

Optimization of Turning Parameters Using Taguchi and ANOVA Method- A Review

1Aditya Raj, 2R P Singh

1Research scholar, 2Asst. Professor

1Institute of professional studies college of Technology and management , gwalior,

2Institute of professional studies college of Technology and management , gwalior

Abstract - In This research work, literature review was done to understand the effects of various parameters involved in turning operation on Lathe machine. Effects of rotational speed (Wr), Depth of cut (Dc) and feed rate on the surface conditions/roughness of the specimen were studied from the work of different researches carried out in this domain. How taguchi method, and Analysis of variance have been used by previous researchers, a detailed study was done for that.

keywords - Turning, Lathe, Depth of cut, feed rate, Cutting speed, Taguchi, ANOVA

INTRODUCTION

It is a well known fact that machining is a shaping process of great importance having wide range of applications. In modern day automated system, machining can play a significant role to reduce production time and capital investment. One of the fundamental machining operation is turning which is used to produce cylindrical shapes. Generally machining is performed on lathe. In metal cutting and experimental work, turning is most commonly used operation. Turning is mainly used for reducing the diameter of the given work piece, up to a desired level of dimension, and to generate a smooth finish on the external surface of work piece metal.

Turning is one of the important machining processes in which metal cutting is done and removal takes place in the form of metal chips in order to obtain finished product having desired level of surface roughness, size and shape. The cutting tool is held in tool post and moved longitudinally along the axis of specimen at a constant rate and specimen is rotated, resulting in the removal of metal layers to form a cylindrical surface. Moreover, turning is also used to as secondary process to improve surface finish and quality for a product obtained from primary process like extrusion, casting or drawing process. With the help of single point cutting tool, turning can generates shapes having axial symmetry. Basically a single-point cutting tool has one cutting edge for metal removal. In most of the cases the cutting tool is held in a fixed position while work piece is rotated rotating about a turning axis. It means we can say due to relative motion between cutting tool and work piece, process of turning is performed. Workpiece is mounted in the chuck which is driven by an electric motor. In this industrial age, importance of turning operation has increased. The main aim manufacturing industries is to minimize the cost and increase the quality of machined product. If machining time can be reduced than machining efficiency increases, which is possible by high speed machining. An important characteristic of turning operation to measure speed of machining is, material removal rate and a high value of MRR is always better. Therefore, proper and systematic use of experimental and statistical models can help to optimize the process parameters. Dr.Taguchi developed design of experiments (DOE) for analyzing high quality systems at a reasonable cost of Optimization for a single response results. Practically, while addressing a real life engineering problem, it becomes necessary to analyze the use of multi response optimization technique, This is because of the fact that performance of any manufactured products is often a mixed result of multiple quality characteristics.

The main challenge for the engineers is to determine optimal parameters for desired output by the proper use of available resources. It is a difficult task to identify and design appropriate parameters affecting the desired output. A lot depends on the experience of researcher and the data provided by the designer of machine tool. Therefore, need of optimization arises due to economic factors and quality of product to be obtained. Taguchi's method is one of the best method to improve quality and identify the contribution of every factor affecting it. The primary objective of taguchi's design is that product can perform well even in the presence of noise.

LITERATURE REVIEW

Extensive literature survey is required to understand the work done by previous researchers. It helps to build a framework of the undergoing project. No research is complete if due credit is not given to the esteemed researchers in a particular domain. Main highlights of literature reviews are as follows:

Taguchi technique was used by **Chandrakanth P ,Reddy Pk (2017)** on turning parameters of inconel 625 (super alloy) for Optimizing of high speed turning parameters. It was found by them that this super alloy finds great applications in the field of automobile industry as well as aerospace industry. Therefore, proper knowledge of their machinability at higher speeds of cutting is required, which is limited so far. Moreover, adequate amount of research has not been carried out for optimization of process conditions in order to improve quality of machinability.

