Asian Review of Mechanical Engineering
ISSN: 2249-6289 (P) Vol.4 No.2, 2015, pp.18-22

DOI: https://doi.org/10.51983/arme-2015.4.2.2399

Optimization of Drilling Parameters on EN31 Steel with Chromium Coated Drill Bit by Using TAGUCHI Method

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***Abstract* - The metal cutting is very essential to try for high metal removing rate and the best product quality. The major problem in achieving high productivity and best quality is short life span of a tool. To enhance the life of tool many new materials are developed so has to meet the market demand and competitive price for this there should be proper control over various cost involved in machining named as material cost labor cost and tooling cost the material cost can be controlled by using special material which meet all required properties with reduced price. The methodology of Modified Taguchi optimization method for simultaneous minimization and maximization of Surface roughness (Ra), machining time and material removal rate of EN31 Alloy steel affect the aesthetical aspect of the final product and hence it is essential to select the best combination values of the CNC drilling process parameters to minimize as well as maximize the responses. The experiments were carried out by a CNC lathe, using physical vapor deposition coated Chromium nitride drilling tool bit for the machining of EN19. The experiments were carried out as per L9 orthogonal array with each experiment performed under different conditions of such as speed, type of drilling tool, and feed rate. The Taugchi method and analysis of variance (ANOVA) was employed by using MINITAB-15 software to identify the level of importance of the machining parameters on Surface roughness (Ra), Machining time and Material Removal Rate (MRR).**

***Keywords:* CNC drilling, ANOVA, Taugchi method, CNC lathe, Surface roughness and MRR.**

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 vapor deposition.

EN31 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, EN31 promises fruitful development for applications in the automobile sector due to its high strength.

A. CNC LATHE

Computer numerical controlled (CNC) lathes are rapidly replacing the older production lathes (multi spindle, etc.) due to their ease of setting, operation, repeatability and accuracy. They are designed to use modern carbide tooling and fully use modern processes. The part may be designed and the tool paths programmed by the CAD/CAM process or manually by the programmer and the resulting file uploaded to the machine, and once set and trailed the machine will continue to turn out parts under the occasional supervision of an operator.

The machine is controlled electronically via a computer menu style interface; the program may be modified and displayed at the machine, along with a simulated view of the process. The setter/operator needs a high level of skill to perform the process, however the knowledge base is broader compared to the older production machines where intimate knowledge of each machine was considered essential. These machines are often set and operated by the same person, where the operator will supervise a small number of machines (cell).

The design of a CNC lathe varies with different manufacturers, but they all have some common elements. The turret holds the tool holders and indexes them as needed, the spindle holds the work piece and there are slides that let the turret move in multiple axes simultaneously. The machines are often totally enclosed, due in large part to occupational health and safety (OH&S) issues.

B. Physical Vapour Deposition (pvd)

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II. LITERATURE REVIEW

P.Venkataramaiah - 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 taughi method. It consist of two phases artificial neural network (ANN) continued to that ANN is analyzed with S/N ratio of Taughi approach. This work is useful in predicting the multi responses while cutting different materials in different drilling parameters.

YogendraTyagil - 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, taughi 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).

Mustafa Kurt - the aim of the work reported here was to utilize Taguchi methods to optimize surface finish and hole diameter accuracy in the dry drilling of Al 2024 alloy. Although modern metal-cutting cutting speeds (30, 45, and 60 m/min), feed rates (0.15, 0.20, and 0.25 mm/rev), depths of drilling (15 and 25 mm), and different drilling tools (uncoated and TiN- and TiAlN- coated) with a 118° point angle. Confirmation tests with the optimal levels of machining parameters are carried out.

Rivero - As a result of the need to automate assembly in the aircraft industry. The main difficulties' in dry drilling are accelerated tool wear due to work piece. Dry drilling tests were performed using uncoated drills and two different coatings produced by means of an arc Evaporation PVD process. Experiments consisted of machining with a 10-mm diameter three-edged drill to produce 25-mm deep joining process in aircraft manufacturing. Tool wear evolution and burr size were analyzed, as well as the impact of the process parameters on torque, power, feed, force and tool temperature.

M. Montoya - 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.

III. PROPOSED METHOD

A. TAGUCHI APPROACH

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 [1][2] 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[3] 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 [5][6] of common interest for optimization of Static Problems. The formulae for signal to noise ratio are designed so that an experimenter can always select the largest factor level setting to optimize the quality characteristic of an experiment. Therefore a method of calculating the Signal-To-Noise ratio we had gone for quality characteristic. They are

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

1. 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:

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

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

TABLE I SURFACE ROUGHNESS AND S/N RATIOS VALUES FOR THE EXPERIMENTS ANALYSIS OF VARIANCE (ANOVA)

Designation	Peck	Feed	Speed	Ra
$A_1B_1C_1$	2.5	0.02	200	0.495
$A_1B_2C_2$	2.5	0.04	400	0.323
$A_1B_3C_3$	2.5	0.06	600	0.99
$A_2B_1C_2$	3.5	0.02	400	0.392
$A_2B_2C_3$	3.5	0.04	600	0.659
$A_2B_3C_1$	3.5	0.06	200	1.548
$A_3B_1C_3$	4.5	0.02	600	0.969
$A_3B_2C_1$	4.5	0.04	200	0.761
$A_3B_3C_2$	4.5	0.06	400	0.907

