RJC

RASĀYAN *J. Chem.*
Vol. 15 | No. 2 |1312-1318| April - June | 2022
ISSN: 0974-1496 | e-ISSN: 0976-0083 | CODEN: RJCABP
http://www.rasayanjournal.com
http://www.rasayanjournal.co.in

STUDIES ON GLASS FIBRE REINFORCEMENT OF COMMERCIAL VINYL ESTER/FURAN RESIN HYBRID MATRIX RESIN SYSTEM

Priyanka Bhargava[1,✉], H.C. Kataria[2], and Sandesh Kumar Jain[3]
[1]Barkatullah University, Bhopal-462026 (M.P.) India
[2]Govt. Geetanjali Girls College, Bhopal-462038 (M.P.) India
[3]CIPET, Bhopal-462023 (M.P.) India
[✉]Corresponding Author: priyankabhargava60@gmail.com

ABSTRACT

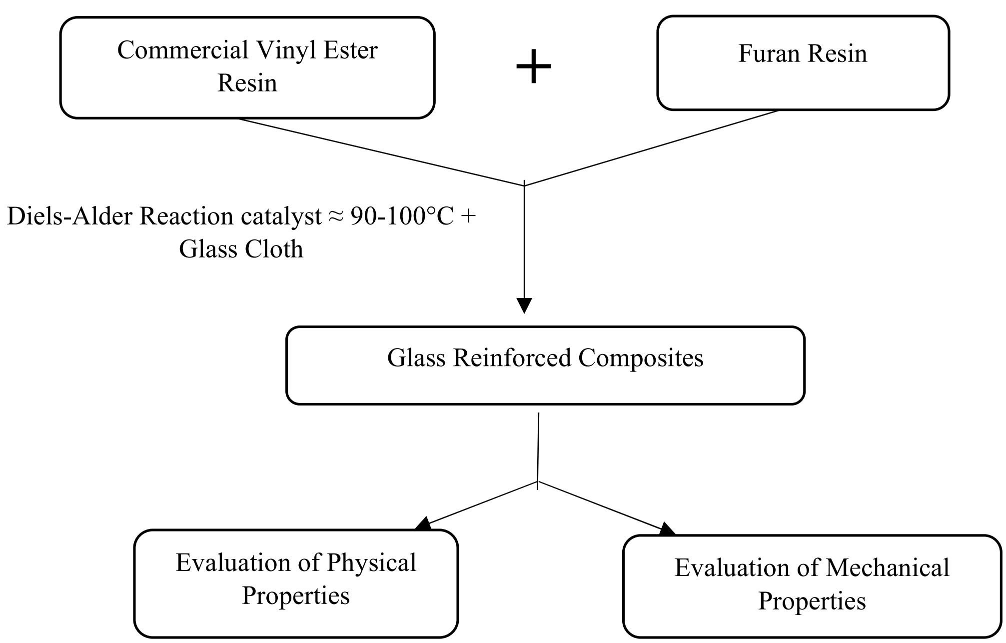
The commercial vinyl ester (VE) resin and Furan resin (FR) were blended in various proportions. The appropriate catalyst was added. Such a blend in form of viscous syrup was applied on glass fibre and the glass-reinforced composites (GRC) were fabricated by the 'hand layup' method. The so-called GRC was formed due to interacting crosslinking between VER and FR as well as *'in situ'* Diels-Alder reaction between VER and FR. All the GRC samples were tested for their physical properties and mechanical strength. ASTM methods were employed for such tests. The resultant parameters show that produced GRC samples have good mechanical properties.

Keywords: Vinyl Ester, Furan Resin, Diels Alder Reaction, Composites, Reinforcement, Glass Fibre, Mechanical Properties.

