Optimization of Cutting Parameters in Turning of En-19 by using Taguchi and Genetic Algorithm

D. Vishnu Vardhan Reddy¹
Assistant Professor,
Department of Mechanical Engineering,
Annamacharya Institute of Technology and Sciences, Rajampet-516126.

N. Jaya Krishna²
Assistant Professor,
Department of Mechanical Engineering,
Annamacharya Institute of Technology and Sciences, Rajampet-516126.

N. Bhaskar³
Assistant Professor,
Department of Mechanical Engineering,
Annamacharya Institute of Technology and Sciences, kadapa-516004.

Abstract—This paper deals with the Taguchi technique and Genetic algorithm (GA) for predicting the responses of turning operation on CNC lathe machine for EN19 steel. The number of experiments has been carried out using Taguchi’s orthogonal array in the design of experiments (DOE). The cutting parameters are spindle speed, feed rate and depth of cut. The Analysis of Variance (ANOVA) and Signal-to-Noise ratio were used to study the performance characteristics in turning operation. The accurate mathematical model has been developed using genetic algorithm. The genetic algorithm is used to get the optimum cutting parameters by using the regression equations of different parameters. The research showed acceptable prediction results for the developed model.

Keywords — Taguchi, GA, DOE, ANOVA.

I. INTRODUCTION

Turning is the process of removal of metal from the outer diameter of a rotating cylindrical work piece. Turning is used to reduce the diameter of the work piece, usually to a specified dimension, and to produce a smooth finish on the metal. The selection of EN-19 steel is widely used in production of gears, bolts, studs and a variety of applications where a good quality high tensile steel grade is suited. In the past, Asheem Kumar (2014) investigated the effect of cutting speed, feed, axial and radial depth of cut on cutting force in machining of EN19 steel in turning process for achieving the optimum surface finish. Shahiskant (2014) investigated the effect of pulse on time, pulse off time, discharge current and gap voltage in machining of EN19 steel in EDM process. They concluded that pulse off time, discharge current, gap voltage and the interaction terms were significant where as the pulse on time had almost negligible effect towards MRR. Ashish Kabra (2013) investigated the effect of process parameters in CNC turning on Surface roughness, feed and radial forces of EN19 steel. They also verified with the help of confirmation experiments using matlab and genetic algorithm. Abdelouahhab Jabri (2013) developed a multi-optimization technique based on genetic algorithms to search optimal cuttings parameters such as cutting depth, feed rate and cutting speed of multi-pass turning processes. Two objective functions are simultaneously optimized under a set of practical of machining constraints, the first objective function is cutting cost and the second one is the used tool life time. The proposed model deals multi-pass turning processes where the cutting operations are divided into multi-pass rough machining and finish machining. Results obtained from Genetic Algorithms method are presented in Pareto frontier graphic; this technique helps us in decision making process.

II. MATERIALS AND METHODS

A. EN 19 STEEL

A high quality alloy steel specification usually supplied as a high tensile steel grade to EN19T or EN19U. This grade offers good ductility and shock resisting properties combined with resistance to wear. With these characteristics it is a popular high tensile engineering steel with a tensile of 850/1000 N/mm². At low temperatures EN19 has reasonably good impact properties. It is also suitable for a variety of elevated temperature applications. For maximum wear and abrasion resistance EN19 can be nitride to give a shallow depth wear resistant case. Flame or induction hardening can give a case hardness of 50 HRC or higher.

<table>
<thead>
<tr>
<th>TABLE I. CHEMICAL COMPOSITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Element</td>
</tr>
<tr>
<td>Weight%</td>
</tr>
</tbody>
</table>

Genetic algorithm, differing from conventional search techniques, start with an initial set of random solutions called population. Each individual member of the population is called chromosome, representing a solution to the problem at hand. A chromosome, is a string of symbols or genes, it is usually, but not necessarily, a binary bit string. The chromosomes evolve through successive iterations called generations. During each generation, the next chromosomes are evaluated using some measure of fitness.

