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CHAPTER 1 INTRODUCTION Drilling is a method to reduce gaps through an example 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 **2**

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. **2**

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 2

.

A suitable model can help in the focused recruitment of the most apt feed rates, spindle speeds and geometrical cutting tool shapes. 2

A detailed review of dynamic cutting models is provided in Ehmann et al. [1]. The study of drilling 2

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 10

of cylindrical nature, and

always of circular cross-section. Drill bits come in many sizes 1

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 1

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 1

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 1

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. 3

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 1

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. 1.1.1.

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 1

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. 1.1.2. 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. 1.1.3. 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. 1.1.4. Others 1

1. 1.1. 1.2. 1.3. 1.3.1. 1.3.2. 1.3.3. 1.3.4. 1.1.4.1 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 1

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. 7

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 1

a few commercial enterprises, basically PCB fabricating, which obliges numerous gaps with distances across which are under 1 mm, strong carbide bits are utilized. 1.1.4.2

Polycrystalline diamond(PCD) is one of the hardest metals of all materials and is 1

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 1

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 aluminum composites,

carbon fiber 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 1

coming about because of a response

between the carbon in the PCD and the iron in the metal Coatings. 1

1. 1.1.1. 1.1.2. 1.1.3. 1.1.4.1 1.1.4.2 1.1.4.3

Titanium nitride (TiN) is a hard artistic material that can be utilized to coat a fast steel bit **1**

(more often than not a turn bit), augmenting the

cutting life by three or more times. On the **1**

other hand,

when the bit is honed the new edge won't have the advantages of the **1**

covering. hardwoods can abbreviate theirTitanium

aluminum nitride (TiAlN) is a similar coating that can extend tool life five or more times. **1**

1.1.4.4

Titanium carbon nitride (TiCN) is another coating also superior to TiN. **1**

1.1.4.5

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. **1**

Figure 1 :

Diamond coated 2mm bits, used for drilling materials **1**

1.1.4.6

Zirconium nitride has been used as a drill bit coating for some tools under the **1**

Craftsman brand name.

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 13/4 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 CAPACITIES VALUES 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 used 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 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 First No. 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 Table No.4: PROPERTIES OF ALUMINIUM 6061 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. 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 11.3Ã—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 used in the process 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 soft wares 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 123 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:Interation 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 this 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 From the graph above the thrust increases with increases in drill diameter and feed but it decreases with increases in speed of rotation of drill. Figure 18: Main Effects plot for Torque From the graph above 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 Figure 24: Contour Plot of

Torque vs Drill dia and Speed of Drill Figure 25: Contour Plot of Thrust vs feed and Speed of Drill Figure 26: Contour Plot of Torque vs feed and Speed of Drill 5.2 FOR MILD STEEL Table No.12: Experimental Details S.NO 1 2 3

C4 C5 C6 C7 C8 1 1 1 1 **4**

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 **6**

-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)) **5**

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 From the graph above 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 37: Main Effects Plot for Thrust From the graph above 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 above graph 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 above graph 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.