PERFORMANCE ANALYSIS OF ALTERNATE CUTTING FLUIDS ON MILD STEEL & ALUMINIUM MATERIALS WITH OPTIMIZATION

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

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in
Mechanical Engineering

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CERTIFICATE

This is to certify that the Project Report entitled **“Performance Analysis of Alternate Cutting Fluids on Mild Steel & Aluminium Materials with Optimization”** being submitted by **K. Karthik (319126520014), R. Narendra (319126520038), M. Akash (319126520025), K. Satya Vinay (319126520015), D. Sudheer Babu (319126520010),** to the Department of Mechanical Engineering, ANITS is a record of the bonafide work carried outby them under the esteemed guidance of **Mrs. P. Ramya** The results embodied in the reporthave not been submitted to any other University or Institute for the award of any degree or diploma.

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ABSTRACT

Cutting fluids are used in the machining process to improve surface smoothness, dimensional accuracy, wash away chips, prevent corrosion, and disperse heat. Cutting fluids lubricate the tool, chip, and work piece interfaces, reducing cutting forces, abrasion, and adhesion. Sulphur, the principal component of conventional cutting fluid, is non-biodegradable, non-renewable, unsustainable, and extremely dangerous to the environment. Due to improved knowledge about the environmental and health concerns produced by ordinary metal working fluids such as cutting fluids, industries are seeking for eco-friendly cutting fluids in the current circumstances.

Numerous studies looked at whether vegetable oil-based cutting fluids may be ecologically friendly while yet functioning well. These oils have been recognised internationally as a possible source of ecologically favourable because of their biodegradability, renewability, and good lubricating performance. When blended in appropriate quantities with non-edible or waste oils, vegetable or edible oils can also be utilised as a cutting fluid. Edible oils such as sunflower, peanut, and palm oils, as well as non-edible oils such as castor and neem oils, are intriguing replacements for petroleum-based oils since they are biodegradable. As a result, vegetable-based oils have a greater potential for usage as industrial lubricants. Several investigations are being undertaken in order to generate new bio-based cutting fluids from diverse vegetable oils that are widely available in the world.

The need for renewable and biodegradable lubricants is expected to grow as a result of environmental concerns and limits on contamination and pollution. Vegetable oils are an environmentally friendly and long-lasting source of oil. The majority of vegetable oils are triacylglycerides, which have a molecular structure of three long chain fatty acids joined by ester bonds at the hydroxyl groups.

The performance analysis involves the investigation of wear characteristics, cutting force analysis, temperature analysis, and surface finish on mild steel and aluminium materials. The wear characteristics of an instrument reveal a lot about its lifespan. In manufacturing, the surface polish achieved on a machined surface is crucial. Wear

resistance, fatigue strength, corrosion resistance, and frictional power losses are all affected by the surface finish. Inadequate surface quality leads oil coatings on the peaks of micro imperfections to break, resulting in near-dry friction and considerable wear of the rubbing surface. Based on the input characteristics, individual optimisation will be applied to select the optimal oil.

Finishing methods are therefore utilised in machining to attain a very high surface quality. The best alternative cutting fluid is established by analysing the performance of numerous food and non-edible oils on mild steel and aluminium.

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NOMENCLATURE

Ra - Arithmetic average of the absolute peak values, unit of surface roughness

mm - millimeter, unit of length

RPM - Rotations per minute, unit of angular velocity

°C - Degree of centigrade, unit of Temperature

μ - microns, unit of length

RMS - Root mean square

S/N - Signal-to-Noise Ratio

ANOVA - Analysis of Variance

CHAPTER-1

INTRODUCTION

1.1 PROPERTIES OF CUTTING FLUID

Cutting fluids are liquids or gases that aid in cutting during machining processes. Only at the tool and work piece interface is operation performed. Cutting fluid performs several functions, including minimizing tool overheating, lowering power consumption, reducing tool wear and heat production, giving a good surface finish, washing away chips, and preventing work piece corrosion.

1.1.1 PROPERTIES OF CUTTING FLUIDS

Although the required properties of the cutting fluid should be formulated for each specific machining operation, some of the qualities required in a good cutting fluid could be listed as follows:

a) Excellent lubricant properties to reduce friction and heat generation
b) Good cooling action to effectively dissipate heat generated during machining
c) Strong anti-adhesion qualities to prevent metal seizing between the chip and
d) the rake face.
e) Good wetting characteristics, which allow the fluid to penetrate deeper into contact areas and cracks.
f) Should not induce rust and corrosion to machine components.
g) Fluids with comparatively low viscosity to allow metal chips and dirt to settle out
h) Stable solution or emulsion, provide a safe working environment (non-misting, non-toxic, non-flammable (smoking)), should be cost effective to use, filter, and dispose. If there was a single product that met all of the specific cutting needs.

1.1.2 BENEFITS OF CUTTING FLUID

All machining methods aim to Improve quality and efficiency to reduce machining expenses.. This may be performed by machining at the highest cutting speed achievable while ensuring the greatest tool life and the fewest component rejections (junk),and the least amount of downtime. Certain machining processes can be performed "dry," however cutting fluids have been widely used and play an important role in machining areas. Cutting fluids affect the productivity of machining processes by increasing tool life, improving work piece quality, and preventing the cutting tool and machine from overheating. Increased cutting speeds and feed rates may be achieved with proper cutting fluid application. In general, a successful cutting fluid doesn't just improve the performance of the machining process, but also fulfil a number of criteria. These cutting fluids are non-toxic, do not risk operator health, do not start fires, do not create smoke or fog, and are less expensive. One disadvantage of using cutting fluids is waste management.

1.1.3 TYPES OF CUTTING FLUID

Cutting oils, often known as simple oil or straight cutting oil, are obtained from petroleum, animal, or vegetable sources. Cutting lubricants used in metal cutting operations without further dilution have excessive lubricity, poor cooling properties, and increase the danger of fire. They may also create a noxious mist or smoke which is hazardous to the operator's health. Cutting oils are only used in low-temperature, low-speed cutting techniques.

1.1.4 DIRECT CUTTING FLUIDS

Cutting oils, sometimes referred to as plain oil or straight cutting oil, are derived from petroleum, animal, or vegetable sources. Cutting lubricants used in metal cutting operations without additional dilution have high lubricity, poor cooling qualities, and increase the risk of fire. They may also emit a poisonous mist or smoke that is harmful to the operator's health. Cutting oils are utilised exclusively in low-temperature, low-speed cutting procedures.

1.1.5 WATER SOLUBLE CUTTING FLUIDS

Emulsified oils are a water-based water in oil suspension. This cutting fluid is created by mixing oil including an emulsifier substance(s) to increase the water stability of the emulsion. The following are the general compositions of water-based lubricating oil:

BASE OIL + EMULSIFIER + ADDITIVES

Base oil:

Metal cutting fluids are made from basic oils that have been refined. Mineral, edible, and nonedible oils are the many types of basic oils accessible. a) Mineral oils: Mineral oils are a byproduct of petroleum that are commonly utilised for lubricating, cooling, and moisturising. b) Edible oils: The majority of edible oils are plant-based oils. Based on vegetables

Cutting fluids are environmentally friendly since they are renewable and biodegradable. c) Non-edible oils: Because global availability of fossil fuels is limited and need for power conveniences is increasing, it is necessary to increase bio lubricant production. Bio lubricant is an alternative to mineral oil lubricant since it is non-toxic, biodegradable, and environmentally friendly.

Emulsifier:

They are responsible for dispersing the oil in water in order to create a stable oil in water emulsion. Thermal conductivity, kinematic viscosity, and pH increased as emulsifier content increased, but flash point and fire point reduced as emulsifier level grew.

Additives:

Neutralizers, corrosion and rust inhibitors, lubrication additives, biocides and fungicides, and foam inhibitors are all examples of additives.

1.1.6 ENVIRONMENTAL ASPECTS OF CUTTING FLUID

Cutting fluids suffer chemical alterations when they are utilised regularly over time. These changes are the result of environmental causes such as metal chip contamination and tramp oil. Bacterial and yeast growth is hazardous to the environment and influences the effectiveness of cutting fluids. Cutting fluids diminish in quality with time and with usage, and when this happens, they must be discarded. Fluid waste disposal is expensive and has a negative influence on the environment. Because of changes in human environmental thinking, Throughout history, the emphasis on lubricants has switched from biodegradability to renewability.

Some characteristics of an environmentally friendly lubricant are as follows:

a) Biodegradability
b) Toxicity
c) Renewability

d) Life cycle assessment (LCA)
e) Energy saving and fuel economy

Mineral oil has a low biodegradability, which increases the risk of long-term environmental damage. They are also a finite and rapidly depleting resource. Because of bacterial growth and contamination from tramp oil and fine metal swarf from the machining operation, the cutting fluid within a coolant system deteriorate over time. When maintaining the fluid through regular make-up operations becomes uneconomical, it is dumped.

Cutting fluids are liquids or gases that help in the cutting process during machining. The procedure is only carried out at the interface between the tool and the work piece. Cutting fluid serves numerous purposes, such as minimising tool overheating, lowering power consumption, reducing tool wear and heat output, providing a good surface finish, washing away chips, and avoiding work piece corrosion.

Cutting fluids are hazardous to operator health during machining processes because they can vaporise, atomize, and Because of the high pressure and temperature, mist is produced. Operators can inhale cutting fluid airborne particles, causing mild respiratory difficulties, asthma, and a variety of cancers (oesophagus, stomach, pancreas, colon, etc.). Mist, vapours, smoke, and odours can all induce severe skin responses and respiratory problems. Dermatological issues arise when operators come into contact with cutting fluid.

1.1.7 EDIBLE OIL BASED CUTTING FLUIDS

Triacyl glycerides (triglycerides) are glycerol molecules composed of three long chain fatty acids linked by ester bonds at the hydroxyl groups. Vegetable oil triglycerides include fatty acids of the same length, ranging from 14 to 22 carbons. Their unsaturation levels, however, differ. Vegetable oils have good lubricating properties due to their triglyceride composition. Long polar fatty acid chains combine to generate high-strength lubricant coatings that aggressively engage with metallic surfaces, decreasing friction and wear. Vegetable oil has a higher viscosity index. In contrast, vegetable oils have poor thermal and oxidative stability. Vegetable oils outperform other oils for various reasons, including:

a) Adhere more securely to metal surfaces than mineral oils. Vegetable oil molecules are densely aligned, resulting in a thick, strong, and long-lasting lubricating film layer. Its lubricating layer boosts the vegetable oil's ability to absorb pressure. Mineral oil molecules, on the other hand, are non-polar by nature. They align randomly along a metal surface, forming a weaker lubricating layer. As a result, vegetable oils are more effective lubricants.

b) Vegetable oils emit less smoke and provide less of a fire risk since they have a higher flash point. A higher flash point value allows the cutting fluid to be used in high-temperature environments.

c) Viscosity is another oil attribute that influences machining productivity. The intrinsic viscosity of vegetable oils increases as the machining temperature rises. Vegetable oils have a slower viscosity decline than mineral oils. Vegetable oils stay more fluid than mineral oils when the temperature drops, allowing for faster drainage from chips and work pieces. Vegetable oils' greater viscosity index assures that they will deliver more stable lubricity over the whole operating range of temperature.

d) As a result, mineral oil parameters such as viscosity and boiling temperature are more subject to fluctuation.

e) Because vegetable oil has a higher boiling point and a larger molecular weight, it loses less from vaporisation and misting.

1.1.8 NON EDIBLE OIL BASED CUTTING FLUID

As the supply of fossil fuels shrinks globally and demand for energy-based conveniences increases, there is a need to increase bio lubricant production. Bio lubricant is a non-toxic, biodegradable, and ecologically friendly alternative to mineral oil lubricant since it is created from non-conventional energy resources. India has enormous potential for producing bio-lubricants from non-edible oil seeds. Prospective non-edible sources in India include Karajan, Mahua, Castor, Linseed, and others.

In terms of volatility, oxidative stability, low carbon forming propensity, viscosity, stability, and reactivity to additives, non-edible vegetable oils beat traditional lubricants. The aforementioned changes, in conjunction with climatic circumstances, have resulted in significant advances in lubricating oils. As environmental considerations are prioritised, industrial clients all over the world have begun to realise that some bio lubricants, particularly those based on non-edible vegetable oils, provide cost effective lubrication in all service conditions.

1.2 MACHINING

Machining is a production process in which industrial tools and machinery are moved in accordance with computer software that has been pre-programmed. The approach may be used to control a variety of complex machinery, such as grinders, lathes, mills, and routers. Machining can accomplish three-dimensional cutting operations in a single set of prompts.

The technology, abbreviated "CNC," works in contrast to — and so overcomes — the limits of manual control, in which live operators must prompt and lead milling equipment orders via levers, buttons, and wheels. To the untrained eye, a system may appear to be a typical set of computer components, but the software programmes and consoles used in machining differentiate it from all other types of computation.

Fig1.1: Universal Milling Machine

UNIVERSAL MILLING MACHINE

Specification:

TABLE SIZE - 300x1330MM
NO OF SPEEDS - 16
POWER - 5HP
Tool shank - BT-40 type
RANGE OF SPEED - 63-3000RPM

VERTICAL TOOL ATTACHMENT
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ROTARY TABLE

1.3 SURFACE ROUGHNESS

Surface roughness, often known as roughness, is a measure of the texture of a surface. To quantify an actual surface, the vertical differences from its ideal shape are employed. If these fluctuations are significant, the surface is rough; if they are little, the surface is smooth. Roughness is frequently seen as a high frequency, short wavelength component of a measured surface. Yet, knowing both the amplitude and frequency is frequently essential to ensure Roughness is an important factor in determining how an actual item will interact with its surroundings. Rough surfaces often have greater friction coefficients and wear faster. Since roughness can improve adhesion more than smooth surfaces, it is widely used to forecast mechanical component performance. That a surface is fit for its intended purpose. Although roughness is generally undesirable, it is difficult and expensive to control in manufacturing. Raising the roughness of a surface generally significantly raises its production costs. This typically results in a trade-off between the manufacturing cost of a component and its application performance.

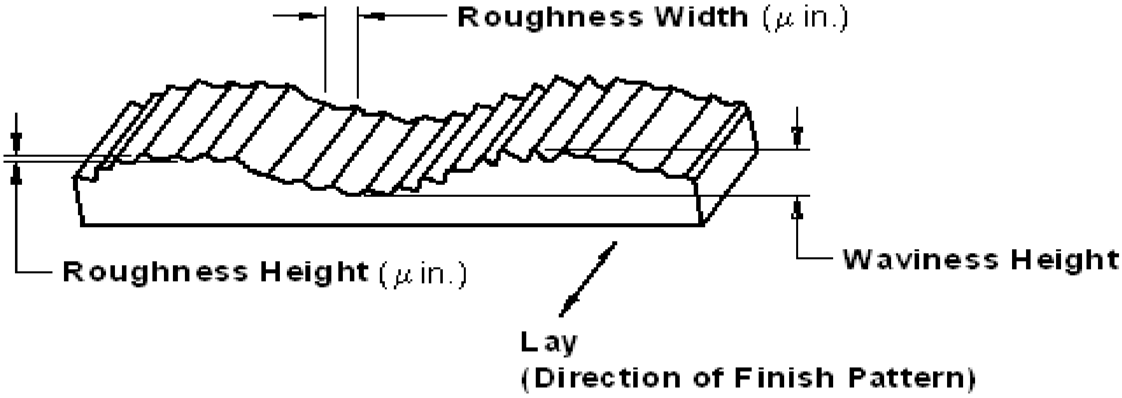


Fig 1.2: Image of Surface Texture

In handling the numerous geometrical portions to be analysed, the direct contact technique of measuring surface roughness of machined components offers limited flexibility. Friction, wear and tear, light reflection, heat transfer, lubricant distribution and retention, coating, and other functional aspects of components are all affected by surface roughness. As a result, the desired surface finish is often defined, and adequate measures to assure quality are necessary. As a result, examining the surface roughness of the work piece is crucial for establishing component quality.

1.3.1 SURFACE ROUGHNESS TESTER

Surface topography is crucial in establishing the function of a surface. A significant percentage of component failure originates at the surface, either as a result of a single manufacturing discontinuity or as a continuous decline in surface quality. Laps and folds are typical of the former, which create fatigue failures, whereas grinding damage generated by the usage of a worn wheel causes stress corrosion and fatigue failure. The most important parameter characterising surface integrity is surface roughness. Surface roughness must be kept within specified limitations in the industrial sector. As a result, determining surface roughness is crucial for controlling the quality of machining work pieces. The next sections explain the notion of surface roughness and the primary methods for measuring it.

Based on the roughness amplitude and wavelength values expected from the surface, the proper instrument settings for a valid roughness measurement may be chosen.

Any such argument must begin with a few definitions. The most significant are:

The local variations of a surface from its ideal shape, such as a perfect flat shape, a perfect cylindrical shape, a spherical shape, and so on, are referred to as SURFACE TEXTURE. Surface texture roughness and waviness are typically employed to establish its measurement. Surface texture has several elements that, when combined, determine the profile of a surface. As an example:

a) The microstructure of the material

b) The cutting tool's action

c) The cutting tool's instability on the material

d) Defects in the machine tool guide routes

e) The speed of the cutting tool, feed rate, and depth of cut are the main factors that influence surface texture.

ROUGHNESS: A quantitative evaluation of the process marks generated during surface manufacture, as well as other characteristics such as material structure. The cutting tool's action, chemical activity, polishing, lapping, and the material's structure all influence surface roughness.

WAVINESS: A longer wavelength shift of a surface away from its fundamental form (for example, a straight line or an arc). Machine or work deflection, cutting force, noise, heat treatment, or warping tensions can all produce it. When both process and machine-caused anomalies occur at the same time, roughness is stacked on top of waviness.

The dominating direction of the surface texture is referred to as the LAY. Generally, lay is determined by the manufacturing process and form used. A flat surface is often produced via turning, milling, drilling, grinding, and other cutting tool production methods.

PROFILE is the point at where a surface intersects a sectioning plane that is (typically) perpendicular to the surface. It represents a three-dimensional surface in two dimensions. Profiles are typically measured perpendicular to the surface's lay over the surface. To put it simply, it is a graphical representation of the surface.

CENTER LINE (Mean line): It is poisoned in such a way that the total of the regions enclosed by the profile above and below the centre line is equal during the sample time.

FILTERS are electrical or mathematical methods or algorithms that separate distinct wavelengths and allow us to see just the wavelengths that interest us.

CUT-OFF is a filter that is used to separate or filter a component's wavelengths. Cut-offs are numerical values that, when selected, minimise or remove unwanted wavelengths on the surface. A roughness filter cut-off of 0.8mm, for example, allows wavelengths below 0.8mm to be assessed but wavelengths above 0.8mm have their amplitude reduced; the greater the wavelength, the more severe the reduction. With a 0.8mm waviness filter cut-off, wavelengths above 0.8mm are examined, while wavelengths below 0.8mm have their amplitude reduced.

Fig 1.3: Surface Roughness tester

Specification:

Speed:	Measuring: 0.25mm/s (0.01”/s)
	Returning: 0.8mm/s (0.03”/s)
Measuring range:	350µm
Mass:	290g
Standard probe:	Code No. 178-395
Type :	inductive
Stylus:	Diamond cone
Skid radius:	40mm
Tip radius:	2µm
Measuring force:	0-75mN
Auto sleep function:	after 30 seconds

SAMPLE LENGTH: We sample the data after filtering it with a cut-off. The data is sampled by splitting it into equal sample lengths. The cut-off and sample lengths have the same numeric value. That is, assuming a 0.8mm cut-off is employed.

The filtered data will be split into 0.8mm samples. These sample lengths are chosen to allow for a thorough statistical study of the surface. For the most part, five sample lengths are used for analysis.

Ra = Arithmetic mean deviation.

Rz = Ten-point height of irregularities

It is the difference between the average of five highest peaks and the average of five deepest valleys within the sampling length.

1.4 WEAR

Due to flank wear, the tool component in contact with the final product erodes. This may be expressed using the Tool Life Expectancy equation.

Crater Wear happens when the rake face is degraded by chip contact. This is relatively common for tool wear and has no effect on tool performance unless it becomes severe enough to cause a cutting edge failure. This can be caused by either a low spindle speed or a low feed rate. This is especially prevalent in orthogonal cutting, which has the greatest tool temperature. Crater wear occurs at a height that is roughly comparable to the cutting depth of the material.

As material being machined accumulates on the cutting edge, this is referred to as a built-up edge. Some materials, most notably aluminium and copper, anneal to a tool's cutting edge. It is most frequent in softer metals with lower melting points. It may be avoided by increasing cutting speeds and using lubrication. It shows as alternating dark and shiny rings when drilled.

Some General effects of tool wear include:

a) Increased Cutting Forces

b) Increased Cutting Temperatures

c) Poor Surface Finish
d) Decreased Accuracy Of Finished Part
e) May lead to tool breakage

Tool wear can be decreased by milling with lubricants and coolants. They reduce friction and warmth, which leads to fewer tool wears.

1.4.1 PIN ON DISC:

In ostensibly non-abrasive circumstances, materials are evaluated in pairs. Tool wear is measured using the experimental attention concept. The coefficient of friction can also be calculated.

Fig 1.4: Pin on disc equipment.

Specifications:

Speed:	200- 2000RPM
Normal load:	5-200N
Frictional force:	0.1 – 200N Wear track diameter: 40 to 140mm Wear: 200 – 2000 µm
Pin diameter:	3,4,8,10 & 12
Ball diameter:	10mm
Wear disc size:	Dia 165mm× 8mm thick, EN- 31 hardened to 62HRc, groundto surface roughness 1.6Ra
Software:	winducom 2010

It comprises of a driven spindle and chuck for holding the rotating disc, a lever-arm device for holding the pin, and attachments for applying regulated tension to the pin specimen against the revolving disc specimen. Another method pits a spinning pin centred on the disc against a stationary disc. In either case, the wear track on the disc is a circular with many wear passes on the same track. The system may contain a friction force.

A measurement system, such as a load cell, that allows the coefficient of friction to be calculated.

Motor Drive: For motor drive, a variable speed motor capable of maintaining a constant speed under load is required. The motor should be positioned such that it does not interfere with the test.

Revolution Counter: The machine must feature a revolution counter or its equivalent that records the number of disc rotations, as well as the ability to shut off the machine after a predetermined number of revolutions.

Pin Specimen Holder with Lever Arm: One such design connects a stationary specimen holder to a pivoting lever arm. Adding weights, as one technique of loading, produces a test force proportional to the mass of the weights applied. The pivot of the arm should preferably be positioned in the plane of the wearing contact to eliminate excessive loading forces induced by sliding friction. The pin holder and arm must be of sufficient construction to restrict cutting forceal mobility during the test.

