Lal K [2016], stated that for producing power in the solar thermal power plants, parabolic solar collector have been used. Due to the improved thermo-physical properties of the nanofluid like density, thermal conductivity, heat capacity and viscosity, they enhances the efficiency in the solar energy when nanofluids are used as working fluids. Nanofluids are manufactured by suspending the nanoparticles in the base fluids like ethylene glycol, water etc.Computational as well as experimental, both the studies have been presented in this paper.

Nanofluid CuO- H_2O(DI) has been used of .01% concentration. Mass flow rate of 20 Litres/hr is used to analyze the system performance in ANSYS FLUENT 14.5. It is the computational fluid dynamics based tool. For modeling the solar fluxes, solar solar load model has been used. For the heat transfer modeling which comprising of conduction, convection and radiation, S2S radiation model has been used. It has been analyzed from the both CFD and experimental analysis that performance of the collector get enhanced using nanofluids.

4] Kate Atul Shriram prof. S D Ambekar(2015): The growing demands for high productivity of machining need use of high cutting velocity and feed rate . Such machining inherently produces high cutting temperature which not only reduces tool life but also impairs product quality. Application of cutting fluids changes the performance of cutting operations because of their lubrication,cooling,and chip flushing functions but the conventional cutting fluids are not that effective in such high production machining particularly in continuous cutting of materials like steels.

5] A.N.M Khalil,M.A.M Ali,A.I.Azmi(2015): A nano lubricant is a new kind of engineering lubricant made of suspended particles in a base lubricant it offers quality machined part with minimum power consumption during machining. However the application of nanolubricant without surfactant leads to agglomeration after a certain period of time. Hence this paper investigates effect of Al_2O_3 nanolubricant with surfactant on tool wear during turning process of AISI 10150 mild steel bar with minimum quantity lubricant. Different cutting fluid condition namely dry nanolubricant. tool wear rate were evaluated at constant cutting speed.

6] Nithin K Mani(2015): In this study an attempt has been made to investigate the machining characteristics on EN8 steel using AL_2O_3 nano fluids as coolant. EN8 which are commonly used in the automobile applications has been found to have high roughness value generated on the machined surface A CNC turning operation was performed on the EN8 steel using HSS tool. Al nano particle with high thermal conductivity has been used with water as base fluids to form AL_2O_3 nano fluids to reduce the heat formation. The results obtained showed a better surface finish on the machined surface indicating considerably reduced surface roughness.

7] Kandwal. S et al. [2015], analyzed that with increase in the Temperature of the nanofluids and distilled water, thermal conductivity also increases. With increase in concentration at a particular temperature, increase in the thermal conductivity of the nanofluids is analyzed. Thermal conductivity gets enhanced by 8.5% at 56°C when we add 0.5% concentration of the nanoparticles. With increase in the temperature, viscosity of the nanofluid and distilled water get decreased. During addition of the nanoparticles viscosity of the base fluid increases. Viscosity of the base fluid get increased by 14% when we add 0.5% concentration of thermal conductivity. Values obtained from the experiments are almost same as values obtained from the models for viscosity and thermal conductivity. But when it comes to increase in the concentration from 0.1 to 0.5%, values obtained from the Jeffrey and Maxvell models are under prediction. The models which are used for the validation of viscosity are also not in a good agreement with the experimental values i.e. experimental values are much lesser which are obtained from the models at the higher concentrations.

8] Mahesh Suresh Patil[2015], considered Nanofluids as a promising choice for several heat transfer applications. With the increasing awareness for energy saving and efficiency improvement in various thermal systems, including refrigeration systems, there is a growing interest in the refrigerant-based nanofluids owing to their superior thermo-physical properties. Nanorefrigerants are a class of nanofluid, which consist of suspended nanoparticles in a base refrigerant. In this paper, it is intended to include many articles on refrigeration systems that use nanorefrigerants, published in the period from 2005 to 2015. Although this is an extensive review, it could not include all the papers, and only some major research works were selected. It is believed that the dependency of thermal conductivity and other properties on temperature will make the thermal systems more efficient while operating at a high temperature. The literature reviews associated with the performance characteristics of nanorefrigerants in refrigeration systems for the last 10 years have been compiled and presented in this paper. Furthermore, recent studies related to thermo-physical properties of nanorefrigerants and nanolubricants have also been summarized and reviewed in this paper.

9] Shailesh kumar Dwivedi[2015], has investigated main problem associated with any metal cutting operation is introduction of undesirable elevated temperature at the cutting zone. Higher temperature at the tool-work interface becomes cause for failure of cutting tools and formation of micro cracks. The reason behind high temperature formation is high rate of friction between tool-work and tool-chip interface caused by continuous rubbing action of forming chip with tool face and the shearing failure of chip. To overcome this problem the solution which is most widely used comes into picture, is implementation of cutting fluid.

The purpose of cutting fluids is to provide cooling and to reduce the friction between tool and work piece at the shear zone. It is well known that application of minimum quantity lubrication (MQL) as a cutting fluid is more preferable than normal flood cooling technique because of many advantages over normal flood cooling. To increase the effectiveness of MQL addition of nanoparticles is done. In the present work a water-soluble-oil-based MQL technique with different volume fraction of aluminum oxide (Al_2O_3) nanoparticles is used as the cutting fluid for turning of 17-4 PH grade stainless steel. Experiment is carried out using 4 different volume concentrations inclusion of Al_2O_3 nanoparticles in the base fluid with MQL lubrication technique and the experimental results are plotted on the basis of that. The results clearly indicated the beneficial aspects of Al_2O_3 in reducing the cutting temperature by virtue of enhanced heat transfer characteristics of nanoparticles of Al_2O_3. It is observed that the rate of temperature dissipation from tool and work piece increases on increasing the volume fraction of Al_2O_3 nanoparticles and dynamic fluctuation of cutting forces also reduces during introduction of nanoparticles. On the other hand major decrement on the cutting force, tool wear rate and chip thickness along with improved surface quality has also seen, on percentage increment in concentration of Al_2O_3 nanoparticles.

2.2 Al_2O_3 nanolubricant effect on thermal properties

10] A.N.M Khali[2015],proposed that nanolubricant is a new kind of engineering lubricant made of suspended particles in a base lubricant. It offers quality-machined part with minimum power consumption during machining. However, the application of nanolubricant without surfactant leads to agglomeration after a certain period of time. Hence, this paper investigates the effect of Al_2O_3 nanolubricant with surfactant Sodium Dodecylbenzene Sulfonate (SDBS) on tool wear during turning process of AISI 10150, mild steel bar with minimum quantity lubricant. Different cutting fluid conditions namely; dry; nanolubricant and nanolubricant with SDBS surfactant were tested. Tool wear rate were evaluated at constant cutting speed of 1273 rpm, feed rate of 0.2 mm/rev, and depth of cut of 0.1 mm. The results exhibit positive influence of Al_2O_3 nanolubricant with surfactant in alleviating tool wear during turning operations.

11] Ling Huang[2014], prepared Nano-scale Al_2O_3 spherical particles via hydrothermal method and modified by silane coupling agent, can be well-dispersed in lubricating oil. The tribology properties of Al_2O_3 nanoparticles as lubricating oil additives have been studied by four-ball and thrust-ring friction test, which illustrate that the modified Al_2O_3 nanoparticles can effectively improve the lubricating behaviors compared to the base oil. When the added concentration is 0.1 wt%, the friction coefficient and the wear scar diameter are both smallest. The lubrication mechanism is that a self-laminating protective film is formed on the friction surface and the wear behavior changes from sliding friction to rolling friction.

12] Lorenzo Cremasch[2014], presents experimental data of solubility and miscibility of three types of Al_2O_3 nanolubricants with refrigerant R-410A. The nanoparticles were dispersed in POE lubricant by using different surfactants and dispersion methods. The nanolubricants appeared to have slightly lower solubility than that of R-410A but actually the solid nanoparticles did not really interfere with the POE oil solubility characteristics. High viscosity suspensions are expected to stabilize the nanoparticles and avoid clustering. This aspect was verified in the present paper for the Al_2O_3 nanolubricants and long term stability and the degree of agglomeration, when present, were measured. The data identified optimum combinations of surfactants to achieve stable and uniform nanolubricant dispersions for several months. Surfactants affected slightly the thermal conductivity, specific heat, viscosity, and solubility properties of the nanolubricants. The specific heats of the nanolubricants were lower than that of POE oil at temperatures from 0° to 20°C while they were similar at 40°C. Thermal conductivity ranged from 1.1 times higher at 5°C to 1.4 times higher at 40°C than that of POE lubricant. The viscosity at nanoparticle concentration of 10 wt. % was 30 to 40 percent higher than that of POE oil. The thermal and viscosity data for three nanolubricants provided in this paper advance the basic understanding of nanoparticles interaction with R-410A refrigerant and POE lubricant mixtures.

13] Mark A. Kedzierski[2013],presents liquid kinematic viscosity and density measurements of a synthetic polyolester-based aluminum oxide (Al_2O_3) nanoparticle dispersion (nanolubricant) at atmospheric pressure over the temperature range 288 K–318 K. Two Al_2O_3 particles diameters were investigated: approximately 60 nm and 10 nm. A good dispersion of the spherical nanoparticles in the lubricant was maintained with a surfactant. Viscosity and density measurements were made for the neat lubricant along with twelve nanolubricants with differing nanoparticle and surfactant mass fractions. A new model was developed to predict the kinematic viscosity of the nanolubricant by summing the viscosities of the nanoparticle, the surfactant and the base lubricant. The resulting correlated model for the liquid kinematic viscosity was a function of temperature, nanoparticle mass fraction, surfactant mass fraction, and nanoparticle diameter. The measurements are important for the design of nanolubricants for heat transfer and flow applications.

14] Hasan M. I. et al. [2012], investigated the performance of the counter flow micro-channel heat exchanger (CFMCHE) which is using nanofluid as a cooling medium. Cu-water and Al_2O_3-water, the two nanofluids have been used as working fluids for the cooling purpose. It has been analyzed from the paper that performance of the counter flow micro-channel heat exchanger (CFMCHE) gets better when nanofluids have been used as cooling medium. It is also investigated that there is no increase in the extra pressure drop due to the use of ultra fine solid particles in nanofluids and the low volume fraction concentrations. An important fact has been analyzed in the paper that at the higher flow rates, heat absorption is not dominated by the nanoparticle but the volume flow rate. Also, effect of the nanoparticles at the entrance region of the channels have been analyzed more due to developing of the boundary layer of the solid particles.

15] Veeranna Sridhara[2011], proposed that ultrahigh performance cooling is one of the important needs of many industries. However, low thermal conductivity is a primary limitation in developing energy-efficient heat transfer fluids that are required for cooling purposes. Nanofluids are engineered by suspending nanoparticles with average sizes below 100 nm in heat transfer fluids such as water, oil, diesel, ethylene glycol, etc. Innovative heat transfer fluids are produced by suspending metallic or non-metallic nanometre-sized solid particles. Experiments have shown that nanofluids have substantial higher thermal conductivities compared to the base fluids. These suspended nanoparticles can change the transport and thermal properties of the base fluid. As can be seen from the literature, extensive research has been carried out in alumina-water and CuO-water systems besides few reports in Cu-water-, TiO2-, zirconia-, diamond-, SiC-, Fe3O4-, Ag-, Au-, and CNT-based systems. The aim of this review is to summarize recent developments in research on the stability of nanofluids, enhancement of thermal conductivities, viscosity, and heat transfer characteristics of alumina (Al_2O_3)-based nanofluids. The Al_2O_3 nanoparticles varied in the range of 13 to 302 nm to prepare nanofluids, and the observed enhancement in the thermal conductivity is 2% to 36%.

16] V.vasu,praful p.ulhe(2010): In most of metal industries the use of cutting fluids has become more problematic in terms of both employee health and environmental pollution but the use of cutting fluid generally causes economy of tools and it become easier to keep tight tolerances and to maintain workpiece surface properties without damages because of these some alternatives has been sought to minimize or even avoid the use of cutting fluid in machining operations. Some of these alternatives are dry machining and machining with minimum quantity of lubrication (MQL).

