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Investigation to Appraise the Abrasive Water Jet Response of Curaua/Basalt Hybrid Polyester Composites

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ABSTRACT

The application of natural fiber composite material in structural and interior parts of the automotive system is emerging. In this article an investigation is made to understand the effect of abrasive water jet machining parameters on surface roughness and kerf angle of the Curaua and Basalt fibers hybrid reinforced polyester composites. To identify the most effective machining parameter the MOORA and Principle Component method are used. It is found that jet pressure and feed rate are the most significant factors in influencing the surface roughness and kerf angle. Further, the effect of basalt content in the Curaua composites mechanical properties of Curaua composites, perhaps, a minor influence, is found with parameter optimization of basalt content.

KEYWORDS

Abrasive Water Jet, Hybrid Composite, MOORA, Parameter Optimization

INTRODUCTION

In recent years the application of composite materials is inevitable in aerospace, and automotive and structural applications. Around 50 ~ 60% of aerospace alloys are now replaced with composite materials (Wang, Pattarachaiyakoop, & Trada, 2011) among bio-degradable is receiving much interest from the research and industrial sectors (Groover, 2004). In general thermoset and thermoplastics materials are commonly used as matrix for the composite unit. Polyester, epoxy and phenolic resins are some of the engineering polymers used in automotive and aerospace applications, similarly few thermoplastics like polypropylene, poly vinyl chloride and polyethylene also in demand with the automotive sectors (Malkapuram, Kumar, & Vuvraj, 2009). The most commonly used natural fibers are cotton, linen, jute, Curauá, coconut, hemp, coir, etc. (Siva & Winowlin Jappes, 2011). Besides, several engineering structural applications are still catered by synthetic fibers like Basalt, glass, carbon, boron and aramid. Nonetheless, recent eco-concern society greatly supports the use of vegetable fibers in engineering applications with plastics due to their excellent biodegradable properties, even though they are so critical about low mechanical properties and water absorption characteristics compared to the synthetic fibers (Dhand, Mittal, Yop, Soo-JinPark, & Hui, 2015). Synthetic fibers

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are good enough to withstand the moisture content and possess greater mechanical properties than the vegetable fibers and even worse in biodegradable properties.

Basalt is a semi-natural fiber invented a decade ago attracting the automotive and aerospace sectors for replacement of various full synthetic materials in place. Zhongyu Lu et al. (2016) conducted the studies on basalt fiber reinforced polymer to understand the effect of elevated temperatures on the mechanical properties. The experimental result revealed that basalt reinforced composites have better mechanical and thermal resistance property than the glass fiber reinforced composites. Soares et al. (2016) studied the mechanical behavior of basalt fibers in a basalt/polyester, authors concluded that, the modulus of newly developed basalt composite are fall between modulus of Glass fiber and Carbon fiber composites which encourages the use of Basalt fiber in engineering polymers. Pucci et al. (2017) studied the surface characterization and wetting properties of single basalt fiber, reported that size of the fiber play an important role in the property. The selection of proper size of the fiber decides the porosities present in the composites.

On the other hand, growing vegetable fiber substitutes governing many engineering applications. Research thrust leads new identification of vegetable fiber day-by-day. On the series, the Curauá a native Brazilian fiber found in North Amazon region receives higher attractions now-a-days. Souza et al. (2016) have studied the use of Curauá fibers as reinforcements in composites, reported that elastic modulus, tensile strength, and flexural strength are increase in Curauá fiber reinforced with polymer composites. Monteiroa et al. (2013) have studied the processing and properties of continuous and aligned Curauá fibers incorporated into the polyester matrix and reported that composites fabricated in press mold and room temperature have shown the highest flexural properties among the other fabricated. Frollini et al. (2015) studied fabricated the bio-composites using poly(Butylene succinate) and Curauá, the results that reducing the length of the Curauá fiber increase the impact strength of the composites but increasing length of the fiber not affecting the flexural strength of the composites. Hybridization of natural and synthetic fiber will increase the mechanical and biodegradable properties as synergy. Junior et al. (2012) have studied the effect of Curauá based hybrid intra-laminate glass composites, reported that Curauá/glass composites are superior in mechanical properties and could replace the glass reinforced composites materials. Junior et al. (2013)) studied the hybridization Effect on the Mechanical Properties of Curauá/Glass Fiber Composites, reported that tensile strength and elastic modulus are increase if the glass fiber incorporated with Curauá fiber.

However, production is a big challenge in hybrid composite due to their unequal inherent and extrinsic properties. Compression molding and resin transfer molding (RTM) techniques are some of the suitable fabrication techniques to produce such hybrid composites in larger fiber volume fractions. Sreekumar et al. (2007) have made a comparative study on mechanical properties of sisal-leaf fiber-reinforced polyester composites fabricated by two different ways viz. compression molded and transfer molded. The transfer molded composite found good in producing less void composites than the compression molded. Perhaps, resin transfer molding allows incorporating higher volume percentage of fiber into the polymer matrix.

Meanwhile in-service sectors, the fabricated composites had undergone several machining operations during assembly. It is most important now-a-days to find the optimum parameters to perform machining on the vegetable fiber polymer composites to attain desire shape, size and quality. Several researchers are trying to optimize the conventional machining of fiber reinforced composites perhaps optimizing machining parameters for unconventional found weak. Azmira and Ahsanb (2009) have conducted AWJ machining on glass/epoxy composite laminates and arrived that, jet pressure and stand-off distance are most influencing parameter in determining the output responses while machining the ceramic fiber composites. In this work an attempt is made to develop Curauá fiber composite hybrid with semi-natural Basalt fiber through resin transfer molding process.

Initially the application of MOORA technique is limited to material selection process and later attempt has been made by Gadakh et al. (2011) to study the effectiveness of the technique in manufacturing-oriented problems. Six case studies have been considered to understand the

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