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Few Aspects in Hard Turning Process

B.Purna Chandra Sekhar[1*], K.Srinivas[2], S.Radhika[3]
[1]Dept. of ME, ANU College of Engineering & Technology, Guntur, AP, India.
[2,3]Dept. of ME, RVR&JC College of Engineering, Guntur, AP, India.
[3]Third Company, Affiliation, Address etc.

[*]Corresponding author- csboyapati29@yahoo.com

Abstract

Hard turning is the process of machining hardened steels that are above 45HRC. In manufacturing, hard turning has emerged as a potential area because of its many advantages over grinding as a finishing operation. Besides many advantages of hard turning operation, one has to implement to achieve close tolerances in terms of surface finish, high product quality, reduced machining time, low operating cost and environmental friendly characteristics. Taguchi method is a powerful tool to design optimization for quality. It is used to find the optimal cutting parameters such as cutting speed, feed rate, depth of cut and nose radius as the overall cost can be reduced. The present study predominantly focuses on the usage of Taguchi's method in hard turning.

Keywords: Machining Materials, Mechanical alloying, response surface method, Taguchi method, hard turning

Introduction

Manufacturing sector is still hesitant to implement fast and economically hard turning technology compared to slow and costly grinding. The process of turning hardened steels within a range of 45–68 HRC with a variety of tipped tools is called hard turning. Machining is quiet popular manufacturing process in manufacturing sector of high precision distinct metal parts. Figure 1 describes the difference between hard turning and conventional machining. With advent of new kind of tools such as Cubic Boron Nitride (CBN), Polycrystalline Cubic Boron Nitride (PCBN), poly-crystalline diamond (PCD), coated, Chemical Vapor Deposition (CVD), Physical Vapor Deposition (PVD) and ceramic tools, better surface finish will be accessible without any finishing and complementary operation such as grinding.

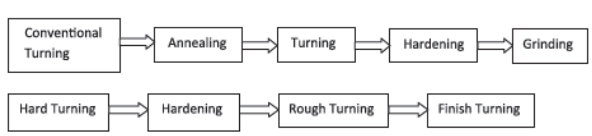

Fig1. Comparison of conventional machining and hard turning[13]

Turning of hardened steels into finished parts by eliminating intermediate machining and reducing grinding processes has been a cost effective method for manufacturing high quality automotive components [1]. Besides, hard turning is flexible, environment friendly and higher output substitute to cylindrical grinding. However, surface quality and process reliability is still considered not on par with grinding processes, due to issues related to different geometrically defined cutting tools [2]. Figure 2 depicts the factors that influence hard turning process. To optimize the tooling cost, ceramic cutting tools are right candidates for light and continuous cutting. Geometry of the insert also has major influence upon the surface integrity, single point cutting tool gives uniform micro structural changes compared to grinding as this will increase functional performance of the product. Hence correct tool geometry must be selected for a given application or may produce subsurface damage and high tensile residual stresses on the surface of the machined work piece [2, 3, 4 and 5]. Generation of heat during hard turning and heat dissipation along the insert corner is also affected by geometry due to change in work material flow around the cutting edge [3].

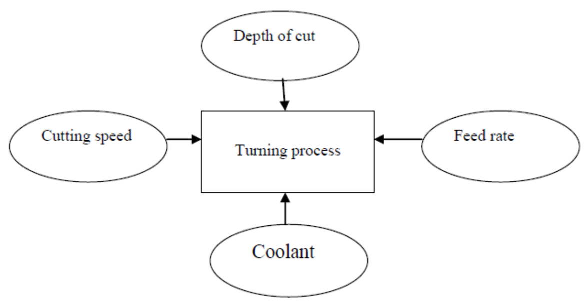

Fig 2. Factors affecting the turning process

Few works related to Taguchi method

Dr. Genichi Taguchi, a Japanese engineer, developed a new method that is known as Orthogonal array design, which adds a new dimension to conventional experimental design. Taguchi method is a broadly accepted method of DOE which has proven to produce high quality products at subsequently low cost. Although similar to DOE, the Taguchi design only conducts the balanced (orthogonal) experimental combinations, which makes the Taguchi design even more effective than a fractional factorial design. Taguchi proposed that engineering optimization of a process or product should be carried out in a three-step approach namely system design, parameter design and tolerance design. In system design, the engineer applies scientific and engineering knowledge to produce a basic functional prototype design. According to the Ross et al. [6] the objective of the parameter design is to optimize the settings of the process parameter values for improving performance characteristics and to identify the product parameter values under the optimal process parameter values. The steps included in the Taguchi parameter design are: selecting the proper Orthogonal Array (OA) according to the number of controllable factors (parameters); running experiments based on the OA; analyzing data; identifying the optimum condition; and conducting confirmation runs with the optimal levels of all the parameters [7]. The main effects indicate the general trend of influence of each parameter.

