Effect of Corn Husk Powder Mixture on Mechanical Properties Using a Matrix Polyester and Vinylester

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Abstract.
The development of composite material technology continues to grow across various industries due to its advantages, including low density, high mechanical strength, and corrosion resistance. The use of synthetic fibers in composites has drawbacks in terms of environmental impact and production cost, making natural reinforcing materials such as corn husk powder a sustainable alternative. This study aims to determine the effect of adding corn husk powder on the mechanical and physical properties of a composite using a mixed matrix of polyester resin (70%) and vinylester resin (30%). The composites were fabricated using the hand lay-up method with corn husk powder mass variations of 0, 2, 5, 7, and 12 grams, and were tested for impact toughness using the Charpy method according to the ASTM D6110 standard. The results show that the addition of corn husk powder significantly increased the composite's impact toughness. Impact values increased progressively from 0.007 J/mm² at 0 grams, to 0.043 J/mm² (2 grams), 0.062 J/mm² (5 grams), 0.085 J/mm² (7 grams), reaching the highest value of 0.149 J/mm² at 12 grams. The 12-gram variation was identified as the best composition in this study, producing the highest absorbed energy and impact toughness. These results indicate that corn husk powder has strong potential as a natural reinforcing material in polyester–vinylester based composites, while also adding value to agricultural waste and supporting the development of environmentally friendly materials.
Keywords: *composite, corn husk powder, polyester, vinylester and hand lay-up andCharpy impact test.*

I. INTRODUCTION

Most composites currently in use still utilize synthetic fibers such as fiberglass and carbon fiber. Despite their excellent mechanical properties, synthetic fibers have several drawbacks, including being environmentally unfriendly, difficult to decompose naturally, and requiring relatively high production costs. Therefore, developing composites based on natural reinforcement materials is a sustainable and environmentally friendly alternative solution. One natural material with potential use as a composite reinforcement is corn husk powder.

Corn husk powder is an agricultural waste-based reinforcing material that is abundantly available in Indonesia. Corn husks are generally used as animal feed or even discarded as waste, so their use as a composite reinforcing material can provide added economic value while reducing environmental problems. Corn husk powder has potential as a composite reinforcing material because it contains a relatively high cellulose content. This cellulose content plays a role in increasing the bond between the powder particles and the matrix, thereby contributing to the improvement of the mechanical properties of the resulting composite material. Compared to fibers, the use of powders has the advantage of more even distribution of the reinforcement within the matrix and ease of mixing.

In addition to the type of reinforcement, the choice of matrix also plays a crucial role in determining the characteristics of the composite. Polyester resin is a type of thermosetting polymer matrix widely used in industry due to its good mechanical properties, relatively high chemical resistance, ease of fabrication, and relatively economical price compared to other types of resins such as epoxy. Therefore, the use of a polyester matrix in corn husk powder-reinforced composites is expected to produce composite materials that are lightweight, strong, and affordable in terms of production costs.

Based on the description, research on the effect of corn husk powder mixture on the mechanical properties of composites using a polyester matrix is important to be carried out. Variations in the percentage of corn husk powder mixture need to be studied experimentally to determine the optimal composition that produces the best mechanical properties, especially in impact testing using the ASTM D6110 standard. This research is expected to provide scientific information on the potential of corn husk powder as a composite reinforcing material and its contribution to improving the performance of environmentally friendly and economically valuable composite materials.

II. RESEARCH METHOD

This research design is focused on the development of green composite materials that utilize corn husk waste as reinforcement and polyester and vinylester resins as matrices. In general, this case study aims to analyze the extent to which the addition of variations in volume or weight of corn husk powder affects the impact toughness and mechanical strength of the material compared to pure polyester and vinylester.

Research Design Method

The initial stage of the research includes the preparation of corn husk powder through a cleaning process. After drying, the corn husk powder is mixed with a matrix mixture of 70% polyester resin and 30% vinylester using the hand lay-up method, with certain weight fraction variations. The mixture is then poured into a mold that has been coated with a release agent and left for 24 hours until the curing process is complete.

