OPTIMIZATION OF PROCESS PARAMETERS OF HIGH SPEED MILLING FOR PHOSPHOR BRONZE

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ABSTRACT

Every day scientists are developing new materials and for each new material, we need economical and efficient machining and it is also predicted that, Taguchi method is a good method for optimization of various machining parameters as it reduces the number of experiments. In the present work, by using taguchi approach the End milling of EN-31 steel alloy is carried out in order to optimize the milling process parameters and to minimize the surface roughness. This paper deals with optimization of selected milling process parameters Speed, Feed rate, Depth of cut and coolant flow Taguchi orthogonal array is designed with three levels of milling parameters and different experiments are done using L9 orthogonal array, containing four columns which represents four factors and nine rows which represents nine experiments to be conducted and value of each parameter was obtained. The nine experiments are performed and surface roughness is calculated. The Signal to Noise Ratio (S/N) ratio of predicted value and verification test values are valid when compared with the optimum values. It is found that S/N ratio value of verification test is within the limits of the predicted value and the objective of the work is full filled.

1.0 Introduction

The objective of this project work is to find out the set of optimum values for the selected control factors in order to reduce surface roughness using Taguchi's robust design methodology and to develop the prediction models for surface roughness considering the control factors. In the present work, Taguchi method is used to determine the optimum cutting milling parameters more efficiently. Four control factors viz. cutting speed, feed rate, depth of cut and coolant flow are investigated at three different levels. The work piece material used is EN-31 steel alloy. Taguchi method is used to optimize the process parameter i.e. surface roughness using signal-to-noise ratio for milling process of the work piece materials. Experiments are carried out using L9 (34) orthogonal array.

Computer numerical control

Numerical Control is the automation of machine tools that are operated by precisely programmed commands encoded on a storage medium, as opposed to controlled manually via hand wheels or levers, or mechanically automated via cams alone. In modern CNC systems, end-to-end component design is highly automated using computer-aided design (CAD) and computer-aided manufacturing (CAM) programs. CNC (Computer Numerical Control) is the general term used for a system which controls the functions of a machine tool using coded instructions processed by a computer. The application of CNC to a manual machine allows its operation to become fully automated

Problem definition

Advanced materials exhibit very excellent technical properties. However, the high cost of both raw materials and processing reduce their uses. Alternatively advanced machining process such as CNC flame Cutting is normally used. Advanced material such as MS nickel-base alloys, titanium alloys and stainless steel can be used as the work piece in this type of cutting. A torch in which temperatures as high as 30,000°C are achieved by injecting aflame gas tangentially into an electric arc formed between electrodes in a chamber; the resulting vortex of hot gases is emerges at a very high speed through a hole in the negative electrode, to form a jet for welding, spraying of molten metal, and cutting of hard rock or hard metals.

Flame cutting

Oxy-fuel welding and oxy-fuel cutting are the processes that uses gases as a fuel and oxygen for welding and cutting the metals, respectively. French engineers Edmond Fouche and Charles Picard became the first to develop oxygen-acetylene welding in 1903. Pure oxygen is used than that of air to increase the flame temperature that allows melting of the work piece material e.g. steel in a room environment.

Taper cutting using WEDM process

Taper cutting is a unique application of the wire electrical discharge machining process used for production of difficult-to-machine parts involving complex shapes, tight corners, deep slots and features with multiple angles used in the aerospace and defense applications. In WEDM process, the material is cut by a series of discrete electric discharges between the wire electrode and the work material submerged in a dielectric fluid. The region where the discharge occurs is heated to extremely high temperatures causing melting of work surface and its removal.

2.0 literature review

Abdulkareem, MohdZain, Z. (2011) The Last forty years there is tremendous research in machining and development in technology. With increase in competition in market and to attain high accuracy now a days the non-conventional machining are become lifeline of any industry. One of the most important non-conventional machining methods is CNC flame Machining. It has high accuracy, finishing, ability of machining any hard materials and to produce intricate shape increases its demand in market

Aggarwal, V., Garg, R. K. (2015) Mild steel and stainless steel are difficult to machine in traditional machining method. Wire cut electrical discharge machining (WEDM), a hybrid manufacturing technology which enables machining of all engineering materials. This research article deals with the investigation on optimization of the process parameters of the wire cut EDM of mild steel and stainless steel. Material removal rate, surface roughness, were studied against the wire cut EDM process parameters, such as pulse on, voltage and wire feed rate.

