EXPERIMENTAL INVESTIGATION ON MQL BASED TURNING ON SS 304

A project report
submitted in partial fulfilment of the requirements for
the award of the degree of

Bachelor of technology

In

Mechanical engineering

Submitted by

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CERTIFICATE

This is to certify that the project report entitled "**EXPERIMENTALINVESTIGATION ON MQL BASED TURNING ON SS 304**" has been carried out by **R. CHANDRA SEKHAR (318126520159), B. VENKATA SAI PRANEETH (318126520124), V. VAMSHI PAVAN KUMAR (319126520L26), RAVI SRI KEERTHANA (318126520158), B. DEEKSHITHA KUMARI (318126520123)** in partial fulfilment for the award of **Bachelor of Technology** in **Mechanical Engineering** to the Andhra university, Visakhapatnam.

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Project guide

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ABSTRACT

Turning is the one of the machining processes used to reduce the diameter of cylindrical work piece. The quality of machining operation depends on output parameters like Surface Finish (S.F) and Material Removal Rate (MRR). Further Material Removal Rate and Surface Finish of machined components mainly depends on different process variables like Speed, Feed, Depth of cut and type of Cutting Fluid.

The present work is focused on machining of Stainless-Steel Alloy: SS304. By considering various machining parameters to find the effect on MRR, surface roughness, tool tip temperature under minimum quantity of lubrication as palm oil to predict the responses are MRR, Surface roughness and tool tip temperature. Further validated the obtained results using GRA methos for finding the optimum combination of input parameters.

It has an excellent corrosion resistance and forming characteristics and is most widely used in chemical, Petro-chemical, fertilizer industries, food processing, Dairy equipment, pharmaceutical industries, hospitals and heat exchangers in Refrigeration & Air conditioning.

An attempt was made by using palm oil as MQL during turning of stainless steel 304 with varying process parameters: speed, feed and depth of cut. Based on Taguchi Design of Experiments (DOE), 27 experiments were carried out for different speed, feed and depth of cut. The output machining characteristics like Surface Finish (SF), Material Removal Rate (MRR), Cutting tool tip temperatures are evaluated. The output parameters are optimized using individual optimality and Grey Relation Analysis (GRA). The best combination of process parameters are analysed. Based on the results, it can be concluded that MRR is influenced predominantly by Depth of cut, Surface finish by cutting fluid and cutting speed.

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION TO LATHE MACHINE

A lathe is a machine tool which turns cylindrical material, touches a cutting tool to it, and removes the material from the work piece to get the required shape and size. The lathe is one of the machine tools mostly used in material removal process. A material is firmly fixed to the chuck of a lathe and switched on and the chuck is rotated. And since the table which fixed the byte can be moved in the vertical direction and the right-and-left direction by operating some handles. It touches a byte's tip into the material by the operation, and makes a mechanical part.

1.1.1 TYPES OF LATHES

Engine Lathe: The most common form of lathe, motor driven and comes in large variety of sizes and shapes.

Bench Lathe: A bench top model usually of low power used to make precision machine small work pieces.

Lathe: A lathe that has the ability to follow a template to copy a shape or contour.

Automatic Lathe: The lathe in which the work piece is automatically fed and removed without use of an operator. Cutting operations are automatically controlled by a sequencer of some form.

Turret Lathe: The lathes which have multiple tools mounted on turret either attached to the tailstock or the cross-slide, which allows for quick changes in tooling and cutting operations.

Computer Controlled Lathe: Highly automated lathes, where cutting, loading, tool changing, and part unloading are automatically controlled by computer coding.

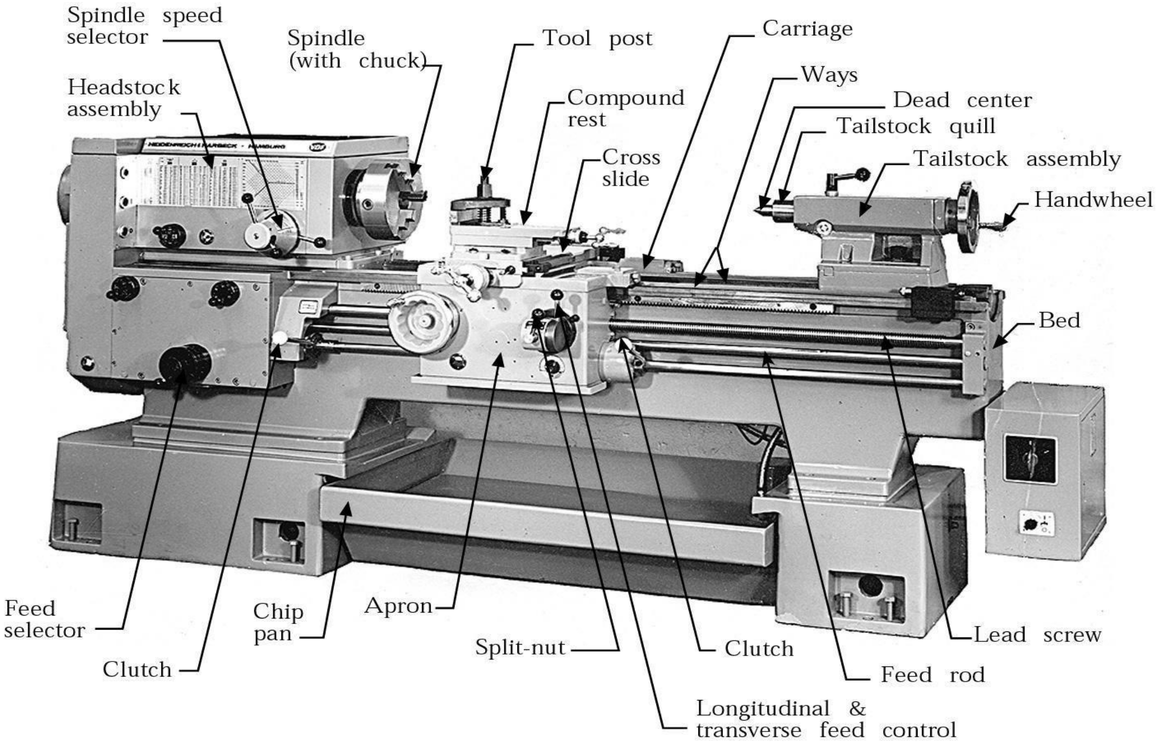

Fig 1.1: Lathe Machine

1.1.2 LATHE CONSTRUCTIONAL FEATURES

Bed and Ways: The bed is the base or foundation of the parts of the lathe. The main feature of the bed is the ways, which are formed on the bed's upper surface and run the full length of the bed. The ways keep the tailstock and the carriage, which slide on them, in alignment with the headstock

Headstock: The headstock contains the headstock spindle and the mechanism for driving it. In the belt-driven type, shown in figure 9-2, the driving mechanism consists of a motor-driven cone pulley that drives the spindle cone pulley through a drive belt. The spindle can be rotated either directly or through back gears. When the headstock is set up for direct drive, a bull gear pin, located under a cover to the right of the spindle pulley, connects the pulley to the spindle. This connection causes the spindle to turn at the same speed as the spindle pulley.

When the headstock is set up for gear drive, the bull gear pin is pulled out, disconnecting the spindle pulley from the spindle. This allows the spindle to turn freely inside the spindle pulley. The back gear lever, on the left end of the headstock, is moved to engage the back gear set with a gear on the end of the spindle and a gear on the end of the spindle pulley. In this drive mode, the drive belt turns the spindle pulley, which turns the back-gear set, which turns the spindle. Each drive mode provides four spindle speeds, for a total of eight. The back gear drive speeds are less slow than the direct drive speeds.

Tailstock: The primary purpose of the tailstock is to hold the dead centre to support one end of the work being machined. However, the tailstock can also be used to hold tapered shank drills, reamers, and drill chucks. It can be moved on the ways along the length of the bed and can be clamped in the desired position by tightening the tailstock clamping nut. This movement allows for the turning of different lengths of work. The tailstock can be adjusted laterally (front to back) to cut a taper by loosening the clamping screws at the bottom of the tailstock.

Before you insert a dead centre, drill, or reamer, carefully clean the tapered shank and wipe out the tapered hole of the tailstock spindle. When you hold drills or reamers in the tapered hole of the spindle, be sure they are tight enough so they will not revolve. If you allow them to revolve, they will score the tapered hole and destroy its accuracy.

Carriage: The carriage is the movable support for the cross-feed slide and the compound rest. The compound rest carries the cutting tool in the tool post. The carriage travels along the bed over which it slides on the outboard ways.

