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Process Optimization for Turning Operation - a Review

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Abstract: **-- This dissertation work shall focus on the unique response -Residual Stress - found upon turning the workpiece using CNC turning center. The material chosen is EN353, which is used in Automobile applications like shafts & gears, where the case of the part is expected to be hard while the core should stay soft to offer toughness during shock loading. The research shall be performed upon identifying fundamental machining parameters that influences this response. Statistical techniques shall be used to determine the optimal settings for the given parameters. The experiment shall be performed at a suitable facility and the optimal results shall be validated through experimentation. The residual stresses are being considered to be measured using `Hole Drilling Method' or a suitable technique at the test lab. The objective of the work shall be to optimize the parameters in order to realize reduced level of residual stress while maintaining the rate of production for the given component.**

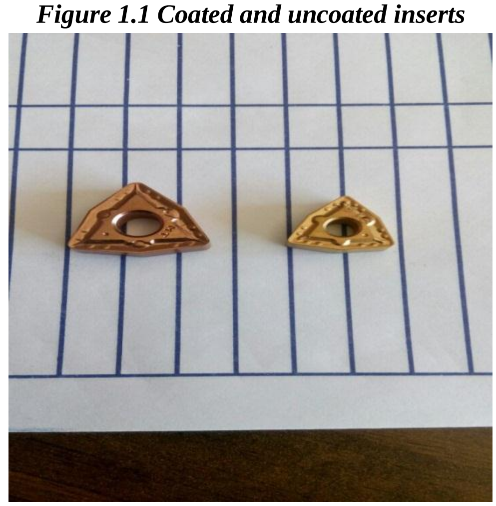
Keywords- **CNC turning, Speed, Feed, Depth of cut, Residual Stress, Optimization, Process parameters, Statistica treatment1.**

1.INTRODUCTION

Machining industries continuously demanding for higher production rate and improved machinability as quality, and productivity play significant role in today's manufacturing market. The extent of quality of the procured item (or product) influences the degree of satisfaction of the consumers during the usage of the procured goods. Higher production rate can be achieved at high cutting speed, feed, depth of cut which is limited by tool wear, capability of tooling, surface finish and accuracy required selection of cutting parameters is generally a compromise between several variables and it can be easily possible to determine by using response surface methodology. .

CNC machines are commonly used in industry. The operation of this machine is expensive because it has many parameters to consider. Optimization of cutting parameters are usually difficult work where the following aspects are required, knowledge of machining, empirical equations relating forces, power, surface finish, and dimensional accuracy etc. The productivity enhancement of manufacturing processes imposes the acceleration of the design and evolution of improved cutting tools with respect to the achievement of a superior tribological attainment and wear-resistance. Today the majority of ceramic cutting tools are in use employ with chemical vapor deposition (CVD) or physical vapor deposition (PVD) hard coatings. The high hardness, wear resistance and chemical stability of these coatings offer proven benefits in terms of tool life and machining performance. The first technique is the CVD. This method deposits thin films on the cutting tools through various chemical reactions. Most tool coatings were traditionally deposited using the CVD technique until the recent development of PVD. This method deposits thin films on the cutting tools through physical techniques, mainly sputtering and evaporation. The reason PVD is becoming increasingly favorable over CVD is the fact that the coating process occurs under much lower temperature. The high temperature during the CVD process causes deformation and softening of many cutting tool substrates and especially high speed steel. Another advantage of applying the PVD technique is the ability to deposit much thinner films. And so, it is much more promising for the deposition of multi-layered coatings, which have been found to reduce wear considerably.

Figure 1.1 Coated and uncoated inserts



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The use of coolant to increase tool life has been an issue with different views. However, environmental and economic considerations of developed countries led to implementation of dry machining.

Today, there are two obvious trends in cutting tool developments. Dry machining is desirable to avoid the extra costs and environmental problems associated to cutting fluids. High speed machining of hardened steel has the potential of giving sufficiently high quality of the machined surface to make finishing operations such as grinding and polishing unnecessary. Both cases tend to intensify the heat generation along the tool surfaces, and consequently the tools must possess further improved, thermal and chemical stability. A general theory covering all relevant properties and parameters involved in the design and application of tribological coating composites is very far from being realized. Such a theory would have to treat the long chain of relations ranging from the coating deposition parameters to the tribological response of the coated components.

2. LITERATURE REVIEW

The literature review focuses on study done on related journal papers and articles. The literature covers the turning process related to input parameters and machining parameters on output response parameters using optimization techniques.