17] Nur Atikah Bt Ali[2010],investigated that Nanofluids is a kind of new engineering material which consisting of solid nanoparticles with size typically of 1-100nm by dispersing it into based fluids. This research presents the preparation of Aluminum Oxide (Al_2O_3) nanofluids by using two-step methods. This nanofluids was prepared by dispersing Al_2O_3 nanoparticles (<50nm) in distilled water based fluids with the addition of calculated amount of Sodium Dodecylbenzene Sulphonate (SDBS) as a surfactant and absence of SDBS surfactant. The nanofluids were sonicated with ultrasonic vibrator at power of 700 Watt and frequency of 40k Hz for 15 minutes. It was tested that with the presence of surfactant in the nanofluids, the nanofluids was stable for 2 weeks. Absence of surfactant cause the small amount of particle aggregates had settled out of suspension after 1 day. Stabilization of the Al_2O_3 nanofluids with and without surfactant can be obtained with Transmission Electron Microscopy (TEM). Distilled water based fluids display Newtonian behavior but it transform to non-Newtonian fluid with the addition of Al_2O_3 nanoparticles. Viscosity of the Al_2O_3 nanofluids was measured both as a function of Al_2O_3 nanoparticles volume fraction and temperature between 30o C and 60oC using Brookfield DV- II Pro Viscometer and results showed that no anomalous effects of viscosity with increasing of temperatures. The range of the viscosity from 30o C and 60oC is between 4.05 cP to 2.55 cP and viscosity of nanofluids increase with the Al_2O_3 nanoparticles volume concentration. The result then was compared with the previous researcher's experimental data. Thermal conductivity of the Al_2O_3 nanofluids water based was predicted using regression equation then compared it with previous experimental data.

18] C. J. Ho et al. [2010], conducted the experiments on the copper microchannel heat sink to investigate forced convective cooling performance where Al_2O_3/water nanofluid have been used as coolant. The results obtained for the pumping power, the thermal resistance, friction factor, the averaged heat transfer coefficient and the maximum wall temperature are helpful in determining the hydraulic and thermal performances of the heat sink cooled with nanofluid. This has been shown by the results that performance of the nanofluid cooled heat sink is more than the water cooled one because it has higher average heat transfer coefficient, lower wall temperature with high pumping power and lower thermal resistance. Increase in the dynamic viscosity have been observed due to dispersion of the alumina nanoparticles in the water and for the nanofluid cooled heat sink, friction factor was found slightly increased.

19] Shokouhmand H. et al. [2008], studied that nanofluids as coolant were used to analyze the performance of the micro-channels heat sinks. The friction coefficients and heat transfer for the nanofluid flow are base on the experimental correlations and theoretical modeling. When study was done on the specific micro-channel heat sink geometry, it was found that the nanofluids were more capable in enhancing the micro-channel heat sink performance as compared to the pure water as the coolant. The reason for the enhanced performance was increase in thermal conductivity of the coolant and thermal dispersion effect of the nanoparticles. Nanofluids have another advantage in the microchannels using as coolant is that there is no extra pressure drop occur due to the small nanoparticle size. When study was done on the specific minichannel heat sink geometry, it was also found that the nanofluids were more capable in enhancing the micro-channel heat sink performance as compared to the pure water as coolant.

20] Poh-Seng Lee et al. [2005], analyzed that experimental investigation is presented to explore the classical correlation’s validity for analyzing the thermal behavior in single phase rectangular micro-channels that is based on conventional sized channels. The range of the micro channel is considered from 194 µm to 534 µm in width, with the channel depth is taken as five times the width of the channel in each case. There were ten micro-channels in parallel and each piece was made of copper. The de-ionized water was used for the experiment and an Reynolds no. was ranging from approximately 300 to 3500. Numerical predictions those obtained were based upon the continuum and classical approach. Those predictions were found in a appropriate agreement with the data showing average deviation of 5%.

21] Satish G. kandilkar [2004], analyzed that for the compact heat exchangers and the conventional channels, techniques of the heat transfer enhancement for the single phase are presented. The major techniques which are consisting of breakup of boundary layer, electric fields, secondary flow and mixtures, flow transition, entrance region, vibrations are discussed in the paper. For the single phase flows in the micro-channels and the mini-channels, applicability of these techniques are evaluated. For the critical applications, applicability of the single phase cooling is extended by heat transfer enhancement devices for the micro-channels and mini-channels.

22] Schmidt [2003], investigated the problems regarding the heat transfer and fluid flow are highlighted which are associated with electronic cooling. In the heat transfer and fluid flow, classical approaches are not followed by solution to these problems. Solution to the problems are generally combination of application of the technical tools and engineering judgments. The component junction temperature and system operations has some strong functions i.e.
performance and reliability of electronic systems. Need of understanding the governing physical laws is essential to find correct solution to the problem. Concurrently, it is very important to know that where this physical law should be implemented and what each law controls. In the cooling of electronic system, two forms of energy transport are presented i.e. heat transfer and fluid flow. In many cooling problems these two phenomena are strongly coupled. To obtain the solution for these problems may require numerical simulation or experimentation as problems become complex.

23] K.P.Sodavadia(2001): This research work presents the performance of nano cutting fluid in machining one of the most fundamental process in manufacturing industries. The heat generated at the tool chip interface during machining is critical for work piece quality. The cutting fluids which are widely used to carry away the heat generated at the tool workpiece interface in machining process that do not possess a pathogenic clinical history and are relatively free from inherent hazards. Hence there arises a need to develop eco friendly and user friendly nano cutting fluid over conventional cutting fluids. Coconut oil has been used as one of the cutting fluids in this work because of its thermal and oxidative stability which is higher than that of other vegetable based cutting fluids used in machining industries.

CHAPTER 3

PREPARATION OF Al_2O_3 AND MUSTARD OIL AMALGAMATION NANO LUBRICANTS

The purpose of this study is to investigate the agglomeration condition of stock nanopowder and the amount of dispersion energy needed to reach an optimum nanofluid dispersion using two ultrasonic methods. Particle size distribution was compared with increasing amount of input energy until diminishing returns were reached for each nanofluid dispersion method. Choosing base oil suitable for extensive nanofluid research is critical. The oil should have no additives to ensure that the changes in performance are due to the addition of nanoparticles and surfactant alone. A low viscosity mineral oil offers a wide range of low load applications. For this preparation mustard oil was chosen as the controlled base fluid of the oil-base nanofluid research because it satisfies the criteria and filler material as Al_2O_3 nano powder with 50nm size. The surfactant can greatly affect the stability of the solution. This chemical group is composed of a ‘head’ and ‘tail’ component. The hydrophilic heads will orient themselves towards anything that is not oil in an oil system, which means the glass of the test vials, air, and nanoparticles contained in solution.

This research work focused to calculate the variation of tool tip temperature, work piece surface finish, work piece temperature during machining, chip formation with varying coolant such as mustard oil, another one is combination of Al_2O_3 nano powder and mustard oil with various weight percentage combinations. For this analysis initially preparing the alumina oxide reinforced mustard oils.

3.1 Al_2O_3 (Aluminium oxide Powder):

Alumina is the most cost effective and widely used material in the family of engineering ceramics. The raw materials from which this high performance technical grade ceramic is made are readily available and reasonably priced, resulting in good value for the cost in fabricated alumina shapes. With an excellent combination of properties and an attractive price, it is no surprise that fine grain technical grade alumina has a very wide range of applications. Alumina nanoparticles are light, nontoxic and non-sparking. The important factors in selecting it are that it can be easily formed, machined or cast. It has a silvery appearance and possesses high tensile strength, high thermal conductivity, and excellent corrosion resistance. Weight for weight it is twice as good as a conductor of electricity as copper. The principal uses of alumina nanoparticles are in the manufacture of automobiles, commercial vehicles, aerospace, marine, railways, containers and packaging, cooking utensils, electronics, electrical transmission wire, telecommunications cable, paint pigment, metallurgy, batteries, energy storage, superconductors, construction industry, etc. Previous studies on nanofluids have focused on the effect of Al_2O_3 nanoparticles on thermo physical characteristics and tribological properties of nanofluids. Wang et al. (1999) studied effective thermal conductivity of mixtures of fluids and nanometer-size particles measured by a steady-state parallel-plate method. The tested fluids contain two types of nanoparticles, Al_2O_3 and CuO, dispersed in water, vacuum pump fluid, engine oil, and ethylene glycol. Experimental results show that the thermal conductivities of nanoparticle–fluid mixtures are higher than those of the base fluids. Using theoretical models of effective thermal conductivity of a mixture, they have demonstrated that the predicted thermal conductivities of nanoparticle-fluid mixtures are much lower than their measured data, indicating the deficiency in the existing models when used for nanoparticle–fluid mixtures.

Fig: 3.1 (a) Alumina oxide (50nm) Fig: 3.1 (b) Aluminium powder Fig: 3.1 (c) Al $_2O_3$ structure

Table: 3.1 Properties of Al_2O_3:

Property	Magnitude	Values
Bulk Modulus	165	Gpa
Flexural Strength	330	Mpa
Elastic Modulus	330	Gpa
Shear Modulus	124	Gpa
Hardness	1175	Kg/mm^2
Fracture Toughness	3.5	$Mpa*m^{1/2}$
Porosity	0	(%)

The dry powder chosen for this investigation was Nanotech alumina nanopowder from Nanophase Technologies with a particle size of 50nm. It was surface functionalized, but the exact surface chemistry was proprietary information.

Fig: 3.2 Branson 1510 Ultrasonic Cleaner Ultrasonic ting an Alumina Nanofluid.

3.2 Mustard oil:

Oil seed crops occupy an important place in the agriculture and industrial economy of the country. India is perhaps the only country in the world having the largest number of commercial varieties of oil seeds. Mustard Oil is also one of the major oil seeds from which edible oil is produced. In Northern & Central India, it is medium of cooking food. Besides it is also used in preparation of Pickles. The Mustard Oil Cake (By Product) is used as cattle feed.

The term mustard oil is used for two different oils that are made from mustard seeds:

- A fatty vegetable oil resulting from pressing the seeds,
- An essential oil resulting from grinding the seeds, mixing them with water, and
- Extracting the resulting volatile oil by distillation.

Table: 3.2 Properties of Mustard oil

Density	285 kg/m^3
Flash point	220^{0}c
Fire point	260^{0}c

Fig:3.3 Mustard oil

3.3 Samples Preparation:

In dry powder evaluation, alumina nanoparticles were wetted, dispersed, and a drop of the aqueous alumina nanofluid was placed on a pre-cleaned glass slide. The slide was placed on a hot-plate until all the water evaporated and dry powder remained. This was done to promote the self-alignment of particles in a more uniform distribution across the glass surface.

To investigate the distribution of nanoparticle size in the nanofluids, mustard oil taken as a base fluid and aluminium oxide as filler for preparation of 1000 ml samples was prepared using mustard oil containing 1%wt, 2%wt and 3%wt alumina nanopowder. The level of the water bath was controlled equal to the height of the nanofluid in the glass. The ultrasonic bath was operated at 70 watts for increasing time durations until diminishing returns in particle size distributions were reached. Nanofluids subjected to the ultrasonic homogenizer were also placed in a water bath. The penetration depth of the processing tip into the solution was controlled to be a half inch and was operated at 160 watts. A water bath was also used for the ultrasonic homogenizer for heat management. Particle size distribution data was taken immediately after dispersion of each nanofluid sample.

Table: 3.3 weight percent of mustard oil and Al_2O_3 for sample preparation

Type of oil	Volume (ml)	Al_2O_3 (filler)		Mustard oil (base fluid)	
		%	grams	%	grams
Mustard + 1% Al_2O_3	1000	0.5	4.55	99.5	904.55
Mustard + 2% Al_2O_3	1000	1	9.1	99	900.9
Mustard + 3% Al_2O_3	1000	1.5	13.65	98.5	896.95

3.3.1 Magnetic stirring Process:

A magnetic stirrer or magnetic mixer is a laboratory device that employs a rotating magnetic field to cause a stir bar (also called "flea") immersed in a liquid to spin very quickly, thus stirring it. The rotating field may be created either by a rotating magnet or a set of stationary electromagnets, placed beneath the vessel with the liquid.