The hardened specimens were then cut and tested according to international standards, namely ASTM D6110 for impact testing. The test data were analyzed statistically to determine the effect of the addition of powder on the impact toughness value of the composite. The final evaluation was carried out by observing the fracture surface to identify the material failure mechanism and determine the most optimal mixture composition.

Determination of Research Variables

This research is based on experimental testing to determine the correlation between the addition of natural reinforcement and the structural characteristics of the material. Variable determination was carried out rigorously to ensure data validity, allowing an objective analysis of the causal relationship between the mixture composition and the resulting mechanical performance.

1. Independent Variable

Independent variables are parameters that are systematically manipulated in research to observe their influence on the object of observation.

a. Parameters: Weight fraction of corn husk powder.

b. Description: Variation of mass percentage of powder

2. Dependent Variable

The dependent variable is a parameter that is measured and observed as a technical response to changes in the independent variable.

a. Composite mechanical properties. The dependent variable is a parameter measured and observed as a technical response to changes in the independent variable. The data used in this study are the results of Charpy impact testing according to ASTM D6110 standards.

Data Collection Method

Data collection in this study was conducted experimentally through a series of tests on corn husk powder composite specimens with polyester and vinylester matrices at each weight fraction variation. The data collected included mechanical and physical testing data as described below.

Impact Test Data Collection

Impact test data collection was conducted using a Charpy impact tester machine according to ASTM D6110 standards. Data was taken directly from the machine and the results of specimen dimension measurements. The data collection procedure is as follows:

1. Each specimen was measured for dimensions (width b and thickness h) using a vernier caliper before testing, then the fracture cross-sectional area was calculated using the formula $A = b \times h$.
2. The specimen is mounted on the impact tester machine stand horizontally with the notch position opposite to the pendulum.

3. The pendulum is released and strikes the specimen until it fractures. The energy absorbed by the specimen (E) is read directly from the scale on the impact tester in Joules.
4. The impact toughness value is calculated using the formula HI = E / A with units of J/mm².

Each weight fraction variation was tested with 3 specimens, resulting in a total of 15 specimens. The final value used was the average value of the 3 specimens in each variation.

Data analysis

All collected test data were then analyzed quantitatively and presented in tables and graphs to facilitate comparison between variations in corn husk powder weight fractions. The optimum composition was determined by comparing the impact toughness values of each corn husk powder variation, thus determining the weight fraction that provides the best overall composite characteristics.

III. ANALYSIS AND RESULTS

Specimen Preparation

In this study, composite specimens were made from corn husk powder reinforcement with a polyester resin matrix using the hand lay-up method. The variations in the weight fraction of corn husk powder used were: 0 g, 2 g, 5 g, 7 g, and 12 g. is the mass of corn husk powder mixed into the polyester–vinylester matrix. with specimen sizes referring to the ASTM D6110 standard.

Before the mixing process, the corn husks were cleaned, dried, ground, and sieved to obtain a uniform powder. The corn husk powder was then mixed with a mixture of 70% polyester resin and 30% vinylester resin, which had been supplemented with a catalyst. The mixture was stirred until homogeneous, then poured into molds previously coated with a release agent. The composite was then cured for 24 hours until it hardened.

Fig 1 powder dosage

The powder is weighed according to the specified units.

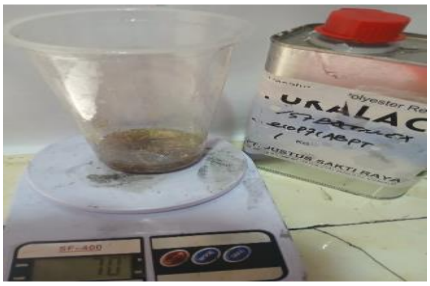

Fig 2 pouring 70% polyester resin

Then the polyester resin is poured into the corn husk powder with a ratio of 70%.

Fig 3 after mixing 30% vinylester resin

After pouring the polyester resin, pour the vinylester resin at a rate of 30%.

Fig 4 shows the resin after stirring.

After pouring the polyester and vinylester resin into the container, stir the resin and fiber thoroughly. Once evenly distributed, pour in the catalyst at a rate of 1% of the resin volume.