Wear Measuring Systems: Linear wear measurement instruments should be more sensitive. Any balance used to estimate the mass loss of the test specimen must be more sensitive; more sensitivity may be required under low wear situations.

The pin-on-disk wear test necessitates the use of two specimens. One is a pin with a radiused point, and the other is usually a flat circular disc. As the pin specimen, a firmly gripped ball is commonly used. The test machine revolves the disc or pin specimen around the disc centre. In each case, the sliding route is a circle on the disc surface. The plane of the disc can be oriented. Typically, an arm or lever with associated weights is used to press the pin specimen against the disc at a predetermined stress. Several loading systems, such as hydraulic or pneumatic, have been investigated. Wear findings for the pin and disc are provided individually as volume loss in cubic millimetres. Each material should be evaluated in both the pin and disc positions when testing two distinct materials.

1.5 CUTTING FORCE ANALYSIS

According to the findings, cutting pressures rise with increasing feed per tooth and axial depth of cut, but decrease with increasing cutting speed. The radial depth of cut has a considerable impact on the cutting force components. Cutting force analysis is the technique of determining the forces applied on a cutting tool during machining operations such as turning, milling, drilling, and so on. Force directions and amplitudes fluctuate across cutting operations1. The angle between the blade and the surface, the frictional force between the blade and the machine, and the elastic-recoil force exerted by the machine material itself when bent and deformed all contribute to the cutting force of a blade.

1.5.1 DYNAMOMETER

A dynamometer is a device for measuring force, torque, or power. For example, the power produced by an engine, motor, or other rotating prime mover may be calculated by simultaneously measuring torque and rotational speed (RPM). This device is used to measure and show data at the same time. The Lathe Tool Dynamo Meter is useful for researching and analysing the best feed.

Fig 1.5: Dynamometer

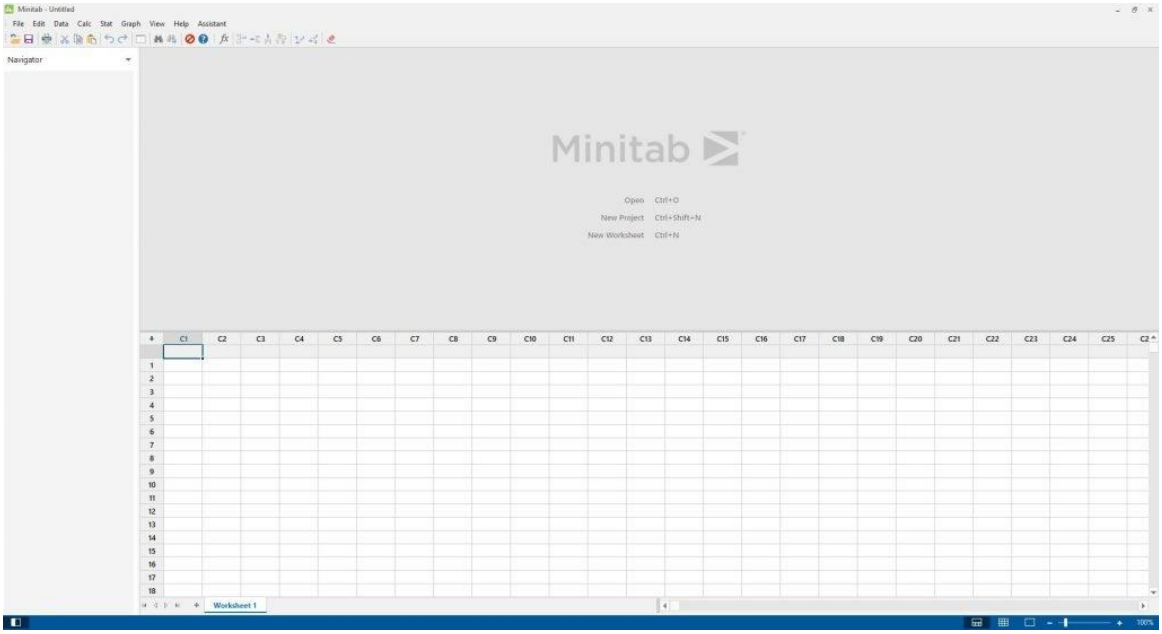
CAPACITY		FORCE
X-AXIS	-	500kgf
Y-AXIS	-	500kgf
Z-AXIS	-	500kgf

1.9 INDIVIDUAL OPTIMIZATION

Individual optimisation is a collection of mathematical principles and methods used to address quantitative problems in physics, biology, engineering, economics, and business. It is also known as mathematical programming.

1.9.1 MINI TAB

Minitab is a piece of statistical software. It was founded in 1972 at Pennsylvania State University by Barbara F. Ryan, Thomas A. Ryan, Jr., and Brian L. Joiner. Minitab started as a reduced version of the National Institute of Standards and Technology's OMNITAB statistical analysis tool. It may be used to learn statistics as well as perform statistical research. Statistical analysis computer software is more exact, trustworthy, and quicker than manually computing statistics and creating graphs. Minitab is relatively easy to use once you learn the fundamentals. Minitab Inc. is a privately held firm established in State College, Pennsylvania, with subsidiaries in Coventry, England (Minitab Ltd.), Paris, France (Minitab SARL), and Sydney, Australia (Minitab Pty.). Minitab is now frequently used in tandem with the adoption of six sigma, CMMI, and other statistics-based process improvement methodologies. The software, Minitab 14, is available in seven languages: English, French, German, Japanese, Korean, Simplified Chinese, and Spanish. Minitab is a statistical analysis programme. It can be used for both learning statistics and conducting statistical research. Statistical analysis computer software offer the advantage of being more precise, dependable, and faster than manually computing statistics and generating graphs. After you understand the principles, Minitab is relatively simple to use. Minitab Inc. also makes two other items that work in tandem with Minitab 14: An excellent trainer Quality Companion 3, an integrated tool for managing Six Sigma and Lean Manufacturing projects that allows Minitab data to be combined with management and governance tools and documents, is an eLearning package that teaches statistical tools and concepts in the context of quality improvement that integrates with Minitab 14 to simultaneously develop the user's statistical knowledge and ability to use the Minitab software. Minitab files are divided into two categories: projects and worksheets. Worksheets are files that include data; consider a spreadsheet that has data variables. Commands, graphs, and worksheets comprise projects. When you save a Minitab project, you save graphs, spreadsheets, and commands. each piece can be saved separately for use in other documents or Minitab projects. Similarly, you can print projects and their components.



1.6 MINITAB Interface

CHAPTER 2

LITERATURE REVIEW

The effort aims to produce alternative cutting fluids due to their advantages such as biodegradability, non-toxicity, environmental friendliness, and availability. The preceding chapter addressed the sort of experiment planned and the equipment used to determine the performance characteristics of different cutting fluids. To comprehend the issues connected with standard cutting fluids. Discover the benefits, uses, and drawbacks of cutting fluids. This chapter examined many papers to identify gaps in alternative cutting fluids research.

Abdalla, H.S. and Patel, S. *et al* **[1]** state that Metal working fluids (MWFs) are a type of lubricant that is widely utilized in machining processes. The majority of MWFs are mineral oil-based fluids intended to increase productivity and quality of manufacturing activities. Metal working fluids (MWFs) are used to cool and lubricate the contact surfaces of metal cutting and shaping operations. Because of its benefits, MWFs are becoming more popular in the machining sector. According to reports, the European Union alone utilises around 320,000 tonnes of MWFs each year, at least two-thirds of which must be disposed of. Despite their widespread usage, they pose serious health and environmental risks throughout their entire life cycle. According to reports, skin contact with cutting fluids caused approximately 80% of all occupational illnesses among operators. According to estimates, around 700,000 to one million workers in the United States are exposed to MWFs. Because cutting fluids have a complicated composition, they may cause irritation or allergies. Microbial toxins are also produced by bacteria and fungus present, particularly in water-soluble cutting fluids, and are extremely dangerous to operators. To address these issues, scientists and tribologists are investigating potential alternatives to petroleum-based MWFs. Synthetic lubricants, solid lubricants, and vegetable-based lubricants are examples of such options.

Sharafadeen *et al* **[2]** investigated on The effectiveness of vegetable oil-based cutting fluids in Mild steel machining utilising ground nut oil, palm oil, and a 1:1 blend of ground nut and palm oil on turning a Mild steel shaft was evaluated. The workpiece temperature and chip formation rates were compared to mineral oils and dry machining while employing these vegetable oils as cutting fluids at varying cutting speeds, feed rate, and depth of cut. When groundnut oil was utilised as the cutting fluid, the temperature of the workpiece was extremely near to that of standard oil. Palm oil has the largest overall chip thickness due to its lubricating capability.

Prerana and Chhibber *et al* **[3]** stated that Because fossil fuels are depleting throughout the world, and the demand for energy-based conveniences and mobility issues is rising, there is a need to enhance bio lubricant manufacturing. Bio lubricant is a non-conventional energy resource-based alternative to mineral oil-based lubricant that is non-toxic, biodegradable, and environmentally beneficial. India has a lot of potential for making bio lubricants from of non-edible oil seeds. There are over 100 types of oil-seeds accessible, with just 13-14 varieties having been tapped thus far. Pongamiapinnata (Karanja), Meliaazadirachta (Neem), Madhucaindica (Mahua), Linseed (Liniumusitatissimum), Castor oil (Ricinuscommunis), and Rice Bran oil are among the potential non-edible sources in India (Oryza sativa).

Lawal *et al* **[4]** investigated the By completing turning operations on a lathe at various speeds, the ability of cooling, lubrication, and comparison with traditional cutting fluid was demonstrated. Cutting fluid made from groundnut oil was discovered to be the finest coolant at all speeds.

Xavior *et al* **[5]** investigated the The effect of cutting fluids on tool wear and surface roughness during AISI 304 austenitic stainless steel turning. For turning operations, a carbide tool is employed. Coconut oil, emulsion, and a plain cutting oil-immiscible with water were utilised as cutting fluids. The experiments are carried out using Taguchi's design of experiment (DOE) with an L27 (3)4 orthogonal array, with cutting speed, depth of cut, feed rate, and cutting fluid type as essential input factors. When machined at a constant depth of cut of 0.5mm, federate of 0.2, 0.25, and 0.28mm/rev, and cutting speed of 38.95, 61.35, and 97.38m/min, the findings showed that coconut oil has less surface roughness and tool wear than straight cutting oils and soluble oils. The authors discovered that I feed rate has a greater influence on surface roughness with a 61.54% contribution and cutting speed has a greater influence on tool wear with a 46.49% contribution for all cutting fluids; and (ii) coconut oil has a better relative performance than conventional oil in reducing tool wear and improving surface finish.

E. Kuram · B. Ozcelik *et al* **[6]** stated that The usage of vegetable-based cutting fluids as an alternative to mineral-based cutting fluids has raised demand for biodegradable cutting fluids. Mineral-based oils are a finite and rapidly depleting resource, but vegetable-based oils are renewable. Normal cutting fluids are polluted with metal particles and deteriorated goods, reducing their efficacy. To lessen the negative environmental consequences of cutting fluid use, harmful components in their formulations must be removed or lowered to a tolerable level.

Belluco and De Chiffre *et al* **[7]** studied the Drilling performance of vegetable-based oils in AISI 316 L austenitic stainless steel using conventional 'High Speed Steel' Cobutt (HSS-Co) tools. Six cutting oils were tested for efficacy by assessing tool life, cutting forces, and chip formation. They employed a commercial mineral-based oil as a control, as well as five vegetable-based (rape seed oil) cutting fluids with varying levels of sulphur and phosphor. To study the influence of various fluids on all gathered parameters, an analysis of variance is done. A mix of rapeseed oil, ester oil, and meadow foam oil with sulphur and phosphor additives enhances tool life by 177%, while cutting force is lowered by less than 7%, and all vegetable-based fluids outperform commercial mineral oil used as a control product.

Ojolo *et al* **[8]** experimentally determined the The effect of straight biological oils such as groundnut oil, coconut oil, palm kernel oil, and shear butter oil on cutting force during the cylindrical turning of three materials with tungsten carbide tools (mild steel, copper, and aluminium). Each workpiece is cut at spindle speeds of 250, 330, 450, and 550 rpm, with a continuous feed of 0.15 mm/rev and a depth of cut of 2 mm. The results showed that bio-lubricants are suitable oils for metalworking fluids, however their effects on cutting forces vary depending on the material. Groundnut oil demonstrated reduced cutting forces when turned aluminium at 8.25 m/min with feeds of 0.10, 0.15, and 0.20 mm/rev. Palm kernel oil generated the greatest results when copper was spun at a feed rate of less than 0.15 mm/rev. Groundnut oil offered the best results for copper when machined at higher speeds.

Salete *et al* **[9]** revealed that Cutting fluids must contain emulsifiers and bactericides as additions. According to the author, detergent (10%) may be used as an emulsifier since it aids in the retention of oil particles in water, and phenol (5%) can be used as a bactericide to prevent the development of bacteria in cutting fluid, which is commonly generated by prolonged exposure of the emulsifier to air.

X.C.Tan *et al* **[10]** stated that The key concerns for traditional cutting fluid selection are quality and price. Yet, the environmental impact and green production must be considered. Green manufacturing's purpose is to lessen the environmental impact of product production processes. The environmental impact varies depending on the type of cutting fluid used in the machining process. As a result, the three key factors impacting cutting fluid selection are quality, cost, and environmental impact.

Salete Martins Alves *et al* **[11]** described "Since mineral oils have low biodegradability, an increasing demand for bio oils has opened the door to employing vegetable oils as an alternative to petroleum-based polymeric fluids." According to current industry research, vegetable oil can even increase cutting performance, lengthen tool life, and improve surface finishing when compared to mineral oil. Despite their many environmental benefits, vegetable oils are more sensitive to oxidation or hydrolytic breakdown. Vegetable oil has certain challenges in usage due to insufficient oxidative stability and problems connected with use at high or low temperatures. The issue of weak oxidative stability can be alleviated by chemically altering the structure of vegetable oil."

Nurul Adlina *et al* **[12]** reported that Because viscosity is an important characteristic of lubricants that influences machining. If the lubricating oil is too thick or too thin, the wear on the cutting tool may be greatly increased. The higher the oil's viscosity index, the more stable the lubrication across the working temperature range. Because of increased friction between the tool and the workpiece, the viscosity of the lubricant has a direct effect on the heat generated during machining processes. Oil spreadability is related to viscosity, which means that the higher the viscosity of the oil, the lower the spreadability, and vice versa. During cutting, a low degree of heat reduces torque. As a cutting tool overheats, it expands thermally in both the cutting tool and the workpiece, increasing torque due to cutting tool penetration into the workpiece. As a result of this scenario, high temperatures are created at the tool-workpiece contact. At high temperatures, the penetration of a cutting tool into a workpiece has an influence on the surface quality of the specimen.

Sreejith P, Ngoi B *et al* **[13]** analysed to reduce the negative environmental consequences of cutting fluids, the best answer is to eliminate the harmful components from their formulation. Yet, different procedures are preferable to formulation. The most efficient strategy to reduce the environmental impact of cutting fluids is to reduce the amount utilised and replace mineral-based cutting fluids with ecologically friendly cutting fluids such as vegetable-based cutting fluids. Dry machining is the most environmentally friendly approach. Dry machining not only lowers water and air pollution, but it also reduces the operator's health risk. Dry machining, on the other hand, is inefficient. for several cutting tasks. In this scenario, a little amount of lubricant (MQL) can be injected into the cutting zone to increase machinability. MQL minimises cutting fluid use, however it employs cutting fluids in the form of mist, which raises the operators' health risks.

Khan MMA, Dhar NR *et al* **[14]** analysed The cutting performance of MQL machining provides the benefits mainly by reducing the cutting temperature, which improves the chip-tool interaction and maintains sharpness of the cutting edges. MQL jet provides reduced tool wear, im- proves tool life and better surface finish as compared to dry machining of steel. Surface finish and dimensional accuracy improved mainly due to reduction of wear and damage at the tool tip by the application of MQL. Such reduction in tool wear would either enhance tool life or productivity, allowing higher cutting velocity and feed.

Fox NJ, Stachowiak GW *et al* **[15]** analysed that Vegetable based cutting fluids can be considered environmentally friendly since these fluids are renewable and have high levels of biodegradability. Vegetable oils consist of tri acyl glycerides (triglycerides) which are glycerol molecules with three long chain fatty acids attached at the hydroxyl groups via ester linkages. The fatty acids in vegetable oil triglycerides are all of similar length, between 14 and 22 carbons long and their unsaturation levels are varying. The triglyceride structure of vegetable oils provides desirable properties of lubricant. Long, polar fatty acid chains provide high strength lubricant films which interact strongly with metallic surfaces and reduces both friction and wear.

Ulrich Krahenbuhl *et al* **[16]** stated that Vegetable oil technology is bringing significant gains in productivity and tool life. Utilizing vegetable oil-based coolants when machining allows for pleasant surface finishes and dimensional tolerances. They also noted that the size of vegetable oil molecules is relatively homogenous, but the size of mineral oil molecules varies. As a result, mineral oil parameters such as viscosity and boiling temperature are more subject to fluctuation. Vegetable oils have a greater flash point, which reduces the creation of smoke and the risk of a fire. A higher flash point value permits the cutting fluid to be used under high temperature situations.

Swarup Paul *et al* **[17]** performed Turning operation on mild steel with 18-4-1 HSS cutting tool at various speed-feed-depth of cut combinations using various cutting fluids. Surface roughness performance analysis with increasing rate of feed or depth of cut using a cutting fluid based on vegetable oil. While the cooling capacity of vegetable oil-based cutting fluids is slightly lower than that of traditional cutting fluids, vegetable oils can still be employed as a coolant during machining due to superior surface smoothness.

According to the literature, there is a gap in the application of vegetable-oil based cutting fluids on non-ferrous materials. It has been discovered that groundnut oil, sunflower oil, palm oil, and castor, neem samples may be used as basis oils since they contain the attributes that cutting oil should have. Minimal attempts have been made in performance analysis such as surface roughness, cutting force analysis, and wear rate employing cutting fluids during machining of mild steel and non-ferrous metals such as aluminium.

CHAPTER 3

EXPERIMENTATION

The performance of edible and non-edible oils as cutting fluids is investigated in this study. The process also entails preparing cutting fluids to determine whether or not they may be employed as effective cutting fluids. Wear rate measurement with a pin on disc, cutting force analysis with a dynamometer, surface roughness with a surface roughness tester, and temperature analysis are all part of this performance analysis. This performance has been compared with conventional cutting fluid, which is used in industries. Viscosity of all cutting fluids are determined to correlate the performance characteristics with it.

3.1 DETERMINATION OF VISCOSITY OF OIL SAMPLES

Viscosity is a fluid attribute that governs the resistance to flow supplied by one layer of fluid to its adjacent layer. It is a measure of a lubricating oil's flow ability; the lower the viscosity, the better the flow ability. It is mostly due to the cohesive interactions between the lubricating oil molecules.

Red Wood viscometer, Stopwatch, Kohlrausch flask, Thermometer, Filter paper, and Weight Machine are used to measure the viscosity of sample oils.

First, the viscometer cup is thoroughly cleaned with a suitable solvent, such as CCl4, ether, petroleum spirit, or benzene, and dried to remove any traces of solvent. The viscometer is then levelled using levelling screws. The outside bath is now filled with water to determine the viscosity at 30°C and below. The jet is closed with a ball valve, and the test oil is poured into the cup up to the tip of the indicator. A clean dry Kohlrausch flask is immediately placed below and directly in line with the discharge jet, and a clean thermometer and stirrer are inserted in the jar and the cup is covered with a lid. Slowly heat the bath water with constant stirring until the oil in the cup reaches the correct temperature. As at, the ball valve is lifted and the stop watch is started. The oil from the jet pours into the flask until the meniscus reaches the 50 ml mark on the neck of the receiving flask. The time it takes for 50 mL of oil to gather in the flask is recorded, and the viscosity of the oil is calculated using the calculations below.

Range	Kinematic Viscosity (stokes)30 – 100
Seconds	(0.00264 T) – (1.79/T)
100 – 2000 Seconds	(0.00247T) – (0.5/T).

Fig 3.1: Redwood Viscometer

Table 3.1: Viscosity of Edible and Non-Edible

Oil Sample	**Temperature (°C)**	**Kinematic Viscosity(stokes)**
Castor oil	30	3.15
Sunflower oil	30	0.370
Groundnut	30	0.313
Neem oil	30	0.17
Palm oil	30	0.0566

3.2 CUTTING FLUID PREPARATION

Oils of Sunflower (Helianthus), Groundnut (Arachishypogaea), Castor oil (Ricinus communis) and Neem oil (Azadaricta indica) are selected for cutting fluid preparation. Getting rid of any foreign substances or pollutants, these local oils are filtered via cotton filters. The additives are as follows:

Table 3.2: Additive added and their composition

Component	**Function**	**Percentage (vol/vol)**
Base Oil	Base Oil	80
Detergent (n-dodecyl benzene sulphonate)	Emulsifier	10
Citric Acid	Anti Oxidant	5
Phenol	Disinfectant	5

An emulsion (detergent/n-dodecyl benzene sulphonate) is added to the solution to prevent water separation, and the combination is blended at room temperature. The produced samples are treated with citric acid extract right away. Citric acid includes vitamin C, which works as an antioxidant and inhibits bacterial growth. Bactericide (5% of total mix) is used to keep biodegradable organisms at bay. According to the advice of earlier researchers in this field, the fluid samples utilised in this work are processed into cutting fluid. Each cutting fluid sample is made by measuring 1200 mL of fixed oil (in a 1-litre measuring beaker) and mixing it with water at a 1:10 fluid-to-water ratio. When kept at ambient temperature, This mixture is made up of 10% vol/vol normal soap and the appropriate amounts of other components.

Fig 3.2: Groundnut oil based Cutting Fluid

The following table gives information of the costs involved in purchasing the cutting fluids

Table 3.3: cost of cutting oils

Cutting Fluids	Cost in INR (per litre)
Castor oil	200
Sunflower oil	195
Ground nut oil	210
Neem oil	500
Palm oil	180

3.3 MEASUREMENT OF WEAR RATE

Wear is a process of surface interaction that results in the distortion and removal of material from the surfaces as a result of mechanical action between the sliding faces. Wear is also used to describe the dimension loss caused by plastic deformation. It causes "metallic wear," which is the deterioration of metal surfaces. Wear can be caused by a variety of reasons, including corrosion, erosion, abrasion, chemical reactions, or a combination of these.

