Experimental Investigation on Response Surface Method Analysis of Composite Material

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Abstract- *This paper evaluates the Various optimization techniques have been proposed in metal cutting process for determining the optimum process design. Generally, the process design parameters in metal cutting processes are relatively few such as cutting speed, feed rate and depth of cut i.e. Independent parameters; however, their optimization remains a challenge due to several other factors related to processing conditions and shape complexities like Surface Roughness, MRR which are Dependent Parameters. In this project we introduced a new material through research which can decrease production development cost and time and also accelerate the process of product development.*

Composite materials are light in weight and have a good strength which make the system reliable and robust. Composite material providing insight in system problem underlying physics and model weakness and also opening up new research fields and technologies which will create new growth opportunities. The proposed research work aims to investigate mechanical properties and machining parameter in turning of composite material. Optimum machining parameters are of great concern in manufacturing environments. The main objective of this research work is to optimize surface roughness of composite material specifically in turning process by changing parameter such as depth of cut, cutting speed and feed rate and also predict the mechanical properties of composite material.

The RSM optimization is needed in industry to increase the production rate by minimizing the surface roughness of the specimens.

Keywords- Response surface method, Composite material, Optimization, Machining parameter, Mechanical property.

I. INTRODUCTION

1.1 GENERAL

Composite unite many of the best qualities that traditional materials have to offer. The two components of a composite include reinforcement and matrix. The matrix binds the reinforcement it together to merge the benefits of both original components. Composites are improving the design process and end products across industries. Each year composites continue to replace traditional materials like steel and aluminium. As composite cost come down and design flexibility improves fibre reinforced composites like carbon fibre and fiberglass open up new design opportunities. Composites have a high strength to weight ratio. Composites are durable. Composites open up new design options. Composites are now easier to produce.

Machining of composite materials is difficult to carry out due to the anisotropic and non homogeneous structure of composites and to the higher abrasiveness of their reinforcing constituents. This is typically results in damage being introduced into the work piece and in very rapid wear development in the cutting tool. In metal cutting mechanism is plastic deformation. The material is softer than the tool and the cheap flows over the cutting edge. But in machining of composites the focus here will be CFRP there is no cheap to speak of. Instead the material removal mechanism might be better described as shattering. Rather than sharing material away, the impact of the cutting edge fractures the hard carbon fibres. In the process the cutting edge undergoes considerable abrasion that can lead to rapid wear. Carbide can work as a tool material do carbide tools machining composites often have to be changed frequently hence diamond tooling is likely to last much longer the choices in diamond tooling for CFRP include diamond grit plated onto a mandrel. Diamond coating applied through chemical vapour deposition or solid inserts made from polycrystalline diamond (PCD).The shattering of composites is like the deformation of metal in at least one way. Just as in metal cutting the energy of the cut it still transformed into heat. CFRP has a particularly hard time dissipating this heat. No chip is generated to carry the heat away and the material has low thermal conductivity. The resulting heat build of causes the danger of melting or otherwise damaging The matrix coolant might not help because coolant might not be allowed in the machining of certain composite parts. Therefore the tool and the tool path are all that remain to hold down the heat of machining. Sharp angles are generally one of the keys to accomplishing this. Sharp angle tools for composites feature high positive rake angles for a quick sharp clean cut that keeps heat to a minimum. Such tools also incorporate clearance angles that are sufficient to prevent the age of the tool from rubbing as it passes.

The purpose of optimization is to achieve the best design relative to a set of prioritized criteria or constraints. These include maximizing factors such as productivity, strength, reliability, efficiency and utilization. In any machining process apart from obtaining the accurate dimensions achieving a good surface quality and maximize and metal removal are also of utmost importance. A machining process involves many process parameters which directly or indirectly influence the surface roughness and metal removal rate of the product in common. Surface roughness and metal removal in turning process are varied due to various parameters of which feed, speed, depth of cut are important ones. The selection of proper combination of machining parameters yields the desired surface finish and metal removal rate the proper combination of machining parameters is an important task as it determines the optimal values of surface roughness and metal removal rate. It is necessary to develop mathematical models to predict at the influence of operating conditions. The preparation of quality surfaces is very important process in the surface engineering the surface roughness will influence the quality and effectiveness of the subsequent coatings for protection against corrosion and wear resistance and finishes quality of decorative layers.

