

# Experimental Study of Mechanical and Physical Properties of Jute/Wood Plastic Composite

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**ABSTRACT:** Non-Newtonian fluids such as polymers, foodstuffs, pulps, glues, ink, molten plastics, or slurries are increasingly used in various manufacturing, industrial, and engineering applications. Many simultaneous transport processes exist in industrial and in engineering applications. Due to the increasing popularity of polymeric materials, extrusion is one of the most important production methods. The use of composite materials for industrial application has increased tremendously, due to which the research work in this area has increased. In this research work, experimental investigation of the mechanical properties of Wood Plastic (Polypropylene/High Density Polyethylene, Teak and Jute) composite was carried out. Mechanical properties were analyzed and results were compared. It was observed that wood gives a positive impact on the mechanical properties of the wood plastic composite.

**KEYWORDS:** Composite, Extrusion, Mechanical properties, Jute, Saw dust

## I. INTRODUCTION

Wood Plastic composite have a variety of application in automotive engineering, aerospace engineering, civil engineering etc. as they have good mechanical properties, less weight, corrosion resistance as compared to other materials. These additional advantages of Wood plastic composites give them an upper hand. Many scientists and researchers are working in this area to enhance the mechanical properties of the composites by using special fillers and additives. Teak, Acacia, Neem, Deciduous trees are commonly found in all parts of India. The wood from these trees possess good mechanical properties. The powder of these wood powders along with HDPE High Density Poly Ethylene is fed to Single Screw Extrusion Machine. Out of these wood teak wood is widely used. Now a day, the plastic wastes have a major concern of environmental pollution. Plastic is mainly a non-biodegradable material so it produces a large amount of solid waste. Plastic is use in our day to day life because it has various good properties as it is lighter in weight, high strength and also bad conductor of heat and electricity and it is also easy to convert it in a desired shape.

On the other hand the waste of wood is also a major concern the wood processing industries have dumping problem of wood waste. They generally burn it or needs large area for disposing it. Composites are the materials which form by combining two or more types of different components which are chemically different in nature, to improve the property of the material. These are generally used for buildings, bridges and structures.

The various types of composites are:- 1. Conventional Composites 2. Advanced Composites material

## II. RELATED WORK

**Oblak (2016)** studied the behaviour of recycled high density polyethylene after mechanical by one-hundred consecutive extrusions. These results have shown that after 100th recycling material mechanical properties reduced by 20%. **Leangauer(2015)** studied the effect on extruder by changing the operating conditions such as temperature,

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pressure and flow rate(mass) on the shape of pellets of Poly-propylene. It was observed that mass flow of cylindrical pellets (long) was more in comparison to cylindrical pellets (small).

