Overview of Machining of Polymer Matrix Composites

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Abstract- **This review shows details of machining of fiber-reinforced polymer composites by conventional and nonconventional means that the anisotropy and in homogeneity characterizing their microstructure and the abrasiveness of their reinforcement components. During machining, very rapid cutting tool wear development is experienced, and surface integrity damage is often produced in the machined parts. An accurate selection of the proper tool and machining conditions is therefore required, taking into account that the phenomena responsible for material removal in cutting of fibre reinforced plastic composite materials are fundamentally different from those of conventional metals and their alloys.**

Index terms- **Composite material, fibre reinforced plastic (FRP), machining: conventional and non-conventional**

I.INTRODUCTION

Fibre reinforced plastic (FRP) composites found their initial industrial field of application in the aeronautical industry, but to date they find usage in a very large number of industrial sectors: aerospace, sporting goods, nautical, construction, medical, automotive, train manufacturing, etc. Flow chart of the machining of the polymer matrix composites (PMC) given below.

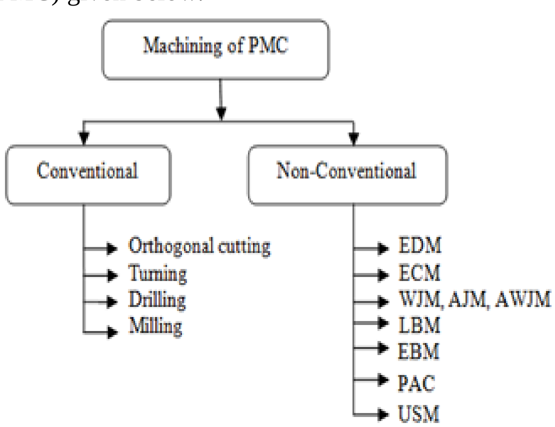

Fig. 1 Classification of machining of PMC

II. CONVENTIONAL MACHINING PROCESSES

A. Orthogonal cutting

Orthogonal cutting forms the basis of all machining operations: therefore, several research efforts have been spent to understand the material removal mechanisms that are occurring during orthogonal cutting of FRP composites to support the comprehension of the main FRP conventional cutting processes, such as drilling, milling, trimming, etc. [1].

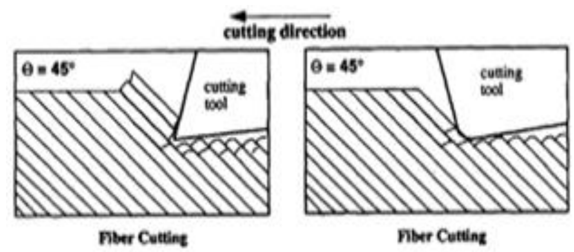

Fig. 2.1 Cutting mechanism in orthogonal machining

B. Turning

Turning, along with drilling, milling, and trimming, is one of the most widely employed cutting processes for the machining of FRP composite materials and is applied to rotation-symmetric parts, such as shafts, tubes, gears, spindles, etc. [2].

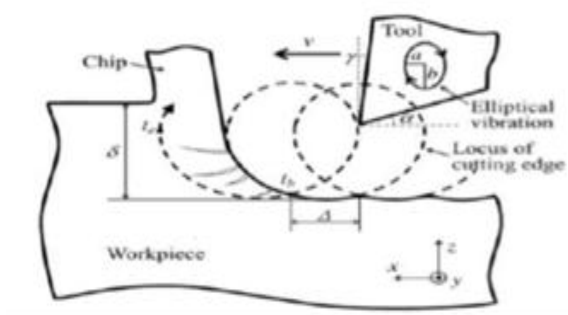

Fig. 2.2 Vibratory assisted turning

C. Drilling

Research and review studies in drilling of composite materials were reported in [4], in particular with reference to the influence of machining parameters and tool geometry on the delamination. Anadequateselectionofdrillingtoolsandmachiningpara meterstoextendthelifecycle of the FRP laminates as a consequence of enhanced reliability [5].

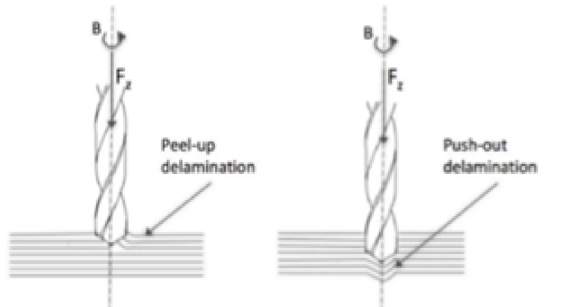

Fig. 2.3 Peel up and out delamination at entrance and exit

D. Milling

A study on tool life performance of uncoated and diamond coated carbide end mills in CFRP milling was reported in [3], showing that for diamond coated tools, higher feed rate and smaller coating thickness cause tool wear through fracture and delamination of the diamond coating. The flank wear of the diamond coated tools was significantly lower than the one of the uncoated tool and tended to increase at higher feed rate.

