International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 07 Issue: 12 | Dec 2020 www.irjet.net p-ISSN: 2395-0072

Study on Effect of Microwave Irradiation on Tensile strength of Glass fiber and Hemp Reinforced Polymer Composites

Mohammed Bilal

Mechanical Engineer, Mysuru, Karnataka, India.

Abstract - *Glass fiber and Hemp Reinforced polymer composites seem to be the best alternative composite material and having superior properties over natural fibers. The glass fiber and hemp incorporated composites were fabricated with Epoxy resin, Microwave Radiation were passed on them and the tensile strength of these composite samples were noted and analyzed. The specimen is prepared according to ASTM standards. The effect of combination of fibers before and after irradiation is investigated. The samples were tested by Digital UTM machine. It generates graphs between force and displacement has been obtained directly from machine by applying pull load on it. From observed reading Without Radiation at Room temperature the maximum tensile strength obtained was 49.73MPa. The best Microwave Radiation dosages for Glass fiber and Hemp Reinforced polymer composites is obtained when the samples were heated at 120^0C for 8 minutes and 24seconds. The maximum Tensile strength obtained was 79.2MPa which is 1.6 times more than the specimen which was not irradiated.*

Key Words: **Glass fibre, Hemp, Epoxy resin, Tensile Strength, Microwave irradiation.**

1. INTRODUCTION

A composite material is made up of two or more materials with different physical and chemical properties they were combined to produce different characterized material and it is different from individual component. The main reason to choose composite is weight to strength ratios, some fiber reinforced composite can be stronger and have low density. As the traditional materials were basically metals such as Steel, HSS, Brass, Copper etc. which were much heavier and costlier to machine. As all engineering materials these composites have particular strength and weakness. It should be considered at the specifying stage; composites are not be the right material for all job. The major reason for development of composite is we can change the reinforcement and the matrix material ratios to achieve final properties of component. For example, if final product needs to be fire resistance, we can use a fire-retardant matrix at development stage. So now a day's industries are giving importance to natural and synthetic polymer composites. The fibers also classified as natural and synthetic fibers. The natural fibers are ecofriendly and synthetic fibers has very good mechanical strength. Natural fibers are cotton flax, jute, silk, wool and mohair etc. and they are directly extracted from plantsand animals. The synthetic fibers are man-made rather than natural fibers, these fabrics are made by polymerization process and these include polyester, acrylic, nylon, glass fiber, rayon and acetate etc. These fiber reinforced composites consist of three components basically (i). fiber as discontinues phase, (ii). matrix region, (iii). fine interphase region.

In any of the Fiber Reinforced Composite materials its strength is determined by individual strength of fiber and matrix material and the coherence adhesion between these two constituents. Orientation, length and the volume fraction of fibers and crystalline structure of matrix material also affects the strength of Polymer Matric Composites. These fibers sometime fail due to the internal structure and mechanical load. The main reason for failure is internal cracks these can made composite as instability. To further enhance the strength these composites were treated with Microwave radiation with a temperature from 40^0C to 140^0C. The treated specimen is then gone through tensile test and the coherence bond between composite layers are checked with an aid of Scanning Electron Microscope (SEM).

The literature survey shows that the composites treated with different radiation will increases the mechanical properties. Chinedum ogonna, Danning li [1] et al. in composite part anapplied science and manufacturing, September 2018 said that composites via microwave irradiation will greatly reduce the curing time and increases the efficiency. And that article gives review about current scientific challenges with microwave irradiation of fiber reinforced composites. Daisuke Shimamoto [2] et al. in Advance composite material, 1-9 May 2016 said that the mechanical properties of carbon fiber/ epoxy resin composite which was fabricated using vacuum assisted resin transfer molding were investigated 2.45 GHz frequency. The samples were treated with microwave irradiation for 20 min at 120°C were compared to theconventional oven for 300min at 120°C and that shows the components irradiated bymicrowave had better adherence properties between fiber and resin as compared to the conventional oven for same temperature and time. Sandhya Rao [3] el at. In microwave assisted processing of polymer matrix composites at Indian journal of advances in chemical science SI 2016 said that microwave processing of aerospace graded glass fiber-epoxy composite has shown that the process time saved up to 90% and energy saved in conventional thermal curing process is only 60%. In addition of this thermal and mechanical properties achieved by this microwave irradiation are superior.

