Experimental Investigation Of Cutting Parameters And Optimization Of Lathe Machine Using Lathe Tool Dynamometer Adopting Taguchi Method: A Review

Madhukar Sorte[1], Ninad Thopate[2], Mayur Nyahale[3], Vikas Yadav[4], Umesh Thorat[5]

[1]Asso.Prof.in Mech Engg Department, SCOE, Navi Mumbai,madhukar.sorte@gmail.com
[2]BE Mechanical Student, SCOE, Navi Mumbai, ninaddream@gmail.com
[3]BE Mechanical Student, SCOE, Navi Mumbai, mayurnyahale@gmail.com
[4]BE Mechanical Student, SCOE, Navi Mumbai, yadavvikas9480@gmail.com
[5]BE Mechanical Student, SCOE, Navi Mumbai, umeshthorat55@gmail.com

Abstract: In this paper an attempt is made to review the literature on optimization of cutting parameters in machining using Taguchi method. The cutting parameters include cutting speed, depth of cut, feed rate etc their effect on the surface roughness, dimensional accuracy, tool wear. Surface roughness is used to determine and evaluate the quality of a final product. In order to get better surface finish, the proper setting of cutting parameters is crucial before the process takes place. So it becomes important for the manufacturing industry to find the suitable levels of process parameters for obtaining desired surface roughness.

Key words: *Cutting parameters, surface roughness, dimensional accuracy, tool wear Taguchi Method, Lathe Tool Dynamometer, Cutting Parameters, orthogonal array.*

1.0 INTRODUCTION

The manufacturing industries specially are focusing their attention on dimensional accuracy and surface finish. The important goal in the modern industries is to manufacture the products with lower cost and with high quality in short span of time. There are two main practical problems that engineers face in a manufacturing process. The first is to determine the values of process parameters that will yield the desired product quality (meet technical specifications) and the second is to maximize manufacturing system performance using the available resources.

In machining process, phenomena that can be measured such as cutting force, vibration, torque, surface finish, sound etc. commonly occurred.

In the present study, an attempt has been made to investigate the effect of cutting parameters on cutting forces and tool wear on machining jobs. The machining experiments were performed in accordance to Taguchi's method obtained results reveal that, cutting speed and depth of cut have significant effect on feed force whereas feed rate and depth of cut are factors that significantly influences on thrust force. The depth of cut and cutting speed has predominant effect on tool wear. Feed rate have less significant effect on tool wear. But, in case of cutting force modeling, all the three parameters have significant effect. Key parameters and their effects on tool wear and cutting forces have also been presented in graphical contours which may help for choosing operating parameter preciously. Optimized model indicates desirability level for economy in machining process. The Taguchi method is a well-known technique that provides a systematic and efficient methodology for process optimization and this is a powerful tool for the design of high quality systems. Moreover the consumers always demand for high quality, short lead time, durability and less cost. Due to these factors it becomes important to take some initiative steps regarding the same.

2.0 MOTVATION

In the market with an increased demand for quality manufacturing along with the short lead time and short product life cycles, the increasing consumer awareness always looks for the cost factor and quality so this becomes most important for the manufacturers to take some initiative steps. In machining process the major problem is with the tool wear. Due to tool wear we need to replace the tool often and it increases the cost of production. Also the tool on getting blunt improper machining finish is obtained and the energy consumed gets wasted. The production time increases leading to production delays. Also by improper machining the jobs surface finish is ruined causing it to rejection leading to wastage of material and significant loss to the industry.

In the lathe machine operation we find that the machining speed, depth of cut , feed rate are not standardized or designed as per requirement. Lack of this information hampers the lead time, surface finish and dimensional accuracy etc which increases the energy consumption, tool wear thereby ultimately increasing machining cost.

3.0 LITERATURE SURVEY

Sachin Ohder, Debabrata P, Bhisal Khatau, Santosh T. [2] concluded that Taguchi method of experimental design has been applied for optimizing the process parameters for turning Al-SiC alloy. Results obtained from Taguchi method closely matched with ANOVA. Best parameters found for lesser tool force are: Cutting Speed (100 RPM), Feed (0.125 mm/rev) and Depth of Cut (0.5mm) for machining on a high speed lathe and the result indicated by prediction model of regression equation was found to be almost confirming with the actual values obtained from experimental analysis.

