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Optimization of Performance Parameters for En24 Alloy Steel on CNC Turning Machine Using Three Geometries of Inserts by Taguchi Method

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Abstract— EN24 Alloy Steel has a wide variety of applications in different industries. The Challenge of modern machining industries is mainly focused on achieving high quality, in term of part/component accuracy, surface finish, high production rate and increase the product life with lesser environmental impact. It is necessary to change and improve existing technology and develop product with reasonably priced. So, it is necessary control the process parameter in any manufacturing process. The typical controllable machining parameters for the CNC lathe machines are speed, feed, depth of cut, tool geometry, cutting environment, tool material, work material, etc. which affect desired output like material removal rate, surface roughness, power consumption, tool wear, vibration etc. In this paper an attempt is made to review the literature on optimizing the machining parameters in turning processes by using different tool inserts. Optimization of machining parameters and also need to determine which parameters are most significant for required output. One of the technique widely used for optimization of machining parameters is Taguchi and Grey Relational Analysis approach help to determine which parameters are most significant.
Keywords— Turning, EN24 Alloy steel, Taguchi method, Grey Relational Analysis

I. INTRODUCTION

Today, in this competitive market where material, time, quality, processes are the main factor that contributes towards profit incurred to the company. Now trend has been changed significantly from the past where only quality was considered as the main goal. But now profit and quality both are considered as main concern. Much of modern day machining is carried out by computer numerical control (CNC), in which computers are used to control the movement and operation of the mills, lathes, and other cutting machines. The aim of the industries is focussed on low cost production and high quality products in less time. It is very important now for manufacturers to enhance the efficiency of product and process, keeping the tolerances of stricter part maintained, and thus improving the quality of part. Design of experiments via Taguchi method can be used for attaining high quality at minimum cost. Also the quality obtained by means of the optimization of the product or process is found to be cost effective. Turning is one of the most basic machining operation process for material removal.

EN24 is a high quality, high tensile, alloy steel and finds its typical applications in the manufacturing of automobile and machine tool parts. Properties of EN24 steel, like low specific heat, and tendency to strain-harden and diffuse between tool and work material, give rise to certain problems in its machining such as large cutting forces, high cutting tool temperatures, poor surface finish and built-up edge formation. This material is thus difficult to machine. The purpose of metal cutting operation is commonly called machining is to produce a desired shape, size and finish of a component by removing the excess metal in the form of chips from rough block of material. Metal cutting processes in general should be carried out at high speeds and feeds with the least cutting effort at a minimum cost.

II. PROCESS AND PERFORMANCE PARAMETERS

A. Optimization Of Multiple Objective Such As

1) Surface Roughness
2) Material Removal Rate
3) Cylindricity

B. Process Parameters Such As

1) Cutting speed
2) Feed
3) Depth of cut

III. METHODOLOGY

A. *Taguchi Method*

Among the available methods, Taguchi design is one of the most powerful DOE methods for analyzing of experiments. It is widely recognized in many fields particularly in the development of new products and processes in quality control. The salient features of the method are as follows: a. A simple, efficient and systematic method to optimize product/process to improve the performance or reduce the cost.

B. *Grey Relational Analysis*

While optimizing the responses in single objective optimization, the effects of process parameters on other performances have not been considered. However, in actual practice, all the performance criteria should be optimized so as to achieve the optimum machining condition, which will provide the best results for higher productivity as well as higher reliable products in terms of higher accuracy and surface finish during machining. In grey relational analysis, experimental data that is measured features of quality characteristics of the product are first normalized ranging from zero to one this process known as normalization of grey relational result.