The carriage has T-slots or tapped holes to use for clamping work for boring or milling. When the carriage is used for boring and milling operations, carriage movement feeds the work to the cutting tool, which is rotated by the headstock spindle.

You can lock the carriage in any position on the bed by tightening the carriage clamp screw. But you do this only when you do such work as facing or parting-off, for which longitudinal feed is not required. Normally the carriage clamp is kept in the released position. Always move the carriage by hand to be sure it is free before you engage its automatic feed.

Apron: The apron is attached to the front of the carriage and contains the mechanism that controls the movement of the carriage and the cross slide.

Feed Rod: The feed rod transmits power to the apron to drive the longitudinal feed and cross feed mechanisms. The feed rod is driven by the spindle through a train of gears. The ratio of feed rod speed to spindle speed can be varied by using change gears to produce various rates offered. The rotating feed rod drives gears in the apron; these gears in turn drive the longitudinal feed and cross feed mechanisms through friction clutches.

Some lathes do not have a separate feed rod, but use a spline in the lead screw for the same purpose.

Lead Screw: The lead screw is used for thread cutting. It has accurately cut Acme threads along its length that engage the threads of half nuts in the apron when the half nuts are clamped over it. The lead screw is driven by the spindle through a gear train. Therefore, the rotation of the lead screw bears a direct relation to the rotation of the spindle. When the half nuts are engaged, the longitudinal movement of the carriage is controlled directly by the spindle rotation. Consequently, the cutting tool is moved a definite distance along the work for each revolution that the spindle makes.

Cross feed Slide: The cross-feed slide is mounted to the top of the carriage in a dovetail and moves on the carriage at a right angle to the axis of the lathe. A cross feed screw allows the slide to be moved toward or away from the work in accurate increments.

Compound Rest: The compound rest mounted on the compound slide, provides a rigid adjustable mounting for the cutting tool. The compound rest assembly has the following principal parts:

1. The compound rest swivel**,** which can be swung around to any desired angle and clamped in position. It is graduated over an arc of 90° on each side of its centre position. For easier setting to the angle selected. This feature is used for machining short, steep tapers, such as the angle on bevel gears, valve disks, and lathe centres.

2. The compound rest, or top slide**,** which is mounted on the swivel section on a dovetailed slide. It is moved by the compound rest feed screw.

This arrangement permits feeding the tool to the work at any angle (determined by the angular setting of the swivel section). The graduated collars on the cross feed and compound rest feed screws read in thousandths of an inch for fine adjustment in regulating the depth of cut.

1.1.3 ACCESSORIES AND ATTACHMENTS

Accessories are the tools and equipment used in routine lathe machining operations. Attachments are special fixtures that may be mounted on the lathe to expand the use of the lathe to include taper cutting, milling, and grinding. Some of the common accessories and attachments are described in the following paragraphs.

Tool Post: The sole purpose of the tool post is to provide a rigid support for the tool. It is mounted in the T-slot of the compound rest. A forged tool or a tool holder is inserted in the slot in the tool post. By tightening a setscrew, you will firmly clamp the whole unit in place with the tool in the desired position.

Tool holders: Notice the angles at which the tool bits are set in the various holders. These angles must be considered with respect to the angles ground on the tools and the angle that the tool holder is set with respect to the axis of the work.

Two types of tool holders that differ slightly from the common tool holders are those used for threading and knurling.

The threading tool holder has a formed cutter which needs to be ground only on the top surface for sharpening. Since the thread form is accurately shaped over a large arc of the tool, as the surface is worn away by grinding, the cutter can be rotated to the correct position and secured by the setscrew.

A knurling tool holder carries two knurled rollers which impress their patterns on the work as it revolves. The purpose of the knurling tool is to provide a roughened surface on round metal parts, such as knobs, to give a better grip in handling. The knurled rollers come in a variety of patterns.

1.1.4 VARIOUS LATHE OPERATIONS

- **Turning** – produces straight, conical, curved, or grooved work pieces
- **Facing** – produces a flat surface at the end of the part
- **Boring** – to enlarge a hole
- **Drilling** - to produce a hole
- **Cutting off** – to cut off a work piece
- **Threading** – to produce threads
- **Knurling** – produces a regularly shaped roughness

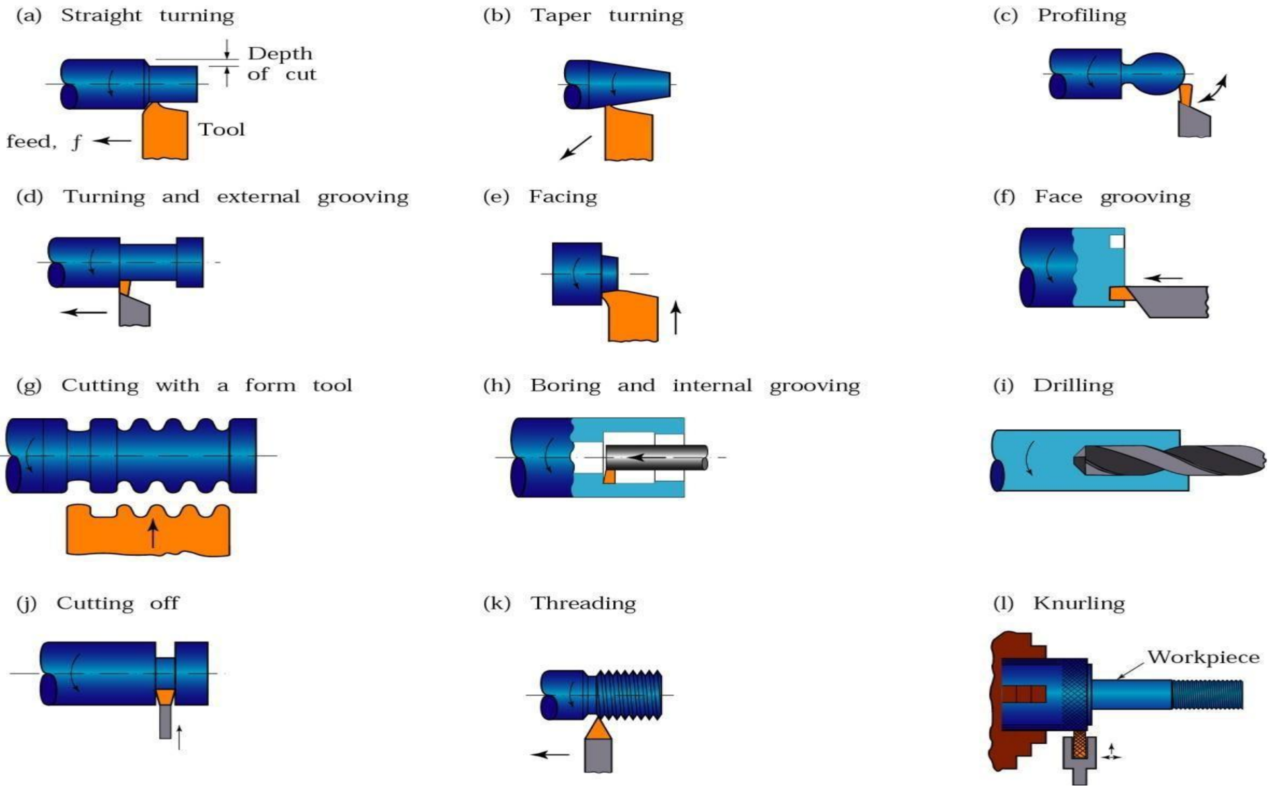

Fig 1.2: Types of lathe operations

1.2 CUTTING TOOLS

Cutting tools employ a wedging action. All the power used in cutting metal is ultimately expended in heat. A tool that has been used on heavy cuts has a small ridge of metal directly over the cutting edge. This bit of metal is much harder than the metal being cut, and is almost welded to the edge of the tool, indicating that an immense amount of heat and pressure was developed. In high-speed production work, coolants help absorb the heat from the cutting edge of the tool. A steady stream of cutting compound should be directed at the point of the cutting tool, so that it spreads and covers both the cutting tool and the work. There are several different materials used to make cutting tools or cutter bits. In order to machine metal accurately and efficiently, it is necessary to have the proper lathe tool ground for the particular kind of metal being machined, with a keen, well supported cutting edge. Some of the materials used to make cutting tools are:

- Carbon steel cutting tools are less expensive, and can be used on some types of metal successfully.
- High-speed steel cutting tools are the most popular type of lathe tools. They will withstand higher cutting speeds than carbon steel cutter bits.
- Satellite cutting tools will withstand higher cutting speeds than high-speed ones. Satellite is a nonmagnetic alloy which is harder than common high-speed steel.
- Carbide cutting tools are made of carbide for manufacturing operations where maximum cutting speeds are desired. Mostly used ones are tungsten carbide, tantalum carbide and titanium carbide.