Knowledge of the contribution of individual parameters is the key to decide the nature of the control to be established on a production process. ANOVA is the statistical treatment most commonly applied to the results of the experiments to determine the percentage contribution of each parameter against a stated level of confidence [6]. According to Roy et al. [8] Taguchi suggests two different routes for carrying out the complete analysis. In the standard approach, the results of a single run or the average of repetitive runs are processed through the main effect and ANOVA (raw data analysis). The second approach, which Taguchi strongly recommends for multiple runs is to use the Signal-to-Noise (S/N) ratio for the same steps in the analysis. The Grey system theory proposed by Deng et al. [9] has been proven to be useful for dealing with poor, incomplete and uncertain information. An advantage of the Taguchi method is that it emphasizes a mean performance characteristic value close to the target value rather than a value within certain specific limits, thus improving the product quality. Additionally, Taguchi's method can be used to quickly narrow the scope of project or to identify problems in a manufacturing process from data already in existence Fraley et al. [10]. There have been many research contributions and several books explaining and reviewing Taguchi's ideas [11, 12]. Most of these, however, have not adequately captured the diverse views on the topic. In particular, the Taguchi methodology has not been well represented in statistical journals.

In the work of Dureja and Bhatti [13] Taguchi L9 orthogonal array has been applied for experimental design. S/N ratio and ANNOVA analysis were performed on D3 steel to identify significant parameters influencing tool wear and surface roughness. Results signify the cutting speed to be the most significant factor influencing flank wear. In [14] the influence of cutting parameters on cutting force and surface finish in turning operations. The authors used work material of 1050 steel (hardness of 484 HV) with tool made of ceramic with an Al203 + Tic matrix (KY1615) . Feed rate was found to be the most significant parameter for surface roughness in the work of [15] in which evaluation of dry turning of inconel718 using carbide inserts was done using Taguchi's L9 array.

Mahamani used Taguchi method to optimize the machining parameters. The influence of process parameters on cutting force and surface roughness during turning of AA2219-TiB2/ZrB2 In situ metal matrix composites was done. L27 orthogonal layout was used for experimentation [16]. The response graph and analysis of variance shows that feed rate has strongest effect on surface roughness and cutting force. Shreemoy et al in their work [17] have done multi objective optimization of machining parameters during dry turning of IASI 304 Austenite stainless steel. Three imp characteristics MRR, cutting force and surface roughness were measured. Same time in [18] Design of experiment was done to optimize the turning parameters like cutting speed, depth of cut and feed of duplex steel. Duplex steels during machining are generally prone to mechanical strengthening Feed rate and cutting speed have statistically significant effect on surface roughness parameters Ra, Rz where increase of factors effect increase surface roughness but then feed rate is set to level 0.1 mm/rev factor cutting speed has smaller effect.

The work of Chandrasekaran [19] used Taguchi method for studying the macinability of AISI 410 on CNC lathe for surface roughness.L27 orthogonal array , analysis of variance are used in this investigation. Aditya Kulkarni et al. [20] investigated the optimum value of power consumption with considering various parameters. In this optimization method used is taguchi method and ANOVA result shows that increase in cutting fluid consideration level from 3% to 9% resulted significantly decrease in power consumption.

Ilhan Asilturk et al. [21] have studied cutting parameter for machining of co28cr6mo medical material. In this method used is taguchi and RSM. It is found that ANNOVA can be reliably used in RSM and taguchi orthogonal array design model and theoretical studies that will be conducted in future. D. Manivel et al.[22] have studied optimization of surface roughness and tool wear in hard turning of austempered ductile iron (grade 3). The method used is taguchi method. In this work, it was found that the taguchi method was successfully used in reduction of production cost and production time in turning of ADI. In future other could be considered like different coating material, lubricant and cutting tool geometry, all these factors would effect on the surface roughness and tool wear. Sujit Kumar Jha et al. [23] investigated that various parameters for turning operation on CNC of aluminum. The method used is taguchi method. It was found that the material removal rate is mainly affected by cutting speed, depth of cut and feed rate, by increasing any one the material removal rate is increased. Milan kumar das et al. [24] have studied that optimization for response variables like MRR and surface roughness of EN 31 steel in plasma arc cutting. Method used is weighted principal component analysis. The test insures the improvement of S/N ratio from initial to optimal condition and improvement is 54%. From the study it can be concluded that the proposed methodology can be treated as a very effective and powerful approach to tackle multiple response problem in industrial experiments.

Conclusions

Currently, hard turning is of high interest for academicians and researchers and it is the best option for replacement of grinding process in many cases as the hard turning process is more economical than grinding. The hard turning process is essentially a high speed, low feed and low depth of cut finishing process. The cutting speeds, as reported in various works, range between 100 and 250 m/min [25–31]. In order to establish the correct combination of input parameters, trial experiments are to be performed which consume lots of time and manufacturing cost. Multiple hard turning operations may be performed in a single setup rather than multiple grinding setups thus reduces the production cost. The tool life shortens with increasing cutting speed and feed. Different combinations of workpiece and tool material have to be investigated to find the optimal feed and speed ranges for machining.

Same time, Taguchi method is one of the most effective systems of offline quality control system. Taguchi method is used where the quality is improved at the design stage instead of controlling it at the manufacturing stage. A customer usually considers several correlated quality characteristics of a product. The main disadvantage of the Taguchi method is that the results obtained are only relative and do not exactly indicate what parameter has the highest effect on the performance characteristic value. Also, since orthogonal arrays do not test all parameter combinations, this method should not be used with all relationships between all parameters. Taguchi method has been criticized in the literature for its difficulty in accounting for interactions between parameters. Another limitation is that the Taguchi methods are offline, and therefore inappropriate for a dynamically changing process such as a simulation study.

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