Optimization of Cutting Parameters using Cryogenically Treated High Speed Steel Tool by Taguchi Application

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ABSTRACT

In the field of mechanical engineering, engineers are always looking for ways to improve the properties of materials. Cryogenic treatment of tooling steels is a proven technology to increase wear resistance and extend intervals between component replacements. The main idea of this paper is to apply Taguchi method to optimize cutting parameters in turning operation using cryogenic treated (CT) and untreated (UT) high speed steel (HSS) tools, so that the scope of cryogenic treatment on HSS tool material may be presented for the benefit of medium and small scale industry using HSS tools for cutting operation. Taguchi L25 orthogonal array is employed to study the performance characteristics in turning operations of AISI 1020 steel bars using CT and UT HSS tools. The microstructure has been found more refined and uniformly distributed after cryogenic treatment of HSS tool. It has been observed that optimum machining parameters in both the cases (CT HSS and UT HSS tools) are higher cutting speed (49.9 to 75.7 m/min.), lower feed rate (0.15 mm/rev.), medium depth of cut (0.40 mm). Analysis of variance (ANOVA) indicates that the cutting speed is most significant parameter followed by feed rate in case of CT HSS tool and depth of cut in case of UT HSS tool.

Keywords: Analysis of Variance (ANOVA), Cryogenic Treatment, High-Speed Steel Tools, Surface Roughness, Taguchi

1. INTRODUCTION

The commonly used cutting tool material in conventional machine tools is high-speed steel (HSS). In modern industry the goal is to manufacture low cost, high quality products in a short time. Turning is the first most common method for cutting and especially for the finishing machine parts. In a turning operation, it is important task to select cutting parameters for achieving high cutting performance. Usually, the desired cutting parameters are determined based on experience or by use of a handbook. Cutting parameters are reflected on surface
roughness, surface texture and dimensional deviations of the product. Surface roughness, which is used to determine and to evaluate the quality of a product, is one of the major quality attributes of a turning product.

Surface roughness is a measure of the technological quality of a product and a factor that greatly influences manufacturing cost. It describes the geometry of the machined surfaces and combined with surface texture. The mechanism behind the formation of surface roughness is very complicated and process dependent. To select the cutting parameters properly, several mathematical models (Taguchi, 1990; Ross, 1988; Phedke, 1989; Disney & Pridmore, 1989; Youg & Tarng, 1998) based on statistical regression or neural network techniques have been constructed to establish the relationship between the cutting performance and cutting parameters. Then, an objective function with constraints is formulated to solve the optimal cutting parameters using optimization techniques. Therefore considerable knowledge and experience is required for this approach. In this study, an alternative approach based on the Taguchi method (Abuelnaga & EI-Dardiry, 1984; Chryssolouris & Guillot, 1990; Chua, Rahman, Wong, & Loh, 1993) is used to determine the desired cutting parameters more efficiently. Mohan Lal, Renganarayanan, and Kalanidhi (2001) studied the improvement in wear resistance and the significance of treatment parameters in different tool and die materials. The results indicated that cryogenic treatment imparts nearly 110% improvement in tool life. Nalbant, Gökçay, and Sur (2007) stated that the Taguchi method is used to find optimal cutting parameters for surface roughness in turning. The orthogonal array, the signal-to-noise ratio, and analysis of variance are employed to study the performance characteristics in turning operations of AISI 1030 steel bars using TiN coated tools. Three cutting parameters namely, insert radius, feed rate, and depth of cut, are optimized with considerations of surface roughness.

Singh Hari (2008) performed experimentation to obtain an optimal setting of turning process parameters – cutting speed, feed and depth of cut, which may result in optimizing tool life of TiC coated carbide inserts while turning En24 steel (0.4% C). The effects of the selected process parameters on the tool life and the subsequent optimal settings of the parameters have been accomplished using Taguchi’s design of experiments approach. The results indicate that the selected process parameters significantly affect the mean and variance of the tool life of the carbide inserts. The percent contributions of parameters as quantified in the S/N pooled ANOVA envisage that the relative power of feed (8.78%) in controlling variation and mean tool life is significantly smaller than that of the cutting speed (34.89%) and depth of cut (25.80%). The predicted optimum tool life is 20.19 min.

Kolahan Farhad, Manoochehri Mohsen, Hosseini Abbas (2011) conducted experiments to simultaneously model and optimize machining parameters and tool geometry in order to improve the surface roughness for AISI1045 steel. Several levels of machining parameters and tool geometry specifications are considered as input parameters. The surface roughness is selected as process output measure of performance. A Taguchi approach is employed to gather experimental data. Then, based on signal-to-noise (S/N) ratio, the best sets of cutting parameters and tool geometry specifications have been determined. Using these parameters values, the surface roughness of AISI1045 steel parts may be minimized.

Singh A H (2007) conducted experimentation on the effect of cryogenic treatment on machining characteristics of titanium alloy (Ti–6Al–4V). In his experimentation, he predicted the best rpm range for conventional milling of titanium alloy (Ti–6Al–4V) using HSS tool material. The specimen was a cryogenic treated cylindrical rod for which a cryogenic treated HSS end mill was used to generate a cavity. The results indicated that best machining range is between 300 and 500 rpm, surface roughness improves by 47.91%, surface hardness increases by 2.25%, material removal rate increases by 4.38% and the tool wear rate decreases by 52.9%. Grewal J (2007)
A Multiresponse Optimization Model for Statistical Design of Processes with Discrete Variables
www.igi-global.com/chapter/a-multiresponse-optimization-model-for-statistical-design-of-processes-with-discrete-variables/170150?camid=4v1a