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Study and Investigation on 3d Printed Wastewood and Walnut Filament With Epoxy Resin Ly566 by Using Fdm

M. Keerthana[1], Dr. V. Diwakar Reddy[2], B. Raghavendra Prasad Nayak[3]

[1]PG Student, Sri Venkateswa University College of Engineering, Department of Mechanical Engineering, Tirupathi, Andhra Pradesh, India, 517502.
[2]Professor, Sri Venkateswara University College of Engineering, Department of Mechanical Engineering, Tirupathi, Andhra Pradesh, India, 517502.
[3]Faculty, Sri Venkateswara University College of Engineering, Department of Mechanical Engineering, Tirupathi, Andhra Pradesh, India, 517502.

Abstract:
The study emphasizes the physical and mechanical properties of the composite filaments, their compatibility with FDM printing and the processes used in production. With Fused deposition modelling (FDM) techniques wastewood, walnut shell particles mixed with epoxy resin are the instances of the recycled materials used in this creation and review of this work. Negotiating the diverse range of 3D printing processes and materials, each with unique qualities such as biodegradability, dimensional accuracy, surface smoothness, and post-processing requirements, is crucial for determining the optimal solution. To assess their potential for a range of uses, the manufactured samples were tested for characteristics like tensile, flexural strength as well as thermal stability. The Taguchi method is used to optimize the results beyond the testing phase in order to discover the ideal parameter levels. It fosters sustainable manufacturing by investigating ecologic materials for 3D printing that adhere to high performance standards. The outcomes provide important new information on the function of sustainable composites in additive manufacturing.

Keywords: Composite filaments, Biodegradable materials, Fused deposition modelling (FDM), Taguchi method, Additive manufacturing, 3D printing.

1. INTRODUCTION

Researchers as well as businesses are becoming more intrigued by recyclable polymers and composites because they are easy to produce, environmentally beneficial and suitable for a number of uses. Addressing societal and environmental issues has made the usage of biodegradable materials rather than plastics crucial. The most significant environmental benefits are less contaminants, a smaller carbon footprint and decreased toxicity. The research presented here validates a growing focus on reducing environmental effect while maintain high performing standards by reusing materials. The composite filaments are generated through a meticulous process that involved mixing finely ground scrap wood and walnut shell particles with epoxy resin before extruding them into printable filaments. These filaments were used in FDM based 3D printing to make test specimen. Fused deposition modelling is one of the most used for additive manufacturing. It works by depositing material in layers to form a three-dimensional object. A computerized 3D model of the thing is built with CAD software. The model is exported into

STL format. The image file is processed using slicing software, which breaks the model into horizontal layers and produces a G- code file with printer instructions. The subsequent step is to set up the printer, which includes material loading and calibration.

Literature review:

The body of literature concerning the utilization of polylactic acid (PLA) in Fused Deposition Modelling (FDM) predominantly emphasizes the influence of process parameters on mechanical properties.

Muammel M. Hanon highlights that a significant number of studies focus on these factors.

Istvan Oldal provides a comprehensive overview of 3D-printed biodegradable polymers and their applications using FDM, identifying PLA, ABS, and nylon as the most frequently employed materials for pure and composite filaments.

Boparai KS and Singh R investigate the challenges and potential applications of thermoplastic composites designed for FDM filament production.

Sanjitha Wasti explores the use of bio-based materials in FDM, identifying three approaches: the direct use of bio-based polymers like PLA or PHA, blending these polymers with fillers, and combining hydrocarbon-based polymers such as ABS, nylon, and PCL with bio-based fillers. Research on PLA-based FDM primarily centres on analysing factors that influence the mechanical performance of printed components.

Samarthya Bhagia's research provides a detailed examination of high molecular weight PLA, addressing the specific requirements for filament extrusion and bio-composite printing. The study evaluates mechanical, thermal, and viscoelastic properties, alongside imaging and spectroscopic analyses, to understand the impact of incorporating biomass into PLA-based materials. The work concludes by discussing the applications, recycling, upcycling, and future opportunities within the context of bio-refineries.