The cutting end of the cutting tool is adapted to its cutting requirements by grinding its sides and edges at various angles. Since the cutting tool is more or less tilted in the tool holder, the angles are classed as either tool angles or working angles.

- Top back rake is the inclination of the face of a tool to or from the base. If it inclines away from the base, the rake angle is positive. If it inclines away from the base, the rake angle is negative. The cutting angle should be as large as possible for maximum strength at the edge and to carry heat away from the cutting edge. On the other hand, the larger the cutting angle, the more power is required to force it into the work.

Side rake angle is the angle between the face of a tool and a line parallel to the base. The cutting tool will not cut without side rake, and this angle relieves excessive strain on the feed mechanism also varies with the material being machined.

- Front clearance angle is between the flank and a line from the cutting edge ++perpendicular to the plane of the base. Front clearance depends somewhat on the diameter of the work to be turned.

- Side clearance is the angle between the side of a tool and a line from the face edge perpendicular to the plane of the base. In turning, the clearance angle allows the part of the tool bit directly under the cutting edge to clear the work while taking a chip.
- Side relief angle is between the portion of the side flank immediately below the side-cutting edge and a line drawn through this cutting-edge perpendicular to the base. It is usually measured in a plane at right angles to the side flank and hence is normal side relief.

1.2.1 CUTTING TOOLS FOR TURNING MACHINES

It is well known that the efficiency of the cutting process varies depending on tool material and geometry. Since turning operations were introduced, the tool design and its material techniques have been greatly enhanced. This section briefly introduces

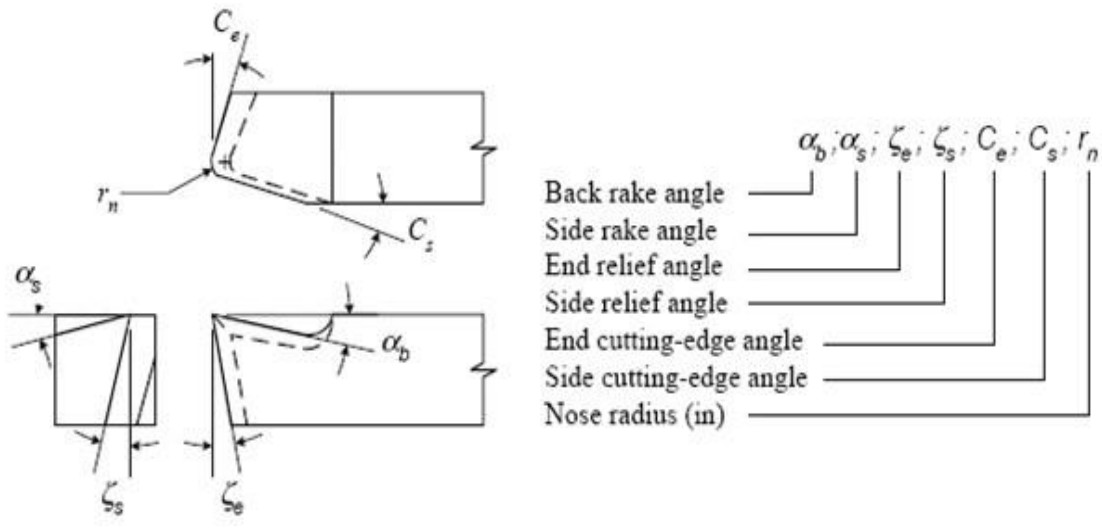

Fig 1.3: Cutting Tool Nomenclature, According to The American Standards Association

1.2.2 INSERT TOOL & IDENTIFICATION

A large proportion of modern cutting tools are indexable inserts and tool holders. Dimensional specifications of the inserts and tool holders are given in the American National Standard ANSI B212.12-1991. Several types of tools are used to create indexable inserts, including single-point cutting tools, which have a cutting edge at one end, most modern face milling cutters, side milling or slotting cutters, boring tools and a wide variety of special tools. The objective of this type of tooling is to provide an insert with several cutting edges. When an edge is worn, the insert is indexed in the tool holder until all the cutting edges have deteriorated, after which it is discarded. The insert is not intended to be reground since the inserts are often coated by the hardened materials. The advantage is that tool‟s cutting edges can be changed rapidly without removing the tool holder from the machine; tool-grinding costs are eliminated.; and the cost of the insert is less than the cost of a similar, brazed carbide tool. Depending on the raw material and cutting process, the insert size and shape must be chosen carefully.

To select a tool size and shape, most insert tool manufacturers use either the American National Standards Institutes (ANSI) indexable insert identification system or the International Organization of Standards (ISO) systems to describe an insert in its entirety. The ANSI system is explained in this section.

The ANSI standard identification consists of up to ten positions. Since the carbide insert was introduced, it has been accepted widely because of its hardness and rigidity. By applying coatings, more wear-resistant inserts were created, allowing much harder material production. Some examples of the coating insert and its properties are shown in the next section.

1.2.3 INSERT TOOL COATING MATERIALS

Several coating materials have been developed to increase the durability, mechanical properties and effectiveness of removing heat from the "hot spot" of the tool. The most frequently used coating layers are titanium carbide (TiC), aluminum oxide (Al_2O_3) and titanium nitrate (TiN). TiC has a strong resistance flank wear; TiN helps to increase the resistance to crater wear and decrease the coefficient of friction between tool and work piece and between tool and chips and Al_2O_3contributes to the thermal and chemical stability of the tool. A t low cutting speeds, when abrasion is the main wear mechanism, the presence of TiC coating will increase tool life greatly. However, flank wear does not depend on the thickness of the coating. As the cutting speed increases, diffusion becomes an important wear mechanism due to high temperature. In these instances, the presence of a coating with thermal and chemical stability (such Al_2O_3) grows in importance.

Insert material

For the experimentation, the physical vapor deposition (PVD) TiAlN coated carbide inserts are used. Standard Kennametal inserts (CNMG 120408 MS KC5010)

1.3 MINIMUM QUANTITY LUBRICATION

MQL is a clean manufacturing technique which is also known as near-dry machining. In MQL, a drastically reduced amount of cutting fluid is sprayed in the cutting zone. A flow rate in the range of 10–100 mL/h are commonly applied for most industrial applications.

Due to low consumption of cutting fluids, MQL is considered as an environmentally friendly cooling technique. Moreover, several researchers observed that MQL machining has the potential to offer comparable or even better machinability compared to traditional dry and wet machining. Due to its low consumption of cutting fluid and machining performance, MQL machining has been discussed and researched worldwide as an clean alternative to traditional wet machining.

In MQL machining, cutting fluids are delivered without or with a medium such as air. In airless system, cutting fluid is supplied using a pump and fluids in the form of micro droplets which is injected to the tool–chip interface through a nozzle. In the system with air, a tiny amount of cutting fluid is mixed with air and delivered in the form of an aerosol spray through a diffuser or nozzle. The cutting fluid and air may either mix inside the nozzle or outside the nozzle. For the inside nozzle mixing process, extremely fine droplets of atomized cutting fluids mixes with air in the nozzle and sprayed to the cutting zone . In this process, harmful mists and vapours are reduced. Moreover, the mixture setting is very easy to control. This technique has benefits such as reduction of manufacturing cost and impact on the environment as well as human life.

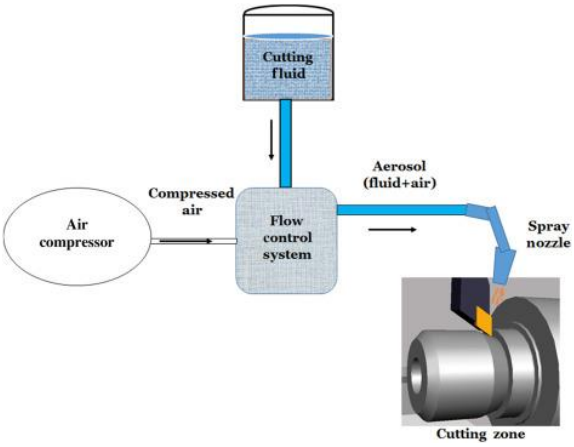

Fig 1.4: Schematic representation of MQL. MQL, minimum quantity lubrication

1.4 CUTTING FLUIDS

Cutting fluid is a type of coolant and lubricant designed specifically for metalworking processes, such as machining and stamping. There are various kinds of cutting fluids, which include oils, oil-water emulsions, pastes, gels, aerosols (mists), and air or other gases.