Fig 5 resin molding process

Then pour it into the mold and wait for 24 hours according to the lay up method.

Fig 6 resin specimen

After the pressing process is complete, the resin is then released into the mold.

Observations showed that all variations successfully formed composite specimens in good condition. However, at higher powder fractions, the specimen surfaces were slightly rougher and contained several voids, which are suspected to affect the mechanical properties of the composite. All specimens that met the criteria were then used for impact, density, and water absorption testing.

1.1 Impact Test Results

1.1.1 Implementation of Impact Testing

Impact testing in this study was conducted using an Impact Tester using the Charpy method according to ASTM D6110 standards. The test aimed to determine the ability of the corn husk powder composite with a polyester matrix to absorb energy from shock loads until it fractures. The test procedure refers to the method outlined in Chapter III.

Before testing, each specimen was measured for width and thickness using calipers to determine the fracture cross-sectional area. The specimen was then mounted on a horizontal testing machine stand with the notch facing the opposite direction of the pendulum's swing.

The pendulum is then lifted to an initial angle according to the machine's capacity, then released, striking the specimen until it fractures. After the specimen fractures, the absorbed energy value indicated by the machine is recorded as test data. The impact toughness value is then calculated based on the ratio of the absorbed energy to the fracture cross-sectional area of the specimen.

Testing was conducted on five variations of corn husk powder composition, namely 0%, 2g, 5g, 7g, and 12g. Each variation consisted of three specimens, resulting in a total of 15 specimens tested. All test data were then processed in tables and graphs to analyze the effect of corn husk powder addition on the impact toughness of the composite.

1.1.2 Impact Test Result Data

Impact testing was conducted on composite matrix specimens made with five variations in polyester and vinylester resin compositions. Each variation was tested three times to obtain more representative data. All specimens that met the criteria were then used for Charpy impact testing.

The results of impact testing on each variation of polyester and vinylester resin mixture are presented in Table 4.1

Table 4.1 Impact test results data

Resin mix variations	Specimen 1(J)	Specimen 2(J)	Specimen 3(J)	Average(J)
70% polyester 30% vinyl ester Powder: 0 G	1	1	1	1.00
70% polyester 30% vinyl ester Powder: 2 G	5	6	6	5.66
70% polyester 30% vinyl ester Powder: 5 G	8	8	8	8.00
70% polyester 30% vinyl ester Powder: 7 G	11	11	11	11.00
70% polyester 30% vinyl ester Powder: 12 G	20	18	20	19.33

Calculation of impact test value

The impact test calculation is carried out based on the absorption energy data obtained from the impact test. It is calculated using equation (2.2.7), namely:

$$\boldsymbol{HI} = \frac{\boldsymbol{E}}{\boldsymbol{A}}$$

Information:

HI= Impact toughness (J/mm²)

E= Energy absorbed (J)

A= Cross-sectional area of specimen fracture (mm²)

The cross-sectional dimensions are:

Width: 12.7 mm

Thickness: 10.16 mm

So the cross-sectional area is obtained:

A= 12.7 x 10.16

A= 129.03mm^2

Next, the following calculations are carried out:

1 . Variation 70% polyester 30% vinylester Powder: 0 G

$$\text{Specimen 1:} HI = \frac{1}{129{,}03} = 0{,}007 \ J/mm^2$$

$$\text{Specimen 2:} HI = \frac{1}{129{,}03} = 0{,}007 \ J/mm^2$$

$$\text{Specimen 3:} HI = \frac{1}{129{,}03} = 0{,}007 \ J/mm^2$$

Based on the calculation results, Specimens 1, 2, and 3 with a composition of 70% polyester: 30% vinylester without the addition of corn husk powder (0 g) produced the same impact toughness value, namely 0.00775 J/mm². The similarity of these values indicates that the three specimens have a uniform ability to absorb impact energy before breaking, so that the average value can be used as a comparison.

