# Selection of a biocomposite material as an alternative for the manufacture of the rotor of a gravitational vortex turbine


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## Introduction

An innovative machine in the field of micro hydropower is the gravitational vortex turbine, designed to capture the natural flow of water and generate energy. This turbine works through the creation of a free surface vortex, from which its kinetic energy is used. It consists of an inlet channel that leads water to a circular basin, which has an opening at its base, allowing the formation of the vortex that drives a rotor equipped with multiple blades. This rotor is connected to an electric generator that produces energy, and finally, the water is evacuated through an outlet channel.

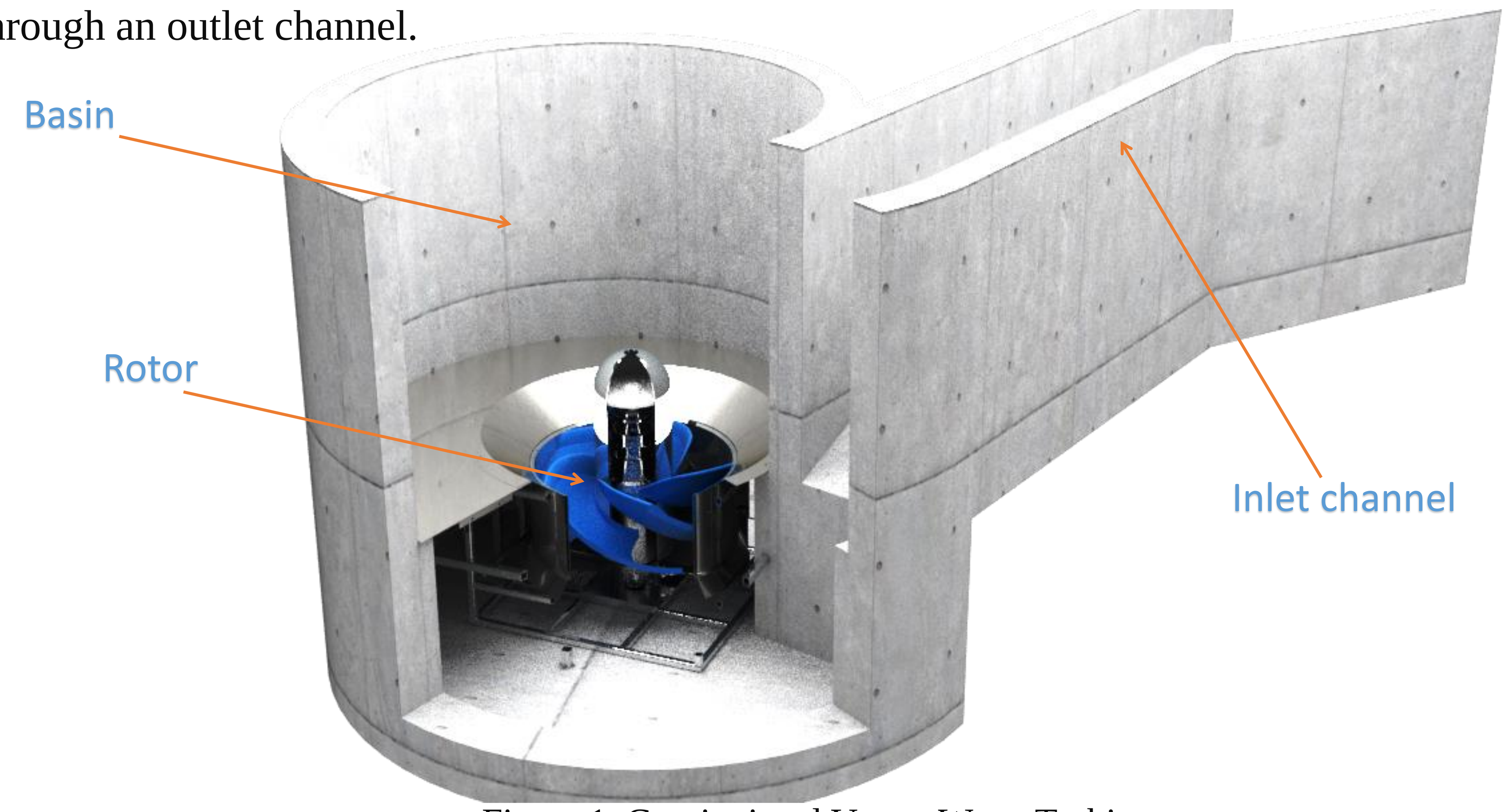


Figure 1. Gravitational Vortex Water Turbine.

