A THESIS REPORT
ON

OPTIMIZATION OF PROCESS PARAMETERS IN DRILLING OPERATION USING TAGUCHI METHOD

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE AWARD OF THE DEGREE OF
MASTER OF TECHNOLOGY
IN
PRODUCTION AND INDUSTRIAL ENGINEERING

SUBMITTED BY
ASHISH TRIPATHI
2K13/PIE/05

UNDER THE GUIDANCE OF
Dr. RANGANATH M.S.
ASSOCIATE PROFESSOR

DEPARTMENT OF MECHANICAL ENGINEERING
DELHI TECHNOLOGICAL UNIVERSITY
MARCH, 2016

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DECLARATION

I hereby declare that the work presented in this report, titled **"OPTIMIZATION OF PROCESS PARAMETERS IN DRILLING OPERATION USING TAGUCHI METHOD"** in partial fulfilment for the award of the degree of M.Tech in Production and Industrial Engineering, submitted in the Department of Mechanical engineering, Delhi Technological University, Delhi, is original and to the best of my knowledge and belief, it has not been submitted in part or full for the award of any other degree or diploma of any other university or institute, except where due acknowledgement has been made in the text.

Ashish Tripathi

Ashish Tripathi
Roll No. 2K13/PIE/05
M.Tech. Production and Industrial Engineering

Date: 01-04-2016

CERTIFICATE

This is to certify that the research work embodied in this dissertation entitled **"OPTIMIZATION OF PROCESS PARAMETERS IN DRILLING OPERATION USING TAGUCHI METHOD" submitted** by Ashish Tripathi, Roll no. 2K13/PIE/05 student of Master of Technology in Production and Industrial Engineering under Department of Mechanical Engineering, Delhi Technological University, Delhi is a bonafide record of the candidate's own work carried out by him under our guidance.

1/4/16

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ABSTRACT

Drilling can be described as a process where a multi-point tool is used to remove unwanted materials to produce a desired hole. It broadly covers those methods used for producing cylindrical holes in the work piece. In this study, the basic aim was to find optimal parameter in drilling to minimise the value of thrust and torque and to compare the same between Al-6061 and Mild steel. In this study specimen of Mild steel and Al-6061 of height (70mm) and diameter (40mm).Taguchi was used as the optimization technique. The experiment was performed by taking the three factors each having 3 levels. Based on the sequence, drilling was done by taking HSS drill bit of different size diameter. In particular, it is found that high speed and low feed and small diameter is giving a better result having low torque and thrust and the value of thrust and torque is more for mild steel.

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CHAPTER 1 INTRODUCTION

Drilling is a method to produce hole in which different investigation and studies have been completed over a compass of time. Drilling is basically for assembling industry like watch assembling industry, Aerospace industry, Automobile industry, semiconductors and restorative commercial ventures. Boring is needed in commercial ventures for get together identified with mechanical latches. It was expressed that roughly 55000 openings were drilled as a complete single unit in the generation of Air transport A350 plane.

The assembling commercial enterprises intentionally have been centring their consideration on exactness in measurements and surface completion. Surface harshness is the most critical parametric prerequisite and it is a list of nature of item. A surface completion of good degree is needed keeping in mind the end goal to upgrade the properties, exhaustion quality, scraped area resistance, erosion resistance and ergonomics i.e. claim of the item. Keeping in mind the end goal to acquire the enhanced slicing parameters to accomplish the best accessible surface completion, commercial enterprises in assembling area have depended on the utilization of handbook based upon the data and the administrator's experience. The need to choose and actualize ideal machining conditions and well-suited cutting apparatuses has been felt of high significance more than couple of decades. So as to add to a surface unpleasantness model and to enhance, it is fundamental to comprehend the present status of work here. Customary practice prompts poor surface complete and lessening in the ease of use and efficiency alongside usefulness because of inadequately streamlined utilization of machining capacity. This causes high assembling cost and low item quality. Drilling is probably the most important conventional mechanical process associated with chipboard processing. In the furniture industry, for instance, large quantities of holes have to be drilled due to the use of connections, handles and hinges. A considerable part of this field is still being devoted to major drilling-optimization issues such as the appropriate cutting parameters or tool geometries. Controllable procedure parameters incorporate cutting pace, device geometry, nourish and instrument setup. Different components, for example, device, work piece, apparatus wear, machine vibration, corruption, work piece and instrument material variability can never be controlled effectively. The vital cutting parameters considered for exchange here are profundity of cut, sustain and cutting speed. It is observed that in the majority of the cases surface harshness diminishes with expansion in pace of cutting and decline in food and profundity of cut. Since these cutting parameters will choose the kind of chips which are gotten at the season of machining of a solitary steady material in this manner, we need to examine them so that no such manufactured up edge chips development.

1.1 WHY THIS WORK AND ITS IMPORTENCE

The measurement of torque and thrust in drilling enable us to find the amplitude of vibration produced that will decide the type of setup needed for that work. Also we can determine the work piece material suitable for different type of drill material. Also the works that has been previously done on the subject were done manually there was less work done by the better design of experiment technique Taguchi. This enabled me to take up the work and pursue it in the bigger aspect. The material also is not a old material but a relatively new and is having better and good properties than the previously available material.

1.2. TORQUE AND THRUST

Drilling is presumably the most vital customary mechanical procedure related with chipboard preparing. In the industry of furniture , for example, vast amounts of holes must be penetrated because of the utilization of, handles and hinges. A considerable part of this field is still being devoted to major drilling-optimization issues such as the appropriate cutting parameters or tool geometries.

Chip drilling requires entirely different process parameters for the optimization process: in the earlier process, the smoothness or surface roughness of the surface processed and tool wear are given equal importance. In chip drilling, the earlier parameter is prioritized over the new given the complexity to drill .

A suitable model can help in the focused recruitment of the most apt feed rates, spindle speeds and geometrical cutting tool shapes.

The study of drilling is often presented, some complexities which are dependent upon the intricate geometry of the twist drill. Drill bits are nothing but tools used for cutting and to produce holes of cylindrical nature, and always of circular cross-section. Drill bits come in many sizes but in single cylindrical shape and have many uses. These bits are connected to a mechanism, often simply referred to as drill, which rotates them and provides enough torque and axial force to produce the hole.

The shank is the part of the drill bit which is to be hold by the chuck of a drill. The two cutting edges of the drill bit are at one end, and the shank is at the other.

Drill bits come in standard sizes, defined in the iso records so that they can be used independently.

Exceptionally, specially-shaped bits can cut holes of non-circular cross-section.

The term drill might imply to either a drilling machine or to a drill bit to be used in a drilling machine. Drill bit or bit is used throughout to refer to a bit for use in a drilling machine, and drill refers always to a drilling machine.

Diverse materials are utilized to make the driiling tools, contingent upon the recommended utilization of the item. Numerous materials of high hardness, for example, carbides, are more fragile than steel, and are by a long shot more subject to breaking, basically if the drill is definitely not held at a consistent recommended point to the example; e.g., when hand-held. Steels :Soft low carbon steel bits are modest, yet don't hold a sharp edge well and require successive pounding or honing. They can be utilized just for penetrating wood; notwithstanding meeting expectations with life span as compared to the softwoods.

1.2.1 Bits made from high carbon alloy steel are much more durable than low-carbon steel bits due to the properties given by hardening and tempering of the material. If they are heated over a particular temperature (e.g., by frictional heating while drilling) they lose their temper, resulting in a brittle cutting edge. These bits can be used on wood or metal.

1.2.2 High speed steel (HSS) is a form of tool steel; HSS bits are hard, and much more effective against the heat than high carbon steel.HSS can be used to drill hardwood, metal and most other materials at greater cutting speeds than carbon steel bits, and they have replaced carbon steels.

1.2.3 Cobalt steel alloys are combinations of high speed steel which contain more cobalt percentage. They hold their hardness at a very higher temperature, and used to drill stainless steel and other hard materials. The main disadvantage of cobalt steels is that they are even more brittle than standard HSS.

1.2.4 Others

1.2.4.1 Tungsten carbide and different carbides are to a great degree hard, and can bore for the most part all materials while holding their edge longer than some other bit. The material is not modest and more weak than steels; consequently they are for the most part utilized for boring tool tips, little bits of hard material settled or brazed or welded onto the tip of a touch made of less hard metal. On the other hand, it is currently basic in like manner employment shops to utilize strong carbide bits. In little sizes it is hard to fit carbide tips; in a few commercial enterprises, basically PCB fabricating, which obliges numerous gaps with distances across which are under 1 mm, strong carbide bits are utilized.

1.2.4.2 Polycrystalline diamond (PCD) is one of the hardest metals of all materials and is in this way having high imperviousness to wear. It comprises of a layer of precious particles, normally around 0.5 mm (0.020 in) thick, reinforced in a sintered mass to a tungsten carbide bore. Bits are delivered utilizing this material by either brazing little pieces to the tip of the apparatus or to shape the front lines, or by sintering PCD into a vein in the tungsten carbide "nib". The nib cis later brazed to a carbide shaft; it can then be outfitted to complex geometries that would some way or another reason braze disappointment in the littler "fragments". PCD bits are commonly utilized as a part of the car, aviation, and different commercial ventures to bore grating aluminium composites, carbon fibres fortified plastics, and other rough materials, and in applications where machine downtime to supplant or hone worn bits is astoundingly unreasonable. It ought to be noticed that PCD is not utilized on ferrous metals because of abundance wear coming about because of a response between the carbon in the PCD and the iron in the metal Coatings.

1.2.4.3 Titanium nitride (TiN) is a hard artistic material that can be utilized to coat a fast steel bit (more often than not a turn bit), augmenting the cutting life by three or more times. On the other hand, when the bit is honed the new edge won't have the advantages of the covering. Hardwoods can abbreviate their Titanium (TiAlN) is a similar coating that can extend tool life five or more times.

1.2.4.4 Titanium carbon nitride (TiCN) is another coating also superior to TiN.

1.2.4.5 Diamond powder is used as an abrasive, most often for cutting tile, stone, and other very hard materials. Large amounts of heat are generated by friction, and diamond coated bits often have to be water cooled to prevent damage to the bit or the workpiece.

Figure 1 : Diamond coated 2mm bits, used for drilling material

Chapter 2 Literature review

In this we studied certain research papers collected by us and making these papers as our source of light, we proceeded in the direction of measurement of torque and thrust.

Papers that were studied:-

C. Tsao and H. Hoeing, presented the prediction and evaluation of thrust force and surface roughness in drilling of composite material using candle stick drill. The approach was based on Taguchi method and the artificial neural network. The experimental results indicated that the feed rate and the drill diameter were the most significant factors affecting the thrust force, while the feed rate and spindle speed contributed most to the surface roughness. In this study, the objective was to establish a correlation between the feed rate, spindle speed and drill diameter with the induced thrust force and surface roughness in drilling composite laminate. correlations were obtained by multi-variable regression analysis and radial basis function network (RBFN) and compared with the experimental results. The results indicated that the RBFN is more effective than multi-variable regression analysis. It used Kistler 9257 piezoelectric dynamometer to measure the forces.

D.A. Stephson et. al. developed a model for calculating main cutting edge torque, thrust, and radial force distributions for drilling gray cast iron with solid carbide and carbide-tipped drills. Unlike previous models, this model was applicable to arbitrary point geometries and includes radial forces due to point asymmetry. A general parametric method for characterizing complex point geometries was first explained. Using this method, along with empirical cutting force models from end turning tests, torque, thrust, and radial force calculations are carried out for ten representative drills covering a range of available geometries. Calculated and measured torque values agreed to within the repeatability of the measurements. Calculated thrust force values were reasonable, but were significantly lower than measured values in most cases, since chisel edge contributions are not included.

Diana M. Rincon and A. Galip Ulsoy found that Drill bit vibrations can have an adverse effect on drilling performance resulting in lobed holes, burr formation and tool breakage. An analytical model for predicting torque, thrust and radial forces in drilling was developed. The model included the effects of the drill bit transverse deflections which lead to variations from the mean values in the cutting forces. Simulations for a drill, exhibiting increasing elliptical translational motion due to drill vibrations, indicate a significant increase in the ranges of the torque and thrust while maintaining essentially constant mean values. The same qualitative trends are also observed experimentally. The model, when drill vibrations are negligible, reduces to previous models for predicting the mean torque and thrust in drilling. The mean drilling torque and thrust values predicted are in good agreement with experimental data and with previously published models.

L.B. Zhang et. al. showed that delamination is a dramatic problem associated with drilling fiber-reinforced composite materials (FRCMs), which, in addition to reducing the structural integrity of the material, also resulted in poor assembly tolerance and has the potential for long-term performance deterioration. Solution to the problem lied in reducing the thrust force of drilling. In this paper, a theoretical analysis for predicting mean values of thrust and torque in vibration drilling FRCMs was presented. This was based on mechanics of vibration of cutting analysis and the continuous distributions of thrust and torque along the lip and the chisel edge of a twist drill. The result of the simulation study had shown a very good agreement between the theoretical predictions and the experimental evidence. On the same cutting conditions, the thrust and the torque by the vibration drilling method were reduced by 20–30 percent, compared with conventional drilling.

L.P. Wang et.al. developed a method for predicting the thrust and torque in vibration micro drilling. The model was based on the mechanics of vibration cutting analysis, which involved the development of a dynamic uncut chip thickness and its analysis for each vibration cutting element at the lips and chisel edge. The proposed method had been tested for a range of vibration parameters and feeds. The predicted thrust and torque values had been equated with those obtained in vibration micro-drilling experiments.

The study of drilling has often presented some difficulties which are linked to the complex geometry of the twist drill (fig). In practice, generally empirical equations are used to calculate thrust force and torque. These equations are very approximate, because they do not take all the cutting parameters into account. They often use only the feed speed and the diameter of the drill. Few theoretical works have been undertaken on drilling. Bera and Bhattacharya [17] described the first attempt to use a cutting model to determine torque and thrust in drilling. They analyzed the whole drill and considered that the chisel edge acted as an indenting tool and the lip as a cutting tool. They assumed that the resultant force per unit length of the lip is constant.

Williams [15] recognised the significance of the feed on the resultant velocity and on altering the cutting geometry. In making predictions of torque and thrust, Williams argued that a portion of the drill acted as an orthogonal cutting edge because the cutting velocity is assumed to be perpendicular to the cutting edge. The model that will be studied in this work uses the geometry of a conventional twist drill. It is based on an analysis of the thrust and the torque continuity, from the force distribution along the cutting edges. It uses no preliminary experimental results. The purpose of the study is to establish predictive formulae to calculate thrust amid torque of drilling.

This can been calculated by various procedures as it depends upon various independent variables which come into play during the drilling process and these vary from the depth of cut to feed to speed or even the surface roughness to be produced or initial roughness. Tsao [1] reported that the feed rate and the drill diameter are recognized as the most significant factors affecting the thrust force. Depending upon these variables various researchers used various methods to find out the force and thrust produced in the drilling process.

CHAPTER3 EXPERIMENT SET-UP

3.1 MACHINE

Radial Drilling machine:

It is type of drilling machine which has more number of degree of freedom than conventional drilling machine and this machine is named so because the drilling tool can be move radialy in radial arm fixed to machine.

Drilling machine used in this process is radial and the specifications are as follows;

Table 1: Machine specifications (Drilling machine)

Radial drilling machine	Type –RM-62
Drilling capacity	50 mm in steel
Drilling rough bores	90 mm in steel
Boring with supported boring bar	1200 mm in steel
Trepanning	200 mm in steel
Tapping whitworth	$1_{3/4}$ inches
Tapic metric fine threads	56 mm
12 spindle speeds	40-1700 rpm
6 spindle feeds	0.12 mm/rev to 1.2 mm/rev
Spindle diameter	81.8
Drilling pressure	1650 kg
Drill power	4.8/6 h.p
Arm elevating motor power	2 H.P
Max drilling radius	1500
Min. drilling radius	530
Max drill transverse	970
Diameter of column sleeve	350
Max distance column to spindle	1325
Min distance column to spindle	355
Max distance base plate to spindle	1450
Min distance base plate to spindle	385
Working surface of base plate length	1490
Width	910

DIMENSIONS	
Base plate overall length	2190
Overall width	925
Swing of arm	1860
Overall height of machine	2760
Approx. net weight	3160
Case dimensions	
Length	2810
Width	1280
Height	2983

Figure 5: Radial Drilling machine in Metal Cutting Lab, DTU

The experimental set up was made by connecting the machine and the dynamometer and the results were thus obtained while conducting the experiments.