RASĀYAN *J. Chem.*, Vol. 15, No.2, 2022

INTRODUCTION

Commercial Vinyl ester resins have a history of applications due to their excellent mechanical properties and corrosion resistivity.[1] Such resin is incorporated by acrylate/styrene as a reactive diluent for the enhancement of glass-reinforced composites.[2-8] The vinyl esters having acrylate group which have a tendency (as dienophile) to react with 'diene' via Diels-Alder reaction.[9] One of the 'diene' types of resin is furan resin which has a furan ring with 'diene' system.[9]



Flow Chart-1

http://doi.org/10.31788/RJC.2022.1526896

The furan resins are also well known for their excellent casting properties.[10] The advantages of furan resins are they produced from renewable resources i.e., agricultural waste such as rice husk, maize cob, bagasse, etc. The clubbing of vinyl ester (as dienophile) and furan resin (as diene) via Diels-Alder reaction has not been attempted for the new material. Thus, it was thought to investigate the glass reinforce composites based on commercial vinylester- furan hybrid system. So, the present paper comprises the research work shown above.

EXPERIMENTAL

Materials

Vinyl ester-type 601(Bisphenol-A based) was procured from Shree Shyam Global, Ahmedabad. Its viscosity is 255cp at 25°C. Gel time is around 23 minutes at 25°C. Styrene content is 45%. Stability in the dark is 6 months. Furan resin was prepared from 2-furan methanol by the reported method.[11] E-glass cloth woven fabric (epoxy/acrylate compatible) of 25 mm thickness was purchased from the local market. Other reagents used were of laboratory grade.

Composite Preparation

The Vinyl ester (VE): Furan resin (FR) composition in percentage was prepared as follows:

	VE	FR
1	85	15
2	80	20
3	75	25
4	70	30
5	65	35

The mixture of Vinyl ester and Furan resin as mentioned above was taken in a 250 ml beaker. The tetrahydrofuran solvent was poured and stirred on a magnetic stirrer at $\sim 30° \pm 2°C$. The appropriate catalyst such as MEK Peroxide and Co-naphthenate were added. The whole mixture was then kept aside for half an hour. Ten pieces of glass cloth of 15cm×15cm were immersed into an above mixture of VE: FR. The pieces were dried at 70°C. All the prepregs were then compressed between stainless steel flat plates by using a Teflon sheet as releasing agent at a pressure of 150 psi. Then the whole assembly was put into the oven and kept at 100°C for 10 hours. Further, the temperature raised to 120°C for 2 hours. After cooling, the composite (laminate) was obtained and it was cut into size for mechanical testing.

MEASUREMENTS

Density

Specimens of size 10×10×5 mm^3 were taken from the casted composites. The weight of these specimens was measured from a weight machine and density was calculated by:

$$\text{Density} = \frac{\text{Mass}}{\text{Volume of specimen}}$$

Moisture Absorption Measurement

This was measured followed by the ASTM D750 method. The GRC specimen of 75×50×5 mm^3 was immersed in distilled water for half of the month. The results were calculated as

$$\%\ \text{absorption} = \frac{\text{Difference in weight}}{\text{Original weight}} \times 100$$

$$= \frac{\text{W} - \text{Wo}}{\text{Wo}} \times 100$$

W = Weight after absorption at GRC
Wo = Original weight of GRC

Moisture Content Measurement

This was measured followed by the ASTM D4442 method. The pre-weighted test specimen (75×50×5 mm) were dried in an oven at 103°C until reproduced results. The percentage moisture content was calculated as

$$Percentage\ moisture\ content = \frac{Wo - Wg}{Wo} \times 100$$

Where W_o = Initial mass and W_g = Final mass

Thermogravimetric Analysis

Thermogravimetric analysis of all the five cured samples was performed on Universal V 2.6 DTA instrument up to 600 °C in the air at a 10 °K/min heating rate.