Kimiyasu sato[4] et al. in carbon fiber/epoxy composite material cured thermally and with microwave irradiation, 13 November 2014 said that microscopic study with aid of scanning electron microscope was performed on fractured samples surfaces to identify the failure, the microwave irradiation exhibits mechanically ductile behavior even though its highest degree of polymerization and the use of microwave gives the stronger physical and chemical bonding linkage at interface of composites.

2. MATERIALS AND METHODOLOGY

Epoxy Resin (L 12)

Lapox L-12 is liquid, unmodified epoxy resin of medium viscosity which can be used with various hardener for making fiber reinforced polymer composites. It capable to induce cure at room temperature but it requires high temperature to full cure. Hardener K-6 used withLapox L-12 epoxy to cure at faster rate. This epoxy holds the good dialectic properties, low shrinkage, high temperature resistance and Fatigue and adherence properties to composites.

TABLE 1. Properties of Lapox L12

Property	Values
Tensile strength (MPa)	85-95
Flexural strength (MPa)	115
Glass transition temperature (°C)	120-130
Tensile modulus (MPa)	10,000
Compressive strength (MPa)	180-190

Natural fiber (Hemp)

The fibers which are directly extracted form plant and animals are called as natural fibers.

Hemp

These natural fibers typically found in northern hemisphere and those plant called cannabis sativa species that grown specifically for industrial purpose and many products can derived from it. It can refine into clothing, Biodegradable plastic, textiles, insulation etc. however the hemp fibers are extremely strong and durable it can be usable and replace for wood for many jobs.

FIGURE 1. Hemp plant and Hemp fiber (Source: Hemp plant.com

Synthetic fiber (Glass fibers)

The fibers are fibers made by humans with chemical synthesis. Generally, these fibers will be created by extruding method through spinnerets. Even through polymerization process we can extract synthetic fibers like combining monomer to make polymer. These are more durable than natural fibers.

Glass fibers

The Glass fiber consist of many extremely fine fibers of glass. These can be made with silica based or other formulation glass are can extruded with suitable diameter. There is common type of glass fiber used in fiber reinforcement polymer are like E-Glass which is alumino-borosilicate glass, and other types are A-glass which is Alkali-lime glass with no boron oxide C-type has high boron oxide along with constituents etc. These glass fibers hold the very good thermal insulation properties, high surface area to weight ratios and good chemical resistance properties.

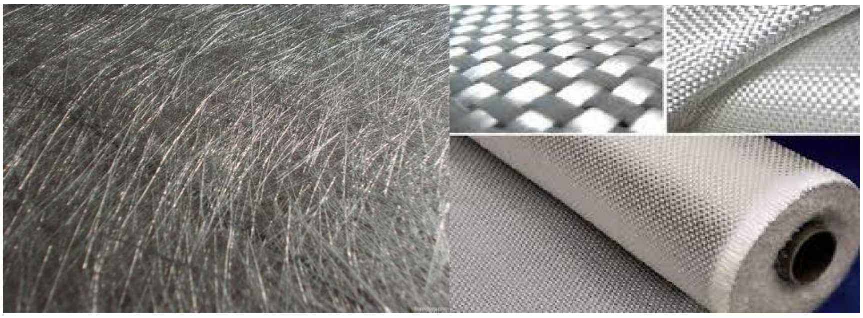


FIGURE 2. Glass fiber (Source: Glass fiber photos.com)

3. PREPARATION OF SPECIMEN

The Hemp fibers are cleaned with NaOH and treated with other chemicals solution to remove the impurities. Then the treated fibers are then weaved in the form of mat for being used to make composite laminates. And glass fibers are placed with hemp with help of epoxy resin the laminates were made by Hand lay-up method because it's an easiest method and low cost we can made laminates without any size limitations. Hemp and glass fiber were placed one over another alternatively with aid of epoxy and allowed to cure in mouldbox (for 24 hours), In order to remove laminates plates from mouldbox plastics are used, and finally the laminate plates were removed and cut from plates as per American society for testing materials (ASTM) standards for Tensile test.

4. RESULTS AND DISCUSSIONS

The study of Tensile strength of Hemp and glass fiber were conducted as per ASTM standards.

The specimen was made according to the ASTM-D3039 standard and prepared sample were tested with aid of Digital Universal testing machine at the rate of 0.3mm/min and at the load of 1kN. The test is carried out until specimen were broken down and the result were shown in form of stress strain curves. The table 2 shows the values obtained from tensile testing of microwave irradiated specimen with various temperature dosages and timings. For microwave irradiation process some calculation should be done to obtain the irradiation time for particular temperature.