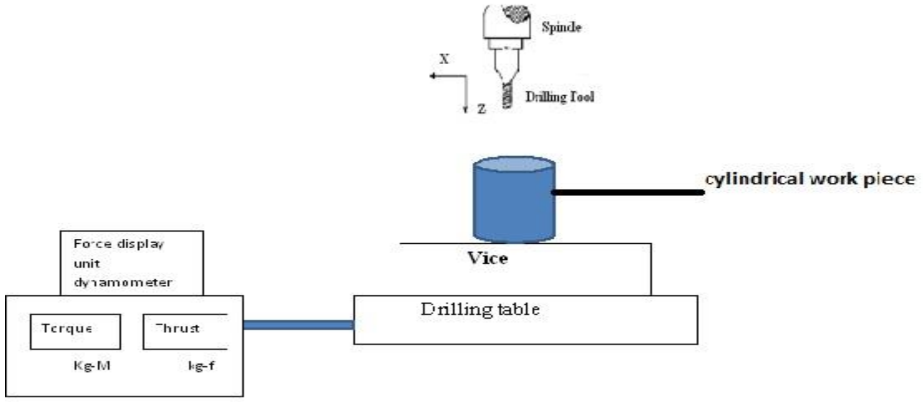

Figure: 6 Experiment Setup used

3.2 MATRIAL/WORKPIECE

3.2.1 ALUMINIUM 6061 BARS

Aluminium-6061 is precipitation hardening aluminium alloy,. It is easily available in pre-tempered grades such as 6061-O which means it is annealed and tempered grades such as 6061-T6 which means it is solution zed and artificially aged and 6061-T651 which means it is solution zed, stress-relieved stretched and artificially aged.

The first digit of the four digits in the designation implies the alloy group in terms of the major alloying elements of which it is constituted.

Table 2 : Aluminium alloys

Alloys	Primary Constituent
1XXX	Minimum of 99.00% and higher purity of aluminium
2XXX	Copper is main alloying element
3XXX	Manganese is main alloying element
4XXX	Silicon is main alloying element
5XXX	Magnesium is main alloying element
6XXX	Magnesium and Silicon are main alloying elements
7XXX	Zinc is main alloying element
8XXX	Other elements
9XXX	Unused series

Table No.3: Composition of Al-6061

ELEMENT	PERCENT PRESENT
Magnesium(Mg)	0.80-1.20
Silicon(Si)	0.40-0.80
Iron(Fe)	0.0-0.70
Copper(Cu)	0.15-0.40
Chromium(Cr)	0.04-0.35
Zinc(Zn)	0.0-0.25
Titanium(Ti)	0.0-0.15
Mangnese(Mn)	0.0-0.15
Others(Total)	0.0-0.15
Other(each)	0.0-0.05
Aluminium(Al)	Balance

Table No.4: PROPERTIES OF ALUMINIUM 6061

PROPERTY	**VALUE**
Density	2.7 g/cc
Brinell Hardness Number	95
Ultimate Tensile Strength	310 MPa
Tensile Yield Strength	276 MPa
Modulus of Elasticity	68.9 GPa
Poisson's ratio	0.33
Fatique Strength	96.5 MPa
Machinability	50%(comparing with other aluminium alloys)
Shear Modulus	26 GPa
Shear Strength	207 MPa
Thermal Conductivity	167 W/m-k
Melting Point	582-652°C

Uses

6061 is mostly used for the following:

- constructing structure of aircraft, such as wings and fuselages. 6061 is more generally utilised as a part of homebuilt aircraft than business or military aircraft. Aluminium alloy 2024 has more strength, but 6061 aluminium alloy is easily workable and it also behaves resistant to corrosion even when the material surface is peeled off. Whereas, 2024 is corroded easily, hence it is used with a thin coating of Al-clad to make it corrosion resistive.
- yacht construction, including small utility boats.
- wheel spacers used as a automotive parts

- packaging of foodstuffs and beverages using aluminium cans.
- bicycle components and frames.
- The acclaimed Pioneer plaque had been made of this specific amulgum of aluminium.
- the auxiliary chambers and baffle systems in firearm sound silencer (essentially gun silencer for decreasing weight and enhancing mechanical operation). Lower and upper receivers of majority of the AR-15 rifle variants.

  Most of the aluminium the docks and the gangways are built with 6061-T6 extrusions, and welded into spot.
- aluminium 6061 is likewise utilized in some ultra-high vacuum (UHV) chambers
- parts for remote control model aircraft, for most of helicopter rotor segments.

3.2.2 MILD STEEEL

Table 5: Chemical composition of mild steel

ELEMENTS	**MAXIMUM WEIGHT %**
Carbon(c)	0.45
Sulphur(s)	0.60
Manganese(Mn)	1.00
Phosphorous(p)	0.40
Silicon(Si)	0.35

Table 6: Mechanical and Physical properties of Mild Steel

PROPERTIES	VALUES
Density	7085 kg m-3
Thermal conductivity	48 Jm-1K-1S-1
Thermal expansion	11.3×10-6 K
young’s modulus	210 GNm-2
Tensile strength	600 MNm-2

3.3 DYANAMOMETER

A dynamometer is a device used to find the torque and thrust in the machine either in drilling or any other machining process. Dynamometer is nothing but a simple electrical machine which is used to measure the value of the force and torque exactly in the process. A dynamometer is first balanced with respect to a known force and then the pointer is moved with respect to the new force coming into action at that point or in that process. It is nothing but a device for the dynamic calculation of the power produced in the engine while in the common available machine it is used for the prediction of torque. There are various kinds of dynamometers which are available in the market they are referred according to the source of power they work upon:- 1. Break dynamometer. 2. Break current dynamometer 3. Eddy current dynamometer 4. Hydraulic dynamometer. Break dynamometers are the oldest in business and are mechanical machines most commonly called as the shoe which when gets in contact of hub rubs against it and produces the desired measurement. Power for the hub to move provided by the engine. Hydraulic dynamometers may be defined as the machines which use hydraulic power to muster up the power to run the components. The load given to the engine is changing depending upon the valve which opens and closes with the change in pressure. Eddy current dynamometers are devices in which the engine is provided or passed through the current and causes the disk to have an effect of lens law and this causes a force on the machine to move and stick to the hub and thereby measure the thrust or torque. Changing the amount of current in the machine changes the load settings of the machine in which it is placed. If the dynamometer is made in connection to the engine rod then it is coined as engine dynamometer. If the dynamometer is made in contact to the driving wheels of the vehicle or then is named as chassis dynamometer. A digital type dynamometer is used to measure thrust and torque. Reading provided by drill tool dynamometer was in MKS unit system.

Figure7: dynamometer in Metal Cutting Lab, DTU

3.4 SOFTWARE

The software used is Minitab 15 which is used to draw the graphs and plots for the desired factors and responses. Minitab is a not only a software but a complete package of statistical tools designed and produced at the Pennsylvania State University by researchers namely, Thomas A. Ryan, Barbara F. Ryan, Jr., and Brian L. Joiner in 1972.

Minitab came to the market with its first soft version called as Omni-tab it was a program or algorithm use for the research work in the NIST ; the coding and the manual of omni-tab was printed in 1986.

Minitab is owned by Minitab Inc, it is a privately owned company with its headquarters situated in the State College of Pennsylvania, with its other branches in Coventry, England, Paris, France and Sydney, Australia.

In the present scenario, mini-tab is used in close usage and induction of other softwares which are also optimizers and can be used to bring better results.

Minitab 17, is the new version of this software, and is available in 8 languages: Japanese, Korean, Portuguese English, german , french, Simplified Chinese, & Spanish.

Minitab Inc. sells two other products that come in handy while using Minitab 17:

1. Quality Trainer: an eLearning file that allows in understanding the statistical tools.
2. Quality Companion 3: a tool integrated to the system so that it can be used to involve both the six sigma and the lean manufacturing so as to use the product in all types of fields and make it an all round.

CHAPTER 4: METHOD USED

Taguchi method

Taguchi has built up a technique for the utilization of outlined analyses, including an expert's handbook. This strategy has taken the outline of investigations from the selective universe of the analyst and brought it all the more completely into the universe of assembling. His commitments have additionally made the professional work easier by bolstering the utilization of less trial plans, and giving a clearer comprehension of the variation nature and the monetary outcomes of value building in the realm of assembling. Taguchi presents his methodology, utilizing test configuration for :

– planning items/forms in order to be strong to natural conditions;
– planning and creating items/forms in order to be strong to part variety;
– minimizing variety around an objective worth

The goal of the parameter configuration is to advance the settings of the procedure parameter values for enhancing execution attributes and to distinguish the item parameter values under the ideal procedure parameter values. Furthermore, it is normal that the ideal procedure parameter qualities got from the parameter configuration are unfeeling to the variety of natural conditions and other commotion variables. In this way, the parameter configuration is the key stride in the Taguchi technique to accomplishing high caliber without expanding expense.

Essentially, established parameter outline, grew by Fisher, is intricate and difficult to utilize. Particularly, a substantial number of tests must be completed when the quantity of the procedure parameters increments. To fathom this undertaking, the Taguchi strategy utilizes an exceptional outline of orthogonal clusters to contemplate the whole parameter space with a little number of investigations just. A misfortune capacity is then characterized to figure the deviation between the trial quality and the coveted worth. Taguchi suggests the utilization of the misfortune capacity to gauge the execution trademark going amiss from the coveted quality. The estimation of the misfortune capacity is further changed into a sign to-clamor (S/N) proportion.. For the most part, there are three classes of the execution trademark in the examination of the S/N proportion, that is, the bring down the-better, the higher-the-better, and the ostensible the-better. The S/N proportion for every level of procedure parameters is processed in light of the S/N investigation. Despite the classification of the execution trademark, the bigger S/N proportion compares to the better execution trademark. In this manner, the ideal level of the procedure parameters is the level with the most noteworthy S/N proportion. Besides, a measurable investigation of fluctuation (ANOVA) is performed to see which transform parameters are factually critical. With the S/N and ANOVA investigations, the ideal mix of the procedure parameters can be anticipated. At last, an affirmation analysis is led to check the ideal procedure parameters

- Verify the ideal procedure parameters through the affirmation test.

4.2 STRUCTURE OF TAGUCHI METHOD:

Taguchi system has been scrutinized in the writing for its trouble in representing collaborations between parameters. Another restriction is that the Taguchi routines are logged off, and in this way wrong for a powerfully changing process, for example, a recreation study. Besides, since the Taguchi routines manage planning quality as opposed to revising for low quality, they are connected most viably at ahead of schedule phases of procedure improvement An extensive number of investigations must be done when the quantity of the procedure parameters increments. To illuminate this undertaking, the Taguchi strategy utilizes an uncommon configuration of orthogonal exhibits to contemplate the whole process parameter space with just a little number of examinations. Utilizing an orthogonal exhibit to plan the investigation could help the planners to ponder the impact of different controllable variables on the normal of value attributes and the varieties in a quick and monetary way, while utilizing a sign to-clamor proportion to dissect the trial information could help the fashioners of the item or the maker to effortlessly figure out the ideal parametric

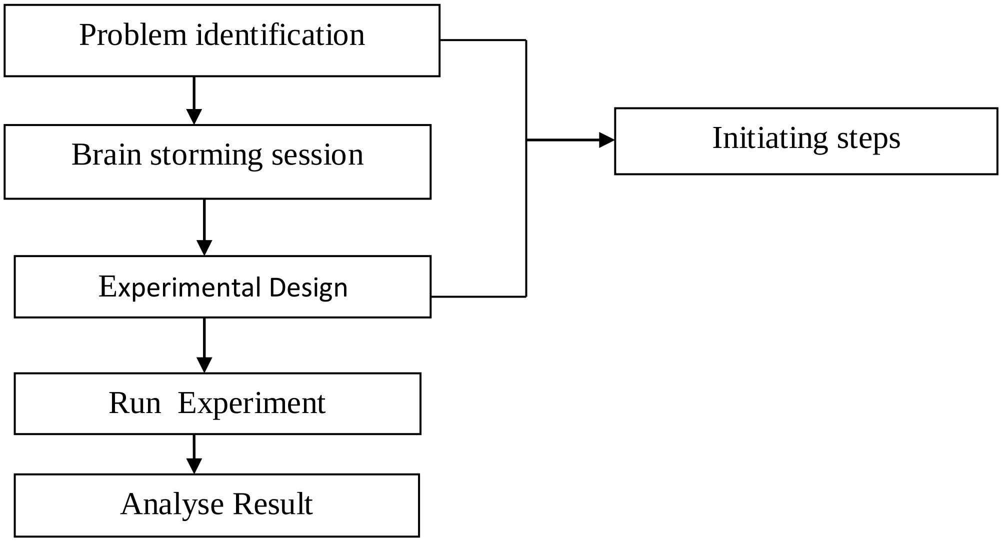

Figure8: Structure of Taguchi method

CHAPTER 5 DATA- ANALYSIS

In this analysis, three machining variables were chosen as control components, and every parameter was intended to have three levels, signified 1, 2, and 3 (Table 5). The trial outline was by L27 (3^13) cluster in view of Taguchi system, while utilizing the Taguchi orthogonal exhibit would extraordinarily lessen the quantity of tests. An arrangement of examinations planned utilizing the Taguchi system was directed to explore the connection between the procedure parameters and delamination element.