Wear occurs as a result of friction and heat buildup between two parts. This has an impact on the product's surface finish. Cutting fluid is used to overcome this. The PIN ON DISC equipment is used to evaluate the performance of wear characteristics with respect to various cutting fluids by following condition:

- By maintaining the constant speed and varying the loads.
- By maintaining the constant load and varying the speed.

The following procedure is followed on Pin on Disc equipment as shown in fig:1.4.1 in

Initially the apparatus is kept at no load condition and check for the correct alignment of tooland workpiece. Now the apparatus is kept at a constant speed of 750rpm. The load of 4 kg, 6 kg and 8kg are applied as the disc is made to rotate and corresponding readings are taken. Similarly by maintaining 4kg constant load with varying speed of 750, 1000 and 1250 rpm corresponding reading taken. The same procedure is applied for different cutting fluids and corresponding readings are taken. Graph is drawn between tool wear and time for different cutting fluids. The corresponding graphs are compared and results are plotted.

Table 3.3.1:
Wear rate by maintaining the constant speed and varying the loads (microns)
(MILD STEEL)

Cutting fluids	**4Kg load**	**6Kg load**	**8Kg load**
Castor	2	3	3
Ground nut	5	7	9
Sunflower	3	6	11
Neem	4	7	11
Palm oil	11	25	37
Water soluble	112	191	264

Table 3.3.2:
Wear rate by maintaining the constant speed and varying the loads (microns)
(ALUMINIUM)

Cutting fluids	**4Kg load**	**6Kg load**	**8Kg load**
Castor	1	2	2
Ground nut	3	4	5
Sunflower	2	4	6
Neem	2	4	6
Palm oil	5	12	18
Water soluble	52	89	123

Table 3.3.3:

Wear rate by maintaining the constant load and varying the speed.
(MILD STEEL)

Cutting fluid	750rpm	1000rpm	1250rpm
Castor	2	3	3
Groundnut	5	7	10
Sunflower	3	4	7
Neem	4	11	13
Palm oil	8	10	13
Water soluble	108	147	208

Table 3.3.4:

Wear rate by maintaining the constant load and varying the speed.
(ALUMINIUM)

Cutting fluid	750rpm	1000rpm	1250rpm
Castor	1	2	2
Groundnut	3	4	5
Sunflower	2	2	4
Neem	2	6	7
Palm oil	4	5	7
Water soluble	51	69	97

3.4 MACHINING PARAMETERS

Cutting parameters are functions that strongly influence the machining process; these typically include cutting speed, feed, and depth of cut. Aside from these, there are numerous more variables that influence the outcome of a machining process. Other than speed, depth of cut, and feed rate, the cutting parameters based on machining circumstances are size, material and hardness of the work piece, cutting tool material, hardness, tool shape and dimensions, and lastly type of cutting fluid.

Table 3.4.1:
Machining parameters for MILD STEEL

Speed (rpm)	727
Feed (mm/sec)	105.5
Depth of Cut (mm)	0.5

Table 3.4.2:
Machining parameters for ALUMINIUM

Speed (rpm)	727
Feed (mm/sec)	90.1
Depth of Cut (mm)	0.5

3.5 FACE MILLING OPERATION

Face milling is the machining process of cutting the surfaces that are perpendicular to the cuter axis. During face milling operations, the workpiece should be fed against the milling cutter so that the pressure of the cut is downward, thereby holding the piece against the table.

The generated surface is at right angles to the cutter axis and is combined result of actions of the teeth located on both periphery and face of the cutter.

Fig3.3: Face milling operation

3.6 MEASUREMENT OF SURFACE ROUGHNESS

Surface roughness is a measure of the texture of a surface and is quantified by the vertical deviations of a real surface from its ideal form. Surface topography is of great importance in specifying the function of a surface. A significant proportion of component failure starts at thesurface due to either an isolated manufacturing discontinuity or gradual deterioration of the surface quality.

Surface roughness values are displayed as follow

Table 3.6.1:
Surface roughness (Ra) values in microns
(MILD STEEL)

Cutting fluid	**Perpendicular to lay direction**	**Lay direction**	**Opposite to lay direction**	**Average value**
Castor oil	0.16	0.15	0.15	0.1533
Sunflower oil	0.2	0.21	0.29	0.2333
Groundnut oil	0.14	0.37	0.67	0.3933
Neem oil	0.26	0.14	0.17	0.19
Palm oil	0.4488	0.1862	0.264	0.299
Direct Cutting Oil	0.17	0.16	0.16	0.1633

Table 3.6.1:
Surface roughness (Ra) values in microns
(ALUMINIUM)

Cutting fluid	**Perpendicular to lay direction**	**Lay direction**	**Opposite to lay direction**	**Average value**
Castor oil	1.399	13.417	8.33	7.715333
Sunflower oil	1.532	14.693	8.554	8.259667
Groundnut oil	1.236	8.053	6.541	5.276667
Neem oil	1.202	8.058	6.889	5.383
Palm oil	1.296	9.246	7.085	5.875667
Direct Cutting Oil	0.849	4.962	4.088	3.299667

Surface Roughness is measured using electronic instrument Surface roughness tester which basically consist of detector stylus which traces over the workpiece. The electronic actuator isconnected to a processor and display unit, Sample length is set to 40 mm where the probe withstylus travels 40mm of length on the surface of work piece during which tip of 0.01mm radiustravels over the lays of the surface and the roughness values are processed by the processor with the movement of probe when passed over the rough surface.

3.7 CUTTING FORCE ANALYSIS

In line Cutting force monitoring is primarily utilized in machining applications to identify tool condition, surface quality, dimensional errors, and chatter phenomenon. At a computer numerically controlled vertical machining Centre, a series of milling experiments using coolant are carried out. Fig. 1 depicts the experimental setup. The milling cutter with a diameter of 50 mm is used for the experiments. The work piece was made using a normal grade aluminium block. The cutting speed, depth of cut, and feed rate remained unchanged at 2000 rpm, 0.6mm, and 150mm/min, respectively. The relationship between the change in cutting force and the surface roughness during face milling is studied in this study for various cutting fluids.

Fig 3.7.1 : Sensor and systematic arrangement for force analysis

Fig 3.7.2 : Dyanamometer for force analysis

Table 3.7.1:
Cutting Force in all three directions
(MILD STEEL)

CUTTING FLUID	**Fx (kgf)**	**Fy (kgf)**	**Fz (kgf)**
Castor oil	28.1455	11.69	21.81
Neem oil	25.5868	12.92	16.963
Sun flower oil	33.2628	16.612	24.2333
Ground nut oil	30.7	15.3815	21.7
Palm oil	35.82	17.8426	31.5
Direct Cutting Oil	20.46	11.074	21.8

Table 3.7.2:
Cutting Force in all three directions
(ALUMINIUM)

CUTTING FLUID	**Fx (kgf)**	**Fy (kgf)**	**Fz (kgf)**
Castor oil	15.1194	4.3	9.6933
Neem oil	15.1	5.52	12.116
Sun flower oil	12.09	4.91	12.11
Ground nut oil	21.16	6.757	14.53
Palm oil	27.21	7.371	12.116
Direct Cutting Oil	9.071	3.68	9.5

3.8 TEMPERATURE ANALYSIS

The thermal behavior should be more pronounced, leading to more problems in a technology transfer from conventional machining. To best understand the performance of cutting fluid it is necessary to evaluate the thermal behavior of lubricant to dry machining. Determination of the maximum temperature and temperature distribution along the rake face of the cutting tool is of particular importance because of its controlling influence on tool life, as well as, the quality of the machined part. The radiation techniques are non-contact thermographic methods to measure the surface temperature of the body based on its emitted thermal energy. It is available for both temperature field measurement (infrared thermography)including photo cameras with films sensitive to infrared radiation and infrared cameras, and for point measurement (infrared pyrometer). The radiation technique has many advantages overthe thermo-electric technique including: fast response; no adverse effects on temperatures andmaterials; no physical contact; and allowing measurements on objects, which are difficult to access. The high temperatures encountered in HSM are due to many reasons: more heat is generated; heat generation is concentrated over a small area; and the adiabatic nature of the process where less heat is dissipated away from the cutting zone due to a short contact time.

Fig3.8: Infrared thermometer

For same machining parameters temperatures at the work piece with and without cooling aredetermined.

Table 3.8.1:
Temperature at the workpiece (MILD STEEL)

Cutting fluid	**With coolant(°C)**
Castor oil	29.5
Sun flower oil	28.5
Groundnut oil	29
Neem oil	29.2
Palm oil	28.5
Direct Cutting Oil	29.5

Table 3.8.1:
Temperature at the workpiece (ALUMINIUM)

Cutting fluid	**With coolant(°C)**
Castor oil	28.2
Sun flower oil	28
Groundnut oil	27.8
Neem oil	27.6
Palm oil	28.6
Direct Cutting Oil	28

CHAPTER 4

RESULTS AND DISCUSSION

Due to greater attention to the environmental and health repercussions of industrial activities by government law and a growing awareness level in society, industrialists are being obliged to reduce their use of mineral oil-based cutting fluids as cutting fluid. Cutting fluid formulas became more sophisticated as cutting processes became more harsh. As cutting operations got harsher, cutting fluid compositions became more advanced. There are several types of cutting fluids on the market today, with cutting oils or water-miscible fluids being the most common. The wear rate, cutting force, workpiece temperature, and surface roughness of vegetable and non-vegetable based cutting fluids were determined, and the findings from the vegetable based cutting fluids were compared.

4.1 WEAR ANALYSIS:

In this study, wear rates are examined using biodegradable, readily available food (Groundnut and Sunflower) and nonedible fluids (Castor and Neem). The outcomes are compared to normal mineral fluids (Direct and water Soluble). Wear measurements and analyses of edible, non-edible, and direct base cutting fluids are performed in two steps. In the first step, the velocity of the aforementioned fluids are varied at a constant load of 4kg (750, 1000, 1250 rpm).

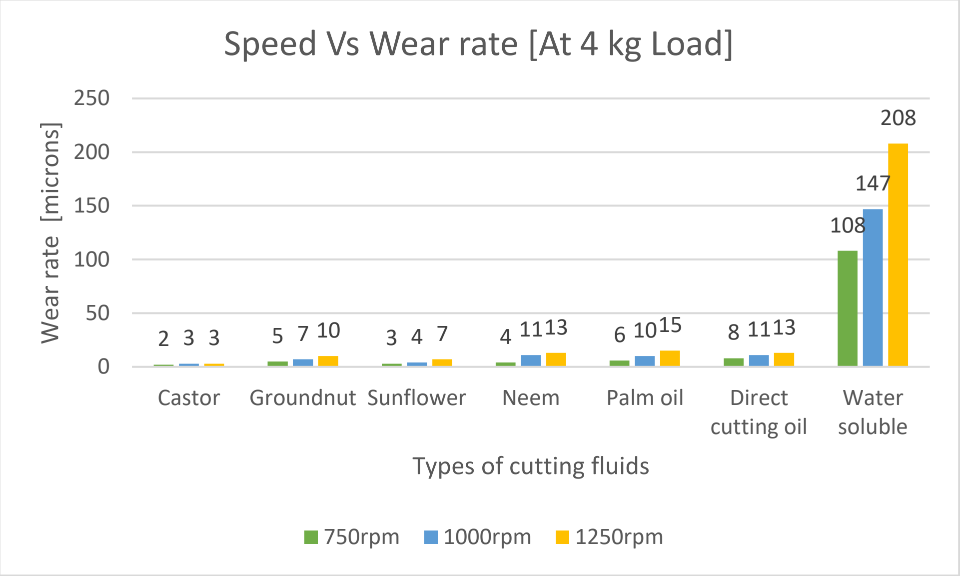


Fig 4.1.1: Wear analysis at constant load and varied Speeds On Mild steel

The Figure 1 displays a wear study of all cutting fluids utilised. Castor cutting fluid has a low wear rate. The castor cutting fluid has a high viscosity in compared to the other fluids used, which assists in the lubrication of the contact surfaces of the pin and disc, resulting in a reduced wear rate. Sunflower, groundnut, neem, and water soluble are the other fluid viscosities, in that order. Figures 1 and 2 show the same wear rate trend; when the viscosity of the cutting fluid decreased, the wear rate rose. Because of the larger volume of water in cutting fluid, the wear rate of water soluble cutting fluid is fairly high.The graphs in the figure show that as the speed is increased from 750-1000-1250 rpm, the wear rate increases, which is mostly due to an increase in friction on mild steel material.

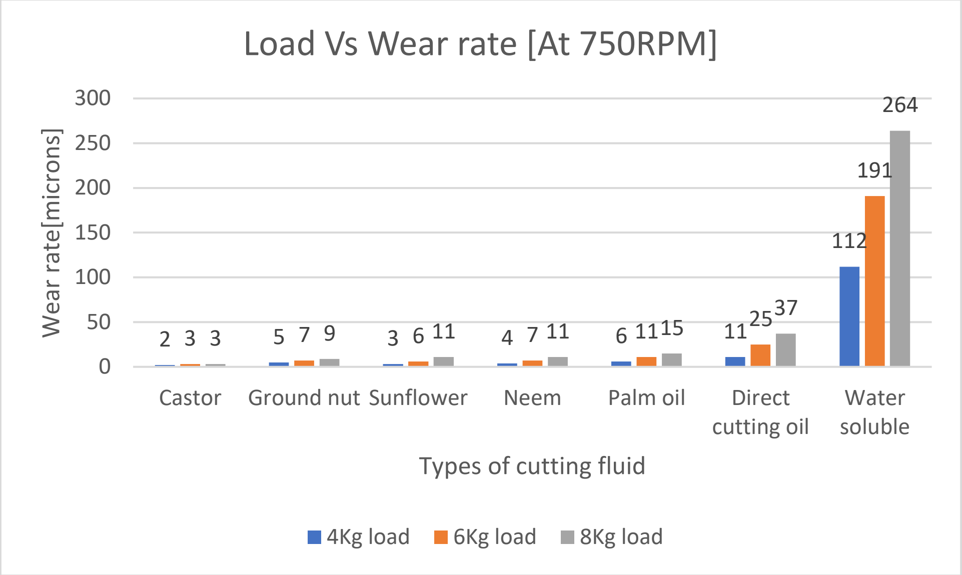


Fig 4.1.2: Wear analysis at constant load and varied Speeds on Mild Steel

The graphs in the figure demonstrate that at constant speed, as the weight on the pin increases from 2-6-8 kg, the wear rate increases, owing to an increase in friction as the load increases. Material: Mild steel

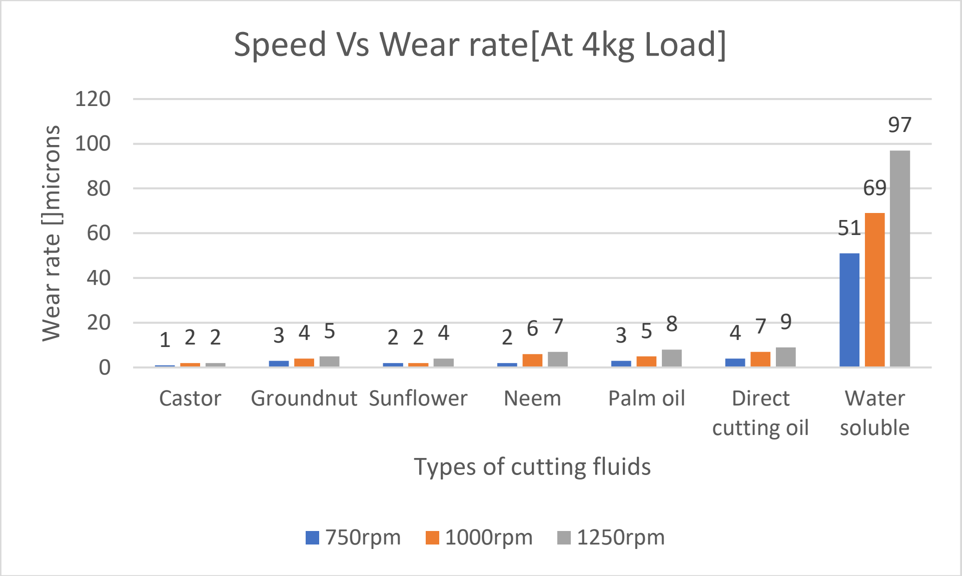


Fig 4.1.3: Wear analysis at constant load and varied Speeds On Mild steel

The graphs in the figure illustrate that when the speed increases from 750-1000-1250 rpm, the wear rate increases, owing to an increase in friction on the aluminium material.

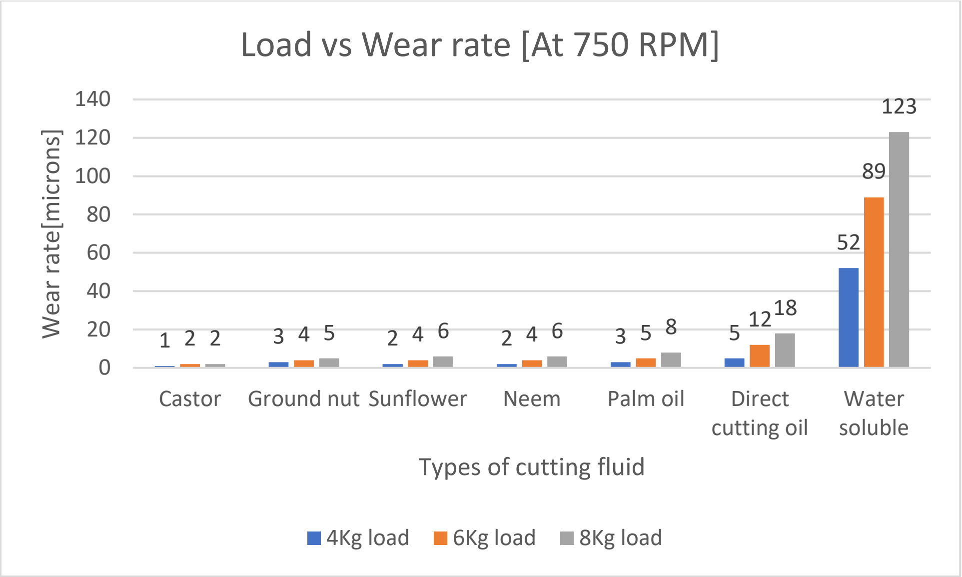


Fig 4.1.4: Wear analysis at constant load and varied Speeds on Mild Steel

The graphs in Figure 2 show that when the weight on the pin increases from 4-6-8 kg at constant speed, the wear rate increases due to an increase in friction as the load increases. About Aluminum Material

4.2 SURFACE ROUGHNESS ANALYSIS:

The effect of cutting fluids on wear and surface roughness during face milling of mild steel flats is investigated in this paper. Figure depicts the variance of surface roughness for the a for ementioned alternate Edible and Non Edible cutting fluids.

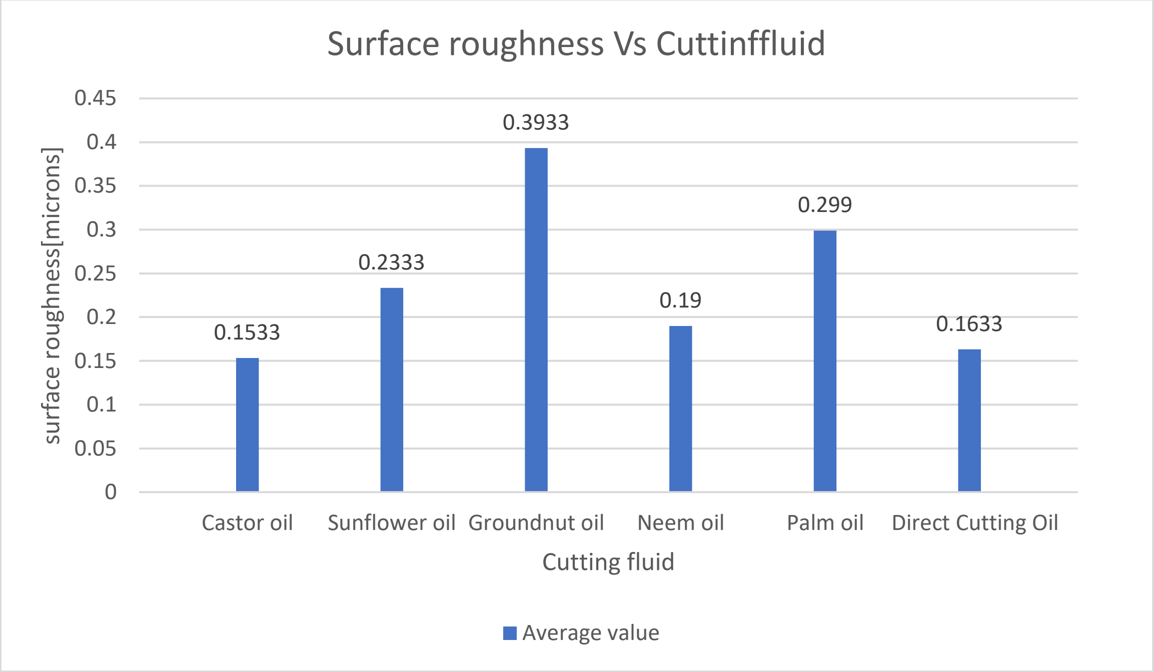


Fig4.2.1: Surface roughness (Ra) vs Cutting fluids On Mild steel

The effect of cutting fluids on wear and surface roughness during face milling of aluminium flats is investigated in this paper. Figure 4.3 depicts the variance of surface roughness for the aforementioned alternate Edible and Non Edible cutting fluids.