2 . Variation 70% polyester 30% vinylester Powder: 2 G

$$\text{Specimen 1:}HI = \frac{5}{129{,}03} = 0{,}038\ J/mm^2$$

$$\text{Specimen 2:}HI = \frac{6}{129{,}03} = 0{,}046\, J/mm^2$$

$$\text{Specimen 3:}HI = \frac{6}{129{,}03} = 0{,}046\ J/mm^2$$

Based on the calculation results, in the composition variation of 70% polyester: 30% vinylester with the addition of 2 g of corn husk powder, Specimen 1 produced an impact toughness value of 0.03875 J/mm², while Specimen 2 and Specimen 3 each had an impact toughness value of 0.04650 J/mm². The difference in these values indicates a variation in the specimen's ability to absorb impact energy. In general, the addition of 2 g of corn husk powder provided a higher impact toughness value compared to the composition without the addition of powder, so that the composite's ability to absorb impact energy increased.

3 . Variation 70% polyester 30% vinylester Powder: 5 G

$$\text{Specimen 1:}HI = \frac{8}{129{,}03} = 0{,}062\, J/mm^2$$

$$\text{Specimen 2:}HI = \frac{8}{129{,}03} = 0{,}062\ J/mm^2$$

$$\text{Specimen 3:}HI = \frac{8}{129{,}03} = 0{,}062\ J/mm^2$$

Based on the calculation results, in the composition variation of 70% polyester: 30% vinylester with the addition of 5 g of corn husk powder, the three specimens produced the same impact toughness value, namely 0.06200 J/mm². The similarity of these values indicates that each specimen has a uniform ability to absorb impact energy before breaking. In addition, the impact toughness value in the 5 g variation is higher than the 0 g and 2 g variations, thus indicating that the addition of 5 g of corn husk powder increases the composite's ability to absorb impact energy.

4 . Variation 70% polyester 30% vinylester Powder: 7 G

$$\text{Specimen 1:}HI = \frac{11}{129{,}03} = 0{,}085\ J/mm^2$$

$$\text{Specimen 2:}HI = \frac{11}{129{,}03} = 0{,}085\ \ J/mm^2$$

$$\text{Specimen 3:}HI = \frac{11}{129{,}03} = 0{,}085\ \ J/mm^2$$

Based on the calculation results, in the composition variation of 70% polyester: 30% vinylester with the addition of 7 g of corn husk powder, the three specimens produced the same impact toughness value, namely 0.08525 J/mm². The similarity of these values indicates that each specimen has a uniform ability to absorb impact energy before breaking. The impact toughness value in the 7 g variation is also higher than the 0 g, 2 g, and 5 g variations, thus indicating that the addition of 7 g of corn husk powder provides an increase in the composite's ability to absorb impact energy.

5 . Variation 70% polyester 30% vinylester Powder: 12 G

$$\text{Specimen 1:}HI = \frac{20}{129{,}03} = 0{,}155 J/mm^2$$

$$\text{Specimen 2:}HI = \frac{18}{129{,}03} = 0{,}139\, J/mm^2$$

$$\text{Specimen 3:}HI = \frac{20}{129{,}03} = 0{,}155\ J/mm^2$$

Based on the calculation results, in the composition variation of 70% polyester: 30% vinylester with the addition of 12 g of corn husk powder, Specimen 1 and Specimen 3 produced an impact toughness value of 0.15500 J/mm², while Specimen 2 was 0.13950 J/mm². The difference in these values indicates a slight variation in the specimen's ability to absorb impact energy. However, in general, the 12 g variation produced the highest impact toughness value compared to the previous variation, thus indicating that the addition of 12 g of corn husk powder increased the composite's ability to absorb impact energy.

Impact Test Average Value

Table 2 average impact test values

Resin mix variations	Average ipack Value (J/)mm^2
Variation 70% polyester 30% vinylester Powder: 0 G	0.007 J/mm^2
Variation 70% polyester 30% vinylester Powder: 2 G	0.043 J/mm^2
Variation 70% polyester 30% vinylester Powder: 5 G	0.062 J/mm^2
Variation 70% polyester 30% vinylester Powder: 7 G	0.085 J/mm^2
Variation 70% polyester 30% vinylester Powder: 12 G	0.149 J/mm^2

Based on the average impact toughness value in each mixture variation, it can be seen that the addition of corn husk powder has an effect on the composite's ability to absorb impact energy. The variation without the addition of powder (0 g) produces the lowest impact toughness value, which is 0.007 J/mm². After adding 2 g of corn husk powder, the impact toughness value increases to 0.043 J/mm², then continues to increase in the 5 g variation of 0.062 J/mm², 7 g of 0.085 J/mm², until it reaches the highest value in the 12 g variation, which is 0.149 J/mm².