Magnetic stirrers are often used in chemistry and biology, where they can be used inside hermetically closed vessels or systems, without the need for complicated rotary seals. They are preferred over gear-driven motorized stirrers because they are quieter, more efficient, and have no moving external parts to break or wear out (other than the simple bar magnet itself). Magnetic stir bars work well in glass vessels commonly used for chemical reactions, as glass does not appreciably affect a magnetic field. The limited size of the bar means that magnetic stirrers can only be used for relatively small experiments, of 4 liters or less. Stir bars also have difficulty in dealing with viscous liquids or thick suspensions. For larger volumes or more viscous liquids, some sort of mechanical stirring is typically needed.

The figure 3.4 represents the stirring process.

Fig: 3.4 Amalgamation of Mustard (99 %) and 1% Al_2O_3 Sample preparation through stirring process

Because of its small size, a stirring bar is more easily cleaned and sterilized than other stirring devices. They do not require lubricants which could contaminate the reaction vessel and the product. Magnetic stirrers may also include a hot plate or some other means for heating the liquid.

A stir bar is the magnetic bar placed within the liquid which provides the stirring action. The stir bar's motion is driven by another rotating magnet or assembly of electromagnets in the stirrer device, beneath the vessel containing the liquid. Stir bars are typically coated in Teflon, or less often in glass. Glass coatings are used for liquid alkali metals (except lye, which will eat through glass) and alkali metal solutions in ammonia. Both coatings are chemically inert and do not contaminate or react with the reaction mixture.

The sample preparation of various weight percentages of Al_2O_3 with mustard oil represents Figure 3.5, Figure 3.6,Figure 3.7 .

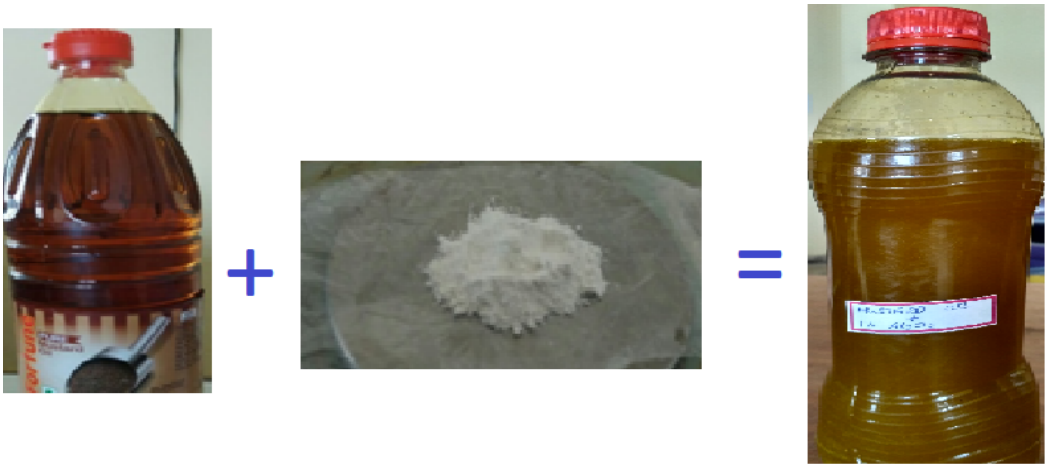


Figure:3.5 Prepared sample of Mustard oil + 1% Al_2O_3

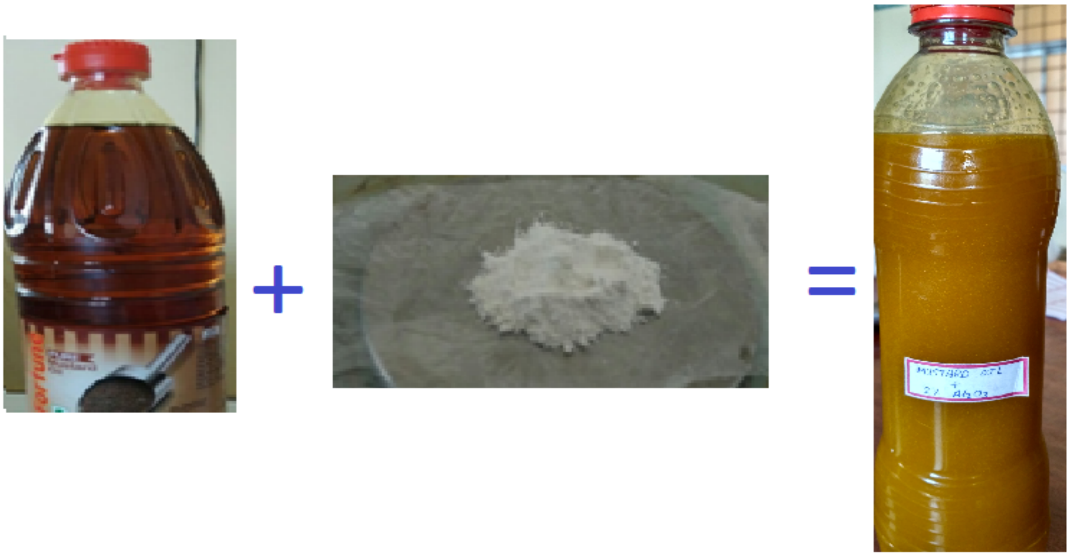


Figure:3.6 Prepared sample of Mustard oil + 2% Al_2O_3

Figure:3.7 Prepared sample of Mustard oil + 3% Al_2O_3

3.4 Thermal analysis for prepared samples :

In the previous paragraph described the preparation of Al_2O_3contained mustard oil with various weight percentages, and the main objective of this research to reduce the tool wear , tool and work piece temperature. Basically the lubricant fluid efficiency depends on the thermal properties particular fluid in this area prepared samples required to calculate thermal properties. In this section clearly indicating basic thermal properties of prepare samples such a tests are density, viscosity,calorific value,flash point and fire point.

Thermal analysis is a branch of materials science where the properties of materials are studied as they change with temperature. It is usual to control the temperature in a predetermined way - either by a continuous increase or decrease in temperature at a constant rate (linear heating/cooling) or by carrying out a series of determinations at different temperatures (stepwise isothermal measurements). More advanced temperature profiles have been developed which use an oscillating (usually sine or square wave) heating rate (Modulated Temperature Thermal Analysis) or modify the heating rate in response to changes in the system's properties (Sample Controlled Thermal Analysis).

In addition to controlling the temperature of the sample, it is also important to control its environment (e.g. atmosphere). Measurements may be carried out in air or under an inert gas (e.g. nitrogen or helium). Reducing or reactive atmospheres have also been used and measurements are even carried out with the sample surrounded by water or other liquids. Inverse gas chromatography is a technique which studies the interaction of gases and vapours with a surface - measurements are often made at different temperatures so that these experiments can be considered to come under the auspices of Thermal Analysis.

3.4.1 Importance of flash and fire point:

The flash point is the lowest temperature at which vapours of a volatile material will ignite, when given an ignition source. The flash point may sometimes be confused with the auto ignition temperature, which is the temperature at which the vapour ignites spontaneously without an ignition source. The fire point is the lowest temperature at which the vapour will keep burning after being ignited and the ignition source removed. The fire point is higher than the flash point, because at the flash point the vapour may be reliably expected to cease burning when the ignition source is removed. Neither flash point nor fire point depends directly on the ignition source temperature, but it may be understood that ignition source temperature will be considerably higher than either the flash or fire point.

All liquids have a specific vapour, which is a function of that liquid's temperature and is subject to Boyle's Law. As temperature increases, vapour pressure increases. As vapour pressure increases, the concentration of vapour of a flammable or combustible liquid in the air increases. Hence, temperature determines the concentration of vapour of the flammable liquid in the air. A certain concentration of a flammable or combustible vapour is necessary to sustain combustion in air, the lower flammable limit, and that concentration is different and is specific to each flammable or combustible liquid. The flash point is the lowest temperature at which there will be enough flammable vapour to induce ignition when an ignition source is applied. The figure 3.6 represents the flash and fire point equipment which is used in this research to calculate fire and flash point and the obtained results are tabulated in the table 3.4.

Figure: 3.8 Flash and Fire point equipment

3.4.1.2 Calculation of flash and fire point for Amalgamation of Mustard oil and Al_2O_3 lubricants:

Table :3.4 Fire and Flash points for Amalgamation of Mustard and Al_2O_3

Property	Pure mustard oil	1% Al_2O_3	2% Al_2O_3	3% Al_2O_3
Flash point	220^0c	200^0c	190^0c	190^0c
Fire point	260^0c	240^0c	220^0c	210^0c

3.4.2 Calculation of viscosity for Amalgamation of Mustard oil and Al_2O_3 lubricants:

The viscosity of a fluid is a measure of its resistance to gradual deformation by shear stress or tensile stress. For liquids, it corresponds to the informal concept of "thickness"; for example, honey has a much higher viscosity than water.

Viscosity is a property of the fluid which opposes the relative motion between the two surfaces of the fluid in a fluid that are moving at different velocities. When the fluid is forced through a tube, the particles which compose the fluid generally move more quickly near the tube's axis and more slowly near its walls; therefore some stress (such as a pressure difference between the two ends of the tube) is needed to overcome the friction between particle layers to keep the fluid moving. For a given velocity pattern, the stress required is proportional to the fluid's viscosity.

A fluid that has no resistance to shear stress is known as an ideal or in viscid fluid. Zero viscosity is observed only at very low temperatures in super fluids. Otherwise, all fluids have positive viscosity, and are technically said to be viscous or viscid. In common parlance, however, a liquid is said to be viscous if its viscosity is substantially greater than that of water, and may be described as mobile if the viscosity is noticeably less than water. A fluid with a relatively high viscosity, such as pitch, may appear to be a solid.The Figure: 3.7 represent the Viscocity of Al_2O_3 and result is tabulated in the table 3.6 – 3.8.

Figure: 3.9 Redwood Apparatus For Measuring the Viscocity of oil

3.4.2.1 Sample Calculation of viscosity for Amalgamation of Mustard oil and Al_2O_3 lubricants:

V = (0.26*time) – (171 / temperature).

At 40^0c time = 27.9 sec

V = (0.26*27.9) - (171/40)

= 2.979 mm^3/sec

Table :3.5 viscosity for pure mustard oil at various temperatures

Temperature(^{0}c)	Time(sec)	V=(0.26*time) - 171/(temp)
40	27.9	2.979
50	24	2.82
60	20.75	2.545
70	17.07	1.995
80	15.06	1.77

Table :3.6 viscosity for Amalgamation of Mustard oil (99 %) and 1% Al_2O_3 at various temperatures

Temperature(^{0}c)	Time(sec)	V=(0.26*time)-171/(temp)
40	30.6	3.681

50	27.2	3.685
60	23.16	3.1716
70	19.1	2.523
80	15.8	1.97

Table :3.7 viscosity for Amalgamation of Mustard oil (98 %) and 2 % Al_2O_3 at various temperatures

Temperature(^{0}c)	Time(sec)	V=(0.26*time)-171/(temp)
40	26	2.485
50	24	2.82
60	20	2.35
70	18	2.237
80	14.6	1.65

Table :3.8 viscosity for Amalgamation of Mustard oil (97 %) and 3% Al_2O_3 at various temperatures

Temperature(^{0}c)	Time(sec)	V=(0.26*time)-171/(temp)
40	24.40	2.669
50	23	2.56
60	19	2.09
70	16.30	1.795
80	13.62	1.403

3.4.3 Density for Amalgamation of Mustard oil and Al_2O_3 lubricants:

The density, or more precisely, the volumetric mass density, of a substance is its mass per unit volume. The symbol most often used for density is ρ (the lower case Greek letter rho), although the Latin letter D can also be used. Mathematically, density is defined as,

$$\rho = (\text{Mass}/\text{Volume})$$

where ρ is the density, m is the mass, and V is the volume. In some cases (for instance, in the United States oil and gas industry), density is loosely defined as its weight per unit volume, although this is scientifically inaccurate – this quantity is more specifically called weight. Figure 3.8 represents the weight of mustard oil.

Figure: 3.10 Weighing Machine

For a pure substance the density has the same numerical value as its mass concentration. Different materials usually have different densities, and density may be relevant to buoyancy, purity and packaging. Osmium and iridium are the densest known elements at standard conditions for temperature and pressure but certain chemical compounds may be denser.