Table No.7: Different Factors

d(drill bit diameter)(mm)	S(speed)(mm/min)	f(feed)(mm/rev)
8	150	.12
10	300	.20
12	440	.30

Taguchi Orthogonal Array Design

L27 (3**3)

Factors: 3

Runs: 27

Columns of L 27(3**13) Array

1 2 3

C4=d (drill diameter)

C5=s (speed of drill)

C6=f (feed)

C7=torque

C8=thrust

5.1 FOR AL-6061

Table no.8: Experimental Details

Exp.No.	1	2	3	C4	C5	C6	C7	C8
1	1	1	1	8	150	0.12	0.2	72
2	1	1	1	8	150	0.12	0.2	76

3	1	1	1	8	150	0.12	0.2	69
4	1	1	2	8	300	0.20	0.2	85
5	1	1	2	8	300	0.20	0.2	87
6	1	1	2	8	300	0.20	0.3	81
7	1	1	3	8	440	0.30	0.4	145
8	1	1	3	8	440	0.30	0.6	168
9	1	1	3	8	440	0.30	0.4	152
10	2	1	2	10	150	0.20	0.4	121
11	2	1	2	10	150	0.20	0.5	132
12	2	1	2	10	150	0.20	0.7	136
13	2	2	3	10	300	0.30	0.7	148
14	2	2	3	10	300	0.30	0.7	158
15	2	2	3	10	300	0.30	0.7	153
16	2	2	1	10	440	0.12	0.4	101
17	2	2	1	10	440	0.12	0.3	92
18	2	2	1	10	440	0.12	0.3	97
19	3	2	3	12	150	0.30	1.0	255
20	3	2	3	12	150	0.30	1.2	262
21	3	2	3	12	150	0.30	1.2	259
22	3	3	1	12	300	0.12	0.6	157
23	3	3	1	12	300	0.12	0.6	158
24	3	3	1	12	300	0.12	0.6	158
25	3	3	2	12	440	0.20	0.9	212
26	3	3	2	12	440	0.20	0.9	203
27	3	3	2	12	440	0.20	0.9	205

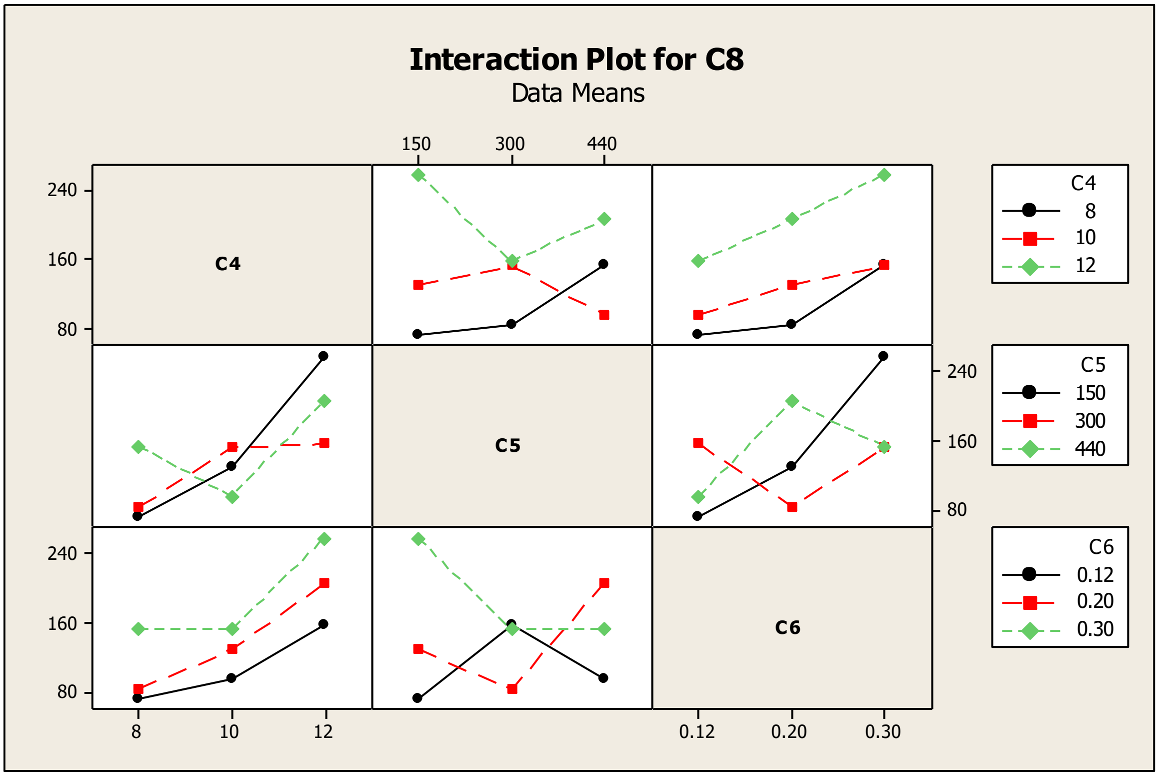

Figure 9:Interaction Plot for Thrust

In first row: for minimum thrust

If s=150 then d=8; if f=0.12then d=8

If s=300 then d=8; if f=0.20 then d=8

If s=440 then d=10; if f=0.32 then d=8

In second row: for minimum thrust

If d= 8 then s=150; if f=0.12 then s=150

If d=10 then s=440;if f=0.20 then s=300

If d=12 then s=300;if f=0.30 then s=440

In third row: for minimum thrust

If d=8 then f=0.12; if s=150 then f=0.12

If d=10 then f=0.12 ;if s=300 then f=0.20

If d=12 then f=0.12 ; if s=440 then f=0.12

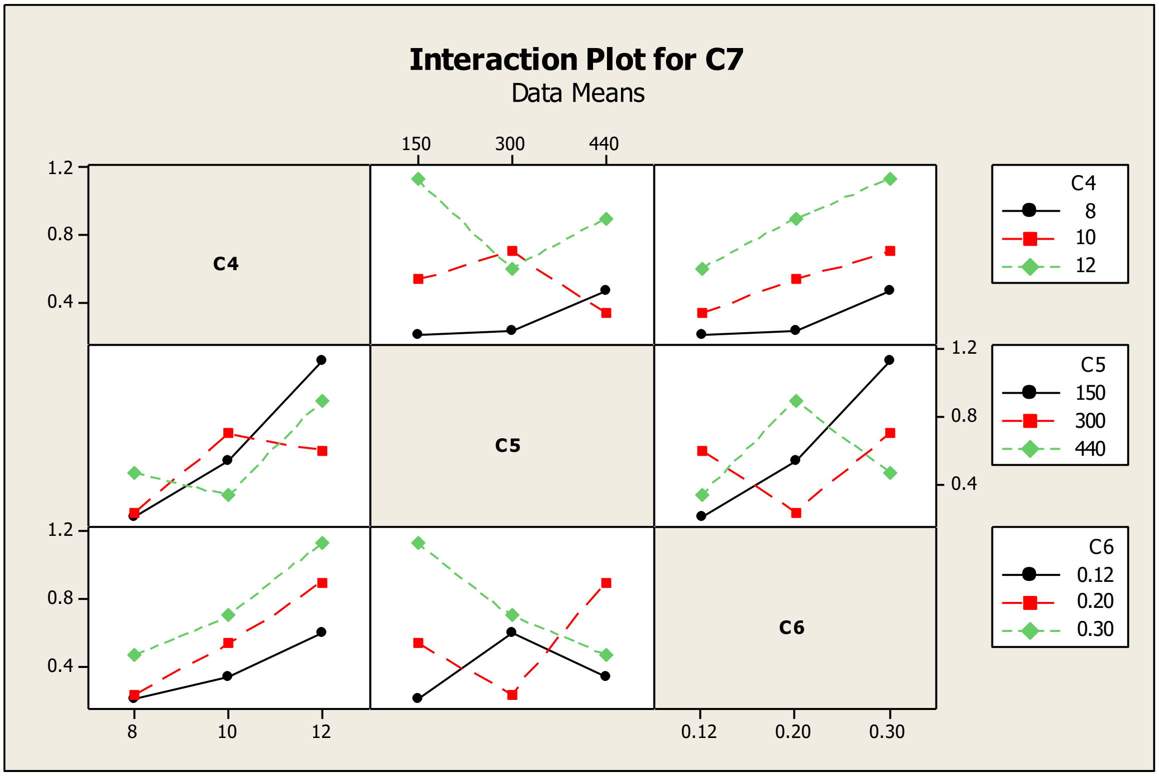

Figure 10: Interaction Plot for Torque

In first row: for minimum torque

If s=150 then d=8; if f=0.12 then d=8

If s=300 then d=8; if f=0.20 then d=8

If s=440 then d=10; if f=0.30then d=8

In second row: for minimum torque

If d= 8 then s=150; if f=0.12 then s=150

If d=10 then s=440;if f=0.20 then s=300

If d=12 then s=300; if f=0.30 then s=440

In third row: for minimum torque

If d=8 then f=0.12; if s=150 then f=0.12

If d=10 then f=0.12; if s=300 then f=0.20

If d=12 then f=0.12; if s=440 then f=0.12

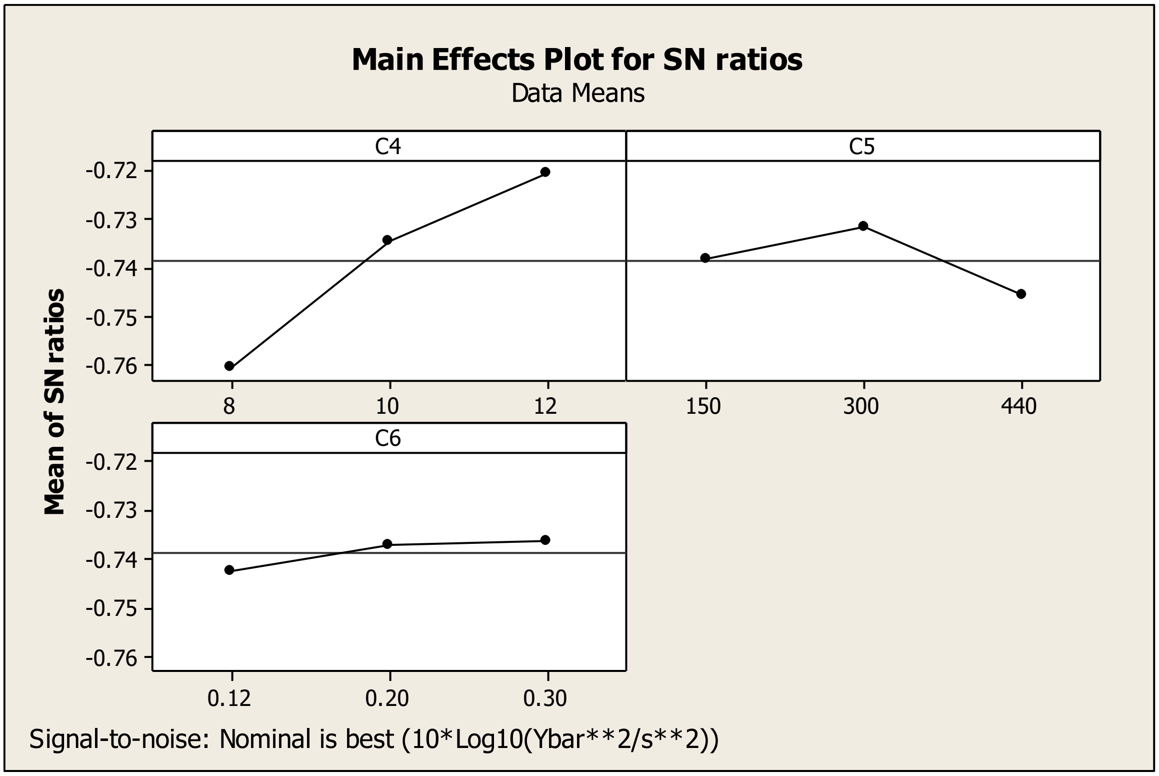

Figure 11: Main Effect Plot for S-N Ratio

Nominal is best (10*Log10(Ybar**2/s**2))

Table No.9: Response Table for Signal to Noise Ratios

Level	C4	C5	C6
1	-0.7607	-0.7385	-0.7426
2	-0.7348	-0.7319	-0.7373
3	-0.7206	-0.7456	-0.7361
Delta	0.0401	0.0137	0.0065
Rank	1	2	3

Table No.10:Response Table for Means

Level	C4	C5	C6
1	52.09	77.09	54.63
2	63.48	66.09	70.39
3	104.27	76.67	94.83
Delta	52.18	11.00	40.19
Rank	1	3	2

Table No.11:Response Table for Standard Deviations

Level	C4	C5	C6
1	56.88	83.85	59.48
2	69.07	71.87	76.58
3	113.28	83.52	103.17
Delta	56.40	11.98	43.69
Rank	1	3	2

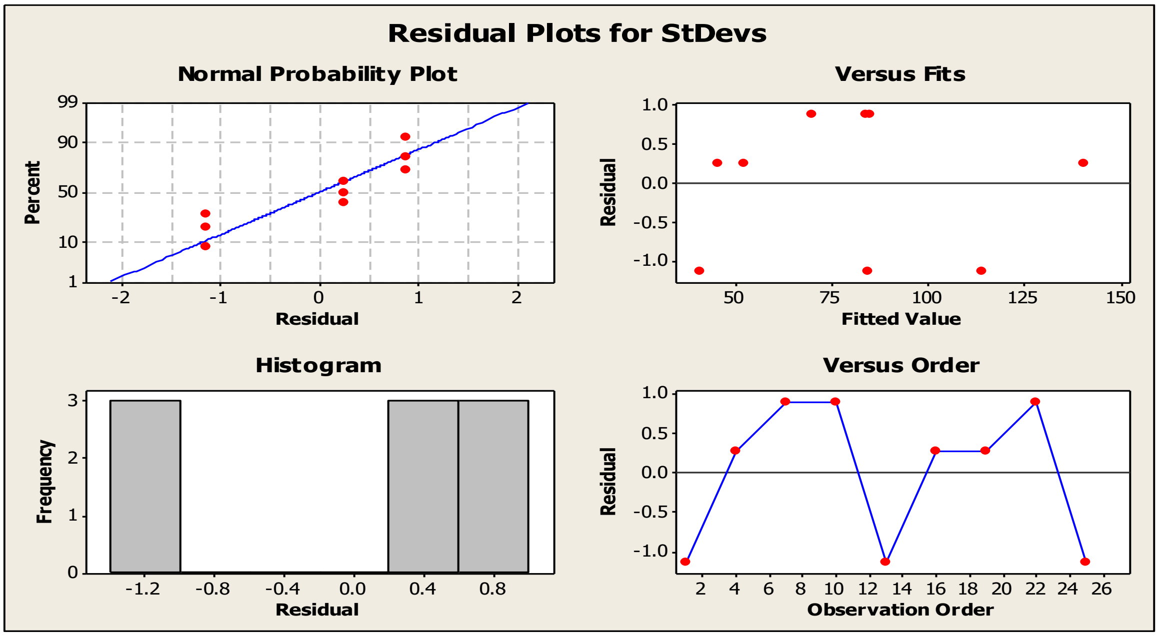

Figure 12: Residual Plot for StDevs

This straight line in Figure 12 indicates the normal distribution of residuals.