1.4.1 TYPE OF CUTTING FLUID

Types of cutting fluids: -

- Straight Oil
- Soluble Oil
- Mineral Oil
- Synthetic Liquids
- Semi-Synthetic Fluids
- Solid and Paste Lubricants
- Cutting Oil

1.4.2 CUTTING FLUID AND CUTTING FLUID IN MACHINING:

Cutting fluid is a fluid used primarily to remove heat generated during metal cutting & other machining processes. It is also used as a lubricant in some cases.

A cutting fluid is a substance designed specifically for metal-working and machining processes that serve as both lubricant and coolant during these processes.

This fluid is usually applied as the machining process is taking place. Cutting fluids may be applied by flooding, a fluid jet, mist spraying, etc.

1.5 PROCESS PARAMETERS

A turning operation is one of the simplest cutting processes to analyse, because it is performed using a single point cutting tool. A representation of a turning operation with its main parameters. The work piece rotates at an angular speed equal to the spindle speed (n) given in rev/min (rpm) units. The cutting speed (V), measured in meters per minute (m/min), can be computed as given Equation (1.1):

Where D_1 is the unmachined diameter in the proper units. Sometimes the average of the machined and unmachined diameters, $(D_1+D_2)/2$ is used instead of D_1 in this equation.

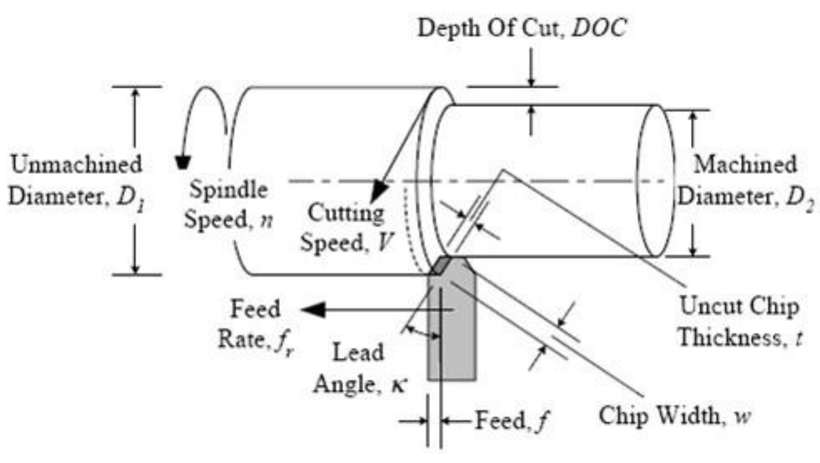

Fig:1.5, Oblique Cutting Parameters in A Turning Operation

The feed (f) measured in mm/rev or in/rev defines the tool advancement in the axial direction (Z axis) per revolution. The feed rate (f) measures the tool linear speed along the same direction in mm/min or in/min. The following equation defines the relation between feed rate and feed.

$$f_n = f_r$$

The depth of cut (t) measures the distance that the cutting tool is fed into the work piece in the radial direction (X axis). This parameter, measured in mm or in.

The lead angle measures the orientation of the tool cutting edge, with respect to the radial direction (X axis). When this angle is zero, the operation is called Orthogonal Cutting. For any other angle, the operation is called Oblique Cutting.

The cross-sectional area of the undeformed chip, needed for the analysis of cutting stresses can be computed as:

$$A = wt = tf$$

To estimate the power required and the efficiency in the cutting operation, the Metal Removal Rate (MRR) is needed. The MRR in a turning operation, measured in mm3/min or in3/min, is given as:

$$MRR = Vft$$

1.6 MATERIALS AND ITS APPLICATIONS

Materials comprise all natural and synthetic substances and constitute the physical matter of products and systems, such as:

- Machines, Devices, Commodities
- Power plants and Energy supplies
- Means of habitation, Transport, and Communication

It is clear that materials characterization methods have a wide scope and impact for science, technology, the economy and society.

1.6.1 BASIC FEATURES OF MATERIALS

Materials can be of natural origin or synthetically processed and manufactured. According to their chemical nature they are broadly grouped traditionally into inorganic and organic materials. Their physical structure can be crystalline, or amorphous. Composites are combinations of materials assembled together to obtain properties superior to those of their single constituents. Composites are classified according to the nature of their matrix: metal, ceramic or polymer composites, often designated MMCs, CMCs and PMCs, respectively. Figure 1.1 illustrates with characteristic examples the spectrum of materials between the categories natural, synthetic, inorganic, and organic.

1.7 TURNING PROCESS PARAMETERS AND RESPONSE VARIABLES

1.7.1 PROCESS PARAMETERS

The input process parameters affecting the response of Turning process are:

•**Cutting speed** •**Depth of cut** •**Feed** • Cutting **fluid**

1.7.2 RESPONSE VARIABLES

Turning process performance can be measured by the Material Removal Rate (MRR), Surface Roughness (SR) of the work piece that has been machined. These two machining characteristics have to be calculated for the selected input parameters. The process parameters should be chosen properly so as to have maximum MRR, minimum SR. The response variables for Turning process are discussed below.

1.7.2.1 MATERIAL REMOVAL RATE (MRR)

The material removal rate (MRR) of the work piece is the amount of the material removed per minute. MRR and Cutting speed capabilities of Turning have increased enormously over the years. They are influenced by the age and type of machine along with the properties and characteristics of the work piece being cut. The machine settings set by the operator and programmer also affect the MRR and cutting speed.

Material removal rate has been calculated by the following formula:

$$MRR = vfd$$

v=cutting speed
f=feed rate
d=depth of cut

v=m/min

f= mm/rev

d=mm

1.7.2.2 SURFACE ROUGHNESS (RA) OR SURFACE FINISH

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. It is a measure of the texture of a surface. It is quantified by the vertical deviations of a real surface from its ideal form. If these deviations are large, the surface is rough. If small, the surface is smooth. The Surface Roughness is represented as Ra.

1.8 DESIGN OF EXPERIMENTS

1.8.1 DESIGN OF EXPERIMENT TECHNIQUES

1. Factorial Design

2. Response Surface Methodology
3. Mixture Design
4. Taguchi Design

Among those, Taguchi Design is selected for finding the relative significance of various parameters.

1.8.2 TAGUCHI METHOD

The general steps involved in the Taguchi Method are as follows:

1. Define the process objective, or more specifically, a target value for a performance measure of the process.
2. Determine the design parameters affecting the process. Parameters are variables within the process that affect the performance measure such as temperatures, pressures, etc. that can be easily controlled.
3. Create orthogonal arrays for the parameter design indicating the number of and conditions for each experiment. The selection of orthogonal arrays is based on the number of parameters and the levels of variation for each parameter.
4. Conduct the experiments indicated in the completed array to collect data on the effect on the performance measure.
5. Complete data analysis to determine the effect of the different parameters on the performance measure.

1.8.3 ANALYSIS OF EXPERIMENTAL DATA

Once the experimental design has been determined and the trials have been carried out, the measured performance characteristic from each trial can be used to analyse the relative effect of the different parameters. To determine the effect each variable has on the output, the signal-to-noise ratio, or the S/N ratio, needs to be calculated for each experiment conducted.

1.8.3.1 SIGNIFICANCE OF SIGNAL-TO-NOISE RATIO

The signal-to-noise concept is closely related to the robustness of a product design. A Robust Design or product delivers strong „signal". It performs its expected function and can cope with variations ("noise"), both internal and external. In signal-to Noise Ratio, signal represents the desirable value and noise represents the undesirable value. There are three Signal-to-Noise ratios of common interest for optimization of Static Problems. The formulae for signal to noise ratio are designed so that an experimenter can always select the largest factor level setting to optimize the quality characteristic of an experiment. Therefore, a method of calculating the Signal-to-Noise ratio has gone for quality characteristic.

They are: (i) Smaller-the better, (ii) Larger-the better

SMALLER-THE BETTER

Impurity in drinking water is critical to quality. The less impurities customers find in their drinking water, the better it is. Vibrations are critical to quality for a car, the less vibration the customers feel while driving their cars the better, the more attractive the cars are:

The Signal-to-Noise ratio for smaller the better is:

$$S/N = -10log_{10}\left(\frac{\sum y^2}{N}\right)$$

LARGER-THE BETTER

If the number of minutes per dollar customers get from their cellular phone service provider is critical to quality, the customers will want to get the maximum number of minutes they can for every dollar they spend on their phone bills.

