Chapter 9
Application of Taguchi Method with Grey Fuzzy Logic for the Optimization of Machining Parameters in Machining Composites

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ABSTRACT

Glass fiber reinforced plastic (GFRP) composite materials are continuously displacing the traditional engineering materials and are finding increased applications in many fields, such as automobile, marine, sport goods, et cetera. Machining of these materials is needed to achieve near-net shape. In machining of composite materials, optimization of process parameters is an important concern. This chapter discusses the use of Taguchi method with Grey-fuzzy logic for the optimization of multiple performance characteristics considering material removal rate, surface roughness, and specific cutting pressure. Experiments were planned using Taguchi's orthogonal array with the cutting conditions prefixed. The cutting parameters considered are workpiece (fiber orientation), cutting speed, feed, depth of cut, and machining time. The machining tests were performed on a lathe using coated cermet cutting tool. The results indicated that the optimization technique is greatly helpful in achieving better surface roughness and tool wear simultaneously in machining of GFRP composites.

DOI: 10.4018/978-1-4666-0128-4.ch009

1. INTRODUCTION

Glass fiber reinforced polymer (GFRP) composite materials are most widely used in different engineering industries because of their excellent properties such as low density, high strength, high stiffness to weight ratio, excellent durability and design flexibility. They are finding applications in aerospace, automobile and marine industries. The accurate machining of these composites is required to manufacture the components in the industry. The need for machining has increased day-by-day. The machining of these materials are necessitated to manufacture the components with near nett-shape. The mechanism behind the machining of fiber reinforced polymer composite is quite different from that of metals due to its non homogeneous and anisotropic properties, and it brings about many undesirable results, such as rapid tool wear, rough surface finishes on finished components, and a defective sub-surface layer with cracks and delamination (Santhanakrishnan et al, 1989). The studies on machining of GFRP composites have been reported by some of the authors (Sakuma and Seto., 1983; Caprino et al., 1996; An et al., 1997; Jose Mathew et al., 1999, Cenna and Mathew, 2002 and Palanikumar et al., 2004). The general criteria adopted for evaluating machinability are tool life / tool wear and surface roughness.

The performance of a tool can be evaluated either in terms of tool life as decided by tool wear or performance indicators such as machining forces/ specific cutting pressure, temperature and related features. Normally, the specific cutting pressure is dependent on the tool work material pair. Hence, during the machining of polymeric composites with any given cutting tool, the variation of specific cutting pressure can be attributed to the changes in the geometrical form of the cutting edge (Sreejith et al., 2000). Sakuma and Seto (1983) studied the force relation in face turning of GFRP composites. According to Konig et al., (1985), the cutting forces for the machining of glass and carbon fiber composites distinctly rise with feed rate. Takeyama and Lijima (1988) studied the cutting force with varied fiber angles. The cutting force is greatly influenced by the fiber angle, and the minimum cutting force is given at approximately 30° fiber angle, in which the matrix is sheared along the fibers without being hindered by the fibers. The reason why the cutting force increased steeply at larger fiber angles than 30°, although shear takes place along the fibers, is because the compressive stress on the rake face increased to such an extent as otherwise shearing would take place across the fibers. Sang-Ook An et al. (1997) have reported that, the cutting force decreased with decrease in the feed rate and if the depth of cut decreased, the cutting force decreased. The trend for change in the cutting force with change in the depth of cut is similar to that for changes in the feed rate, according to the tool materials and geometries. Santhanakrishnan (1990) analyzed the surface roughness and morphology. It is known that during machining of FRP composites, the mechanism of cutting is associated with the combination of plastic deformation, shearing and rupturing of fibers along with machining of the matrix material. This constructs the surface texture. Spur and Wunsch (1988) have studied the turning of glass fiber-reinforced (GFR) polyester and epoxy composites and found an increase in the feed rate which increases the surface roughness but no dependence on the cutting speed for all the fiber orientations.

Optimization of process parameters is an important criterion in the machining process to achieve high quality. There are different methods of optimization is adopted by different researchers. The review of literature indicates that various traditional optimization techniques like Lagrange's method (Brewer, 1996), geometric programming (Walvekar and Lambert, 1970), goal programming (Sundaram, 1978), break even point (Tsai, 1986), dynamic programming (Agapiou, 1992), etc have been successfully applied for optimizing the machining parameters. Fuzzy logic (Palanikumar,

Reserve Capacity of Mixed Urban Road Networks, Network Configuration and Signal Settings
Masoomeh Divsalar, Reza Hassanzadeh, Iraj Mahdaviand Nezam Mahdavi-Amiri (2017). *International Journal of Applied Industrial Engineering (pp. 44-64).*
www.irma-international.org/article/reserve-capacity-of-mixed-urban-road-networks-network-configuration-and-signal-settings/173695