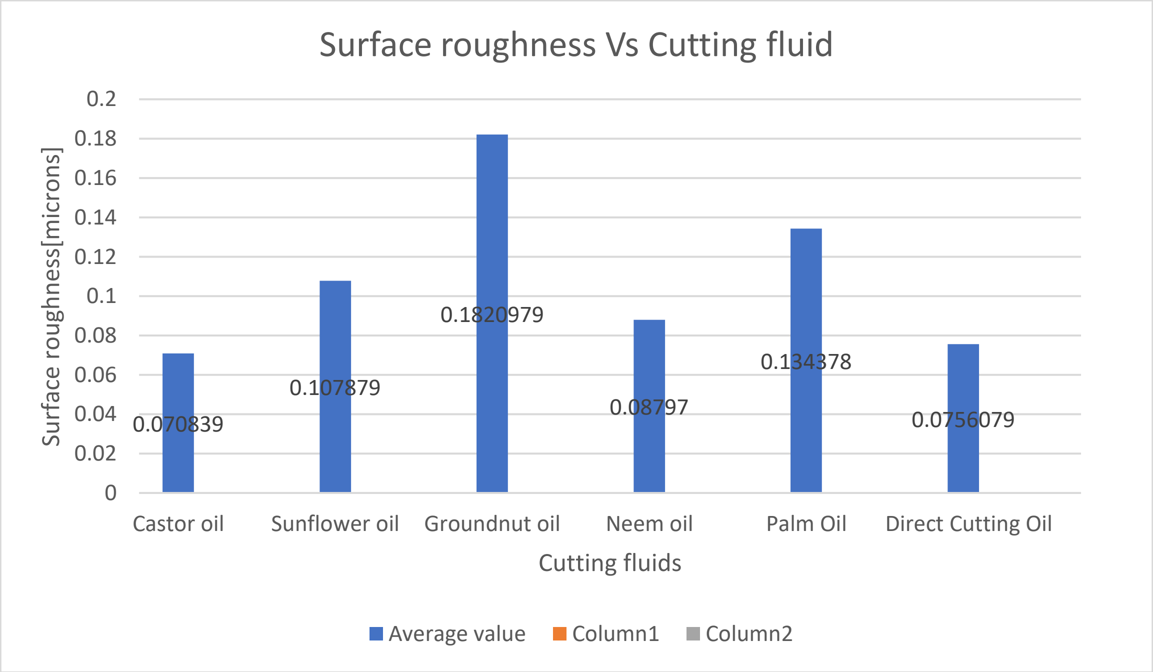


Fig4.2.2: Surface roughness (Ra) vs Cutting fluids On Mild steel

In general, castor oil outperformed the other cutting fluids in terms of minimising tool wear and enhancing surface smoothness, followed by sunflower, neem, and groundnut oils.

It is also discovered that the surface roughness is lower in samples with less cutting force during machining, which is connected to the viscosity of the cutting fluids.

4.3 CUTTING FORCE ANALYSIS:

Because relatively low heat conductivity induces the development of serrated chips, which further increases the variation in cutting forces, interrupted cutting procedures such as milling are frequently prone to difficulties affecting cutting force of the machine-tool-workpiece fixation device system. In milling or other interrupted cutting processes, a low Young modulus creates significant changes in chip thickness, i.e., high cutting force levels, particularly chattering or self-excited cutting force, which causes tool edge micro chipping and early end of service life. This type of cutting force also increases in reaction to the creation of serrated chips, which is also a result of limited heat conductivity and increases cutting force variations.

X-axis: feed direction

Y-axis: transverse direction

Z-axis: vertical/spindle axis direction

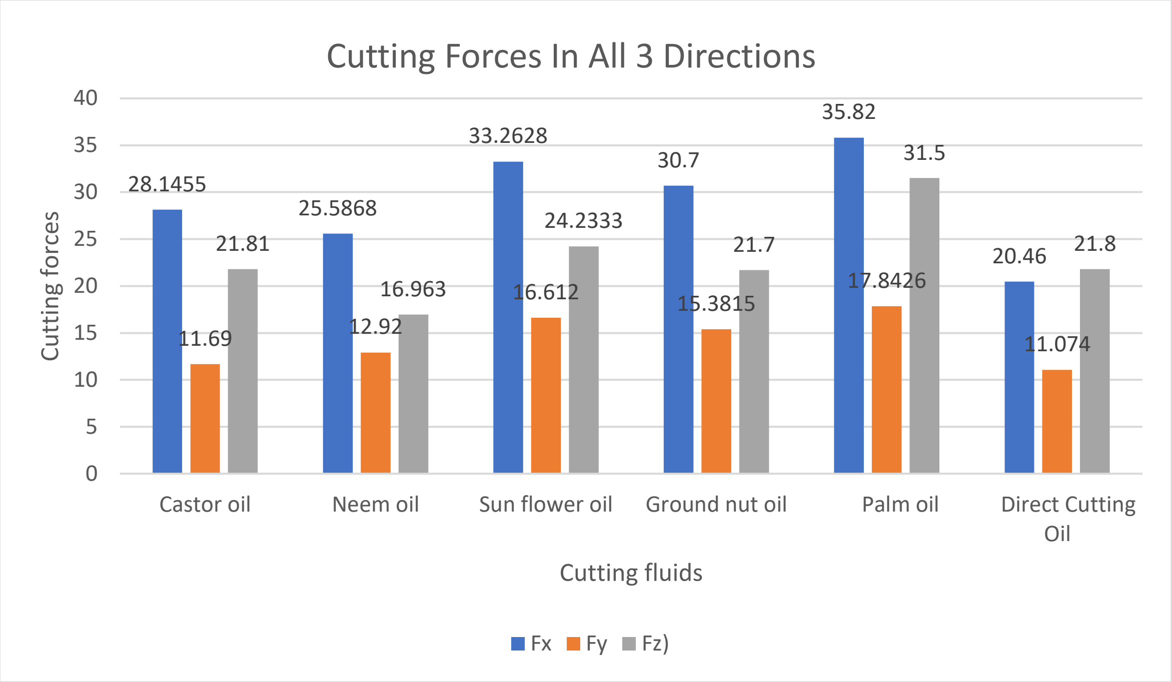


Fig 4.3.1: Cutting forces in all 3 directions vs Cutting fluids on Mild Steel material

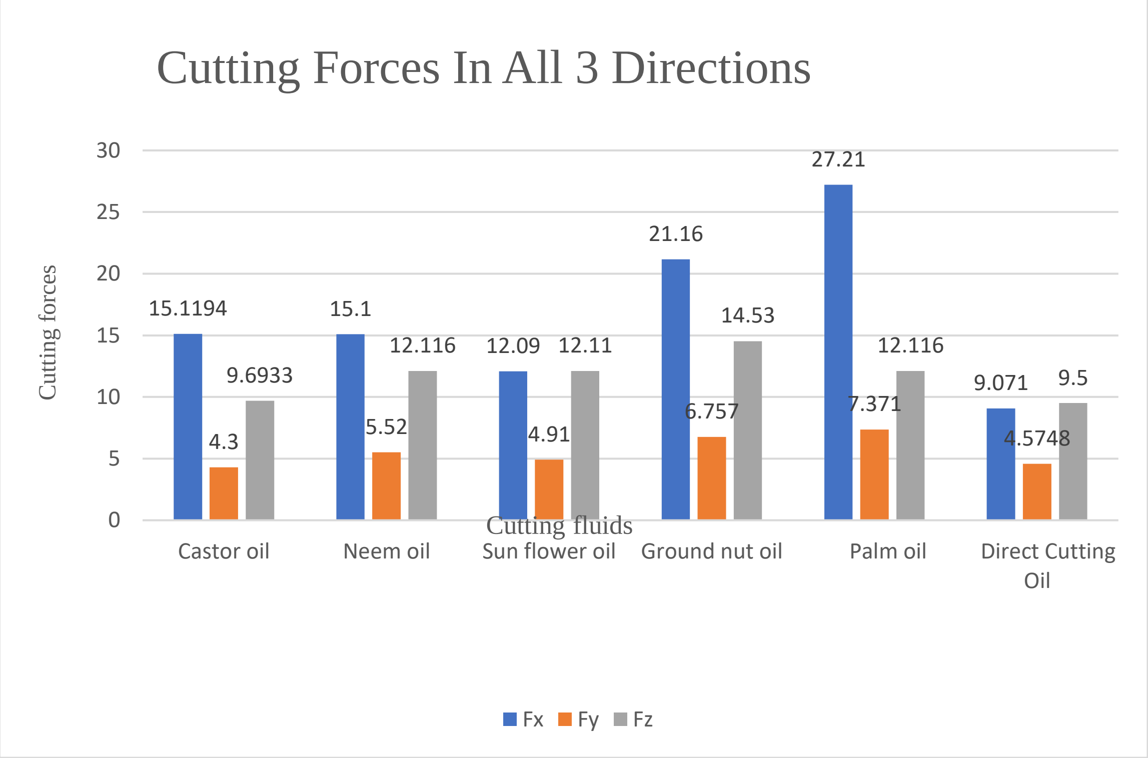


Fig4.3.1: Cutting forces in all 3 directions vs Cutting fluids on Aluminium material

It was observed that the cutting force are more predominant in feed direction than other directions.Castor is minimizing the cutting force during machining due to its viscosity results in higher surface finish than other cutting fluids. Next to castor oil, neem and sunflower oils are minimising the cutting force followed by groundnut oil.

4.4 TEMPERATURE ANALYSIS:

Most of the components require certain machining in different machines. During machining the operators encounter certain difficulties such as premature tool failure and poor surface finish due to high temperature at tool–work piece interface. In this context, this study.

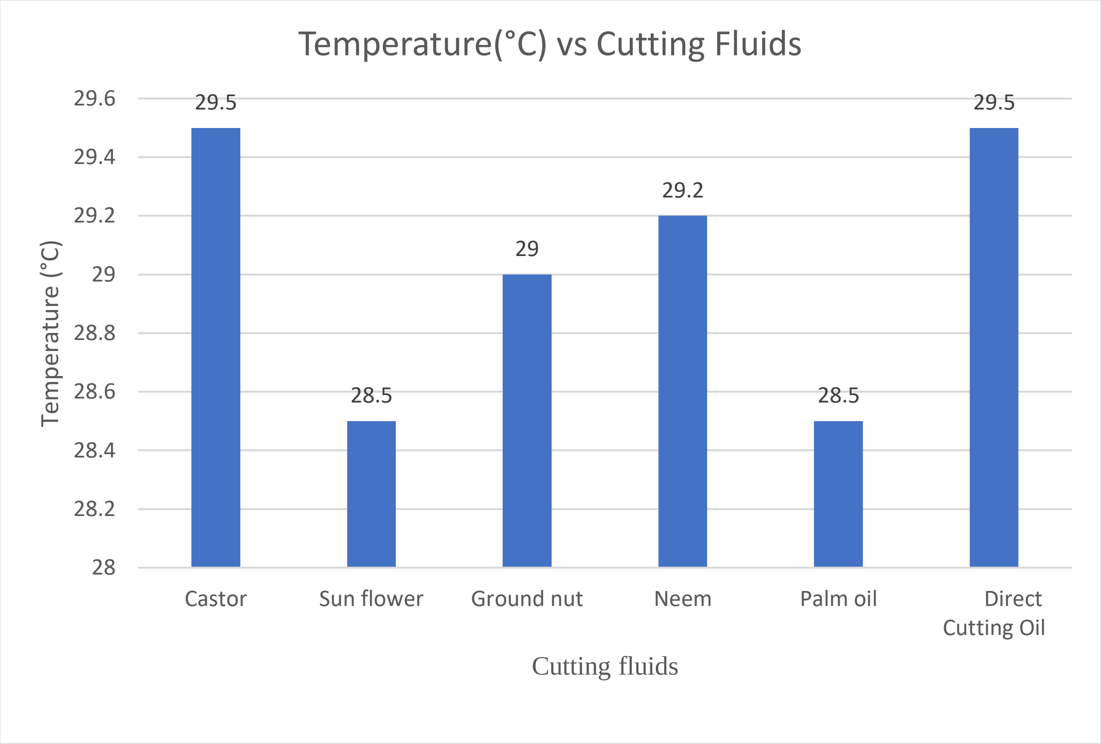


Fig 4.4.1: Temperature vs Cutting fluids on Mild Steel Material

It is vital to comprehend the theory underlying the performance of cutting oils during machining. The most essential component controlling the heat transfer coefficient, which affects cooling performance, is the viscosity of the cutting fluid employed.

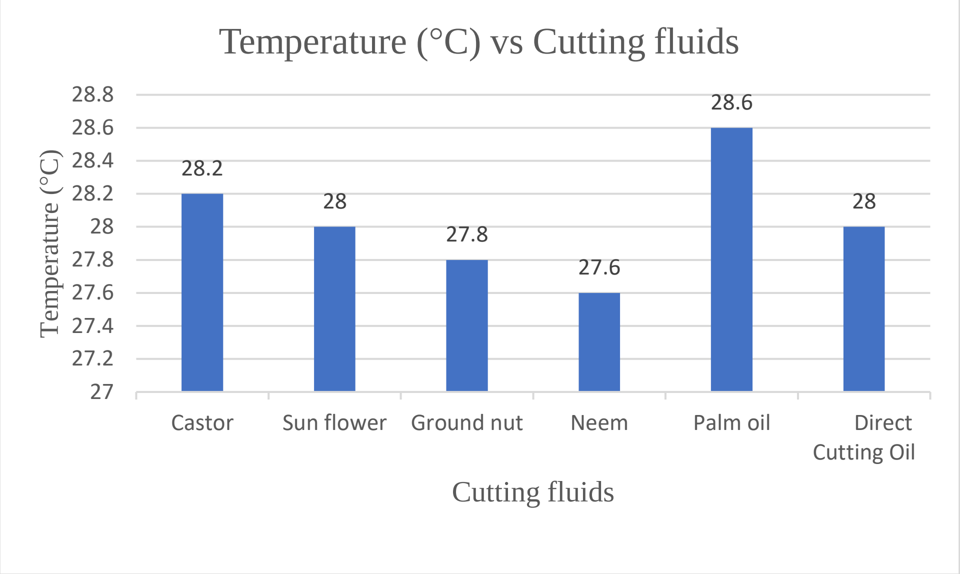


Fig 4.4.2: Temperature vs Cutting fluids on Aluminum

Heat is generated during machining processes, which has a negative impact on work piece surface finish and dimensional accuracy, tool wear and life, and production rate. Lubricants are used in machining operations to achieve cooling and reduce chip adherence to the work piece or tool. The maximum cutting temperatures were obtained when machining dry, followed by the application of castor oil, sunflower oil, groundnut oil, and neem oil in decreasing order.

The results indicated that in general, castor oil performed better than the other cutting fluids in reducing the tool wear and improving the surface finish followed by sunflower, neem and groundnut oils. It is also observed that the surface roughness is less for the samples having less cutting force during machining which in turn related to the viscosity of the cutting fluids

So we are only considering castor oil for optimization

4.5 INDIVIDUAL OPTIMALITY:

The tabulated response values thus generated while machining Mild steel & Aluminium material using Taguchi DOE L9 experiments are taken for determining individual response (Ra, Rt, Rz, Fx, Fy, Fz, and Temp) using Signal-to-noise (S/N) ratios. S/N ratios are calculated using equation-5.1, as surface roughness, tool temperature and forces are needed to have minimum disturbance . The calculated SN ratios are tabulated in Table

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

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

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

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

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

Where 'n' is the number of observations, opt is the optimal S/N ratio, avg is the average S/N ratio, and ideal is the ideal level of each S/N ratio parameter.

Sample calculation of individual optimality of Ra (MS)

The average of S/N ratio (η average) = -1.586635366

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

Table Calculation of Individual Optimality of Ra (MS)

Level	Speed(rpm)	Feed	DoC	optimal design
1	-15.029	3.139	-1.587	A3-B1-C1
2	-9.718	-2.244		
3	19.987	-5.655		

OPTIMAL DESIGN: A3-B1-C1

The S/N ideal speed (η ideal speed) = 19.987

The S/N ideal feed (η ideal feed) = 3.139

The S/N ideal depth of cut (η ideal doc) = -1.587

$\eta_{\text{optimum}} = \eta_{\text{average}} + \sum_{i=1}^{n}(\eta_{\text{ideal}} - \eta_{\text{average}}) = 24.71227073$

Response optimum = $(10 \pm \eta_{\text{optimum}}/10)$ ^0.5 = (10((24.71227073/10))^0.5 = 0.058128145

Table 4.5.1: Experimental input parameters L9 orthogonal array for mild steel specimen

Speed(rpm)	Feed	DoC	Ra (µm)	S/N(Ra)	Rt (µm)	S/N(Rt)	Rz (µm)	S/N(Rz)
727	105.5	0.5	3.2744	-10.30263463	29.094	-29.27606869	21.018	-26.45182775
727	196.1	0.5	6.0863	-15.68706711	54.0789	-34.66055698	39.2162	-31.86931018
727	290.38	0.5	9.0125	-19.09690555	80.07882	-38.0703533	58.0704	-35.27909635
1350	105.5	0.5	1.7766	-4.991793155	16.51	-24.35494147	11.9	-21.51093923
1350	196.1	0.5	3.3023	-10.37633049	30.69	-29.73993777	22.13	-26.89962828
1350	290.38	0.5	4.88996	-13.78610613	45.4449	-33.14970304	32.7695	-30.3093963
2000	105.5	0.5	0.05813	24.71199354	0.05449	25.27366384	0.05449	25.27366384
2000	196.1	0.5	0.108	19.33152489	0.10129	19.88866858	0.10129	19.88866858
2000	290.38	0.5	0.16	15.91760035	0.15	16.47817482	0.15	16.47817482

Fx	S/N(Fx)	Fy	S/N(Fy)	Fz	S/N(Fz)	Temp(°C)	S/N(Temp)
28.1455	-28.9882	11.69	-21.3563	21.81	-26.7731	29.5	-29.39644032
52.3159	-34.3727	21.7289	-26.7408	40.5397	-32.1576	29.55	-29.4111497
77.4681	-37.7825	32.1757	-30.1506	60.03	-35.5674	29.59	-29.4228993
14.0407	-22.9478	5.7926	-15.2575	10.4298	-20.3655	29.68	-29.44927793
26.0985	-28.3323	10.7671	-20.642	19.3866	-25.75	29.7	-29.45512899
38.646	-31.7421	15.9436	-24.0517	28.7071	-29.1598	29.74	-29.46681928
8.3665	-18.4509	3.5764	-11.0689	6.163	-15.7958	29.75	-29.4697394
15.5513	-23.8353	6.6478	-16.4536	11.4556	-21.1804	29.77	-29.47557669
23.0281	-27.2452	9.844	-19.8634	16.9633	-24.5902	29.8	-29.48432528

(MILDF STEEL) Castor oil-Ra

Taguchi Analysis: Ra (µm) versus Speed(rpm), Feed, DoC

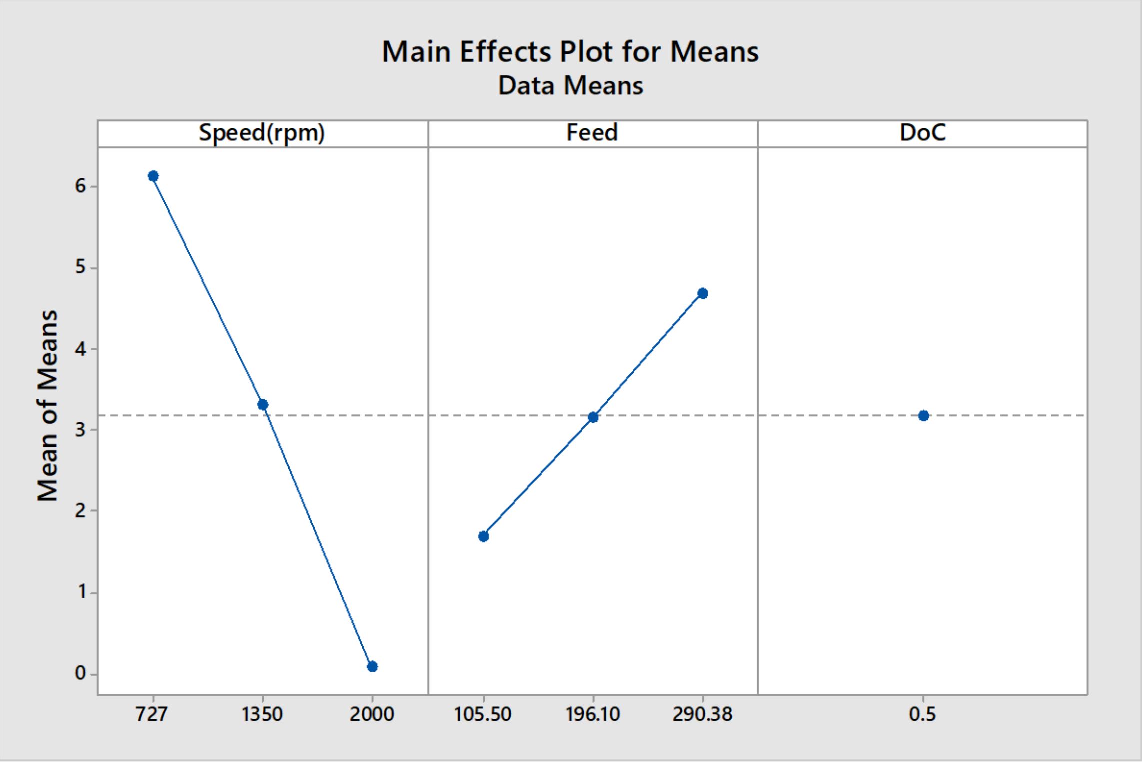
Response Table for Signal to Noise Ratios
Smaller is better

Level	Speed(rpm)	Feed	DoC
1	-15.029	3.139	-1.587
2	-9.718	-2.244	
3	19.987	-5.655	
Delta	35.016	8.794	0
Rank	1	2	3

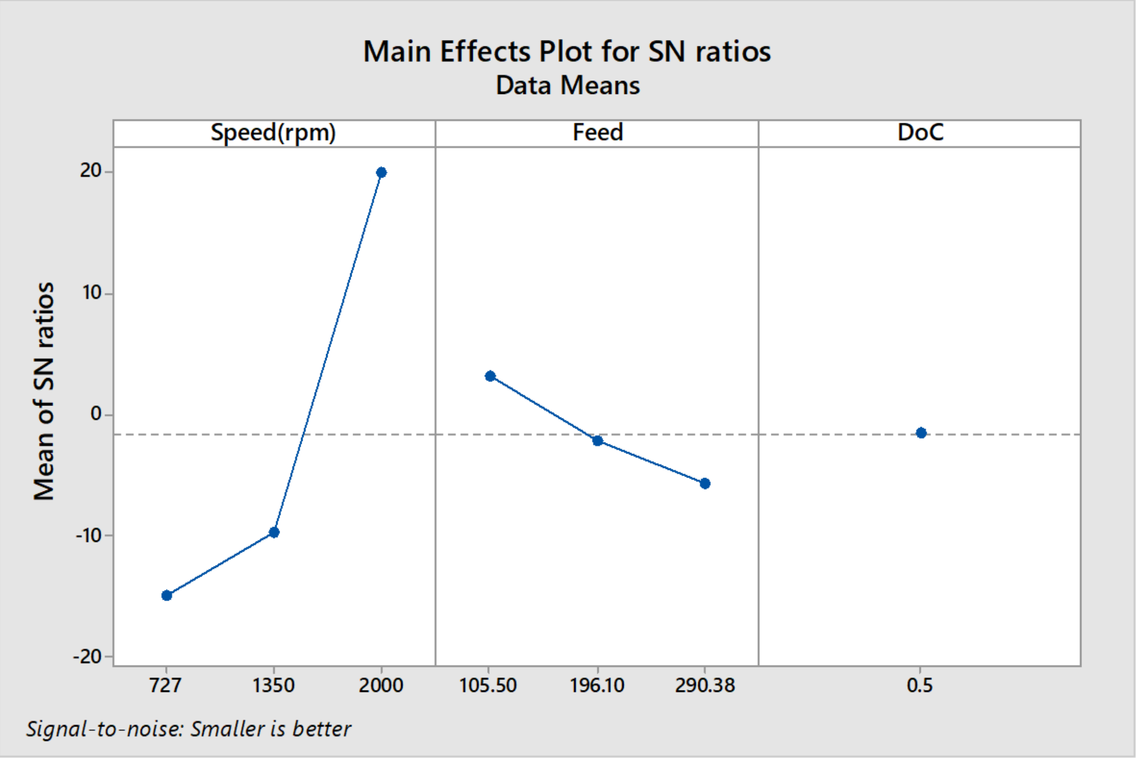
Response Table for Means

Level	Speed(rpm)	Feed	DoC
1	6.1244	1.703	3.1854
2	3.323	3.1655	
3	0.1087	4.6875	
Delta	6.0157	2.9844	0
Rank	1	2	3

