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An Experimental Investigation with Minimum Quantity Lubrication and its Comparison with Various Vegetable Oil Based Cutting Fluids during Turning

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Abstract

Environmental and Ecological issues call for the reduction in usage of cutting fluids in metal cutting industry. New techniques are being inquired to achieve this objective. Hard turning with minimum quantity lubrication is one such technique which can alleviate the pollution problems associated with cutting fluids. In the present work, vegetable oil based cutting fluids like castor oil, palm oil and ground nut oil is made to drop at tool-work interface using over-head system. The present paper deals with experimental investigation carried out for machinability study of AISI D3 steel in combination with CVD coated cemented carbide inserts of different styles and to obtain optimum process parameters using TOPSIS and Desirability function analysis. An orthogonal array, closeness coefficient, composite desirability and analysis of variance (ANOVA) are applied to study the performance of process parameters such as insert style, cutting fluid cutting speed, feed and depth of cut with consideration of quality characteristics i.e., Surface roughness, material removal rate and specific energy. Finally a clear comparison is presented between DFA and TOPSIS

*Keywords:*AISI D3 steel; CVD coated tool; Surface roughness; Material removal rate; Specific energy; ANOVA; Minimum quantity lubrication; Desirability function analysis; TOPSIS;

1. Introduction

The important goal in the modern industries is to manufacture the product 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 product quality (meet technical specifications) and the second is to maximize manufacturing

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system performance using the available resources. The challenge of modern machining industry is mainly focused on achievement of high quality ,in terms of work piece dimensional accuracy, surface finish ,high production rate, less wear on the cutting tools ,economy of machining in terms of cost saving and increase the performance of the productWith reduced environmental impact. During the recent years, the use of lubricants in Metal cutting gaining popularity, by the mid-19thcentury mineral oil has been extensively used in machining operation. In the year 1883, Taylor used water as lubricant in machining and observed that the cutting speed has been increased by 30-40%.

The main objective of machining operation is to improve quality and productivity without sacrificing machining cost. The same can be achieved by machining at highest cutting speed with appropriate feed and depth of cut. Machining can be done either in dry conditions or with usage of cutting fluid which improves productivity and tool life, quality but prevent the cutting tool and machine from overheating as well. The proper application of cutting fluid provides higher cutting speeds and higher feed rates possible. The selection of cutting fluid not only improves cutting performance but also fulfils a number of requirements which are non-harmful to health for operators, not a fire hazard, no smoke (or) for and cost is less. Cutting fluids are applied at the cutting zone to improve cutting performance. The primary function of cutting fluid is to reduce interface temperature between tools and work thus tool lip will be extended. Secondary cutting fluid acts as good lubricant by which heat generated due to friction will be reduced. To conclude with high lubricant capacity are suitable in low speed machining such as screw cutting, broaching, gear cutting and difficult to cut materials whereas cutting fluids with high cooling ability are generally employed in high speed machining.

In the present work, AISI D3 steel was selected as work material which finds applications in the manufacture of Blanking & Forming dies, press tools, punches, bushes, forming rolls and many more. For the purpose of experimentation, factorial design experiments are considered as per Taguchi DOE. By advocating Taguchi design, a clear understanding of the nature of variation and economic consequences of quality engineering in the world of manufacturing can be obtained. In the present study, desirability function analysis (DFA) and technique for order preference by similarity to an ideal solution (TOPSIS) were performed to combine the multiple performance characteristics in to one numerical score which is an indicative of the optimal process parameter setting. Analysis of variance (ANOVA) is also performed to investigate the most influencing parameters on the surface roughness, material removal rate and specific energy.

2. Literature Review

W.H.Yang& Y.S Tang [1] envisages that the Taguchi method is a powerful tool to design optimization for quality and is used to find the optimal cutting parameters for turning operations. An orthogonal array, the signal to noise ratios and ANOVA are employed to investigate the cutting characteristics of S45C steel bars using Tungsten carbide cutting tools. Through this study, not only optimal cutting parameters for turning operations obtained, but also the main cutting parameters that affect the cutting performance in turning operations are found.

S.Tripathy&D.K.Tripathy[2] presented the experimentation on powder mixed electro discharge machining and application of Taguchi method in combination TOPSIS and Grey relational analysis to evaluate the effectiveness of optimizing multiple performance characteristics for PMEDM of H-11 die steel using copper electrode. The effect of process parameters on the response characteristics has been investigated. Analysis of variance and F-test were performed to determine the significant parameters at 95% confidence level. Predicted results have been verified by confirmatory test

T.Saravanan& R. Udaykumar[3] presents the machining of hybrid metal matrix using a mediumduty lathe. The optimum machining parameters have been identified by a composite desirability value obtained from desirability function analysis as the performance index and significant contribution of parameters can then be determined by analysis of variance.

PapiyaBhowmiketal [4] focused on an experimental investigation into the role of green machining on surface Roughness (Ra), in the machining of aluminium AA1050. A comparative study of turning experiments, between VBCFs and MBCFs under various cutting conditions, using neat or straight Sunflower oil and Coconut oil, was conducted using the same machining parameter set-up. Vegetable oils used on the principle of Minimum Quantity