1.2MotivationandObjectives

Optimization is an act, process or methodology of obtaining the best results under given circumstances. The word ‘Optimum’ is taken as ‘Minimum’ or ‘maximum’ depending upon the circumstances. While designing, construction, and maintenance of any engineering system, engineers have to take many technological and managerial decisions at certain stages. The ultimate aim of all such decisions is either to minimize the effort required or to maximize the desired benefit. Since the effort required or the benefit desired in any practical situation can be defined as the process of finding the conditions that give the maximum or minimum value of a function. So in our case we have to minimize the surface roughness so that the specimen after turning process will be smooth.

Various optimization techniques have been proposed in metal cutting process for determining the optimum process design. Generally, the process design parameters in metal cutting processes are relatively few such as cutting speed, feed rate and depth of cut i.e. Independent parameters; however, their optimization remains a challenge due to several other factors related to processing conditions and shape complexities like Surface Roughness, MRR which are Dependent Parameters.

In this project we introduced a new material through research which can decrease production development cost and time and also accelerate the process of product development. Composite materials are light in weight and have a good strength which make the system reliable and robust. Composite material providing insight in system problem underlying physics and model weakness and also opening up new research fields and technologies which will create new growth opportunities.

The RSM optimization is needed in industry to increase the production rate by minimizing the surface roughness of the specimens.

1.3 AIM AND OBJECTIVES

AIM

Experiment Investigation of mechanical properties and machining parameter in turning of composite material using Response surface method

Objectives

1. To select & manufacture Composite material.
2. To investigate Mechanical Properties of Composite Material.
3. To predict machining parameters that contributes to optimize Surface Roughness.
4. To compare Mechanical properties & Surface roughness of composite with another material.

II. LITERATUREREVIEW

1.Vipin Kumar Sharma Qasim Murtaza S.K. Garg "RESPONSE SURFACE METHODOLOGY & TAGUCHI TECHQUINES TO OPTIMIZATION OF C.N.C. TURNING PROCESS".[1]

This paper outlines the fractional factorial approach of D.O.E. techniques (Taguchi & Response Surface Methodology) are applied to optimize turning process parameter in order to obtain better surface finish. The turning parameters evaluated are cutting speed, feed, and depth of cut. An orthogonal array, signal-to-noise (S/N) ratio, and Pareto analysis of variance (ANOVA) are employed to analyze the turning parameters. Main and interaction effects of process parameters on the quality characteristics (surface roughness) have been analyzed and the results shows that feed and interaction of cutting speed depth affects the surface finish greatly. The parameter for getting better surface finish are cutting speed of 2400 rpm, feed rate 40 mm/min, and depth of cut 0.5 mm.

2.Dr. M. K. Pradhan "Optimization of MRR, TWR and surface Roughness ofEDMed D2 Steel using an integrated approach of RSM, GRA andEntropy measutement Method".[2]

In this research, a hybrid optimization approach is proposed for the determination of the optimal process parameters that maximizes the material removal rate, minimize surface roughness & the tool wear rate. Three input parameters namely pulse current (Ip), pulse duration (Ton) & pulse off time (Toft) of electrical discharge machining were considered for this analysis. The experiments were planned as per response surface methodology and subsequently gray relational analysis has been used to optimize the aforesaid response and finally the weight of the responses was determined by the entropy measurement method. Analysis of variance is used to find the effect of input parameters on the responses and found that Ton was the most influencing parameter followed by Ip and Toff in EDM of D2 steel. The R2 value for the grey relational grade model was 0.919. These results provide useful information about how to control the responses and ensure higher productivity, high-accuracy and higher surfaces-quality surfaces. This method is simple with easy operability. The assessment outcome provides a scientific reference to obtain the minimal condition of surface integrity, and they were found to be a pulse current of 5A, pulse duration of 60 ItS, and pause time of 45 its.

3.Adrian, BEJINARU MIHOC Gheorghe "MANUFACTURING PROCESS AND APPLICATIONS OF COMPOSITE MATERIALS".[3]

This paper is presented some manufacturing processes of composites, as laminating, filament winding, pultrusion, resin transfer molding, and them large applications in aeronautics, automotive, maritime, etc. Also, a FEA of slide bearing form PA6 reinforced with glass fibers that change the slide bearing from bimetallic used of machine tools is analyzed.