Main Effects Plot for Means



Main Effects Plot for SN ratios



(MILDF STEEL) Castor oil-Rt

Taguchi Analysis: Rt (µm) versus Speed(rpm), Feed, DoC

Response Table for Signal to Noise Ratios
Smaller is better

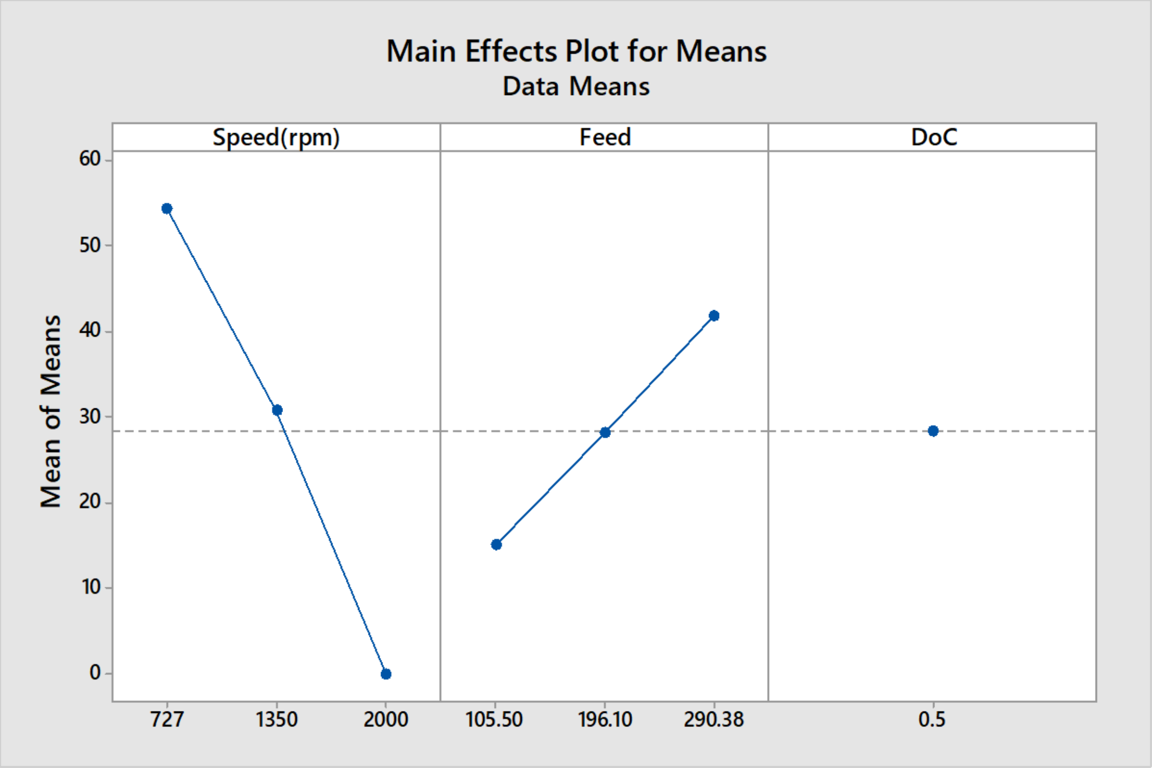
Level	Speed(rpm)	Feed	DoC
1	-34.002	-9.452	-14.179
2	-29.082	-14.837	
3	20.547	-18.247	
Delta	54.549	8.795	0
Rank	1	2	3

Response Table for Means

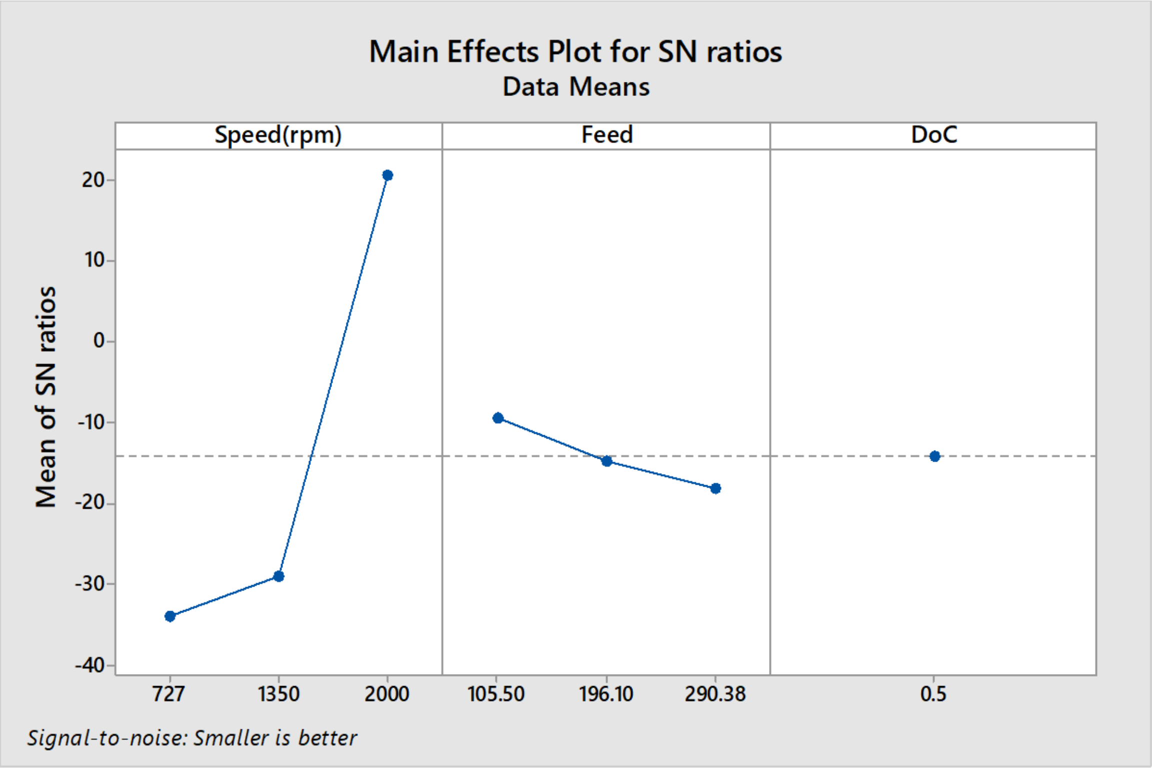
Level	Speed(rpm)	Feed	DoC
1	54.4172	15.2195	28.4669
2	30.8816	28.2901	
3	0.1019	41.8912	

Delta	54.3153	26.6717	0
Rank	1	2	3

Main Effects Plot for Means



Main Effects Plot for SN ratios



(MILDF STEEL) Castor oil-Rz

Taguchi Analysis: Rz (μm) versus Speed(rpm), Feed, DoC

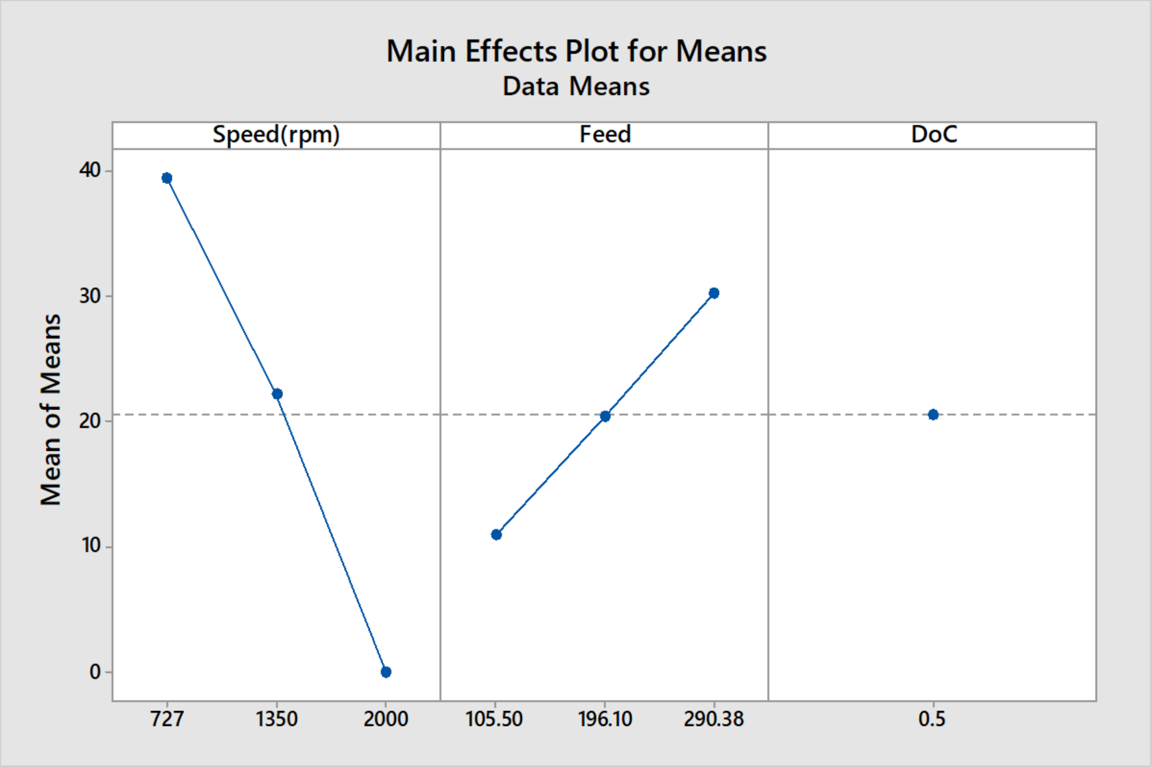
Response Table for Signal to Noise Ratios
Smaller is better

Level	Speed(rpm)	Feed	DoC
1	-31.2	-7.563	-12.298
2	-26.24	-12.96	
3	20.547	-16.37	
Delta	51.747	8.807	0
Rank	1	2	3

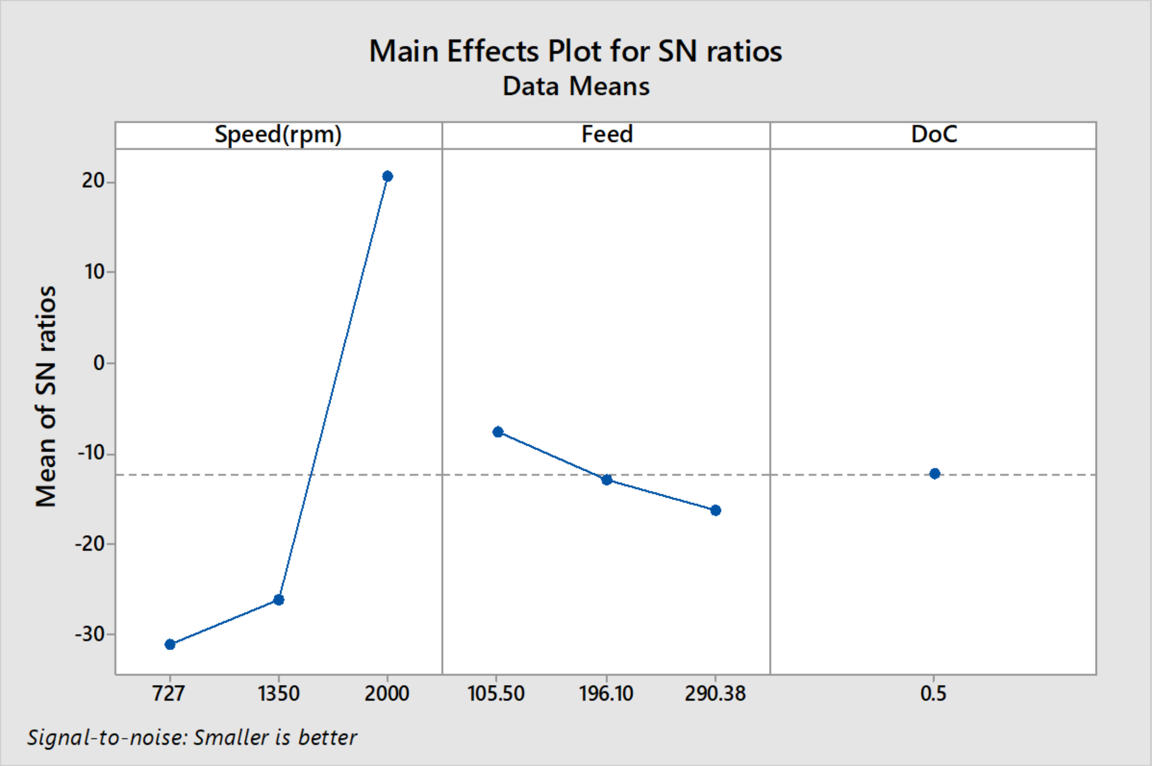
Response Table for Means

Level	Speed(rpm)	Feed	DoC
1	39.4349	10.9908	20.6011
2	22.2665	20.4825	
3	0.1019	30.33	
Delta	39.3329	19.3391	0
Rank	1	2	3

Main Effects Plot for Means



Main Effects Plot for SN ratios



<u>(MILDF STEEL) Castor oil-Fx</u>

Taguchi Analysis: Fx versus Speed(rpm), Feed, DoC

* ERROR * Factor DoC is (essentially) constant. No calculations were done.

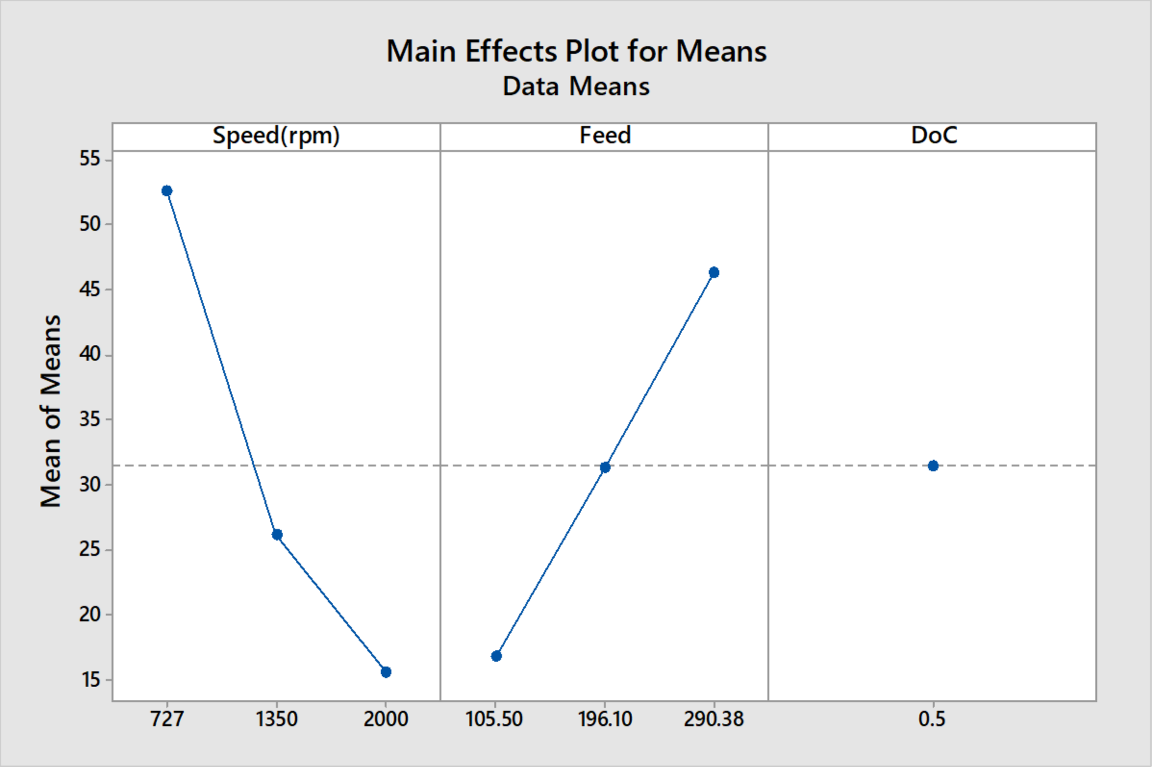
Response Table for Signal to Noise Ratios
Smaller is better

Level	Speed(rpm)	Feed	DoC
1	-33.71	-23.46	-28.19
2	-27.67	-28.85	
3	-23.18	-32.26	
Delta	10.54	8.79	0
Rank	1	2	3

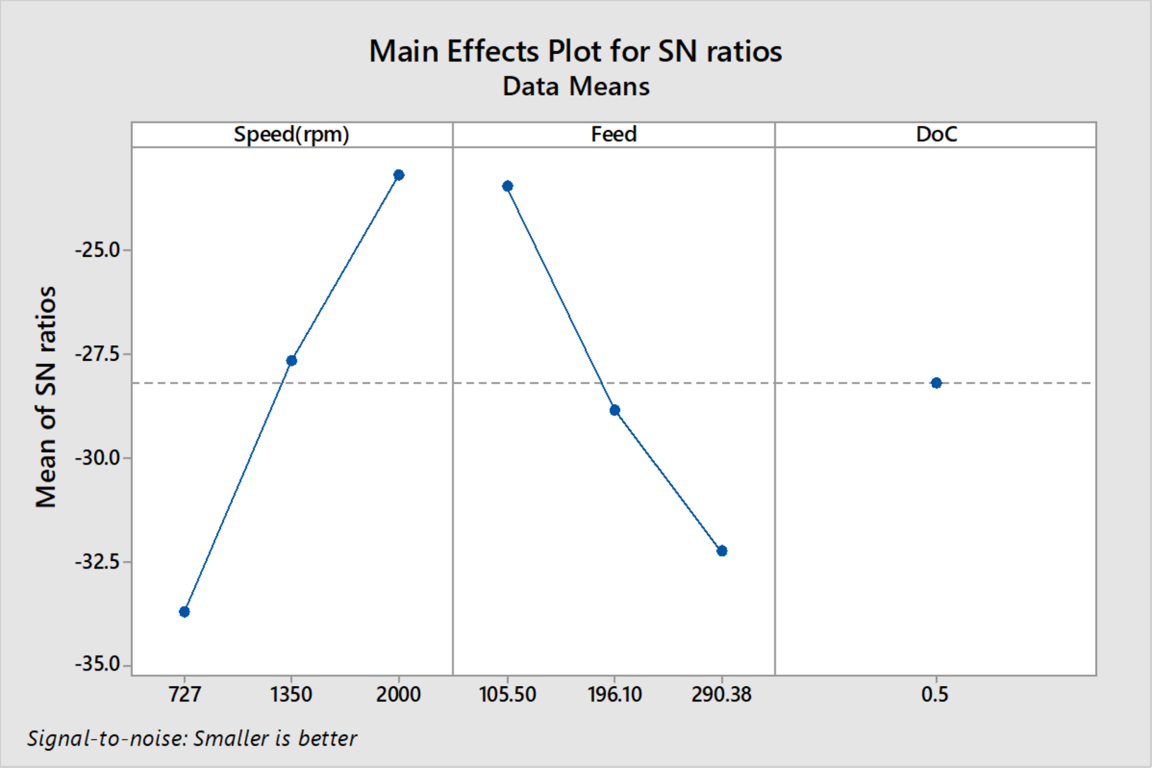
Response Table for Means

Level	Speed(rpm)	Feed	DoC
1	52.64	16.85	31.52
2	26.26	31.32	
3	15.65	46.38	
Delta	36.99	29.53	0
Rank	1	2	3

Main Effects Plot for Means



Main Effects Plot for SN ratios



(MILDF STEEL) Castor oil-Fy

Taguchi Analysis: Fy versus Speed(rpm), Feed, DoC

* ERROR * Factor DoC is (essentially) constant. No calculations were done.

