

Process Parameter Optimization on H11 Steel in CNC Drilling Process through Coated and Uncoated Drill Bits

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ABSTRACT: The aim of this project is to predict the exact roundness of internal bore in H11 material after machining process. The purpose of this project to study factors, which were affecting to roundness and hardness of stainless steel turning. Experimental design was conducted as three factors and three levels. Furthermore, the experiment has to be done by turning with non-cooling. Geometrical effect likes that roundness error has to be analyzed through CMM. The Taguchi method has to be employed to identify the level of importance of the machining parameters.

I. INTRODUCTION

Drilling is one of the basic machining process of making holes and it is essentially for manufacturing industry like automobile industry, medical industry, and aerospace industry. Especially drilling is necessary in industries for assembly related to mechanical fasteners. It is reported that around 55,000 holes are drilled as a complete single unit production of the AIR BUS A350 aircraft (3) Drilling of metals is increasing requirements for producing small products and more highly functional. With increasing demand for precise component production, the important of drilling processes is increasing rapidly. Because of the requirement of deeper and smaller holes required in the above said industries. It is required for drilling process technologies to achieve higher accuracy and higher productivity. There are several convectional and non-conventional manufacturing process by which drilling can be possible Drilling using laser beam, electron's beam and electric discharge methods and also electrolytic polishing, electro chemical machining has been frequently used by industries and for experimental researches. However, for general application, conventional drilling process is preferred due to the higher economical benefits than other processes and also it has highly productivity than other non -convectional drilling processes. Physical vapour deposition (PVD) describes a variety of vacuum deposition methods used to deposit thin films by the condensation of a vaporized form of the desired film material onto various work piece surfaces (e.g., onto semiconductor wafers). The coating method involves purely physical processes such as high-temperature vacuum evaporation with subsequent condensation, or plasma sputter bombardment rather than involving a chemical reaction at the surface to be coated as in chemical vapour deposition. H11 steel is an important material with desirable properties, including high resisting in nature against wear and can be used for components which are subjected to severe abrasion, wear, high surface loading. Hence, H11 promises fruitful development for applications in the automobile sector due to its high strength. Turning is the most widely used process among all the machining processes. The increasing importance of turning operations is gaining new dimensions in the present industrial age, in which the growing competition calls for all the efforts to be directed towards the manufacture of machined parts economically and surface finish is one of the most critical quality measures in mechanical products. As the competition grows closer, the customer now has increasingly high demands on quality, making surface finish and tool wear which manufacturing industry. In a machining operation, selection of machining parameters is the most critical job (Nikolaos & Manolakos 2010). It requires a number of experiments and considerable knowledge to get optimum machining parameters for a particular machining operation. Recently, rapid developments in the manufacturing industry have increased the machining processes. CNC turning is one of the most popular and efficient machining operations, with which, the high surface finish of work piece can be easily obtained. CNC turning is especially preferred in the machining of hardened steel (Diniz & Micaroni 2002).