IV. LITERATURE SURVEY

M.Korat, et. al. [1] studied Optimization of effects of cutting parameters on surface finish and MRR of EN24/AISI4340 work material by employing Taguchi techniques. Results were obtained minimum surface roughness (SR) and maximum material removal rate for optimal cutting parameters. Krishankant, et. al. [2]investigated optimization of turning process by the effects of machining parameters applying Taguchi methods to improve the quality of manufactured goods, and engineering development of designs for studying variation. EN24 steel is used as the work piece material for carrying out the experimentation to optimize the Material Removal Rate. The MRR values measured from the experiments and their optimum value for maximum material removal rate.V. Suresh Babu, et. al.[3] studied development of an empirical second order model for the predicting the surface roughness in machining EN24 alloy steel using Response Surface Method. The experiments were conducted by varying cutting speeds, feed rates, and depths of cut under dry cutting condition. The effect of process parameters with the output variable were predicted which indicates that the highest cutting speed has significant role in producing least surface roughness followed by feed and depth of cut. The optimized parameters are verified and validated through a validation experiment, which concurs with the predicted optimal value in the design of experiment and also inline to the previous researches. R. Kumar, et. al.[4] investigated analysis the effects of input parameters such as speed (rpm), feed (mm/rev), depth of cut (mm) and nose radius (mm) on output parameter such as material removal rate and surface roughness. The experiment was performed with different combination values of input parameter. Equal weightage has been assigned to all input parameter and a (Multi attribute decision making) MADM approach then performed to find out the best result. E. Koorapati, et. al. [5] investigated the surface roughness produced during hard turning of hard chrome plated surfaces with various cutting inserts. The optimization of the surface roughness was carried out with Taguchi's Design of Experimentation technique. The results of the experimentations revealed that the hard turning operation can be extended to the hard chrome plated surfaces. Rahul Davis, et. al. [6] investigated that, optimal setting of these turning process parameters –spindle speed, feed rate and depth of cut, which may result in optimization of tool life of Carbide P-30 cutting tool in turning En24 steel (0.4 % C). Turning operations were performed by Carbide P-30 cutting tool under various dry cutting conditions by using sample specimens of EN-24 steel. The results depict that Spindle speed followed by feed rate and depth of cut was the combination of the optimal levels of factors that significantly affects the mean and variance of the tool life of the carbide cutting tool and gives the optimum tool life. M. Adinarayana, et. al.[7] investigated the study to optimize the effects of process variables on surface roughness, MRR and power consumption of En24 of work material using PVD coated tool. In the present investigation the influence of spindle speed, feed rate, and depth of cut were studied as process parameters. The optimal cutting parameters for minimum surface roughness, maximum MRR and minimum power consumption were obtained using Taguchi technique. The contribution of various process parameters on response variables have been found by using ANOVA technique. S. R. Das, et. al.[8] have explored evaluate the performance of multilayer coated carbide inserts during dry turning of hardened EN24 steel (47 HRC). The effect of machining parameters (depth of cut, feed and cutting speed) on surface roughness parameters (Ra and Rz) were investigated by applying ANOVA. Results showed that surface roughness parameters (Ra and Rz) are mainly influenced by feed and cutting speed, whereas depth of cut exhibits minimum influence on surface roughness (Rz) and negligible influence in case of surface roughness (Ra). Hari Singh, et. al.