S. R. Subramaniam this investigation examines the growth in creating pure Polylactic Acid (PLA) using FDM and the opportunities it presents as an advanced material when combined with filler components to produce potential composites. A description of current advancements in PLA composites has been given, as well as am explanation of the method of manufacturing and the composite's importance.

Disha Deb to alleviate these problems, PLA composites are employed. In this review work, we looked into various natural fibres that can be utilized to build PLA composites. As a result, the study intends to provide optimal waste management through the use of 3D printing. The substances mentioned are primarily agricultural byproducts, such as those derived from leaves and barks. They are partially biodegradable, but also inexpensive.

Rao Ravella Sreenivas offers a comprehensive understanding of the Taguchi Methodology, highlighting its effectiveness as a statistical tool for applications in biotechnology.

Moradi M. and Beygi R. examine the 3D printing of Acrylonitrile-Butadiene Styrene (ABS) using Fused Deposition Modelling (FDM), utilizing Artificial Neural Networks (ANN) and Response Surface Methodology (RSM) for process analysis and optimization.

The writers of the above literature review investigated and concentrated on 3D printing on biodegradable materials that disintegrate or compost instead of plastic and dangerous elements that do not decompose and aid in intricate the varied multiple ideas.

2. METHODOLOGICAL FRAMEWORK

2.1 Materials constituents

Wastewood: Sawdust a prevalent byproduct of wood working, is gaining traction as a sustainable material for 3D printing, particularly when combined with composite filaments. Combining sawdust with thermoplastic binder such as PLA enables the production of ecofriendly filaments with distinct properties.

Walnut shell: Walnut shells, which are typically discarded as crop leftover, are gaining popularity as a 3Dprinting material. Walnut shells, coarsely powdered, can be included into composite filaments. Portable, with moderate strength. Although less flexible than pure plastics, they are nonetheless appropriate for decorative or low stress applications.

Acrylonitrile Butadiene Styrene (ABS): ABS is a prominent polyamide for 3Dprinting because of its durability, versatility and low cost. It's high tensile and impact strength enables stability overtime and wear resistance. Under usual conditions, the material is resistant to scratches and distortion.

Figure 1: Sawdust wood

Figure 2: Walnut filament

Figure 3: ABS Filament

2.2 Composition

- Waste wood is composed of 80% wood and 20% Polylactic acid.
- Walnut filament is composed of 80% walnut shell and 20% Polylactic acid.
- Acrylonitrile-Butadiene Styrene.

2.3 Printing parameters

Table 1 Specimen parameters

Orientation (degrees)	Layer Thickness (mm)	Print speed (mm/sec)
0	0.12	30
45	0.16	45
90	0.2	60

2.4 Specimen

Type IV as per ASTM D638 specimen

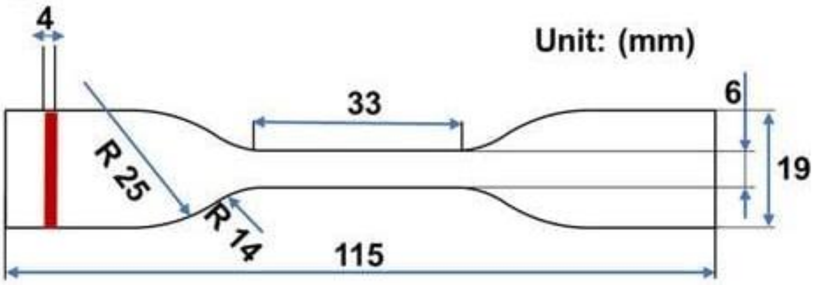
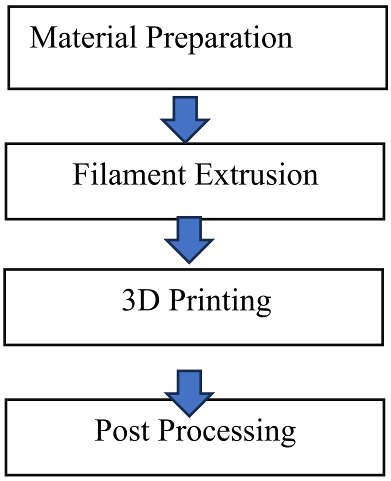