The Signal-to-Noise ratio for the bigger-the-better is:

$$S/N = -10log_{10}\left(\frac{1}{n}\sum\frac{1}{y^2}\right)$$

1.9 ANALYSIS OF VARIANCE (ANOVA)

Analysis of Variance (ANOVA) is a statistical method for determining the existence of differences among several population means. The aim of ANOVA is the detect differences among several population means; the technique requires the analysis of different forms of variance associated with the random samples under study. The Analysis of Variance is used to find out the percentage contribution of input process parameters for response variables.

CHAPTER-2

LITERATURE REVIEW

2.1 SUMMARY OF LITERATURE

This chapter reports the brief literature survey in the areas of minimum quantity of lubrication experiments on different materials by using different lubricants with different processes to optimize the cutting parameters.

VenkataRao.R&Kalyankar.V.D.[1]is adopted multi-pass turning operations is to produce products with low cost and high quality, with a lower number of cuts. Parameter optimization plays an important role in achieving this goal. Process parameter optimization in a multi-pass turning operation usually involves the optimal selection of cutting speed, feed rate, depth of cut and number of passes. In this work, the parameter optimization of a multi-pass turning operation is carried out using a recently developed advanced optimiza-tion algorithm, named, the teaching–learning-based optimization.

Manjunatha.R & Umesh [2] aims to get the optimal turning parameters liSpeed, Feed & Depth of cut to opmize the value of output parameters like Feed force, Tangential Force & surface roughness by machining E-19 steel with an coated carbide tool insert. Taguchi Technique is used in their study.

RamanujamR, Venkatesan. K,VimalSaxena,Philip Joseph"s[3] work presents on optimization of input parameters by using Dry Turning on Inconel 718.This study is carried out by using Taguchi"s L9 Orthogonal array. Finally concluded that feed and depth of cut was found to be significant parameters for his experimentation.

Shreemoy kumarnayak, Jatin Kumar Patro, Shailesh Dewavyam, Sowmya Gangopadhyaya [4] aims at investigating the influence of different machining parameters such as cutting speed (Vc), feed (f) and depth of cut (t) on different performance measures during dry turning of AISI 304 austenitic stainless steel. ISO P30 grade uncoated cemented carbide inserts was used a cutting tool for the current purpose. L27 orthogonal array design of experiments was adopted with the following machining parameters: speeds 700, 750, 800 m/min., feeds 0.12, 0.14, 0.16 mm/rev. and times 0.6 1,0.8, 1.0 mm. Three important characteristics of machinability such as material removal rate (MRR), cutting force (F c) and surface roughness(R a) were measured. Attempt was further made to simultaneously optimize the machining parameters using single variable optimization.

KomsonJirapattarasilp & Choobunyen Kuptanawin[5] carries their work on stainless stell JIS:SUS 303 and tried to know the effect of turning parameters on Roundness & Hardness of Work piece. As the result of the experiment, it could be concluded that cooling was mainly affected to the roundness. Non-cooling cutting or dry-cutting would cause of worse quality for roundness. It means that cooling on turning was the better process for quality of roundness.

Hrelija Marko, KlancnikSimon,IrgolocTomaz, PaulicMatej, Balic Joze, Brezocnik Miran [6] are tried to concentrate on adopting the advanced technologies to modernize the production firms to reduce the products cost & manufacturing times. Due to the dynamic processes and increase of the machining parameters optimizing the information which is essential for production of significantly harder materials. For solving such problems, various intelligent methods, such as Particle swarm optimization or similar type of intelligent optimization was used. This paper proposed, how to successfully gain optimal cutting parameters – cutting speed, feed rate and depth of cut with a view to cutting force, surface finish and tool life.

Harsha y Valera, SanketBhavsar [7] worked on EN31steel to get good surface roughness 20 and less power consumption in turning the input parameters like Speed, Feed& Depth of cut are considered. Optimized the cutting parameters for achieving better surface finish with reduced power consumption.

2.2 SCOPE OF THE WORK FROM THE LITERATURE:

- From the above literature, it is understood that various researchers considered various machining parameters to find the effect on MRR, surface roughness, tool tip temperature in which most of the work is done on different types of steels and other materials under presence of various lubricants. the authors are identified some of gaps in the literature in the areas of performing the experiments using minimum quantity of lubrication during turning process.

- Hence, in this work, the authors have chosen SS 304 as base material with input parameters of speed, feed and depth of cut under the minimum quantity of lubrication as palm oil to predict the responses are MRR, Surface roughness and tool tip temperature. Further the authors validated the obtained results using GRA methos for finding the optimum combination of input parameters.

2.3 OBJECTIVES OF PRESENT WORK

- Experimental determination of the effects of the various process parameters cutting speed, feed, and depth of cut on the performance measures like material removal rate, cutting tool tip temperature and surface roughness in TURNING process under MQL.
- Single variable optimization of the process parameters of TURNING process using Taguchi DOE.
- Validation of the results by using gray relation analysis (GRA) with individual optimisation technique to predict the responses as MRR, Surface roughness and tool tip temperature.

CHAPTER-3

PROBLEM STATEMENT

Turning is the one of the machining processes used to reduce the diameter of cylindrical work piece. The quality of machining operation depends on output parameters like Surface Finish (S.F) and Material Removal Rate (MRR). Further Material Removal Rate and Surface Finish of machined components mainly depends on different process variables like Speed, Feed, Depth of cut and type of Cutting Fluid.

The present work is focused on machining of Stainless-Steel Alloy: SS304. By considering various machining parameters to find the effect on MRR, surface roughness, tool tip temperature under minimum quantity of lubrication as palm oil to predict the responses are MRR, Surface roughness and tool tip temperature. Further validated the obtained results using GRA methos for finding the optimum combination of input parameters.

It has an excellent corrosion resistance and forming characteristics and is most widely used in chemical, Petro-chemical, fertilizer industries, food processing, Dairy equipment, pharmaceutical industries, hospitals and heat exchangers in Refrigeration & Air conditioning.

An attempt was made by using palm oil as MQL during turning of stainless steel 304 with varying process parameters: speed, feed and depth of cut. Based on Taguchi Design of Experiments (DOE), 27 experiments were carried out for different speed, feed and depth of cut. The output machining characteristics like Surface Finish (SF), Material Removal Rate (MRR), Cutting tool tip temperature are evaluated. The output parameters are optimized using individual optimality and Grey Relation Analysis (GRA). The best combination of process parameters are analysed. Based on the results, it can be concluded that MRR is influenced predominantly by Depth of cut, Surface finish by cutting fluid and cutting speed.

CHAPTER 4

EXPERIMENTATION

4.1 SELECTION OF WORK MATERIAL

STAINLESS STEEL 304alloy: SS 304 is chosen to study and this material can find various applications. Because of its as-welded and good corrosion resistance. Due to this this was used in most of the industrial applications, for manufacturing of interior parts of automobiles. In view of the present research objectives, experimental investigation and analysis were carried out in different parametric combinations, for deriving effective parametric combination.

Table 4.1 Chemical composition of SS 304

Element	C	Mn	P	S	Si	Cr	Ni	N_2	Iron
%	0.08	2.00	0.045	0.03	0.75	20.0	10.00	0.1	Bal

The work piece dimensions are length 90 mm and diameter is 30 mm.

Table No: 4.2 Mechanical and Thermal properties of Material

Mechanical Properties	
Density(g/cc)	8
Poison's ratio	0.29
Elastic Modulus (Gpa)	193-200
Ultimate Tensile Strength (Mpa)	1260-1390
Yield Point (Mpa)	1041-1160
Elongation at break (%)	70
Hardness (HRC) BRINELL	123
Thermal Properties	
Melting Point(^{0}C)	1400-1455
Thermal Conductivity(W/m.K)	16.2
Specific Heat(J/Kg.K)	435

4.3 CUTTING TOOL AND SPECIFICATIONS

The tool is Cemented carbide cutting tool.

insert seat size code - 09

Insert seat size code - 3/8

Operation type - Finishing

Cutting edge length - 9.6719 mm

Insert thickness - 3.175 mm

Inscribed circle diameter - 9.525 mm

Corner radius - 0.8 mm
Fixing hole diameter - 3.81
mm 36 hand - N
Tool style code CNMG-PF

Grade - 4325

Insert shape code – C

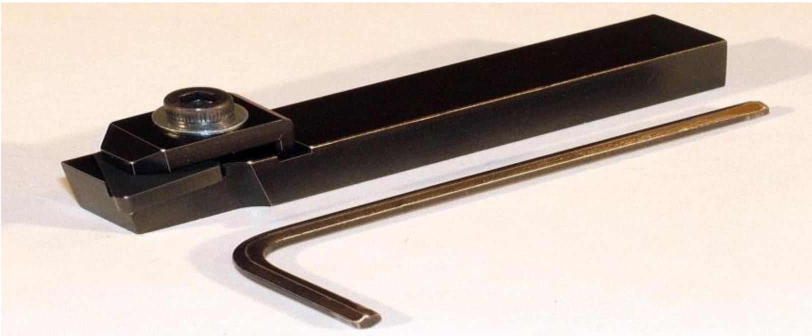

Fig. 4.1.1 Carbide insert tool

4.4 EQUIPMENT USED

This chapter reports briefly about the equipment's used for experimentation on turning of SS304 under MQL.