Tian-Syung Lan et.al.[1] elaborate a competitive optimization approach using orthogonal array. Cutting depth, feed rate, speed, and tool nose runoff with three levels of each. The surface roughness (Ra) and tool wear ratio (2mm) are primarily observed as independent objectives for developing two combinations of optimum single-objective cutting parameters.Further the levels of competitive orthogonal array are then proposed between the two parameter sets. Therefore, the optimum competitive multi-quality cutting parameters can be achieved.It shows that MRR and Tool wear ratio are advanced but with minor decrease in surface roughness. Taguchi method was applied for the analysing result.L9 orthogonal array was used.

Mahendra Korat et.al.[2]investigated the effect of process parameters on surface finish and MRR of EN24. Speed, Feed, Depth of cut, Nose radius, Cutting environment (wet and dry) were choosen as input parameters for the experimental work with three levels of 4 parameters and 2 cutting environment conditions and L18 orthogonal array was choosen.Result showed showed that nose radius has the greatest effect on surface roughness and is followed by feed, depth of cut, cutting speed and coolant condition in that order.

R.Saravanan et.al.[3] explores the various optimization procedure for solving the CNC turning problem to find the optimum operating parameters such as cutting speed and feedrate.Objective is total production time considering cutting force, power, tool–chip interface temperature and surface roughness of the product. Conventional and non-conventional optimisation techniques and procedure are used. Their results are compared. It is observed that a BSP is able to find the exact answer, but it is not flexible enough to include more variables and equations. The results obtained by SA are comparable with the BSP and the flexibility of the method needs further investigation. The Nelder Mead SA deviates from the boundary search method by 1%–3%, but with simple modification it can be extended to other machining problems by including one more variable. The Genetic Algorithm(GA) method also deviates from boundary search method by 1%–3%, but by adopting a suitable coding system, it can be used to solve any type of machining optimisation problem such as milling, cylindrical grinding, surface grinding, etc.

H.Ganesan et.al. [4] paper presents a multi-objective optimization technique, based on genetic algorithms, to optimize the cutting parameters in turning processes.For this work objective functions, minimum operating time and minimum production cost and minimum tool wear are simultaneously optimized. Optimal time of 3.135 min and minimum cost of 1.569rs and minimum tool wear of 0.487 for each iteration of GA. Optimum cutting parameters were obtained as speed of 1254.762 rpm and feed 0.375 mm/rev and depth of cut 0.51 mm.

Sachin C Borse[5] confabulate the optimization of surface roughness and MRR in dry turning of SAE52100 steel with carbide inserts.Input parameters were taken as speed,feed,depth of cut. Design of experiments was done with Taguchi approach and L9 orthogonal array was selected.For Ra cutting speed is dominant factor.Increase in feed rate there is increase in Ra value.Increase in speed there is decrease in Ra value due to higher cutting

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temperature made the material ahead of tool soffer and plastic.MRR improves as cutting speed and feed rate is kept at higher level.

Sanjay Kajal et.al.[6] used design of experiments to study the effect of turning parameters on surface roughnessof EN 351 steel.Mathematical predication model of the surface roughness had been developed in terms feed, cutting speed, and depth of cut of single point cutting tool.Results showed that speed increases Ra also increases but feed decreases Ra decreases. But in the case of depth of cut, it increases with increase in surface roughness values.Optimized factor for minimizing surface roughness Ra is feed rate f1=0.1mm/rev, cutting speed,V3=225m/min, depth of cut d3=1.5mm.

Waleed Bin Rashid et.al. [7] provided the experimental results on turning of AISI 4340 steel (69 HRC) using a carbide boron nitrate cutting tool. An orthogonal array was implemented using a set of judiciously chosen cutting parameters. Subsequently, the longitudinal turning trials were carried out in accordance with a well-designed full factorial based Taguchi matrix. The speculation indeed proved correct as a mirror finished optical quality machined surface (an average surface roughness value of 45 nm) was achieved by the conventional cutting method using a carbide boron nitrate(CBN) cutting tool. The design of experiment using Taguchi's approach can be used to evaluate the effect of control parameters for parameter optimization. Taguchi's approach allows the study of the whole parameter space with a limited number of experiments, as long as they were carried out in a planned orthogonal array. This methodology helps reduce the variability of the response variable and is therefore an important tool for improving the productivity of the experiments.