[9] have found in this paper is to obtain an optimal setting of turning process parameters (cutting speed, feed rate and depth of cut) resulting in an optimal value of the feed force when machining EN24 steel with TiC-coated tungsten carbide inserts. The results indicate that the selected process parameters significantly affect the selected machining characteristics. Hari Singh, [10] have investigated that optimal setting of turning process parameters –cutting speed, feed and depth of cut, which may result in optimizing tool life of Ti coated carbide inserts while turning En24 steel (0.4 % C). The percent contributions of parameters as quantified in the S/N pooled ANOVA envisage that the relative power of feed (8.78 %) in controlling variation and mean tool life is significantly smaller than that of the cutting speed (34.89 %) and depth of cut (25.80 %). The predicted optimum tool life is 20.19 min. Umesh Gupta et. al.[11] investigated surface roughness in turning of EN24 material with process parameters cutting speed, feed, depth of cut using single level PVD coated and triple level CVD coated insert by using RSM methodology. The experimental results indicated that the Feed is the most significant factor affecting the surface roughness one followed by cutting speed with depth of cut to be the least one. Puneet saini et. al.[12] investigated optimization of surface roughness and MRR in turning of EN24 material with process parameters spindle speed, feed, depth of cut using Response surface methodology . Through multi response optimization the optimum value of the surface roughness (Ra) 1.46389 µm and for MRR is 403.458 mm3/sec. It is also concluded that feed rate & depth of cut are the major significant factor affecting surface roughness & MRR. Amit Aherwar et. al[13] found that stastitical and regression analysis of vibration of cutting tool in turning of EN24 with process parameters cutting speed, feed, depth of cut. From experimental results, the amplitude of vibration of the cutting tool was ascertaining for each machining performance criteria. It has been observed that cutting speed has a maximum contribution on cutting tool vibration in both the directions. Confirmation runs demonstrates that the optimized result and the values obtained through regression analysis are within the prescribed limit. Jakhale Prashant P. et. al. [14] investigated surface roughness in turning of alloy steel (EN24) with with process parameters cutting speed, feed, depth of cut using three insert geometries. The results shows that highest surface finish (lowest Ra) is obtained at a cutting speed of 100 m/min, feed rate of 0.24 mm/revolutions and a depth of cut of 1mm. and Best surface roughness at high cutting speed(i.e 150 m/min) is obtained from DNMG (12 06 08) insert than other two type of insert. Rahul Davis et. al. [15] have investigated that optimization of surface roughness with cutting parameters spindle speed, feed and depth of cut in turning of EN24 material using ANOVA. As a result of the analysis none of the factor was found to be significant. Taguchi method has shown that feed rate followed by Spindle speed and depth of cut was the combination of the optimal levels of factors while turning EN24 steel by carbide cutting tool in dry cutting condition. M. Adinarayna et. al. [16] investigated optimization of power consumption, MRR, surface roughness in turning of EN24 spindle speed, feed, depth of cut using genetic algorithm. The results shows that the assigned weights to the objective function shows insignificant by entrophy method. Rahul Davis et. al. [17] investigated surface finish in turning of EN24 Alloy steel spindle speed, feed, depth of cut using carbide P-30 cutting tool. The results of the analysis show that none of the factors was found to be significant. Taguchi method showed that feed rate followed by depth of cut and spindle speed was the combination of the optimal levels of factors while turning EN24 steel by carbide cutting tool. Sandip Malik et. al. [18] investigated surface finish, MRR, and cutting rate in W-EDM of EN24 alloy steel using tungsten carbide tool. The study demonstrates that the WEDM process parameters can be adjusted so as to achieve better metal removal rate, surface finish, electrode wear rate.