5. CALCULATIONS FOR MICROWAVE IRRADIATION

The Domestic Micro-Wave device consisted of 6 values of watts-100W, 180W, 300W, 450W, 600W, 900W.

- Average is taken i.e. (100+180+300+450+600+900) / 6 = 421.66W ~ 450W
- To find the time for various temperature like (°C) 40, 50, 60, 70, 80, 90, 100, 110, 120, 130, 140.
- 100W = 3.1593°C / Min (standard)
- Which means when Micro-wave radiations are passed at 100W, there is addition of 3.1593°C every Minute.
- Therefore, 450W = 14.217 °C / Min(Taken as Reference)

To find time-

450W in °C * Time (t) = Variable Temperatures (T)

Example – At constant 450W 1)14.217 * t = 40°C

Therefore time (t) = 2 minutes 48 seconds.

TABLE 2. Tensile test results

Temperature in (C)	Irradiation time in minutes and seconds Mins.	Sec.	Maximum load (kN)	Maximum stress (MPa)	Young's modulus (GPa)
40	2	48	3.447	53.034	4.751
50	3	30	3.594	55.296	5.073
60	4	12	3.682	56.639	5.846
70	4	54	3.769	57.992	6.055
80	5	36	3.880	59.700	6.058
90	6	18	3.892	59.874	6.179
100	7	0	4.094	62.986	6.188
110	7	42	4.148	63.815	6.224
120	8	24	4.677	71.961	6.955
130	9	0	4.561	70.163	6.984
140	9	48	4.224	64.988	6.419

From above table, it was observed that the specimen irradiated with dosage of 120°C for 8minutes and 24 seconds has highest load baring capacity of 4.677kN, and maximum tensile stress/strength obtained is 71.961 MPa and Young's modulus of 6.955 GPa. It was shown that tensile strength of specimen is increased by 1.56 time greater than specimen with no dosage.

Hemp and glass fiber composite treated with microwave radiation and untreated specimen

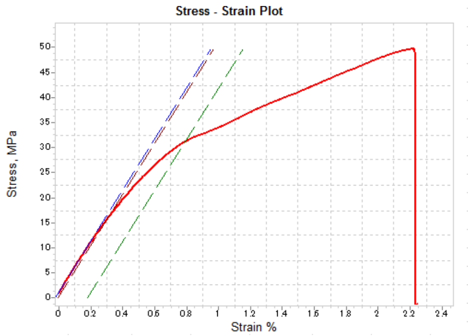
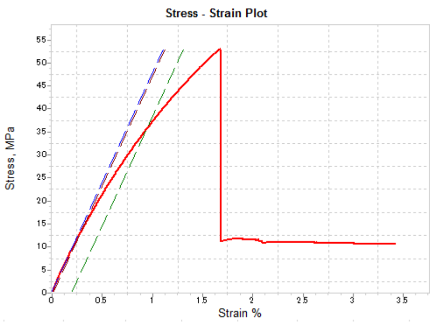
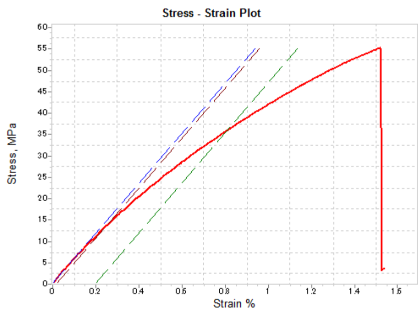