Figure 4: Specimen Dimensions

2.5 Sequential procedure



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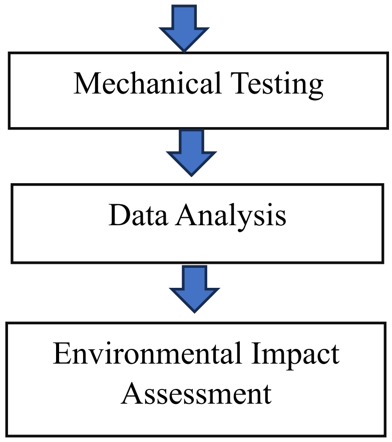

The first stage in producing filament appropriate for 3D printing is to collect and cure walnut and waste wood. Make that the filament is contaminant free and consistent. Utilizing the extrusion technique to generate printed filament from scrap wood and walnut shell. The walnut and wood are crushed, combined with binding agent and extruded into filaments. The filament is thereafter tested to ensure that it meets FDM printing standards in terms of mechanical qualities, consistency and diameter uniformity. For superior printing quality, change the printer's temperature, speed and layer height. By using CAD software to design test objects that will be manufactured. Tensile strength, flexibility and surface quality are just a few of the material properties that should be assessed utilizing these tools. Samples should be allowed to cool after printing before being coated with epoxy resin LY566.Testing the impact resistance of printed samples with and without epoxy resin coating. Using thermal analysis to determine the degradation temperature and thermal stability.

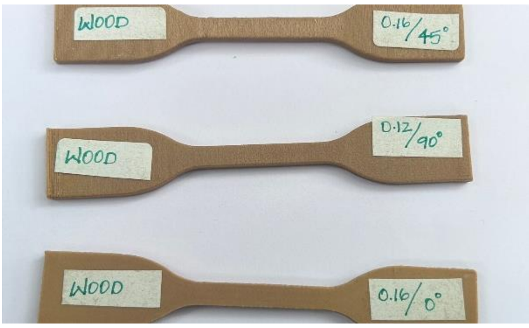

Figure 5: 3D printed wood filament

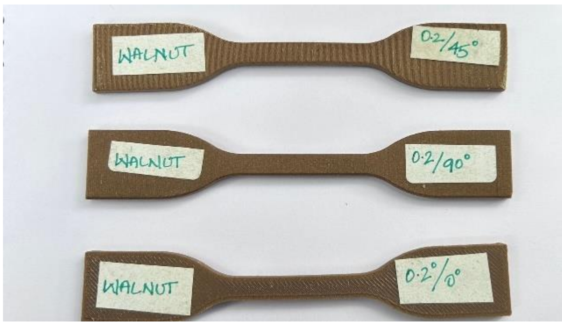

Figure 6: 3D printed walnut filament

3. Outcomes and interpretation

The assessment outcomes for the materials have been listed below as follows

Table 2: Composite material-wood

SL.NO	PROPERTIES	UNIT	TEST METHOD	RESULT
1	HARDNESS	Shore D°	ASTM D 2240	75,77,76,75,76
2	MELTING POINT	°C	THERMAL METHOD	148
3	HEAT RESISTANCE	%	150°C/10 MIN	DEFORMATION OBSERVED
4	TENSILE STRENGTH			
	1)0.12/0°	MPa	ASTM D 638	43.21
	2)0.12/45°	MPa	ASTM D 638	27.67
	3)0.12/90°	MPa	ASTM D 638	29.79
	4)0.16/0°	MPa	ASTM D 638	42.35
	5)0.16/45°	MPa	ASTM D 638	34.17
	6)0.16/90°	MPa	ASTM D 638	29.79
	7)0.20/0°	MPa	ASTM D 638	43.10
	8)0.20/45°	MPa	ASTM D 638	33.70
	9)0.20/90°	MPa	ASTM D 638	29.79