TABLE I

YEAR	AUTHOR NAME	MATERIAL	PROCESS PARAMETER	PERFORMANCE PARAMETER	METHODOLOGY	Orthogonal Array	SIGNIFICANT FACTOR
2012	M. Korat, Neeraj Agrawal	EN24	Cutting Environment, Cutting speed, Feed, Depth of Cut, Nose Radius	MRR, Surface Roughness	Taguchi	L18	Nose Radius
2012	Krishankant, Jatin Taneja, Mohit Bector, Rajesh Kumar	EN24	Spindle speed, Feed, Depth of Cut	MRR	Taguchi	L9	Feed
2011	V. Suresh Babu, S. Sriram Kumar, R. V. Murali, M. Madhava Rao	EN24	Cutting speed, Feed, Depth of Cut, Nose Radius	Surface Roughness	Response Surface methodology	L18	Feed

2013	Raman Kumar, Jaspreet Singh Rai, Navneet Singh Virk	EN24	Spindle speed, Feed, Depth of Cut, Nose Radius	MRR, Surface Roughness	MADM (Multi attribute decision making)	L9	Cutting speed
2013	Eshwara Prasad Koorapati, Mohandas K N, Ramesh C S, Balashanmugam N	EN24	Cutting speed, Feed, Depth of Cut	Surface Roughness	Taguchi	L9	Feed
2012	Rahul Davis , Jitendra Singh Madhukar	EN24	Spindle speed, Feed, Depth of Cut	Tool Life	Taguchi	L9	Depth of cut
2013	M. Adinarayana, G. Prasanthi, G. Krishnaiah	EN24	cutting speed, Feed, Depth of Cut, Power consumption	Surface Roughness, MRR, Power consumption	Taguchi	L27	Surface roughness-Feed, MRR-cutting speed, , Power consumption- cutting speed
2013	Sudhansu Ranjan Das, Amaresh Kumar, Debabrata Dhupal, Kali Charan Rath	EN24	cutting speed, Feed, Depth of Cut	Surface Roughness	Taguchi	L27	Feed
2006	HARI SINGH and PRADEEP KUMAR	EN24	cutting speed, Feed, Depth of Cut	Feed force	Taguchi	L27	Depth of Cut
2008	HARI SINGH	EN24	cutting speed, Feed, Depth of Cut	Tool life	Taguchi	L27	Cutting Speed
2014	Umesh Gupta, Amit Kohali	EN24	Cutting Environment, Cutting speed, Feed, Depth of Cut	Surface Roughness	RSM	L20	Feed
2014	Puneet Saini , Shanti Parkash	EN24	Cutting speed, Feed, Depth of Cut	Surface Roughness, MRR	RSM	L18	Surface Roughness-Feed, MRR-Depth of cut
2014	Amit Aherwar, Deepak Unune, BhargavPathri, Jai kishan	EN24	Cutting speed, Feed, Depth of Cut	vibration of cutting tool	RSM	L9	vibration level of cutting tool-Cutting speed

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2013	Jakhale Prashant P, Jadhav B. R.	EN24	Cutting speed, Feed, Depth of Cut	Surface Roughness	Taguchi	L9	Depth of cut
2012	Rahul Davis, Jitendra Singh Madhukar, Vikash Singh Rana, Prince Singh	EN24	Spindle speed, Feed, Depth of Cut	Surface Roughness	Taguchi	L18	Depth of cut
2014	M Adinarayana, G Prasanth and G Krishnaiah	EN24	Spindle speed, Feed, Depth of Cut	Surface Roughness, MRR, Power consumption	Genetic Algorith m	L27	Feed
2014	Rahul Davis, Vikrant Singh, Shaluza Priyanka	EN24	Spindle speed, Feed, Depth of Cut	Surface Roughness	Taguchi	L9	Spindle speed
2013	Sandeep Malik Dr. Vineet Singla	EN24	Cutting speed, Feed, Depth of Cut	Surface Roughness, MRR,	Grey Relationa l analysis	L9	Cutting speed

V. CONCLUSION

From the above literature review we found that most of the researcher have taken input parameters (controllable factors): speed (18 research papers out of 18 mentioned above research cases), feed (18/18) and depth of cut (18/18) and only few researcher taken input parameter: nose radius (3/18), environment (1/18) and output parameters: Surface roughness for turning (13/18), few researcher taken output parameter: material removal rate (7/18) We also found that for surface roughness the most significant parameters are speed, feed and nose radius and least significant parameter is DOC and for MRR the most significant parameters are DOC, feed and speed and least significant parameter is nose radius.

VI. FUTURE SCOPE

Material EN24 is widely used in industries for the different application e.g. uses for checkered plates, nuts & bolts, studs, shafts storage tanks, beams, channels, angles, hydraulic press rugged structures, washers, pipes & tubes, air receivers etc. and few worked on quality parameters like MRR, surface roughness for facing, power consumption, geometric tolerance like circularity, cylindricity, perpendicularity, etc. Taguchi approach help to determine optimal parameter condition for required output with help of lesser number of experiment (with help Orthogonal Array) & ANOVA approach help to determine which parameters is most significant. Simultaneously, multi objective optimization methods help to determine optimal parameter condition for all outputs with help of lesser number of experiment (with help Orthogonal Array)