Figure 3.11 Prepared samples with 0%, 1% , 2%, 3% Al_2O_3 in Mustard oil

Table :3.9 Density for Amalgamation of Mustard oil and Al_2O_3

Property	**Pure mustard oil**	**1% Al_2O_3**	**2% Al_2O_3**	**3% Al_2O_3**
Density(gr/ml)	0.91	0.919	0.929	0.937

Table :3.10 Themal properties for Amalgamation of Mustard oil and Al_2O_3

Property	**Pure mustard oil**	**1% Al_2O_3**	**2% Al_2O_3**	**3% Al_2O_3**
Density	0.91	0.919	0.929	0.937
Viscosity (40 ^{0})	2.979	3.681	2.485	2.669
Fire point	220^0c	200^0c	190^0c	190^0c
Flash point	260^0c	240^0c	220^0c	210^0c

From the above results we observe that viscosity is higher for Amalgamation of Mustard oil and 1% of Al_2O_3, flash and fire point is high for pure mustard oil.

CHAPTER 4

EXPERIMENTAL EVALUATION OF THERMAL POPERTIES USING Al_2O_3 AND MUSTARD OIL AMALGAMATION NANO LUBRICANTS ON MACHINING

In this chapter calculating the effect of Amalgamation of Mustard oil and Al_2O_3 nano lubricants on the performance of turning process using all geared lathe machine. For this analysis lubricants are used those which are prepared with various weight percentages and tested their basic thermal properties previously.

4.1 Materials used In Experimentation:

In the present experiment EN8 with diameter ø32mm and length 200 mm work material shown in Figure 4.1 and EN8 properties are tabulated in table 4.1. And different lubricants are 0%, 1%, 2%, 3% Al_2O_3 Amalgamation of Mustard oil nano lubricants shown in table 4.2 and in figure 4.2. Generally these materials are commonly used grade in automobile industries and machine tool industries. Chemical composition of the two different materials.

4.1.1 Work Piece EN8:

The term Mild Steel applies to all low carbon Steel that does not contain any alloying elements in its makeup and has a carbon content that does not exceed 0.25%. The term “Mild” is used to cover a wide range of specifications and forms for a variety of Steel.

Mild Steel is used in mechanical engineering applications for parts that will not be subject to high stress. When in its bright cold drawn condition the steel is able to endure higher levels of stress, particularly on smaller diameters. Compared to normal Mild Steel, bright Mild Steel provides tighter sectional tolerances, increased straightness, and a much cleaner surface. The main advantage of cold drawn Steel is that Steel can be brought closer to the finished machine size, reducing machining costs. Another benefit of bright Steel bars is a marked increase in physical strength over hot rolled bars of the same section.

EN8: unalloyed medium carbon Steel (BS 970 080m40) has high strength levels compared to normal bright Mild Steel, due to thermo mechanical rolling. EN8 is suitable for all round engineering purposes that may require a Steel of greater strength.

Fig: 4.1 EN8 (AISI 1040)

Table 4.1 Properties of Work piece (EN8):

PARAMETERS	**VALUES**
Maximum stress	700-850 N/mm^2
Yield stress	465 N/mm^2 Min
Hardness	201-255 Brinell
Elongation	16% min

4.1.2 Amalgamation of Mustard oil and Al_2O_3 lubricants:

Figure 4.2 Prepared samples with 0%, 1% , 2%, 3% Al_2O_3 in Mustard oil

Table :4.2 Themal properties for Amalgamation of Mustard oil and Al_2O_3

Property	**Pure mustard oil**	**1% Al_2O_3**	**2% Al_2O_3**	**3% Al_2O_3**
Density (gram/ml)	0.91	0.919	0.928	09373
Viscosity (40 ^{o}c)	2.979	3.681	2.485	2.669
Fire point (^{o}c)	220	200	190	190
Flash point (^{o}c)	260	240	220	210

4.2 Importance of Lathe Machine:

Machining is one of the most important material removal methods in the technology of manufacturing. It is basically a collection of material working processes that involves other processes such as drilling, shaping, sawing, planning, reaming, and grinding among others. Machining is practically a part of the manufacture of all metals and other materials such as plastics, and wood as well. An important machine that is useful in machining is the lathe machine.

Fig: 4.3 All Geared Lathe machine

A lathe machine is generally used in metalworking, metal spinning, woodturning, and glass working. The various operations that it can perform include the following: sanding, cutting, knurling, drilling, and deforming of tools that are employed in creating objects which have symmetry about the axis of rotation. Some of the most common products of the lathe machine are crankshafts, camshafts, table legs, bowls, and candlestick holders.

4.3 Flow meter Measurement:

Flow measurement is the quantification of bulk fluid movement. Flow can be measured in a variety of ways. Positive-displacement flow meters accumulate a fixed volume of fluid and then count the number of times the volume is filled to measure flow. Other flow measurement methods rely on forces produced by the flowing stream as it overcomes a known constriction, to indirectly calculate flow. Flow may be measured by measuring the velocity of fluid over a known area.

A positive displacement meter may be compared to a bucket and a stopwatch. The stopwatch is started when the flow starts, and stopped when the bucket reaches its limit. The volume divided by the time gives the flow rate. For continuous measurements, we need a system of continually filling and emptying buckets to divide the flow without letting it out of the pipe.

Fig: 4.4 Flow meter Measurement

4.3.1 Flow meter Calculation procedure:

For flow rate:

Area of collecting tank = $\pi/4(52.5)^2$

$= 2136mm^2$

stage1:

Time = 120sec

Q= (A*L)/T mm^3/sec

Length = 6mm

Discharge=(2163.6*6)/120

= 108.8 mm^3/sec

stage 2:

Time = 120sec

Length= 9.5mm

Q=(2163.6*9.5)/120

=171.23 mm^3/sec

Stage 3

Time = 60sec

Length= 11mm

Q=(2163.6*11)/60

=396.55 mm^3/sec.

4.4 Surface roughness:

Surface roughness often shortened to roughness, is a component of surface texture. It is quantified by the deviations in the direction of the normal vector of a real surface from its ideal form. If these deviations are large, the surface is rough; if they are small, the surface is smooth. Roughness is typically considered to be the high-frequency, short-wavelength component of a measured surface (see surface metrology). However, in practice it is often necessary to know both the amplitude and frequency to ensure that a surface is fit for a purpose.

Roughness plays important roles in determining how a real object will interact with its environment Rough surface usually wear more quickly and have higher friction coefficients than smooth surfaces (see tribology). Roughness is often a good predictor of the performance of a mechanical component, since irregularities in the surface may form nucleation sites for cracks or corrosion. On the other hand, roughness may promote adhesion.

Fig: 4.5 Surface Roughnesses

Although a high roughness value is often undesirable, it can be difficult and expensive to control in manufacturing. Decreasing the roughness of a surface will usually increase its manufacturing costs. This often results in a trade-off between the manufacturing cost of a component and its performance in application.

Roughness can be measured by manual comparison against a “surface roughness comparator”, a sample of known surface roughness’s, but more generally a surface profile measurement is made with a profilometer that can be contact (typically a diamond stylus) or optical (e.g. a white light interferometer or laser scanning co focal microscope).

4.5 Tool Maker’s Microscope:

The tool maker’s microscope is a versatile instrument that measure by optical means with no pressure being involved, thus very useful for measurement on small and delicate parts. It is designed for:

a) Measurement on parts of complex form e.g. - profile of external thread, tool, templates, gauges, etc.

b) Measuring centre to centre distance of holes in any plane.

c) A variety of linear measurements.

d) Accurate angular measurements

Fig: 4.6 Tool makers Microscope

4.5.1 Principle of measurement:

A ray of light from a light source is reflected by a mirror through 90’ It then passes through a transparent glass plate (on which flat parts may be placed). A shadow image of the outline or counter of the workspaces passes through the objective of the optical head and is projected by a system of three prisms to a ground glass screen. Observations are made through an eyepiece. Measurements are made by means of cross lines engraved on the ground glass screen. The screen can be rotated through 360’; the angle of rotation is read through an auxiliary eyepiece.

4.6 Temperature Gun Measurement:

Temperature guns have electronic sensors that enable them to collect the amount of heat energy coming from a given object whose temperature would otherwise be difficult to measure. These guns often use infrared beams and you only have to aim at the object whose temperature you are interested in measuring without having to touch it. The sensors have the capability to collect the accurate temperature provided the gadget is functional. There are however some basics that you must know in order to use these temperature guns correctly.

Fig: 4.7 Temperature gun

First, the temperature gun uses beams to collect information on the heat energy that is coming from a given object. Thus, the gun does not state whether the heat is coming from the intended object or the surroundings. This means that in order to collect the right temperature measurement, you will have to ensure that you point the gun directly at the object whose temperature you intend to measure. You need to be as close as possible to avoid reading other heat waves that may interfere with your reading’s accuracy. The gun will only read the heat energy on the area where it is pointing, and for accuracy, you must aim directly at the object whose temperature you intend to measure.

4.7 Machining operation on workpiece using Amalgamation of Mustard oil and Al_2O_3:

For testing the cooling performance of tool and work piece on the lathe machine we use Amalgamation of Mustard oil and Al_2O_3 as a lubricant. Work piece is fixed into the chuck and tool is fixed on the tool holder. The machining is done at speed 190 rpm, depth of cut at 1&2 mm and feed rate at 0.4&0.6 rev/min. The turning operation is performed on the work piece by pouring the lubricant (Amalgamation of Mustard oil and Al_2O_3) on the work piece at 1%, 2%, and 3% wt. The figure 4.9 represents the supplying of lubricant to the work piece.

The temperature of tool and work piece is measured by using temperature gun and surface should be measured with Taly surf equipment. The figure 4.8 represents the turning operation on the work piece.

Fig: 4.8 Surface Machining

Fig: 4.9 Machining with pure mustard oil

The coolant is supplied on the work piece we observe that temperature decreases at 2% wt of Al_2O_3 and tool temperature also decreases. So that Amalgamation of Mustard oil and Al_2O_3 gives the better performance than the present lubricants.

CHAPTER 5

RESULTS AND DISCUSSION

This chapter deals with the results obtained and the discussions based on the machining operation carried out on EN8 steel. Results are obtained for depth of cut surface roughness, tool wear, tool and work piece temperature.

5.1 Experimental analysis outcomes at various machining and lubricant conditions

This chapter present the results of chemical composition of workpiece material, Physico chemical analysis of the oil samples. The percentage oil yield for the vegetable oils, graphical representation of temperature with specified spindle speed at 190rpm, chip thickness with specified spindle speed, surface roughness with specified spindle speed and surface roughness with feed rate respectively for all the various cutting fluids and dry drilling environment.

Table 5.1: output parameters of machining without lubricant at machining conditions Speed=190 rpm, feed=0.4& 0.6 mm/rev, and depth=1&2mm

Speed	Feed	Depth Of cut (mm)	Temperature(ºc)		Surface Roughness Ra (µm)	Tool Wear (mm)
			Tool	Work piece		
190rpm	0.4 mm/rev	1	45	50.8	5.3	0.05
		2	49.3	52.8	6.4	0.062
	0.6 mm/rev	1	46.3	48.9	6.9	0.053
		2	50.8	50.3	7.5	0.064

In the above table it represents that tool temperature is lower at feed 0.4mm/rev, depth 1mm ,work piece temperature lower at feed 0.6mm/rev, depth 1mm,,surface roughness is higher at feed 0.4mm/rev,depth 2mm and tool wear at feed 0.4mm/rev, depth 1mm.

Table 5.2: output parameters of machining with pure Mustard oil at machining conditions Speed=190 rpm, feed=0.4& 0.6 mm/rev, and depth=1&2mm

Speed	Feed	Depth Of cut (mm)	Temperature(^{o}c)		Surface Roughness Ra (µm)	Tool Wear (mm)
			Tool	Work piece		
190rpm	0.4 mm/rev	1	44	49.8	5.2	0.04
		2	48	51.6	6.3	0.059
	0.6 mm/rev	1	45.3	47.8	6.8	0.048
		2	49.8	49.8	7.3	0.063

In the above table it represents that tool temperature is lower at feed 0.4mm/rev, depth 1mm work piece temperature lower at feed 0.6mm/rev, depth 1mm,,surface roughness is higher at feed 0.4mm/rev,depth 2mm and tool wear is higher at feed 0.4mm/rev, depth 1mm.

