ABSTRACT

Carbon fiber reinforced polymer (CFRP) composites are widely used in aerospace field because of their outstanding lightweight material characteristics, tensile strength and stiffness properties. The tools used in composite machining exhibits different cutting performance and machining quality under different cutting conditions. The combination of tool material, tool geometry and cutting conditions strongly influences the tool life and surface quality of the machined parts. The main objective of this research is to evaluate the optimum cutting conditions for different tools with respect to feed speed, cutting speed and depth of cut for attaining required surface finish and dimensional accuracy. Edge trimming of CFRP blanks with two sets of cutting tools of 10 mm diameter; polycrystalline diamond (PCD) two flute cutter and tungsten carbide two flute end mill cutter was conducted. The operation was carried out on a computer numerical control (CNC) machining center by varying cutting speed, feed speed and depth of cut. Machining quality was determined using a stylus roughness tester which evaluated the surface roughness parameters R_a and R_z. Tool wear measurement was done using an optical microscope which determined the maximum flank wear. Normal, feed and axial forces, average and maximum tool temperature and spindle power were monitored using a data acquisition system and the information was recorded and analyzed after each pass. These responses were correlated with the tool wear. Experimental results indicated that the flank wear in PCD tool is considerably smaller than carbide tool and a PCD tool produces excellent surface finish even at higher cutting lengths. The analysis of SEM images explained the wear mechanisms. The wear of PCD tools was attributed to uniform wear by soft abrasion. This was due to the extrusion of binder from between the PCD grains, followed by removal of the grains from the cutting edge. The wear of carbide tools is characterized by abrasive wear and rounding of the cutting edge. This occurred mainly by hard abrasion of the carbide grains. A tool wear equations were developed for PCD and tungsten carbide tools and the dependency

of tool wear on machining parameters was studied. Regression analysis of PCD tools confirmed that when average temperature, resultant force, feed force and power were introduced as independent variables in the polynomial tool wear model, the tool wear prediction is improved. For tungsten carbide tools, tool life was observed to be inversely proportional to cutting speed, feed speed and depth of cut. An expanded Taylor tool life equation was developed. In addition, a tool wear equation with power, average temperature and resultant force as independent variables provided higher tool wear predictive capabilities for carbide tools. To check the adequacy of the regression model for carbide tools, validation runs were conducted and the experimental tool wear obtained from validation experiments were compared with the tool wear obtained using regression. An approximate average error of 5% confirms that the experimental and regression tool wear values are very close. The equations and analysis permits trimming of CFRP to be designed such that tool wear is optimized and well forecasted.