4.Sivaraos, K.R.Milkey, A.R.Samsudin, A.K.Dubey, P.Kidd "Comparison between Taguchi Method and Response Surface Methodology (RSM) in Modelling CO2 Laser Machining".[4]

The applications of Taguchi method and RSM to modelling the laser parameters when machining industrial PVC foams is presented. The influence of cutting speed, laser power, frequency, duty cycle, and gas pressure on kerf width has been considered in this investigation according to Taguchi method using a standard orthogonal array L27 and RSM using a central composite design. Taguchi technique as well as 3D surface plot of RSM revealed that the cutting speed is the most significant factor in minimizing kerf width followed by laser power and etc. A predictive mathematical model was then developed through a regression analysis in both analytical tools to study the response. Though both the techniques predicted near values of average error, the RSM technique seems to be more promising in predicting the response via mathematical modeling over the Taguchi technique.

5.Pranav R. Kshirsagar, Somesh R. Pise, Sunil A. Pokalekar, Mahindra Goudadaba, Duradundi Sawant. Badkar "Optimization of Surface Roughness of EN8 Steel in CNC Turning Operation by Taguchi Concept".[5]

In the present research work the effect of CNC machining parameters: cutting speed Cs, depth of cut Dcand feed rate F on the surface roughness (Ra) in a turning of EN8 Steel is investigated using the Taguchi method and ANOVA. A three level, three parameter design of experiment,L9 orthogonal array using Minitab 14 software, the signal-to-noise (S/N) ratio is employed to study the performance characteristics in the turning of EN8 Steel by taking coated carbide inserts cutting tool on CNC turning machine. The statistical methods of signal to noise ratio (S/N ratio) and the analysis of variance (ANOVA) are applied to investigate effects of cutting speed, depth of cut and feed rate on surface roughness. The analysis of variance (ANOVA) is applied to study the optimization of the process parameters affecting the surface roughness was achieved with the Taguchi orthogonal test design. The results are verified by taking confirmation experiments. The present investigation indicates that feed rate is the most significant factors influencing the surface roughness Ra for turning of EN8 steel material.

6.Ranganath M S, Vipin & Harshit "Optimization of Process Parameters in Turning Operation Using Response Surface Methodology: A Review".[6]

The parameters affecting the roughness of surfaces produced in the turning process for various materials have been studied by many researchers. Design of experiments were conducted for the analysis of the influence of the turning parameters such as cutting speed, feed rate and depth of cut on the surface roughness. The results of the machining experiments were used to characterize the main factors affecting surface roughness by the DOE techniques like Taguchi, Full factorial, Response Surface Methodology and other methods. The key element for achieving high quality at low cost is Design of Experiments (DOE). Response surface methodology (RSM) is an effective tool for robust design, it offers a simple and systematic qualitative optimal design to a relatively low cost. In this paper RSM, an approach of DOE used by various researchers to analyze the effect of process parameters like cutting speed, feed, and depth of cut on Surface Roughness of work material while machining with various tools and to obtain an optimal setting of these parameters that may result in good surface finish have been discussed.

7.Rupinder Singh and J. S. Dureja "Comparing Taguchi Method and RSM for Optimizing Flank Wear and Surface Roughness During Hard Turning of AISI D3 Steel".[7]

The present work attempts to investigate tool wear (flank wear) and surface roughness (Ra) during finish hard turning of AISI D3 steel (58HRC) with coated carbide (TiSiN–TiAlN PVD coated) cutting tool. Taguchi L9 (3)3 orthogonal array has been applied for experimental design. Signal-to-noise (S/N) ratio (Lower the best) and analysis of variance (ANOVA) analyses were per- formed to identify significant parameters influencing tool wear and Ra. The cutting speed and feed were the most significant factor influencing tool wear (flank wear), and feed is the most significant factor influencing Ra. Mathematical models for both response parameters, i.e., tool wear and Ra were obtained through regression analysis. The confirmation experiments carried out at optimal combination of parameters given by Taguchi analysis predicted the response factors with less than 5 % error. In addition to this desirability function module, response surface methodology (RSM) was applied to arrive at the optimal setting of input param- eters to minimize tool wear and Ra and to compare this with optimal setting of parameters given by Taguchi analysis. The optimization results provided by desirability function optimization is quite close to the optimal solutions provided by Taguchi analysis.

