Investigation of Hybrid Composite Properties Fabricated from Bagasse Fibers Reinforced with Al$_2$O$_3$ and SiC for Light Weight Applications

Yobsan Alemu Heyi$^1$, Gutata Kbeta Woyessa$^1$, Moera Gutu Jiru$^1$, Genet Bekele Alemu$^1$, Lamrot Kebede$^1$ and Meseret Tedesa$^2$

$^1$Department of Mechanical Design and Manufacturing Engineering, Adama Science and Technology University, Adama/ Ethiopia

$^2$Department of Mechanical Engineering, Dire Dawa University/Ethiopia

Abstract: The primary purpose of this study was to investigate mechanical properties of hybrid composite fabricated from bagasse fibers reinforced with Al$_2$O$_3$ and SiC for automotive purposes. The technique applied was referred to as the hand layup technique for the fabrication of composite. The experiment was conducted based on Taguchi L9 orthogonal array design. Data shows that the maximum tensile and flexural strength were 39.9 and 56.1 MPa respectively. Hardness and impact strength were 75.05 HV and 14 J respectively. The results indicated that the increasing Al$_2$O$_3$ and SiC wt.% increase the tensile strength and after bagasse fiber wt.% reaches optimum values the tensile strength decreased. Increasing Al$_2$O$_3$ wt.%, increases flexural strength and after bagasse fiber and SiC wt.% reaches optimum values, flexural strength was decreased. Increasing bagasse fiber wt.% increases the hardness of composite, and increasing Al$_2$O$_3$ and SiC wt.% increases the hardness, then after reaching optimum values the hardness was decreased. Increasing Al$_2$O$_3$ wt.% after the optimum values decrease the impact strength, and increasing bagasse fiber and SiC wt.% increase impact strength. The developed hybrid composite material was found to be improved the properties of composites after addition of Al$_2$O$_3$ and SiC powder as filler materials. This thesis recommends higher institutes, automotive companies, manufacturing companies, the construction sector and the government to conduct on how to utilize this abundant waste of bagasse fiber resource.

Keywords: Hybrid composite, Alumina, silicon carbide, Bagasse fiber, Hand lay-up.

1. INTRODUCTION

Composite materials are formed when two or more materials with different properties are combined. The properties of composite materials are superior to individual constituents. This has provided the main motivation for the research and development of composite materials, Kawade and Narve (2017). The composite properties may be the volume fraction sum of the properties of the constituents or the constituents may interact in a synergistic way resulting in improved or better properties, Verma (2012). Advantages of composites over their conventional counterparts are the ability to meet diverse design requirements with significant weight savings as well as the strength-to-weight ratio, Marimuthu and Chandramohan (2011). Natural fibers are well suited for making automobile parts and they can be used as wood substitutes in the construction sector were studied by Mochane et al. (2019). Bagasse fiber one of the natural fiber. Ethiopia currently produced an average of 893,270 tons of Ethiopian Sugarcane Bagasse (ESCB) annually. Though some portion of it is burnt to provide energy and some used as livestock feed, on average nearly 123,011 tons of surplus is to spare without any considerable application, Ayele et al. (2014).

Tadesse and Teshale, (2017) Provides a new area for research development in Ethiopia in which the bagasse can be converted to nitrocellulose and used for different applications including reinforcing in the polymer matrix that can address issues regarding bagasse. The hybridization of composites is one of the most efficient ways of enhancing the mechanical properties of composite material laminates. This new methodology is known as hybridization in which one or more fibers and filler particles are added into a composite, Wankhade et al. (2020). The natural fiber composites are manufactured by hand layup, spray lay-up, compression moulding, filament winding, and injection moulding methods, Srinivas et al. (2017). Alumina (Al$_2$O$_3$) has excellent hardness, dielectric property, wear resistance and chemical inertness properties, Sathiyanarasu et al. (2020). Silicon carbide is one of the best filler material that is being used in composite, Rajesh et al. (2014). The benefits of using SiC as reinforcement are improved stiffness, strength, thermal conductivity, wear resistance, fatigue resistance, reduced thermal expansion and
dimensional stability, Devendra and Rangaswamy (2012). Unsaturated Polyester resin with the brand name (TOPAZ-1110 Phthalic Anhydride) was used as matrix material.

In this study, fabrication of a hybrid composite reinforced with Al₂O₃/SiC, bagasse fibers and polyester were investigated. Sample preparation of a hybrid composite was performed based on the Taguchi method and hand layup technique. After preparation of samples, the mechanical properties and morphological analysis of the hybrid composite were performed based on ASTM standard method for each test.

Table 1 shows short summary of selected research works.

Research Gap

Several researches were done on experimental investigation of bagasse fibers reinforced polyester composite. From literature reviews there was no experimental investigation done on alumina and silicon carbide reinforced bagasse fibers and polyester matrix. In addition to this the improvement of mechanical and physical properties of composites with the addition of alumina and silicon carbide was not done.