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II. LITERATURE REVIEW

The behavior of a material is greatly dependent upon its surface, the environment and its operating conditions. Surface engineering can be defined as the branch of science that deals with methods for achieving desired surface requirements and behavior in service for engineering components. The surface of any component may be selected on the basis of texture and color, but engineering components generally demand a lot more than this. Engineering components must perform certain functions completely and effectively under various conditions, possibly in aggressive environments. Modern process environments, which contribute to wear, can be very complex, involving a combination of chemical and physical degradation. Surface properties of the component used in a particular working environment have to be designed with that environment in mind. **P.VENKATARAMAIAH** [1] et al has Investigated on the controllable parameters (cutting speeds, feed rates, type of drill tool, cutting fluids) of drilling operations with influence the response of (torque, cutting force, surface roughness, material removal rate, power) in En8. Drilling is undertaken HSS tool only, by using taguchi method. It consist of two phases artificial neural network (ANN) continued to that ANN is analyzed with S/N ratio of Taguchi approach. This work is useful in predicting the multi responses while cutting different materials in different drilling parameters. **A.NAVANTH, T. KARTHIKEYA SHARMA** [2] A study of taguchi method based optimization of drilling parameter in dry drilling of al 2014 alloy at low speeds; International Journal of Engineering Sciences & Emerging Technologies, August 2013. International Journal of Engineering and Advanced Technology (IJEAT) ISSN: 2249 – 8958, Volume-2, Issue-1, October 2012 **M. MONTOYA** [3] et al this paper aims to establish the wear mechanisms of coated and uncoated tungsten carbide drills when drilling carbon fiber reinforced plastics (CFRP)/aluminum alloy (Al) stacks. During the drilling experiments, thrust forces were measured. For both coated and uncoated drills, abrasion was the dominant tool wear mechanism, affecting the entire cutting edges higher wear was observed on uncoated tools which caused a significant increase in thrust force during drilling both Al and CFRP materials. **YOGENDRATYAGI** [4] et al In this paper the drilling of mild steel with CNC drilling machine by using a tool high speed steel by applying Taguchi methodology. A L9 array, taguchi method and analysis of variance (ANOVA) are used to formulate the procedure tried on the change of parameter. Design offers a systematic method for optimization surface finish as well as high material removal rate (MRR). **TURGAYKIVAK** [5] et al this paper focuses on the optimization of drilling parameters using the Taguchi technique to obtain minimum surface roughness (Ra) and thrust force (Ff). A number of drilling experiments were conducted using the L16 orthogonal array on a CNC vertical machining centre. The experiments were performed on AISI 316 stainless steel blocks using uncoated and coated M35 HSS twist drills under dry cutting conditions. It was found that the cutting tool was the most significant factor on the surface roughness and that the feed rate was the most significant factor on the thrust force. **A.I. FERNÁNDEZ-ABIA** [6] et al analyzed the market of turning tools is coped majority by hard metal tools with CVD coating. However, availability of tools with sharp cutting edges is essential in light turning of small parts. In this context, PVD process is optimum for obtaining sharp edges. Therefore, a methodology is presented to evaluate the performance of PVD advanced tools for turning of difficult to machine materials. Four coatings were tested: AlTiSiN (nACo®), AlCrSiN (nACRo®), AlTiN and TiAlCrN. The analysis was developed carrying out wear tests and analyzing different signals such as cutting forces, EDX analysis of inserts, part roughness and insert image analysis. Results indicate that the best coatings for turning of difficult to machine materials as austenitic stainless steel sarenACo® and AlTiN coatings, since they offer the best performance.

PROBLEM IDENTIFICATION

The determination of optimal cutting condition for specified surface roughness and accuracy of product are the key factors in the selection of machining process. In drilling operations, and especially boring operations, are associated with serious vibration-related problems. To reduce the problem of vibration and ensure that the desired shape and tolerance are achieved, extra care must be taken with production planning and in the preparations for the machining of a work-piece.

Through this investigation of the vibrations involved is therefore an important step toward solving the problem. Researches have been done to improve cutting tool material, tool geometry and cutting parameter to optimize the machining process. The diameter and length of boring bar are the most important factor has to be considering in boring operation, following the other cutting parameter such as spindle speed, feed rate and peck increment.

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III. METHODOLOGY

1 OVER VIEW OF CMM

The typical 3 "bridge" CMM is composed of three axes, an X, Y and Z. These axes are orthogonal to each other in a typical three-dimensional coordinate system. Each axis has a scale system that indicates the location of that axis. The machine will read the input from the touch probe, as directed by the operator or programmer. The machine then uses the X, Y, Z coordinates of each of these points to determine size and position with micrometer precision. A coordinate measuring machine (CMM) is also a device used in manufacturing and assembly processes to test a part or assembly against the design intent. By precisely recording the X, Y, and Z coordinates of the target, points are generated which can then be analyzed via regression algorithms for the construction of features. These points are collected by using a probe that is positioned manually by an operator or automatically via Direct Computer Control (DCC). DCC CMMs can be programmed to repeatedly measure identical parts, thus a CMM is a specialized form of industrial robot.