Table 3: Composite material- walnut shell

SL.NO	PROPERTIES	UNIT	TEST METHOD	RESULT
1	HARDNESS	SHORE D°	ASTM D 2240	72,71,73,70,71
2	MELTING POINT	°C	THERMAL METHOD	133
3	HEAT RESISTANCE	%	150°C/10 MIN	DEFORMATION OBSERVED
4	TENSILE STRENGTH			
	1)0.12/0°	MPa	ASTM D 638	37.22
	2)0.12/45°	MPa	ASTM D 638	15.47
	3)0.12/90°	MPa	ASTM D 638	14.76
	4)0.16/0°	MPa	ASTM D 638	37.06
	5)0.16/45°	MPa	ASTM D 638	18.26
	6)0.16/90°	MPa	ASTM D 638	11.56
	7)0.2/0°	MPa	ASTM D 638	38.79
	8)0.2/45°	MPa	ASTM D 638	28.68
	9)0.2/90°	MPa	ASTM D 638	15.14

Table 4: Composite material- ABS

SL.NO	PROPERTIES	UNIT	TEST METHOD	RESULT
1	HARDNESS	SHORE D°	ASTM D 2240	72,70,71,70,71
2	MELTING POINT	°C	THERMAL METHOD	212
3	HEAT RESISTANCE	%	150°C/10MIN	DEFORMATION OBSERVED

4	TENSILE STRENGTH			
	1)0.12/0°	MPa	ASTM D 638	39.75
	2)0.12/45°	MPa	ASTM D 638	26.71
	3)0.12/90°	MPa	ASTM D 638	23.44
	4)0.16/0°	MPa	ASTM D 638	44.68
	5)0.16/45°	MPa	ASTM D 638	30.41
	6)0.16/90°	MPa	ASTM D 638	9.96
	7)0.2/0°	MPa	ASTM D 638	42.45
	8)0.2/45°	MPa	ASTM D 638	25.43
	9)0.2/90°	MPa	ASTM D 638	12.99

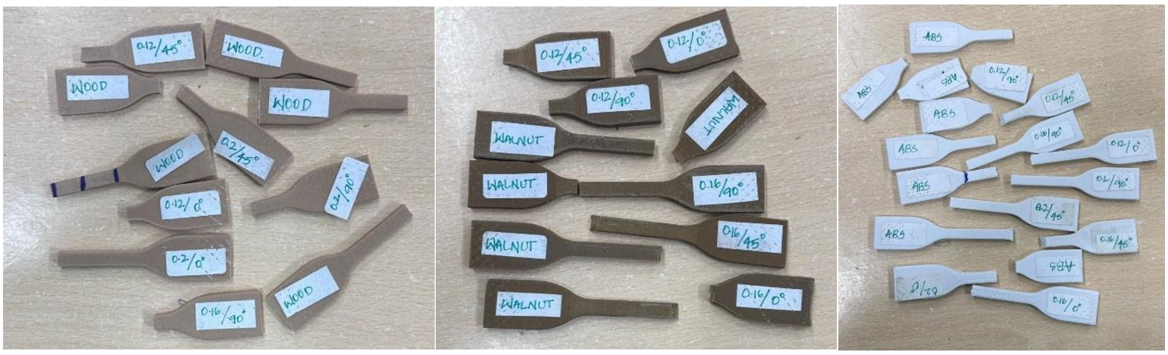

Figure 7: Specimens after testing

For the aforementioned testing results, the graph is produced accordance to the materials