Table 5.3: output parameters of machining with Amalgamation of Mustard oil and 0.5 % Al_2O_3 at machining conditions Speed=190 rpm, feed=0.4& 0.6 mm/rev, and depth=1&2mm

Speed	Feed	Depth Of cut (mm)	Temperature(^{o}c)		Surface Roughness Ra (µm)	Tool Wear (mm)
			Tool	Work piece		
190 rpm	0.4 mm/rev	1	42.6	47.9	4.8	0.048
		2	46.4	47.9	6	0.058
	0.6 mm/rev	1	42	45.8	6.3	0.049
		2	47.9	47.6	6.9	0.058

In the above table it represents that tool temperature is lower at feed 0.6mm/rev, depth 2mm, work piece temperature lower at feed 0.6mm/rev, depth 1mm, surface roughness is higher at feed 0.4mm/rev ,depth 1mm and tool wear at feed 0.4mm/rev, depth 1mm.

Table 5.4: output parameters of machining with Amalgamation of Mustard oil and 1 % Al_2O_3 at machining conditions Speed=190 rpm, feed=0.4& 0.6 mm/rev, and depth=1&2mm

Speed	Feed	Depth Of cut (mm)	Temperature(ºc)		Surface Roughness Ra (µm)	Tool Wear (mm)
			Tool	Work piece		
190 rpm	0.4 mm/rev	1	37.3	43	4.2	0.046
		2	42.3	39.8	5.3	0.045
	0.6 mm/rev	1	39.3	41.3	5.9	0.04
		2	43	43.6	6.1	0.046

In the above table it represents that tool temperature is lower at feed 0.4mm/rev, depth 1mm,work piece temperature lower at feed 0.4mm/rev, depth 2 mm, surface roughness is higher at feed 0.4mm/rev ,depth 1mm and tool wear at feed 0.6mm/rev, depth 1mm

Table 5.5: output parameters of machining with Amalgamation of Mustard oil and 2 % Al_2O_3 at machining conditions Speed=190 rpm, feed=0.4& 0.6 mm/rev, and depth=1&2mm

Speed	Feed	Depth Of cut (mm)	Temperature(ºc)		Surface Roughness Ra (µm)	Tool Wear (mm)
			Tool	Work piece		
190 rpm	0.4 mm/rev	1	37.9	44.8	3.8	0.032
		2	44.2	43.1	4.8	0.038
	0.6 mm/rev	1	41.8	43	5.1	0.036
		2	44.8	45.3	5.6	0.04

In the above table it represents that tool temperature is lower at feed 0.4mm/rev, depth 1mm,work piece temperature lower at feed 0.6mm/rev, depth 1mm, surface roughness is higher at feed 0.4mm/rev ,depth 1mm and tool wear at feed 0.4mm/rev, depth 1mm.

Table 5.6: output parameters of machining with Amalgamation of Mustard oil and 3 % Al_2O_3 at machining conditions Speed=190 rpm, feed=0.4& 0.6 mm/rev, and depth=1&2mm

Speed	Feed	Depth Of cut (mm)	Temperature(°c)		Surface Roughness Ra (µm)	Tool Wear (mm)
			Tool	Work piece		
190 rpm	0.4 mm/rev	1	38.3	46.1	3.8	0.034
		2	45.3	44.9	5.1	0.037
	0.6 mm/rev	1	43.1	44.2	5.4	0.039
		2	46.1	46.01	6.3	0.048

In the above table it represents that tool temperature is lower at feed 0.4mm/rev, depth 1mm,work piece temperature lower at feed 0.6mm/rev, depth 1mm, surface roughness is higher at feed 0.4mm/rev ,depth 1mm and tool wear at feed 0.4mm/rev, depth 1mm.

Table 5.7: output parameters of machining with Amalgamation of Mustard oil and 4 % Al_2O_3 at machining conditions Speed=190 rpm, feed=0.4& 0.6 mm/rev, and depth=1&2mm

Speed	Feed	Depth Of cut (mm)	Temperature(°c)		Surface Roughness Ra (µm)	Tool Wear (mm)
			Tool	Work piece		
190 rpm	0.4 mm/rev	1	38.9	46.9	4.2	0.039
		2	45.9	45.6	5.3	0.042
	0.6 mm/rev	1	44.3	44.9	6.1	0.043
		2	46.9	44.5	6.9	0.052

In the above table it represents that tool temperature is lower at feed 0.4mm/rev, depth 1mm,work piece temperature lower at feed 0.6mm/rev, depth 1mm, surface roughness is higher at feed 0.4mm/rev ,depth 1mm and tool wear at feed 0.4mm/rev, depth 1mm.

5.2 Graphical representations of the results:

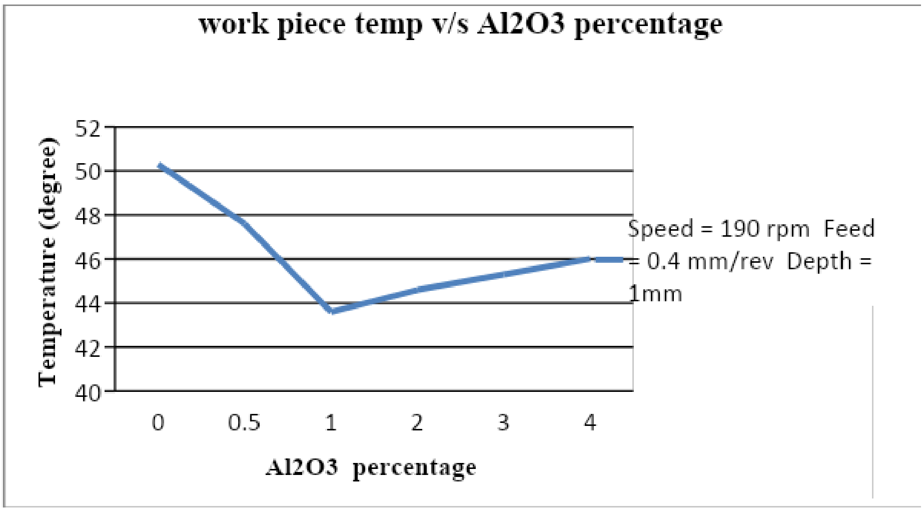


Fig: 5.1 variation of Work piece temp for varying % of Al_2O_3 reinforced mustard oil at speed=190rpm, feed=0.4mm/rev, depth=1mm

The figure 5.1 represents that work piece temperature is lower at 1% wt of Al_2O_3 at speed=190 rpm, feed=0.4mm/rev, depth=1mm and higher work piece temperature is obtained at 0% Al_2O_3.

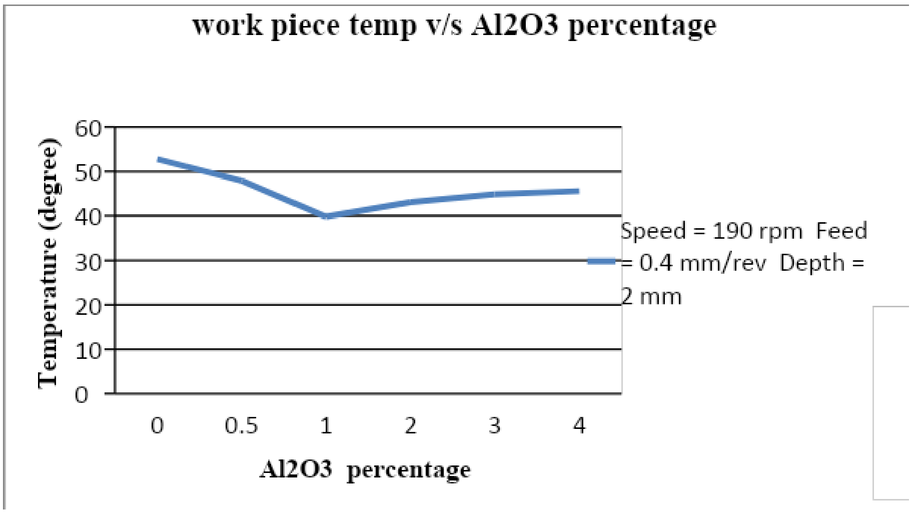


Fig: 5.2 variation of Work piece temp for varying % of Al_2O_3 reinforced mustard oil at speed=190rpm,feed=0.4mm/rev, depth=2mm

The figure 5.2 represents that work piece temperature is lower at 1% wt of Al_2O_3 at speed=190 rpm, feed=0.4mm/rev, depth=2mm and higher work piece temperature is obtained at 0% Al_2O_3.

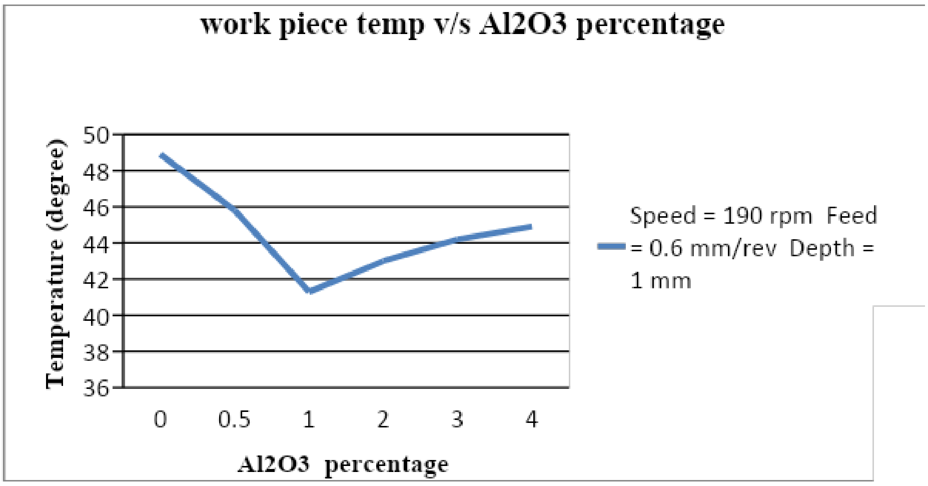


Fig: 5.3 variation of Work piece temp for varying % of Al_2O_3 reinforced mustard oil at speed=190rpm,feed=0.6mm/rev, depth=1mm

The figure 5.3 represents that work piece temperature is lower at 1% wt of Al_2O_3 at speed=190 rpm, feed=0.6mm/rev, depth=1mm and higher work piece temperature is obtained at 0% Al_2O_3.

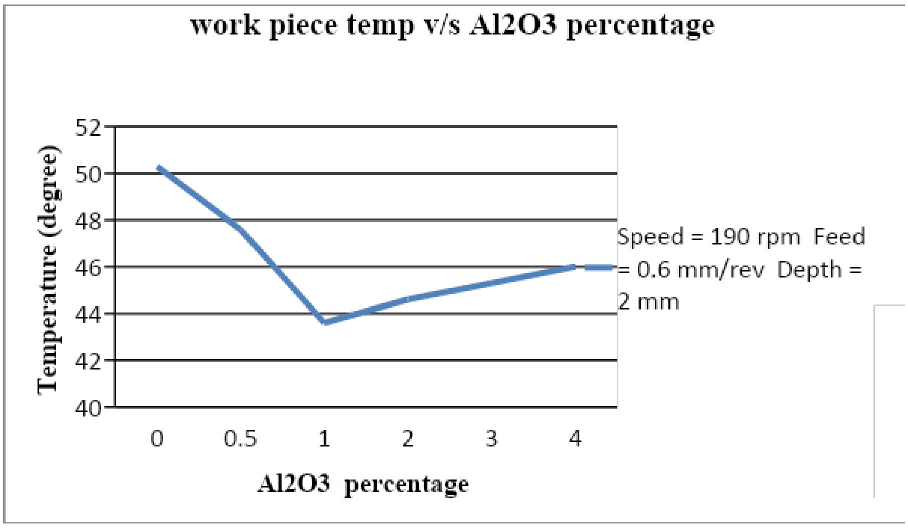


Fig: 5.4 variation of Work piece temp for varying % of Al_2O_3 reinforced mustard oil at speed=190rpm,feed=0.6mm/rev, depth=2mm

The figure 5.4 represents that work piece temperature is lower at 1% wt of Al_2O_3 at speed=190 rpm, feed=0.6mm/rev, depth=2mm and higher work piece temperature is obtained at 0% Al_2O_3.