Technical facts Parts

Coordinate-measuring machines include three main components:

- The main structure which includes three axes of motion. The material used to construct the moving frame has varied over the years. Granite and steel was used in the early CMM's. Today all the major CMM manufacturers build frames from aluminium alloy or some derivative and also use ceramic to increase the stiffness of the Z axis for scanning applications. Few CMM builders today still manufacture granite frame CMM due to market requirement for improved metrology dynamics and increasing trend to install CMM outside of the quality lab. Typically only low volume CMM builders and domestic manufacturer in China and India are still manufacturing granite CMM due to low technology approach and easy entry to become a CMM frame builder. The increasing trend towards scanning also requires the CMM Z axis to be stiffer and new materials have been introduced such as ceramic and silicon carbide.
- Probing system
- Data collection and reduction system - typically includes a machine controller, desktop computer and application software.

Availability

These machines can be free-standing, handheld and portable.

Specific parts Machine body

The first CMM was developed by the Ferranti Company of Scotland in the 1950's as the result of a direct need to measure precision components in their military products, although this machine only had 2 axes. The first 3-axis models began appearing in the 1960s (DEA of Italy) and computer control debuted in the early 1970s (Sheffield of the USA). Leitz Germany subsequently produced a fixed machine structure with moving table

In modern machines, the gantry type superstructure has two legs and is often called a bridge. This moves freely along the granite table with one leg (often referred to as the inside leg) following a guide rail attached to one side of the granite table. The opposite leg (often outside leg) simply rests on the granite table following the vertical surface contour. Air bearings are the chosen method for ensuring friction free travel. In these, compressed air is forced through a series of very small holes in a flat bearing surface to provide a smooth but controlled air cushion on which the CMM can move in a frictionless manner. The movement of the bridge or gantry along the granite table forms one axis of the XY plane. The bridge of the gantry contains a carriage which traverses between the inside and outside legs and forms the other X or Y horizontal axis. The third axis of movement (Z axis) is provided by the addition of a vertical quill or spindle which moves up and down through the center of the carriage. The touch probe forms the sensing device on the end of the quill. The movement of the X, Y and Z axes fully describes the measuring envelope. Optional rotary tables can be used to enhance the approachability of the measuring probe to complicated workpieces. The rotary table as a fourth drive axis does not enhance the measuring dimensions, which remain 3D, but it does provide a degree of flexibility. Some touch probes are themselves powered rotary devices with the probe tip able to swivel vertically through 90 degrees and through a full 360 degree rotation.

As well as the traditional three axis machines (as pictured above), CMMs are now also available in a variety of other forms. These include CMM arms that use angular measurements taken at the joints of the arm to calculate the position of the stylus tip. Such arm CMMs are often used where their portability is an advantage over traditional fixed

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bed CMMs. Because CMM arms imitate the flexibility of a human arm they are also often able to reach the insides of complex parts that could not be probed using a standard three axis machine.

Mechanical probe

In the early days of coordinate measurement mechanical probes were fitted into a special holder on the end of the quill. A very common probe was made by soldering a hard ball to the end of a shaft. This was ideal for measuring a whole range of flat, cylindrical or spherical surfaces. Other probes were ground to specific shapes, for example a quadrant, to enable measurement of special features. These probes were physically held against the work piece with the position in space being read from a 3-Axis digital readout (DRO) or, in more advanced systems, being logged into a computer by means of a footswitch or similar device. Measurements taken by this contact method were often unreliable as machines were moved by hand and each machine operator applied different amounts of pressure on the probe or adopted differing techniques for the measurement. A further development was the addition of motors for driving each axis. Operators no longer had to physically touch the machine but could drive each axis using a hand box with joysticks in much the same way as with modern remote controlled cars. Measurement accuracy and precision improved dramatically with the invention of the electronic touch trigger probe. The pioneer of this new probe device was David McMurtry who subsequently formed what is now Renishaw plc. Although still a contact device, the probe had a spring-loaded steel ball (later ruby ball) stylus. As the probe touched the surface of the component the stylus deflected and simultaneously sent the X,Y,Z coordinate information to the computer. Measurement errors caused by individual operators became fewer and the stage was set for the introduction of CNC operations and the coming of age of CMMs.