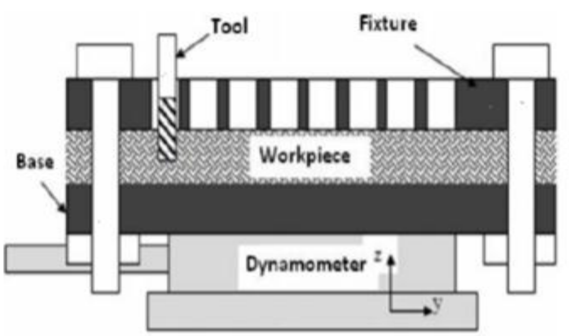

Fig. 2.4 Experimental setup for FRP milling

III. NON-CONVENTIONAL MACHINING PROCESSES

A. Electrical discharge machining (EDM)

Electrical discharge machining (EDM) cancontribute to avoid the typical problems of conventional FRP machining. The EDM process does not involve mechanical energy, thus hardness, strength, toughness, or abrasiveness of the work material does not affect the machining process. Accordingly, the EDM capability to remove material from electrically conducting materials without the application of mechanical force can overcome many of the difficulties that are seen in conventional machining of CFRP composites such as drilling.

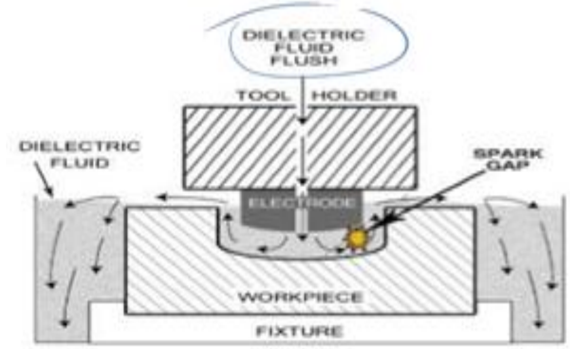

Fig. 3.1 Electric discharge machining of composites

B. Laser beam machining (LBM) –

Zaeh et al. [6] investigated the employment of remote laser cutting for contouring structural CFRP. A positive impact of the HAZ on the mechanical properties was found. Based on FEM simulations, laser contouring with a HAZ = 600 mm almost eliminated the risk of fibre fracture and improved the minimum total fatigue life.

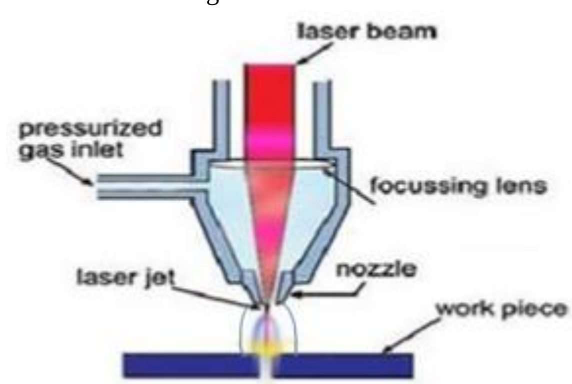

Fig. 3.2 Laser beam machining of composites

C. Abrasive water jet machining (AWJM)

Abrasive water jet machining is used for machining composites as well as sheet metals made of steel and alumminum. In abrasive water jet machining, high-velocity water is forced through a small-diameter jet. As the abrasive impinges on the surface, it cuts the material by inducing a localized stress failure and eroding the material.

In abrasive water jet machining, water pressures up to 60,000 psi (414 MPa) are used to cut the material. Water speeds of 800 m/s and nozzle diameters on the order of 0.25 mm are typical. For most composite applications, abrasive particles are added with the water to increase the cutting speed and to cut thick composite laminates.

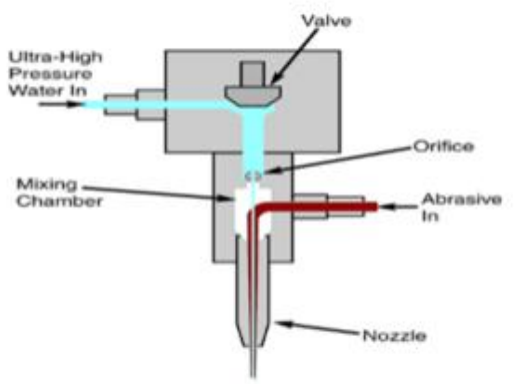

Fig. 3.3 Machining of PMC by AWJM

IV. CONCLUSION

Besides tool geometry and process parameters, the chip formation mechanisms for FRP composites are critically governed by the fibre orientation with respect to the cutting direction: disadvantageous fibre orientations can result in severe damage to the work piece.
In the present review, the key issues concerning the machining of fibre reinforced plastic composite materials were discussed with reference to the main recent research works in the field, when considering both conventional and unconventional machining processes and reporting the more recent research achievements. Conventional cutting processes, such as milling, turning, drilling, and trimming have been investigated.

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