



A COMPARATIVE ANALYSIS OF THE EFFECT OF HEAT TREATMENT & TURNING PROCESS PARAMETERS ON EN 19 – A Review

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Abstract — This paper provides an insight to the effect of cutting parameters on surface roughness, material removal rate & temperature for turning operation. Turning operation is one of the primary operations of machining cylindrical work-piece in industries. In any machining process, apart from obtaining the accurate dimensions, achieving a good surfaces quality, minimum metal removal rate and minimum temperature are importance. In the present research work of a comparative study of various heat treatment was investigated in turning of EN 19 material under the consideration of several turning process parameter. The effect of varying cutting parameters like speed, feed & depth of cut over surface finish, material removal rate & temperature on EN 19 type steel with & without heat treatment. The Taguchi method, a powerful tool of design optimization for quality is used to find the optimal cutting parameters for turning operations.

Keywords-EN 19, Turning process, Surface roughness, MRR, Temperature, Heat treatment, Taguchi method

“I. INTRODUCTION”

The term “Machining” covers a group of machining operations. The three principal machining processes are classified as turning, drilling, and milling. Other operations falling into miscellaneous categories include shaping, planing, boring, broaching, and sawing. The common feature of all machining operations is the use of the cutting tool that removes a certain layer from the workpiece in the form of the chip. To perform machining operations, relative motion is required between the tool and workpiece. This relative motion is achieved in most machining operation is a combined motion consisting of several elementary motions as the primary motion, called the cutting speed and the secondary motion called the cutting feed. Material removed from the part is achieved by the relative movement between the cutting tool and the part. The cutting tool is given a sharp cutting edge and it is forced to penetrate inside the work piece surface to a small depth. The relative motion between the tool and work piece results in a thin strip of material being sheared off from the work piece reducing the thickness of the work piece. This process has to be repeated several times before the entire surface of the work piece can be covered and reduced in depth. Turning is a general term for a group of machining operations in which the work piece carries out the prime rotary motion while the tool performs feed motion. Turning is used for machining cylindrical surfaces. The basic motions of turning are:

- The primary motion is the rotary motion of the work piece around the turning axis.
- The secondary motion is the translational motion of the tool, known as the feed motion .



Figure 1. Turning Operation

“II. HEAT TREATMENT”

Heat treatment is a heating and cooling process of a metal or an alloy in the solid state with the purpose of changing their properties. It can also be said as a process of heating and cooling of ferrous metals especially various kinds of steels in which some special properties like softness, hardness, tensile, strength, toughness etc, are induced in these metals for achieving the special function objective. Heat treatment consists of three basic steps: (i) Heat the metal/alloy to a predetermined temperature. This temperature will, ideally, depend upon the actual composition of carbon steel. (ii) Soaking or holding the metal alloy at that the temperature for some time, so that the temperature across the entire cross section becomes uniform, and (iii) Cooling the metal/alloy at a predetermined rate in a suitable medium like water, oil or air. The rate of cooling is the most important factor. The following heat treatment processes: (i) Annealing, (ii) Normalising, (iii) Hardening, and (iv) Tempering.

Annealing: Annealing is a softening process by heating & slow cooling of the components. In Annealing consists of heating the metal to a suitable temperature, holding at that temperature for a certain time and slowly cooling. In annealing, the work piece is allowed to cool inside the furnace only after switching off electrical power or oil supply to the furnace. This ensures that the work piece cools at a very slow rate. Different terms are used in annealing, depending on the details of the process and the temperature used relative to the recrystallization temperature of the metal being treated.

Normalising: Normalising entails heating to the same temperatures as recommended for annealing except for high carbon steel specimens, which are to be heated to much higher temperatures than for annealing particularly as carbon percentage in sample increases, soaking and then cooling the sample in still air. Main object of normalising is getting rid of internal stresses and grain-refinement.

Hardening: Hardening is a hardness inducing kind of heat treatment process in which steel is heated to a temperature above the critical point and held at that temperature for a definite time and then quenched rapidly in water, oil or molten salt bath. It is some time said as rapid quenching also.