Motorized automated probe head with electronic touch trigger probe

Optical probes are lens-CCD-systems, which are moved like the mechanical ones, and are aimed at the point of interest, instead of touching the material. The captured image of the surface will be enclosed in the borders of a measuring window, until the residue is adequate to contrast between black and white zones. The dividing curve can be calculated to a point, which is the wanted measuring point in space. The horizontal information on the CCD is 2D (XY) and the vertical position is the position of the complete probing system on the stand Z-drive (or other device component). This allows entire 3D-probing, now all using the tactile sensor system

Basically, experimental design methods were developed original fisher. However experimental design methods are too complex and not easy to use. Furthermore, a large number of experiments have to be carried out when the number of the process parameters increases, to solve this problem, the Taguchi method uses a special design of orthogonal arrays to study the entire parameter space with a small number of experiments only. The experimental results are then transformed into a signal- to - noise (S/N) ratio to measure the quality characteristics deviating from the desired values. Usually, there are three categories of quality characteristics in the analysis of the S/N ratio, i.e., the-lower-better, the-higher-better, and the-nominal-better. The S/N ratio for each level of process parameter is compared based on the S/N analysis. Regardless of the category of the quality characteristic, a greater S/N ratio corresponds to better quality characteristics. Therefore, the optimal level of the process parameters is the level with the greatest S/N ratio. Furthermore, a statistically significant with the S/N and ANOVA analyses, the optimal combination of the process parameters can be predicted. Finally, a confirmation experiment is conducted to verify the optimal process parameters obtained from the parameter design. There are 3 Signal-to-Noise ratios of common interest for optimization of Static Problems. The formulæ for signal to noise ratio are designed so that an experimenter can always select the largest factor level setting to optimize the quality characteristic of an experiment. Therefore a method of calculating the Signal-To-Noise ratio we had gone for quality characteristic. They are

1. Smaller-The-Better,
2. Larger-The-Better,
3. Nominal is Best

SMALLER IS BETTER

The signal-to-noise (S/N) ratio is calculated for each factor level combination. The formula for the smaller-is-better S/N ratio using base 10 log is:

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$$S/N = -10 \cdot \log(\sum(Y^2)/n)$$

Where Y = responses for the given factor level combination and n = number of responses in the factor level combination.

LARGER IS BETTER

The signal-to-noise (S/N) ratio is calculated for each factor level combination. The formula for the larger-is-better S/N ratio using base 10 log is:

$$S/N = -10 \cdot \log(\sum(1/Y^2)/n)$$

Where Y = responses for the given factor level combination and n = number of responses in the factor level combination.

NOMINAL IS BEST

The signal-to-noise (S/N) ratio is calculated for each factor level combination. The formula for the nominal-is-best S/N ratio using base 10 log is:

$$S/N = -10 \cdot \log(y^2/s^2)$$

Where s = standard deviation of the responses for all noise factors for the given factor level combination.