(Access this work free of charge at authors' own expense)

International Journal of Engineering Research & Technology (IJERT) ISSN: 2278-0181
Vol. 5 Issue 01, January-2016

http://www.ijert.org

Published by :
IJERTV5IS010607

(This work is licensed under a Creative Commons Attribution 4.0 International License.)
B. Design of Experiments

The design of experiments (DOE) technique has been implemented to conduct the experiments. It is a powerful tool which allows us to model and analyse the influence of determined process variables over the specified variables, which are usually known as response variables. These response variables are unknown functions of the former design variables, which are also known as design factors. Within the design of experiments, there are various types that can be considered. One of the most widely known ones is the orthogonal array design. In this study, the surface roughness of EN19 material was investigated by considering the process parameters, cutting speed, cutting speed and depth of cut. Therefore, a DOE setup was considered cutting speed with two levels, cutting speed and depth of cut with four levels each and then 2x4x4=32 runs were required in the experiments for three independent variables.

III. EXPERIMENTAL DETAILS

The experiments were conducted in CNC lathe machine from Hardinge (Taiwan) company, CNC lathe machine with model number SV 150 with capacity of work piece diameter 150 mm and length 300 mm. The maximum spindle speed of the machine is 6000 rpm and with machining accuracy ±0.5 mm. The number of tools stored in the CNC lathe machine 12 tools. The machining parameters used and their levels chosen are presented in Table

<table>
<thead>
<tr>
<th>TABLE II.</th>
<th>TABLE: CONTROL FACTORS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control Factors</td>
<td>Units</td>
</tr>
<tr>
<td>Depth of cut</td>
<td>Min</td>
</tr>
<tr>
<td>Speed</td>
<td>Rpm</td>
</tr>
<tr>
<td>Feed</td>
<td>mm/rev</td>
</tr>
</tbody>
</table>

The surface roughness was measured by using Surtronic 3+ stylus type instrument manufactured by Taylor Hobson with the following specifications. Traverse Speed: 1mm/sec. Cut-off values 0.25 mm, 0.80 mm and 2.50 mm, Display LCD matrix, Battery Alcance 600 measurements of 4 mm measurement length.

IV. RESULTS AND DISCUSSION

The experiments were conducted as per L32 orthogonal arrays and material removal rate is calculated by using below formula.

\[ MRR = \prod D*N*f/60(\text{mm}^3/\text{min}) \]

The regression equation of material removal rate is

\[ MRR (\text{mm}^3/\text{min}) = - 4892 + 6518 \text{ doc} + 2.99 \text{ speed + 20818 feed}. \]

The regression equations for surface roughness is

\[ = 4.96 - 0.59 \text{ doc} - 0.00225 \text{ speed - 6.57 feed}. \]
A. Optimization using genetic algorithm:

The script function is generated for the above equations and with the help of optimtool solver in MATLAB software optimization can be done. To attain desirable surface roughness the optimum parameters are depth of cut 0.498mm, speed 969.264rpm and feed 0.2 mm/rev. To attain desirable surface roughness the optimum parameters are depth of cut 0.5mm, speed 910.477rpm and feed 0.2 mm/rev.

The multi objective functions are converted into single objective function by using operation research techniques like

\[
\text{Objective Function} = \text{Max}(x) - \text{Min}(y) \quad \text{Where Max}(x) = \text{Max}(\text{MRR}), \text{Min}(y) = \text{Min}(Ra)
\]

\[
\text{OBJECTIVE FUNCTION} = [-4892 + (6518*Doc) + (2.99*Speed) + (20818*Feed)] - [4.96- (0.59*Doc) - (0.002255*Speed) - (6.57*Feed)]
\]

By combining both surface roughness and material removal rate, the optimum process parameters obtained are Depth of Cut 0.25mm, Speed 712.161rpm and Feed 0.05mm/rev.

V. CONCLUSION

Using Taguchi’s orthogonal array design in the design of experiments, the machining parameters which are influencing the surface roughness, material removal rate in turning operation of EN 19 steel has been modeled using genetic algorithm. Based on experimental and GA results, the optimum process parameters obtained for surface roughness and material removal rate are Depth of Cut 0.25mm, Speed 712.161rpm and Feed 0.05mm/rev.

REFERENCES