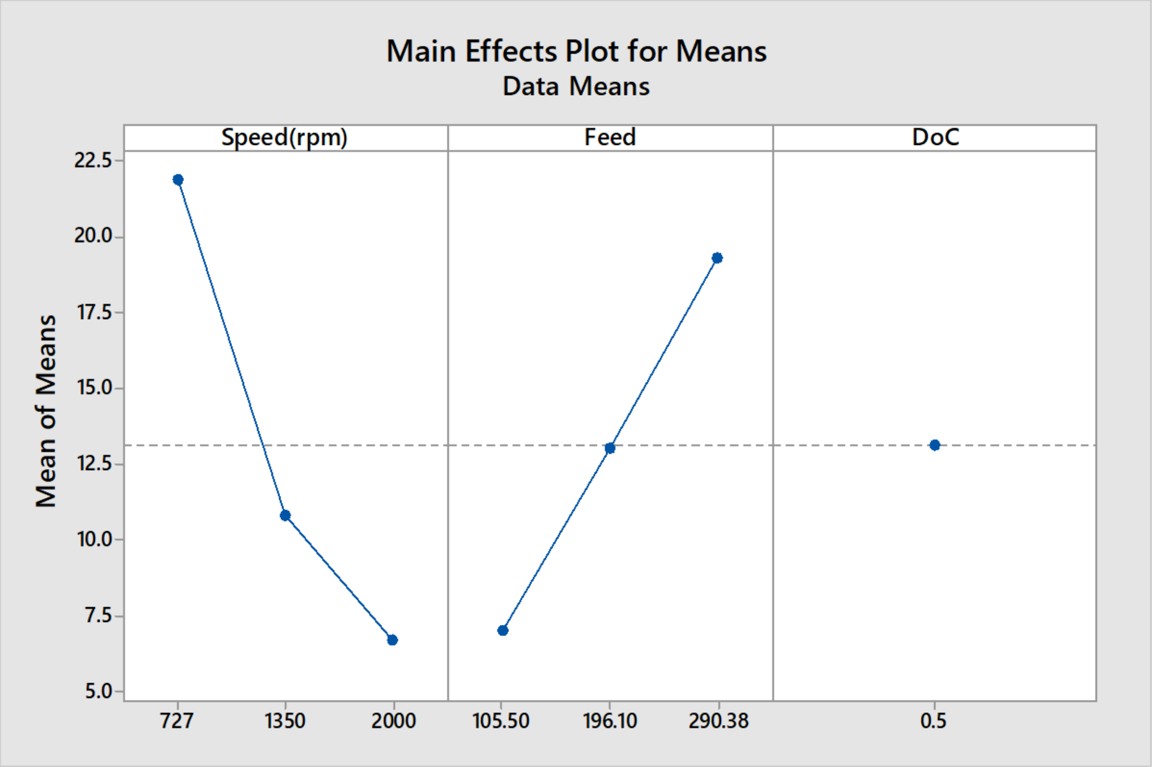
Response Table for Signal to Noise Ratios
Smaller is better

Level	Speed(rpm)	Feed	DoC
1	-26.08	-15.89	-20.62
2	-19.98	-21.28	
3	-15.8	-24.69	
Delta	10.29	8.79	0
Rank	1	2	3

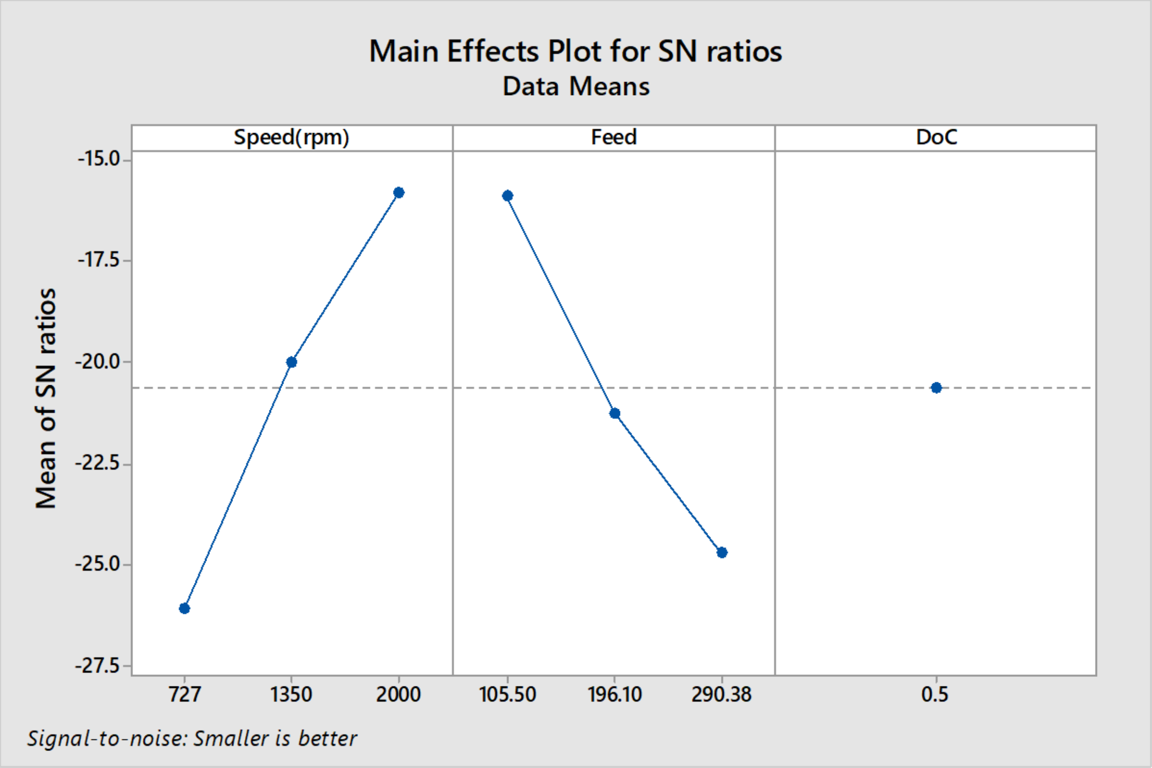
Response Table for Means

Level	Speed(rpm)	Feed	DoC
1	21.865	7.02	13.13
2	10.834	13.048	
3	6.689	19.321	
Delta	15.175	12.301	0
Rank	1	2	3

Main Effects Plot for Means



Main Effects Plot for SN ratios



(MILDF STEEL) Castor oil-Fz

Taguchi Analysis: Fz versus Speed(rpm), Feed, DoC

* ERROR * Factor DoC is (essentially) constant. No calculations were done.

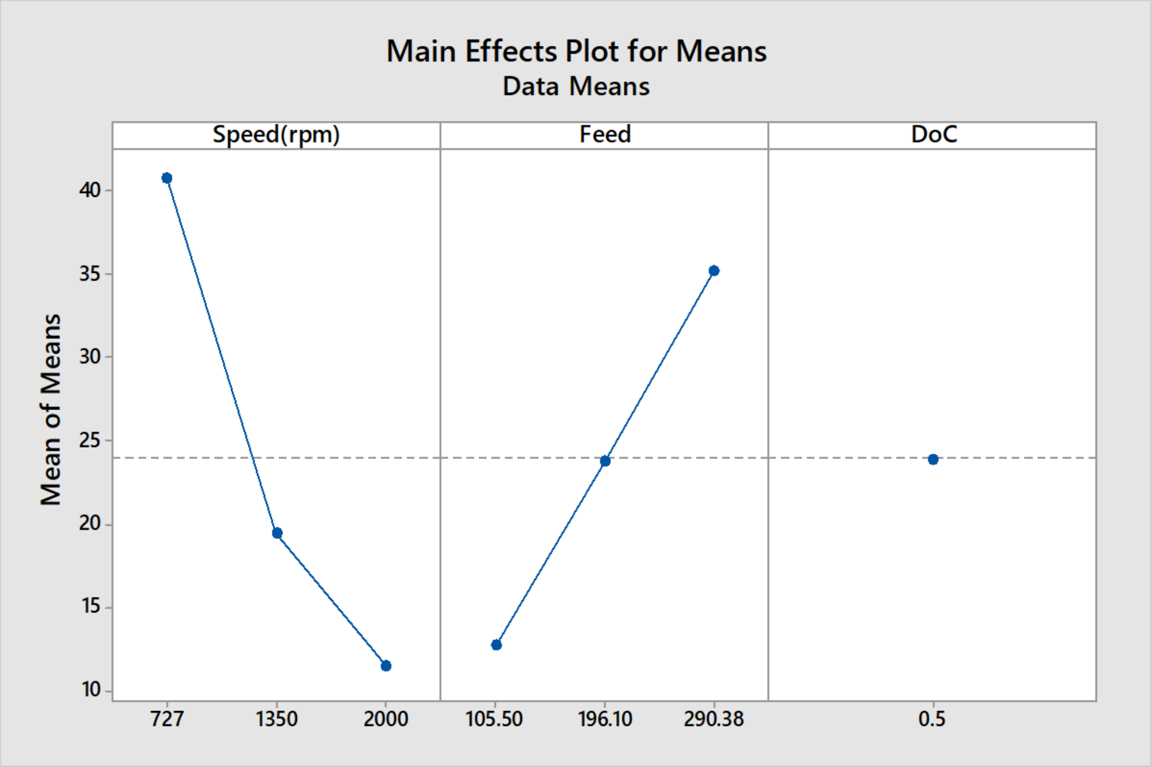
Response Table for Signal to Noise Ratios
Smaller is better

Level	Speed(rpm)	Feed	DoC
1	-31.5	-20.98	-25.7
2	-25.09	-26.36	
3	-20.52	-29.77	
Delta	10.98	8.79	0
Rank	1	2	3

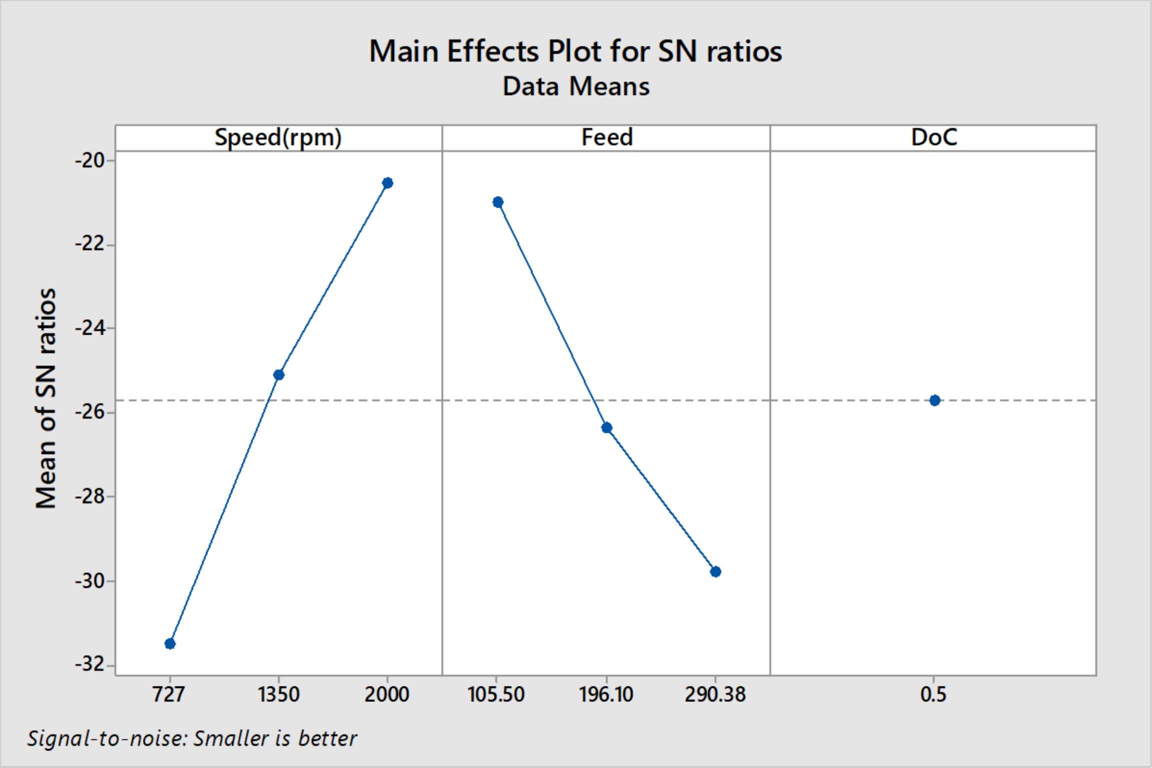
Response Table for Means

Level	Speed(rpm)	Feed	DoC
1	40.79	12.8	23.94
2	19.51	23.79	
3	11.53	35.23	
Delta	29.27	22.43	0
Rank	1	2	3

Main Effects Plot for Means



Main Effects Plot for SN ratios



(MILDF STEEL) Castor oil-Temp

Taguchi Analysis: Temp(°C) versus Speed(rpm), Feed, DoC

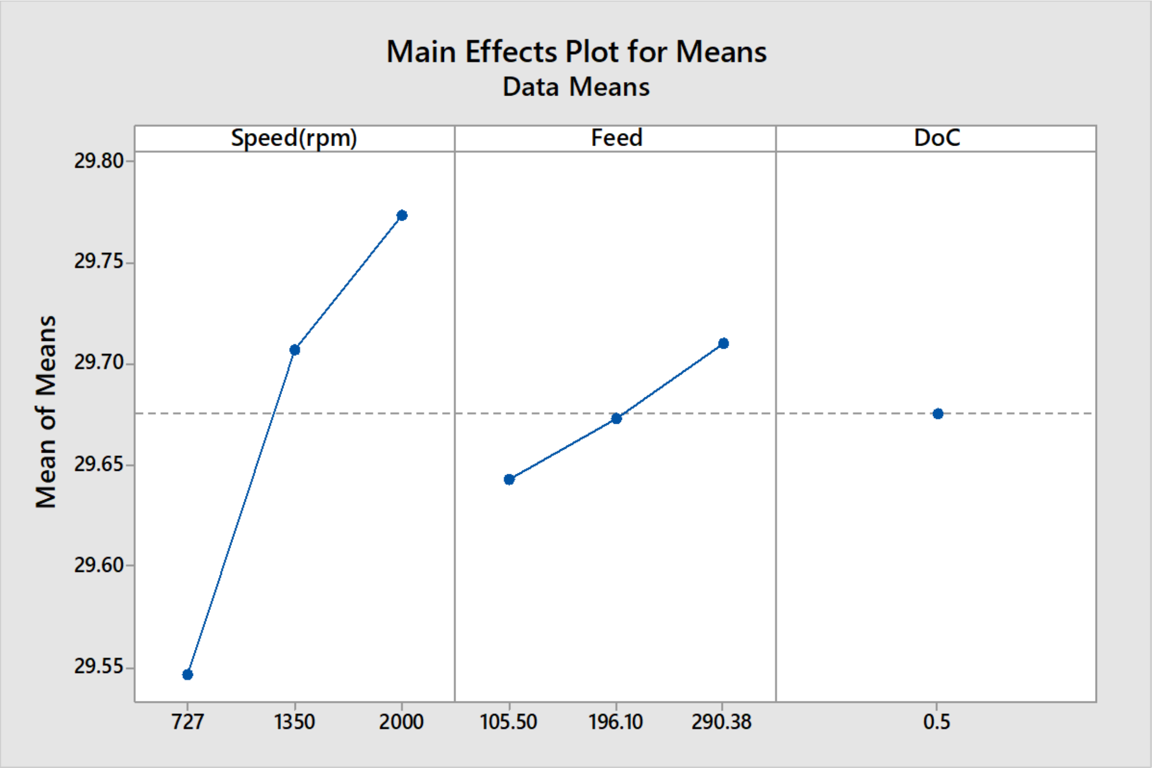
Response Table for Signal to Noise Ratios
Smaller is better

Level	Speed(rpm)	Feed	DoC
1	-29.41	-29.44	-29.45
2	-29.46	-29.45	
3	-29.48	-29.46	
Delta	0.07	0.02	0
Rank	1	2	3

Response Table for Means

Level	Speed(rpm)	Feed	DoC
1	29.55	29.64	29.68
2	29.71	29.67	
3	29.77	29.71	
Delta	0.23	0.07	0
Rank	1	2	3

Main Effects Plot for Means



Main
Plot for SN

OUT PARAMETERS	SPEED	FEED	DOC	OPTIMAL DESIGN
Ra	727	290.38	0.5	A1-B3-C1
Rt	727	290.38	0.5	A1-B3-C1
Rz	727	290.38	0.5	A1-B3-C1
Fx	727	290.38	0.5	A1-B3-C1
Fy	727	290.38	0.5	A1-B3-C1
Fz	727	290.38	0.5	A1-B3-C1
Temp	2000	290.38	0.5	A3-B3-C1

Effects
ratios

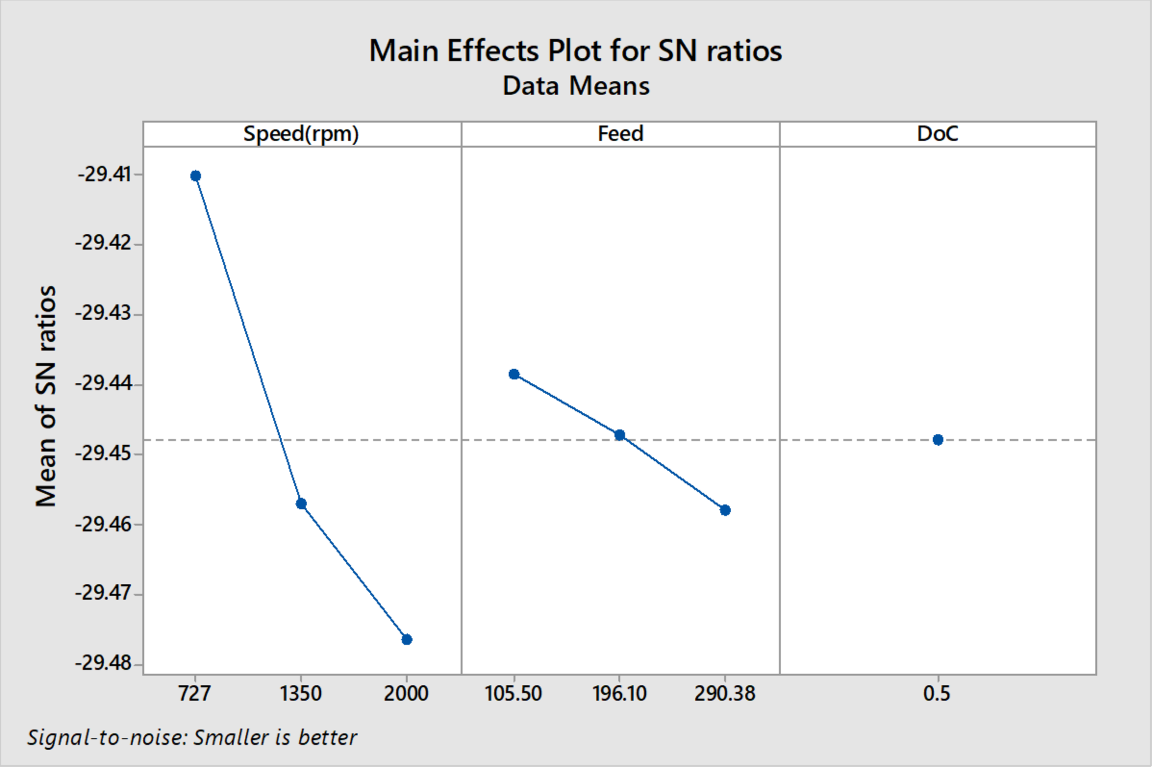


Table 4.5.2: OPTIMUM CUTTING PARAMETERS (MILD STEEL)

Table 4.5.3: Experimental input parameters L9 orthogonal array for Aluminium specimen

SPEED	FEED	DOC	Ra	S/N(Ra)	Rt	S/N(Rt)	Rz	S/N(Rz)
727	90.1	0.5	1.399	-2.91635429	13.417	-22.5531084	8.33	-18.41290003
727	167.31	0.5	2.5978	-8.292114249	24.9145	-27.92904352	15.4682	-23.78879558
727	247.8674	0.5	3.8486	-11.70605551	36.91	-31.3428809	22.916	-27.20277627
1350	90.1	0.5	0.7598	2.386014216	7.062	-16.97855426	5.0923	-14.13827962
1350	167.31	0.5	1.41107	-2.990971173	13.1138	-22.35459761	9.45615	-19.51428613
1350	247.8674	0.5	2.09	-6.402925722	19.4279	-25.76851719	14	-22.92256071
2000	90.1	0.5	0.02484	32.09696817	0.02329	32.65661023	0.02329	32.65661023
2000	167.31	0.5	0.04614	26.7184482	0.04326	27.2782697	0.04326	27.2782697
2000	247.8674	0.5	0.06836	23.30395892	0.0641	23.86351696	0.0641	23.86351696

Fx	S/N(Fx)	Fy	S/N(Fy)	Fz	S/N(Fz)	Temp (°C)	S/N(TEMP)
15.1194	-23.59069114	4.3	-12.66936911	9.6933	-19.72943308	28.2	-29.00498217
28.0757	-28.96661186	7.9848	-18.04528085	17.9998	-25.10535359	28.25	-29.02036904
41.5938	-32.38057198	11.8293	-21.45918092	26.6665	-28.51932036	28.29	-29.03265895
7.1813	-17.1240614	2.51	-7.99347443	4.52	-13.1027687	28.38	-29.06024782
13.3353	-22.50005581	4.6621	-13.37163169	8.3944	-18.4797932	28.4	-29.0663668
19.756	-25.91398035	6.9068	-16.78553761	12.4361	-21.89368411	28.44	-29.07859184
4.2835	-12.63597542	1.54	-3.750414417	2.6699	-8.529899907	28.44	-29.07859184
7.9542	-18.01193013	2.8771	-9.17909914	4.9579	-13.90595526	28.46	-29.08469791
11.7841	-21.42592839	4.2625	-12.59328784	7.3451	-17.31995426	28.48	-29.0907997

(ALUMINIUM) Castor oil-Ra

Taguchi Analysis: Ra versus SPEED, FEED, DOC

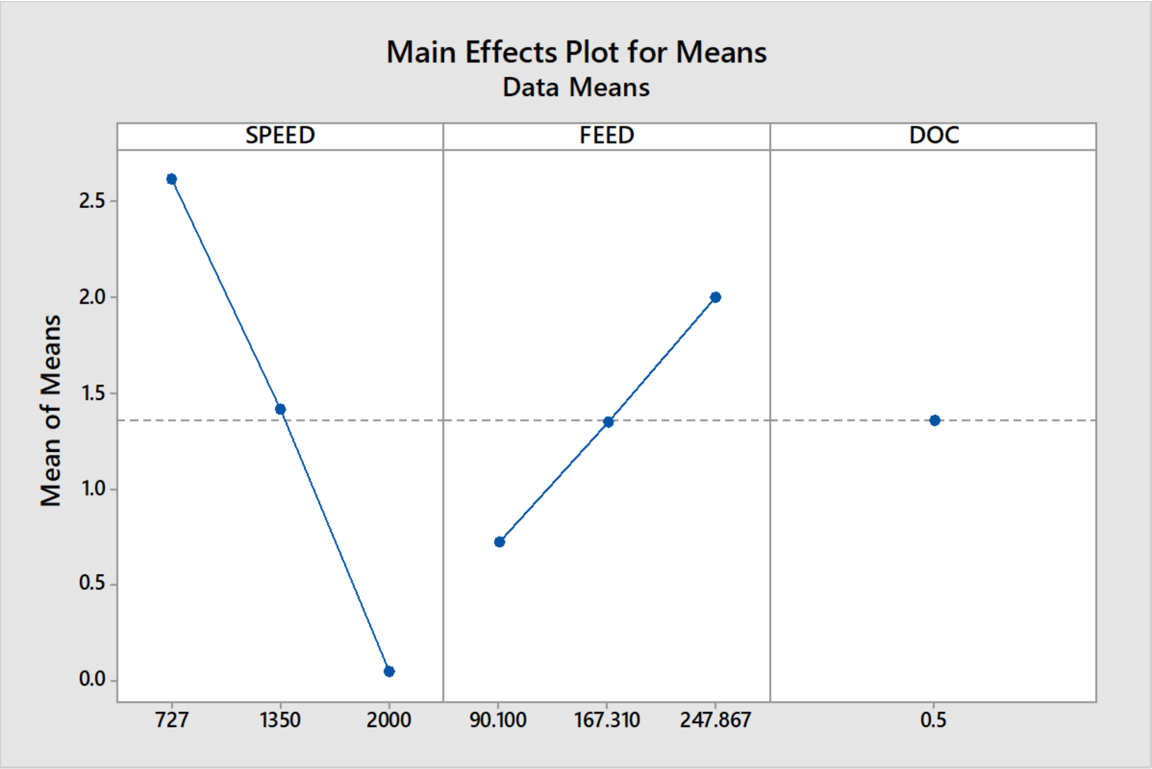
Response Table for Signal to Noise Ratios
Smaller is better