IV. RESULT AND DISCUSSION

Process parameters and their levels

Table 5.1 Process parameters and their levels

Levels	Process parameters		
	Spindle Speed (N) (rpm)	Feed (f) (mm/rev)	Peck increment(mm)
1	700	0.03	0.5
2	800	0.06	1.0
3	900	0.09	1.5

TYPES OF COATED DRILL BIT-PVD Coated TiAl N

7AN ORTHOGONAL ARRAY L9 FORMATION (INTERACTION)

An orthogonal array L9 formation (interaction)

Table 5.2 An orthogonal array L9 formation (interaction)

TRIAL NO.	DESIGNATION	(A)SPEED (N) (rpm)	(B)FEED (f) (mm/rev)	C-Peck increment(mm)
1	A ₁ B ₁ C ₁	700	0.03	0.5
2	A ₁ B ₁ C ₂	700	0.06	1.0
3	A ₁ B ₁ C ₃	700	0.09	1.5
4	A ₁ B ₂ C ₁	800	0.03	1.0
5	A ₁ B ₂ C ₂	800	0.06	1.5
6	A ₁ B ₂ C ₃	800	0.09	0.5
7	A ₁ B ₃ C ₁	900	0.03	1.5
8	A ₁ B ₃ C ₂	900	0.06	0.5
9	A ₁ B ₃ C ₃	900	0.09	1.0

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EXPERIMENTAL DATA FOR H11STEEL [TiAlN-Drill Bit]

Table 5.3 Experimental data for H11 STEEL

S NO	DESIGNATION	(A)SPEED (N) (rpm)	(B)FEED (f) (mm/rev)	C-Peek increment(m m)	SURFACE ROUGHNESS	HARDNESS HRB	ROUNDNESS ERROR
1	A ₁ B ₁ C ₁	700	0.03	0.5	1.280	114	0.007
2	A ₁ B ₁ C ₂	700	0.06	1.0	0.980	126	0.006
3	A ₁ B ₁ C ₃	700	0.09	1.5	1.016	121	0.003
4	A ₁ B ₂ C ₁	800	0.03	1.0	0.807	125	0.005
5	A ₁ B ₂ C ₂	800	0.06	1.5	1.005	122	0.004
6	A ₁ B ₂ C ₃	800	0.09	0.5	0.783	126	0.014
7	A ₁ B ₃ C ₁	900	0.03	1.5	1.154	120	0.001
8	A ₁ B ₃ C ₂	900	0.06	0.5	1.163	127	0.014
9	A ₁ B ₃ C ₃	900	0.09	1.0	2.151	122	0.007

EXPERIMENTAL DATA FOR H11STEEL [HSS -Drill Bit]

Table 5.4 Experimental data for H11 STEEL

S NO	DESIGNATION	(A)SPEED (N) (rpm)	(B)FEED (f) (mm/rev)	C-Peek increment(mm)	SURFACE ROUGHNESS	HARDNESS HRB	ROUNDNESS ERROR
1	A ₁ B ₁ C ₁	700	0.03	0.5	3.751	128	0.004
2	A ₁ B ₁ C ₂	700	0.06	1.0	1.179	118	0.033
3	A ₁ B ₁ C ₃	700	0.09	1.5	3.009	126	0.041
4	A ₁ B ₂ C ₁	800	0.03	1.0	3.458	121	0.022
5	A ₁ B ₂ C ₂	800	0.06	1.5	3.852	124	0.001
6	A ₁ B ₂ C ₃	800	0.09	0.5	2.565	127	0.016
7	A ₁ B ₃ C ₁	900	0.03	1.5	3.820	127	0.009
8	A ₁ B ₃ C ₂	900	0.06	0.5	3.786	123	0.002
9	A ₁ B ₃ C ₃	900	0.09	1.0	2.294	121	0.004

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COMPARISON OF VARIOUS PROPERTIES OF BOTH DRILL BIT 1. SURFACE ROUGHNESS PROPERTIES

