ABSTRACT

In recent years, the composite materials are replacing the conventional materials for a large number of components, particularly where lightweight structures are of prime importance. Composite materials have higher strength to weight and stiffness to weight ratio, high temperature operations, better corrosion and wear resistance, better thermal insulation, etc. The use of composites is growing steadily in various industries such as aircraft, automobile, sporting goods, marine vessels, offshore drilling platforms etc. As a result there is a strong need to understand better the issues associated with the manufacturing of composite components. The existing manufacturing technique of fabricating to near-net shape is incomplete unless the component is subjected to secondary machining operations like trimming, finish grinding, drilling holes/cavities etc.

Though Non Traditional Machining (NTM) processes are preferable, the limitations like, high cost, material dependence, high noise and incapability of producing blind holes/cavities etc. forced the use of conventional machining techniques as an alternative. The conventional machining on FRP material plays a vital role in meeting dimensional accuracy and good surface quality requirements. However due to anisotropy, inhomogenety and abrasive nature of the composite materials especially like GFRP, the conventional machining processes posses some limitations like excessive tool wear, poor surface finish, delamination, fiber pullout, dimensional variation etc. These limitations motivated for the present investigation.
The present investigation involved the study of various issues associated in machining Glass Fiber Reinforced Plastic (GFRP) composite material. Drilling and face turning operations were performed on unidirectional and bi-directional GFRP specimens to evaluate the machinability of these specimens. In drilling the influence of drill speed, feed rate, pad support, fiber percentage and tool diameter on surface roughness values, hole diameter variation, delamination and tool wear were analyzed. A statistical 2k factorial design analysis was used to identify the magnitude and direction of the effect of each parameter on surface quality and tool life. Also FEA models were constructed to evaluate the delamination force in drilling and cutting forces in face turning operations. A standard Linear Elastic Fracture Mechanics (LEFM) model and a modified Merchant's model were used to validate the results predicted by FEA model. Face turning experiments were also conducted on both UGFRP and BGFRP specimen to evaluate the cutting forces. The influences of fiber percentage, fiber orientation, tool geometry on the cutting force and tool wear values were examined. The experimental results have shown good agreement with the FEA and modified Merchant's model.

From these investigations it is observed and recommended that, the voids observed in specimens with higher fiber percentage fabricated by hand lay process could be reduced by proper selection of curing temperature and rolling pressure. Also the difficulty in fiber control and orientation experienced in filament winding process can be reduced by proper design of squeeze roller and guide ring respectively.
The variation in machining performance due to variation in fibre proportion can be improved only by proper selection of tool and cutting parameters. In drilling, use of pad support and optimum-cutting parameters effectively reduced the delamination and resulted in improved surface quality. The UGFRP specimens have shown better surface quality than BGFRP specimens. Variation in hole dimension due to higher fibre proportion causes to vary the clearance between hole and rivet, in turn vary the joint strength. Selection of optimum cutting parameters and fibre percentage are recommended to achieve better joint strength.

In face turning the carbide tipped tool gave better performance comparatively. However for better machinability with HSS tool on GFRP, an optimum cutting and tool parameters are recommended. Excessive tool wear was observed on bi-directional GFRP pipe specimens. The FEA models constructed to predict the cutting force values for various fibre percentage, fibre orientations, tool angles and depth of cuts will save the expenses, time and risk involved in fabrication and machining experimentation.

Thus, this work has presented a study on the influence of cutting and tool parameters on the machining capabilities of GFRP composites possessing a wide range of fibre proportions. It is envisaged that industries involved in the conventional machining of GFRP composites will find useful tips to follow from this work.