Harish Kumar et.al. [8] performed effect of input parameters for improvement of quality of the product of turning operation on CNC machine. Feed Rate, Spindle speed & depth of cut are taken as the input parameters and the dimensional tolerances as output parameter. L9 Array has been used in design of experiment. Taguchi approch gives us the optimal parameters in the CNC turning process using High Speed Steel cutting tools the optimum set of speed, feed rate and depth of cut .The most affecting parameters having the impact of 59.9% is speed and it is most dominant factor.

Vaibhav Joshi et.al. [9] investigated to study the effect of machining parameters on tool wear and surface roughness for turning of VT-20 (titanium wrought alloy).Experiments were carried as per L9 orthogonal array.Cutting parameters were taken as speed,feed rate and depth of cut were taken as inputs and machining was done by CNMG 120408 insert. speed is the most significant controlled parameter for the CNC turning operation followed by feed, and depth of cut with minimization of tool wear and surface roughness.Optimal combinations were found to be A1 (Speed 250 m/min), B1 (0.5 mm) and C3 (Feed 0.25 mm/rev).

Errors between experimental and predicted values were found within a range of ±0.20.For optimal setting tool wear was found to be 0.0531 µm and Ra of 0.3157 µm.

Poornima et.al. [10] studied the effect of cutting parameters for CNC turning of martensitic stainless steel.Response surface methodology(RSM) and genetic algorithm(GA) were used for optimization. The surface quality of the machined parts is the value of surface roughness or the waviness are mainly decided by the three factors speed, feed and depth of cut beyond the levels influenced by the other factors. The results obtained from RSM are R-Sq obtained was 99.9% which indicates that selected parameters significantly affect the response. The best ranges obtained by using the genetic algorithm approach are cutting velocity (speed) -119.93 m/min, Feed-0.15 m/min and Depth of cut -0.5mm. Hence the Optimal surface roughness from GA is 0.74 microns.

Shunmugeshet.al.[11]investigated machining process in turning of 11SMn30 using carbide tip insert under dry conditions.Material selected was alloy of magnesium and zinc. Experiment was carried out using three input parameters namely cutting speed, feed rate and depth of cut. The output parameters were surface roughness of Ra and Rz value.The most dominant factor affecting the surface roughness was feed rate. Optimum factors for minimizing surface roughness Ra and Rz is feed rate f1=0.1mm/rev, Cutting speed, V3=225m/min, Depth of Cut d3=1.5mm. The optimum values for surface roughness Ra and Rz is found to be 1.854 µm and 12.899 µm respectively.

Krupal Pawar et.al [12] studied optimization of process parameters in CNC turning operation.This literature described dry optimization techniques and the literature

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review for the influence of CNC turning parameters of surface roughness as well as other replication variable.Described the soft computing techniques such as taguchi method,Artifical Neural Network,Genetic algorithm,Fuzzy Logic and simulated annealing applications and principal analysis techniques for the turning operation is also described.

P.Tamil Arasu et.al[13] elaborated the machining process parameters on EN353.This literature gives the description about the hardness after heat treatment on EN353.Heat treatment is carried to make the soft materail austenite to hard material martensite .The aim of this paper is to examine the hardness, X-ray diffractometer and effect of microstructure of before and after heat treatment on En 353 steel. It is found that the hardness of the En 353 steel is improved after the heat treatment.

3. SUMMARY OF LITERATURE REVIEW

During the literature survey it was observed from researchers that they studied the influence of various process parameters cutting speed, feed rate, depth of cut, inclination angle, cutting fluid pressure, machining time, chip thickness, nose radius, tool diameter, tool age roughness during machining are investigated. Investigation of response parameters viz. cutting forces, surface roughness, burr formation, material removal rate, tool wear, chip morphology, delamination damage, chip flow, residual stress, micro-hardness and cutting temperature. The workpiece material are machined by using carbide insert, end milling tool, D20 coated carbide ball inserts, bore end mill tool, Tread mill tool, k10 carbide end mill cutter, Ti[C7N3] based cermet micro-end mill tool, Tungsten carbide tool, TiAlN coated solid carbide end mill, F40M composite coating inserts.From the literature review it was observed that, turning process parameter optimization of different statistical methods such as Taguchi method, Artificial neural networking, ANOVA analysis, Response surface methodology, Regression analysis, full factorial design are used. The efficiency of the operation given the variables like speed, feed and depth of cut shall be investigated to offer optimum settings for realizing high rate of material removal or to offer a good surface finish. The study would benefit the industry in realizing higher productivity with a better quality product while minimizing the operating cost in terms of number of spares for tool inserts.

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