Govindan P and Vipindas M P, (2014) investigated machining parameters of different processes for improving efficiencies by reducing the time and cost of manufacturing processes in accordance with optimization of economic model. Products and process were designed in such a way that variations in variables of noise had no impact on quality. It was found by researchers that uses of in experimental design was straightforward and very easy to apply for different engineering applications, which makes it a powerful tool beside its simplicity. Secondary data can act as a source to detect problems in manufacturing process by the proper use of Taguchi method. With its help key parameters affecting performance can be identified so that further experimental work can be carried out where parameters having insignificant effects can be neglected. Now a days, several other techniques are being used for optimization like Scatter diagram, Response surface methodology, Genetic algorithm, fuzzy logic. **Shirpurkar et al., (2012)** found that Taguchi method is most commonly used in the area of machining because it can make performance parameters insensitive to uncontrollable variables like environmental factors. In this paper author has tried to analyse Taguchi method for optimizing surface properties in turning operations. In their research work **Kopac et al. (2002)** discussed 4 machining parameters namely speed of cutting, feed rate, depth of cut and tool material in machining process of C15 E4 steel on a lathe. Orthogonal Array of L16 was used by them in Taguchi technique, it was having 2 levels and 13 was the value of degree of freedom (DOF) in the design of experiments. Cutting speed was reported as the most effective cutting parameter and it was observed by them higher the speed of cutting, better is quality of surface roughness.

R W Lanjewar, P Saha, U Datta, A J Banarjee, S Jain and S Sen (2008) discussed the use different materials of tool along with process parameters to minimize machining forces in the pre-defined range of parameters. Comparative study was done to select the parameters for turning process on AISI 304 stainless steel (austenitic) by using it in auto sharpening machine to evaluate optimum parameters of machining.

Unit cost of production was considered as objective function by **Alakesh Manna, Sandeep Salodkar (2008)** to analyse the procedure of obtaining the machining conditions involved in the turning operation. In this research, the Taguchi method one of the powerful tool in design of experiments, was also used for optimizing the cutting parameters in order to achieve better quality of surface finish as well as in the identification of the most significant parameters in the cost evaluation of turning process.

Taguchi method was used by **Krishankant et.al (2012)** in the optimization of turning process parameters like Feed rate, Spindle speed, Depth of cut in which machining was done on EN24 steel to improve material removal rate (MRR). Bars of 60 mm and diameter 44 mm were used in this research work. Experiments were conducted in such a way that variations of one parameter were investigated while other two variables were kept fixed, thus optimum value of each parameter was obtained. The Metal removal rate (MRR) was found to be the main quality characteristic. New materials are being discovered everyday by the scientists, therefore we need to develop efficient and economical machining process. It was also concluded by them that Taguchi method is a superior method for optimizing various machining parameters because it can reduce the number of experiments.

316L Stainless steel was used by **Gulhane et.al (2012)** for investigating the parameters which affect the surfaces roughness of job produced in the turning operation.

To analyse the impact of turning parameters like speed of cut, depth of cut and feed rate, design of experiments was done. This Design of experiments was conducted for analysis of the influence of turning parameters such as cutting speed, feed rate and depth of cut on surface roughness. It was revealed by them out of these three parameters, surface roughness was most significantly affected by feed rate.

Kaladhar et al. (2012) investigated Taguchi method to analyse the optimal process parameters involved in the turning of austenitic steel (AISI 304) when machining was done on CNC lathe. Tests were conducted at four different levels of feed rate, cutting speed and depth of cut. It was studied by them how these parameters influence the material removal rate (MRR) and surface roughness. The results indicated that cutting speed was most significant in the case of surface roughness which was followed by noise radius. On the other hand Material removal rate (MRR) was greatly affected by depth of cut, followed by speed of cut. **Rodrigues et al. (2012)** used high speed cutting tool for turning of mild steel, their focus was to investigate how the quality of surface finish and cutting forces proposes is affected by cutting speed, depth of cut and feed rate. Experiments were carried out on a precision centre lathe and regression analysis and analysis of variance (ANOVA) with adjusted approach were used by them for establishing a relationship between dependent variables and independent variables.

Research Gap

On the basis of literature survey done so far researcher was able to conclude that

1. Limited studies were available on the optimization of turning parameters using Taguchi and ANOVA altogether.
2. Comparative research of different materials were not available, in most of the research only three parameters have been used, while fourth parameter does not have significant presence.
3. Most of the researcher has used work-piece of mild steel and High speed steel. Use of other materials like aluminium has not been done by majority of researchers.

Conclusion

This paper discusses the application of the optimization tool (Taguchi method) in the optimization of turning operation. Conclusions drawn from this literature survey can be listed as follows:

1. Taguchi's method is more suitable in the analysis of machining operations, when compared to the the optimization approach like genetic algorithm or full factorial design.
2. Design of experiments by Taguchi's Method is easy to apply and accuracy of results is very much similar to the results obtained from other mathematical models.

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