**Hawileh (2015)** analysed the variation of mechanical properties of different FRP laminate. FRP laminate was exposed to different temperature range and the effect on elastic modulus and tensile strength was determined. **Vera-Sorroche (2015)** applied a thermal sensor to verify the time behaviour and thermal homogeneity of polymer used in extrusion. This sensor used in the extruder and was located in a position so that it provide the temperature in the metering section of extrusion moulding machine. **Abeykoon (2014)** developed the extensive model to predict the temperature profile along the melt flow using battery of thermocouple along the flow regime in the extruder. The output flow was measured and compared experimentally using different polymers and die geometry. In this work, it was found that the heterogeneity increases across melt flow upon increasing the screw rpm. **Hatzikiriakos (2009)** proposed a mathematical model containing viscosity terms (Shear thinning and thickening) to analyze the incompressible flow and structural development of PTFE paste. This model was compared with experimental observations and the results were found to be consistent. **Mitsoulis (2009)** formed a mathematical model to model the flow of PTFE paste. Steady state simulations have employed using the conservation equations at isothermal and incompressible conditions. This model helps in explaining the nature of extrusion dies by considering the PTFE behaviour. **Hatzikiriakos (2005)** studied about the different lubricant physical properties on PTFE. The surface tension and viscosity of lubricants have different properties were used in this study. The study shows that the pressure required for PTFE paste was influenced by the lubricant wet ability. **Alagar (2000)** used dibutyltindilaurate catalyst for developing different epoxy resins as GY 250, LY 556, etc. The ASTM guidelines were used to determine various mechanical properties such as tensile strength, impact strength, flexural strength and strain. **Ascione (2010)** used finite analysis to verify the behaviour between the adhesive lap joints and FRP adherents. The method gives an idea about the effects of different characteristics of adherents for the analysis of coupling effect. The results were compared with the same work of different authors and also the factors influencing the interface failure of the adhesive lap joints were discussed. **Ascione (2011)** developed a mathematical model which was able to predict the behaviour of FRP in civil engineering with time. **Keller (2009)** developed a model considering thermo-mechanical properties and used for predicting the behaviour of FRP slab when subjected to fire and mechanical loading. Investigation of thermal condition by variation of temperature for the slab in the cells has been performed. **Bao (2010)** discussed about the different applications of thin cylinders made from FRP in robotic arms, aeroplanes and aerospace engineering due to good mechanical properties. **Karwe (1996)** carried out a numerical study of extrusion cooking of starch based materials in a single screw extruder by considering the low moisture levels and high temperatures. Finite difference approximation was employed to solve the governing non-linear equations for momentum, energy and mass conservation for a non-Newtonian fluid undergoing physicochemical changes. **Chiruvella (1996)** carried out extrusion of Non-Newtonian fluids in extruder and observed the transport phenomena numerically and experimentally. The energy balance across the extruder gives an idea about the equation governing the different operating parameters related with energy. **F.T. Pinho (2012)** used single screw extruder to melt the polymer and obtain simplified model given by Phan-Thien. In the formation of mathematical equation, the assumption of flow path geometry and length of extruder were not considered. **Esfahani (2011)** used unsaturated polyesters (mixture of 1.5 and 3 wt % nano clay) and observe the effect of this mixture on impact properties and flexure properties. This composite was made by glass fibre and clay (binder) by lay-up method. Diffraction (X ray) and TEM analysis were performed for the unsaturated polyesters composites. It was observed that the Flexural property of composite consisting 1.5 wt % Nano clay was better than with 3%. Izod impact test results showed a decrease with increase in Nano clay content. **Tang (2012)** used carbon fibre and polyamide6 composites and investigated their mechanical properties. Additions of PA6 enhance mechanical properties of the composites. **Wilczy\_nski (2014)** developed and simulate the model to investigate the effect of starve fed of thermoplastics in extrusion moulding machine. Formation of the model used for this study has the assumption of melting profile combined with conveying melt condition. **Wang (2007)** performed experiments at elevated temperatures to verify the mechanical properties of reinforcement bars which were used in concrete structures and demonstrate the results related with this study. CFRP bars having diameter 9.5 mm diameter and GFRP bars having diameter (9.5 and 12.7) mm were compared with conventional steel bars having diameter (10 and 15) mm. **Theocarlis (1997)** applied numerical homogenization approach for composites of fibre reinforced and tested its elastic property. Fibre having low and high mechanical properties were investigated and compared with classical and analytical approach. **Tay (1995)** observed the effect of

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compressive loading and strain rate on GFRP and epoxy in pure form. The experimental data were generated by using machines (Instron testing and pressure bar). Pure epoxy in pure form and GFRP found to effective in low strain range. **Shokrieh (2009)** used compressive properties of glass fibre composites by changing strain rates from 0.001- 100 per second. Quasi static conditions were taken and it was found that the absorbed energy increase to about 62% and is equivalent to the compressive strength after measurement. **Shen (2002)** studied about the structure of FRP tube considering its material of construction, thickness of tube wall, size and installation procedure. Mathematical procedure was adopted to calculate the strength requirement for FRP composites. **Ray (2014)** discussed the complexity involve in developing the relation to fit the experimental condition and showed the sensitivity of each parameter on the output rate using normalized sensitivity method. **Mouritz (2003)** proposed a model to predict the effect on tension, compression and flexure properties of FRP composites after burning in fire. The experimental data were generated using cone calorimeter for FRP composites and verify this with the proposed model. **Li (2007)** tested composited (FRP) and observed that the mechanical as well as the tribological properties of carbon found to be effective when subjected to surface treatment. The adhesion between CF and PI can be improved by surface treatment technique.