Level	SPEED	FEED	DOC
1	-7.638	10.522	5.8
2	-2.336	5.145	
3	27.373	1.732	
Delta	35.011	8.791	0
Rank	1	2	3

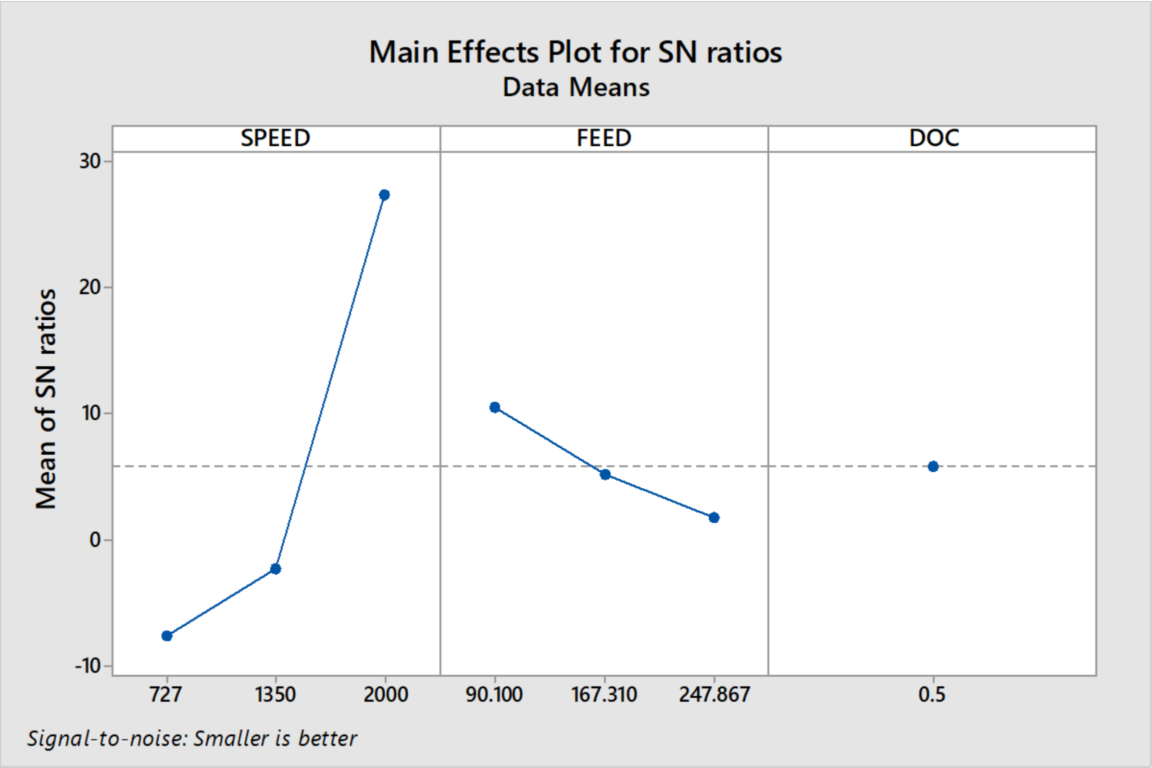
Response Table for Means

Level	SPEED	FEED	DOC
1	2.61513	0.72788	1.36062
2	1.42029	1.35167	
3	0.04645	2.00232	
Delta	2.56869	1.27444	0
Rank	1	2	3

Main Effects Plot for Means



Main Effects Plot for SN ratios



<u>(ALUMINIUM) Castor oil-Rt</u>

Taguchi Analysis: Rt versus SPEED, FEED, DOC

* ERROR * Factor DOC is (essentially) constant. No calculations were done.

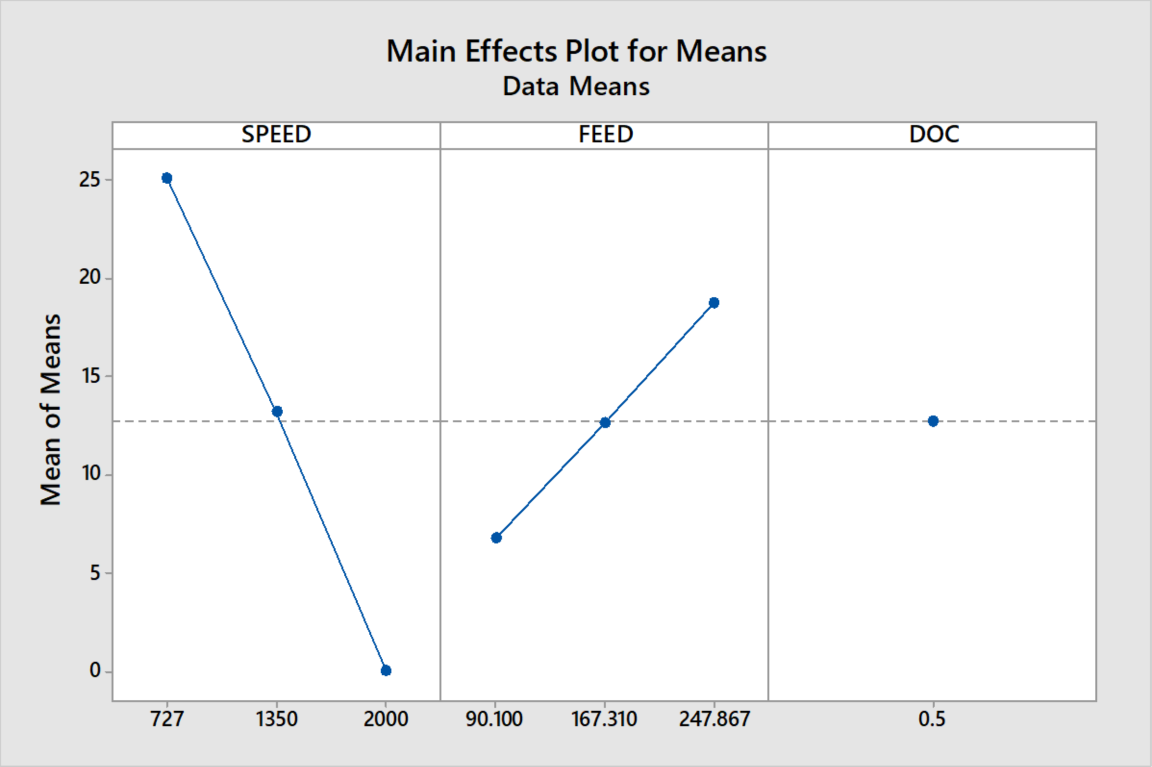
Response Table for Signal to Noise Ratios
Smaller is better

Level	SPEED	FEED	DOC
1	-27.275	-2.292	-7.014
2	-21.701	-7.668	
3	27.933	-11.083	
Delta	55.208	8.791	0
Rank	1	2	3

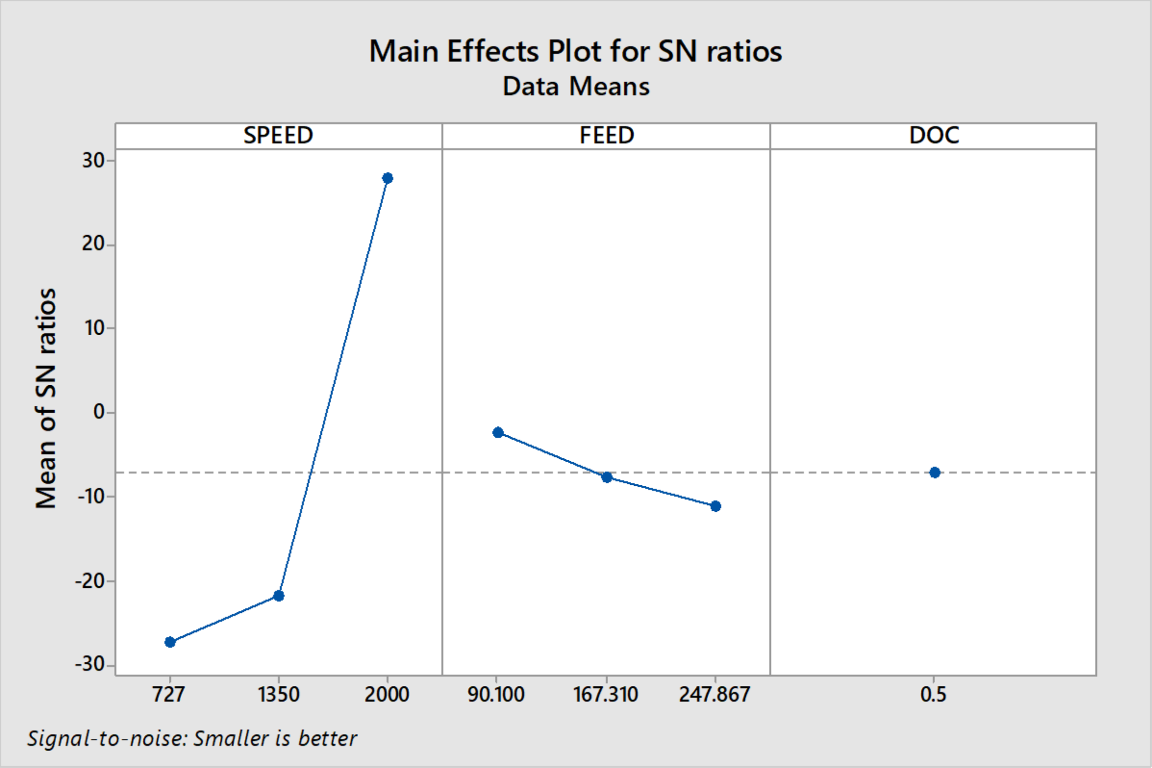
Response Table for Means

Level	SPEED	FEED	DOC
1	25.0805	6.8341	12.7751
2	13.2012	12.6905	
3	0.0435	18.8007	
Delta	25.037	11.9666	0
Rank	1	2	3

Main Effects Plot for Means



Main Effects Plot for SN ratios



(ALUMINIUM) Castor oil-Rz

Taguchi Analysis: Rz versus SPEED, FEED, DOC

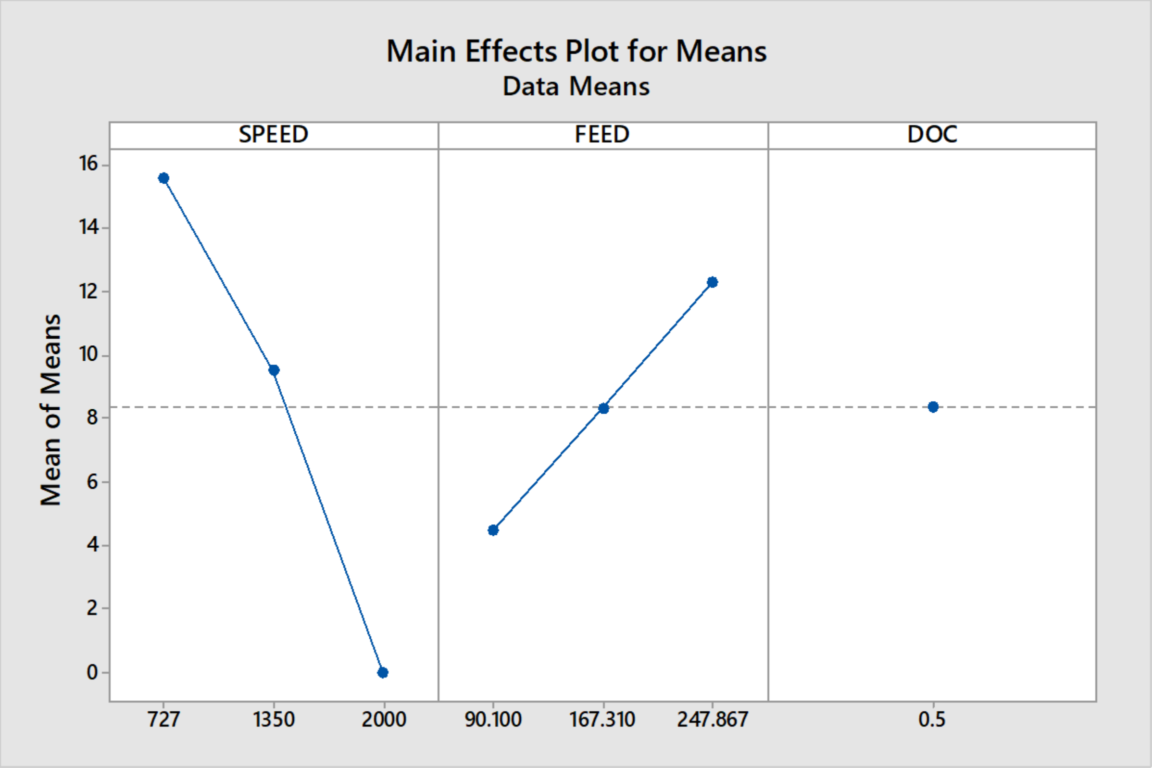
Response Table for Signal to Noise Ratios
Smaller is better

Level	SPEED	FEED	DOC
1	-23.1348	0.0351	-4.6868
2	-18.8584	-5.3416	
3	27.9328	-8.7539	
Delta	51.0676	8.7891	0
Rank	1	2	3

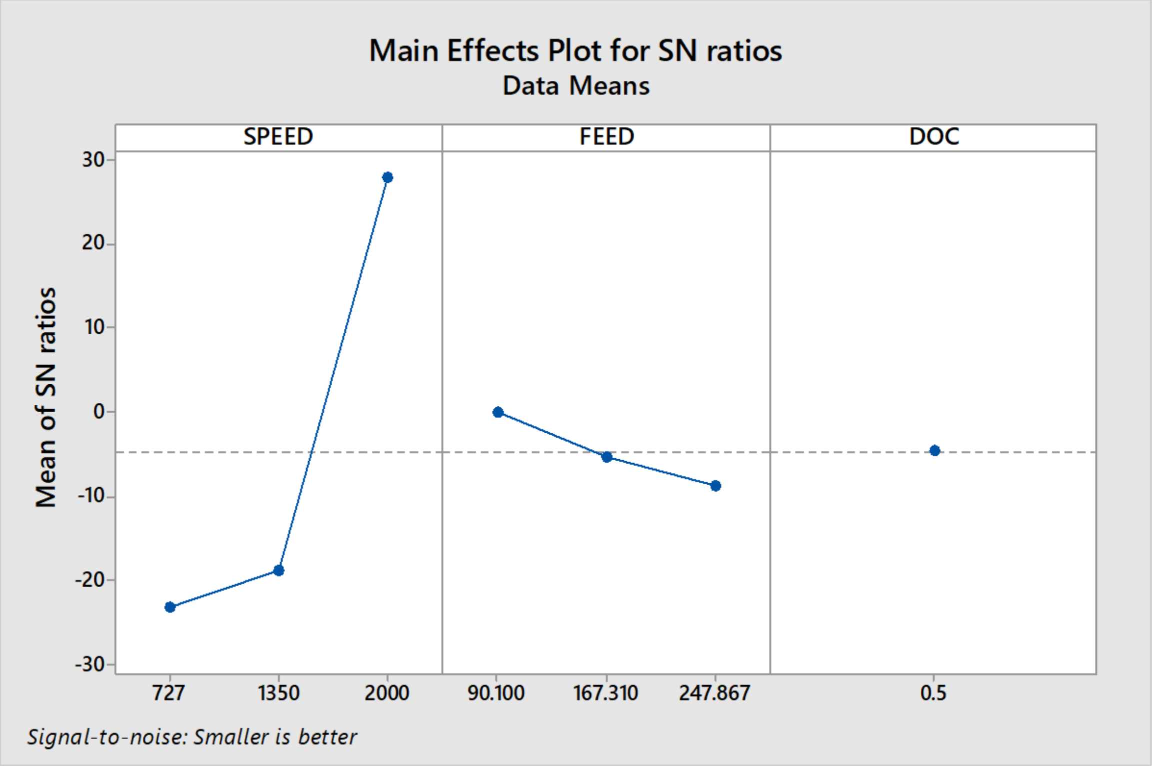
Response Table for Means

Level	SPEED	FEED	DOC
1	15.5714	4.4819	8.377
2	9.5161	8.3225	
3	0.0435	12.3267	
Delta	15.5279	7.8448	0
Rank	1	2	3

Main Effects Plot for Means



Main Effects Plot for SN ratios



(ALUMINIUM) Castor oil-Fx

Taguchi Analysis: Fx versus SPEED, FEED, DOC

* ERROR * Factor DOC is (essentially) constant. No calculations were done.

Response Table for Signal to Noise Ratios
Smaller is better

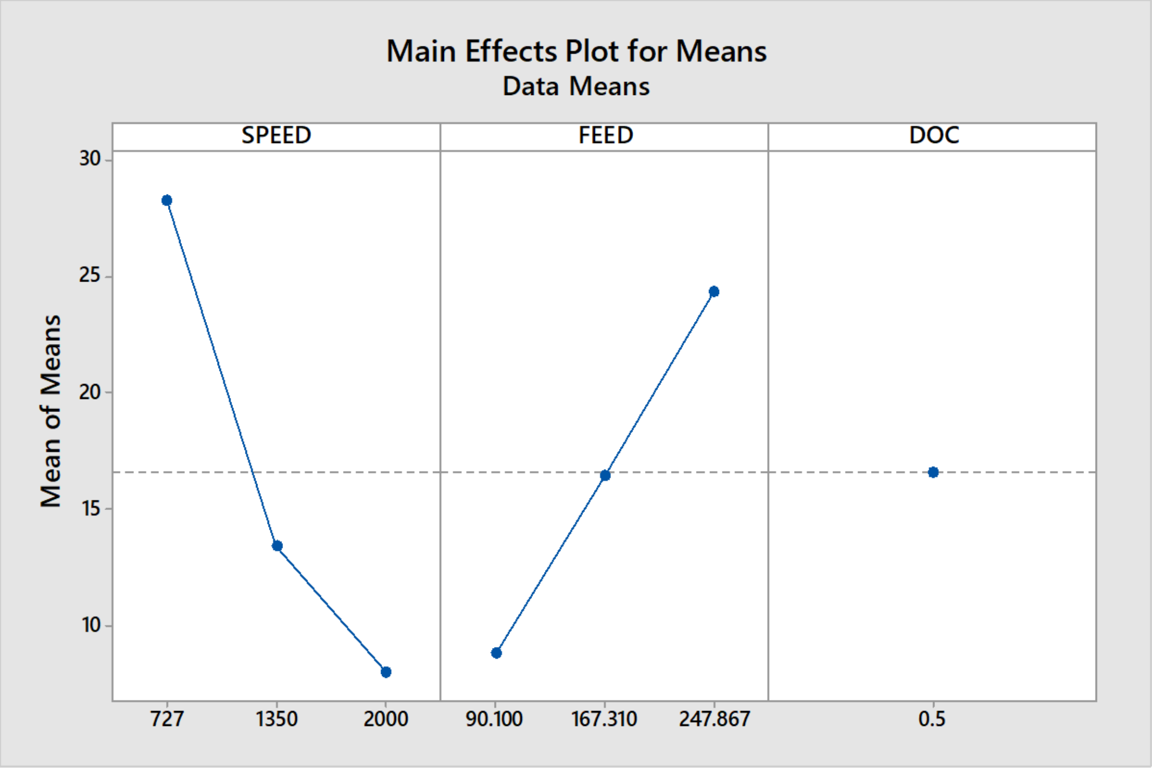
Level	SPEED	FEED	DOC
1	-28.31	-17.78	-22.51
2	-21.85	-23.16	
3	-17.36	-26.57	
Delta	10.95	8.79	0
Rank	1	2	3

Response Table for Means

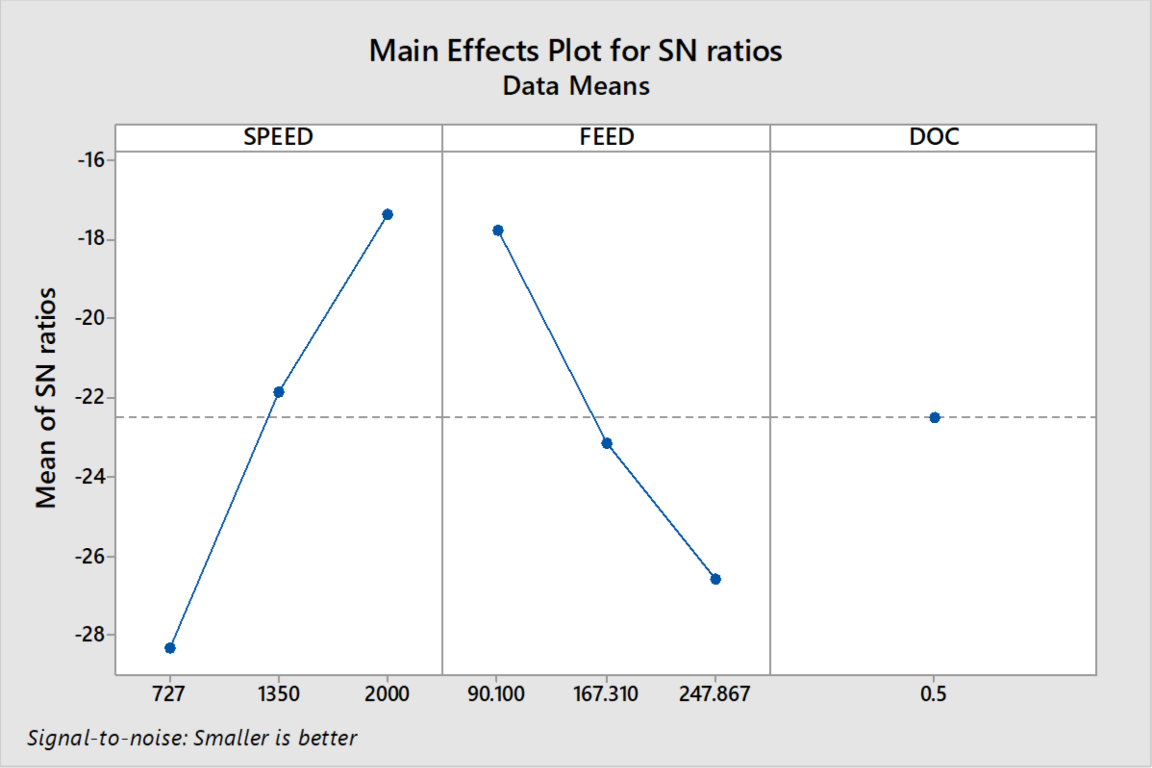
Level	SPEED	FEED	DOC
1	28.263	8.861	16.565