Figure 3 - **Tensile Specimen Stress – Strain Graph Without irradiation**

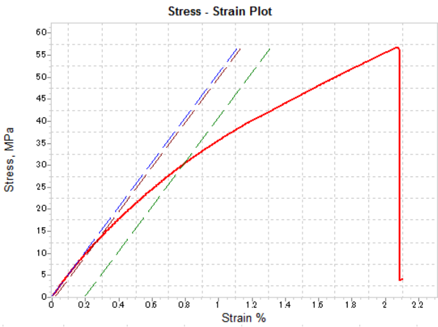
40^0C



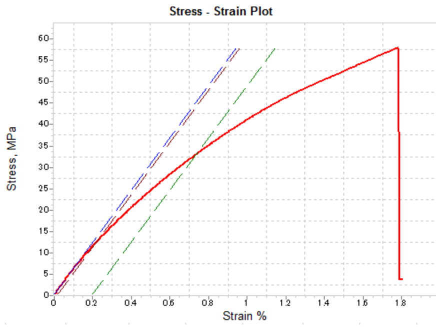
50^0C



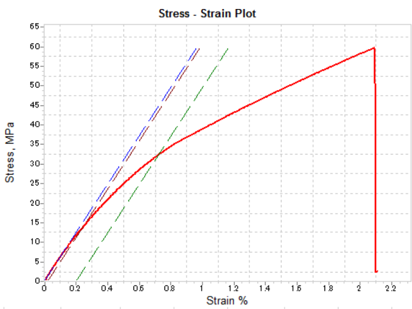
60^0C



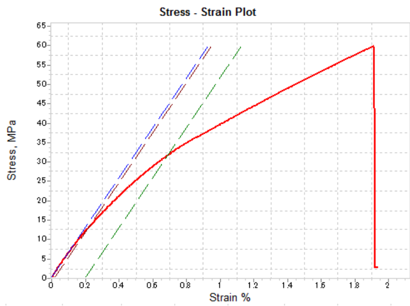
70^0C



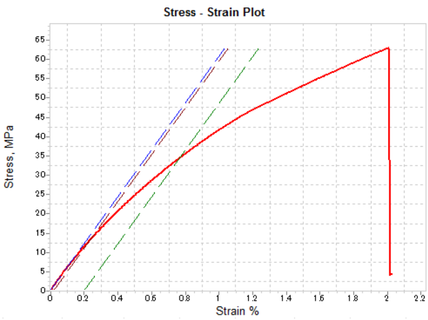
80^0C



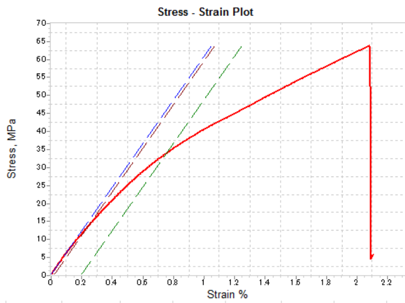
90^0C



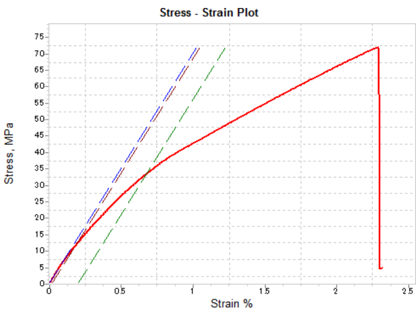
100^0C



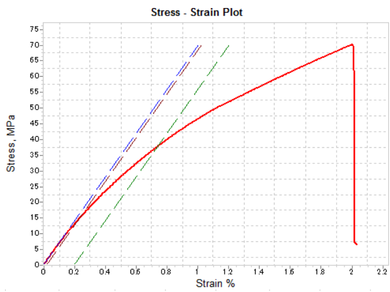
110^0C



120^0C



130^0C



140^0C

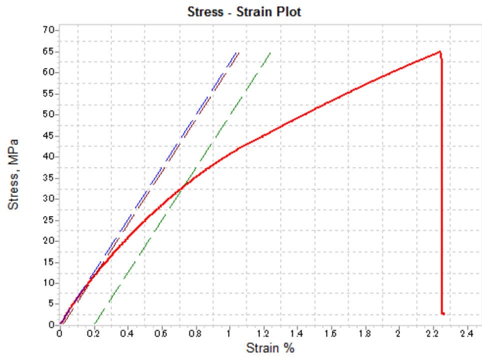


FIGURE 4- Tensile stress strain curve for different Microwave radiation dosages.

The strength of composite is mainly depending on bond between fiber and matrix at their interface. The microwave irradiation will further enhance the bond linkage between their interface and this will assist in curing and this will reduce the material degradation and residual stress in composite. Hence the tensile strength of composite is increased with microwave irradiation increases up to 120^0C temperature with timing of 8 minutes 24 seconds where the tensile value is noted is 71.961 MPa. As dosage further increased, we can find decreasing in tensile strength at 130^0C the tensile strength is 70.163MPa and at 140^0C temperature with a timing of 9minute 48 second there is huge decreasing in tensile strength and it is around 64.988 MPa. So even at higher temperature dosages composite polymer may undergo with reaction like condensation and it may lead to form a very hard impermeable surface. Hence, there may be the chances of trapping of volatiles released. These volatiles may make more voids inside the composites and further there may be also a chance of delamination, thus reduces the strength of composite material.

