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Influence of Awj Parameters on Material Removal Rate, Surface Roughness, and Kerf Angle during Machining of Prosopis Juliflora Bark Fibres/Carbon Reinforced Hybrid Polymeric Composites

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Abstract

This study investigates the impact of changing the settings of the Abrasive Water Jet (AWJ) on the material removal rate (MRR), surface roughness, and kerf angle during the machining process of carbon-reinforced hybrid polymeric composites and Prosopis juliflora bark fibres. The hybrid nature of these materials presents unique machining opportunities as well as difficulties. As a result, optimizing the AWJ settings is essential for productive and efficient machining. The findings demonstrate the intricate connections between the AWJ parameters and the machining characteristics of the hybrid composite. To optimize MRR while minimizing surface roughness and controlling the kerf angle, the optimal parameter combinations are identified. The findings provide valuable insights for the manufacturing industry, particularly concerning sustainable materials and hybrid composites.

Keywords: *AWJ Abrasive Water Jet, MRR material removal rate*

1. Introduction

Hybrid polymeric composites, which blend natural fibres with carbon reinforcement, are gaining popularity in a range of technological applications due to their remarkable strength, low weight, and favorable environmental characteristics. Prosopis juliflora bark fibres are a sustainable, naturally occurring substance that has shown promise for usage as reinforcement in composite matrices. However, machining these hybrid composites is challenging due to the heterogeneous nature of the materials utilized in them. Pressurized water jets with high-velocity abrasive particles are used in the complex and versatile cutting process known as abrasive water jet (AWJ) machining. This method has proven to be effective in cutting a wide range of materials, including composites. The aim of this work is to investigate the effects of AWJ settings on three critical machining parameters: material removal rate (MRR), surface roughness, and kerf angle when carbon-reinforced hybrid polymeric Composites and Prosopis juliflora bark fibres are being machined. Pressurized water jets with high-velocity abrasive particles are used in the complex and versatile cutting process known as abrasive water jet (AWJ) machining. This method has proven to be effective in cutting a wide range of materials, including composites. The current study attempts to investigate the effects of AWJ settings on significant aspects of key machining content. Examining the effects of AWJ settings on three critical machining parameters—material removal rate (MRR), surface roughness, and kerf angle—while machining Prosopis juliflora bark fibres and carbon-reinforced hybrid polymeric composites is the aim of this study. Understanding the intricate relationship between AWJ parameters and the machining performance of these hybrid composites is essential to the advancement of sustainable manufacturing methods. Composite materials are specially blended materials that have noticeable differences in their chemical or physical properties. Composites combine the best features of separate components with the least amount of their respective shortcomings to create a material with enhanced performance qualities. Composite materials are very appealing to a wide range of sectors due to their versatility and flexibility to meet specific application requirements. Because of its exceptional mechanical properties, carbon composites are widely used as a matrix in a range of composite materials. Because of their remarkable resistance to corrosion, low weight, and great tensile strength, carbon fibres are among the materials that work well in scenarios where strength and light weight are crucial [1-3].

2. Overview of Composite

Composite materials are designed blends of two or more distinct materials with noticeably different physical or chemical characteristics. Composites are made to leverage the strengths of individual components while limiting their relative weaknesses in order to create a material with superior performance characteristics. Numerous sectors have shown a great deal of interest in composite materials due to their diversity and capacity to meet specific application requirements. Understanding the general characteristics of composite materials is essential for the current study on carbon composites with Juliflora dark fibres. Typically, a composite is composed of a matrix material and a reinforcing phase. A composite is typically composed of a matrix material and a reinforcing phase.

2.1 Natural Fiber

Integrating Juliflora bark fibres into carbon composites is an intriguing avenue to pursue in the research of natural fibre reinforcement in advanced materials. Adding natural fibres, such those in the Juliflora plant, to composite materials has inherent benefits. These fibres contribute to the overall sustainability of the composite since they are lightweight and usually produced of renewable resources. Juliflora fibres can enhance the composite's mechanical properties by adding a naturally robust element. The resulting composite material may exhibit a balance between the exceptional mechanical properties provided by carbon reinforcement and the eco-friendly attributes of natural fibres. As researchers strive to perfect the fibre content, orientation, and matrix compatibility, these natural fibre composites have the potential to offer a sustainable replacement with competitive mechanical performance in a range of applications, from automobile components to building materials. This quickly evolving field highlights how important it is to leverage the unique properties of natural fibres like Juliflora to encourage the development of high-performance, eco-friendly composite materials. Naturally occurring fibres are abundant and easy to handle, making them a viable alternative to manufactured fibres that may be harmful. Natural fibres are good at absorbing sweat and available in a variety of textures [4-6].