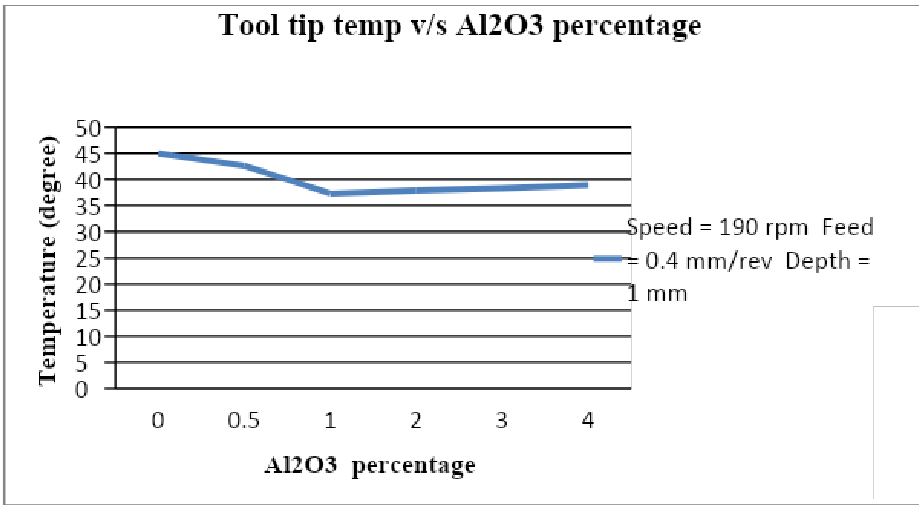


Fig: 5.5 variation of tool tip temp for varying % of Al_2O_3 reinforced mustard oil at speed=190rpm, feed=0.4mm/rev, depth=1mm

The figure 5.5 represents that tool tip temperature is lower at 1% wt of Al_2O_3 at speed=190 rpm, feed=0.4mm/rev, depth=1mm and higher tool tip temperature is obtained at 0% of Al_2O_3.

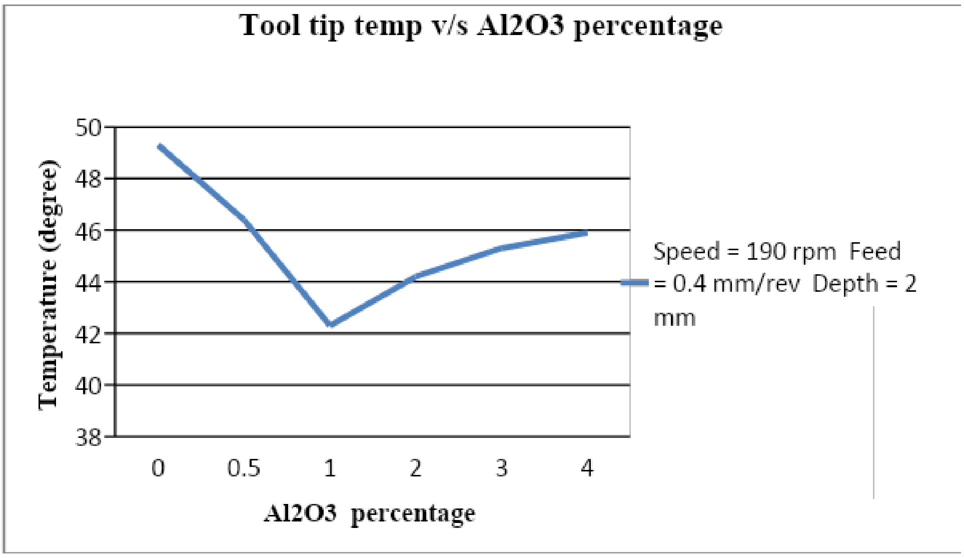


Fig: 5.6 variation of tool tip temp for varying % of Al_2O_3 reinforced mustard oil at speed=190rpm,feed=0.4mm/rev, depth=2mm

The figure 5.6 represents that tool tip temperature is lower at 1% wt of Al_2O_3 at speed=190 rpm, feed=0.4mm/rev, depth=2mm and higher tool tip temperature is obtained at 0% of Al_2O_3.

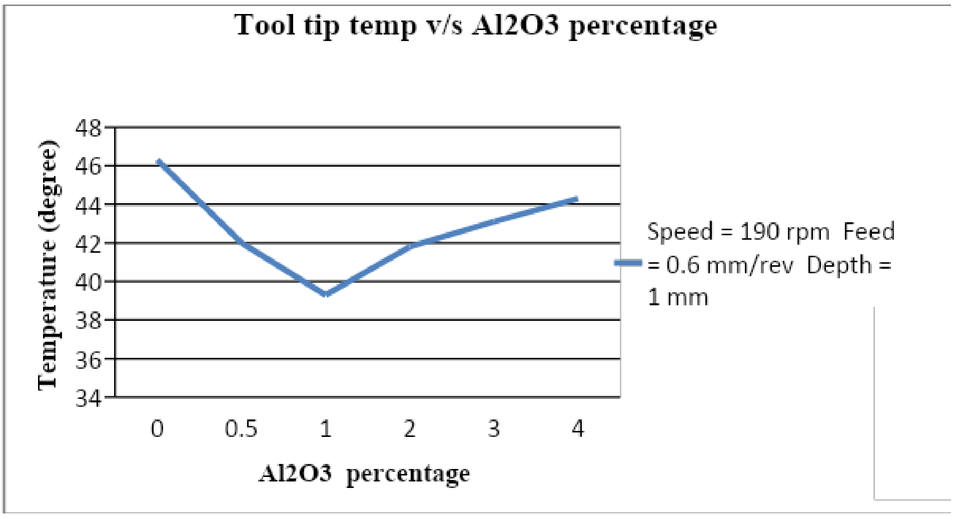


Fig: 5.7 variation of tool tip temp for varying % of Al_2O_3 reinforced mustard oil at speed=190rpm,feed=0.6mm/rev, depth=1mm

The figure 5.7 represents that tool tip temperature is lower at 1% wt of Al_2O_3 at speed=190 rpm, feed=0.6mm/rev, depth=1mm and higher tool tip temperature is obtained at 0% of Al_2O_3.

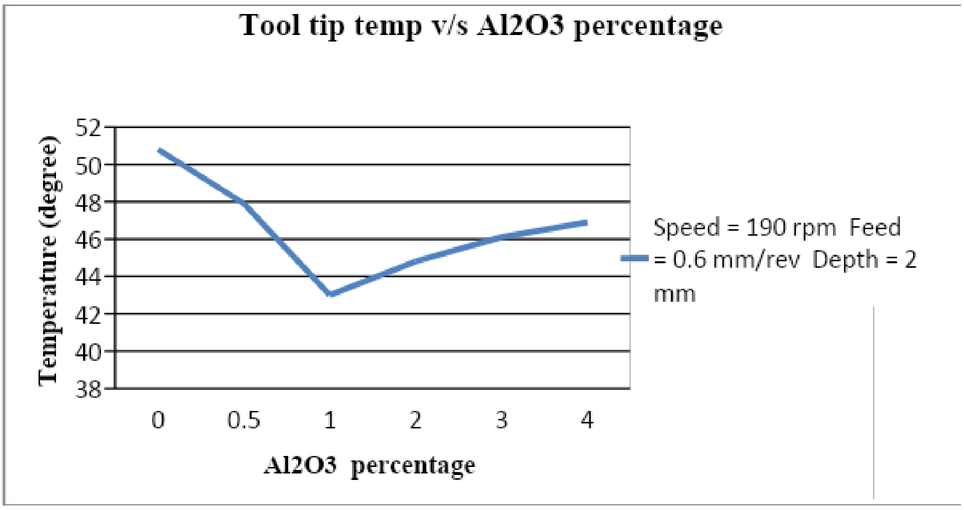


Fig: 5.8 variation of tool tip temp for varying % of Al_2O_3 reinforced mustard oil at speed=190rpm,feed=0.6mm/rev, depth=2mm

The figure 5.8 represents that tool tip temperature is lower at 1% wt of Al_2O_3 at speed=190 rpm, feed=0.6mm/rev, depth=2mm and higher tool tip temperature is obtained at 0% of Al_2O_3.

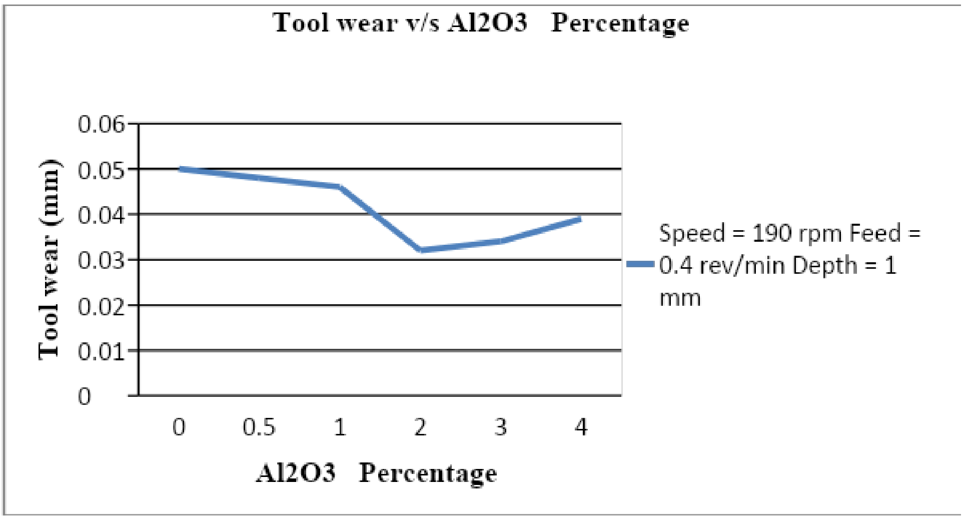


Fig: 5.9 variation of tool wear for varying % of Al_2O_3 reinforced mustard oil at speed=190rpm,feed=0.4mm/rev, depth=1mm

The figure 5.9 represents that tool wear is lower at 2% wt of Al_2O_3 at speed=190 rpm, feed=0.4mm/rev, depth=1mm and higher tool wear is obtained at 0% of Al_2O_3.

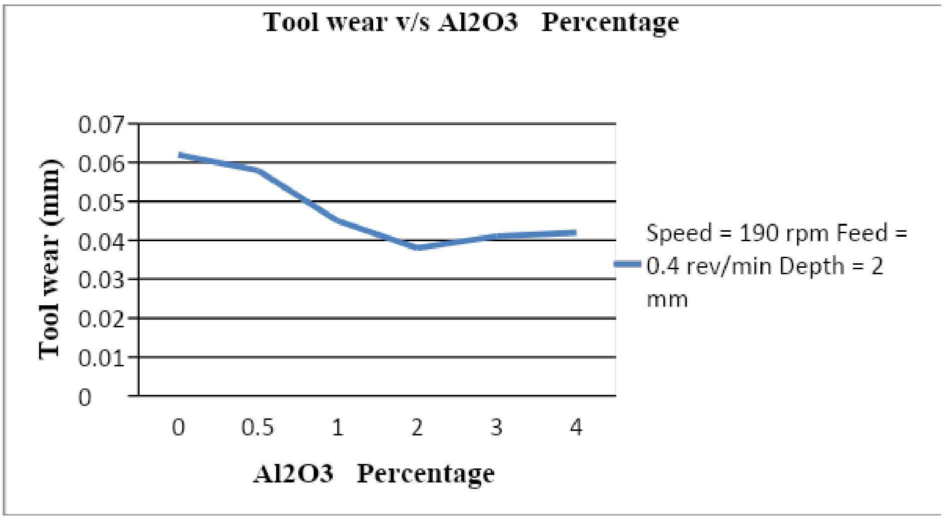


Fig: 5.10 variation of tool wear for varying % of Al_2O_3 reinforced mustard oil at speed=190rpm,feed=0.4mm/rev, depth=2mm

The figure 5.10 represents that tool wear is lower at 2% wt of Al_2O_3 at speed=190 rpm, feed=0.4mm/rev, depth=2mm and higher tool wear is obtained at 0% of Al_2O_3.