TABLE II ANALYSIS OF VARIANCE (ANOVA) RESULTS FOR THE ROUGHNESS MACHINING TIME (ANALYSIS OF RESULT)

Source	DF	SS	MS	F	P	% of contribution
feed	2	0.60383	0.30192	4.5	0.095	52.91
speed	2	0.2693	0.13465	2.01	0.249	23.59
Error	4	0.26819	0.06705			23.5
Total	8	1.14133				100

Table III Machining Time and s/n ratios values for the experiments MRR (ANALYSIS OF RESULT)

Designation	peck	feed	speed	Mc	SNRA1
$A_1B_1C_1$	2.5	0.02	200	7.03	-16.939
$A_1B_2C_2$	2.5	0.04	400	3.55	-11.005
$A_1B_3C_3$	2.5	0.06	600	0.56	5.0362
$A_2B_1C_2$	3.5	0.02	400	3.42	-10.681
$A_2B_2C_3$	3.5	0.04	600	1.22	-1.7272
$A_2B_3C_1$	3.5	0.06	200	3.13	-9.9109
$A_3B_1C_3$	4.5	0.02	600	2.58	-8.2324
$A_3B_2C_1$	4.5	0.04	200	4.12	-12.298
$A_3B_3C_2$	4.5	0.06	400	1.33	-2.477

2. 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:

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

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

3. NOMINAL IS BEST

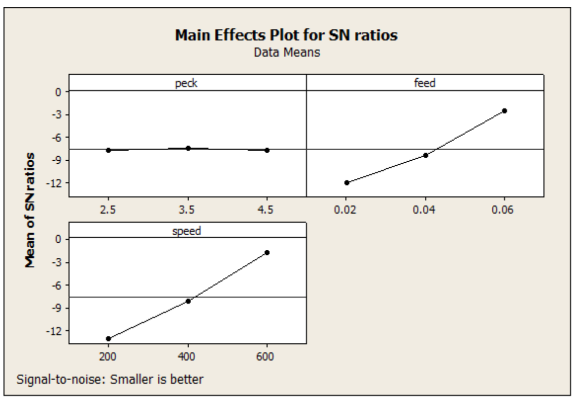
The signal-to-noise (S/N) ratio is calculated for each factor level combination. The formula for the nominal-is-best I S/N ratio using base 10 log is:

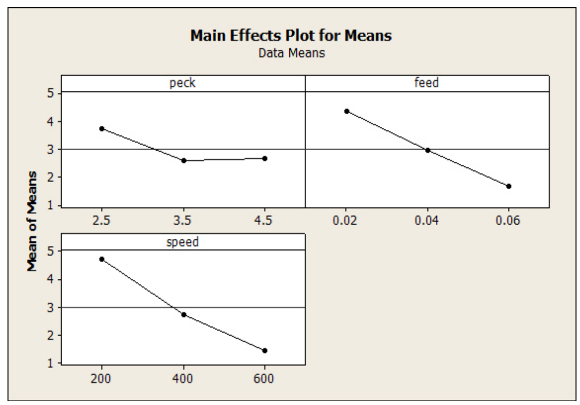
$$S/N = -10*\log(s^2)$$

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

TABLE IV MRR AND S/N RATIOS VALUES FOR THE EXPERIMENTS

Designation	Peck	Feed	Speed	MRR	SNRA2
$A_1B_1C_1$	2.5	0.02	200	0.00059	64.5830
$A_1B_2C_2$	2.5	0.04	400	0.00116	58.7108
$A_1B_3C_3$	2.5	0.06	600	0.00781	42.1470
$A_2B_1C_2$	3.5	0.02	400	0.00123	58.2019
$A_2B_2C_3$	3.5	0.04	600	0.00345	49.2436
$A_2B_3C_1$	3.5	0.06	200	0.00137	57.2656
$A_3B_1C_3$	4.5	0.02	600	0.00163	55.7562
$A_3B_2C_1$	4.5	0.04	200	0.00105	59.5762
$A_3B_3C_2$	4.5	0.06	400	0.00242	52.3237





IV.CONCLUSION

In this experimental investigation, the Taugchi technique and ANOVA were used to obtain optimal drilling parameters in the drilling of EN 31 STEEL under wet conditions. The experimental results were evaluated using ANOVA. The following conclusion can be drawn.

SL.No.	SURFACE ROUGH NESS FOR CHROMIUM DRILL BIT	MACHINING TIMING	MATERIAL REMOVAL RATE
PLAIN EN31 DIE STEEL DRILL BIT	A3,B1 C2 4.5 Peck increment-4.5 Feed -0.02, Speed-400 Rpm, Percentage of Contribution Feed is 52.91%	A3,B2 C1 4.5 Peck increment-4.5 Feed -0.04 Speed-200 Rpm Percentage of Contribution seed is 55%	A3,B2 C1 4.5 Peck increment-4.5 Feed -0.04 Speed-200 Rpm Percentage of Contribution speed is 42%
CHROMIUM COATED EN 31 DIE STEEL DRILL BIT	A3,B1 C2 4.5 Peck increment-4.5 Feed -0.02 Speed-400 Rpm Percentage of Contribution speed is 20%	A3,B2 C1 4.5 Peck increment-4.5 Feed -0.04 Speed-200 Rpm Percentage of Contribution seed is 55%	A3,B2 C1 4.5 Peck increment-4.5 Feed -0.04 Speed-200 Rpm Percentage of Contribution seed is 46%

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