## Problem statemen

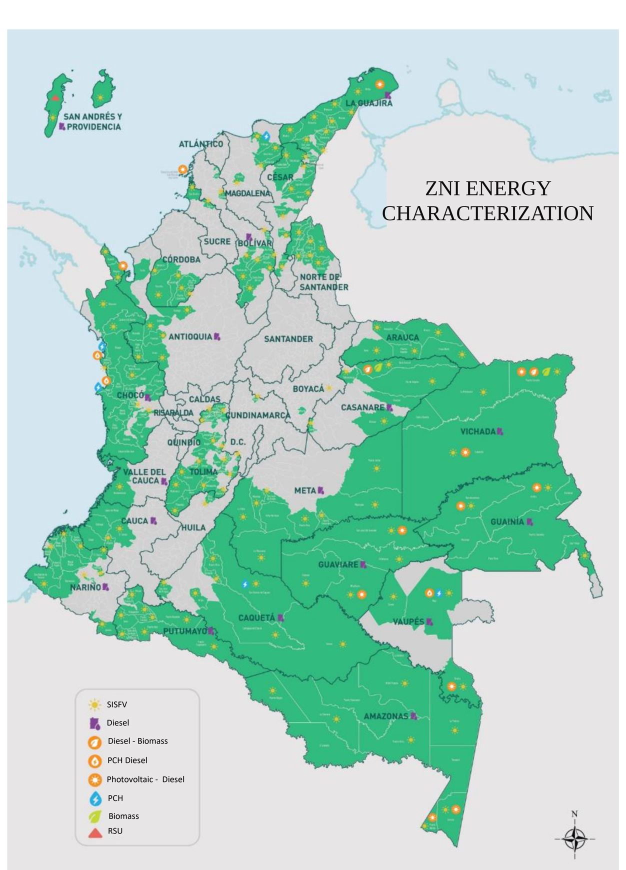


Figure 3. ZNI energy characterization.

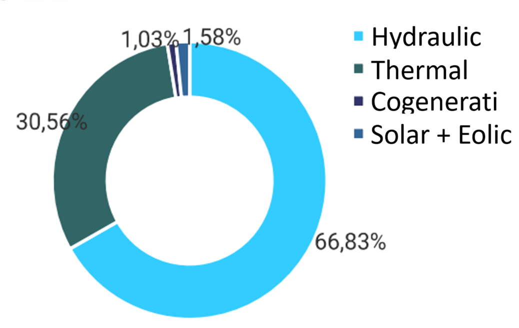


Figure 2. Forms of energy generation in Colombia.

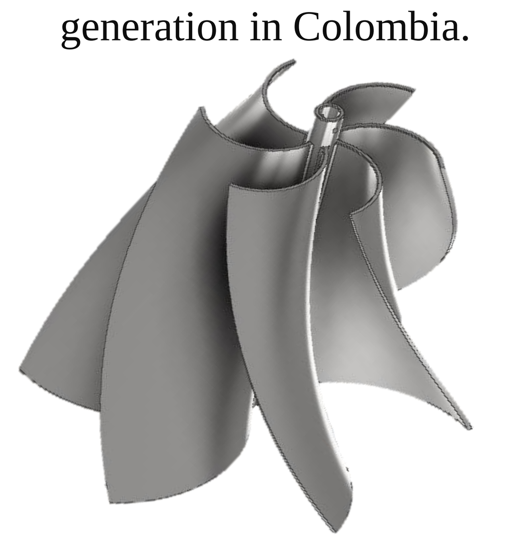

Figure 4. Stainless steel rotor.

To achieve greater efficiency in the operation of the plant, it is suggested to reduce the weight of the impellers and use lighter and more resistant materials [1]. Timilsina et al. recommend investigating lighter materials, such as aluminum, plastic, or composite materials, for their application in structural components for the manufacture of the turbine rotor [2].