6. DISCUSSION

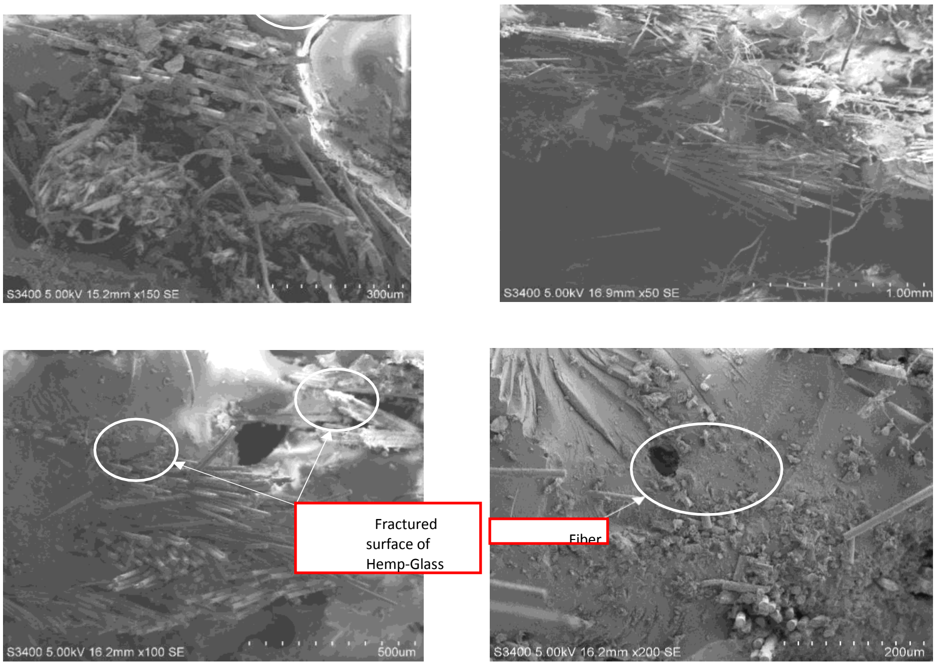


FIGURE 6. SEM Photography at a point where failure of specimen occurred

SEM images shown above clearly shows the breakage of fibers at the point of failure instead of pull out of fibers from matrix material, the area of broken specimen was identified and samples are evaluated. It clearly shows the high magnification images of broken samples of composites.

7. CONCLUSIONS

The glass fiber and hemp reinforced polymer composites were fabricated according to the ASTM standard and they were exposed to Microwave radiation and the tensile property of those samples were noted and analyzed. They were compared with untreated specimens the effect of irradiation is investigated. From the tensile test of composites, we were concluded as without radiation the tensile strength of specimen at room temperature obtained was 45.927 MPa. And the best Microwave radiation dosage for composite is obtained when the samples were at temperature of 120^{0}C for 8 minutes 24 seconds. The maximum tensile strength is 71.961 MPa. Further increase in dosage leads to decreasing in the tensile strength. So, this study has shown the Microwave irradiation will enhance the tensile properties of polymer composites and moreover this irradiation could affect the macro molecular parameters and crystallographic structures of fiber composites.

REFERENCES

1. Chinedum ogonna mgbemena "Accelerated microwave curing of fiber reinforced thermoset polymer composite for structural application" in composite part an applied science and manufacturing. September 2018"
2. Daisuke Shimamoto "Advance composite material" International Conference on Composite Materials, 1-9 May 2016.
3. Sandhya Rao "microwave assisted processing of polymer matrix composites" at Indian journal of advances in chemical science SI 2016.
4. Kimiyasu sato "carbon fiber/epoxy composite material cured thermally and with microwave irradiation" 13 November 2014.
5. Libing cheng, yinggung li "Curing multidirectional Carbon fiber reinforced polymer with indirect microwave heating" in international journal of advanced manufacturing technology on 20th April 2018.

BIOGRAPHIES

Mohammed Bilal born on 21-03-1997 grew up and educated in Mysuru – Karnataka, INDIA is a Dynamic Mechanical Engineer graduated from VVCE, Mysuru, he also holds his Diploma in Mechatronics Engineering, from J.S.S TI's Mysuru. He has completed several Research Projects, Mechanical & Mechatronics Engineering Projects, Participated in National Level Racing & Endurance Competitions. He has also participated and served as host in several International & National Conferences, Seminars, Technical Talks and more. Currently he is working as Quality Management Systems Engineer.