The following equipment were used namely

- LATHE (all geared head) as in Fig 4.4.1
- MQL setup as in Fig 4.4.2
- IR Camera Setup as in Fig 4.4.3
- Talysurf Surface Roughness tester as in Fig 4.5.4
- Cemented Carbide tool insert as in Fig 4.5.5

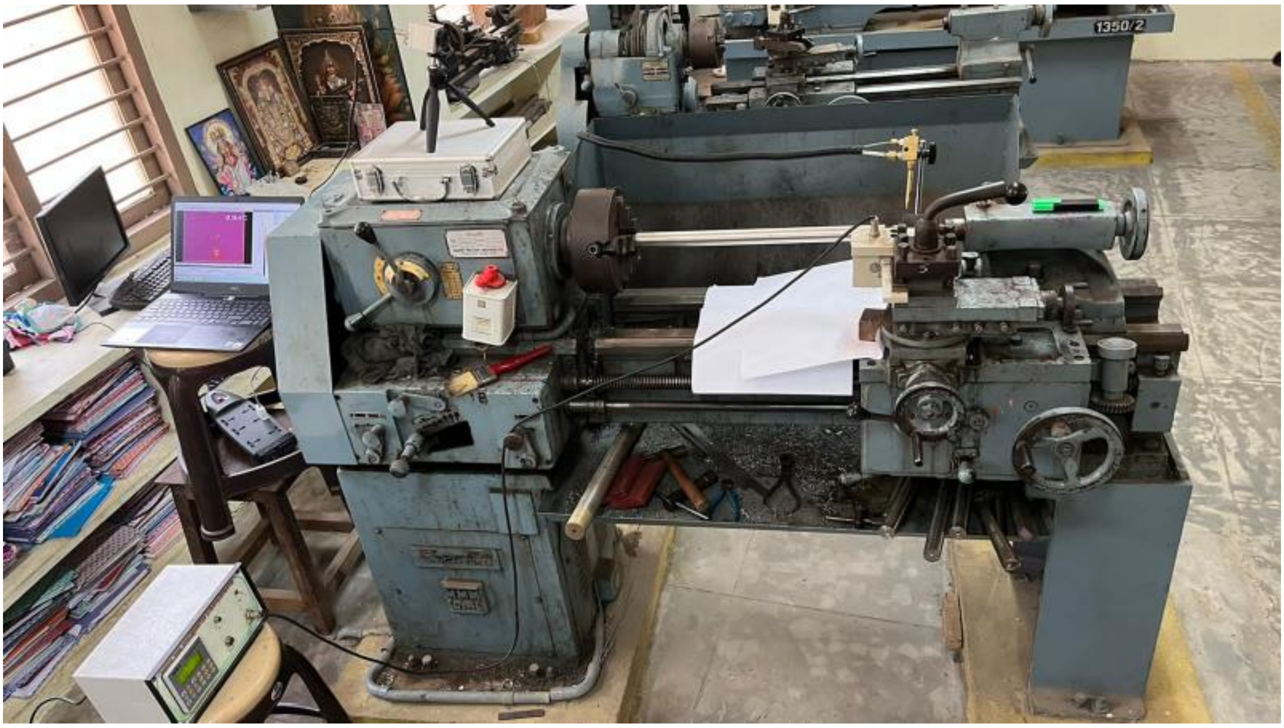

Fig 4.4.1 Lathe (All Geared Head)

Fig 4.4.2 MQL Setup

4.4.3 IR Camera setup

Fig:4.4.4 Talysurf Surface Roughness tester

Fig 4.4.5 Cemented Carbide Tool insert

4.5 EXPERIMENTAL ANALYSIS:

Experimentation on lathe all geared head were carried out under MQL of palm oil. In the present study, SS304 is considered as the workpiece material to study the influence of process parameters such as speed, feed, depth of cut on material removal rate , surface roughness and tool tip temperature. Experiments (27) were carried out for different speed, feed and depth of cut. The values are tabulated in the table 4.5.2

4.6 MEASUREMENT OF SURFACE ROUGHNESS

Surface roughness has been measured by using surface roughness tester as show in Fig4.4.4. Surface roughness values tabulated in Table 4.6.1 are the average values of surface roughness at 3 different locations.

4.7 CALCULATION OF MRR

Material Removal Rate (MRR) is calculated as the ratio of amount of material removed to the time in which material is removed.

$$MRR = vfd$$

v=cutting speed
f=feed rate
d=depth of cut

Table 4.5.1 Machining parameters and their levels

Input Parameters	Level 1	Level 2	Level 3
Speed (RPM)	290	465	740
Feed(mm/rev)	0.193	0.386	0.772
DOC (mm)	0.1	0.2	0.3

Table 4.5.2 Experimental input parameters

S.NO	SPEED (RPM)	FEED (mm/rev)	D.O.C (mm)
1	465	0.77216	0.2
2	740	0.19304	0.1
3	740	0.77216	0.3
4	290	0.38608	0.1
5	465	0.77216	0.1
6	740	0.38608	0.1
7	465	0.38608	0.2
8	290	0.77216	0.3
9	740	0.19304	0.3
10	740	0.38608	0.3
11	290	0.38608	0.3
12	465	0.77216	0.3
13	465	0.38608	0.3
14	740	0.77216	0.1
15	290	0.19304	0.2
16	290	0.19304	0.3
17	740	0.19304	0.2
18	290	0.77216	0.2
19	740	0.38608	0.2
20	740	0.77216	0.2
21	290	0.19304	0.1
22	290	0.77216	0.1
23	465	0.19304	0.1
24	465	0.19304	0.3
25	465	0.19304	0.2
26	465	0.38608	0.1
27	290	0.38608	0.2

Table 4.6.1 Measurement of Surface Roughness

S.NO	SURFACE ROUGHNESS (micron meters)
1	10.598
2	2.008
3	10.096
4	6.747
5	14.141
6	7.409
7	6.624
8	11.102
9	2.846
10	6.93
11	6.97
12	12.25
13	6.179
14	13.534
15	2.362
16	2.098
17	2.739
18	9.031
19	7.263
20	12.273
21	2.178
22	10.847
23	2.595
24	2.163
25	2.652
26	7.911
27	7.383

CHAPTER 5

RESULTS AND DISCUSSIONS

This chapter reports about the experimental results obtained and corresponding results and discussions.

5.1 EXPERIMENTAL RESULTS:

Experimentation on lathe all geared head were carried out under MQL of palm oil. In the present study, SS304 is considered as the workpiece material to study the influence of process parameters such as speed, feed, depth of cut on material removal rate, surface roughness and tool tip temperature.

5.2 GRAY RELATION ANALYSIS (GRA) FOR VALIDATION:

The output parameters are optimized using individual optimality and Grey Relation Analysis (GRA). The table 5.2.1 represents input parameters and output parameters which are obtained from experimentation. the table 5.2.2 represents normalisation and Deviation Sequence of responses using GRA

The values Obtained for output responses are to be normalised using Minitab software.

the below values Obtained as output responses are to be normalised using Minitab software and reported in table 5.2.2 further carried out the deviations in comparisons with experimental values were also reported table 5.2.2

the obtained normalised and deviation values are further validated for finding Gray relation coefficient, Gray Relational Grade and Rank. The values are reported in table 5.2.3. it is inferred that the experiment number 12 is having rank 1, which is best optimum COMBINATION OF INPUT parameters (speed, feed and depth of cut).

It is further observed that the experiment number 3 and 20 are having ranks of 2 and 3 respectively, which are also another set of optimum set of combination of input values.