2	13.424	16.455	
3	8.007	24.378	
Delta	20.256	15.517	0
Rank	1	2	3

Main Effects Plot for Means



Main Effects Plot for SN ratios



(ALUMINIUM) Castor oil-Fy

Taguchi Analysis: Fy versus SPEED, FEED, DOC

Response Table for Signal to Noise Ratios
Smaller is better

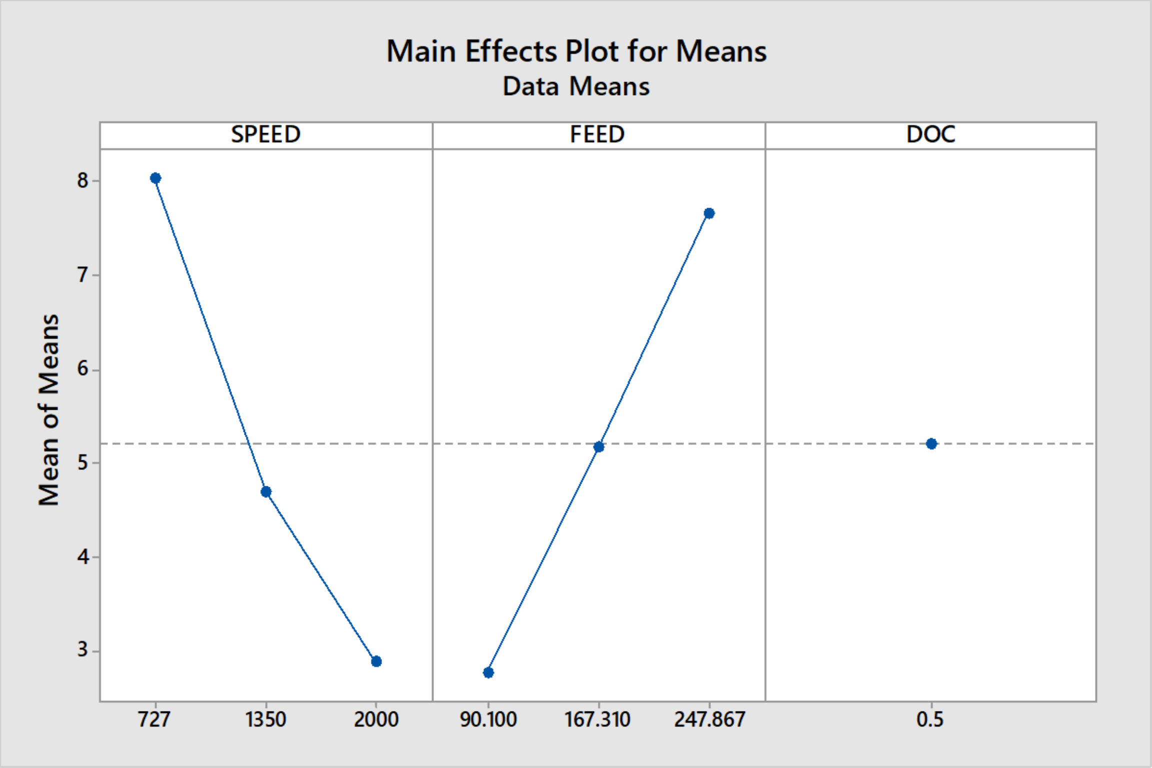
Level	SPEED	FEED	DOC
1	-17.391	-8.138	-12.872
2	-12.717	-13.532	
3	-8.508	-16.946	
Delta	8.884	8.808	0
Rank	1	2	3

Response Table for Means

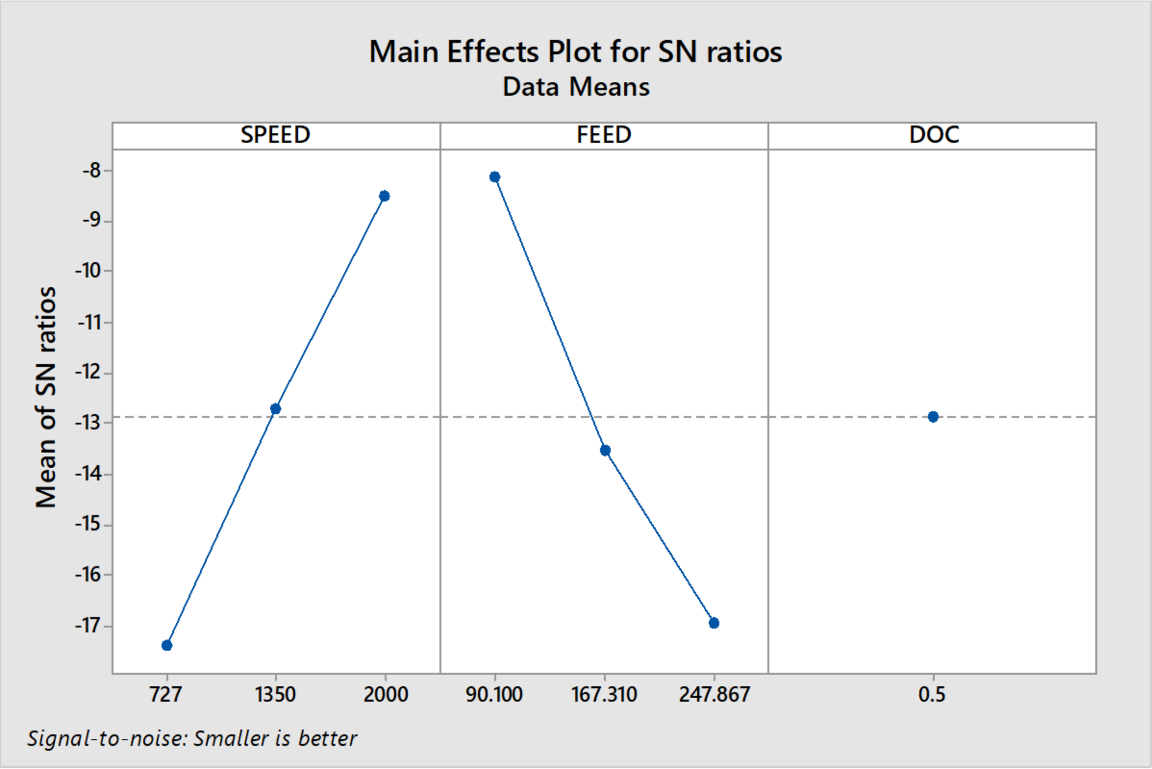
Level	SPEED	FEED	DOC
1	8.038	2.783	5.208
2	4.693	5.175	
3	2.893	7.666	
Delta	5.145	4.883	0

Rank	1	2	3

Main Effects Plot for Means



Main Effects Plot for SN ratios



(ALUMINIUM) Castor oil-Fz

Taguchi Analysis: Fz versus SPEED, FEED, DOC

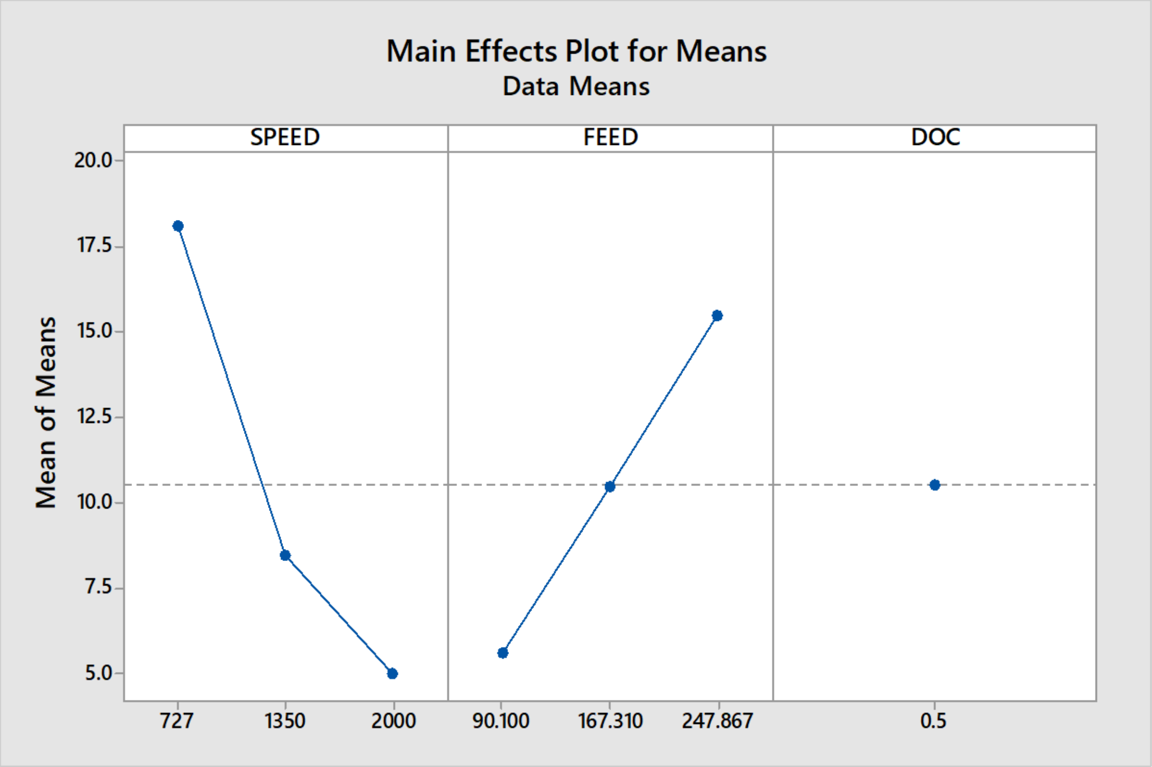
Response Table for Signal to Noise Ratios
Smaller is better

Level	SPEED	FEED	DOC
1	-24.45	-13.79	-18.51
2	-17.83	-19.16	
3	-13.25	-22.58	
Delta	11.2	8.79	0
Rank	1	2	3

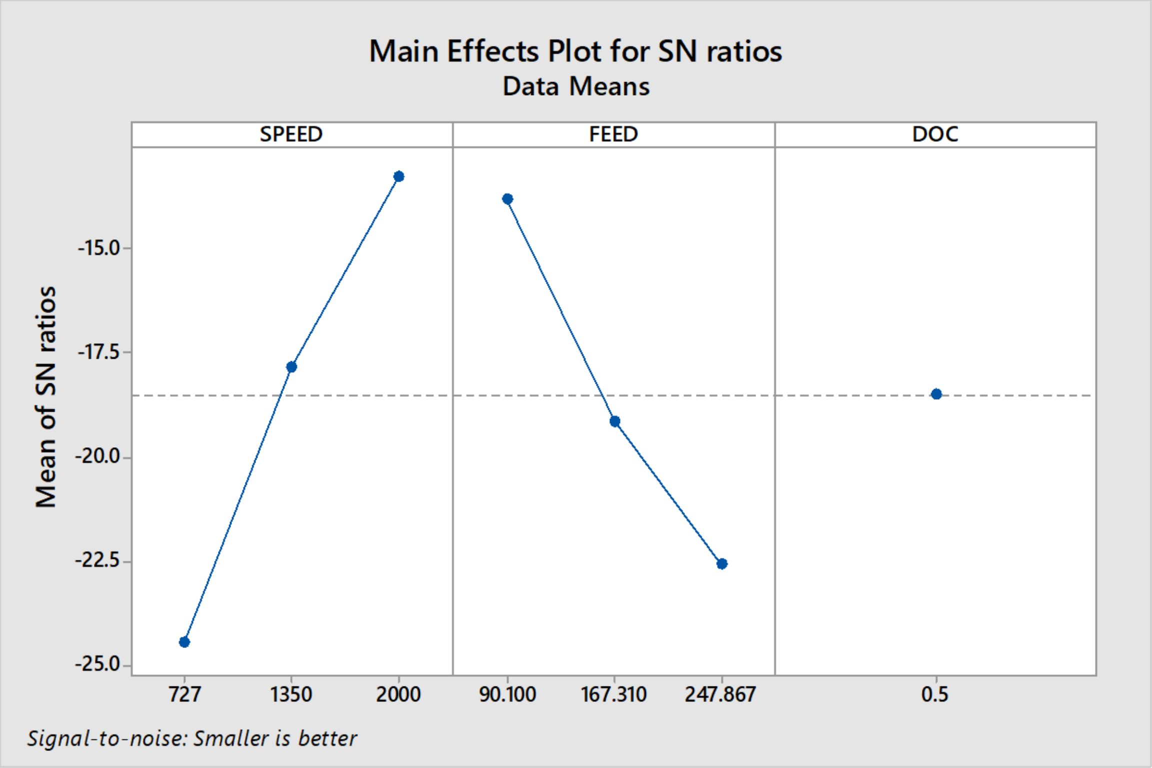
Response Table for Means

Level	SPEED	FEED	DOC
1	18.12	5.628	10.52
2	8.45	10.451	
3	4.991	15.483	
Delta	13.129	9.855	0
Rank	1	2	3

Main Effects Plot for Means



Main Effects Plot for SN ratios



(ALUMINIUM) Castor oil-Temp

Taguchi Analysis: Temp (°C) versus SPEED, FEED, DOC

* ERROR * Factor DOC is (essentially) constant. No calculations were done.

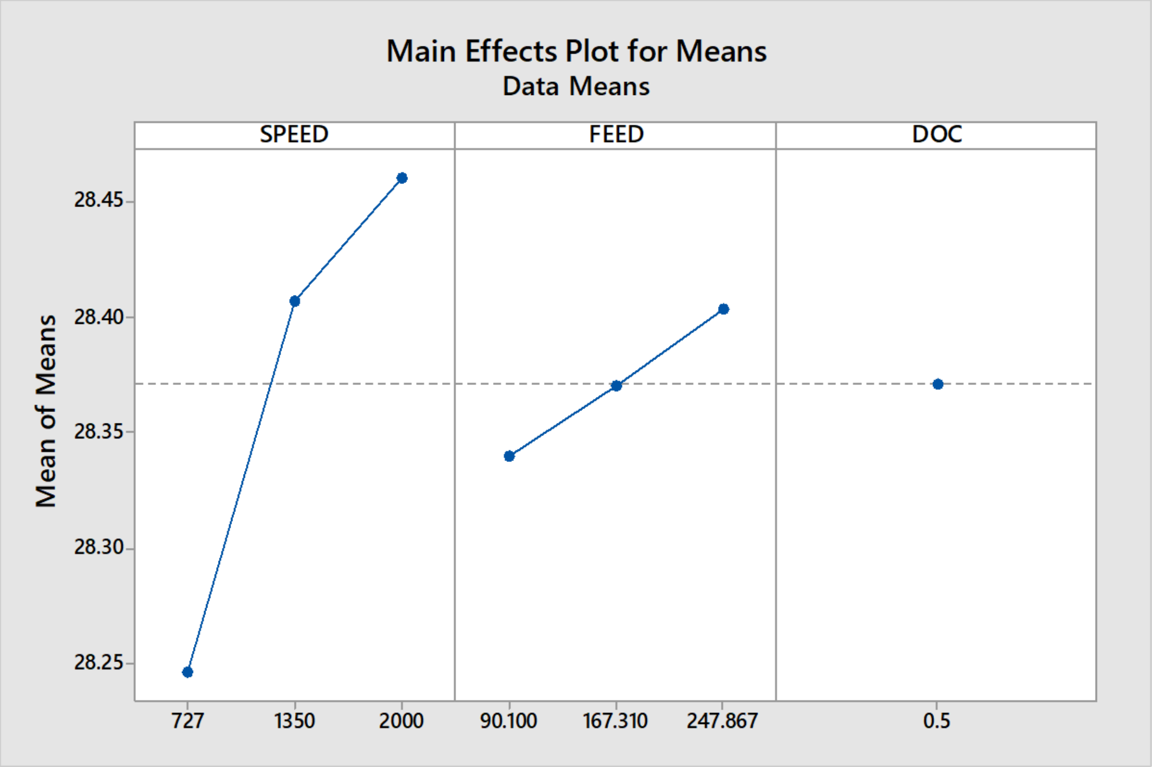
Response Table for Signal to Noise Ratios
Smaller is better

Level	SPEED	FEED	DOC
1	-29.02	-29.05	-29.06
2	-29.07	-29.06	
3	-29.08	-29.07	
Delta	0.07	0.02	0
Rank	1	2	3

Response Table for Means

Level	SPEED	FEED	DOC
1	28.25	28.34	28.37
2	28.41	28.37	
3	28.46	28.4	
Delta	0.21	0.06	0
Rank	1	2	3

Main Effects Plot for Means



Main Effects Plot for SN ratios

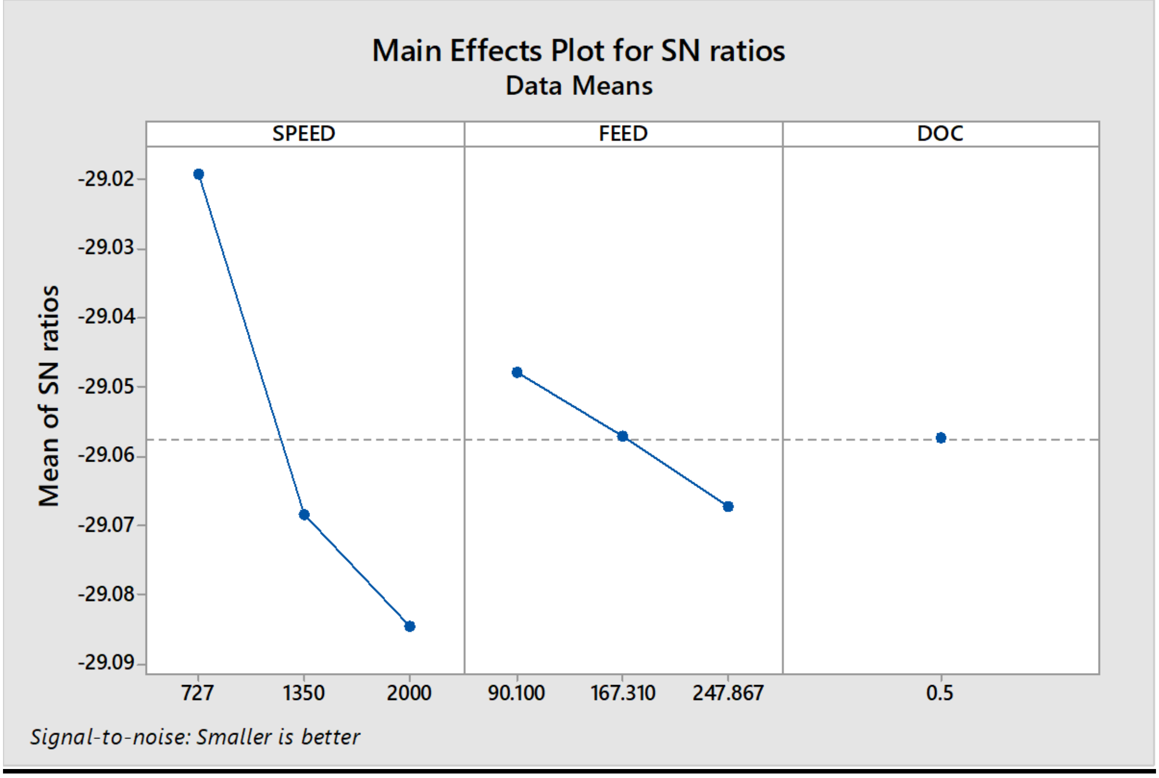


Table 4.5.4: OPTIMUM CUTTING PARAMETERS (ALUMINIUM)

OUT PARAMETERS	SPEED	FEED	DOC	OPTIMAL DESIGN
Ra	727	290.38	0.5	A1-B3-C1
Rt	727	290.38	0.5	A1-B3-C1
Rz	727	290.38	0.5	A1-B3-C1
Fx	727	290.38	0.5	A1-B3-C1
Fy	727	290.38	0.5	A1-B3-C1
Fz	727	290.38	0.5	A1-B3-C1
Temp	2000	290.38	0.5	A3-B3-C1

CHAPTER 5

CONCLUSION

In machining, cooling and lubrication are critical for minimising the severity of contact processes at the cutting tool-work piece interface. Water has traditionally been utilised as a coolant due to its availability and great heat absorption capability. Mineral oils were also utilised, but their limited cooling ability and expensive cost made them unpopular. Oil-based cutting fluids, both edible and non-edible, have been tested to minimise the quantity of lubricant used in metal removal operations. This paper examines current studies on the use of edible and non-edible oil-based metalworking fluids during the machining of aluminium alloys. It has been demonstrated that environmentally benign vegetable-based oils may successfully replace petroleum-based mineral oils as cutting fluids, which can then be further refined for improved performance.

Following conclusions are drawn from the above work :

a) Castor oil appears to be a more effective cutting fluid than mineral-based cutting fluid.
b) Even leftover oils have a lower wear rate than direct cutting oils.
c) As a result, edible and non-edible cutting fluids can readily substitute direct cutting oils in order to decrease wear between tool and workpiece integral.
d) The total cutting force of the machine tool determines tool and machine life.
e) A pin on disc equipment is used to determine the wear performance of cutting fluids (castor, neem, peanut, sunflower).
f) It is possible to deduce that castor oil has less wear than direct cutting oil in both mild steel and aluminium.
g) Castor oil appears to be a more effective cutting fluid than mineral-based cutting fluid.
h) Even residual oils have a lower wear rate than straight cutting oils.
i) The total cutting force of the machine tool determines tool and machine life.

FUTURE SCOPE

In the metalworking business, cutting fluids are the most often utilised process ingredients. They aid in achieving returns in terms of tool life, surface polish, and size accuracy, as well as making chip breaking and chip transfer simpler. Mineral oils were used as the basic stocks for metal working fluids in the industrial sector across the world. In meeting industrial needs, the mineral oil asset, like any other asset, becomes coupled with a liability. Workers and the environment were simultaneously exposed to poisonous mists, oil fumes, and fumes, causing skin and respiratory diseases and damaging the land and water resources via waste disposal. This encouraged researchers throughout the world to develop risk-free biodegradable metal working fluids, which led to the use of liquid agricultural products, namely vegetable oils, for tribological applications.

Many review studies have previously shown the scope of vegetable-based oils efficiently replacing mineral oils, and other research efforts are underway to corroborate this optimism. This study has made an attempt to identify edible and non-edible oils that have demonstrated a prospective scope of emerging as metal working fluids. Castor oil, groundnut oil, sunflower oil, and neem oil have been mentioned as edible and non-edible oils that are being studied further.

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