## Methodology

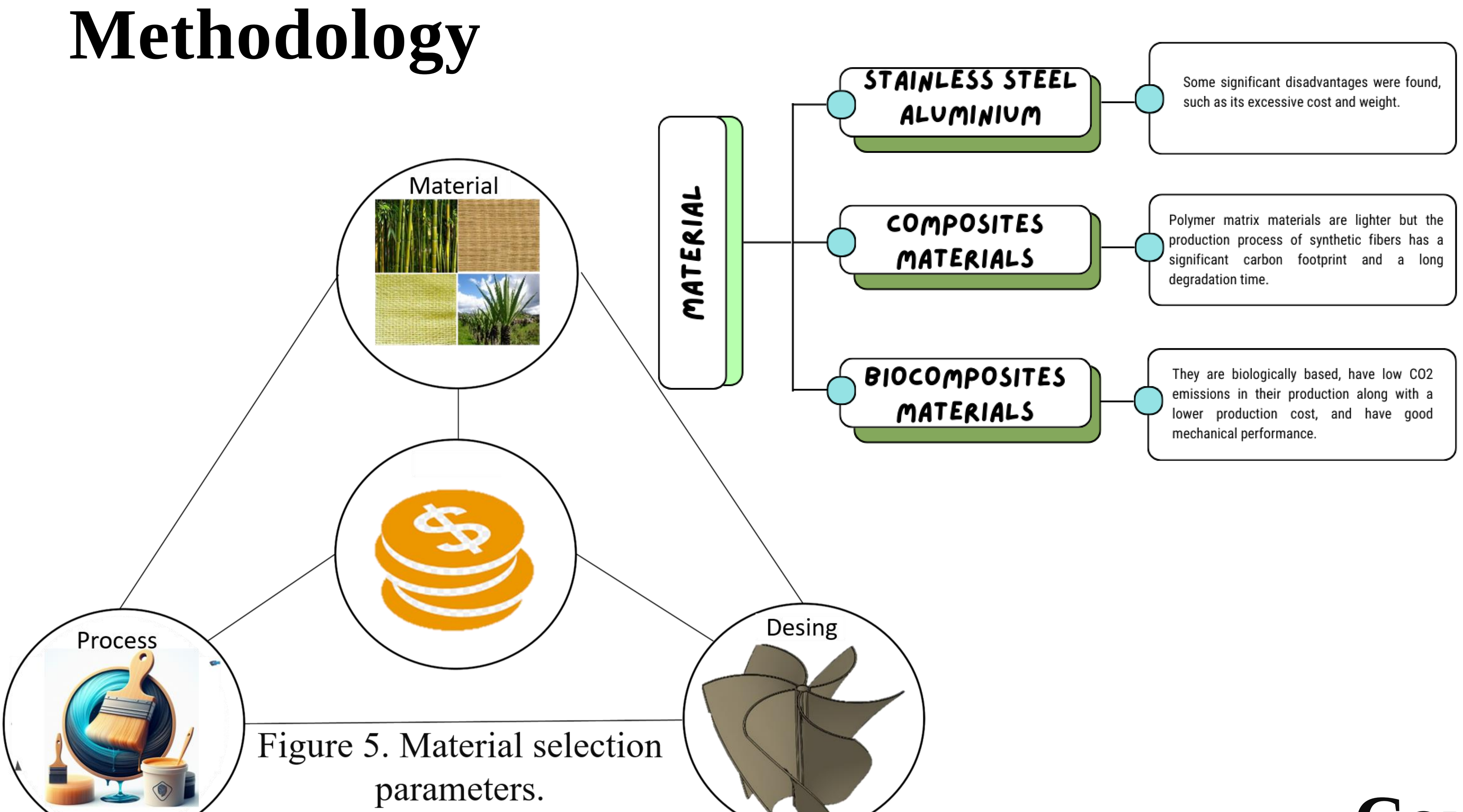


Figure 5. Material selection parameters.

## Results

### ✓ Laminate manufacturing.

Figure 6. Fique fiber laminate with unsaturated polyester resin.

Laminates were manufactured using fique fiber as reinforcement for the biocomposite. They were impregnated with a polyester. Four laminates were obtained with an average thickness of 4 mm. The weight fraction of the components was 60% polyester resin and 40% fique fiber reinforcement.