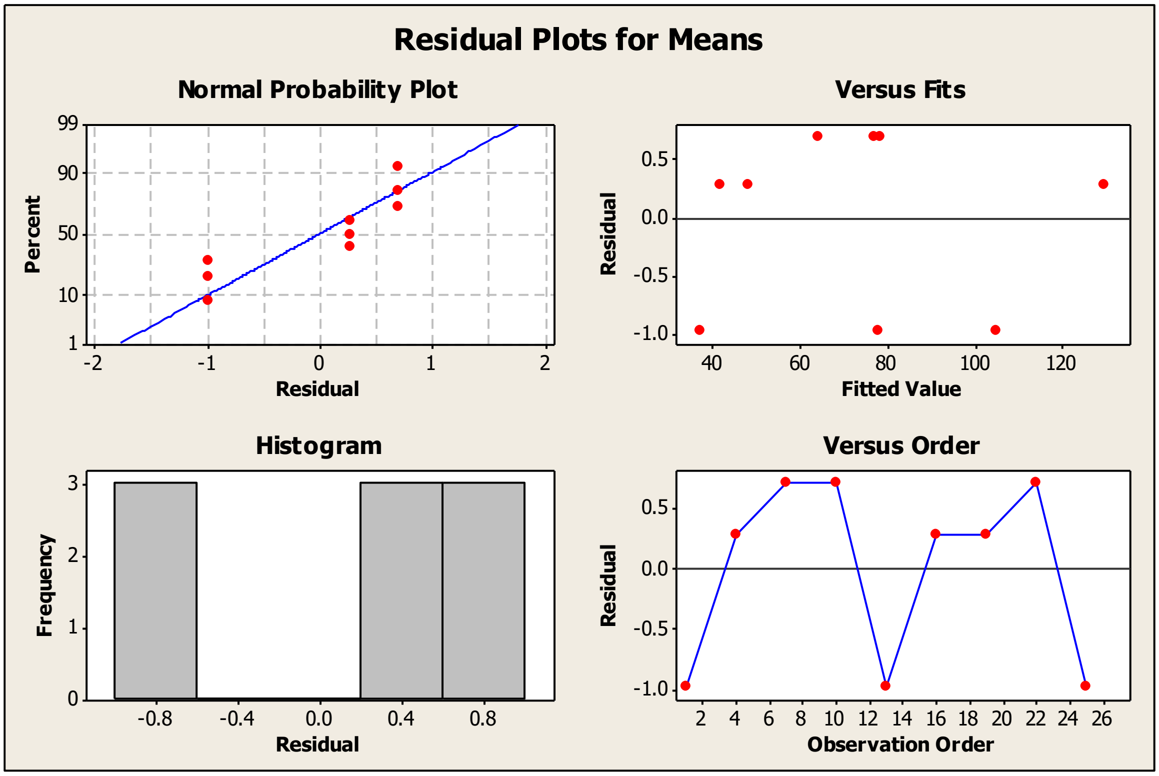

Figure 13: Residual Plot for Means

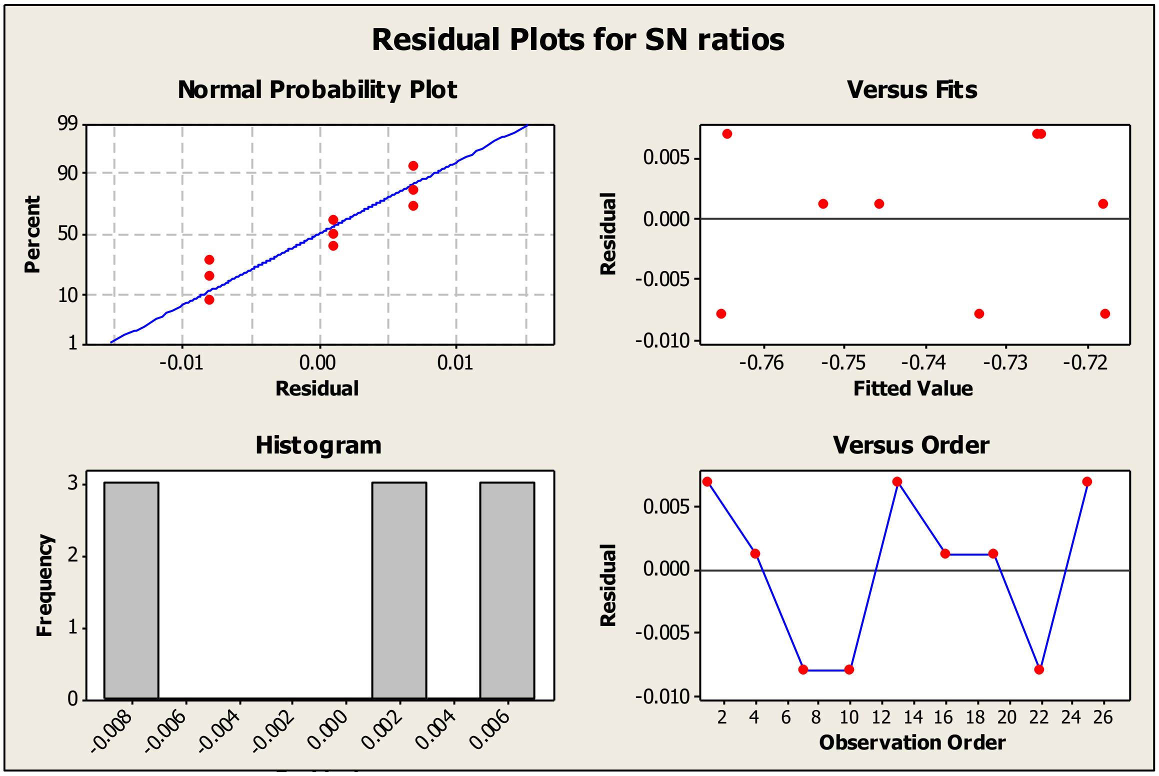

Figure 14: Residual Plots for SN Ratio

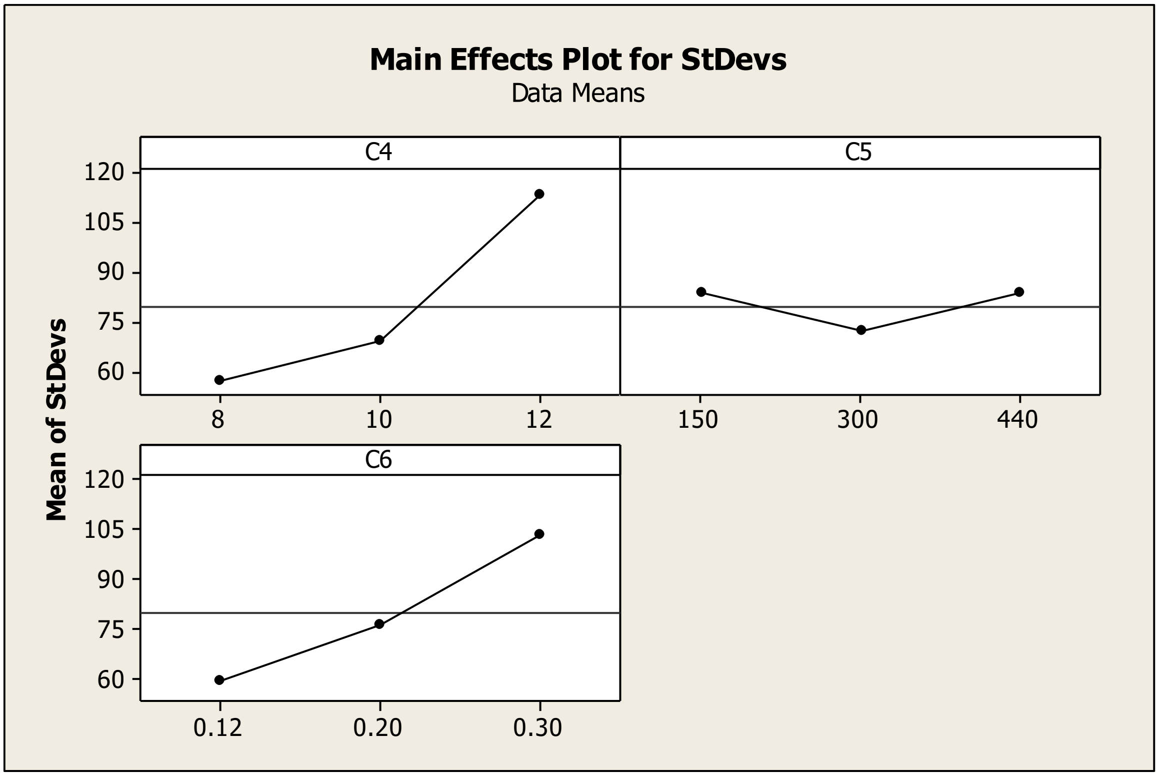

Figure No.15:Main Effects Plot for StDevs

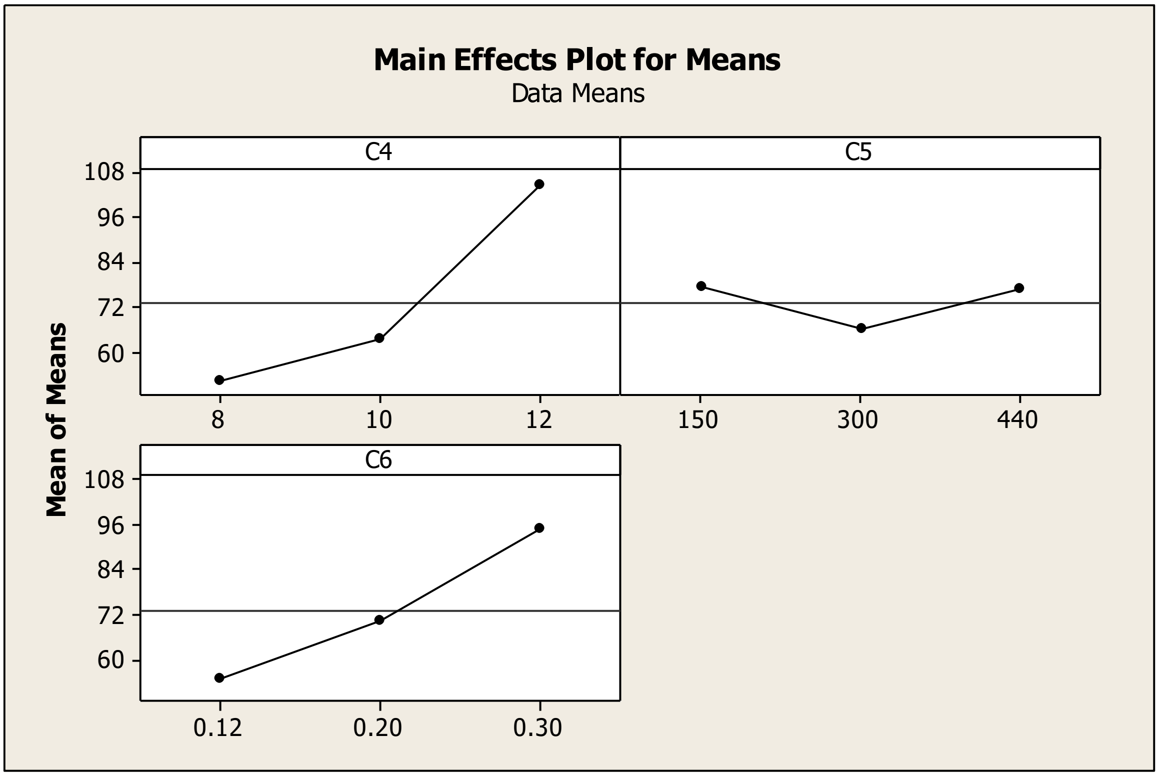

Figure No.16:Main Effects Plot for Means

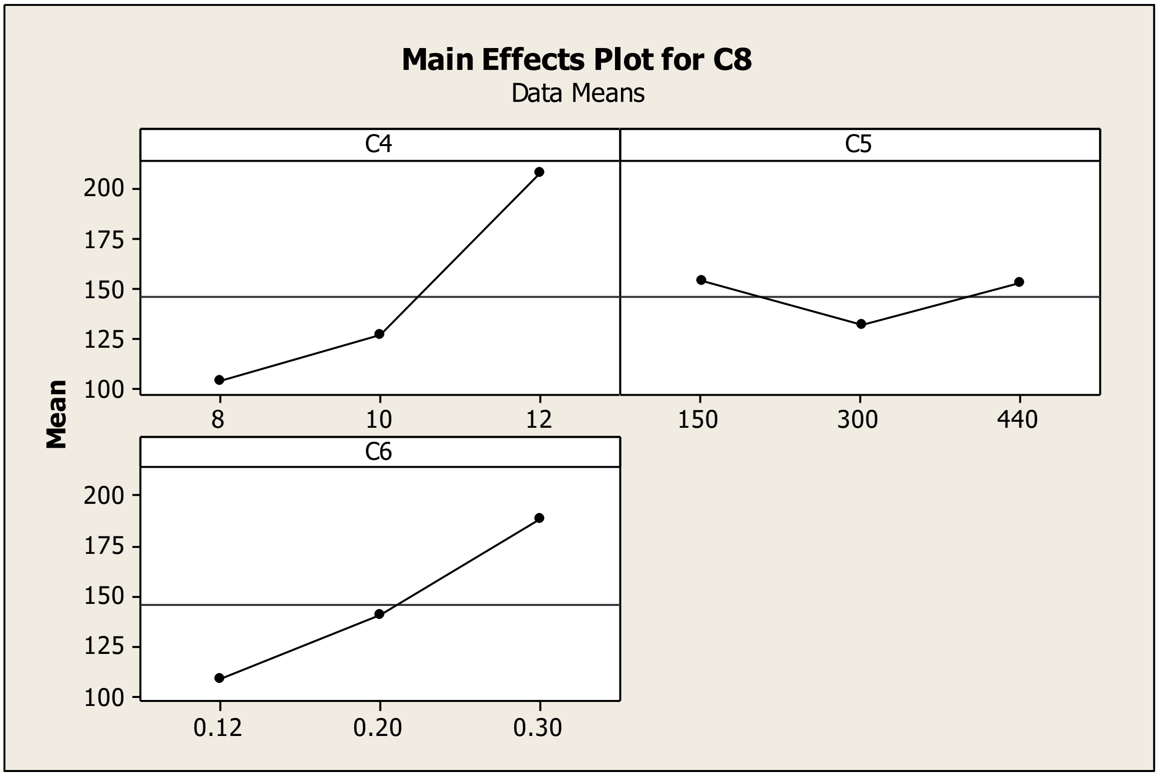

Figure 17: Main Effects Plot for Thrust

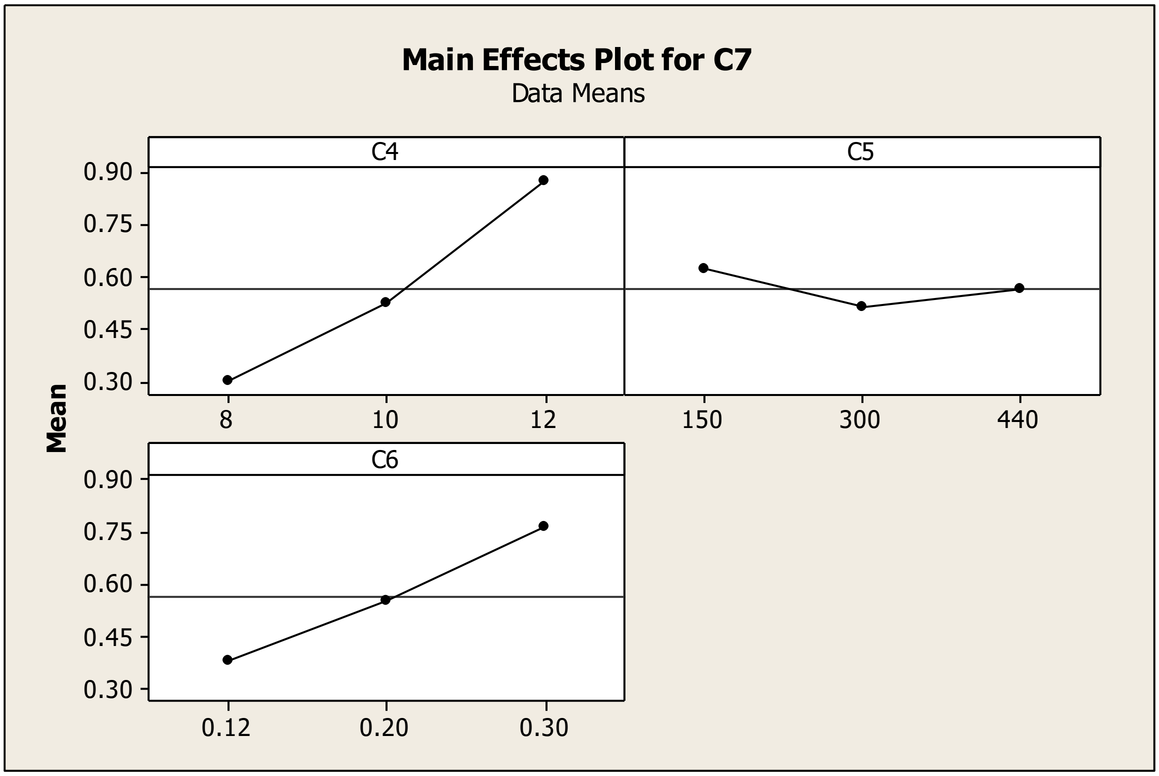

Figure 18: Main Effects plot for Torque

From the graph shown in figure 17 the thrust increases with increases in drill diameter and feed but it decreases with increases in speed of rotation of drill.

Figure 18 indicates that the value of torque increases as the value of drill diameter increases and the relation is linear. The torque decreases as the value of speed of rotation of drill increases. While the torque and feed are nearly directly proportion to each other.