Amini, H., Yazdi, Dehghan, G. H. (2011) Significant technological advancement of wire electrical discharge machining (WEDM) process has been observed in recent times in order to meet the requirements of various manufacturing fields especially in the production of parts with complex geometry in precision die industry. Taper cutting is an important application of WEDM process aiming at generating complex parts with tapered profiles. Wire deformation and breakage are more pronounced in taper cutting as compared with straight cutting resulting in adverse effect on desired taper angle and surface integrity. The reasons for associated problems may be attributed to certain stiffness of the wire.

Amini, K., Nategh, S., Shafyei, A. and Rezaeian, A. (2012) In last forty years there is tremendous research in machining and development in technology. With increase in competition in market and to attain high accuracy now a days the nonconventional machining are become lifeline of any industry. One of the most important non-conventional machining methods is Plasma Arc Machining. Its high accuracy, finishing, ability of machining any hard materials and to produce intricate shape increases its demand in market In thesis work literature has been studied in context to parametric optimization of Plasma Arc Cutting Machine. In order to attain target and optimum results, Taguchi method employed.

Anthony xavior, M. and Adithan, M. (2009) Wire Electrical Discharge Machining (WEDM) is widely used for machining conductive materials which are of great importance in several industrial applications. In this work, process variables optimization of Powder Mixed Wire Electrical Discharge Machining (PMWEDM) of AISI 304 stainless steel (SS) is studied using molybdenum wire as the tool material. This work illustrate the implementation of Taguchi technique and Genetic Algorithm (GA) to identify the optimal process variables of WEDM using dielectric medium mixed with Silicon Carbide(SiC) powder.

3.0 Methodology

Traditional experimental design methods are very complicated and difficult to use. Additionally, these methods require a large number of experiments when the number of process parameters increases. In order to minimize the number of tests required, Taguchi experimental design method, a powerful tool for designing high quality system, was developed by Taguchi. This method uses a special design of orthogonal arrays to study the entire parameter space with small number of experiments only. Taguchi recommends analyzing the mean response for each run in the inner array, and he also suggests analyzing variation using an appropriately chosen signal-to-noise ratio (S/N). There are 3 Signal-to-Noise ratios of common interest for optimization of Static Problems;

Surface Roughness

Surface roughness is an important measure of product quality since it greatly influences the performance of mechanical parts as well as production cost. Surface roughness has received serious attention for many years and it is a key process to assess the quality of a particular product. Surface roughness has an impact on the mechanical properties like fatigue behavior, corrosion resistance, creep life, etc. It also affects other functional attributes of parts like friction, wear, light reflection, heat transmission, lubrication, electrical conductivity, etc. Surface roughness of turned components has greater influence on the quality of the product.

The average surface roughness's (Ra) of the machined samples were measured by using Mitutoyo SJ-310 surface roughness measurement device. The measurement was taken at a distance of 5 mm from top, middle, thebottom of the cut surface. Each test was carried out trice and the averages of the result are taken for the study.

Table: Parameters and their levels

Sl. No.	Parameter	Symbol	Units	Level 1	Level 2	Level 3
1	Pulse ON	A	µs	4	5	6
2	Voltage	B	V	50	60	70
3	Wire feed rate	C	m/min	2	4	6

Taguchi method

Optimization of process parameters is the key step in the Taguchi method to achieve high quality without increasing cost. However, originally Taguchi method was designed to optimize single performance characteristics. According to Taguchi method, the S/N ratio is the ratio of Signal to Noise where signal represents the desirable value and noise represents the undesirable value. The response Ra and Kf reported in Table, which is used to calculate the Signal to Noise Ratio (S/N) using the equation. The experimental results are now transformed into a signal-to-noise (S/N) ratio. Since surface roughness and kerf width is desired to be at minimum, so Lower the Better characteristic is used for S/N ratio calculation

