Chapter 11
Grey-Based Taguchi Analysis Approach for Optimization of Multi-Objective Problem

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ABSTRACT
Due to the increase in complexity and expectations of more reliable solutions for a problem, the importance of multi-objective problem solutions is increasing day by day. It can play a significant role in making a decision. In the present approach, many combinations of the optimization techniques are proposed by the researchers. These hybrid evolutionary methods integrate positive characteristics of different methods and show the advantage to reach global optimization. In this chapter, Taguchi method and the GRA (Grey Relation Analysis) technique are pronounced and used to optimize a multi-objective metal cutting process to yield maximum performance of tungsten carbide-cobalt cutting tool inserts in turning. $L_{18}$ orthogonal array is selected to analyze the effect of cutting speed, feed rate, and depth of cut using cryogenically treated and untreated inserts. The performance is evaluated in terms of main cutting force, power consumption, tool wear, and material removal rate using main effect plots of S/N (Signal to Noise) ratios. This chapter indicates that the grey-based Taguchi technique is not only a novel, efficient, and reliable method of optimization, but also contributes to satisfactory solution for multi-machining objectives in the turning process. It is concluded that cryogenically treated cutting tool inserts perform better. However, the feed rate affects the process performance most significantly.

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INTRODUCTION

Demand of the optimum decision making is rising continuously due to increasing complexity in the problems and requirement of precise decision in different fields. It is essential for reducing material and energy requirements. Problems with multi objectives/criteria are generally known as multiple criteria optimization or multiple criteria decision making (MCDM) problems. The area of multiple criteria decision making has received enormous attention in the recent years, primarily due to rapid development in computer technology, which includes development and availability of user-friendly software, high-speed and parallel processors etc. Depending upon the characteristics of the problems, these can be sub divided into two types: multi-attribute decision analysis and multi-objective optimization. In multi-attribute decision analysis, the set of the feasible alternatives is discrete, predetermined and finite. In multi-objective optimization problems, the feasible alternatives are not identified in advance among the number of known solutions. These problems can be called continuous and one has to generate the alternatives before they can be evaluated (Miettinen, 1999).

Machining is one of the most important processes carried out in an industry to produce a desired shape, size and finish of a component by removing excessive material in the form of chips from a workpiece. It is carried out in a very hostile environment accompanied by deformation in compression, tension and shear by a great deal of friction and heat generation. Higher material removal rate, machining accuracies with a better surface finish are always prime requirements in the machining, with minimum possible cost. The main controlling factors in a machining process that influence the cost involved are: speed, feed rate, depth of cut, cutting tool material, cutting tool profile, workpiece material, tool geometry and cutting fluids (Kalhori, 2001). Carbide tools are the backbone of today’s manufacturing industry. However, tungsten carbide tools probably that most common and widespread high production tools for the purpose of machining. These have the capability to give a better surface finish on the components, and allow the faster machining without getting much effected even at higher temperatures compared to standard high speed steel tools. Cryogenic treatment (CT) has already known as a method that improves the core properties of materials. In case of tungsten carbide cutting tool material, literature is available, which attributes better wear resistance, and hence the increase in tool life to the cryogenic treatment (Kalsi et al., 2010). Although all, machining performance and product characteristics may not be guaranteed to be acceptable, until a planned strategy for the process is adopted. Therefore, optimum cutting conditions are always desired to accomplish the objective.

IMPORTANT OPTIMIZATION METHODS

Till now, various optimization techniques have applied by the researchers in machining. Accepting the best solution after comparing a few solutions is the indirect way of attaining optimal solution in many industrial problems. However, there is no way of guaranteeing an optimal solution with this basic approach. Aggarwal & Singh (2005) in their review discussed different conventional techniques employed for optimization in machining, which includes geometric programming, linear programming, goal programming, sequential unconstrained minimization technique, dynamic programming. The latest are fuzzy logic, artificial neural network technique, scatter search technique, genetic algorithm, Taguchi technique, response surface methodology and their combinations etc. Lin et al. (2001) used convergence network and constructed a simulation model for cutting forces and surface roughness, considering cutting speed, feed rate and depth of cut as input parameters. A regression analysis was adopted in the study to develop a second prediction model to verify the
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