## III. EXPERIMENTAL PROCEDURE

### 3.1 Materials:

High Density Polyethylene and Poly Propylene pallets were obtained from local polymer industry having density in between 0.93-0.97 g/cm<sup>3</sup> and 0.895-0.92 g/cm<sup>3</sup> respectively and the compressive strength is 40 MPa for PP and 20MPa for HDPE. The saw dust was obtained from the local saw mills. Wood waste collected from the different wood processing industries in the powder form was used to mix and form a wood plastic composite. First, we collect the wood waste in the form of powder from different wood processing mill and dried it on the temperature of 102°C in a digital oven. The wood flour at different loading ratio was mixed with the virgin as well as recycled HDPE and form different specimens. The wood flour was in form of uniform size of particles. Finally, HDPE and wood flour were binding together by the help of single screw extruder. Jute fibre collected from the local market in raw form was chopped of 6mm length by the help of sieve analysis. The jute fibre contains the 64.4% cellulose, 12% hemicelluloses, 11.8% lignin, 0.2% pectin and 0.5% wax. Jute fibre was used as received, and no further operation was done on it. The Jute fibres were dried in an oven at 80°C for 3-4 hrs after that a sieve analysis were done on it for the uniform size of the particle.



Figure-1: Wood Flour Powder

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Table-1: Properties of Composites			
S.No.	Properties	Virgin HDPE	Recycled HDPE
1	Density, kg/m <sup>3</sup>	925-960 kg/m <sup>3</sup>	925-960 kg/m <sup>3</sup>
2	Melt Flow Index	0.01 g/10 min. at 190°C	-
3	Grade	Sheet grade (003DB52)	Mixed Grade
4	Processing Temperature	150-200°C	150-200°C



Virgin HDPE



Recycled HDPE

Figure-2

### 3.2 Sample Preparation:

HDPE/PP pellets and saw dust as filler were dumped in the hopper of extruder machine. The temperature of the feed, transition and metering section was kept and regulated throughout to 120°C, 160°C and 190°C respectively using band heaters and their controllers. The motor was started and its speed was set at 1700 RPM. This rotational power was transferred by a gear box to the extruder screw. The RPM of the extruder was fixed at 15 RPM. Due to high temperature the polymer becomes soft in the feed zone, comes in plastic state in transition zone and in metering zone it melts completely. The extruder prepares homogeneous mixture inside the barrel. The mixture is forced to pass through an opening of die. The extruded flow rate depends on screw rotation and the lubricant added to the mixture. In the present study screw rotation is kept fixed so that the weight percent of lubricant changes the extrudate flow rate. The extrudate was collected in and was air cooled. The composite was taken out of the mould after cooling and characterization was done.

## IV. TESTING

**4.1 Aim of work:** Following objectives of the research work is concluded based on the above literature survey for the current study:

1. To study dimensional stability, Mechanical properties and Morphology of the Jute/wood plastic composite made from virgin and recycle HDPE using Jute, wood powder and various filler and additives including binders, hardeners etc.
2. To test the strength of manufactured polymer based reinforced composite like compressive strength, tensile strength, flexural strength and compared with the theoretical results.

**4.2 Testing:** After the fabrication of the laminates, specimens were subjected to various mechanical tests as per ASTM standard D 3039-76. Universal testing machine is used to perform the mechanical tests on the specimen. The experimental results were validated using the theoretical correlations 1 and 2.

$$\text{Tensile stress} = \frac{F}{A} \quad (1)$$

$$\text{Flexural Strength} = \frac{3FL}{2bd^2} \quad (2)$$

Where F is the applied force, A is the cross-sectional area of the specimen, L is the length of the specimen, b is the breadth of the specimen and d is the height if the specimen used.

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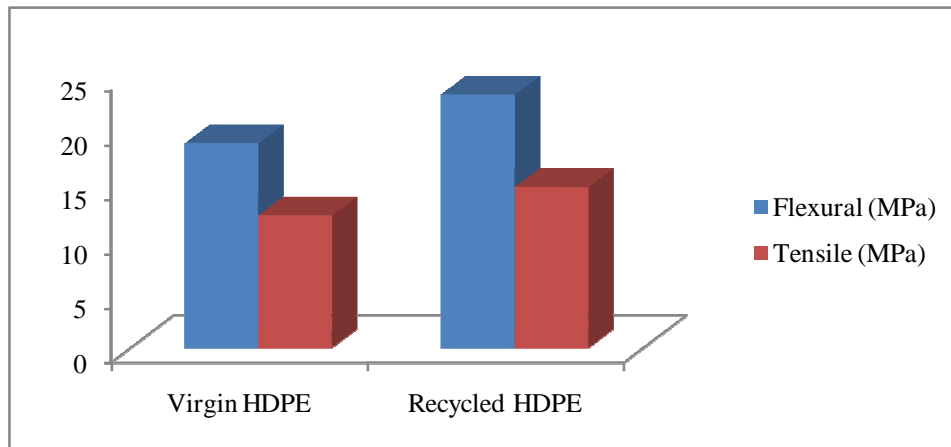
## V. RESULTS AND DISCUSSION