Jithin Babu.R. , Ramesh Babu.[10] stated that in turning Aluminium alloy, use of lower feed rate (0.25 mm/rev), higher cutting speed (76 m/min)and lower depth of cut (0.3 mm) are recommended to obtain better surface finish & minimum cutting forces for the specified test range. For surface roughness ,feed rate is the main influencing parameter with a percentage contribution of 70.35 % followed by cutting speed and depth of cut. For resultant

cutting forces, depth of cut is the most influencing parameter with a percentage contribution of 87.37 % followed by feed rate and cutting speed. The average absolute error between the predicted (MR) and experimental values of surface roughness is around 3.347 % and for cutting forces is around 6.819 %. Average absolute error between predicted (ANN) and experimental values of Surface roughness is 2.868 %and for cutting forces is around 3.807 %. It is well established that ANN models predict surface roughness and cutting forces with high accuracy than multiple regression models.

Ajit Kumar Senapati, Abhijit Bhatta, Avinash Senapati, Omkarnath Mishra, Satyajeet Mohanty [1] stated that taguchi method of experimental design has been applied for optimizing the process parameters for turning mild steel using L9 orthogonal array. Results obtained from Taguchi method closely matched with ANOVA. Best parameters found for lesser tool force are: Cutting Speed (269 RPM), Feed (0.094 mm/rev) and Depth of Cut (0.5mm) for machining on a high speed lathe and the result indicated by prediction model of regression equation was found to be almost confirming with the actual values obtained from experimental analysis.

Narendra Kumar Verma, Ajeet Singh Sikarwar [9] declared that it has been found that feed rate is found to be the most significant factor & its contribution to surface roughness is 47.51 %. The best results for surface roughness (lower is better) would be achieved when AISI 1045 work piece is machined at spindle speed of 620 rpm, feed rate of 0.3 mm/rev and depth of cut of 0.7 mm. With 95% confidence interval. The Surface roughness is mainly affected by feed rate, depth of cut and spindle speed. With the increase in feed rate the surface roughness also increases, as the depth of cut increases the surface roughness first increase and decrease and as the spindle speed increase surface roughness decreases.

Ranganath M.S , Vipin. ,R.S.Mishra , Parshvam Jain , Sushil Kumar [6] identified speed as the most influential process parameter on surface roughness. The optimum surface roughness was reached when the feed rate and depth of cut were set as low as possible. They investigated the effect of the cutting speed , feed rate and depth of cut on surface roughness , in turning of Aluminium. The optimized values for this cutting parameters for minimum surface roughness are also obtained.

Satyanarayana Kosaraju , Venue Gopal Anne, Bangaruu Babu Popuri [13] investigated the effect of process process parameters on machinability performance characteristics and thereby optimization of the turning of Titanium based on Taguchi method. The cutting speed, feed and depth of cut were used as the process parameters where as the cutting force and temperatures were selected as performance characteristics. The L9 orthogonal array based on design of experiments was used to conduct experiments. The degree of influence of each parameters on individual performance characteristics was analyzed from the experimental results obtained using Taguchi method. The cutting speed was identified as the most influential process parameters on cutting force and temperature.

Nityanandhan T , Manickraj K , Kannakumar R [17] concluded that for AISI 304 stainless steel various parameters like cutting forces in x,y,z direction , surface finish and tool wear are experimentally found out. For lathe speed to 450 rpm,600 rpm,750 rpm and feed rate of 0.07mm/min,0.08mm/min and 0.09mm/min. All this experiments was carried out in conventional lathe using Kistler Dynamometer, profile projector. The tool used for turning as tungsten carbide and depth of cuts were 0.5,0.75 and 1mm. In the future, the above parameters will be analyzed and optimized using design of expert software and parameters.

Gurumukh Das , Padam Das [19] demonstrated that whenever, the cutting force estimation problem in drilling machine arises , it is possible to give the initial loading to the trained neural network model and it can give a fairly good estimation of corresponding forces , torque and axial thrust values. Thus, there is an advantage of not using the machine tool id the torque and axial thrust forces are beyond the limit of machine tool.

Ahmed Basil Abdulwahhab , Mostafa Adel Abdullah , Atheer Rasim Mohammed [14] investigated that This research gives how to use Taguchi's parameter design to obtain optimum condition with lowest surface roughness, minimum number of experiments and industrial engineers can use this method. The combination of conditions and their levels (A1B2C3) ((11mm) tool diameter, feed rate (0.038 mm/rev), and spindle speed (930 rpm)) are recommended to order to obtain a lowest surface roughness. Taguchi gives systematic simple approach and efficient method for the optimum parameters. The Maximum surface roughness when tool diameter at (20 mm), feed rate at (0.203 mm/rev), and spindle speed at (12 rpm). Through ANOVA, it is found that the tool diameter the important factor effect with (76.12%) on surface roughness respectively.