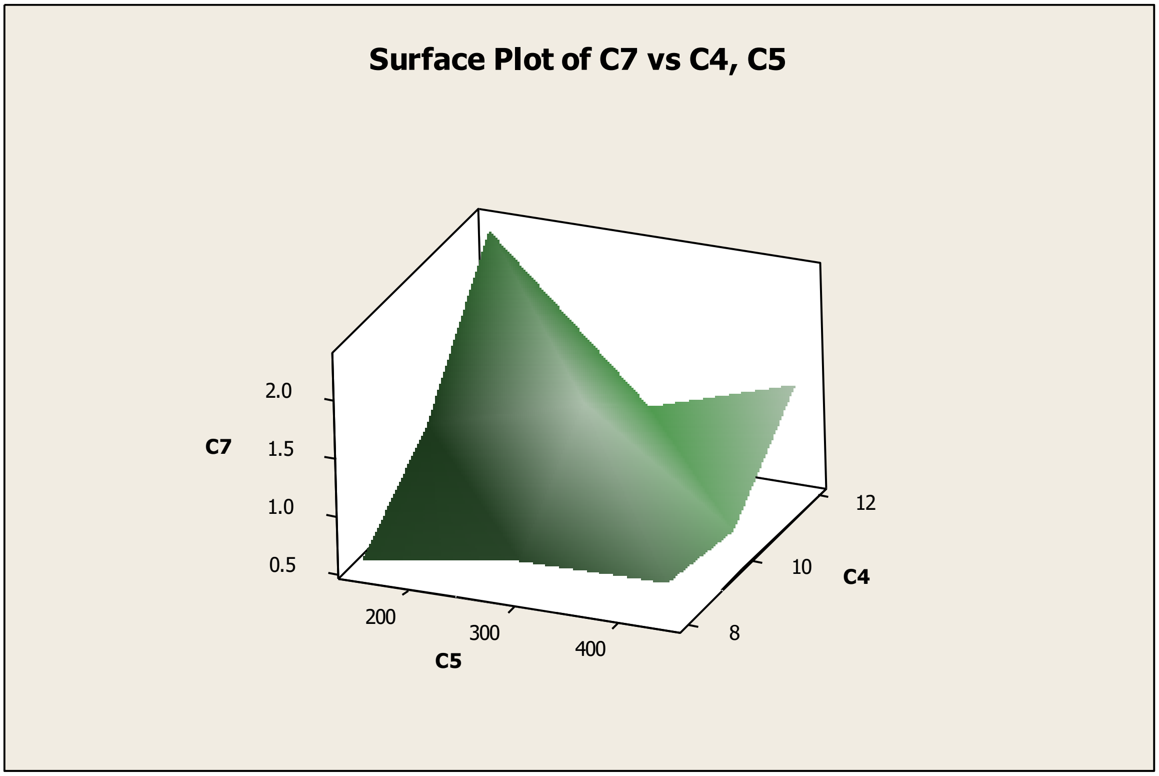

Figure 19: Torque VS Drill diameter and speed of Drill

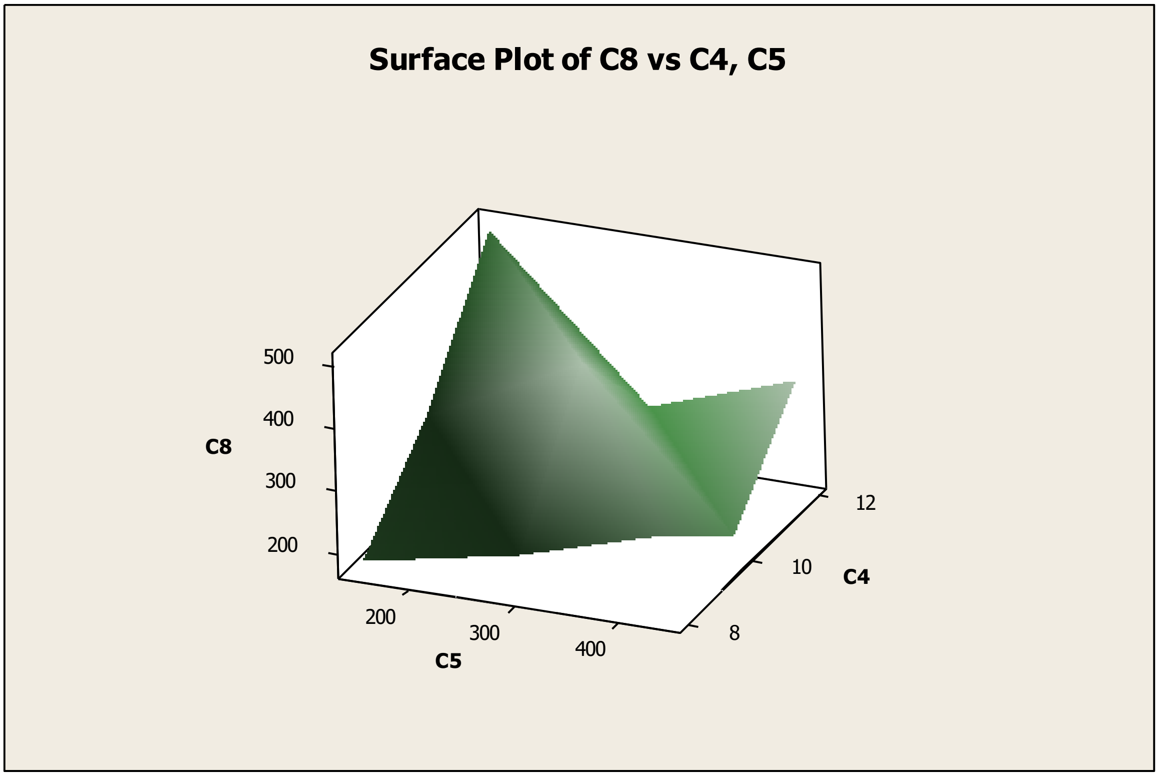

Figure 20: Thrust vs Drill diameter and speed of Drill

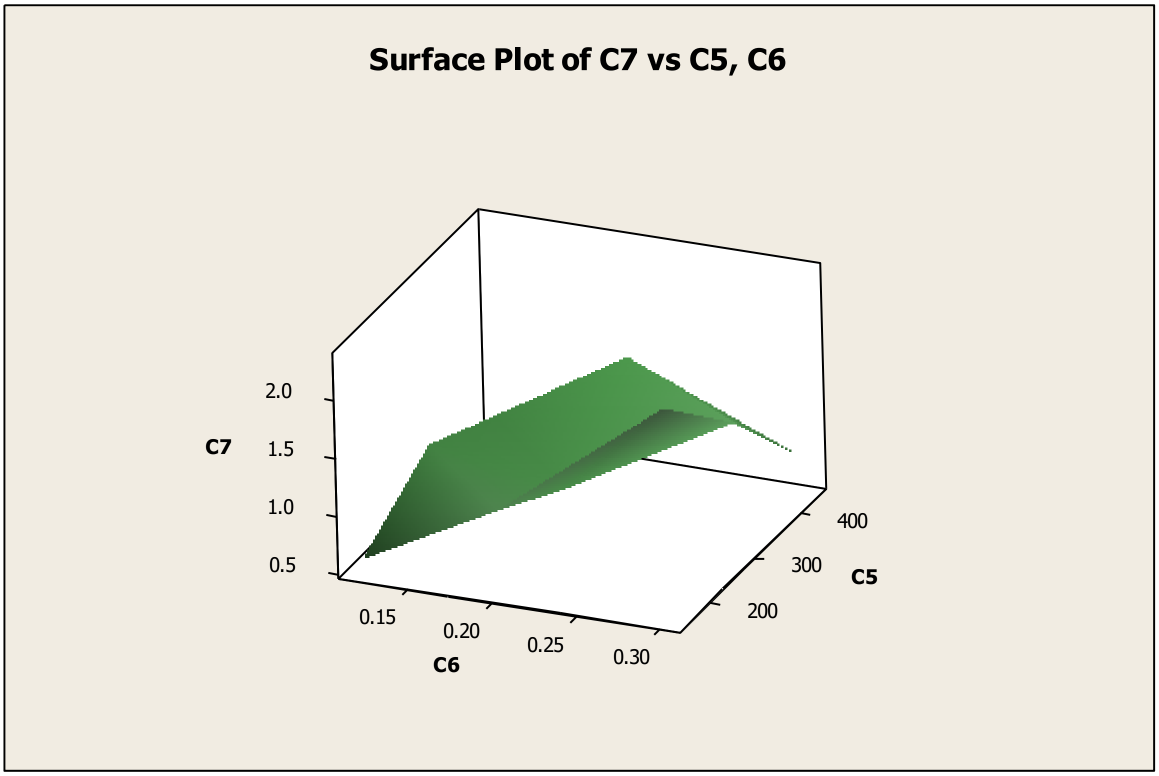

Figure 21: Torque VS feed and speed of Drill

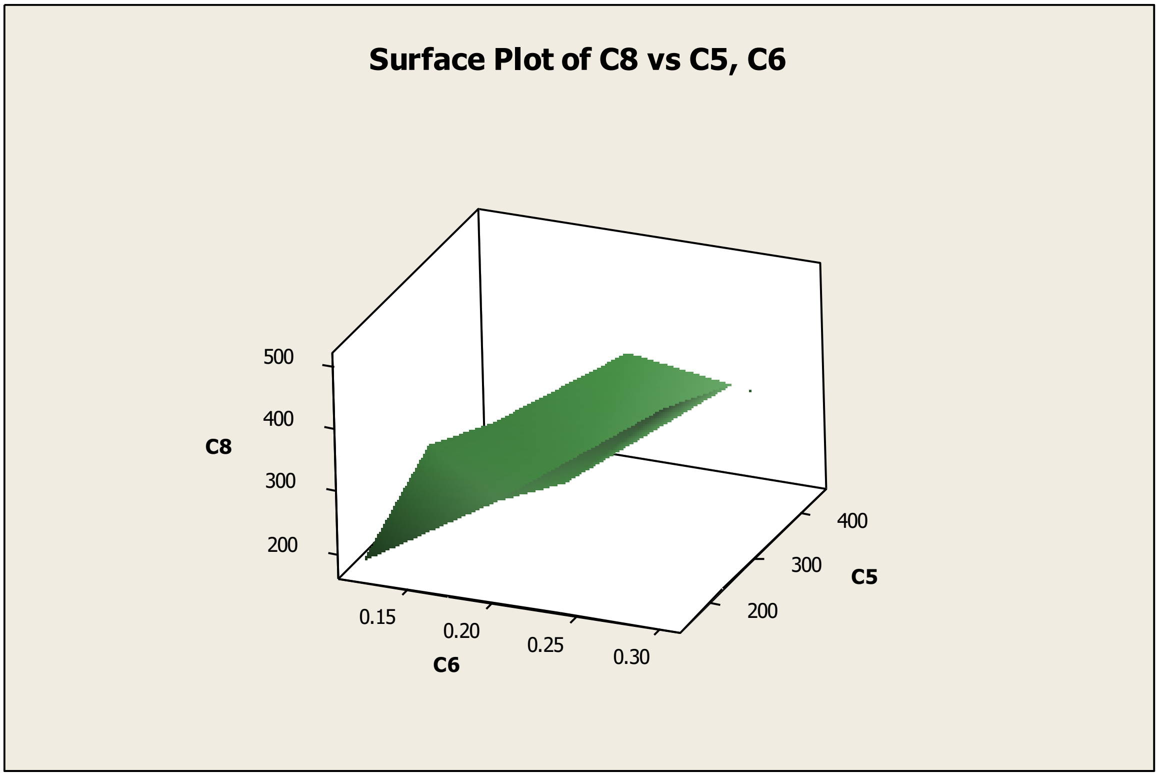

Figure 22: Thrust VS feed and speed of Drill

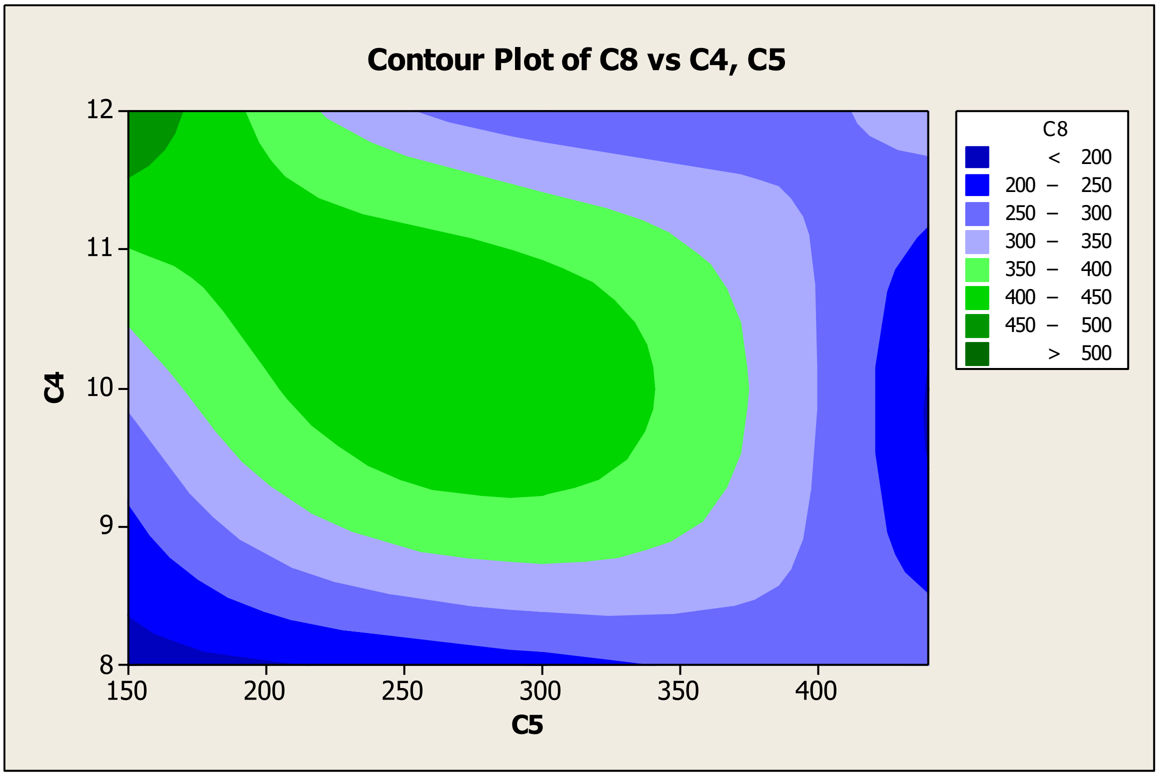

Figure 23: Contour Plot of Thrust vs Drill dia and Speed of Drill

A contour plot is a graphical technique for representing a 3-dimensional surface by plotting constant z slices called contours on a 2-dimensional format.

Figure 23 clearly indicates that

1-for low value of thrust speed should be high and and drill should be low.

2-for low speed and high drill diameter the value of thrust is high.