### 5.1 Comparison between the pure and recycled base composite: -

First of all, we were performed various test on the specimens formed by the Virgin as well as recycled HDPE without mixing of any external agent. Comparison between a virgin and recycled HDPE:

**Table 2:** Tensile and flexural properties

	Virgin HDPE	Recycled HDPE
Flexural (MPa)	18.8	23.80
Tensile (MPa)	12.2	14.18

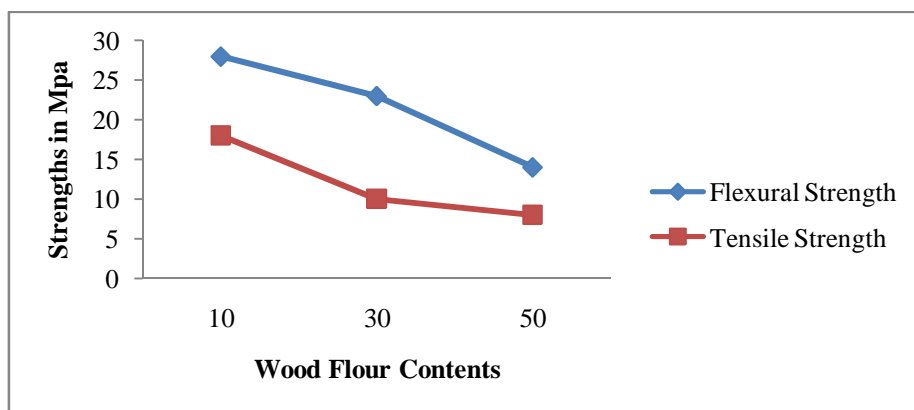


**Fig. 3:** Comparison of mechanical properties

In the above graph we have seen that the virgin HDPE has less flexural as well as tensile strength because in recycled HDPE, it is the mixing of various other composites or coupling agent.

### 5.2 Testing of Wood Plastic Composites: -

Variations of Flexural and Tensile strength with different wood flour ratios are shown below:



**Fig. 4:** Tensile and Flexural strength of Wood flour content loading in vHDPE

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As seen in figure -4, Variations of Tensile and Flexural strength of Wood flour content loading in vHDPE are almost linear and decreasing with increase in wood flour content. A suitable linear curve can be fitted, if number of experimental data is higher.

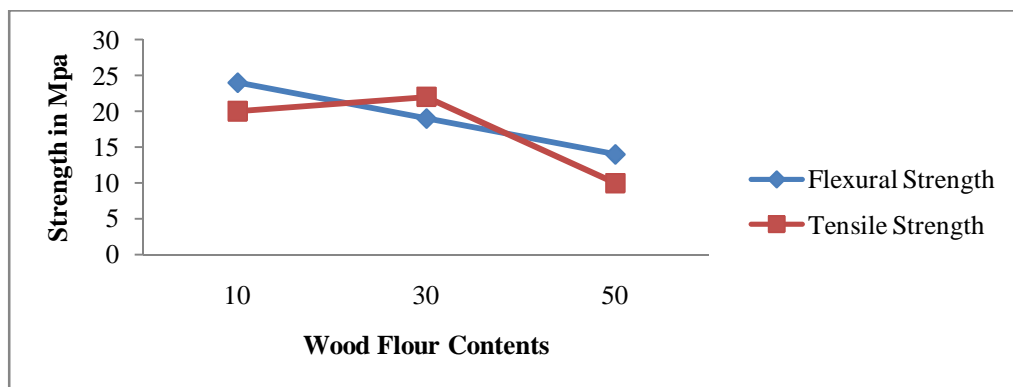


Fig. 5: Tensile and Flexural strength of Wood flour content loading in rHDPE

This is clear from figure -5 that Variations of Flexural strength of Wood flour content loading in rHDPE are approximately linear but tensile strength variations are not linear and reducing trend is registered in both the strengths with increase in wood flour content.