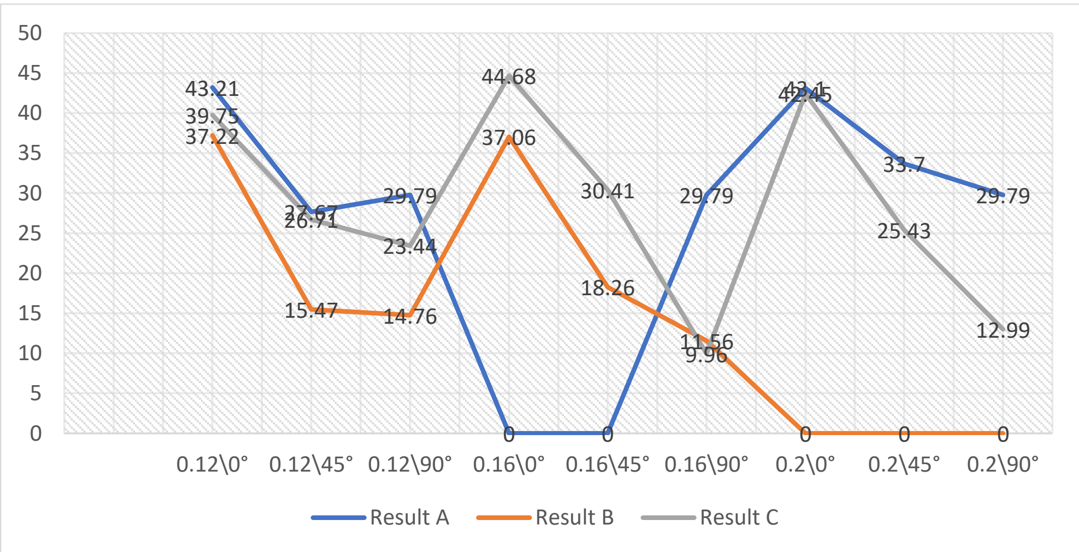

Figure 8: Graphs representing three materials

The graph above shows the tensile strength values for the following materials: wood, walnut shell filament and ABS materials.

4. Taguchi-based analysis

By using MINITAB program, we examine the tensile strength values in tabular form in order to create the required S/N and Means graphs are plotted. By visualizing the graphs, the best optimum levels are obtained. To perform the Taguchi method, initially activate the MINITAB then pick DOE followed up by Taguchi and at last construct the

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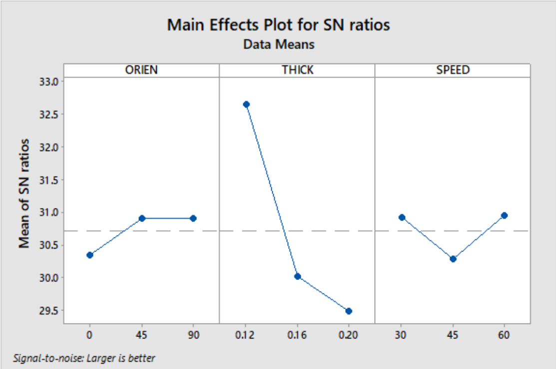
Taguchi design. Then pick up the Taguchi design as level 3, the number of factors as 3 and the variables as orientations, layer thicknesses and print speeds to obtain the L9 design. Subsequently, another time click on stats and Taguchi and analyze, follow by clicking on the action, then select SN ratios then choose the larger is better rule, and finally click OK to obtain the required graphical representations. To Anova analysis, click on the stats the Anova and select general. The result will be extended.



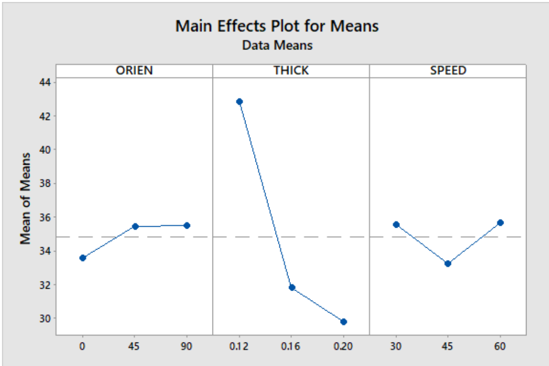
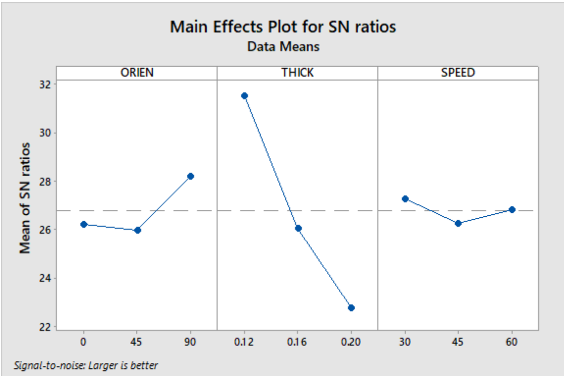


Figure 9: S/N ratios for Wastewood **Figure 10: Means for Wastewood**

The main effects plot for S/N and Means shows the optimal degree of tensile strength for waste wood. The plots were created utilizing the "Larger is better" hypothesis to determine the optimal level based on the ratio charts. The obtained optimum levels are 90°orientation, 0.12 mm of layer thickness with 60 mm/sec of print speed.