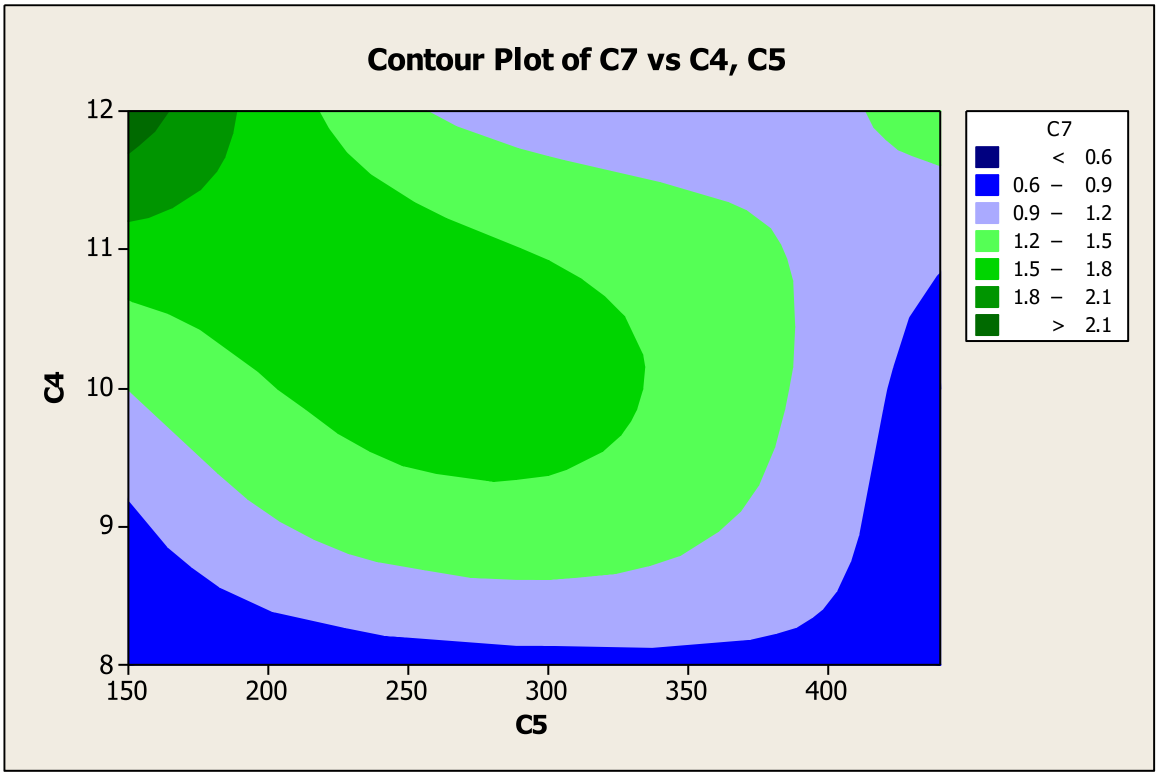

Figure 24: Contour Plot of Torque vs Drill dia and Speed of Drill

Figure 24 indicates that

1-for low value of torque speed should be high and and drill should be low.

2-for low speed and high drill diameter the value of thrust is high

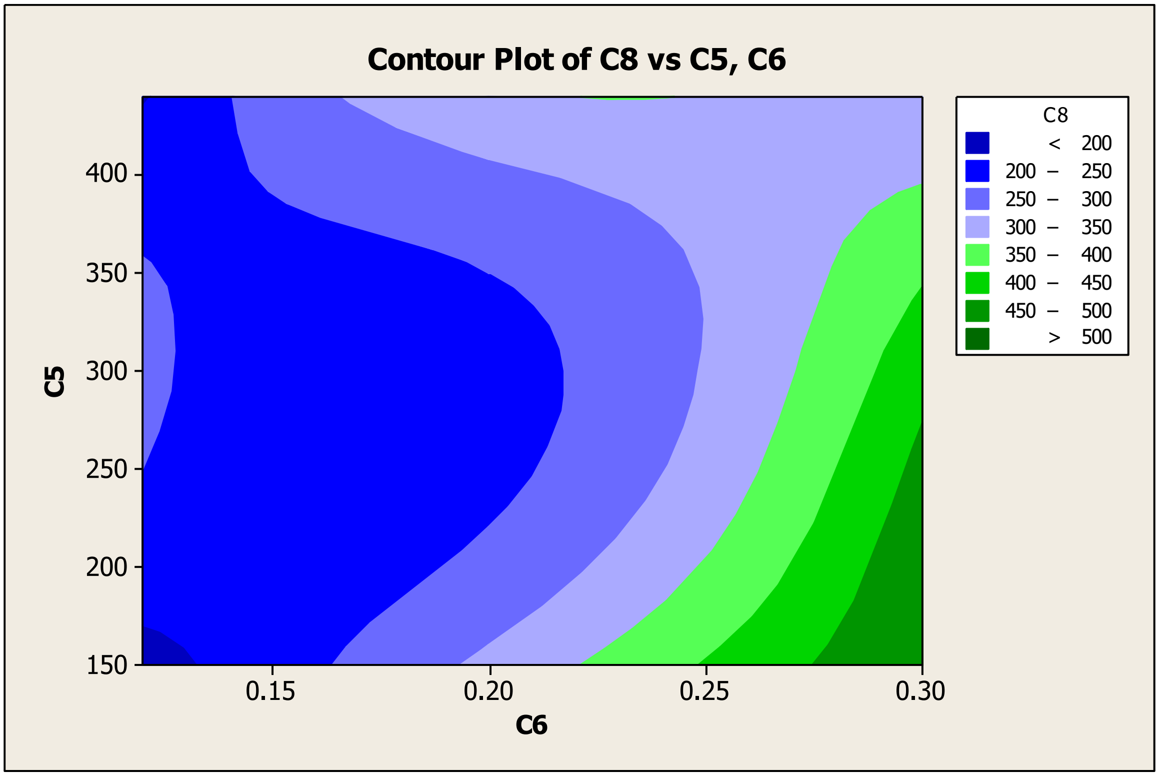

Figure 25: Contour Plot of Thrust vs feed and Speed of Drill

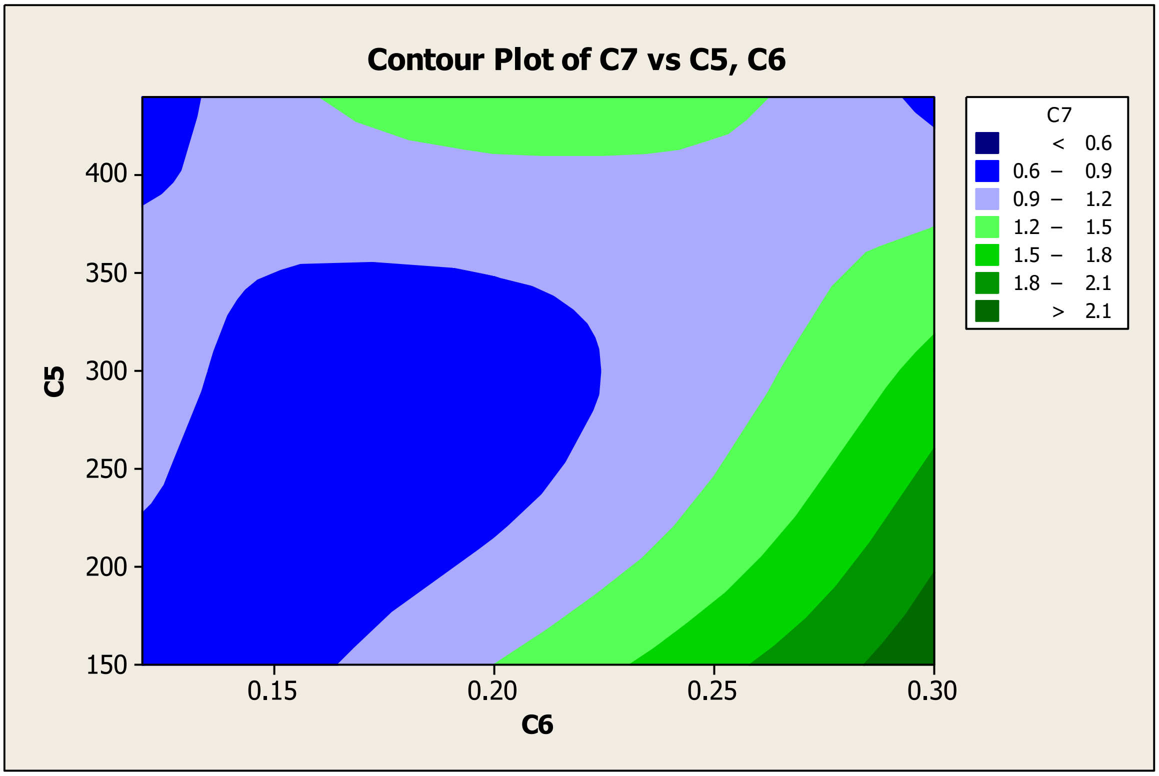

Figure 26: Contour Plot of Torque vs feed and Speed of Drill

From Figure 25 we can say that the value of thrust is between 200N to 250N for feed between 0.15mm/rev to 0.20mm/rev for all speeds and the value of thrust is higher for higher feed and lower speed of rotation of drill.

Figure 26 clearly indicates that

1-for lower torque feed should be low.

2-the value of torque is between 0.6N-M to 0.9N-M for Medium Feed And Speed.

5.2 FOR MILD STEEL

Table No.12: Experimental Details

S.NO	1	2	3	C4	C5	C6	C7	C8
1	1	1	1	8	150	0.12	0.6	180
2	1	1	1	8	150	0.12	0.6	180
3	1	1	1	8	150	0.12	0.6	180
4	1	2	2	8	300	0.2	0.8	232
5	1	2	2	8	300	0.2	0.8	232
6	1	2	2	8	300	0.2	0.8	232
7	1	3	3	8	440	0.3	0.8	300
8	1	3	3	8	440	0.3	0.8	300
9	1	3	3	8	440	0.3	0.8	300
10	2	1	2	10	150	0.2	1.2	312
11	2	1	2	10	150	0.2	1.2	312
12	2	1	2	10	150	0.2	1.2	312
13	2	2	3	10	300	0.3	1.6	433
14	2	2	3	10	300	0.3	1.6	433
15	2	2	3	10	300	0.3	1.6	433
16	2	3	1	10	440	0.12	0.7	195
17	2	3	1	10	440	0.12	0.7	195
18	2	3	1	10	440	0.12	0.7	195
19	3	1	3	12	150	0.3	2.3	500
20	3	1	3	12	150	0.3	2.3	500
21	3	1	3	12	150	0.3	2.3	500
22	3	2	1	12	300	0.12	1	260
23	3	2	1	12	300	0.12	1	260
24	3	2	1	12	300	0.12	1	260
25	3	3	2	12	440	0.2	1.4	340
26	3	3	2	12	440	0.2	1.4	340
27	3	3	2	12	440	0.2	1.4	340

Table No.13: Response Table for Signal to Noise Ratios

Level	C4	C5	C6
1	-0.7371	-0.7236	-0.7295
2	-0.7274	-0.7282	-0.7257
3	-0.7191	-0.7317	-0.7283
Delta	0.0180	0.0081	0.0037
Rank	1	2	3

Nominal is best (10*Log10 (Ybar**2/s**2))

Table No.14: Response Table for Means

Level	C4	C5	C6
1	119	166	106.2
2	157.3	154.7	147.9
3	184.1	139.6	206.3
Delta	65.1	26.4	100.1
Rank	2	3	1

Table No.15: Response Table for Standard Deviations

Level	C4	C5	C6
1	129.6	180.4	115.5
2	171	168.3	160.8
3	200	151.9	224.3
Delta	70.4	28.4	108.7
Rank	2	3	1

