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Design, Implementation, and Analysis of anIn- House Vacuum Assisted Resin Transfer Molding System for Composite Manufacturing and Mechanical Behavior Study

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Abstract: This study has been undertaken to investigate the determinants of stock returns in Karachi Stock Exchange (KSE) using two assets pricing models the classical Capital Asset Pricing Model and Arbitrage Pricing Theory model. To test the CAPM market return is used and macroeconomic variables are used to test the APT. The macroeconomic variables include inflation, oil prices, interest rate and exchange rate. For the very purpose monthly time series data has been arranged from Jan 2010 to Dec 2014. The analytical framework contains**.**

Keywords: VARTM, Composite Manufacturing, Banana fiber, Jute fiber, Epoxy, Hardener, Fabrication Techniques

I. Introduction

Vacuum-Assisted Resin Transfer Molding (VARTM) is a cost-effective way to manufacture large-scalecomposite parts for civil, automotive and defense applications. This procedure uses low-cost tooling to produce high-quality composite parts, making it the ideal production technology for naval top-side structures. Mold fillingunder vacuum pressure becomes challenging as part complexity and size increase, especially when using advancedfiber preforms with low permeability. Dry areas may occur, necessitating component repair or scrapping. Controlling resin flow is crucial for improving process yield and efficiency.[1]

Unlike RTM, VARTM employs a flexible vacuum bag as an upper mold. Resin is injected into the closed mold by creating a vacuum, which also compacts the fabric. The phrases "equivalent" and "effective" permeabilities are misleading when modeling the VARTM process using RTM solver, as there is no commonly agreed definition of "effective" or "equivalent" permeability. In VARTM, extremely permeable distribution mediaare used on top of the fabric. [2]

There are primarily two steps in this approach. In the first step, resin is injected into the mold cavity containing the preform during the mold-filling stage. The second phase involves heating the resin and fiber mixture to a high temperature, which solidifies the catalysed resin and creates composite laminate.[3]

Over the past decade, researchers from several fields have attempted to replace synthetic materials withnatural fibers.
Synthetic fibres include nylon, rayon, polyester, acrylic, glass, and plastic.[4]

Natural fibers are preferred as a reinforcing agent due to their low cost and density. They are renewable,non-abrasive, and biodegradable. Fiber reinforced polymers (FRPs) are made up of high strength and modulus fibers placed in a matrix having a unique interface. Both fibers and matrix maintain their physical and chemical properties in this condition [5]. The banana fiber and jute fiber are taken in a 50/50 ratio and in the proportions of200mm x 200mm. [6]

Materials created by mixing two or more distinct types of fibers into one matrix are known as hybrid composites. In a polymer matrix, hybrids of short fibers with the same diameter and length have certain advantages over using only one kind of fiber. Natural fibers such as banana, kenaf, and jute can be burned to recover energysince they are non-abrasive and renewable.[7]

Over using only one kind of fiber. Natural fibers such as banana, kenaf, and jute can be burned to recover energysince they are non-abrasive and renewable.[7] They have a high calorific value and pose few risks to one's healthor safety when handled. They also have low density, good mechanical qualities, and are reasonably priced. Because of their excellent environmental friendliness, the materials are highly sought-after in technical areas likethe construction and automobile industries. We looked into the mechanical and thermal characteristics of raw juteand epoxy hybrid composites reinforced with banana fibers as a result.[9]

II. Experimental

2.1 Materials

We purchased bananas and natural jute fiber from Fiber Region, a trader in Valasaravakkam, Chennai, Tamil Nadu. Hardener (HY951) and epoxy resin (LY556) were purchased from Herenba Instruments & Engineers in Chennai, India. Vacuum pump (1/16 HP) was bought from Athena Technologies in Mumbai, India. Pressure gauge was purchased from Amazon. Vacuum bags were brought from flip kat

