

Chapter 30

Optimization of Cutting Parameters for AISI H13 Tool Steel by Taguchi Method and Artificial Neural Network

Hrishikesh Pathak
Tezpur University, India

Sanghamitra Das
Tezpur University, India

Rakesh Doley
Tezpur University, India

Satadru Kashyap
Tezpur University, India

ABSTRACT

In the present study an attempt has been made to investigate the effect of cutting parameters (cutting speed, feed rate, and depth of cut) on surface roughness and material removal rate (MRR) during dry turning operation of AISI H13 tool steel as per Taguchi's experimental design technique using an L9 orthogonal array. Signal to noise ratio (S/N) results and Analysis of Variance (ANOVA) were employed in order to investigate the optimal and significant cutting characteristics of H13 tool steel respectively. This paper focuses on optimizing the cutting parameters for minimum surface roughness and maximum MRR of H13 tool steel using high speed steel (HSS) as the cutting tool during turning. The results indicated that feed has a significant influence on surface finish and depth of cut on MRR when turning operation was carried out with HSS cutting tool. An artificial neural network model and regression equations were also developed to obtain minimum surface roughness and maximum MRR at different cutting conditions.

INTRODUCTION

Surface finish is a major factor in the functional performance of machined components. The main aim in today's manufacturing industry is to enhance production efficiency and safety of the products. Product quality and production efficiency can be obtained through lower surface roughness and higher material removal rate while machining. Thus, it is very important to identify the factors affecting surface quality. Among these factors machining conditions play the most significant role.

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Harnessing and precise prediction of machining parameters have been a major challenge in manufacturing sector over the years. Hence, it is evident that numerous research have been conducted till date in order to study the machining characteristics influencing the quality parameters of machined products. It is also known that Taguchi's design of experiments reduces the number of experiments required and also offers a systematic yet efficient approach for optimization of various parameters with regard to performance, quality and cost. Earlier, Yang & Tarn (1998) used Taguchi method to optimize the turning operation of S45C steel bars using tungsten carbide cutting tools and reported that cutting speed, feed rate and depth of cut are the significant cutting parameters which affect surface roughness. They deduced that the maximum contribution towards affecting the surface roughness was by the feed rate, followed by depth of cut, and subsequently, the cutting speed. Lin (2004) used the Taguchi L9 orthogonal array followed by grey relational analysis to compute the optimal cutting parameters (cutting speed, feed, and depth of cut) in order to obtain the desired output in terms of tool life, cutting force and surface roughness. Nalbant et al. (2006) also used a Taguchi L9 orthogonal array to demonstrate that the insert radius and feed rate are the main parameters amongst the three controllable factors (insert radius, feed rate and depth of cut) that influence the surface roughness in turning AISI 1030 carbon steel. Subsequently, Asiltürk & Akkus (2011) used an L9 orthogonal array in formulating the Taguchi method based optimization of cutting parameters (cutting speed, feed rate and depth of cut) in dry turning operation on hardened AISI 4140 with coated carbide cutting tools in a CNC turning machine. The results showed that feed rate had the most significant effect on surface roughness. Additionally, the effects of two factor interactions of the feed rate-cutting speed and depth of cut-cutting speed appeared to be important. In another study, Davis et al. (2013) used Taguchi method to compute the optimal cutting parameters such as pressurized coolant jet, rake angle, depth of cut, spindle speed and feed rate to obtain the minimal surface roughness in EN19 steel. Taguchi's experimental design was also used in various other researches for optimizing the machining parameters to obtain minimal surface roughness values (Kirby et al., 2006; Selvaraj & Chandramohan, 2010; Tzeng et al., 2009, Asiltürk & Neşeli, 2012).

Taguchi method uses generic Signal-to-Noise (S/N) ratio to quantify the variation in output with respect to input parameters. Taguchi method treats optimization problem in two categories: static problem and dynamic problem. There are several S/N ratios available depending on the type of characteristics, including smaller-the-better, larger-the-better and nominal-the-better (Savaş & Kayıkci, 2007). The three S/N ratios of common interest for optimization of static problems:

1. Smaller-the-better

$$\frac{S}{N} = -10 \log_{10} \left(\frac{\sum y_i^2}{n} \right) \quad (1)$$

2. Larger-the-better

$$\frac{S}{N} = -10 \log_{10} \left(\frac{\sum (1/y_i^2)}{n} \right) \quad (2)$$

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