Tempering: Tempering means giving up a certain amount of hardness but shedding great deal of brittleness acquired in the process of hardening. It is a trade off between hardness and brittleness, so that hardened component may give useful service without failure.

“III. TAGUCHI METHOD”

Taguchi's approach has been built on traditional concepts of Design of Experiments (DOE), such as full factorial, fractional factorial design and orthogonal arrays based on signal to noise ratio, robust design and parameter and tolerance designs. Design of experiment (DOE) is a powerful statistical technique for improving product/process designs and solving production problems. A standardized version of the doe, as forwarded by Dr. Genichi Taguchi, allows one to easily learn and apply the technique product design optimization and production problem investigation. Taguchi recommends orthogonal array (OA) for laying out of experiments. These OA's are generalized Graeco-Latin squares. To design an experiment is to select the most suitable OA and to assign the parameters and interactions of interest to the appropriate columns. The use of linear graphs and triangular tables suggested by Taguchi makes the assignment of parameters simple. The array forces all experimenters to design almost identical experiments. In the Taguchi method the results of the experiments are analyzed to achieve one or more of the following objectives:

- To establish the best or the optimum condition for a product or process.
- To estimate the contribution of individual parameters and interactions.
- To estimate the response under the optimum condition.

“IV. LITERATURE REVIEW”

Harsh Y. Valera and Sanket N. Bhavsar^[1] were experimental investigation of surface roughness and power consumption in turning operation of EN 31 alloy steel. Three cutting parameters viz. spindle speed, depth of cut and feed rate are considered. Process responses viz. surface roughness and power consumption parameters of the machined surface and power are measured for every experimental runs. Work material are used 150 mm length and 32 mm diameter of EN 31 steel and tool material are TiN+Al₂O₃+TiCN coated tungsten carbide tool. A total of 15 experiments were carried out with different combination of the levels of input parameter. The experimental setup includes five different spindle speed keeping feed rate of 0.08 mm/rev and depth of cut of 0.4 mm constant, five different feed rate keeping spindle speed of 710 rpm and depth of cut of 0.4 mm constant and five different depth of cut keeping feed rate of 0.08 mm/rev and spindle speed of 710 rpm constant. They conclude that the cutting parameters for achieving better surface finish with reduced power consumption.

Suha K. Shihab, Zahid A. Khan and et al^[2] were investigated the effect of different cutting parameters (cutting speed, feed rate and depth of cut) on cutting force components and material removal rate in dry and wet hard turning processes. The work piece material, hardened alloy steel AISI 52100, was machined on a CNC lathe with coated tool under different setting of cutting parameters. The results were analyzed using method of response surface methodology to determine optimal values of cutting parameters. Castrol coolant is used to wet hard turning processes. They conclude that the depth

of cut has statistically the most significant effect on cutting force components during both dry & wet hard turning processes.

Neeraj Sharma and Renu Sharma^[3] focused on Taguchi method used the optimization of process parameters of turning parts. Process parameters are spindle speed, feed rate and depth of cut. Lathe used in turning of work piece is 45 mm length and 25 mm diameter of AISI 1040 MS bar and high speed steel tool used. The working ranges of the parameters for subsequent design of experiment based on Taguchi's L9 design have been selected. They conclude that the cutting speed and depth of cut were significant variables to the surface roughness of mild steel. Surface roughness decrease with increase in spindle speed, surface roughness with increase in depth of cut.

Ashvin J. Makadia and J.I..Nanavati^[4] used Response surface methodology for the effect of the main turning parameters such as feed rate, tool nose radius, cutting speed and depth of cut on surface roughness of AISI 410 steel. The surface roughness was found to increase with the increase in the feed and it decreased with increase in the tool nose radius. The results obtained show the surface roughness, the feed rate is the main influencing factor on the roughness, followed by the tool nose radius and cutting speed. Depths of cut have no significant effect on the surface roughness.