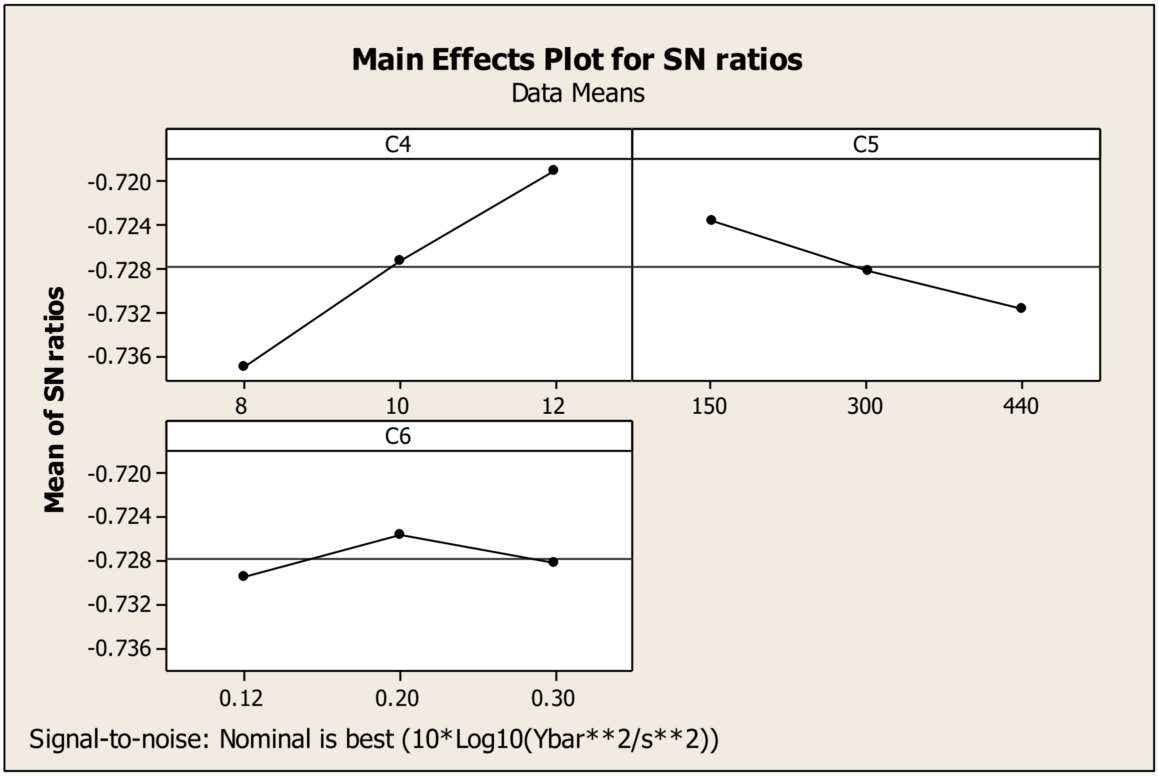

Figure 28: Main Effect Plot for S-N Ratio

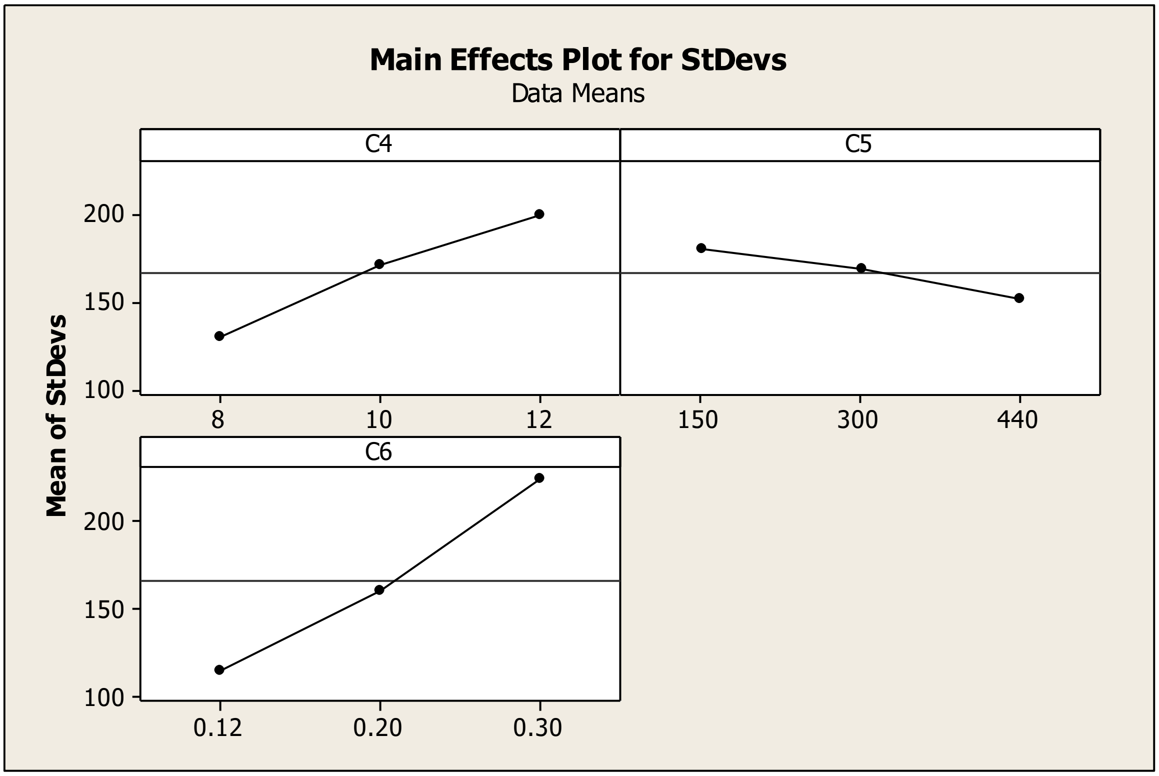

Figure 29: Main Effect Plot for StDevs

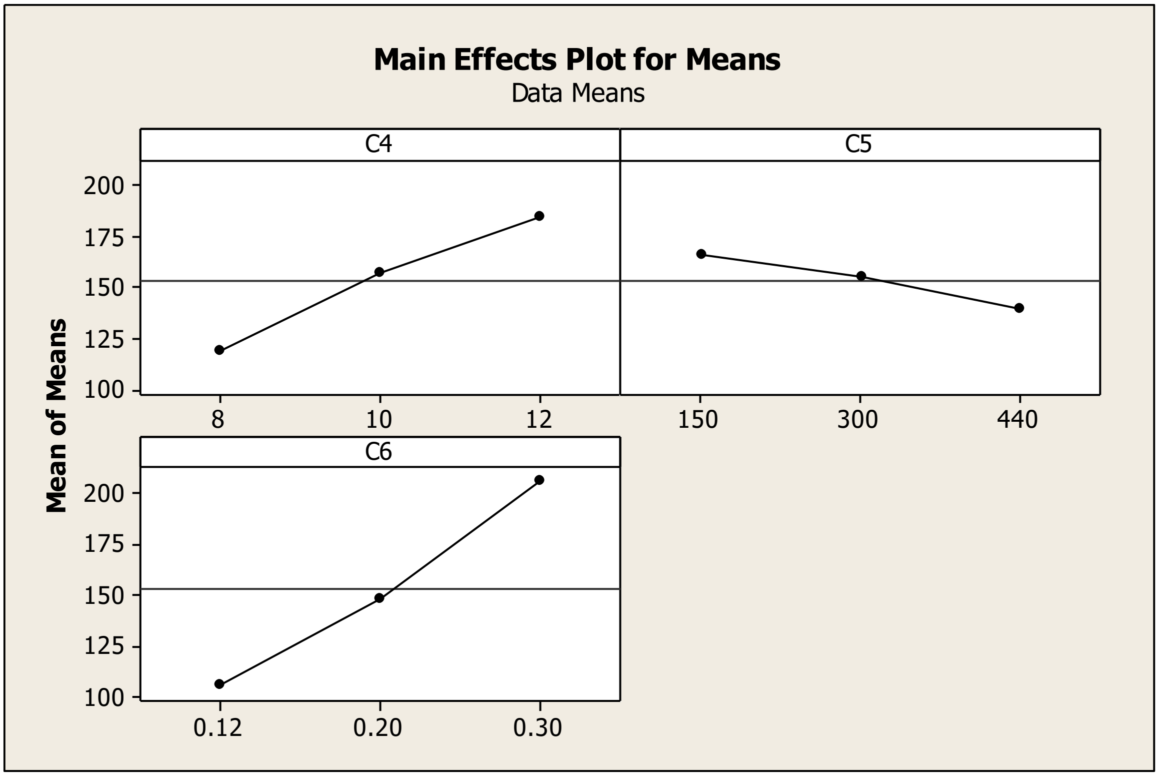

Figure 30: Main Effect Plot for Means

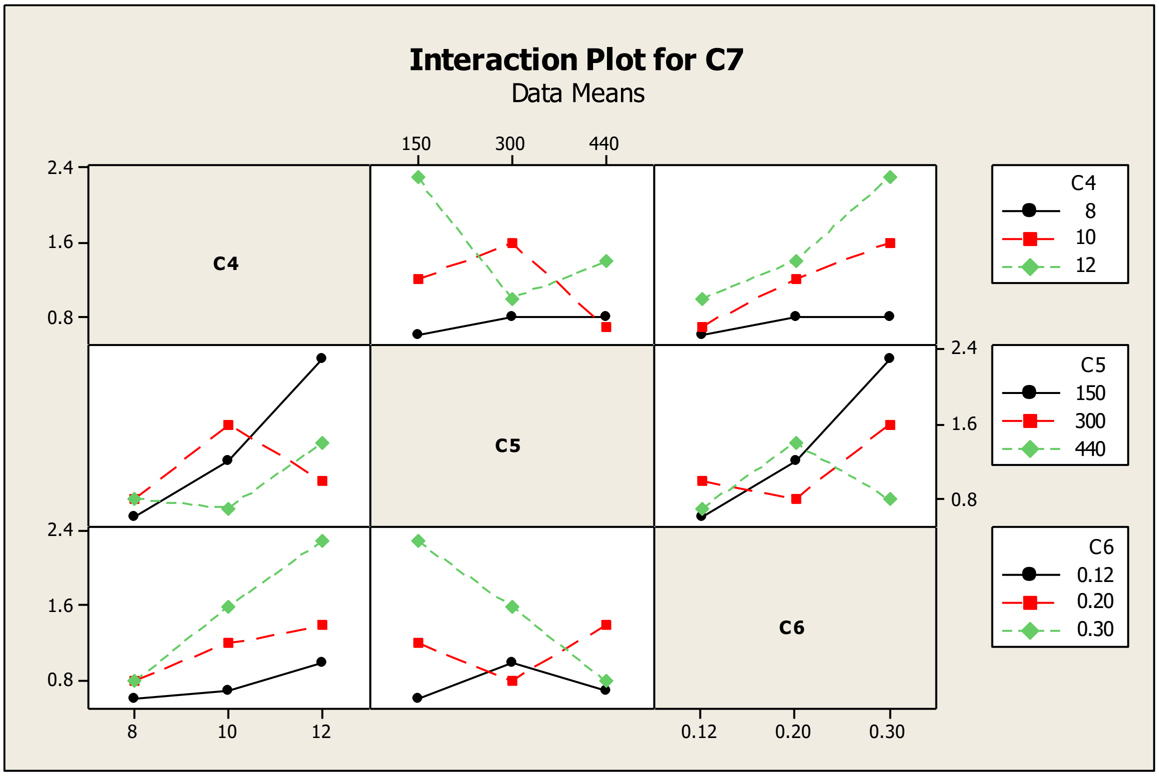

Figure 31: Interaction Plot for Torque

In first row: for minimum torque

If s=150 then d=8; if f=0.12then d=8

If s=300 then d=8; if f=0.20 then d=8

If s=440 then d=10; if f=0.32 then d=8

In second row: for minimum thrust

If d= 8 then s=150; if f=0.12 then s=150

If d=10 then s=440;if f=0.20 then s=300

If d=12 then s=300;if f=0.30 then s=440

In third row: for minimum thrust

If d=8 then f=0.12; if s=150 then f=0.12

If d=10 then f=0.12 ;if s=300 then f=0.20

If d=12 then f=0.12 ; if s=440 then f=0.12

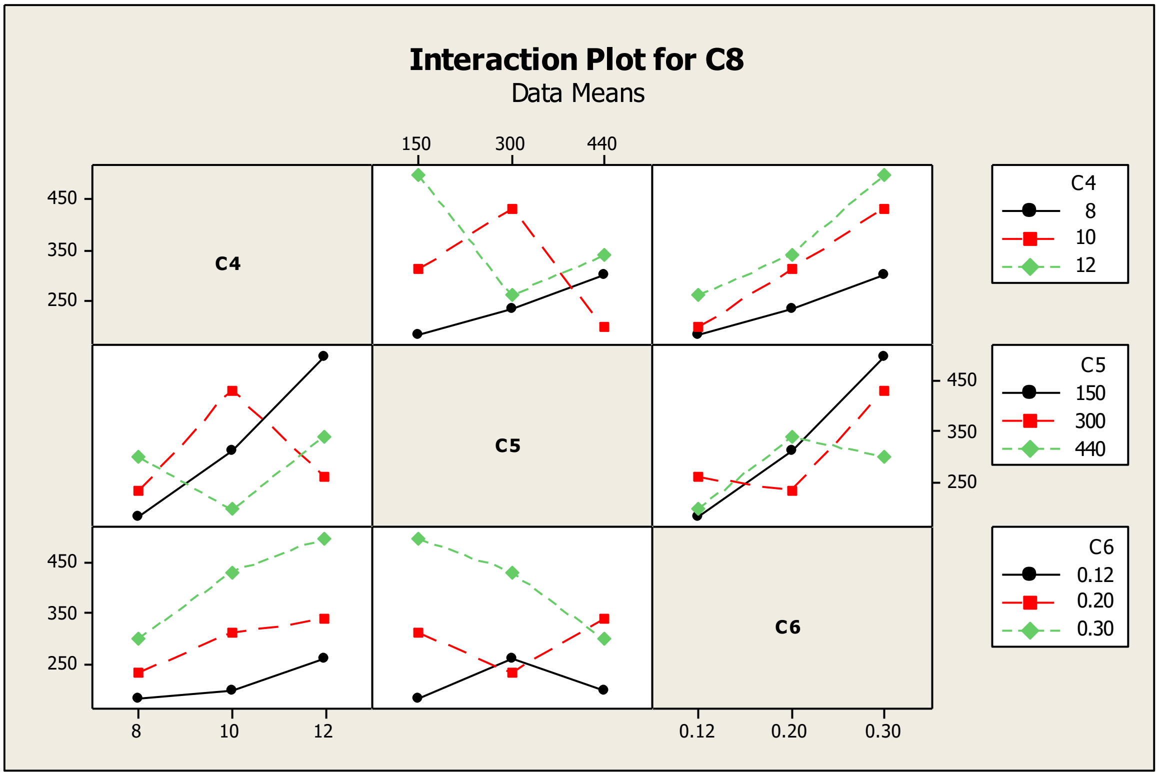

Figure 32: Interaction Plot for Thrust

In first row: for minimum thrust

If s=150 then d=8; if f=0.12then d=8

If s=300 then d=8; if f=0.20 then d=8

If s=440 then d=10; if f=0.32 then d=8

In second row: for minimum thrust

If d= 8 then s=150; if f=0.12 then s=150

If d=10 then s=440;if f=0.20 then s=300

If d=12 then s=300;if f=0.30 then s=440

In third row: for minimum thrust

If d=8 then f=0.12; if s=150 then f=0.12

If d=10 then f=0.12 ;if s=300 then f=0.20

If d=12 then f=0.12 ; if s=440 then f=0.12

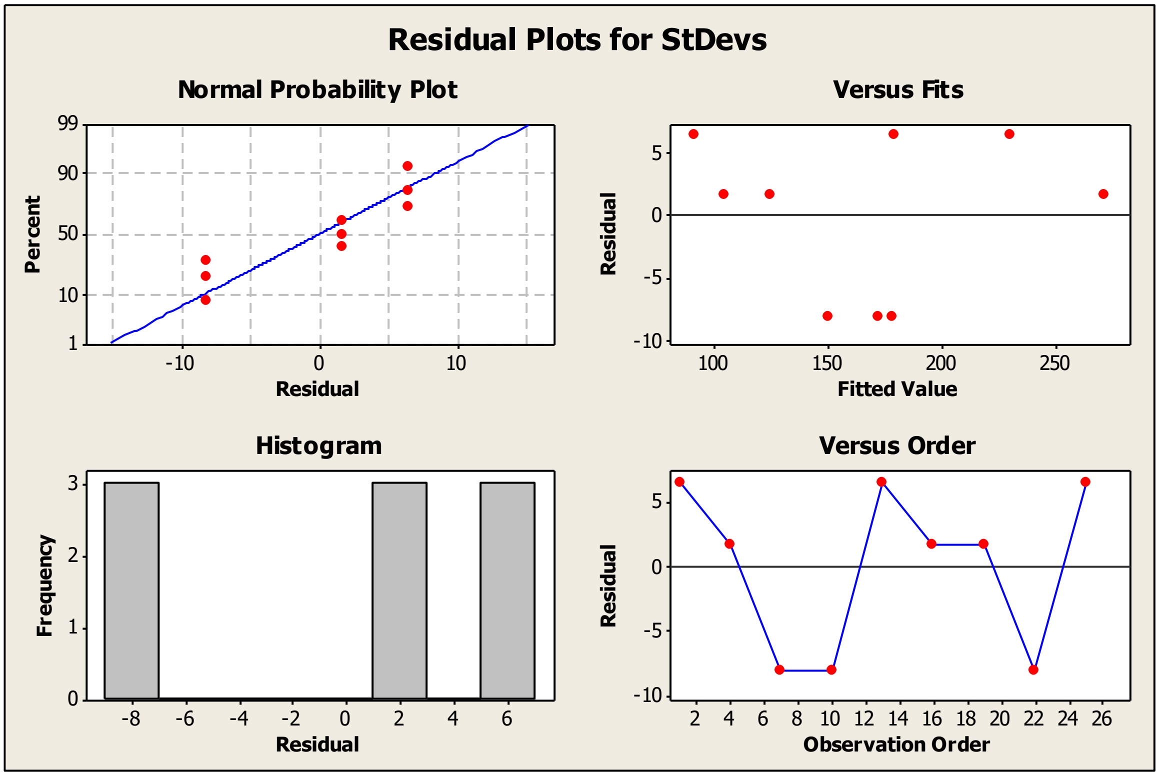

Figure 33: Residual Plot for StDevs

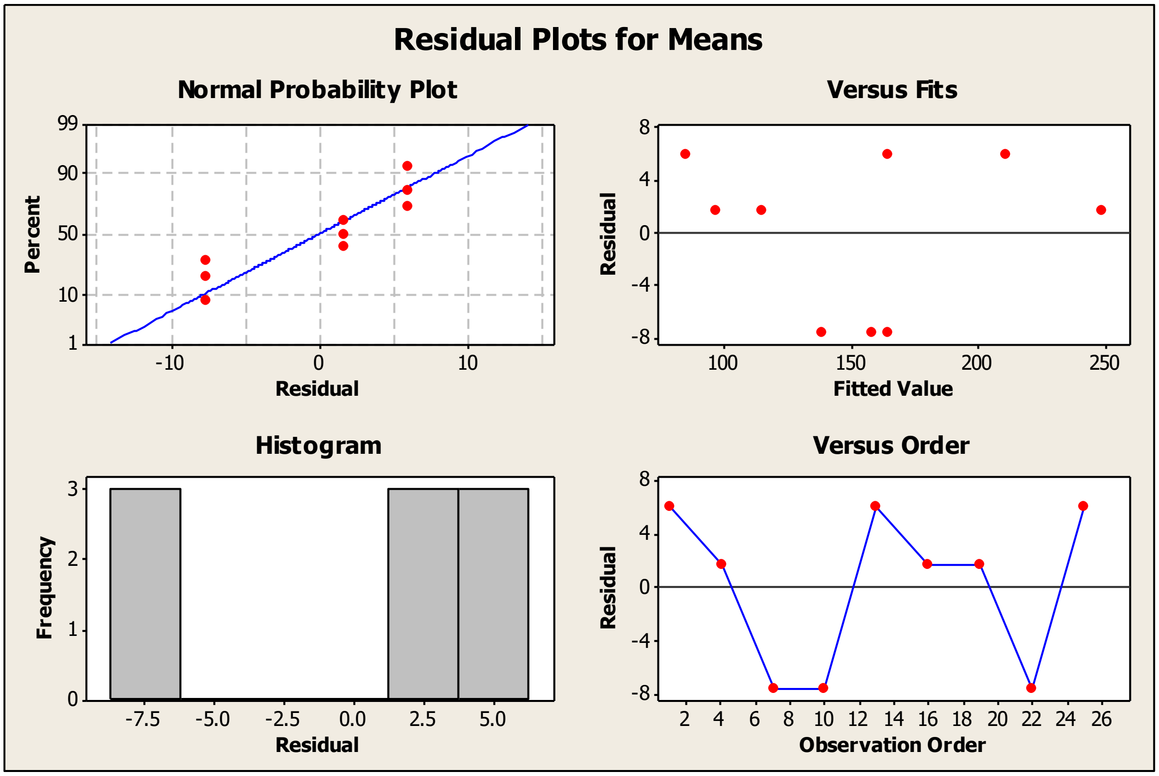

Figure 34: Residual Plot for Means

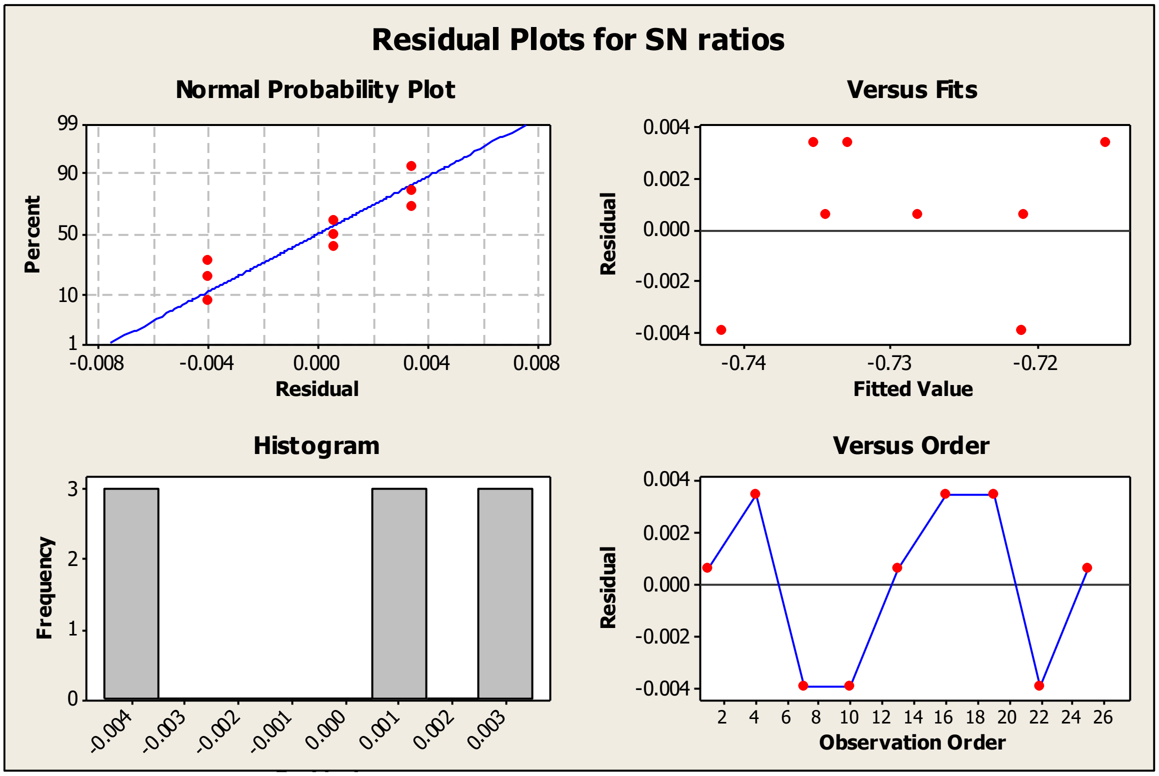

Figure 35: Residual Plot for SN ratios

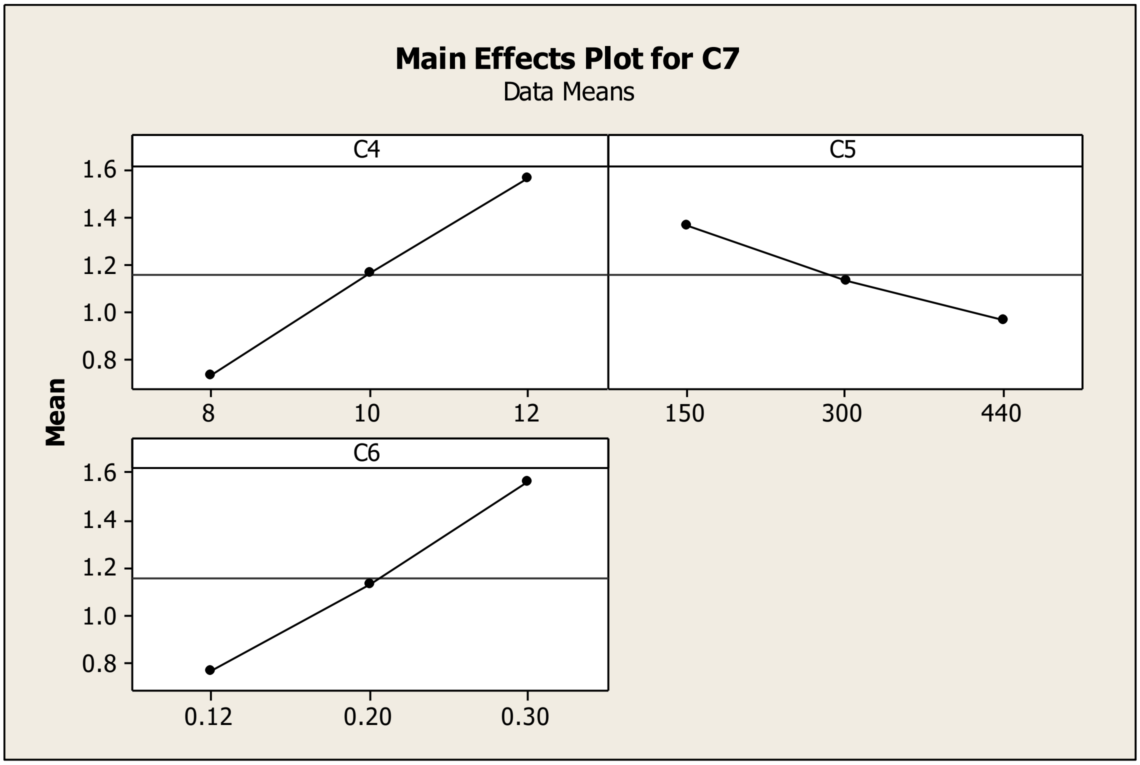

Figure 36: Main Effects Plot for Torque

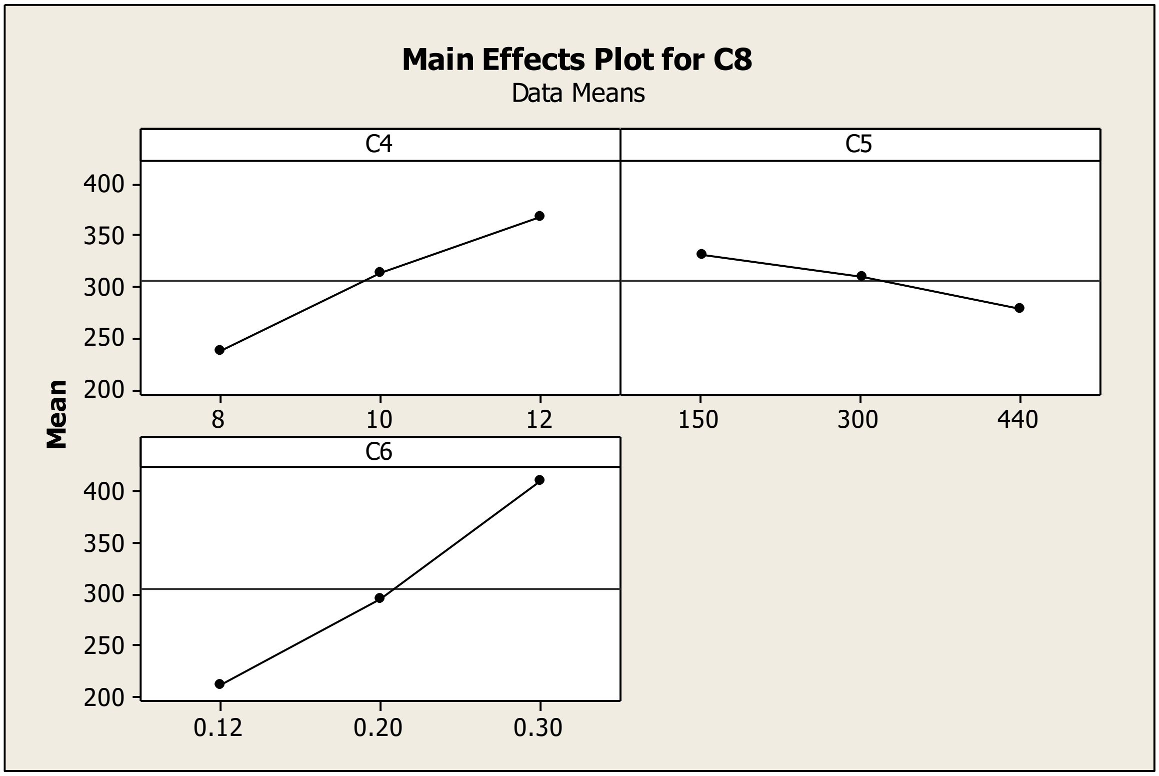

Figure 37: Main Effects Plot for Thrust

From the Figure 36 the value of torque increases as the value of drill diameter increases and the relation is linear. The torque decreases as the value of speed of rotation of drill increases. While the torque and feed are nearly directly proportion to each other.