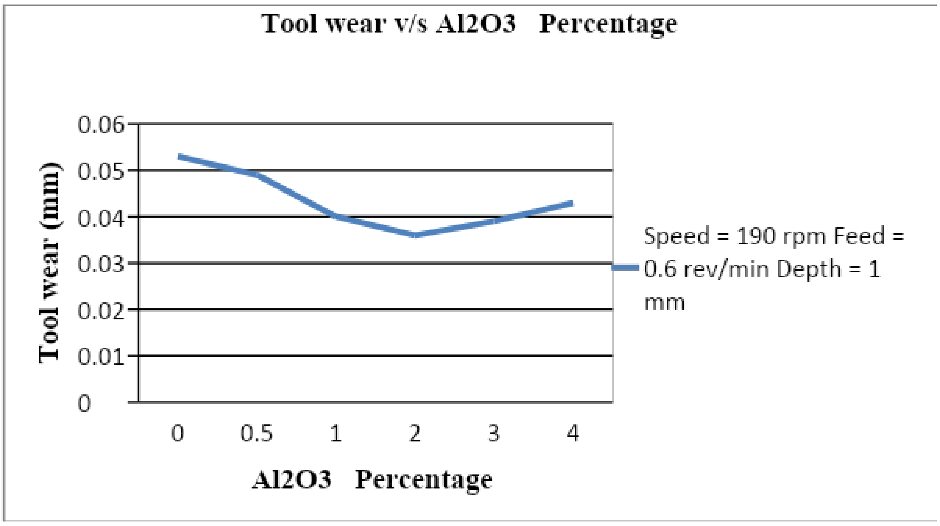


Fig: 5.11 variation of tool wear for varying % of Al_2O_3 reinforced mustard oil at speed=190rpm,feed=0.6mm/rev, depth=1mm

The figure 5.11 represents that tool wear is lower at 2% wt of Al_2O_3 at speed=190 rpm, feed=0.6mm/rev, depth=1mm and higher tool wear is obtained at 0% of Al_2O_3.

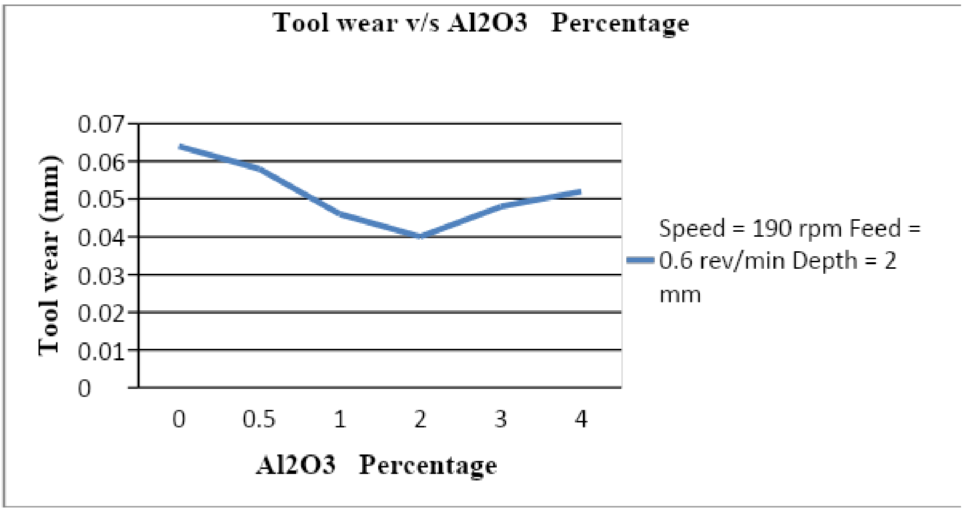


Fig: 5.12 variation of tool wear for varying % of Al_2O_3 reinforced mustard oil at speed=190rpm,feed=0.6mm/rev, depth=2mm

The figure 5.12 represents that tool wear is lower at 2% wt of Al_2O_3 at speed=190 rpm, feed=0.6mm/rev, depth=2mm and higher tool wear is obtained at 0% of Al_2O_3.

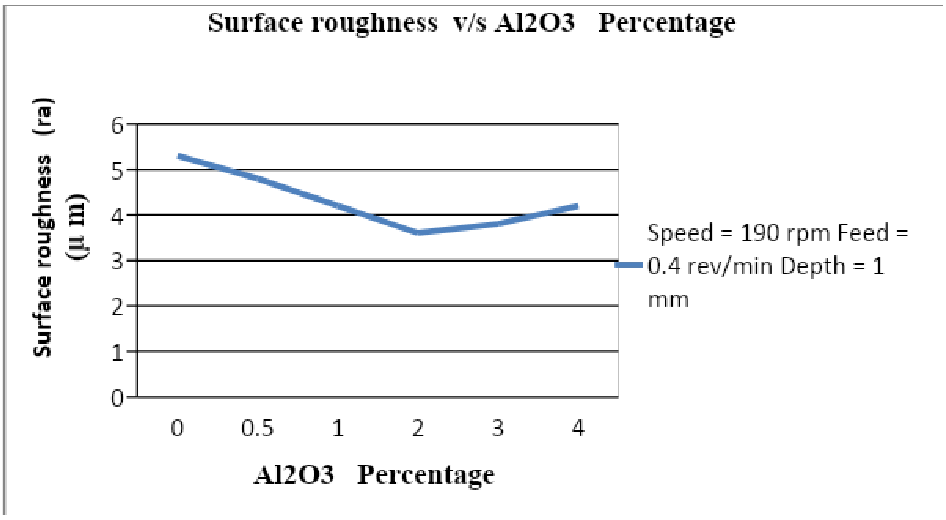


Fig: 5.13 variation of surface roughness for varying % of Al_2O_3 reinforced mustard oil at speed=190rpm,feed=0.4mm/rev, depth=1mm

The figure 5.13 represents that surface roughness is lower at 2% wt of Al_2O_3 at speed=190 rpm, feed=0.4mm/rev, depth=1mm and higher surface roughness is obtained at 0% of Al_2O_3.

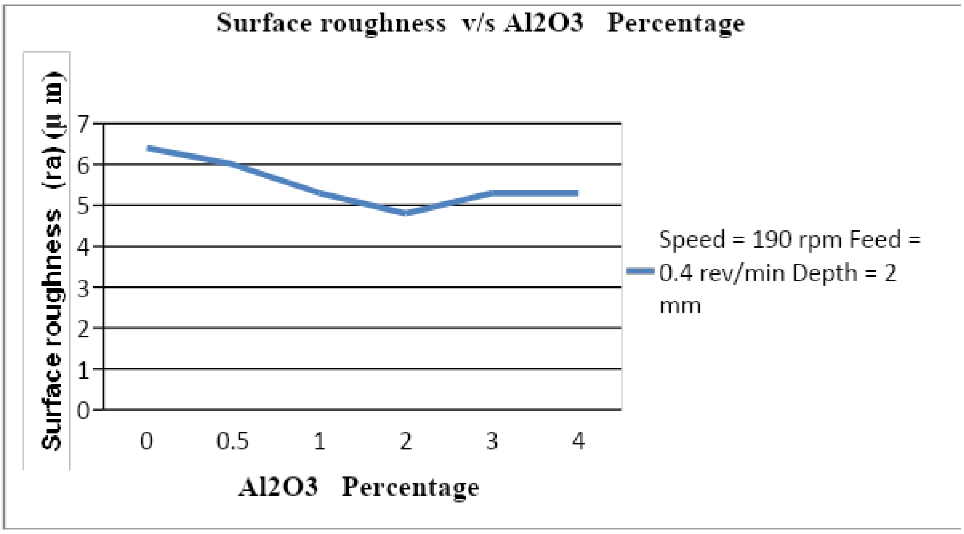


Fig: 5.14 variation of surface roughness for varying % of Al_2O_3 reinforced mustard oil at speed=190rpm,feed=0.4mm/rev, depth=2mm

The figure 5.14 represents that surface roughness is lower at 2% wt of Al_2O_3 at speed=190 rpm, feed=0.4mm/rev, depth=2mm and higher surface roughness is obtained at 0% wt of Al_2O_3.

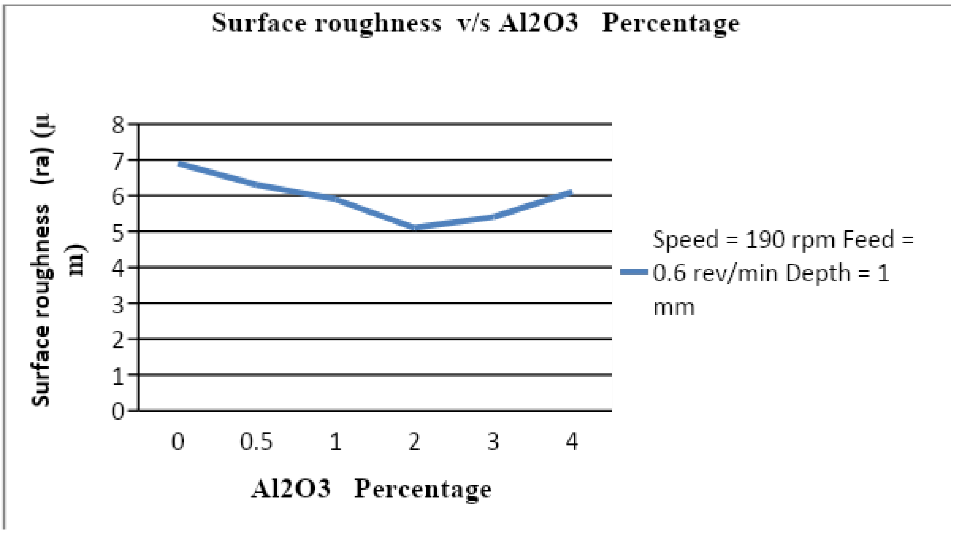


Fig: 5.15 variation of surface roughness for varying % of Al_2O_3 reinforced mustard oil at speed=190rpm,feed=0.6mm/rev, depth=1mm

The figure 5.15 represents that surface roughness is lower at 2% wt of Al_2O_3 at speed=190 rpm, feed=0.6mm/rev, depth=1mm and higher surface roughness is obtained at 0% of Al_2O_3.

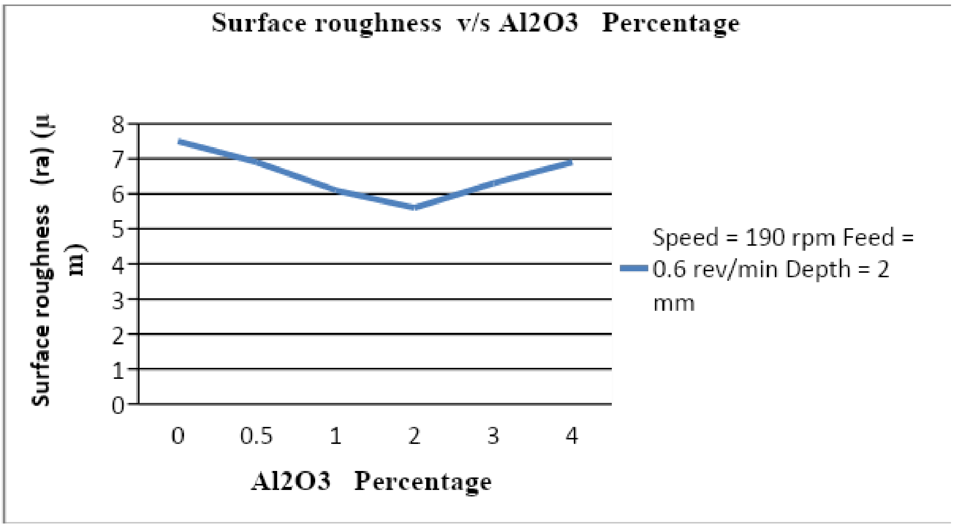


Fig: 5.16 variation of surface roughness for varying % of Al_2O_3 reinforced mustard oil at speed=190rpm,feed=0.6mm/rev, depth=2mm

The figure 5.15 represents that surface roughness is lower at 2% wt of Al_2O_3 at speed=190 rpm, feed=0.6mm/rev, depth=2mm and higher surface roughness is obtained at 0% of Al_2O_3.

