Design and Analysis of Wood Dust-Filled Polymer Composites' Mechanical Properties

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Abstract: The project titled "Design and study of mechanical behavior of wood dust filled polymer composite is the recycling of wood dust obtained from the machining of wood in a wood factory .It has no practical application, but it is used as a source of fire for heating purposes which results in environmental pollution. Hence there is a need for development of new composite material. Segregation of sawdust of different grain sizes was done through mechanical sieve apparatus .The different grain sizes obtained were 600, 300, 212, 120, 75µm. Then 20% saw dust and 80% resin was mixed by hand layup technique which was complemented by catalyst methyl ethyl ketone peroxide [1%] and accelerator cobalt napthane [1%].The mixture was poured in wax polished sheet metal trays of dimension(6*6*0.25)inch3. Then mixture was allowed to solidify for about 2-4 hours. The resultant product was a slab of composite. This procedure was repeated for different grain sizes. The following testes were carried on the model as per ASTM standards are porosity test, density test, hardness test in Rockwell hardness tester, bending test in Universal testing machine. Based on the results Density and hardness are inversely proportional to the grain sizes and bending stress is directly proportional to the grain sizes.

***Keyword*:** ASTM, UTM, RHN, MEKP, CN.

***Abbreviations*:** American standard for testing methods, Universal testing machine, Rockwell hardness number, methyl ethyl ketone peroxide, cobalt napthane.

1. Introduction

Composites materials can be defined as engineered materials, which exist as a combination of two or more materials that result in better properties than when the individual components are used alone. There are five basic types of composite materials: Fiber, particle, flake, laminar and filled composites. There are 2 phases in composites

a. Matrix Phase : It is a bulk part, used for bonding purpose Ex: polymers, ceramics and metals
b. Reinforcement Phase: It gives strength and stiffness to the composite and improve its mechanical properties. Different materials used have different properties and thus affect the mechanical properties of the composite.

1 According to the type of matrix material
   a. Metal matrix composites: In composites metals are in bulk state (AL,Mg,Cu,Fe) .
   b. Polymer matrix composites: These composites are prominent when compared to ceramics and metal matrix composites (polyesters, epoxy resins) .
   c. Ceramic matrix composite: In these composites ceramics is in bulk state, but major disadvantage it is brittle in nature.

2 According to the type of reinforcing material composites
   a. Particulate composites: The reinforcement is of particle nature .It may be spherical, cubic, tetragonal, regular or irregular shape. These particles improve stiffness and hardness properties to the composites.
   b. Fibrous composites: These are generally classified as

1. Synthetic fibers: These are the manmade fibers.

2. Natural fibers: These are natural fibers comes from the plant, animals

It is again classified into

a. Short fiber: It consists of a matrix reinforced by a dispersed phase in the form of discontinuous fibers either of random or preferred orientations.

b. Long fiber: They consist of a matrix reinforced by a dispersed phase in the form of continuous fibers. They can be either unidirectional or bidirectional.

Formulae:

Bending equation is given by $(M/I) = (\sigma_b/C) = (E/R)$

$C=d/2$ …..mm, $I= b*d^3/12$…..mm^4 , $M=W*L/4$, $\sigma_{max}=M/I*C=3WL/2bd^2$……..$N/mm^4$

$E=L^3/48I*$slope of the graph……...N/mm^2

Where, M is bending moment in N-mm

I is moment of inertia of c/s about neutral axis in mm^4

σ_b is max bending stress in N/mm^2

R is radius of curvature in mm

E is elastic modulus in N/mm^2

C is distance from neutral axis to the outer most layer in mm

2. Methodology

1. Making of Sheet Metal Trays

1. Draw the development.
2 Transfer the developments to the flat sheet metal.
3 The material is cut to the dimensions using bench shear.
4 The material is formed to the desired shape using various tools.
5 The edges are joined by soldering

Figure1 Sheet metal tray

Figure 2 Development

2. Segregation of Plywood Saw Dust into Different Grain Sizes

Procedure

1. A rough quantity of saw dust is taken & placed in the top sieve and all the sieves are placed in the descending order from
the top. The top sieves is the coarse and the bottom most is the finest of all the sieves.

2. The whole assembly of the set of the sieves along with the saw wood dust is placed on the sieve shaker & the motor is
switched ON. The sieves are vibrated for 15 min. Then the motor is switched OFF.

3. The saw dust retained in each of the sieves is collected separately.

Figure3 Sieve shaker set

Figure 4 600µm grain size saw dust

Figure 5 300µm grain size saw dust

Figure 6 212µm grain size saw dust

Figure7 120µm grain size saw dust

Figure8: 75µm grain size saw dust

3. Specimen preparation

The fabrication of composites are carried out by simple hand lay up technique .In this technique each wood dust grain sizes of 20%wt is mixed with the 80%wt of Epoxy LY556 resin and stirred well .Then catalyst :Methyl –ethyl ketone peroxide and Accelerator : Cobalt nepthane of 1%wt is added to the mixture and stirred well .This mixture is transferred to wax polished tray and this is allowed to solidify for 2 hours ,finally the solidified specimen is taken out from the tray .This technique is repeated for different grain sizes .According to ASTM standards specimens of suitable dimension are cut using a hacksaw blade for testing.

