

## **ABSTRACT**

Composite materials are a combination of base material and filler material. The foundation material, which binds or holds the filler material in structures, is termed as a matrix or resin, while filler material which is present in the form of sheets, fragments, particles, fibers, or whiskers of natural or synthetic material is known as reinforcement material. The fibers increase the strength and stiffness, increase thermal and fatigue properties, provide better dimensional stability etc. Whereas the basic function of the resin is to transfer load, to hold the fibers, protect fibers from the environmental effects, and mechanical abrasion. Most of the composites can be customized to obtain properties better than individual constituents.

Composites are heterogeneous materials, the study of mechanical characterization in different environmental conditions is very important. The performance of composite materials is often very sensitive to changes in temperature. This arises due to two main reasons. First, the response of the matrix to an applied load is temperature-dependent and, second, changes in temperature can cause internal stresses developed as a result of differential thermal contraction and expansion of the two constituents. Changes in internal stress on varying the temperature can be significant and may strongly influence the behaviour of the material to an applied load and hence the thermal conductivity of composite materials is of interest. This property can be forecasted from the conductivities of the constituents, although the situation may be complex by poor thermal contact across the interfaces.

Each material has an individual post-cure process that relies on raw materials. Post curing variables consist of temperature, a time duration of cure, the time between initial curing and post-curing, and also temperature profile gradient. Polymer composites can be evaluated based on mechanical strength to determine the cure state. Many polymeric materials, development, and control of the manufacturing process require track of the degree of cure.

An experimental set up of hot plate with temperature controller and sensors with punch and mould was prepared to know the effect of load applied during the fabrication process at controlled temperature (in process curing) and hot air oven with temperature controller was developed in the laboratory to know the effect of post-process curing at elevated temperature. Investigations were made to know the effect of in-process curing and post-process curing on mechanical characterization.

The purpose of the present research work is to characterize a composite material developed by post-process curing and in-process curing considering the effect of load, temperature, and time during the process. Test specimens were prepared from jute, basalt, and carbon fibers using vinyl ester as a matrix at different combinations of temperature, load (pressure) and time derived using the Taguchi method by applying in-process and post-process curing. Mechanical tests were conducted and the effects of temperature, load, and time on mechanical properties (tensile strength and flexural strength) were observed. Test specimens from jute using polyester as matrix were also prepared with different fillers (Cu, Al, and SiC) to observe their effects on thermal conductivity, and also mechanical strength was compared to know the effects of fillers.

The heat conduction depends on thermal transport property called thermal conductivity. The measured numerical value of thermal conductivity gives an idea about the use of the material as a heat conductor or insulator. To measure the thermal conductivity of materials for a wide range of temperatures, an indigenous experimental set up was developed which works based on Guarded Hot Plate (GHP) using the principle of a calorimeter. Experiments were performed for measuring the thermal conductivity of jute-polyester composites (with filler and without filler) also of hybrid composites of Bamboo and glass fibers with vinyl ester over a limited range of temperature.

Effects of load, temperature, and time during post-process curing (PPC) and effects of load and temperature during in- processed curing (IPC) were investigated for tensile and flexural properties using ANOVA and Regression Analysis (RA).

Investigations of the research show, in the case of the tensile strength of post-processed cured JVC, the effect of post-curing time was not observed significant after 120 minutes. Whereas in the case of BVC and CVC load and temperature came out as significant parameters, as load and temperature increased, tensile strength also increased. In the case of flexural strength tests, JVC, BVC, and CVC revealed that in most of the cases, all the three parameters viz. Load (L), temperature (T), and time (t) were observed significant but the load (L) came out to be the most significant. Almost in all the combinations as load, temperature, and time increased, flexural strength also increased. In the case of in-process curing of JVC temperature had the most significant effect on tensile and flexural effect.

Statistical models of flexural and tensile strength were proposed based on experimental data and through regression analysis (RA) for IPC and PPC research investigations.

From the experimental data of thermal conductivity measured in the case of hybrid composites, it was observed that the value of thermal conductivity increased on increasing the glass fiber content. The effect of bamboo fiber was to reduce thermal conductivity. It was also observed that in all different plates of JPC prepared by adding fillers of Cu, Al, and SiC separately, thermal conductivity improved significantly in all cases.