5.2 Chip Formation:

The chip formations are investigated to turning AISI 1040 mild steel using high speed steel tool under dry and MQL with different cutting fluids conditions with a spindle speed of 190 rpm and feed rate of 0.4 mm/rev and 0.6mm/rev. The surface roughness of a turning surface depends on the nature of chip removal from the cutting zone. The chip formation examination would give a clear view of the machining parameter influencing the tool wear and surface roughness. During the turning process, chips were collected and examined for general characteristics. On observing the nature of chip formation, chips are short and no curls material is formed. This makes the chips disposal easier from the machined surface; the hard AISI 1040 mild steel particles act as regions of crack propagation, and hence act as effective chip breakers.

In this study, the performances of Amalgamation of Mustard oil and Al_2O3 based cutting fluid were compared with dry condition during machining AISI 1040 mild steel. The chip formation rates of the work-piece using as Amalgamation of Mustard oil and Al_2O3 cutting fluids under cutting speed (190 rev / min) and feed rate (0.4 &0.6 mm/rev) were compared with Amalgamation of Mustard oil and Al_2O3 and dry machining.


(a) (b) (c) (d)

Figure 5.17 Different forms of chips for the EN8 material with various machining parameters and without lubricant

Figure 5.1 (a)-(d) represents the different types of chip formations at different operating conditions of lathe without using any lubricant of machining EN8 material. And the operating conditions are constant speed that is 190 rpm, depths are 1mm and 2mm. In this analysis tool feed varying from 0.4 mm/rev and 0.6 mm/rev. From the above figures continuous chips are obtained at feed rate of 0.4 mm/rev and at 1mm depth.

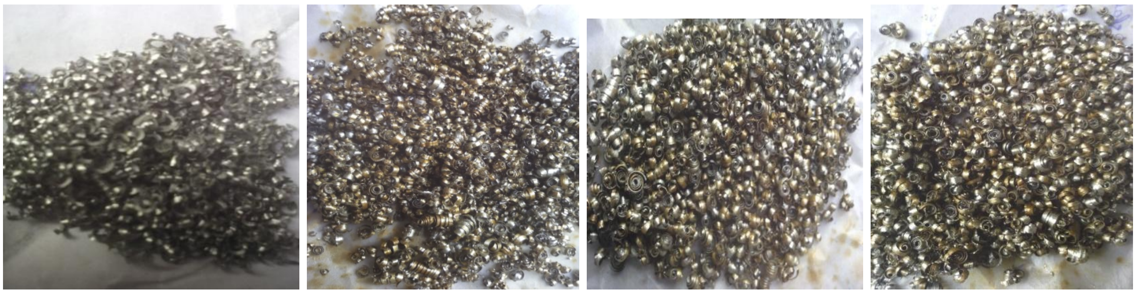
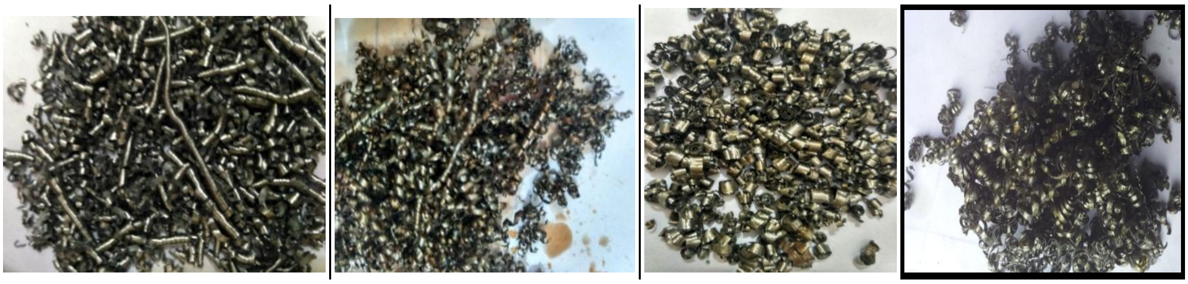

(a) (b) (c) (d)

Figure 5.18 Different forms of chips for the EN8 material with various machining parameters and with pure mustard oil

Figure (a)-(d) represents the different types of chip formations at different operating conditions of lathe with using pure mustard oil of machining EN8 material. And the operating conditions are constant speed that is 190 rpm, depths are 1mm and 2mm. In this analysis tool feed varying from 0.4 mm/rev and 0.6 mm/rev. From the above figures discontinuous chips are obtained at feed rate of 0.4 mm/rev and at 1mm depth.



(a) (b) (c) (d)

Figure 5.19 Different forms of chips for the EN8 material with various machining parameters and with Amalgamation of Mustard oil and Al_2O_3

Figure (a)-(d) represents the different types of chip formations at different operating conditions of lathe with using Amalgamation of Mustard oil and Al_2O_3 at 0.5% of machining EN8 material. And the operating conditions are constant speed that is 190 rpm, depths are 1mm and 2mm. In this analysis tool feed varying from 0.4 mm/rev and 0.6 mm/rev. From the above figures discontinuous chips are obtained at feed rate of 0.4 mm/rev and at 1mm depth.

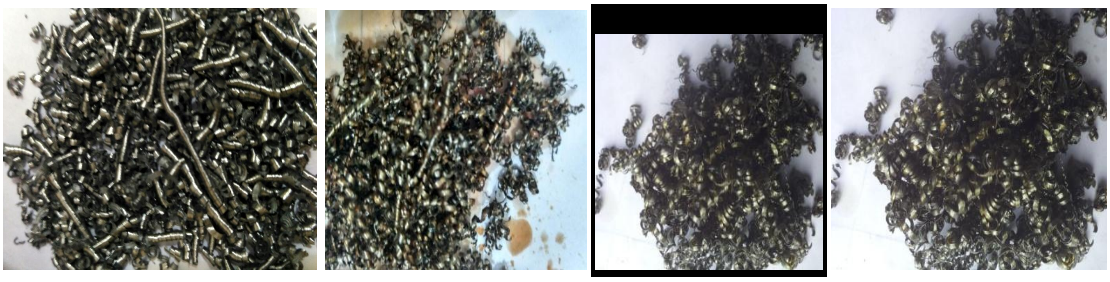


Figure 5.20 Different forms of chips for the EN8 material with various machining parameters and with Amalgamation of Mustard oil and Al_2O_3

Figure (a)-(d) represents the different types of chip formations at different operating conditions of lathe with using Amalgamation of Mustard oil and Al_2O_3 at 1% of machining EN8 material. And the operating conditions are constant speed that is 190 rpm, depths are 1mm and 2mm. In this analysis tool feed varying from 0.4 mm/rev and 0.6 mm/rev. From the above figures discontinuous chips are obtained at feed rate of 0.4 mm/rev and at 1mm depth.

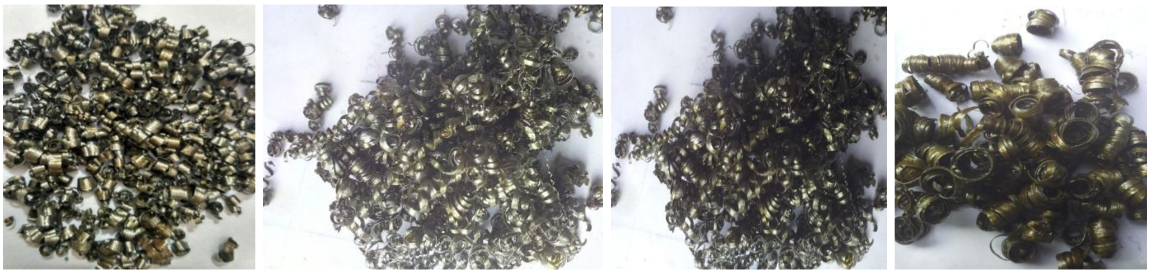


Figure 5.21 Different forms of chips for the EN8 material with various machining parameters and with Amalgamation of Mustard oil and Al_2O_3

Figure (a)-(d) represents the different types of chip formations at different operating conditions of lathe with using Amalgamation of Mustard oil and Al_2O_3 at 2% of machining EN8 material. And the operating conditions are constant speed that is 190 rpm, depths are 1mm and 2mm. In this analysis tool feed varying from 0.4 mm/rev and 0.6 mm/rev. From the above figures discontinuous chips are obtained at feed rate of 0.4 mm/rev and at 1mm depth.

Figure 5.22 Different forms of chips for the EN8 material with various machining parameters and with Amalgamation of Mustard oil and Al_2O_3

Figure (a)-(d) represents the different types of chip formations at different operating conditions of lathe with using Amalgamation of Mustard oil and Al_2O_3 at 3% of machining EN8 material. And the operating conditions are constant speed that is 190 rpm, depths are 1mm and 2mm. In this analysis tool feed varying from 0.4 mm/rev and 0.6 mm/rev. From the above figures discontinuous chips are obtained at feed rate of 0.4 mm/rev and at 1mm depth.

CHAPTER 6

CONCLUSION

The present work has successfully demonstrated preparation and synthesis of Al_2O_3 and mustard oil amalgamation nano lubricants with various weight percentage of filler Al_2O_3 and its applications in lathe turning on EN8 using flow meter.

The surface roughness (Ra). Tool and work piece temperature and tool wear were measured under different cutting conditions for diverse combinations of machining parameters. The final conclusions arrived, at the end of this work are as follows.

Table: 6.1 Comparison of tool temperature for Pure Mustard oil and 1% Al_2O_3 Amalgamation Mustard oil

Feed rate mm/rev	**Fluid type**	**Temperature(°c) at depth=1 mm**	**Variation %**	**Temperature(°c) at depth=2 mm**	**Variation %**
0.4	Pure Mustard oil	44	15	45.3	13
	1% Al_2O_3	37.3		38	
0.6	Pure Mustard oil	48	11.8	49.8	11.2
	1% Al_2O_3	42.3		43	

Table: 6.2 Comparison of work piece temperature for Pure Mustard oil and 1% Al_2O_3 Amalgamation Mustard oil

Feed rate mm/rev	**Fluid type**	**Temperature (°c) at depth=1 mm**	**Variation %**	**Temperature (°c) at depth=2 mm**	**Variation %**
0.4	Pure Mustard oil	49.8	13.6	51.6	19.9
	1% Al_2O_3	43		41.3	
0.6	Pure Mustard oil	47.8	16.7	49.8	12.8
	1% Al_2O_3	39.8		43.6	

Table: 6.3 Comparison of surface roughness for Pure Mustard oil and 1% Al_2O_3 Amalgamation Mustard oil

Feed rate mm/rev	**Fluid type**	**Surface roughness(µm) at depth=1 mm**	**Variation %**	**Surface roughness(µm) at depth=2 mm**	**Variation %**
0.4	Pure Mustard oil	5.2	16.9	6.3	13
	1% Al_2O_3	3.8		4.8	
0.6	Pure Mustard oil	6.8	15	7.3	13.2
	1% Al_2O_3	5.1		5.6	

Table: 6.4 Comparison of Tool wear for Pure Mustard oil and 1% Al_2O_3 Amalgamation Mustard oil

Feed rate mm/rev	**Fluid type**	**Tool wear(mm) at depth=1 mm**	**Variation %**	**Tool wear(mm) at depth=2 mm**	**Variation %**
0.4	Pure Mustard oil	0.04	10	0.059	15
	1% Al_2O_3	0.032		0.038	
0.6	Pure Mustard oil	0.048	15	0.063	16
	1% Al_2O_3	0.036		0.04	

- There is a reduction of 11.8% to 15% in tool tip temperature using 1 % Al_2O_3 and mustard oil amalgamation nano lubricant compared to pure mustard oil.
- There is a reduction of 13% to 19% in work piece temperature using 1 % Al_2O_3 and mustard oil amalgamation nano lubricant compared to pure mustard oil.
- 2% Al_2O_3 nano fluids reduced tool wear 10 to 16% compared to pure mustard oil.
- 2% Al_2O_3 nano fluids surface roughness increased 13% to 16% compared to pure oil.
- From this analysis it is reavealed that feed rate speed are prominent factors which affect the turning of EN8 case hardened steel the feed rate 0.4mm/rev is the most influencing factor in determining the multiple performance characteristics of speed 190rpm , depth 1mm.
- The percentage of error between the predicted and experimental values of the multiple performance characteristics during the confirmation experiments is less than 5% as it is within limit.

Hence it is concluded that feed rate has significant effect on surface roughness & temperature at 1 %, 2% Al_2O_3 prepared for machining of EN8

CHAPTER 7

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