Table 5.2.1 Out parameters Using GRA

Sl.No	Actual Parameters			Responses		
	SPEED (RPM)	FEED (mm/rev)	D.O.C (mm)	TOOL TIP TEMP (^oC)	SURFACE ROUGHNESS (micron meters)	MRR (mm3/min)
1	465	0.77	0.2	290	10.6	6745.66
2	740	0.19	0.1	268	2.01	1324.45
3	740	0.77	0.3	310	10.1	16102.55
4	290	0.38	0.1	260	6.75	1038.08
5	465	0.77	0.1	280	14.14	3372.83
6	740	0.38	0.1	280	7.41	2648.9
7	465	0.38	0.2	290	6.62	3329.03
8	290	0.77	0.3	290	11.1	6310.46
9	740	0.19	0.3	309	2.85	3973.36
10	740	0.38	0.3	300	6.93	7946.71
11	290	0.38	0.3	288	6.97	3114.25
12	465	0.77	0.3	307	12.25	10118.49
13	465	0.38	0.3	289	6.18	4993.54
14	740	0.77	0.1	290	13.53	5367.52
15	290	0.19	0.2	250	2.36	1038.08
16	290	0.19	0.3	280	2.1	1557.13
17	740	0.19	0.2	298	2.74	2648.9
18	290	0.77	0.2	290	9.03	4206.97
19	740	0.38	0.2	300	7.26	5297.81
20	740	0.77	0.2	300	12.27	10735.03
21	290	0.19	0.1	250	2.18	519.04
22	290	0.77	0.1	273	10.85	2103.49
23	465	0.19	0.1	260	2.6	832.26
24	465	0.19	0.3	280	2.16	2496.77
25	465	0.19	0.2	274	2.65	1664.51
26	465	0.38	0.1	270	7.91	1664.51
27	290	0.38	0.2	260	7.38	2076.17

Table 5.2.2. Normalisation & Deviation Sequence of Responses Using GRA

Sl.No	Normalisation			Deviation Sequence		
	TOOL TIP TEMP	SURFACE ROUGHNESS (micron meters)	MRR (mm3/min)	Tt	Ra	MRR
1	0.69	0.852	0.254	0.31	0.148	0.746
2	0.323	0	0.726	0.677	1	0.274
3	1	0.827	0	0	0.173	1
4	0.182	0.621	0.797	0.818	0.379	0.203
5	0.527	1	0.457	0.473	0	0.543
6	0.527	0.669	0.524	0.473	0.331	0.476
7	0.69	0.611	0.457	0.31	0.389	0.543
8	0.69	0.876	0.274	0.31	0.124	0.726
9	0.985	0.179	0.405	0.015	0.821	0.595
10	0.848	0.635	0.203	0.152	0.365	0.797
11	0.658	0.638	0.476	0.342	0.362	0.524
12	0.955	0.926	0.136	0.045	0.074	0.864
13	0.674	0.576	0.338	0.326	0.424	0.662
14	0.69	0.978	0.321	0.31	0.022	0.679
15	0	0.083	0.797	1	0.917	0.203
16	0.527	0.022	0.679	0.473	0.978	0.321
17	0.816	0.159	0.524	0.184	0.841	0.476
18	0.69	0.77	0.392	0.31	0.23	0.608
19	0.848	0.659	0.321	0.152	0.341	0.679
20	0.848	0.927	0.118	0.152	0.073	0.882
21	0	0.042	1	1	0.958	0
22	0.409	0.864	0.595	0.591	0.136	0.405
23	0.182	0.131	0.862	0.818	0.869	0.138
24	0.527	0.038	0.541	0.473	0.962	0.459
25	0.426	0.143	0.659	0.574	0.857	0.341
26	0.358	0.702	0.659	0.642	0.298	0.341
27	0.182	0.667	0.595	0.818	0.333	0.405

Table 5.2.3 Grey Relation Coefficient & Gray Relational Grade

Grey relation coefficient			Gray Relational Grade	Rank	Exp No.
Tt	Ra	MRR	GRG		
0.617	0.772	0.401	0.597	9	**1**
0.425	0.333	0.646	0.468	25	**2**
1.000	0.743	0.333	0.692	2	**3**
0.379	0.569	0.712	0.553	15	**4**
0.514	1.000	0.479	0.664	5	**5**
0.514	0.602	0.512	0.542	18	**6**
0.617	0.563	0.479	0.553	17	**7**
0.617	0.801	0.408	0.609	6	**8**
0.971	0.378	0.457	0.602	7	**9**
0.766	0.578	0.385	0.577	12	**10**
0.594	0.580	0.488	0.554	14	**11**
0.917	0.872	0.367	0.718	1	**12**
0.605	0.541	0.430	0.526	20	**13**
0.617	0.957	0.424	0.666	4	**14**
0.333	0.353	0.712	0.466	26	**15**
0.514	0.338	0.609	0.487	23	**16**
0.731	0.373	0.512	0.539	19	**17**
0.617	0.685	0.451	0.585	11	**18**
0.766	0.594	0.424	0.595	10	**19**
0.766	0.873	0.362	0.667	3	**20**
0.333	0.343	1.000	0.559	13	**21**
0.458	0.786	0.552	0.599	8	**22**
0.379	0.365	0.784	0.510	22	**23**
0.514	0.342	0.521	0.459	27	**24**
0.466	0.368	0.595	0.476	24	**25**
0.438	0.627	0.595	0.553	16	**26**
0.379	0.600	0.552	0.511	21	**27**

5.3 ANALYSIS OF VARIANCE (ANOVA)

Statistical models are based primarily on the acceptance or rejection hypothesis, as in the case of Analysis of Variance (ANOVA). ANOVA uses analysing the variance between groups and in-between groups and accepts or rejects the hypothesis based on statistical value like Fisher’s value (F-value). It treats the hypothesis confirmation or rejection based on comparing the F-value with the critical values. ANOVA with a significance level of 95% is carried over the responses in wet condition orthogonal turn-mill operation and is given in **Tables 5.2.4,5.2.5 and 5.2.6.**

Table 5.2.4 Values of Tool Tip Temperature Using ANOVA

Tool tip temperature							
source	**df**	**adj ss**	**adj ms**	**f - value**	**p- value**	**Remarks**	**% of contribution**
Speed	2	2549	1247.48	25.29	0	significant	37
feed	2	1452	725.81	14.4	0	significant	21
doc	2	2745	1372.7	27.23	0	significant	40
error	20	1008	50.4				
total	26	7754					

Table 5.2.5 Values of Surface Roughness Using ANOVA

Surface Roughness							
source	**df**	**adj ss**	**adj ms**	**f- value**	**p- value**	**remarks**	**% of contribution**
speed	2	3.022	1.511	1.65	0.217	Not significant	0.8
feed	2	375.695	187.848	205.03	0	Highly significant	98.0
doc	2	3.222	1.611	1.76	0.198	Not significant	0.8
error	20	18.324	0.916				
total	26	400.264	191.886				

Table 5.2.6 Values of MRR Using ANOVA

MRR							
source	**df**	**adj ss**	**adj ms**	**f value**	**p value**	**Remarks**	**%of contribution**
speed	2	66701900	33350950	11.84	0	significant	23
feed	2	137957584	68978792	24.48	0	highly significant	47
doc	2	80475257	40237629	14.28	0	significant	28
error	20	56343881	2817194				
total	26	341478623					

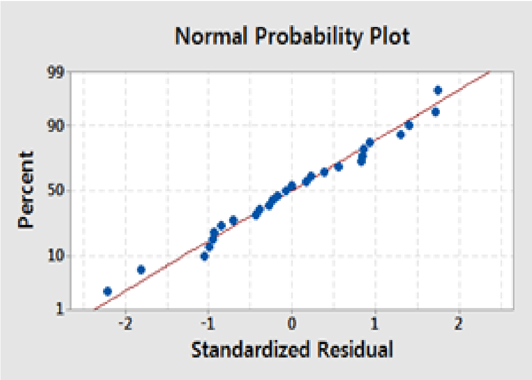

Fig 5.1.1 Normal Probability Plot for Tool Tip Temperature

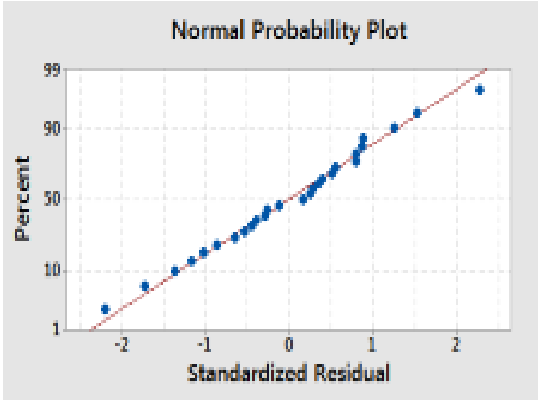

Fig 5.1.2 Normal Probability Plot for Surface Roughness

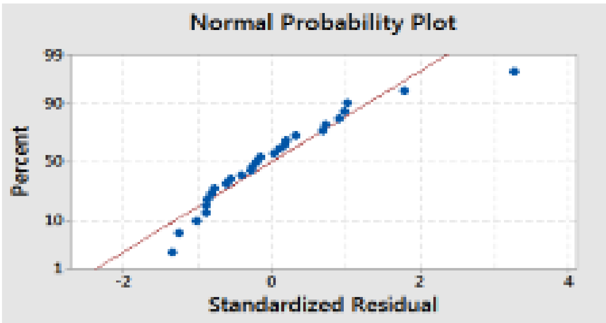

Fig 5.1.3 Normal Probability Plot for MRR

5.4 INDIVIDUAL OPTIMALITY

The tabulated response values thus generated while machining Stainless steel material using Taguchi DOE L27 experiments are taken for determining individual response (Tt, Ra, MRR) using signal-to-noise (S/N) ratios. S/N ratios are calculated using equations,

$$(S/N)_{\text{Smaller-is-Better}} = -10\log\left(\frac{1}{n}\sum_{i=1}^{n} y_i^2\right)$$

$$(S/N)_{\text{Lager-is-Better}} = -10\log\left(\frac{1}{n}\sum_{i=1}^{n} 1/y_i^2\right)$$