S.R.Das, R.P.Nayak and D.Dhupal^[5] focused on an optimization method of the cutting parameters cutting speed, depth of cut and feed in dry turning of AISI D2 to achieve a minimum tool wear and low work piece surface temperature. It determines a pilot plan based on the Taguchi orthogonal array technique and ANOVA to identify the effect of cutting parameters on the reaction variables. They found that cutting depth and cutting speed was the most important parameter influencing the tool wear. Then optimal ranges of tool wear and work piece surface temperatures were predicated. Finally the relationships between the factors and performance criteria by using multiple regression analysis have been developed.

Ranganath M.S., R.S.Mishra and et al^[6] were conducted optimization of surface roughness in CNC turning of Aluminum 6061 using Taguchi techniques. There are cutting speed, feed rate and depth of cut on surface roughness in CNC turning Aluminum 6061 in dry condition. Design of experiments (DOE) were conducted for the analysis of the influence of the turning parameters on the surface roughness by using Taguchi design and then followed by optimization of the results using Analysis of Variance (ANOVA) to find minimum surface roughness. Result shows that the CNC turning gives better results, as speed and feed can be set at any value within a specified range, according to the requirement, compared to a conventional machine in which only some fixed values can be selected. Increase in cutting speed decrease the surface roughness up to a certain extent, but as speed increase beyond a certain limit, the surface roughness increase. Increase in feed rate adversely affects the surface finish slightly, but a large increase deteriorates surface finish to a large extent.

Nexhat Qehaja, Hysni Osmani and et al^[7] have worked on the effect of machining parameters and machining time on surface roughness in dry turning process. The most important measures of surface quality during the machining process is the average surface roughness and it is mostly caused by many machining parameters, such as cutting speed, feed rate, depth of cut, nose radius, machining time etc. The surface roughness was developed based on the response surface method to investigate the machining parameters affecting the roughness of surface produced in dry turning process. The experiment has been designed and carried out on the basis of a three level factorial design. Obtained results are in good accordance with the published results in the field, validating the effectiveness of regression analysis in modelling of surface roughness in dry turning process. They conclude that the feed rate seems to influence surface roughness more significantly than nose radius and cutting time with the regression equation generated, the best combination of design independent variables for achieving the optimization of cutting processes was presented.

R Ramya, S Giridharan and et al^[8] approach to optimization of turning parameters of EN-8 Steel cylindrical rods using Taguchi methodology. In this experimental used the lathe machine and parameters such as cutting speed, depth of cut and feed are greatly influenced by response parameters. The ideal surface roughness is determined by optimal turning parameter of EN8 steel cylindrical rods. EN 8 steel plate having good machinability characteristic and produce reasonable surface finish. The cylindrical rod dimensions are diameter 22 mm and length 100 mm. During turning process all parameters are interact & dependable in turning operation. They conclude that the cutting speed is a dominating parameter for achieving lower surface roughness during turning of EN 8 steel rods.

A.Srithar, K.Palanikumar and B.Durgaprasad^[9] studied about experimental investigation and surface roughness analysis on hard turning of AISI D2 steel using coated carbide insert. The machining of AISI D2 steel work piece having 66HRC hardness is carried out using coated carbide insert. Investigations were carried out on conventional lathe using the prefixed cutting conditions. The results specify that the increase of cutting speed decrease the surface roughness in machining of hardened steel. The gradual increases of feed rate and depth of cut increase the surface roughness in machining of AISI D2 steel by coated carbide insert. The feed rate is highly control the parameter, which influence surface roughness parameters in machining of AISI D2 steel.

“V. CONCLUSION”

The developed models using Design of Experiment (DOE) are reasonably accurate and can be used for prediction within limits. Taguchi gives systematic simple approach and efficient method for the optimum operating conditions. As per selecting the machining parameter there is increase the surface roughness and decrease the MRR, the aim of the paper is decide on approach of performance measurement of high material removal rate, low surface roughness and low tool tip temperature during turning process of with heat treatment and without heat treatment on EN 19 material.

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