Mechanical Properties

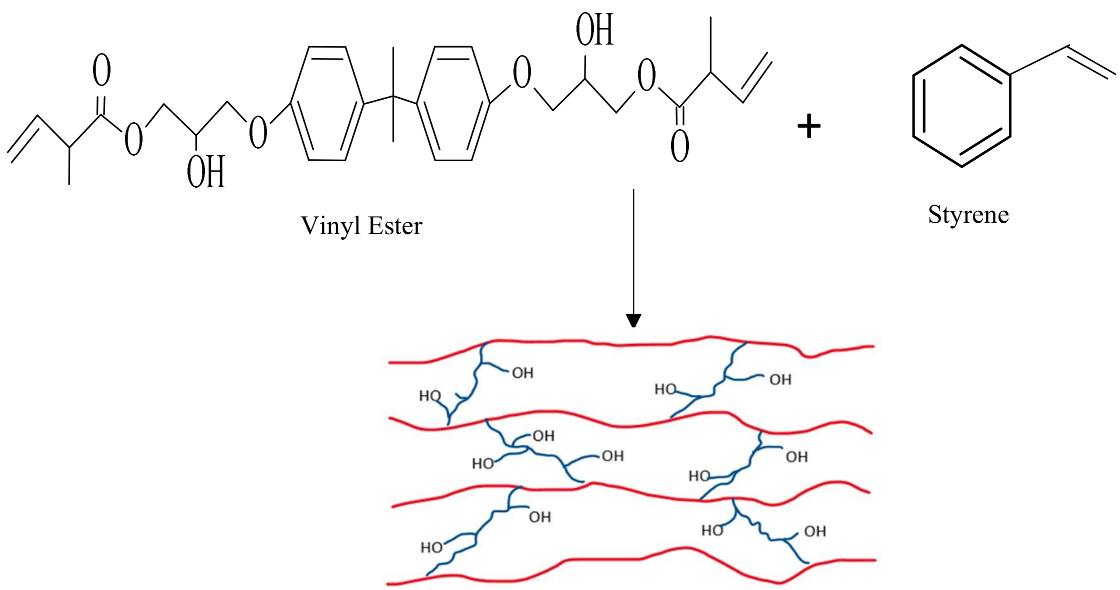
Following ASTM procedures were used to measure most of the mechanical properties of produced composites:

(a)Tensile Strength ASTM D635
(b)Flexural Strength ASTM D790
(c)Impact Strength ASTM D256
(d)Hardness Strength ASTM E 18-07

