Chapter 6
Application of Particle Swarm Optimization for Achieving Desired Surface Roughness in Tungsten–Copper Alloy Machining

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ABSTRACT

The tungsten-copper electrodes are used in the manufacture of die steel and tungsten carbide workpieces due to high thermal and electrical conductivity of copper, spark erosion resistance, low thermal expansion coefficient, better arc-resistance, non-welding, and high melting temperature of tungsten. Since a tungsten-copper electrode is more expensive than traditional electrodes; there is a need to study the machinability aspects, especially the surface roughness of turned components, which has a greater influence on product quality. This chapter deals with the application of response surface methodology (RSM) for the development surface roughness model for turning of tungsten-copper alloy. The experiments were planned as per full factorial design (FFD) with cutting speed, feed rate, and depth of cut as the process parameters. The proposed surface roughness model was employed with particle swarm optimization (PSO) to optimize the parameters. PSO program gives the minimum values of surface roughness and the corresponding optimal machining parameters.

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INTRODUCTION

The electro-discharge machining (EDM) is widely used in the moulds and dies industries due to its good dimensional precision and surface integrity (Stampfl et al., 2000). One of the main characteristics of this method is that no physical contact is made between the electrode and the workpiece. Hence, EDM induced minimum residual stresses as compared to other machining processes (Lee et al., 2004). The EDM is also used when the workpieces with reduced dimensions are required (micro-machining). The EDM is a reproductive shaping process in which the form of tool is mirrored in the workpiece (Her & Weng, 2001; Konig et al., 1998). In order to improve the quality of the EDM product, it is necessary to understand the relationship between the affecting process parameters and the machinability characteristics. Surface finish is one of the most important considerations in determining the machinability of materials. Nowadays in the industries, a greater attention has been paid to accuracy as well as surface roughness, which have greater influence on product quality.

Tungsten-copper electrodes have been extensively used in the production of die steel and tungsten carbide workpieces due to high thermal and electrical conductivity of copper and better spark erosion resistance, low thermal expansion coefficient and high melting temperature of tungsten (Li et al., 2001). The low melting point of copper reduces the resistance to electrode wear. Since, tungsten-copper electrodes are more expensive than traditional electrodes like traditional copper or graphite; they are not used in the commercial EDM processes. Even though, the graphite electrodes have been the mainstay in moulds and dies industry, a new trend is now emerged in form of tungsten-copper electrodes because they provide better surface finish and longer life than graphite electrodes. Due to favorable properties, tungsten-copper electrode is suitable for machining of small holes with flat bottoms, where high-precision machining is the main consideration (Lee et al., 2004). Hence, it is necessary to investigate the surface finish aspects during machining of tungsten-copper alloy.

Turning is the primary operation in majority of the manufacturing processes that produces the components, which have critical features requiring particular surface finish. In industry, the cutting parameters continue to be chosen solely on the basis of handbook values/manufacturer recommendations/operators experience in order to achieve the best possible surface finish. Due to an inadequate knowledge of complexity and parameters affecting the surface finish in turning operation, an improper decision may cause high manufacturing costs and low product quality. Hence, proper selection of cutting tools and process parameters is an important criterion for achieving high surface quality and high metal removal rate in machining process (Konig et al., 1998).

The surface roughness describes the geometry of machined surface combined with surface texture can play a major role on operational characteristics of the part and influences corrosion resistance, fatigue strength, wear rate and coefficient of friction on machined surfaces. The mechanism behind the surface roughness formation is complicated and process dependent; therefore it is very difficult to determine its value through analytical formulae (Benardos & Vosniakos, 2002; Benardos & Vosniakos, 2003). Even though, various theoretical models have been proposed, they are not accurate and are applicable only for a limited range of cutting parameters. The surface finish in turning influenced by various factors such as cutting speed, feed rate, depth of cut, work material characteristics, work hardness, cutting time, tool nose radius, tool angles, cutting fluids, unstable built-up edge, chatter, stability of machine tool and work-piece set up (Octem et al., 2005).

The objective of the present chapter is to determine the optimal cutting conditions for achieving a better surface finish within the chosen constraints

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