This increase in impact toughness indicates that the addition of corn husk powder can improve the composite's ability to absorb energy before fracturing. In this study, the 12 g mixture provided the best impact toughness compared to other mixtures.

Impact Test Average Graph

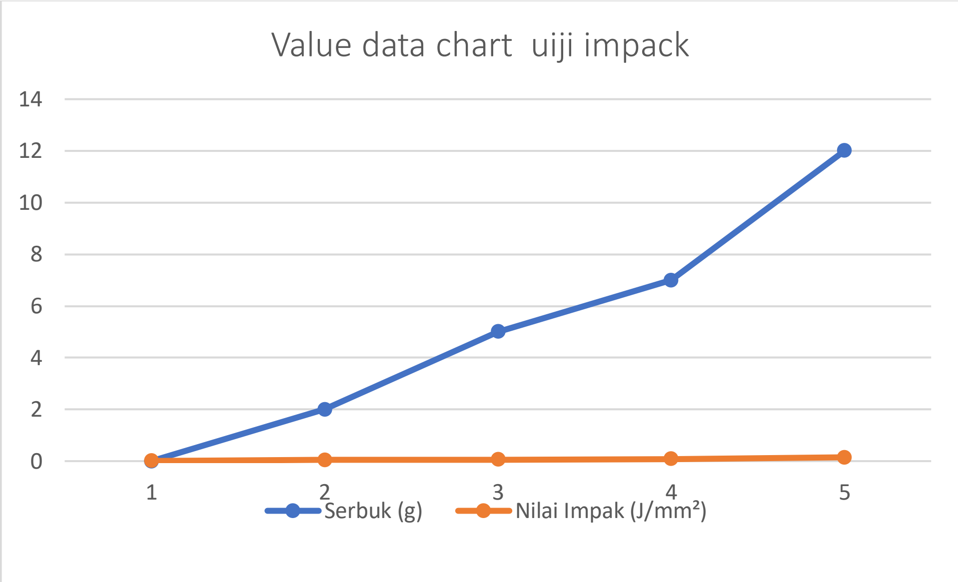

Fig 7 graph of impact test values

Based on the impact test value graph, it can be seen that the addition of powder to a mixture of 70% polyester and 30% vinylester resin causes the impact value to increase. In the variation without the addition of powder (0 g), the impact value obtained was 0.007 J/mm², which is the lowest value. After adding 2 g of powder, the impact value increased to 0.043 J/mm².

The impact value continued to increase with the addition of 5 g and 7 g of powder, amounting to 0.062 J/mm² and 0.085 J/mm², respectively. The highest impact value was obtained with the addition of 12 g of powder, which was 0.149 J/mm².

These results indicate that the more powder added to the resin mixture, the greater the material's ability to absorb impact energy. This indicates that the powder acts as a reinforcement, helping to absorb and distribute energy when the material is subjected to shock loads, thus improving its toughness.

Discussion of Impact Test Results

Impact testing in this study was conducted using the Charpy method according to the ASTM D6110 standard to determine the ability of composite materials to absorb energy due to shock loads. The impact value is obtained from the ratio of the energy absorbed by the specimen to the fracture cross-sectional area, so that the greater the impact value indicates a higher ability of the material to withstand impact loads. This is in accordance with the theoretical basis of the study which states that impact testing is used to measure the toughness of materials against sudden loading.

Based on the test results, the average impact value increased with the increasing amount of corn husk powder added to the mixture of 70% polyester resin and 30% vinylester. In the specimen without the addition of powder (0 g), the impact value was 0.007 J/mm², which was the lowest value. After the addition of 2 g of powder, the impact value increased to 0.043 J/mm². Furthermore, in the 5 g variation, the value was 0.062 J/mm², then increased to 0.085 J/mm² in the 7 g variation. The highest impact value was obtained in the 12 g variation, which was 0.149 J/mm².