Sanjeev Sharma , Rajdeep singh , Sandeep Jindal [18] investigated that the cutting forces and feed forces is directly proportional to depth of cut and feed rate of tool & inversely proportional to feed/rev. Natural frequency & stress produced in tool of dynamometer has been formulated to give the permissible limits of the safe designs.

Yogendar singh chouhan, M. A. Saloda, S. Jindal, Chitranjan Agarwal [21] concluded that the result shows that both two parameters i.e feed rate and spindle speed have their effect on the measured thrust force. The effect of feed rate is more than spindle speed. As feed rate vary, thrust force value also vary due to change in amount of material removal from work piece by tool. There is less effect of spindle speed on thrust force as the increase in spindle speed leads decrement in thrust force. After analysis of data, it is clear that minimum thrust force developed at 0.05 mm/ rev of feed rate and at 250 rpm of spindle speed which save energy and useful production time during drilling of mild steel work piece.

Maheshwari Patil , Dr. R. J. Patil [23] studied the effect of HSS single point cutting tool nose radius on cutting edge strength and tool wear in machining of EN9. This paper presents a survey on variation in tool geometry that is tool nose radius , rake angle, variable edge geometry and their effect on tool wear and cutting edge integrity in the turning operation of components from EN9 plain carbon steel. In their study they have carried out the experimental study of HSS tool or material EN9 with this objective to study the effect of rake angle and nose radius on tool edge integrity and stress produced in the tool material leading to tool edge failure.

M.T.N Hidayah , J.A.Ghani , M.Z.Nuawi , C.H.C Haron [4] studied that in this paper, the cutting force analysis in tool condition monitoring to estimate the tool wear, tool breakage, chatter and etc. in machining process have been reviewed. These problems play an important role in determining and drafting production costs in manufacturing process. The cutting forces in TCM are very important to understand due to the strongly associated with mechanical cutting process, and the application of dynamometers to measure them during machining is important to investigate, monitor and optimize the manufacturing process.

A.Navanth,T Karthikeya [1] Sharma have concluded that In this study, drilling of Al2014 alloy is carried out with the input drilling

parameters considered as spindle speed, point angle and feed rate, and the response obtained are hole diameter and hole surface roughness at the entry and exit of the hole .The drilling parameters are optimized with respect to multiple performances in order to achieve a good quality of holes in drilling of Al 2014 alloy. Optimization of the parameters was carried out using Taguchi method. It was identified that a spindle speed of 300 rpm, point angle & Helix angle of 1300/200 and a feed rate of 0.15 mm/rev is the optimal combination of drilling parameters that produced a high value of s/n ratios of Hole roughness. And also identified that a spindle speed of 200 rpm, point angle & Helix angle of 900/150 and a feed rate of 0.36 mm/rev is the optimal combination of drilling parameters that produced a high value of s/n ratios of Hole Diameter.

Renjith V B, Mathew Baby, K R Jayadevan [12] concluded that as rake angle and tool extension length increases, all the components of cutting force decreases. Whereas with increase in cutting feed, the cutting force increases. Deflection of cutting tool increases with increase in rake angle, cutting feed and tool extension length. Percentage influence of tool extension length, cutting feed and rake angle on the deflection of T-42 CT H.S.S single point cutting tool is 90.48 %, 4.74 % and 2.64 % respectively. Optimum values of rake angle (0°), cutting feed (0.05 mm/rev) and tool extension length (25 mm) which give minimum deflection are found out using Taguchi optimization technique.

B.Tulsiramrao , Dr.K.Srinivas , Dr. P Ram Raddy, A.Raveendra ,Dr.B.V.R.Ravi Kumar [6] studied lathe tool dynamometer measuring cutting force , feed force ,feed force and also thrust force by using strain gauge accelerometer . The dynamometer used in this project is a 500kg force 3-component system. The dynamometer is connected to a data acquisition system . As the tool comes in the contact with the work piece the various forces developed are captured and transformed into numerical form system. In this project various forces for three different mats have been noted down and the materials used in this project are Al, Brass and mid steel . The forces on these materials with variation in speed are studied. Graphs are drawn on how these forces vary due to variation in speed.

Vishwajeet N. Range , Prof.Ajinkya P. ,Prof. Prashant D. Kamble , Dr.Sharad S. Chaudhari [5] optimized drilling parameters using the Taguchi technique to obtain minimum roughness and maximum tool life . A number of drilling experiments were conducted using L16 Orthogonal array on a double spindle drilling machine . The experiments were performed on hardened boron steel using HSS twist drills. Analysis of variances (ANOVA) was employed to determine the most significant control factors affecting the surface roughness and tool life . The cutting speed , feed rate and point angle were selected as control factors . After the sixteen experimental trials , it was found that the point angle was the most significant factor for the tool life and that the feed rate was the most significant factor on the surface roughness roughness . The results of the confirmation experiments showed that the Taguchi method was notably successful in the optimization of drilling parameters.