3. Carbon Fiber

Despite its many advantages, carbon fibre is highly expensive compared to other materials, which may limit its widespread usage in some applications. But ongoing study and advancements in production techniques keep expanding its use and bringing down its price in a variety of sectors. One material that is both extremely strong and lightweight is carbon fibre. It is constructed from slender carbon filaments connected by a polymer matrix, most often epoxy. Because of its excellent strength-to-weight ratio, carbon fibre is widely used in the sports goods, automotive, and aerospace sectors. Its primary attributes are high rigidity, low weight, resistance to corrosion, and distinctive look. Continuous manufacturing advancements are expanding its usage despite its higher cost compared to traditional materials. Carbon fibre contains at least 90% carbon. There are many different types of carbon fibre, and the firms who make them are quite private about their exact manufacturing processes. Carbon fibres are used in the aerospace industry, as well as in the manufacture of luxury cars, sporting goods, and medicinal equipment, due to their exceptional strength and lightweight nature. Synthetic fibres, sometimes known as man-made fibres, are mostly formed of petrochemicals, which are fundamental elements derived from petroleum. All textiles are formed from fibres, which are derived from synthetic or man-made materials. They are made up of either a polymer or a monomer, which is a small unit [7].

4. Selection of Material

4.1. Prosopis Juliflora Fibre

Abrasive Water Jet (AWJ) technology is being used more and more in the materials processing industry to machine Prosopis juliflora bark fibres and carbon-reinforced hybrid polymeric composites. Researchers are looking at the effects of several AWJ parameters on significant machining outcomes, including material removal rate (MRR), surface roughness, and kerf angle. Prosopis juliflora bark fibres in a polymeric matrix with carbon reinforcement present a unique set of machining opportunities and difficulties. A material's composition and structural characteristics have a significant impact on how it responds to an abrasive jet during machining. AWJ features such focus tube diameter, traverse speed, standoff distance, nozzle diameter, jet pressure, abrasive particle size, and abrasive mixing ratio have a significant impact on the efficiency and precision of the machining process. Finding the ideal combination of these variables to control the kerf angle and decrease surface roughness while achieving the desired MRR is the aim of the study [8].

4.2. Extraction of Uliflora Fibre

Prosopis juliflora fibres are necessary for the production of hybrid polymeric composites with carbon reinforcement. Researchers and practitioners in this field are likely looking into the optimal extraction methods that balance mechanical properties, environmental sustainability, and fibre quality in order to optimize the performance of the composite material overall. Prosopis juliflora fibres are necessary for the production of hybrid polymeric composites with carbon reinforcement. Researchers and practitioners in this field are likely looking into the optimal extraction methods that balance mechanical properties, environmental sustainability, and fibre quality in order to optimize the performance of the composite material overall. Figure 1 shows Prosopis Juliflora Bark Fiber [9-12].

Figure 1 Prosopis Juliflora Bark Fiber

4.3. Epoxy Resin

Epoxy Resin LY 556 Properties of Epoxy resin LY-556

1. Visual aspect -Clear, pale yellow liquid
2. Viscosity at 250 C -10000-12000 MPa
3. Density at 250C -1.15-1.20 gm/cm3
4. Flash point -1950 C 3.1.2

4.4. Hardner

Certain types of mixtures have a hardener as a component. The goal of adding a hardener in some combinations is to increase the mixture's strength when it hardens. In other mixtures, a hardener is a curing component. A hardener can function as a reactant or a catalyst in the chemical reaction that occurs during the mixing process. Hardeners are almost always necessary to make epoxy resin work as intended. Without a hardener, epoxies do not achieve nearly as remarkable mechanical and chemical properties as they would with one. The right sort of hardener must be used in order to ensure that the epoxy mixture will meet the requirements of the intended application [13-15].