8.T.Sasimurugan and K.PalanikumarAnalysis of the Machining Characteristics on Surface Roughness of a Hybrid Aluminium Metal Matrix Composite (Al6061-SiC-Al2O3)[8]

Aluminum Metal matrix composites are finding increased applications in in many areas. Adding of the third element to the metal matrix make the composite hybrid. This paper presents The study on the surface roughness characteristics of a hybrid aluminum metal matrix composites.The experimental studies were carried out on a lathe. The characteristics that influence the surface roughness such as feed rate depth of cut and cutting speed where studied which made the analysis come to a conclusion that the surface roughness is increases with the increase of feed rate and it reduces the surface roughness with the increase of cutting speed.

9.Gurpreet Singh , Maninder Pal Singh , Gurmeet Singh "Optimization of the machining parameters for surface roughness during turning of Al/SiC/Gr Hybrid MMC"[9]

In this paper the experimental investigation of turning of Al/SiC/GrMMC components was carried to optimize machining parameters to minimize surface roughness. The experiment is conducted based on taguchi method

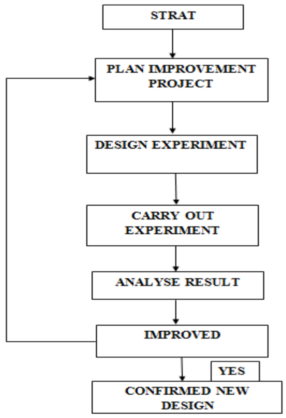
10.ST Mahavuhungu, E T Akinlabi, M A Onitiri,FM Varachia,"Aluminium matrix composites for industrial use advances and trends"[10]

This paper presents The industrial use of aluminum matrix composites its advances and trends. Aluminum metal matrix composites possess the important feature such as superior strength to weight ratio good ductility high strength and high modulus low thermal expansion coefficient excellent wear resistance and excellent corrosion resistance high-temperature creeper resistance and better fatigue strength. They are widely used for high performance applications such as automotive industrial military aerospace and electricity industries.

SummaryofLiterature:

Fromabovereviewsitisclearthatthereis wide application of composite materials in industries. Those materials should have the low cost ,reduced production time with good quality of surface roughness . So the RSM optimization of machining parameters on turning of composite materials gives the optimal solution for multiple variables.

III. METHODOLOGY



3.1 Experimental Setup:

The instrument used for experimental analysis in the form of measurement of Surface roughness Surface roughness tester. Material removal of the E Glass epoxy rod specimen with dimensions (1cm X 12 layers) is carried out by turning process. To achieve the optimum Surface roughness.

3.2 Manufacturing process of composite material :

FABRICATION OF GFRP COMPOSITE

In this experiment, GFRP composites were fabricated by Hand layup technique. For the fabrication of GFRP composite, Epoxy polymer (Araldite LY 556) and Hardener (HY 951) were taken in the ratio of 10:1 by weight by using micro weighing balance. E-glass bi-oven fibers were cut according to the size of mold. The gel was sprayed inside the mold as a releasing agent. Alternate layers of epoxy i.e. epoxy resin with hardener and E-glass fiber laminate was placed until the desired thickness (1 cm – 12 layers) was achieved. The orientation of fiber laminate was kept same throughout all the layers. The whole composite was allowed to cure at room temperature for 36 hrs. The care has been taken to maintain the uniform cross section of composite as much as possible. Because any variation in cross section can lead to stress concentration which will may lead to breaking of composite sample from that point only.

Hand Lay-Up

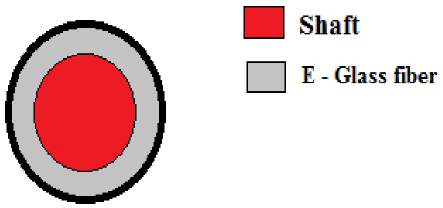
Hand lay-up is an open molding method suitable for making a wide variety of composites products from very small to very large. Production volume per mold is low; however, it is feasible to produce substantial production quantities using multiple molds. Hand lay-up is the simplest composites molding method, offering low cost tooling, simple processing, and a wide range of part sizes. Design changes are readily made. There is a minimum investment in equipment. With skilled operators, good production rates and consistent quality are obtainable