### VI. CONCLUSION

- It was found by testing that the tensile and flexural strength of Recycled HDPE is more as compared to Virgin HDPE.
- Different samples of different compositions were made and tested.
- The composition of wood flour and jute fibre was varied from 10% to 50% in forming the sample.
- 30% Jute loaded sample was found with highest value of tensile and flexural strength which was 14.18 MPa and 23.80 MPa respectively.

### Future Scope

- There is a lot of scope for future scholars to explore this area for research and knowledge. This work can be further extended to study other aspects of such composites like loading pattern, different treatment on mechanical behaviour of wood dust filled polymer composites.
- In future we can make furniture and increase strength of plastic components.

### REFERENCES

- [1] Oblak, P., Gonzalez-Gutierrez, J., Zupančič, B., Aulova, A., & Emri, I. (2016).: Mechanical Properties of Extensively Recycled High Density Polyethylene (HDPE). *Materials Today: Proceedings*, 3(4), 1097-1102.
- [2] Längauer Manuel, Liu Keyan, Kneidinger Christian, SchafflerGernot, Purgleitner Bianca and ZitzenbacherGernot. (2015). Experimental analysis of the influence of pellet shape on single screw extrusion. *Journal of Applied Polymer Science*, 132.
- [3] Hawileh R.A., Obeidah A.A., Abdallaa J. A., Al-Tamimia A. (2015). Temperature effect on the mechanical properties of carbon, glass and carbon-glass FRP laminates. *Journal of Construction and Building Materials*, 342-348.
- [4] Vera-Sorroche J., Kelly A.L., Brown E.C. and Coates P.D. (2015). Infrared melt temperature measurement of single screw extrusion. *Journal of PolymEng Sci.*, 1059-1066.
- [5] Abeykoon C, Martin Peter J., Kelly Adrian L., Kang L., Brown Elaine C. and Coates Phil D. (2014). Investigation of the temperature homogeneity of die melt flows in polymer extrusion. *Journal of PolymEng Sci.*, 2430-2440.
- [6] Alagar M., ThanikaiVelan T. V. and Ashok Kumar, A. (2000). Mechanical properties of E-glass fiber reinforced siliconized epoxy polymer composites. *Journal of Polym. Compos.*, 739-744.

# International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor & UGC Approved Journal)

Website: [www.ijirset.com](http://www.ijirset.com)