5. Testing Method

5.1. Vacuum Bagging Theory

Laminated plies are kept together in vacuum bagging by air pressure working as a clamp. The lamination is enclosed in an airtight envelope. There may be an airtight bag on one side of the envelope and an airtight mould on the other. When the bag is sealed to the mould, the pressure within and outside of this envelope equals atmospheric pressure, or about 29 inches of mercury (Hg), or 14.7 psi. When air is removed from the envelope by a vacuum pump, the air pressure outside the envelope remains at 14.7 psi, while the air pressure inside the envelope lowers. The

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air pressure pushes the sides of the envelope and everything within together, applying equal and even pressure over the envelope's surface. The pressure differential between the interior and outside of the envelope determines how much clamping force is applied to the laminate. The maximum pressure that could theoretically be applied to the laminate, supposing that a complete vacuum could be generated and that all of the air was removed from the envelope, is one atmosphere, or 14.7 psi. The clamping pressure will be a realistic pressure difference of 12–25 inches of mercury (6–12.5 psi). Similar to other laminating techniques, you can mix and match different materials for the laminate. This technique ensures that the clamping pressure is uniformly applied throughout the whole surface, regardless of the material being laminated. This makes it possible for the materials to adhere better and to be more varied and mixed. It works better than mechanical clamping or stapling, which can damage sensitive core materials, only applies pressure to some areas, and may not apply enough pressure in certain areas to create a firm bind. To fill up the gaps, extra glue could also be needed [16-18].

5.2. Vacuum Pumps

The vacuum system's brain is the vacuum pump. Powered vacuum pumps work in reverse to extract air from a closed system and discharge it into space. Their principles are similar to those of air compressors. The vacuum pressure potential, sometimes known as the "Hg maximum" (mercury's chemical symbol is Hg), the displacement in cubic feet per minute (CFM), and the horsepower required to run the pump are the three main characteristics of vacuum pumps. This vacuum level represents the maximum clamping pressure that can be generated. Two inches of mercury are equal to one pound per square inch (1 psi) of air pressure (2 Hg).

6. Final Surface Preparation

Using the proper finishing techniques will protect your product from UV radiation, which over time will cause the epoxy to breakdown, in addition to improving its appearance. Painting and varnishing are the two methods of finishing that are most commonly employed. These coating methods protect the epoxy from ultraviolet light, but they need surface preparation before application. High-build or filling primers with grit levels between 80 and 100 often perform nicely. A grit of 120–180 could be enough for high-solids coatings and primers. When polishing high-gloss coatings, 220–400 grit paper is usually used. When you are satisfied with the texture and fairness of the surface, rinse it again with fresh water. Use a solvent to clean the area, blot dry with a paper towel, and then wet sand again until the beading goes away if the rinse water beads up, indicating pollution.

Figure 2 **Finished Composite Material**

The complex subject of Abrasive Water Jet (AWJ) parameters on material removal rate, surface roughness, and kerf angle during Prosopis juliflora bark fiber/carbon reinforced hybrid polymeric composites machining involves several factors. Using an abrasive particle jet suspended in water at high velocity, materials are cut and shaped in the AWJ process. After the surface has completely dried, add your final layer. To reduce contamination, it is best to begin painting 24 hours after the last sanding. Figure 2 shows Finished Composite Material [19].

6.1. Surface Roughness Alone

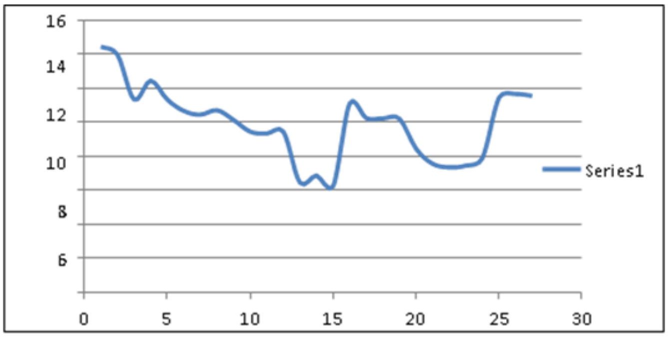

Figure 3 **Graph Shows Trail Numbers and Surface Roughness**

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In this graph explain about surface roughness (between trail numbers as above 20 readings; we plot graphs made a X-axis as a trail numbers and Y -axis as a surface roughness so this is number as a series-1 like feature this will compare the result in output response like the thus values reading likes surface roughness alone. Figure 3 Graph Shows Trail Numbers and Surface Roughness [20].

