Abstract

Fibre reinforced plastic (FRP) composite is an important class of material due to its high strength to weight ratio. They are manufactured to near-net-shape. Processing like trimming and drilling are still necessary for the assembly purpose. Processing of these materials is a major challenge. Firstly, excessive tool wear is observed due to the abrasive nature of the fibres, and second is the defects during machining such as thermal softening of matrix, matrix cracking, fibre pull-out, fuzzing and delamination. Amongst these, delamination is the most severe as the strength of the component is drastically reduced due to delamination resulting in its rejection. This is more severe in case of drilling operation.

Different methods are reported in literature to reduce the delamination during drilling of FRP composites. Experimental, analytical and finite element studies are available in the literature. Very few work is reported on finite element analysis of the process. This is mainly because of the difficulties in finite element analysis. Firstly, twist drill has a complex geometry which is difficult for CAD modeling. Secondly, the FRPs are anisotropic and nonhomogeneous materials which make the material modeling difficult especially for the studies like machining where material damage is to be modeled.

In the present study, a finite element model has been developed to study the delamination during drilling of FRP composites. The model developed has been optimized for the simulation parameters and validated with the experimental results available in the literature. It is then used to study the variation of thrust force, torque and delamination factor with variation in feed rate, speed and drill point angle. Three different point angles, four different speeds and five different feed rates are used for the simulations. The variations in thrust force, torque and delamination factor are also studied for variation in diameters of pilot hole. Comparison has been made with the results predicted by different analytical models.

Delamination and thrust force were observed to be the most sensitive against variation in feed rate, and were observed to be increasing with increase in feed rate. Speed and point angle are relatively insignificant in case of thrust force and delamination. Torque was also observed to be increasing with feed rate but not much variation was observed in torque with variation in speed and point angle. Use of pilot hole with diameter equal to or greater than web thickness has been observed to be an effective method to get delamination-free drilling even at higher feed rates.

Keywords: Composites, Delamination, Drilling, Finite Element Method