From the Figure 37 the thrust increases with increases in drill diameter and feed but it decreases with increases in speed of rotation of drill.

CHAPTER 6 RESULTS

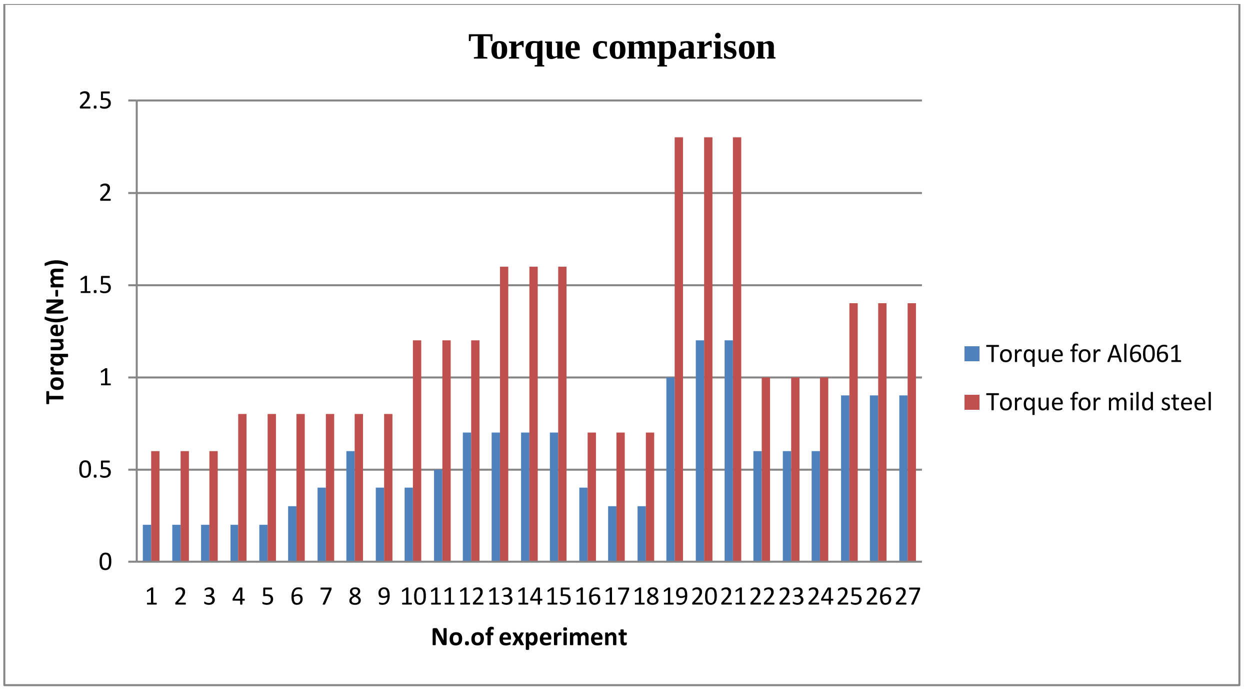

Figure 38: Torque comparison between Al-6061 and Mild steel

We can see from Figure 38 that the value of torque is different for the different set of condition but the value torque is lowest for condition when,

d=8mm
S=150rpm
f=0.12mm

For both the material. But the value of torque is more for mild steel due to having more strength of mild steel.

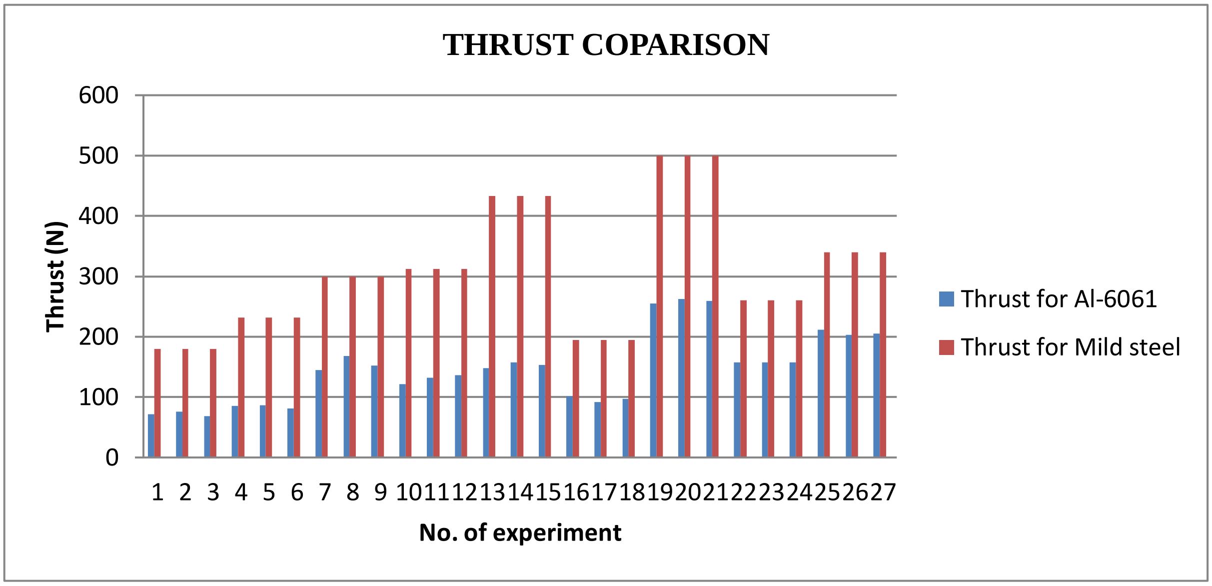

Figure 39: Thrust comparison between Al-6061 and Mild steel

We can see from Figure 39 that the value of torque is different for the different set of condition but the value torque is lowest for condition when

d=8mm

S=150rpm

f=0.12mm

For both the material. But the value of torque is more for mild steel due to having more strength of mild steel.

Chapter 5 CONCLUSION

In this project various research papers were studied and accordingly the different methods to obtain the torque and thrust were analyzed to be taken in the consideration. And it was assessed that the value of thrust and torque is depended upon the parameters of drilling and on work piece material.

Taguchi was adopted to be used as the optimization technique so that the focused parameters could be obtained in a much better and comprehensive ways.

The parameters studied were s, d, f and correspondingly the values were obtained for the thrust and torque in the drilling process.

SUMMARY

1. Drill diameter, speed of rotation, feed affect the drilling process.
2. The torque and thrust are responses of d, s, f.
3. Contour and interaction plots clearly depict the interaction of the various Parameters with respect to other parameters.
4. Taguchi provides less number of experiments and provides better results.

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