BhadrabasolRevappaR. , Bhemappa S. , RageraParmeshwarappa S. ,Bannangadi Swampy Gowda K. [8] analyzed the influence of drilling parameters on thrust force and torque of SiO2 and Alumina(Al2O3) filled into glass fabric reinforced epoxy (G-E) composites .Drilling experiments are conducted on these composite materials using BALTIBOI make radail drilling machine . Two different drill bits (HSS and cemented carbide) are used for experimentation . The influence of cutting parameters like cutting speed and feed on thrust torque on drilling of particulate filled G-E composites has been carried out . The experimental results indicated that the thrust force and torque were increased with increasing feed and speed for all the composites tested.

B.Tulasiramarao, Dr.K.Srinivas, Dr. P Ram Reddy, A.Raveendra, Dr.B.V.R.Ravi Kumar [15] studied that in this project the various forces such as cutting force, feed force and the axial force have been found out with the variation in depth of cut for different materials like aluminium, brass, mild steel & nylon. Whereas in case of brass and nylon there is uniform step increase in the forces with variation in depth of cut.

T. Sreenivasa Murthy, R.K.Suresh, G. Krishnaiah,V. Diwakar Reddy [22] concluded that the ANOVA and F-test revealed that the feed is dominant parameter followed by speed for surface roughness. The optimal combination process parameters for minimum surface roughness is obtained at 450 rpm, 0.05 mm/rev and 0.05mm.A regression model is developed for surface roughness. The developed model is reasonably accurate and can be used of prediction within limits. Taguchi gives systematic simple approach and efficient method for the optimum operating conditions.

Mahadev Naik, Ashish Gorule, Anil Ajgaonkar, Tejas Dudye, Tushar Chavan [24] concluded that taguchi method of experimental design has been applied for investigating multi response process parameter for turning AISI410 steel with L9 orthogonal array. Results obtained from Taguchi method are closely matches with ANOVA. Best parameter found for finished surface are: spindle speed 340 rpm; feed 0.2 mm/rev; depth of cut 0.3 mm. The parameter found for rough
surface are cutting speed 340 rpm; depth of cut 0.3 mm; feed 0.2 mm/rev. Also parameter for optimum combination gives minimum surface roughness and which confirms the test of minimum surface roughness. The confirmation test shows that min value of surfaceroughness for AISI 410 steel as 1.91 μm.

K.Mani lavanya, R.K.Suresh ,A.Sushil Kumar Priya , V.Diwakar [8] Reddy investigated that from the results obtained a Regression Model has been developed for Surface Roughness.They revealed that speed has a greater influence on the Surface Roughness followed by Feed. Depth of Cut had least influence on Surface Roughness.

M Sundeep , M Sudhahar , T T M Kannan , P Vijaya Kumar , N Parthipan [18] concluded that more material removal rates occur at cutting speed 1250 rpm and feed rate 0.02 mm using 8mm drill tool. Good surface is obtained at 0.016 feed rate and cutting speed 1250 rpm using 6 mm drill tool. Lowest thrust forces occur at cutting speed 800 rpm and feed rate 0.02 mm using 6mm drill tool. Lowest torque produced at cutting speed 800 rpm and feed rate 0.02mm using 6mm drill tool.

Jadhav J.S , Jadhav [16] B.R. studied that the feed rate has significant influence on both the cutting force and surface roughness. Cutting speed has no significant effect on the cutting surface & surface roughness of the chosen work piece. Depth of cut has significant influence on cutting force, but an insignificant on surface roughness.

Bhargab Kalita [20] concluded that from the literature survey he observed that many researchers took input parameters: cutting speed, feed rate and depth of cut and few took input parameter: Cutting fluid, drill tool diameter, cutting tools, point angle, clearance angle, type of tool and output parameters were taken : surface roughness, material removal rate (MRR), Thrust force, tool wear, Hole diameter, Hole Accuracy, Roundness error. It is found that for surface roughness the most significant parameters are speed,

feed and drill diameter, cutting fluids and least dominant parameter is dept of cut.

4.0 CONCLUSION

The literature reviews reveals that we need to develop systematic information of input parameters and to get efficient easy to use combination that results in dimensional accuracy and optimum surface finish/roughness. By improper machining the jobs surface finish is ruined causing it to rejection leading to wastage of material and significant loss to the industry. A systemic approach using Taguchi method can be applied to optimize cutting parameters.

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