6.2. Surface Roughness Vs Nozle Diameter

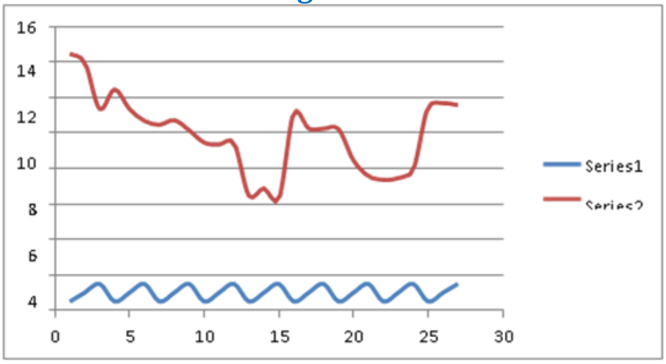

Figure 3 Graph Shows Nozle Diameter and Surface Roughnes

This graph illustrates surface roughness and Nozzle diameter trail numbers as readings above 20. We plotted graphs with X and Y axes for Nozzle diameter and surface roughness, respectively, so that this is number as a series-2 like feature that will compare the output response like the thus values reading likes diameter of the nozzle

6.3. Kerf Angle Alone

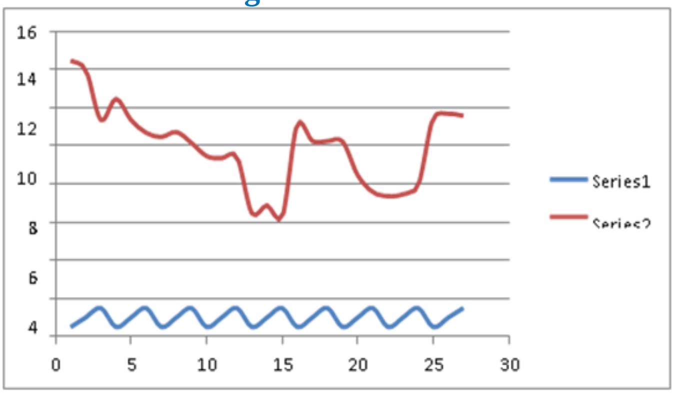

Figure 4 Graph Shows Kerf Angel Alone

We plotted graphs with an X-axis representing trail numbers and a Y-axis representing material removal rate, so this is number as a series-1 like feature that will compare the result in output response like the thus values reading likes. This graph explains the material removal rate between trail numbers as above 20 readings. Figure 4 Graph Shows Kerf Angel Alone.

6.4. Material Removal Rate

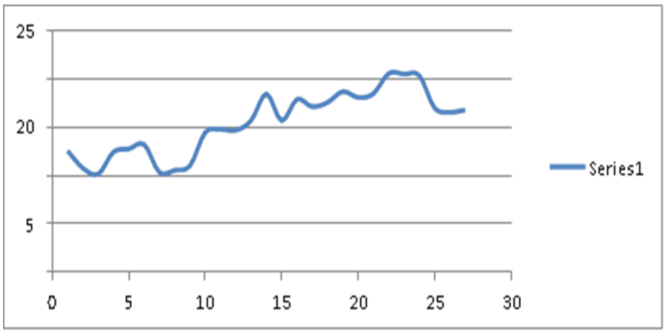

Figure 5 Graph Shows Material Removal Rate

The purpose of this graph is to illustrate the material removal rate between trail numbers as well as readings above 20. To do this, we plotted graphs with X representing trail numbers and Y representing material removal rate. This allows us to compare the output response to the thus values reading, which represents material removal rate. Figure 5 Graph Shows Material Removal Rate [21].

Conclusions

PJ together with for our project, epoxy glue and hardener were applied on carbon fabric. With epoxy glue, the carbon fibres have been successfully reinforced using a simple hoover bagging technique. Additionally, while hybrid polymeric composites reinforced with Prosopis juliflora bark fibres and carbon textiles are being machined, research is being done on the impacts of AWJ parameters on the rate of material removal, surface roughness, and kerf angle. Prosopis juliflora fibres may be effectively used to create composites with varying fibre percentages. A composite containing carbon fabric reinforcements has superior mechanical qualities than one constructed of pure matrix material. Automotive, aerospace, and panel applications all use these composite materials. The findings of this study provide important new insight into the complex link between AWJ parameters and the machining characteristics of hybrid polymeric composites that

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include fibres from Prosopis juliflora bark and carbon added. Optimizing these parameters is crucial to achieving better performance in terms of Material Removal Rate, Surface Roughness, and Kerf Angle. The data acquired from this investigation is essential to enhancing our understanding of the AWJ machining process for these specific hybrid polymeric composites.

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