### ✓ Density estimation

With the rule of mixtures for composite laminated materials, the density of the composite can be estimated according to equation 1 [3].

$$\rho_c = f_m \rho_m + f_f \rho_f \quad (1)$$

### ✓ Tensile and bending test.

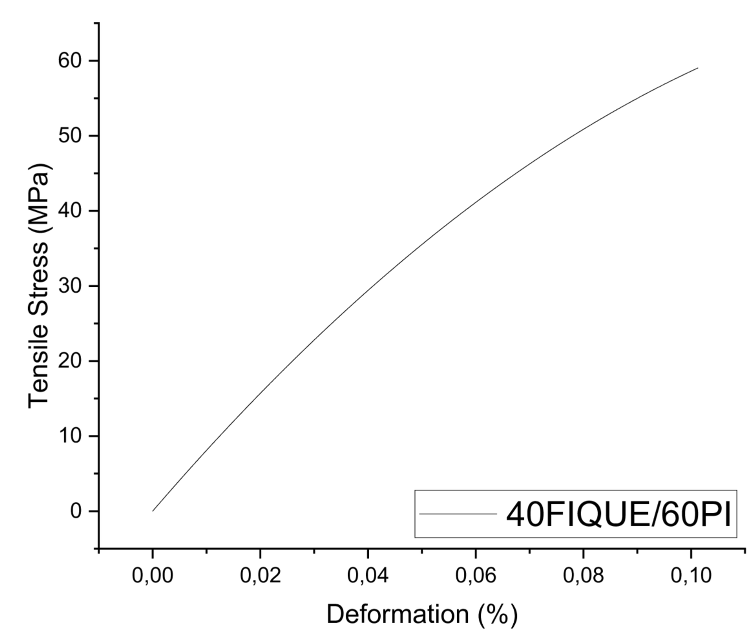


Figure 7. Tensile stress vs strain diagram, 40% Fique bio composite.

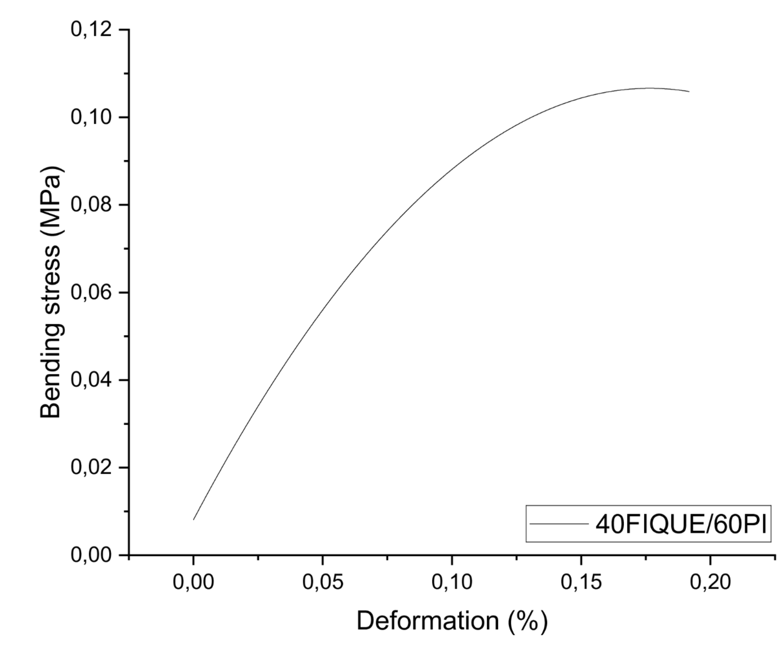


Figure 8. Bending stress vs strain diagram, 40% Fique bio composite.

### ✓ Rotor manufacturing


Figure 9. Rotor manufacturing process.

### ✓ Selection of bio composite material

The properties of materials are evaluated and weighted according to their importance to determine a total score. Minimum values are preferable for some properties (such as density and cost), while maximum values are ideal for others (such as strength, elastic modulus). The material with the highest total score is selected as the most suitable for the application