2.2 VARTM fabrication & Composite manufacturing

First, we take a wooden slab and use a drilling machine to cut holes on one side to attach the vacuum pump. Then, attach the resin pot to the other side of the hardwood slab. Jute and banana fiber were spun in 200 mm by 200 mm increments. The density of the epoxy resin is 1200 kg/m3, but the moduli of jute fiber and bananafiber are around 55 GPa and 43 GPa, respectively. These composites did not contain any particle filler. As indicated, the matching hardener (HY951) and low temperature curing epoxy resin (LY556) were blended in a weight ratio of 10:1. After that, apply a releasing agent to the mould and coat it with fibre mats. After that, preparepeel ply and vacuum bag film and attach tacky tape to the covered mould. Apply peel ply on the fiber mat. Then,at two distinct locations, attach two connectors to the mould's sidewalls. Apply vacuum bag film on the top of thetacky tape. One PVC pipe connects the lamination to the resin pot, while another black hose connects to the vacuum pump. When starting the vacuum pump, make sure there is no air leaking. Turn on the vacuum pump to begin the infusion process. Allow 24 hours for the curing process at room temperature.

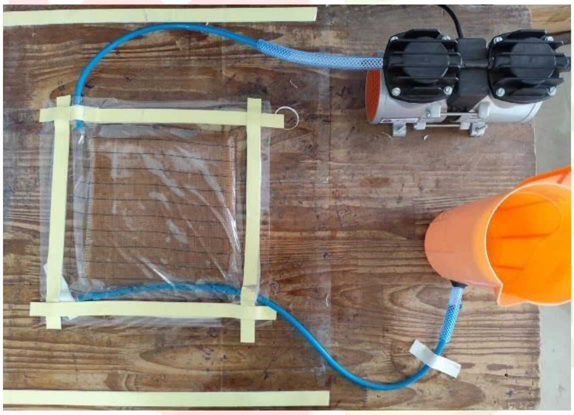

Fig 1a. Vacuum assisted resin transfer molding setup

Fig 1b. Hybrid composite plate

2.3 Mechanical Studies

The test specimens underwent ASTM-compliant mechanical tests following manufacture. The standardsfollowed. Tensile strength was tested using ASTM D 638-14[9] at a speed of 1 mm/min, while flexural strength was obtained using ASTM D 790-17 procedures.[10] The test speed was maintained at 1.2-1.5 mm/min. Tensile and three-point bending tests were conducted utilizing a Universal Testing Machine

Fig 2a. Specimens as per ASTM for tensile test

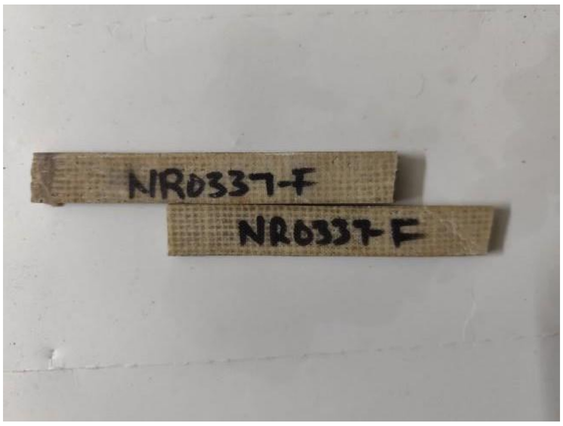

Fig 2b. Specimen cut as per ASTM for flexural test

III. Results and discussion

3.1. . Mechanical studies

It has been discovered that for 50/50 weight ratios of jute and banana fiber reinforced epoxy hybrid composites, the mechanical qualities, such as tensile strength and flexural strength, are at their maximum when using Vacuum-Assisted Resin Transfer Molding (VARTM). Tensile and flexural strength were measured at 24.13MPa and 61.70 MPa, respectively.

Table 1

Mechanical properties of Hybrid composite materials by using VARTM.

Weight ratio of jute/banana	Tensile strength (MPa)	Flexural strength (MPa)
50/50	24.13	61.70

Conclusions

The current study investigates the mechanical and thermal properties of jute fiber and banana fiber reinforced epoxy hybrid composites utilizing VARTM. The mechanical characteristics of jute and banana fiber reinforced epoxy hybrid composites, such as tensile strength and flexural strength, are based on a 50/50 weight ratio. Hybrid composites with a 50/50 weight ratio have improved flexural and tensile characteristics. Poor interfacial bonding between the fiber and matrix is the cause of the increases in mechanical as demonstrated by the data obtained from creating the VARTM machine and reported in this study.

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[10] ASTM D 790-17. Standard tests method for testing flexural properties of unreinforced and reinforcedplastics and electrical insulating material.