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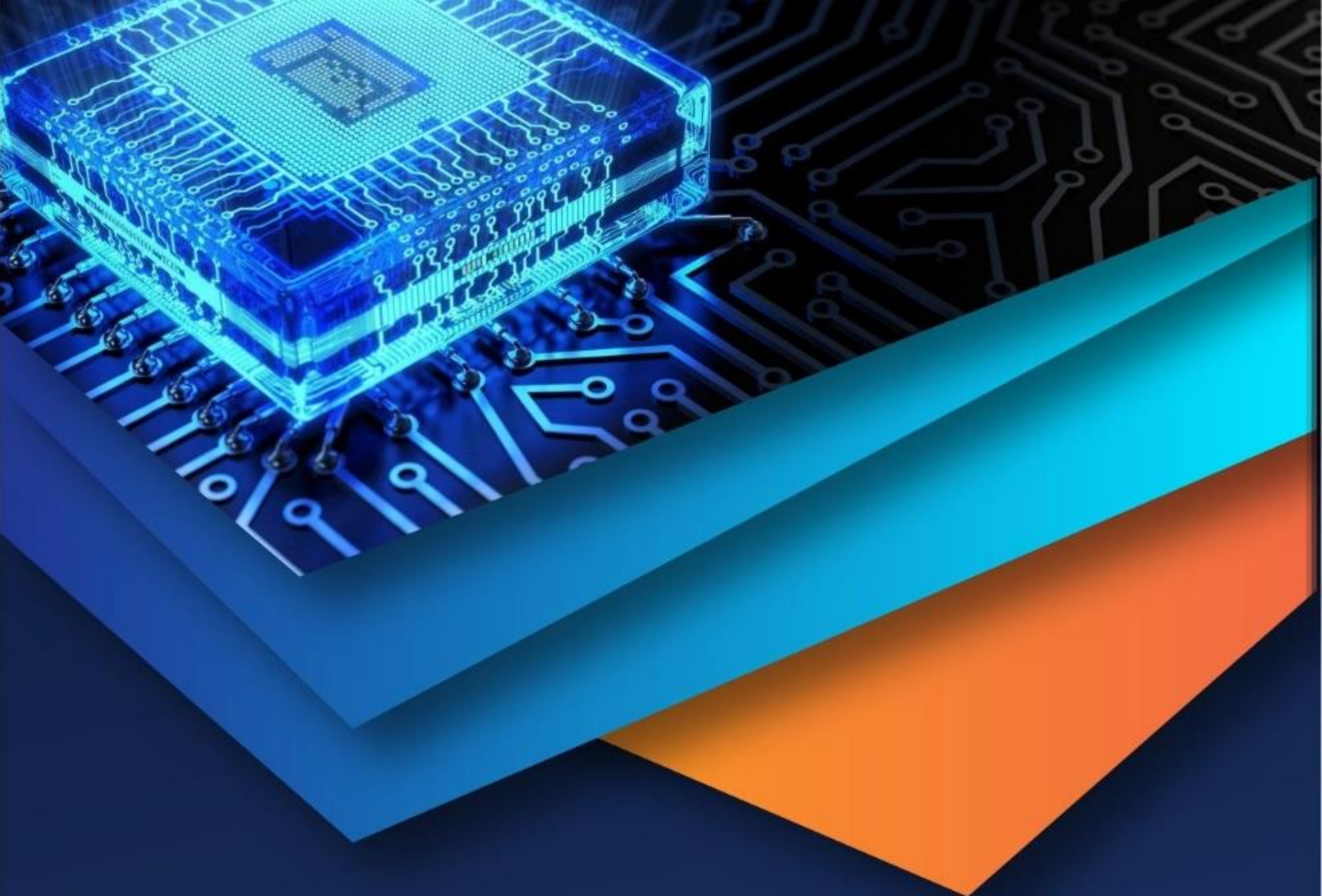

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