The calculated S/N ratios are used to determine the individual optimality of the generated responses basing on the equations.

$$\eta_{\text{optimum}} = \eta_{\text{average}} + \sum_{i=1}^{n}(\eta_{\text{ideal}} - \eta_{\text{average}})$$

$$\text{Response}_{\text{optimum}} = \sqrt{10 \pm \frac{\eta_{\text{optimum}}}{10}}$$

Where ‘n’ is observation number, η_{opt} is optimum S/N ratio, η_{avg} is average S/N ratio, η_{ideal} is ideal level of each S/N ratio parameter.

Sample calculation of individual optimality of Tool tip temperature

The average of S/N ratio ($\eta_{average}$) = -49.01

Response table for S/N rations for Tool tip temperature (Smaller is better)

5.4.1 Calculation of Individual Optimality of Tool Tip Temperature

Level	Speed	Feed	DOC	Optimal design
1	-48.65	-48.74	-48.62	**A1-B1-C1**
2	-49.00	-48.99	-49.04	
3	-49.39	-49.31	-49.38	

The S/N ideal speed ($\eta_{ideal\ speed}$) = -48.65

The S/N ideal feed ($\eta_{ideal\ feed}$) = -48.74

The S/N ideal depth of cut ($\eta_{ideal\ doc}$) = -48.62

$$\eta_{\text{optimum}} = \eta_{\text{average}} + \Sigma_{i=1}^{n}(\eta_{\text{ideal}} - \eta_{\text{average}})$$

= -49.01((-48.65+49.01) +(-48.74+49.01) +(-48.62+49.01)) = -47.99

$$\text{Response}_{\text{optimum}} = \sqrt{10 \pm \frac{\eta_{\text{optimum}}}{10}}\sqrt{10^{(47.99)}} = 250.66^{o}\text{C}$$

Table 5.4.2 Individual Optimal Values of Tool Tip Temperature, Surface Roughness & MRR Machining Using SN Ratio.

Sl.No.	SPEED (RPM)	FEED (mm/rev)	DOC (mm)	Tt (C)	Ra (mic)	MRR (mm3/min)	S/N Ratio of T_T	S/N Ratio of R_a	S/N Ratio of MRR
1	465	0.77	0.2	290	10.6	6764.58	-49.25	-20.5	76.6
2	740	0.19	0.1	268	2.01	1345.64	-48.56	-6.06	62.58
3	740	0.77	0.3	310	10.1	16147.72	-49.83	-20.08	84.16
4	290	0.39	0.1	260	6.75	1054.69	-48.3	-16.58	60.46
5	465	0.77	0.1	280	14.14	3382.29	-48.94	-23.01	70.58
6	740	0.39	0.1	280	7.41	2691.29	-48.94	-17.4	68.6
7	465	0.39	0.2	290	6.62	3382.29	-49.25	-16.42	70.58
8	290	0.77	0.3	290	11.1	6328.16	-49.25	-20.91	76.03
9	740	0.19	0.3	309	2.85	4036.93	-49.8	-9.08	72.12
10	740	0.39	0.3	300	6.93	8073.86	-49.54	-16.81	78.14
11	290	0.39	0.3	288	6.97	3164.08	-49.19	-16.86	70
12	465	0.77	0.3	307	12.25	10146.88	-49.74	-21.76	80.13
13	465	0.39	0.3	289	6.18	5073.44	-49.22	-15.82	74.11
14	740	0.77	0.1	290	13.53	5382.57	-49.25	-22.63	74.62
15	290	0.19	0.2	250	2.36	1054.69	-47.96	-7.47	60.46
16	290	0.19	0.3	280	2.1	1582.04	-48.94	-6.44	63.98
17	740	0.19	0.2	298	2.74	2691.29	-49.48	-8.75	68.6
18	290	0.77	0.2	290	9.03	4218.77	-49.25	-19.11	72.5
19	740	0.39	0.2	300	7.26	5382.57	-49.54	-17.22	74.62
20	740	0.77	0.2	300	12.27	10765.15	-49.54	-21.78	80.64
21	290	0.19	0.1	250	2.18	527.35	-47.96	-6.76	54.44
22	290	0.77	0.1	273	10.85	2109.39	-48.72	-20.71	66.48
23	465	0.19	0.1	260	2.6	845.57	-48.3	-8.28	58.54
24	465	0.19	0.3	280	2.16	2536.72	-48.94	-6.7	68.09
25	465	0.19	0.2	274	2.65	1691.15	-48.76	-8.47	64.56
26	465	0.39	0.1	270	7.91	1691.15	-48.63	-17.96	64.56
27	290	0.39	0.2	260	7.38	2109.39	-48.3	-17.36	66.48
						Avarage	**-49.01**	**-15.22**	**69.73**
						Ideal	-48.65	-14.69	73.3
						Ideal	-48.74	-7.55	73.9
						Ideal	-48.62	-14.94	73.9
						Optimu	-47.98	-6.74	81.64
						Optimu	250.66	2.17	12022

5.4.3 Calculation of Individual Optimality of Surface Roughness

Level	Speed	Feed	DOC	Optimal design
1	-14.689	-7.557	-15.487	**A1-B1-C3**
2	-15.438	-16.939	-15.233	
3	-15.535	-21.166	**-14.941**	

5.4.4 Calculation of Individual Optimality of MRR

Level	Speed	Feed	DOC	Optimal design
1	-65.55	-63.57	-64.44	**A3-B3-C3**
2	-69.65	-69.59	-70.46	
3	**-73.69**	**-75.73**	**-73.98**	

Table 5.4.5 Final Set of Individual Optimal Values and Process Parameters In Machining

Optimal design			T_T (Degree)	R_a (µm)	MRR (mm^3/min)
T_T	R_a	MRR			
A1-B1-C1	A1-B1-C3	A3-B3-C3	250.66	2.17	12022.64

CHAPTER 6
CONCLUSIONS

An attempt was made by using palm oil as MQL during turning of stainless steel 304 with varying process parameters: speed, feed and depth of cut. Based on Taguchi Design of Experiments (DOE), 27 experiments were carried out for different speed, feed and depth of cut. The output machining characteristics like Surface Finish (SF), Material Removal Rate (MRR), Cutting tool tip temperature are evaluated. The output parameters are optimized using individual optimality and Grey Relation Analysis (GRA).

The following conclusions were drawn based on the experimental results:

1. The experimentation of orthogonal lathe machining process under MQL conditions were analysed.

2.Individual optimality of responses have been determined with the help of signal-to-noise ratios. The optimisations reveals that the higher speeds are compatible enough to generate the optimality.

3.It may be inferred from the experimental analysis that the optimal combination set of input parameters are found to be as speed as 465 rpm, feed as 0.77 mm/rev, depth of cut as 0.3 mm. further the output responses are found to be as tool tip temperature as 250.66, surface roughness as 2.17 micro meters, MRR as 12022.6 mm3/min

4. The optimization reveals that the higher speeds are compatible enough to generate optimality. On the other hand, ANOVA is utilized for describing the predominance and importance of every machining parameter while generating responses. ANOVA depicts the feed to be of importance over surface roughness generation while the cutting depth shows familiarity in generating temperatures in eco-friendly machining

FUTURE SCOPE OF WORK:

1. The experimentation may be conducted on different materials under the presence of different MQL fluids which are eco-friendly.

2. The other optimisations techniques may adopt such as genetic logarithms, fuzz ANN techniques for optimizing process parameters.

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