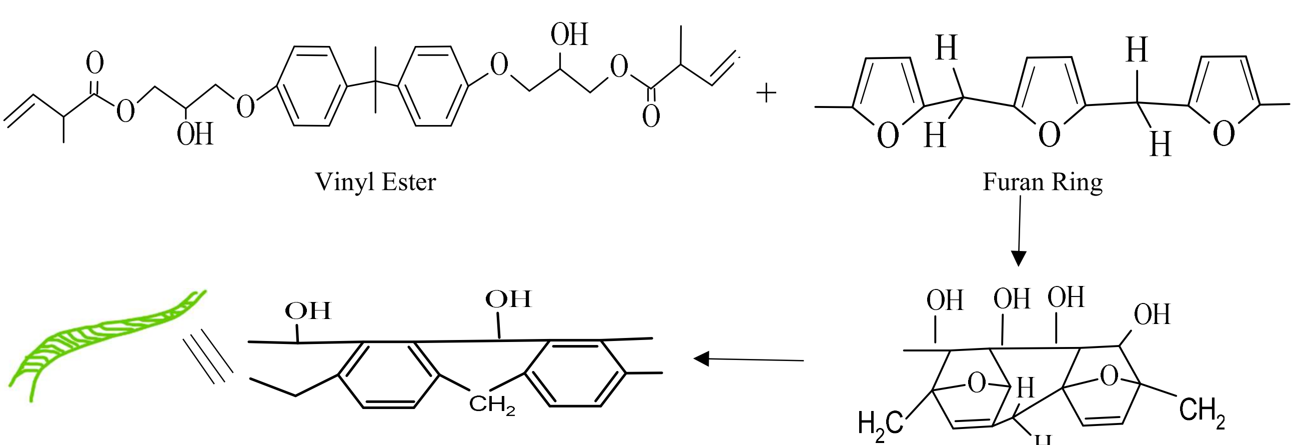
RESULTS AND DISCUSSION

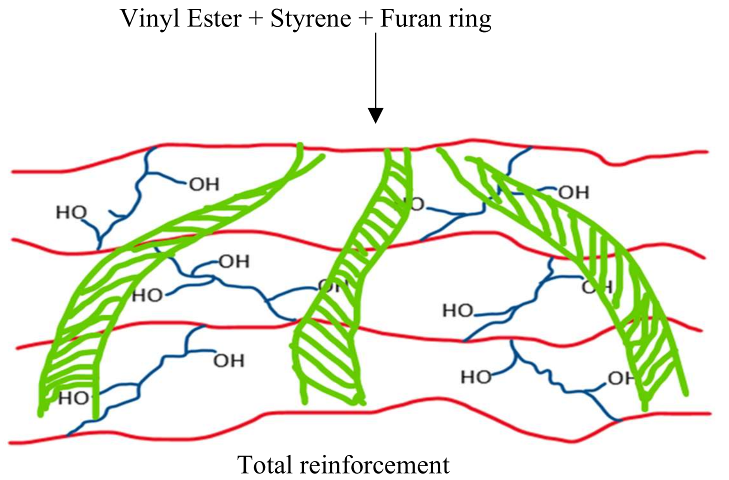
The reaction of vinyl ester and furan resin is exhibited via the addition reaction of acrylate-styrene combination and Diels-Alder reaction of acrylate portion of vinyl ester and furan resin. Such reaction is scanned as follows:

Crosslinking system during reinforcement - Vinyl Ester (VE) + Styrene(S):



Vinyl Ester + Furan ring





Scheme-1: Crosslinking and Diels-Alder Reaction .

The physical properties of VE: FR, 1 to 5 samples were evaluated in terms of density, moisture absorption, and moisture content. The density of all the VEFR composites in the range of 1.393 to 1.419 g/Cm^3 has shown in Fig.-1.

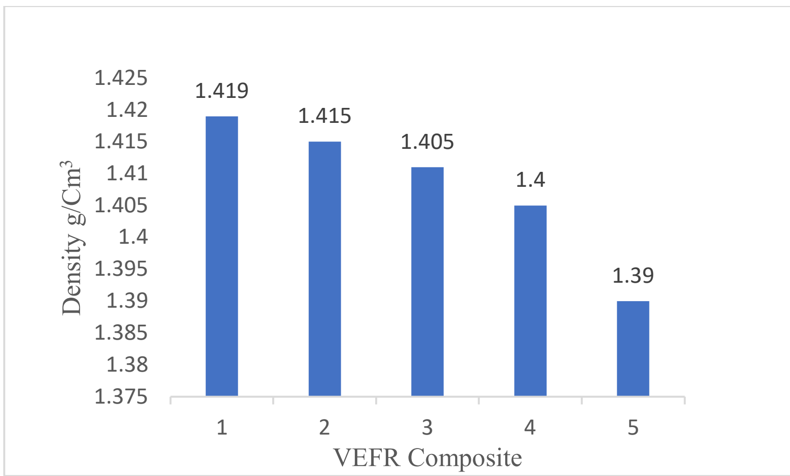


Fig.-1: Density of VEFR Composite Samples

The moisture content test data for all five composites are displayed in Fig.-2. The results show that moisture content for GRC is high for those who have FR content more. It is in the range of 0.8 to 1.7%.