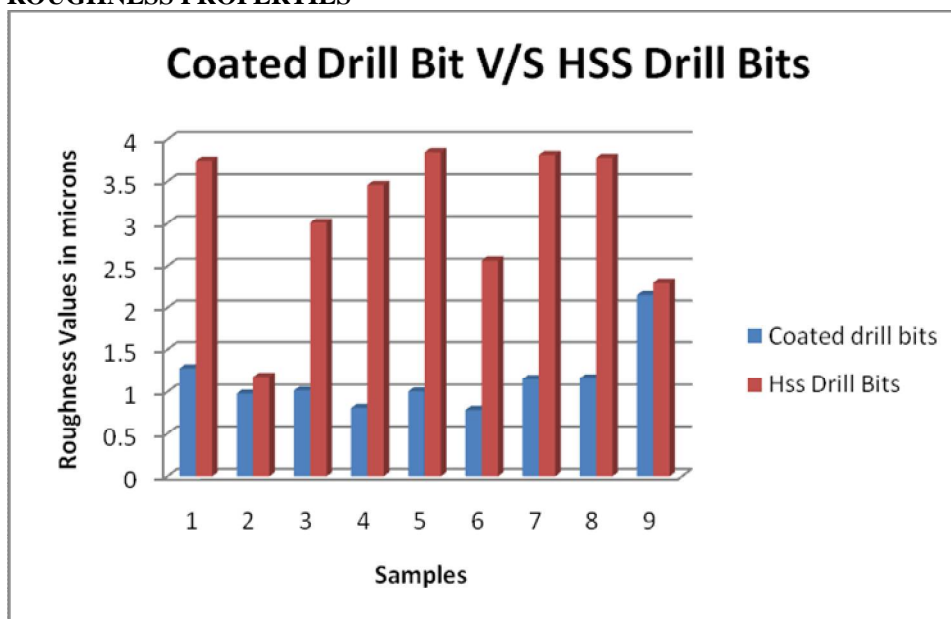


Figure 5.7 Surface Roughness Comparison

By observing the graph it is identified that uncoated drill bits create higher surface roughness than coated drill bits.

2.MECHANICAL PROPERTIES HARDNESS

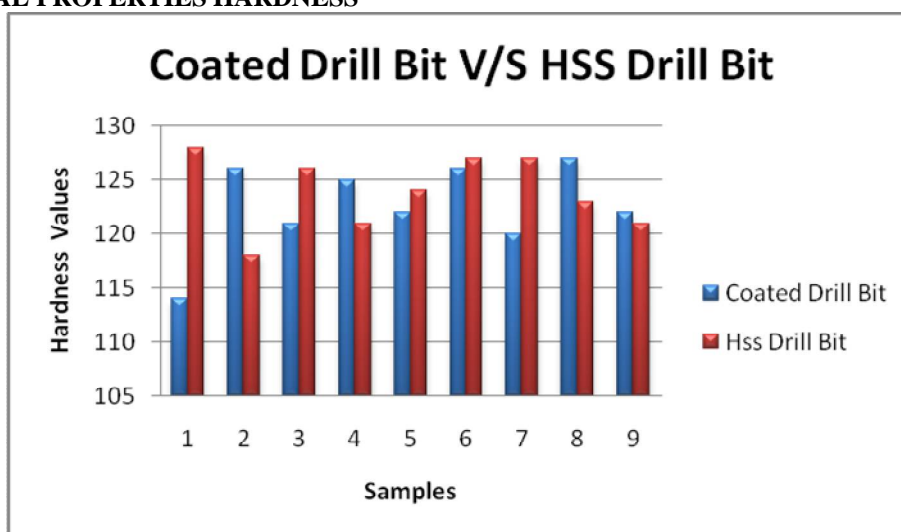


Figure 5.8 Hardness Comparison

Hardness properties changes both drill bits are more are less same. While machining hardness changes in both the drill bits give the equal changes.