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- [7] Ascione Francesco & Mancusi Geminiano. (2010). Axial/Bending Coupled Analysis for FRP Adhesive Lap Joints. *Mechanics of Advanced Materials and Structures*, 85-98.
- [8] Ascione F, Mancusi G. (2010). Failure Criteria for FRP Adhesive Lap Joints: A Comparative Analysis. *Journal of Mechanics of Advanced Materials and Structures*, 157-164.
- [9] Ascione L., Berardi V.P. & D'Aponte A. (2011). A Viscoelastic Constitutive Law For FRP Materials. *Journal for Computational Methods in Engineering Science and Mechanics*, 225-232.
- [10] Bai Yu, Keller Thomas. (2009). Modeling of mechanical response of FRP composites in fire. *Journal of Applied Science and Manufacturing*, 731-738.
- [12] Bao L., NatsBao L., Kamada N., Qian D., Shirayi T., Gotou S. & Kemmochi K. (2010). Improvement of the Bending Characteristics of Thin FRP Cylinders by Imitating Nodes of Bamboo. *Journal of Advanced Composite Materials*, 157-170.
- [13] Chiruvella Raman V., Jaluria Y., KarweMukund V. (1996). Numerical simulation of the extrusion process for food materials in a single-screw extruder. *Journal of Food Engineering*, 449-467.
- [14] Chiruvella Raman V., Jaluria Y., Sernas V. and Esseghir M. (1996). Extrusion of non-newtonian fluids in a single-screw extruder with pressure back flow. *Journal of PolymEngSci.*, 358-367.
- [15] Cruz D.O.A., Pinho F.T. (2012). Analysis of isothermal flow of a Phan-Thien—Tanner fluid in a simplified model of a single-screw extruder. *Journal of Non-Newtonian Fluid Mechanics*, 95-105.
- [16] Esfahani J. M., Esfandh M. and Sabet A. R. (2012). High-Velocity impact behaviour of glass fibre-reinforced polyster filled with nanoclay. *Journal of Appl. Polym. Sci.*, E583-E591.
- [17] Ferrier E., Agbossou A., Michel L. (2014). Mechanical behaviour of ultra-high-performance fibrous-concrete wood panels reinforced by FRP bars. *Journal of Composites Engineering*, 663-672.
- [18] Günaslan Sultan Erdemli, KaraşinAbdulhalim and Öncü M. Emin. (2014). Properties of FRP Materials for Strengthening. *International Journal of Innovative Science, Engineering & Technology*, 656-660.
- [19] Harding J., Welsh L. M. (1983). A tensile testing technique for fibre-reinforced composites at impact rates of strain. *Journal of Materials Science*, 1810-1826.
- [20] Hussain Syed Altaf, R. B. (2008). Prediction Of Elastic Properties Of FRP Composite Lamina For Longitudinal Loading. *Journal of Engineering and Applied Sciences*, 70-75.
- [21] Li, J. a.-H. (2007). Evaluation of tribological performance of surface-treated carbon fiber-reinforced thermoplastic polyimide composite. *Journal of Appl. Polym. Sci.*, 1147-1153.
- [22] Micelli F., NanniAntonio . (2004). Durability of FRP rods for concrete structures. *Journal of Construction and Building Materials*, 491-503.
- [23] Mitsoulis Evan, HatzikiriakosSavvas G. (2009). Modelling PTFE paste extrusion: The effect of an objective flow type parameter. *Journal of Non-Newtonian Fluid Mechanics*, 41-49.
- [24] Mitsoulis Evan, HatzikiriakosSavvas G. (2009). Steady flow simulations of compressible PTFE paste extrusion under severe wall slip. *Journal of Non-Newtonian Fluid Mechanics*, 26-33.
- [25] Mouritz A.P. (2003). Simple models for determining the mechanical properties of burnt FRP composites. *Journal of Material Science and Engineering*, 237-246.
- [26] Ochoa Isaías, HatzikiriakosSavvas G. (2005). Paste extrusion of polytetrafluoroethylene (PTFE): Surface tension and viscosity effects. *Journal of Powder Technology*, 108-118.
- [27] Patil Pramod D., Feng James J., HatzikiriakosSavvas G. (2006). Constitutive modeling and flow simulation of polytetrafluoroethylene (PTFE) paste extrusion. *Journal of Non-NewtonianFluid Mech.*, 44-53.
- [28] Ray B.C. and Rathore Dinesh. (2014). A Review on Mechanical Behavior of FRP Composites at Different Loading Speed. *Journal of Metallurgical and Materials Engineering*, 119-135.
- [29] ShenYuelin, XuMinjie, Chandrashekhara K. & Nanni Antonio. (2002). Finite element analysis of FRP tube assemblies for bridge decks. *Journal of Advanced Composite Materials*, 151-169.
- [30] Shokrieh Mahmood M., OmidiMajid Jamal. (2009). Compressive response of glass-fiber reinforced polymeric composites to increasing compressive strain rates. *Journal of CompositeStructures*, 517-523.
- [31] Tang G., Chang D., Wang D., He J., Mia W., Zhang J. & Wang W. (2012). Mechanical Property Improvement of Carbon Fiber-Reinforced PTFE Composites by PA6 Filler Dispersion. *Journal of Polymer Plastics Technology and Engineering*, 377-380.
- [32] Tay T.E., A. H. (1995). An empirical strain rate-dependent constitutive relationship for glass-fibre reinforced epoxy and pure epoxy. *Journal of Composite Structures*, 201-210.
- [33] Theocaris Pericles S., Stavroulakis G.E., Panagiotopoulos P.D. (1997). Calculation of effective transverse elastic moduli of fiber-reinforced composites by numerical homogenization. *Journal of Composites Science and Technology*, 573-586.
- [34] Wanga Y.C., Wonga P.M.H., Kodurb V. (2007). An experimental study of the mechanical properties of fibre reinforced polymer (FRP) and steel reinforcing bars at elevated temperatures. *Journal of Composite Structures*, 131-140.
- [35] Wilczyński K. J., Nastaj A., Lewandowski A. and Wilczyński K. (2014). A composite model for starve fed single screw extrusion of thermoplastics. *Journal of PolymEng Sci.*, 2362-2374
- [36] 35. Ichazo, M. N, Albano C, GonZalez J Perera R and CAndal M.V,2001 "Polypropylene/wood flour composites: treatment and properties.
- [37] 36 .Jae –Woo Kim, David P. J Harper, Adam M. Taylor 2009: Effect of wood species on the Mechanical and journal od Applied Polymer Science, Vol.112, 1378-1385.