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Figure9 600µm Grain size composite model

Figure10 300µm Grain size composite model

Figure11 212µm Grain size composite model

Figure12 120µm Grain size composite model

Figure13 75µm Grain size composite model

4. Porosity test

Procedure

a. The specimen is placed in a container containing water for 24 hours .
b. Then the sample is taken out from the container and tested for absorption of water.

5. **Density Test: Code - ASTM D 792**
Procedure

a. Initially, the test specimens are weighed.
b. The samples were put in a measuring jar containing water at a pre-determined level. As a result water gets displaced and its level increases.
c. From the volume of water displaced, density of the specimen and the density range is found.

Formula Used

1. Volume Displaced=FR-IR
2. Density=Mass/Volume displaced

6. **Rockwell Hardness test**

Procedure

1. Specimen is placed on the supporting table.
2. Specimen is slowly raised against the indenter with fixed minor load of 10kgf i.e.,needle in smaller dial touches red mark.
3. Major load of 150kgf for C scale is applied by hand lever. Indicator starts rotating and stops at particular point and it is allowed to wait for 15 sec.
4. Major load is released by hand lever and thus the RHN is directly read from the dial.

7. **Bending Test :ASTM C 393**

Procedure

1. Before subjecting the specimen for bending, span length and its center is marked on it .
2. The specimen is fixed on the two end supports.
3. The dial gauge is attached to the span and adjusted to zero.
4. Then load is applied gradually on the specimen, and it goes lateral deflection i.e., bending.
5. The applied load is noted down for each one-division deflection of the specimen & this is continued till specimen fractures.

3. Results And Discussions

1. Density test table

Grain size(µm)	Density range (kg/m3)
600	$1000<\rho<1200$
300	1200
212	$1000<\rho<1200$
120	$1200<\rho<1400$
75	1400

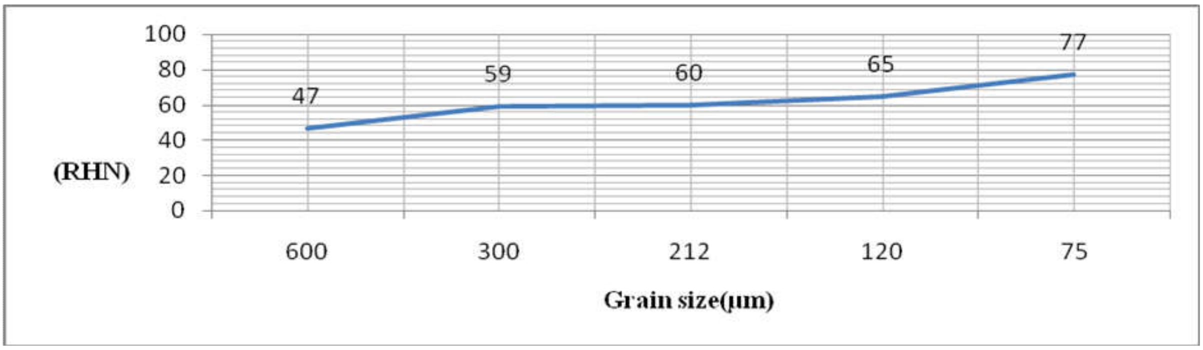
From the above table, we infer that density is inversely proportional to the grain sizes because as the *Reinforcement phase increases the grain size also increases*.

2. Hardness test table

Grain size(µm)	Hardness(RHN)
600	47
300	59
212	60
120	65
75	77

From the above table, we infer that hardness is inversely proportional to the grain sizes because as the surface area of smaller grain size is more.

RHN Graph



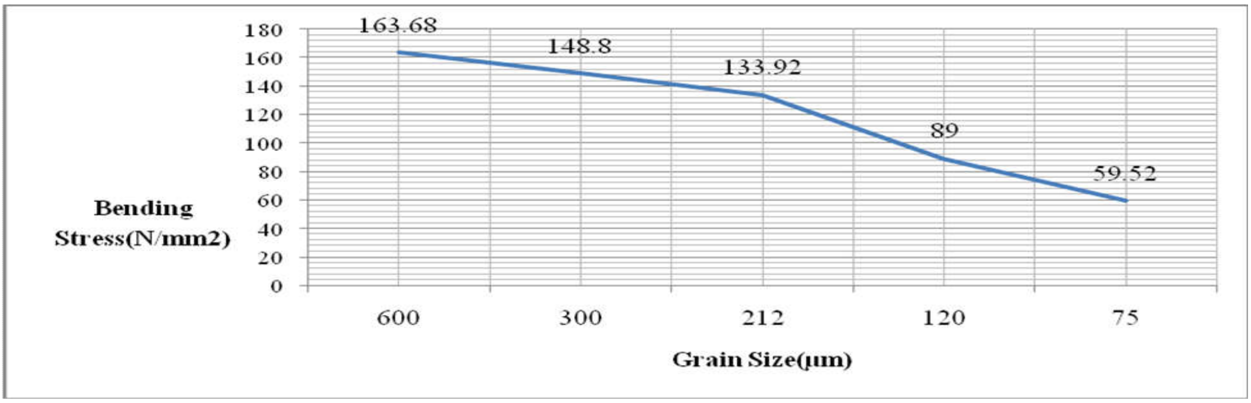
3. **Porosity test**
   It is seen that the composite has not absorbed water. Therefore, it has very low porosity.