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3. GEOMETRICAL PROPERTIES COMPARISION ROUNDNESS

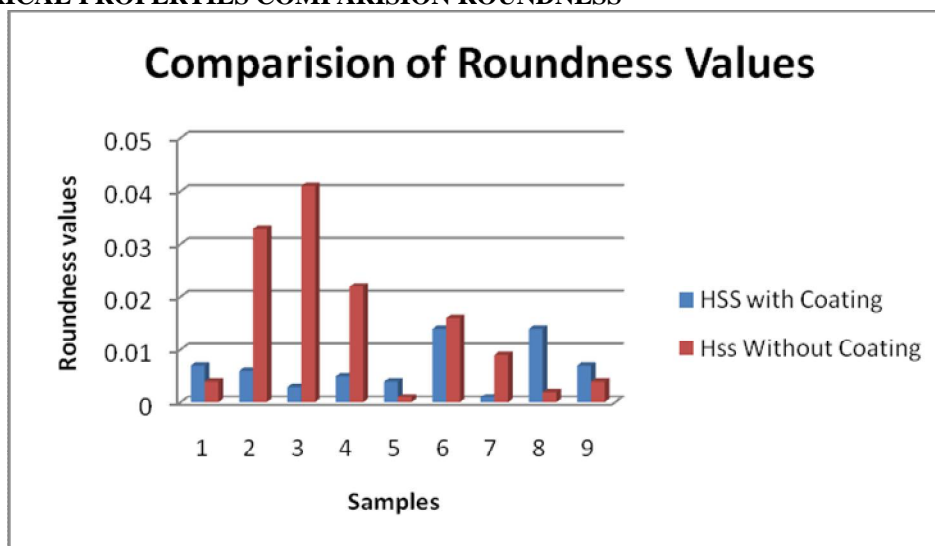


Figure 5.9 Comparison of Roundness values

By observing the value the coated drill bits has less roundness error compared than without coated drill bits.

5.12 SURFACE ROUGHNESSES-TiAIN Drill Bit (ANALYSIS OF RESULT)

S N O	DESIGNATI ON	(A)SPEED(N) (rpm)	(B)FEED (f) (mm/rev)	C-Peck increment(m m)	SURFACE ROUGHNESS Ra (μm)	S/N Response valve (db) for ROUGHNESS (Ra)
1	A ₁ B ₁ C ₁	700	0.03	0.5	1.280	-2.14420
2	A ₁ B ₁ C ₂	700	0.06	1.0	0.980	0.17548
3	A ₁ B ₁ C ₃	700	0.09	1.5	1.016	-0.13787
4	A ₁ B ₂ C ₁	800	0.03	1.0	0.807	1.86253
5	A ₁ B ₂ C ₂	800	0.06	1.5	1.005	-0.04332
6	A ₁ B ₂ C ₃	800	0.09	0.5	0.783	2.12476
7	A ₁ B ₃ C ₁	900	0.03	1.5	1.154	-1.24412
8	A ₁ B ₃ C ₂	900	0.06	0.5	1.163	-1.31159
9	A ₁ B ₃ C ₃	900	0.09	1.0	2.151	-6.65281

Table 5.5 Surface roughness and S/N ratios values for the experiments of H11 STEEL

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ROUNDNESS ERROR RESPONSE FOR EACH LEVEL OF THE PROCESS PARAMETER OF H11 STEEL

Response Table for Signal to Noise Ratios

Smaller is better

Table 5.12 Response Table for Signal to Noise Ratios Larger is better

Level	SPEED	FEED	PECK INCR
1	46.00	49.71	39.08
2	43.69	43.16	44.52
3	46.73	43.54	52.81
Delta	3.04	6.55	13.72
Rank	3	2	1

ANALYSIS OF VARIANCE (ANOVA)

Table 5.13 Analysis of Variance (ANOVA) results for the Metal Removal Rate of H11 STEEL(25mm thickness)
S = 0.00120185 R-Sq = 98.23% R-Sq(adj) = 92.93%