The increase in impact value indicates that the addition of corn husk powder has a positive contribution to the toughness of the composite. Corn husk powder contains a high enough cellulose content so that it can function as a reinforcing material (reinforcement) in the polymer matrix. With the increase in the amount of powder, the distribution of reinforcing particles in the matrix becomes greater so that impact energy can be better absorbed and distributed before fracture occurs. This is in line with the theory in the literature review which explains that the cellulose content in corn husk powder has the potential to improve the mechanical properties of the composite through interfacial bonds between particles and the matrix.

Besides being influenced by cellulose content, the increased impact value also indicates that the polyester and vinylester resin mixture is able to bind the powder particles well. Good interfacial bonding allows impact stress to be distributed more evenly throughout the composite, thereby slowing the occurrence of cracks and fractures. This condition allows the specimen to absorb greater impact energy than the composite without powder addition.

When viewed from the test results graph, it can be seen that the impact value increases gradually with each addition of powder. There is no decrease in the impact value in all variations tested, so it can be concluded that up to the addition of 12 g, the amount of corn husk powder still has a positive effect on the toughness of the composite. The 12 g variation produces the highest impact value of 0.149 J/mm², so in the range of variations in this study it can be said to be the composition that provides the best impact resistance.

The results of this study also support previous research that found that natural reinforcement from corn husks can improve the mechanical properties of composites when properly distributed within the matrix. The research proposal also explains that composites with natural reinforcements have the potential to increase mechanical strength while producing more environmentally friendly materials.

Based on the impact test results, it can be concluded that the addition of corn husk powder has an effect on increasing the impact value of the composite with a matrix mixture of 70% polyester and 30% vinylester. The more corn husk powder added in the variation range of this study, the higher the composite's ability to absorb impact energy. The variation of adding 12 g of corn husk powder produced the highest impact value of 0.149 J/mm², so it can be stated as the best composition in the impact test of this study.

IV. CONCLUSION

Based on the results of research and discussion regarding the effect of adding corn husk powder on the impact test value of composites with a matrix mixture of 70% polyester resin and 30% vinylester using the Charpy method according to the ASTM D6110 standard, the following conclusions can be drawn:

1. The addition of corn husk powder significantly impacted the composite's impact toughness. The greater the amount of corn husk powder added to a mixture of 70% polyester resin and 30% vinylester, the higher the resulting impact strength. This indicates that corn husk powder enhances the composite's ability to absorb impact energy before fracturing.
2. The average impact test value increased with each variation of powder addition, namely 0.007 J/mm² in the 0 g variation, increasing to 0.043 J/mm² in the 2 g variation, 0.062 J/mm² in the 5 g variation, 0.085 J/mm² in the 7 g variation, and reaching the highest value of 0.149 J/mm² in the 12 g variation.
3. The 12-gram corn husk powder variation was the best composition in this study, producing the highest impact toughness value, at 0.149 J/mm². These results indicate that the composite with the 12-gram corn husk powder addition had the best impact energy absorption capacity compared to the other variations.
4. Based on the research results, corn husk powder has the potential to be used as a natural reinforcement in composites with a polyester and vinylester matrix mixture. Utilizing corn husk waste as a reinforcement not only improves the mechanical properties of the composite but also supports the development of more environmentally friendly and value-added materials from agricultural waste, in line with the research objectives.

The conclusion shows that the research objective to determine the effect of adding corn husk powder on the mechanical properties of the composite and to determine the best composition has been achieved, where the variation of 12 grams of corn husk powder produces the most optimal impact test performance.

Suggestion

Based on the results of the research that has been conducted, there are several suggestions that can be given for further research development, namely:

1. Further research is recommended to use a more diverse variety of corn husk powder additions so that the optimum composition that can produce better impact toughness values can be identified.
2. Before being used as a reinforcing material, corn husk powder should be pretreated (alkali treatment) to improve the bond between the powder and the resin matrix, thereby enhancing the mechanical properties

of the composite. This relates to the quality of the interfacial bond between the reinforcement and the matrix, which affects the characteristics of the composite.