Taguchi design approach

Taguchi's comprehensive system of quality engineering is one of the greatest engineering achievements of the 20th century. His methods focus on the effective application of engineering strategies rather than advanced statistical. The original response values are transformed into S/N ratio values. Further analysis is carried out based on these S/N ratio values. The material removal rate is a higher performance characteristic, since the maximization of the quality characteristic of interest is sought and can be expressed as:

$$S/N(MRR) = -10 \text{ Log } \frac{1}{R}\left[\sum_{j=1}^{R}\frac{1}{y^2_j}\right]$$

The surface roughness is the lower-the performance characteristic and the loss function for the same can be expressed as:

$$S/N(Ra) = -10 \text{ Log } \frac{1}{R}\left[\sum_{j=1}^{R} y^2_j\right]$$

The material should serve the desired purpose at minimum cost. Such factors as ease of availability, cost, mechanical properties and manufacturing difficulties were considered while selecting the suitable material for machine tool and damper.

Cutting tool inserts:

Inserts are individual cutting tools with several cutting points. Inserts are usually clamped on the tool shank with various locking mechanisms. Most of high performance cutting tools use the insert method. Here there are three type cutting inserts are using they are

1. Sumitomo ac700g – carbide coated
2. Korloy pc9030 – pvd coated steel grade
3. Taguetec ct3000 – ceramic uncoated

4.0 Results

In the first run experiment is performed using coolant APPRO SOL XL. Readings are tabulated in table Surface roughness is measured and MRR values are calculated using formulae.In the Second run experiment is performed in dry condition. Readings are tabulated in table6 Surface roughness is measured and MRR values are calculated using formulae.

REGRESSION MODELS

Table

: Response table for surface roughness

Level	Cutting Speed (m/min) „A"	Feed (mm/rev) „B"	Depth of Cut (mm) „C"	Hardness of Cutting tool (HRC) „D"
1	-4.9884	1.6082	1.7472	-0.7508
2	0.3184	2.1887	-3.0889	3.7788

3	6.4227	-2.0442	3.0495	-1.2753
Delta	11.4111	4.2329	6.1834	5.0541
Rank	1	4	2	3

Table:Analysis of Variance for MRR

Source	DF	Seq SS	Adj SS	Adj MS	%p
Cutting speed(A)	2	31728492	31728492	15864246	31.87
Feed (B)	2	33219867	33219867	16609933	33.37
Depth of cut(C)	2	14793873	14793873	7396936	14.86
Tool Hardness (D)	2	19783672	19783672	9891836	19.87
Total	2	99525902	99525902		

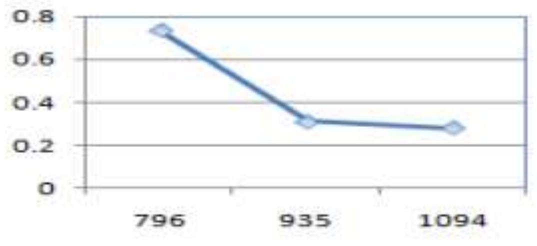
Table: Analysis of Variance for surface roughness

Source	DF	Seq SS	Adj SS	Adj MS	%p	Rank
Cutting speed(A)	2	2.20469	2.20469	1.10234	64.37	1
Feed (B)	2	0.36029	0.36029	0.18014	10.52	4
Depth of cut(C)	2	0.38869	0.38869	0.19434	11.34	3
Tool Hardness (D)	2	0.47096	0.47096	0.23548	13.75	2
Total	8	3.42462				