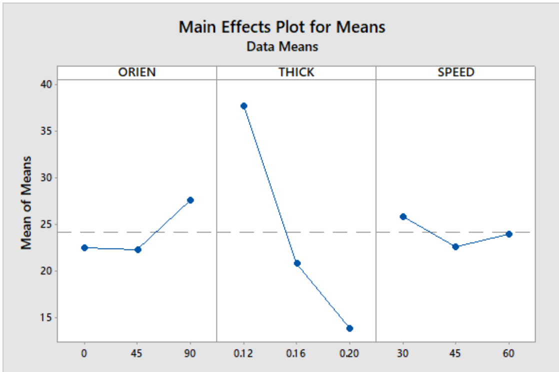
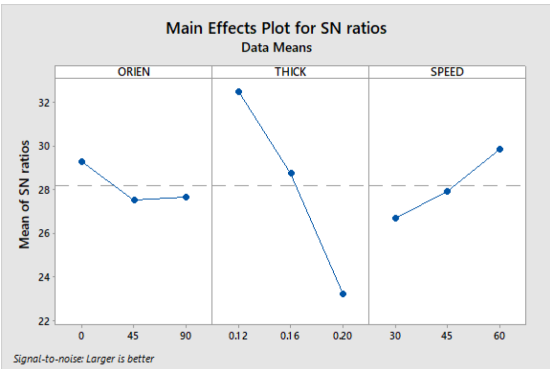


Figure 11: S/N ratios for Walnut filament **Figure 12: Means for Walnut filament**

Comparably, the main effects plot for S/N and means shows the optimum standard for the tensile strength for walnut filament. The obtained plots were created using the "Larger is better" as larger the value the strength of the material is more. The attained levels for this walnut shell filament are 90°orientation, 0.12 mm of layer thickness with 30 mm/sec of print speed



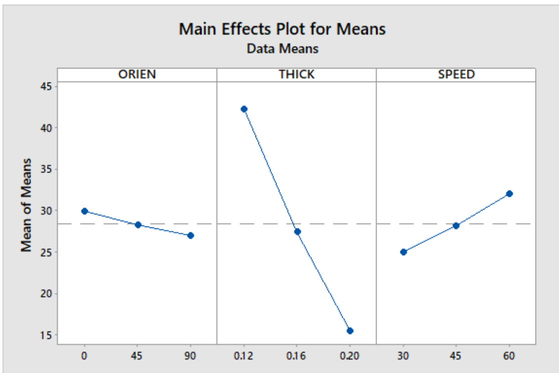


Figure 13: SN ratios for ABS material **Figure 14: Means for ABS material**

In the same way, the major effects plot for S/N and means indicates the optimum stages of tensile strength for ABS material. The resultant plots were constructed using the principle" Larger is better" because we need to evaluate the materials tensile strength which should be high. The acquired levels for this ABS material are 0° orientation, 0.12 mm layer thickness with 60 mm/sec of print speed.

5. Conclusion

Finally, utilizing 3D printing through biodegradable materials like wastewood, walnut shell filament and ABS materials. The constituent parts are then converted into a filament by combining them with PLA and the necessary input parameters like as orientation, layer thickness and print speed. We took multiple samples with closed and open loops for various parameters. Ultimately, we acquired a specimen of the parameters we had provided.

- Following the completion of the specimen, it is tested for hardness, melting point, resistance to heating and tensile strength. Conclusions shows that the wastewood has higher melting point, tensile strength and hardness than walnut filament and ABS polymer in various orientations.
- These tested specimen values are then moved to determine the best optimization level using Taguchi method. The tensile strength values are provided in Taguchi analysis to obtain good optimum levels. For Wastewood material the best ideal levels are 90°orientation, 0.12mm layer thickness with 60 mm/sec print speed.
- For Walnut shell filament the best ideal conditions are 90° orientation, 0.12mm layer thickness with 30 mm/sec print speed.
- For ABS material the optimal levels obtained are 0°orientation ,0.12 mm layer thickness with 60 mm/sec print speed.

By this creating environmentally sustainable consumer products which are utilized as biodegradable composites. Establishing recycling initiatives tailored for PLA wood composites to advance circular economy principles.

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