3. Future research is expected to include not only impact testing but also other mechanical tests such as tensile, flexural, density, and water absorption to more fully understand the composite's characteristics. This aligns with the testing methods planned in the study.
4. In the composite manufacturing process, it is necessary to pay attention to the material mixing process and the curing process so that the resin and powder mixture is more homogeneous and minimizes the formation of voids, so that the test results are better and more consistent.
5. The use of corn husk powder as a composite reinforcing material is expected to continue to be developed because in addition to being able to improve the mechanical properties of the material, it also provides added value to agricultural waste and supports the development of environmentally friendly composite materials.
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REFERENCE

[1]. Akbar, RR, & Ningsih, TH (2024). The Effect of Variations in Powder Orientation and Drying Time on the Tensile Strength of Corn Husk Powder Composites. ***Journal of Mechanical Engineering***, 12(02), 1-6.

[2]. Nugraha, MDA, & Rasid, M. (2021). The Effect of Filler/Corn Husk Powder Structure on Polyester Resin Composite Bending Tests as a Ceiling Substitute. ***MACHINERY Journal of Applied Technology***, 2(2), 66-72.

[3]. Ramadhani, A., Prastowo, SHB, & Handayani, RD (2022). The effect of volume fraction on corn husk powder composite with polyester matrix on tensile strength as raw material for board industry. Mechanical Engineering Dynamics, 12(2), 129-136.

[4]. Syarief, A., & Amin, M. (2016). The effect of variations in the volume fraction of polyester-corn husk (Zea mays) composites on impact, bending, **and tensile strength. Scientific Journal of Mechanical Engineering Kinematics**, 1(1), 1-10.

[5]. Yusroni, AA, & NINGSIH, TH (2025). The Effect of Variations in Powder Composition and Post-Curing Temperature of Corn Husk Powder Composites on Hardness. ***Journal of Mechanical Engineering***, 9-14.

[6]. Rachmadi, W., & Ningsih, TH (2023). Optimization of NaOH Concentration and Soaking Time Treatment and Volume Fraction of Corn Husk Powder Composites for Taguchi Method Bending Tests. ***Journal of Manufacturing, Energy and Automotive Technology Innovation***, 2(1), 30-38.

[7]. Dari, TW, & Elvaswer, E. (2021). Sound Absorption Coefficient and Acoustic Impedance of Corn Husk Powder Panels Using the Tube Method. ***Unand Physics Journal***, 10(4), 473-478.

[8]. Bahrul Ilmi, F. (2025). Analysis of Tensile Strength and Macro Structure of LDPE and PVC Plastic Composites with Corn Husk Powder (Doctoral Dissertation, Muhammadiyah University of Ponorogo).

[9]. Tjahjanti, PH, Widodo, E., Mauliana, MI, & Darmawan, C. (2025). The Effect of Variations in the Composition of Corn Husk, Brass, and Aluminum Powder on the Hardness and Toughness of Non-Asbestos Brake Pad Composites. ***Jurnal Mesin Nusantara***, 8(2), 236-246

[10]. Yudo, E., Adha, A., Subhan, M., & Yuliyanto, Y. (2023). The Effect of Curing Time on Corn Husk Powder Composite Material as an Alternative for Car Bumpers. Manutech: ***Journal of Manufacturing Technology***, 15(02), 159-166.

[11]. Maulana, N. (2024). Strength Characterization of Corn Husk Powder Composite with Epoxy and PVAc Matrix on Physical and Mechanical Properties.

[12]. Akbar, F., Garjati, VN, & Luqyana, D. (2024, December). Extrusion Temperature Effects and Composition of Corn Skin Fiber Enhancer on Composite with Polypropylene (PP) Matrix for 3D Printing Filament Applications: Effect of Extrusion Temperature and Corn Skin Fiber Enhancer Composition on Composite with Polypropylene (PP) Matrix for 3D Printing Filament Applications. In Proceedings of the National Seminar on Mechanical Engineering (No. 1, pp. 357-363).

[13]. Ginting, A. (2015). Utilization of corn husk waste for modular products using twisting techniques. Dynamics of Crafts and Batik: Scientific Magazine, 32(1), 51-62.