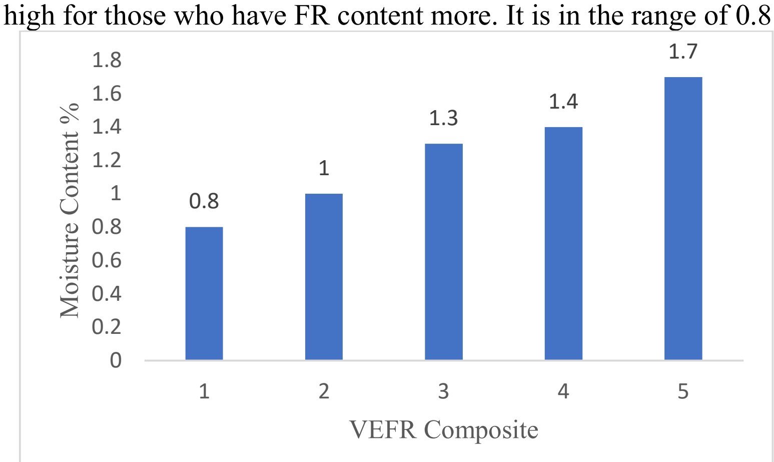


Fig.-2: Moisture Content of VEFR Composite Samples

Moisture absorption data for all GRC samples are presented in Fig-3. The values are found to be 0.5 to 0.85%.

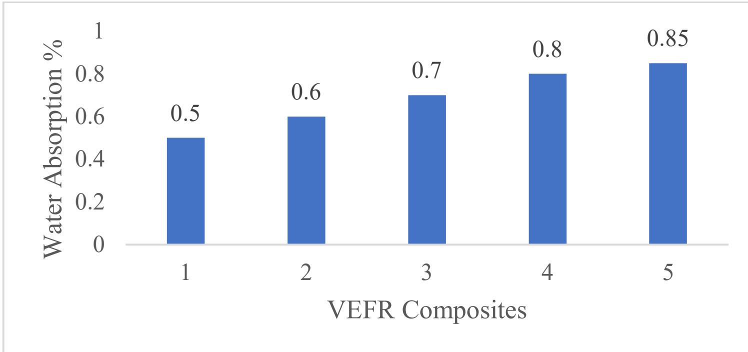


Fig.-3: Water Absorption of VEFR Composite Samples

The moisture absorption is a vital property for furniture making. The values are quite low (Fig.-3). This might be responsible for the presence of less voids present in GRC due to interacting VR: FR blending. Thus, the produced composites may have good outdoor applications. The overall conclusion is that the proportion of FR is high, and the water absorption is high.

The result of the mechanical properties of all five VEFR composite samples is shown histographically in figures 4 to 7. As shown in Fig.- 4, the tensile strength of VE-FR composites is good and increases with an increase in the percentage of FR. The vinyl ester furan resin composite with 30% highest tensile strength i.e., 127 Mpa. This indicates the ability of the blend of resins in enhancing the tensile strength. The uniform dispersion of the VEFR and strong adhesion and capability with segments of FR might be responsible to improve tensile strength. These values also fall in the range indicated in the literature.[12]

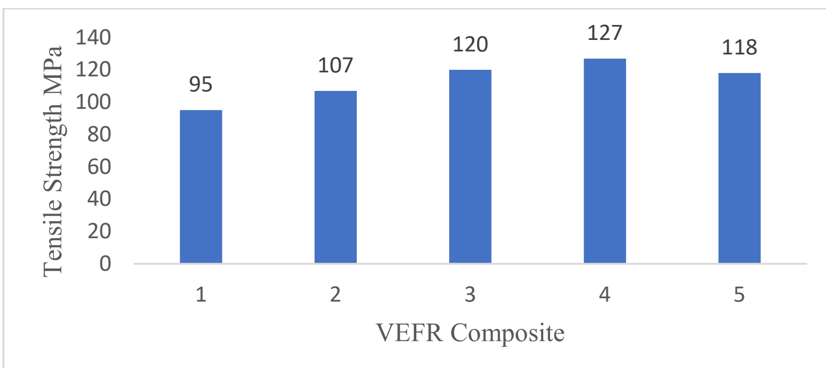


Fig.-4: Tensile Strength of VEFR Composite Samples

As shown in Fig.-5, there is good flexural strength (FS) of VEFR composites in the range of 149-137 MPa. VEFR with 30% FR has the highest FS of 177 Mpa. The uniform dispersion of VEFR and compatibility may enhance the FS of the composite. At a higher percentage of FR, the lower value of FS might be due to poor mobility of FR matrix into glass cloth and thus decrease in the surface area of VEFR interaction.