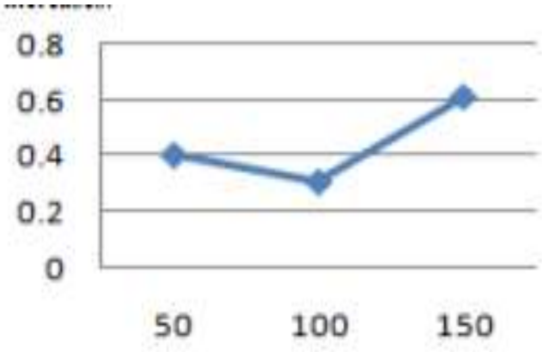
Table: Response table for surface roughness

Level	Cutting Speed (m/min) „A"	Feed (mm/rev) „B"	Depth of Cut (mm) „C"	Hardness of Cutting tool (HRC) „D"
1	-5.13566	1.18467	1.29320	-1.03972
2	0.01450	1.71516	-3.21863	3.21057
3	5.72053	-2.30046	2.52480	-1.57148
Delta	10.85620	4.01561	5.74343	4.78204
Rank	1	4	2	3

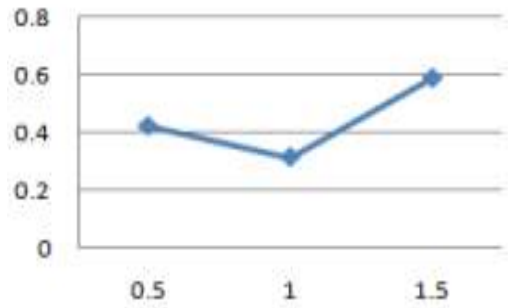
Effect of cutting parameters on surface roughness



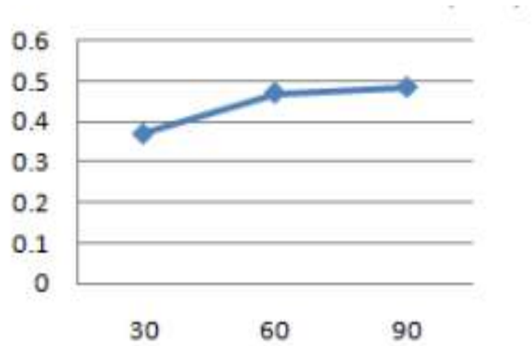
From Fig No, it is observed that, the surface roughness is high at low speed and certainly decreasing from moderate cutting speed to low speed conditions. From Fig No., it is observed that, the surface roughness is high at low feed rate and certainly decreasing from low feed rate to moderate feed rate conditions, but again from moderate to high feed rate, the surface roughness increases.



Graph Surface Roughness v/s Feed Rate



Graph: Surface Roughness v/s Depth of Cut



Graph: Surface Roughness v/s Coolant Flow

It is observed that, the surface roughness is low at low coolant flow and certainly increasing from low coolant flow to moderate coolant flow conditions, and again from moderate to high coolant flow, the surface roughness increases. This can be explained by the reason that, surface roughness increases due to temperature, stress and wear at tool tip increases.

Conclusion:

Present work is concerned with determining the optimum settings of process parameters for single as well as multi response optimization during EDMing of high carbon high chromium steel on the basis of taguchi approach and utility concept. The L25 OA was used for experimental planning. In the first stage (single response) optimal settings of process parameters were obtained individually so as to obtain optimum values for MRR, SR and KW respectively. It is found that TON is the most influencing factor for both KW and MRR, while TOFF has significant effect on SR. In second stage (multi response) response table establishes the combination of higher levels of pulse on time, pulse off time, wire feed and lower flush and lower level of wire tension and upper flush is essential for obtaining optimal value of multiple performances for the predefined weightages.The effect of process parameters cutting speed, Feed, Depth of cut and Tool Hardness on response Characteristics MRR and Surface roughness were studied on 20MnCr5 steel alloy in CNC Turning. Based on results obtained, the fallowing conclusions can be drawn:The experimental results showed that the Taguchi parameter design is an effective way of determining the optimal cutting parameters for achieving low surface roughness and maximum material removal rate. ANOVA suggests that cutting speed is the most significant factor and feed is most insignificant factor for surface roughness and cutting speed is the most significant factor and feed is the most insignificant factor for MRR when the coolant is OFF.

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