MAIN EFFECTS PLOT FOR SN RATIO

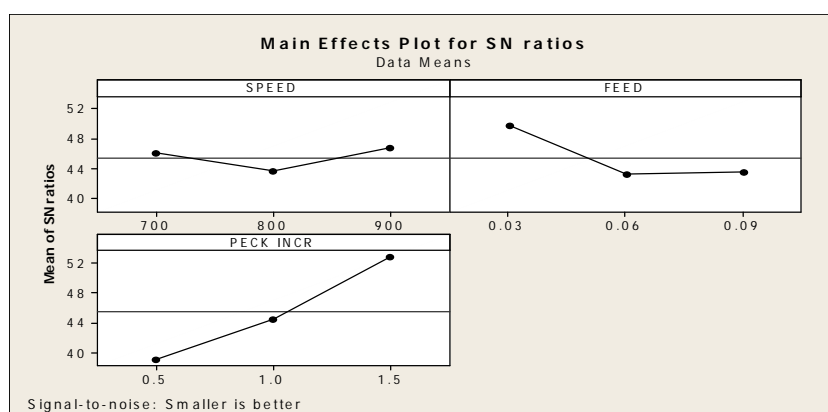


Figure 5.14 Main effects plot for SN ratios for Roundness error

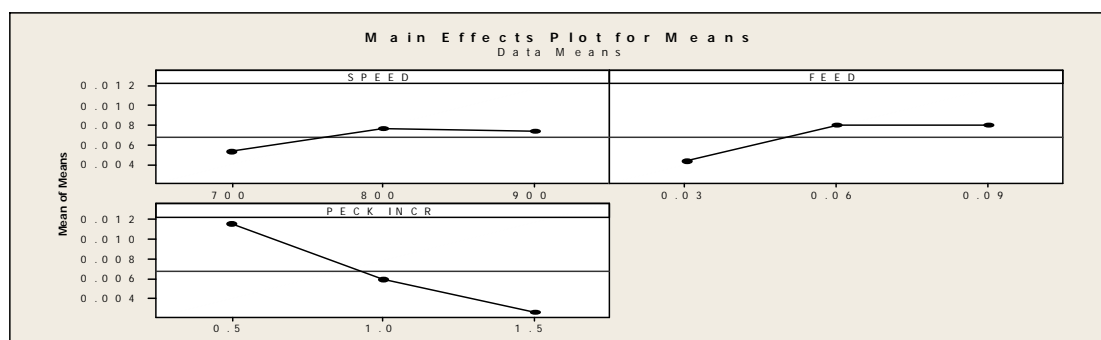


Figure 5.15 Main effects plot for Means for Roundness error

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V. CONCLUSION

In this study, the Taguchi technique and ANOVA were used to obtain optimal drilling parameters in the drilling of H11 under dry conditions. Of both drill bits. The experimental results were evaluated using TAGUCHI&ANOVA. The following conclusion can be drawn and optimal control factor of Titanium Aluminium Nitrate drill bits.

7.1 OPTIMAL CONTROL FACTOR-TiAlN Drill bit

1.Surface Roughness-A3(Speed -900)B1(Feed -0.03)C2(Peck Increment 1.0)

Source of variation	D O F	Sum of squares(S)	Adj SS	Adj MS	F ratio(F)	P value (p)	% of contribution
SPEED	2	0.0000096	0.0000096	0.0000048	3.31	0.232	6
FEED	2	0.0000269	0.0000269	0.0000134	9.31	0.097	16
PECK INCR	2	0.0001242	0.0001242	0.0000621	43.00	0.023	75
Error	2	0.0000029	0.0000029	0.0000014			
Total	8	0.0001636					

2.Hardness -A1(Speed-700)B3(Feed 0.09)C2(Peck Increment 1.0)

3.Roundness Error- A3(Speed-900)B2(Feed 0.09)C1(Peck Increment 0.5)

7.2 PERCENTAGE OF CONTRIBUTION OF PROCESS PARAMETER

1.Surface Roughness-Speed-45%

2.Hardness –Peck Increment-73%

3.Roundness Error- Peck Increment-75%

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