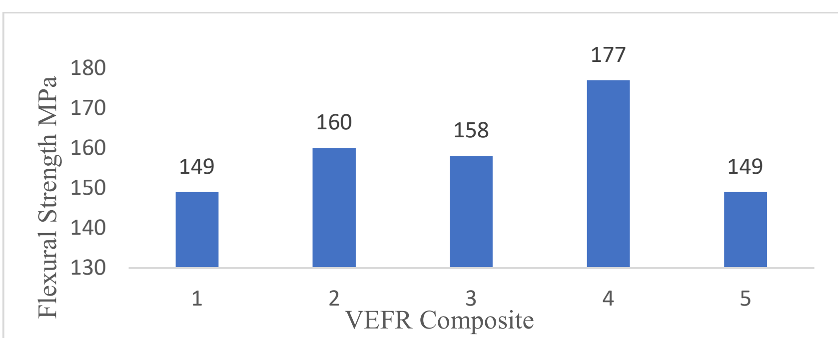


Fig.-5: Flexural Strength of VEFR Composite Samples

The practical data for the impact strength of VEFR composite samples are dispersed in Fig.-6. The figure shows a steady increase in FR content. However, there is a decrease in impact strength for further increase in FR. This may be raised from the weak interfacial interaction between the VE and FR matrix.[13,14]

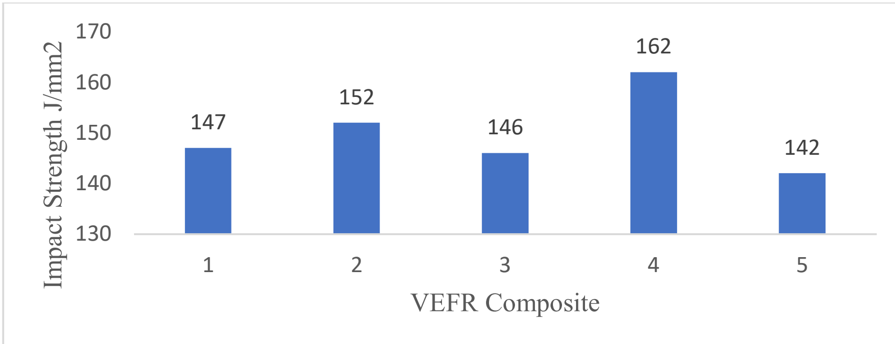


Fig.-6: Impact Strength of VEFR Composite Samples

The Rockwell hardness of VEFR composite samples exhibited good value in the range of 70 to 89 RH shown in Fig-7 Graphical Abstract. The FR with 30% composite (VE: FR-4) has the highest hardness i.e., 89 RH. This indicates the good adhesion and compatibility of VE with FR matrix at 30% FR. The lower value of hardness may be due to the weak adhesion of FR with glass.

