6. CONCLUSION AND FUTURE SCOPE

6.1 Conclusion

The current research work describes the mechanical and thermal behavior of fiber-reinforced polymer composite. The influence of post-processed curing (PPC), considering the effects of load, temperature, and time were investigated for tensile and flexural properties using ANOVA and Regression Analysis. Similarly, investigations were carried out considering the effects of load and temperature during in- processed curing (IPC) using the same ANOVA and Regression Analysis. The indigenous experimental set up was developed to measure thermal conductivity for various natural fibers based composites and composites with different filler materials.

The principal findings of investigations carried out based on the above concepts are depicted below:

- It is identified that natural and synthetic fibers reinforced polymer composites can be employed to various mechanical and thermal related applications e.g. aerospace structures, marine parts, automotive parts, sports, etc.
- To obtain higher tensile strength for jute vinyl ester composite, load during the development of composite must be kept high in post-processed curing (PPC) and the temperature is also to be kept in the order of above $60^{o}C$ as very high temperature may damage fibers of jute being a family of natural fiber category. The effect of post-curing time is not observed significant after 120 minutes.
- In the case of Basalt vinyl ester composite for post-processed curing (PPC), load and temperature come out as significant parameter as load and temperature increases, tensile strength also increases.
- For carbon vinyl ester composite, the trend observed is the same as Basalt vinyl ester composite as both Basalt and Carbon are of the high strength fiber category.
- The experimental results for flexural strength of Jute vinyl ester, Basalt Vinyl ester, and Carbon vinyl ester reveals that in most of the cases, all the three parameters viz. load, temperature, and time are observed significant but load comes out to be the most significant. Almost in all the combinations the load, temperature, and time increase, flexural strength also increases.

- For the case of in-process curing (IPC) of Jute Vinyl ester composite, the temperature has the most significant effect on tensile and flexural effects. The tensile strength and flexural strength significantly improves after 60^{o}C temperature for in-process curing (IPC) conditions.
- The following statistical models of flexural and tensile strength are proposed based on experimental data and through regression analysis carried out for post-processed curing and in-process curing

Tensile Strength: Post Process Curing (PPC)

$$\sigma_{t\_Jute\_PPC=} 13.1906 + 0.084944 * L + 0.0694444 * T + 0.0124074 * t$$

$$\sigma_{t\_Basalt\_PPC=} 102.114 + 0.674778 * L + 0.541667 * T + 0.00944444 * t$$

$$\sigma_{t\_Carbon\_PPC=} 68.8454 + 0.436944 * L + 1.69444 * T + 0.133333 * t$$

Flexural Strength :Post Process Curing (PPC)

$$\sigma_{f\_Jute\_PPC=} 7.04296 + 0.22125 * L + 0.239875 * T + 0.014338 * t$$

$$\sigma_{f\_Basalt\_PPC=} 37.7867 + 1.08183 * L + 1.04042 * T + 0.110417 * t$$

$$\sigma_{f\_Carbon\_PPC=} - 61.9996 + 1.08678 * L + 1.41111 * T + 0.149306 * t$$

Tensile Strength And Flexural Strength : In-Process Curing (IPC)

$$\sigma_{t\_Jute\_IPC=} 22.7498 + 0.0202222 * L + 0.166806 * T$$

$$\sigma_{f\_Jute\_IPC=} 60.8896 + 0.0258944 * L + 0.176403 * T$$

- The indigenously developed experimental setup was used to determine the thermal conductivity of composites made from Bamboo Fibers, Glass fibers, and Bamboo-Glass hybrid fibers with Vinyl ester by measuring total heat supplied and using this value in Fourier equation and Cut bar method to finally evaluate thermal conductivity which is thereafter compared it with Theoretical value-based series model. In most of the cases, the difference between experimental and theoretical values observed below 10 % which proves the capability of experimental setup developed to determine thermal conductivity values.

- The thermal properties of polymer-based composites are critical parameters for material design in heat transfer applications. The properties of natural fibers depend on their inherent physical and chemical structure. There is a hollow cavity in natural fibers, which is called 'lumen' because of that heat conductivity of natural fibers is lesser than that of solid mineral fibers. (Takagi, Nakagaito, and Liu 2015). From the experimental data of thermal conductivity measured, it was observed that on increasing the glass fiber content, the value of thermal conductivity increases. The significance of bamboo fiber is to reduce thermal conductivity.

- Fibers reinforced polymer composite, in general, are having very little value of thermal conductivity. In some of the applications minimum to moderate thermal conductivity is essential along with lightweight and anticorrosive nature of the material. Keeping this is in mind Jute polymer composite with conductive fillers like, Cu, Al, and SiC were successfully developed. The thermal conductivity of this composite was determined through a developed experimental setup. Jute Vinyl ester composite was prepared by adding Cu, Al, and SiC approximately 5%. The result of thermal conductivity reveals that 5% addition of Cu, Al, SiC as filler improves thermal conductivity by 140%, 127%, and 98% respectively.

6.2 Future Scope

- Determination of Mechanical Properties at an elevated temperature
- Determination of the thermal conductivity with varying filler contents
- Statistical modelling of the thermal conductivity using DOE technique