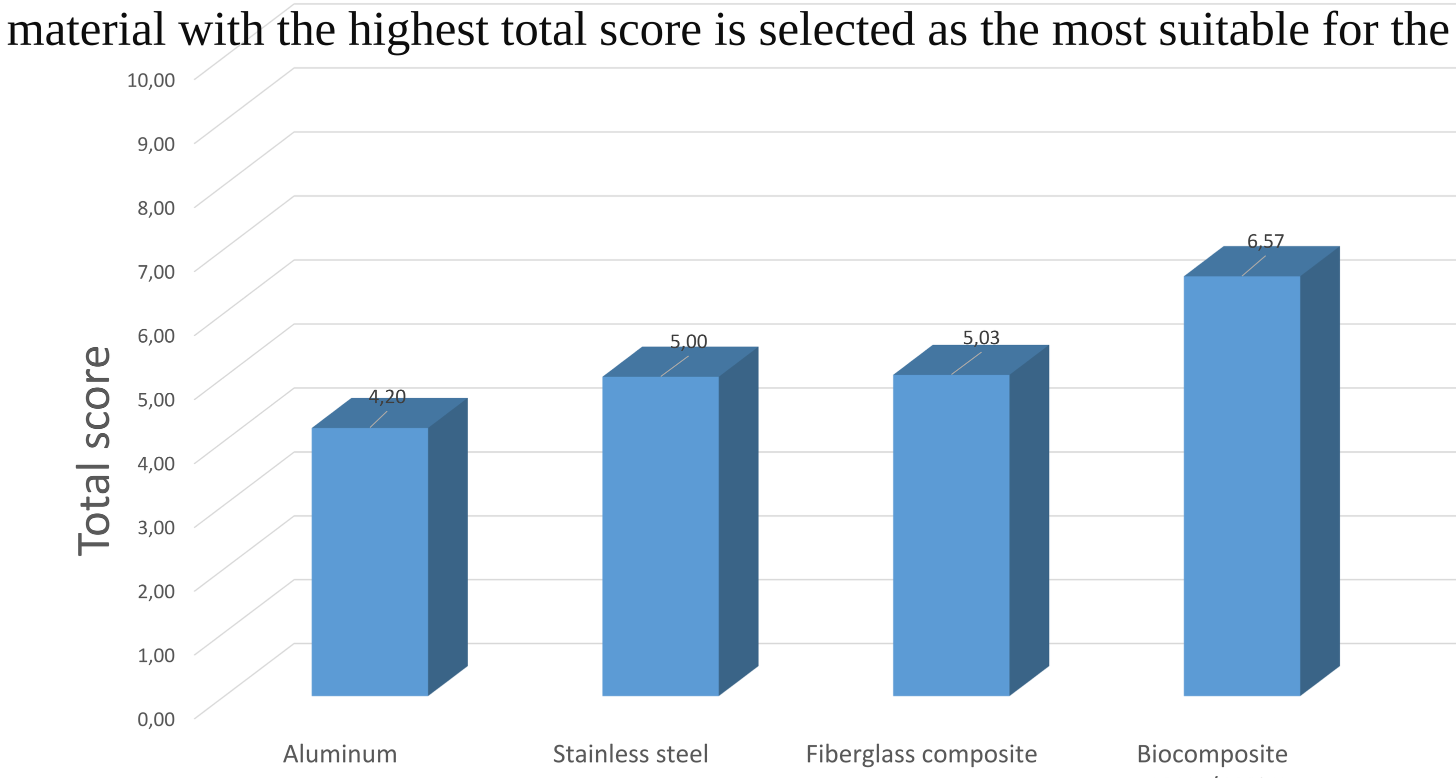


Figure 10. Weighted score for each material

## Conclusions

- The manufacture of laminates using the manual impregnation method, which combined unsaturated polyester resin with three layers of fique fiber, resulted in a composite material with promising mechanical properties.
- The estimation of the density of the bio composite proved to be a crucial aspect. Its lightness, compared to conventional materials such as aluminum and stainless steel, positions it as an attractive alternative to improve the efficiency of hydraulic turbines.
- The resulting material met the characteristics required for the manufacture of the rotor, standing out for its low density, competitive cost, and environmental sustainability.

**Full paper**

## Reference


[1] S. Dhakal, S. Nakarmi, P. Pun, AB Thapa, and TR Bajracharya, "Development and testing of runner and conical basin for gravitational toilet vortex power plant," Journal of the Institute of Engineering, vol. 10, no. 1, pp. 140–148, Aug. 2014, doi: 10.3126/JIE.V10I1.10895.

[2] AB Timilsina, S. Mulligan, and TR Bajracharya, "Water vortex hydropower technology: a state - of - the -art review of developmental trends," Clean Technol Environ Policy, vol. 20, no. 8, pp. 1737–1760, Oct. 2018, doi: 10.1007/S10098-018-1589-0/FIGURES/19.

[3] J. Newell, Materials science. Applications in Engineering, 1st ed. Alfa omega Grupo Editor, SA de CV, Mexico, 2010.