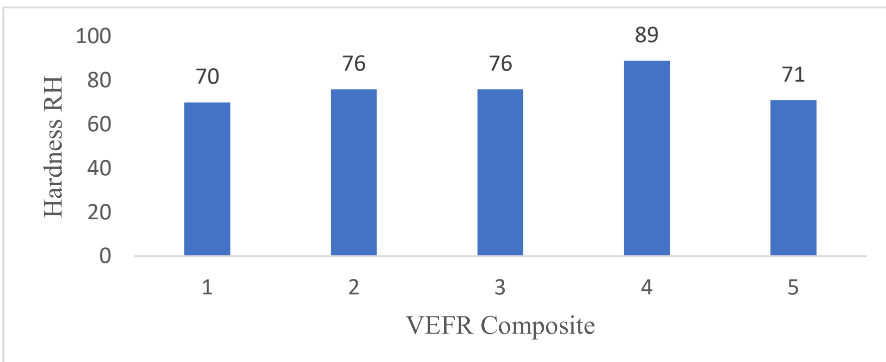


Fig.-7: Hardness of VEFR Composite Samples

CONCLUSION

In this study, the reinforced composites of VEFR have been successfully fabricated and characterized. All the produced composites have good mechanical properties. The highest mechanical properties were observed with FR of 30% composite. In the whole experiment, the VE-FR system may form an interacting and interpenetrating network. This may afford very good mechanical properties.

ACKNOWLEDGEMENT

The authors thank to Principal of Govt. Geetanjali Girls College, Bhopal, and Director of CIPET, Bhopal for providing research facilities.

REFERENCES

1. H.Q. Pham, J. Maurice, 'Epoxy Resins' *Ullmann's Encyclopaedia of Industrial Chemistry,* Weinheim: Wiley-VCM.
2. F.Q. Zhang, Y.Z. Zhao, Y.J. Xu, Y. Liu, & P. Zhu, *Composites Part B: Engineering*, **234**, 109697, (2022), https://doi.org/10.1016/j.compositesb.2022.109697
3. J.P. Torres, L.J. Vandi, M. Veidt, & M.T. Heitzmann, *Composites Part A: Applied Science and Manufacturing*, **98**, 99(2017), https://doi.org/10.1016/j.compositesa.2017.03.010
4. S. He, & T.R. Walsh, *Composites Science and Technology*, **218**, 109168(2022), https://doi.org/10.1016/j.compscitech.2021.109168

5. N.T.T. Nhan, K. Obunai, K. Okubo, O. Shibata, H. Tomokuni and Y. Fujita, *Open Journal of Composite Materials*, **9(4)**, 365(2019), https://doi.org/10.4236/ojcm.2019.94023
6. M. Nodehi, *Innovative Infrastructure Solutions*, **7(1)**, 64(2022), https://doi.org/10.1007/s41062-021-00661-3
7. J.K. Ranjan and S. Goswami, *Polymers and Polymer Composites*, **29(9_suppl)**, S117(2021), https://doi.org/10.1177/0967391120987349C
8. C. Manickam, J. Kumar, A. Athijayamani, & N. Diwahar, *Journal of Engineering Research*, **3(3)**, 25 (2015), https://doi.org/10.7603/s40632-015-0025-4
9. H. Ipakchi, A. Shegeft, A.M. Rezadoust, M. Jalal. Z. Mehr, K. Kabiri and S. Sajjadi, *Iranian Polymer Journal*, **29(4)**, 287(2020), https://doi.org/10.1007/s13726-020-00793-w
10. H. Mariusz, G. Marcin, D. Rafal, *In Microstructure and Properties of Ductile Iron and Compacted Graphite Iron Casting. Springer,* P-27(2015).
11. G. Tondi, N. Cefarin, T. Sepperer, F. D'Amico, R.J.F. Berger, M. Musso, G. Birarda, A. Reyer, T. Schnabel and L. Vaccari, *Polymers*, **11(12)**, 2126, (2019), https://doi.org/10.3390/polym11122126
12. N.R. Patel, & P.P. Gohil, *International Journal of Emerging Technology and Advanced Engineering*, **2(4)**, 91(2012).
13. Md. M. Haque, Md. S. Islam and Md. S. Islam, Md. N. Islam and Md. M. Hugue, *Journal of Reinforced Plastic Composites,* **29**,1734(2009).
14. S. Joseph, M.S. Sreekala, Z. Oommen, P. Koshy, & S. Thomas, *Composites Science and Technology*, **62(14)**,1857 (2002), https://doi.org/10.1016/S0266-3538(02)00098-2

[RJC-6896/2021]