Process

Gel coat is first applied to the mold using a spray gun for a high quality surface. When the gel coat has cured sufficiently, roll stock fiberglass reinforcement is manually placed on the mold. The laminating resin is applied by pouring, brushing, spraying, or using a paint roller. FRP rollers, paint rollers, or squeegees are used to consolidate the laminate, thoroughly wetting the reinforcement and removing entrapped air. Subsequent layers of fiberglass reinforcement are added to build laminate thickness. Low density core materials such as end-grain balsa, foam, and honeycomb, are commonly used to stiffen the laminate. This is known as sandwich construction.

Process of manufacturing E - Glass Test Specimen

1. For the initial level we purchase a 12 mm MS shaft from the market. As per testing requirement divided into 9 Parts.
2. After cutting the shaft we reinforce the E glass fiber on MS shaft for that purpose we prepare a solution made of 90 % Epoxy resin plus 10% Epoxy Hardener.
3. For reinforcement first we take the MS shaft and apply solution on that with the help of a brush. Apply E - Glass fiber layer on it up to 15 mm.



Technical Specifications

ID	Particulars	Vasu-1	Vasu-2	Vasu-3
1	Length of Bed	1350 mm./ 4' - 6"	1600 mm./ 5' - 3"	1800 mm./ 6'
2	Admit Between Centre	522 mm.	750 mm.	978 mm.
3	Height of Centre	215 mm.	215 mm.	215 mm.
4	Width of Bed	270 mm.	270 mm.	270 mm.
5	Spindle Bore	52 mm.	52 mm.	52 mm.
6	Spindle Nose Dia/Threads	74.3 x 6 TPI	74.3 x 6 TPI	74.3 x 6 TPI
7	Taper Bore in Spindle	MT - 6	MT - 6	MT - 6
8	No of Spindle Speed/Range	6/40 to 470 mm.	6/40 to 470 mm.	6/40 to 470 mm.
9	Swing over Cross Slide	230 mm.	230 mm.	230 mm.
10	Swing over Bed	415 mm.	415 mm.	415 mm.
11	Tail Stock Spindle Morse Taper/DiaM.	MT - 4/50 mm.	MT - 4	MT - 4
12	No of Threads / Pitch	TPI 2 to 48	TPI 2 to 48	TPI 2 to 48
13	Electric Motor	2 HP.	2 HP.	2 HP.

Experimental Results

SR.NO.	SPEED (RPM)	FEED (mm/rev)	DEPTH OF CUT (mm)	Surface Roughness (Micron)	MRR mm^3/min
1.	730	0.33	0.5	0.3	120.45
2.	730	0.24	1	8	175.2
3.	730	0.22	1.5	3.5	240.9
4.	459	0.52	0.5	1	119.34
5.	459	0.38	1	2	174.42
6.	459	0.34	1.5	1.5	234.09
7.	284	0.86	0.5	0.5	122.12
8.	284	0.625	1	3.5	177.5
9.	284	0.568	1.5	7.5	241.968

IV. CONCLUSIONS

Composite beam of E-glass fibre with composition 12 layers of glass fibre sheet, 2 portions of Resin for every 1 portion of Hardener is prepared by using hand layup method. This manufacturing process has been selected as it is easy & less expensive method for manufacturing of composite material. This method was also used in reference research papers and it shows appropriate results.

From this it can be concluded that, manufactured beam has proper bonding & cohesiveness. Testing results from Experimental methods are good, so the method used for design & manufacturing of composite beam of E-glass fibre is successful.

To investigate the surface roughness of material the surface roughness measuring test was conducted after turning of E glass fibre. From this it can be concluded that, roughness of E glass fibre was found out successfully using handy surf.

The optimization curve provided by minitab the high speed and feed value for better MRR and surface roughness.The maximum MRR value we are getting at 730 spindle speed, 0.860 Feed and 1 mm of depth of cut is about 3095 while the surface roughness value as -10 micron.

From this it can be concluded that we get optimization graph by RSM method is the for surface roughness and MRR..

Our expectation based on the correlation will be found out from the above analysis. It is suggested that response surface methodology can well be utilized for predicting the surface roughness of carbon fiber reinforced polymer composites.

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