4. **Bending test table**

Grain size(µm)	Bending Stress(N/mm2)
600	163.68
300	148.8
212	133.92
120	89
75	59.52

From the above table, we infer that hardness is inversely proportional to the grain sizes because as the smaller grain size specimen has more harder.

Bending test Graph



4. Conclusions

This work shows that successful fabrication of a plywood dust filled epoxy composites with different grain sizes is possible by simple hand lay-up technique. It has been noticed that the physical properties such as porosity, density, etc & mechanical properties of the composites such as hardness, bending strength of the composites are also greatly influenced by the grain sizes of plywood saw dust. As per results we concluded that Hardness and density is directly proportional to grain size and bending stress is inversely proportional to grain size, and it has low viscosity.

5. References

6. [1] Vinod, K.; Udaya Ravi, M.; Yuvaraja, N. A Study of Surface Morphology and Wear Rate Prediction of Coated Inconel 600, 625 and 718 Specimens. Int. J. Sci. Acad. Res. (IJSAR) 2023, 3, 1–9.

7. [2] Sunte, J. The Test Method for Wear Testing Inconel 625 with a Pin-onDisk Apparatus. IJSRMME, 6(4).

8. [3] Sanjana V.H, Jagadish Kumar K. A Literature Review: The Role of IoT in Shaping Smart Education Environments. International Journal Of Innovative Research In Technology (IJIRT) 2025, V11, Issue12, pg no-6477-6482

9. [4] Dr Vinod Kumar Biradar. Use, Impact, Design, and Fabrication of an Onion Sorting and De- Topping Storage Machine, Research and Reviews on Experimental and Applied Mechanics, 2025 v8, issue 1, pg no-31-35

10. [5] Vinod, K, Effect, Performance and Conversion of Plastic to Crude Oil, International Journal of Scientific Research in Mechanical and Materials Engineering,2025 v9, issue 3, pg no-8-13

11. [6] Manjunath D K Dr. Vinod Kumar Biradar, Dr. Udaya Ravi M, Dr.Yuvaraja Naik., Dr.Puneeth Kuma, "Effect of Nickel Chromium Carbide (Cr3C2-NiCr) On Inconel Specimen 600, 625, and 718 By Vickers Hardness Test, Electrochemical Test, and Wear Performance By DOE Method", "Industrial Engineering Journal",2025. V54, Issue3, pg no-114-126

12. [7] Sumanth U S Dr.Vinod Kumar Biradar, Amoghraj, Sridhara M S. A work on Speech Guided Landmine Detector Robot.International Journal of Engineering Inventions, 2024, V13, Issue5, pg no-276-282

13. [8] Vinod Kumar, Dr.Udaya Ravi M, Dr. Yuvaraja Naik, Comparative Studies on Mechanical Properties and Corrosion rate of Nickel Chromium Carbide (Cr3C2-NiCr) Coated on Inconel 600, 625, 718 specimen", Journal of Propulsion Technology 2023, 44 (4), Page no- 855-870

14. [9] DYN Vinod kumar , Dr. Udaya Ravi M, Effect of aging Treatment on Inconel specimen 600, 625, 718 coated with Nickel Chromium carbide (Cr3C2-NiCr) using salt and acidic corrosion method, The Seybold Report,2022, 17 (10), 675-686

15. [10] V Biradar, The Test method for wear testing Inconel 625 with a pin on disc apparatus, International International Journal of scientific research in mechanical and material engineering (IJSRMME),2022, V6, Issue4, pg no-79-85

16. [11] Fareen S Dr. B S Praveen Kumar,, Development & Characterization of Low Friction Wear & Corrosion Resistant Coating for Automobile Application, International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE),2021, V6, Issue3, pg no-13-16

17. [12] krishnamoorthy PR, Mechanical Behavioural & Friction Stir weldind studies on copper Hybrid Metal Matrix composite, THINK INDIA JOURNAL, 2019, V22, Issue14, pg no-10268-10270

18. [13] Vinod Kumar Biradar, Bharath Kumar P, Domestic Waste to Biodegradable Manure, 2019 JETIR May 2019, Volume 6, Issue 5

19. [14] bukkatatnam manasa , Overview of the Vertical Axis Wind Turbines, 2019/2, JETIR 6 (Issue 2), 59

20. [15] anurag singh, Remote Control Aero plane, IJERMCE,2017/5, V2, Issue5, pg no-704