2. MATERIALS AND METHODS

2.1. Materials

Alumina was the most commonly used filler material for polymer matrix composites due to its relatively high hardness, good oxidation resistance, and chemical stability. It was the most widely used filler materials. Alumina is ceramic materials used as the filler in the present study were purchased from Bangaiere Fine chem-Bangalore; India. Aluminum oxide is a chemical compound made from aluminum and oxygen with the chemical formula Al₂O₃. It was commonly called alumina. It has strong ionic interatomic bonding and commonly occurs in its crystalline polymorphic phase α-Al₂O₃ was investigated.

| No  | Authors                        | Matrix type     | Fiber type and fillers       | Method                      | Results                                                                 |
|-----|-------------------------------|-----------------|------------------------------|-----------------------------|------------------------------------------------------------------------|
| 1   | Athijayamani et al., (2016)   | vinyl ester     | Bagasse fiber               | hand lay-up technique       | Tensile and flexural strength were 63.2 and 62.6 MPa respectively      |
| 2   | Dhibar et al., (2018)         | Polyester       | Bagasse fiber               | hand lay-up technique       | Tensile strength was 12.73 Mpa, Compression strength was 2.315 MPa and water absorption was 27.66% |
| 3   | Tripathi and kumar, (2016)    | Epoxy           | Bagasse fiber               | hand lay-up technique       | Tensile and flexural strength were 58.36 and 59.6MPa respectively and hardness was 98 HRL |
| 4   | Ramlee et al., (2019)         | Phenolic        | OPEFB and bagasse fiber     | hand lay-up technique       | Tensile strength was 5.56 MPa, water absorption was 15.4%, density was 0.521g/cm³ and void content was 6.45% |
| 5   | Aynalem and Sirahbizu, (2021) | Polyester       | Flax fiber Al₂O₃            | hand lay-up technique       | Tensile strength was 37.06 MPa and impact strength was 85.5 KJ/m²      |
| 6   | Rajesh et al., (2014)         | Al₂O₃ and SiC   | Resin transfer moulding     |                             | Tensile, shear and biaxial strength were 61.23, 76.85and 53.52 MPa respectively. Impact strength was 4.38J and hardness value was 61.5 BHN. |
| 7   | Cao et al., (2016)            | Aliphatic polyester | Bagasse fiber             | Hot mounting Press          | Tensile was 26.77 MPa flexural strength was 50.86 Mpa and Impact strength was 11.27KJ/m² |
| 8   | Subramonian et al., (2016)    | Polypropylene   | Bagasse fiber               | Hot pressing.               | Tensile and flexural strength were 19.6 and 57 MPa respectively. hardness value was 104.7 HRC |
| 9   | Zakaria et al., (2020)        | Polyester       | Bagasse fiber               | Hot pressed                 | Tensile and flexural strength were 18 and 38 MPa respectively.         |
| 10  | Mathur et al., (2018)         | Epoxy           | Bagasse fiber               | hand lay-up technique       | Tensile and flexural strength were 22.085 and 36.62 MPa respectively. |
| 11  | Swain and Biswas, (2017)      | Epoxy           | Jute fiber Al₂O₃            | hand lay-up technique       | Hardness value was 37.9HV, tensile strength was 98 MPa and void content was 4.23% |
(Yohanes, 2019). This alumina with an average particle size of 70-230 meshes ASTM with a density of 3.94 g/cm³. The properties of alumina are explained in Table 2.

Table 2: Properties of Alumina (Aynalem and Sirahbizu, 2021)

| Description                        | Alumina  |
|-----------------------------------|----------|
| Density (g/cm³)                   | 3.95     |
| Tensile strength (MPa)            | 200 – 660|
| Young’s modulus (GPa)             | 380      |
| Bending strength (MPa)            | 200 – 600|
| Compressive strength (MPa)        | 1900 – 2000|
| Poisson’s ratio                   | 0.25 – 0.3|
| Coefficient of thermal expansion (°C) | 7.39×10⁻⁶ |

Silicon carbide powder is ceramic materials used as the filler in this it were purchased from Bangaiere Fine chem- Bangalore, India. These powders with an average particle size of 220 meshes ASTM with a density of 3.22 g/cm³. Silicon carbide exhibits favorable mechanical and chemical properties at high temperatures for many applications. The benefits of using SiC as reinforcement were improved stiffness, strength, thermal conductivity, wear resistance, fatigue resistance, reduced thermal expansion and dimensional stability was studied (Devendra and Rangaswamy, 2012). Silicon carbide was produced by combining silica sand and carbon in ancheson graphite electric resistance furnace at a high temperature. It was also prepared by the thermal decomposition of a polymer under an inert atmosphere at low temperatures. It has low density, high strength, high hardness, high thermal conductivity and also excellent thermal shock resistance. Silicon carbide was one of the best filler material that used in composite as investigated (Rajesh et al., 2014). Silicon carbide was selected due to these properties.

Bagasse fibers were selected it have lower thermal conductivity, low density, are environmentally friendly, renewable, cheap, have good stability, are no toxic, and high strength. For this study, fresh bagasse fibers were taken from the wonji sugar factory found in Adama town, Ethiopia. Bagasse fibers sieved with 2 mm opening diameter of sieve and lengths of bagasse fibers were from particle size to 10 mm. General Purpose Polyester Resin was an unsaturated polyester resin. Unsaturated Polyester resin with the brand name (TOPAZ-1110 Phthalic Anhydride) was used.

The characteristics of unsaturated polyester resin are given in Table 3.

Table 3: Characteristics of UPR (Aynalem and Sirahbizu, 2021)

| Description                        | UPR      |
|-----------------------------------|----------|
| Density (g/cm³)                   | 1.09-1.35|
| Tensile strength (MPa)            | 40       |
| Young’s modulus (GPa)             | 3.3      |
| Flexural strength (MPa)           | 45       |
| Poisson’s ratio                   | 0.44     |
| Maximum elongation (%)            | 1        |

Figure 1: Alkali treatments of bagasse fibers. (a) fresh Bagasse fiber (b) NaOH (c) distilled water (d) Soaked bagasse fibers (e) washed (f) cured (g) sieved (h) treated bagasse fibers.
The hardener (curing agent) used was with the brand name methyl ethyl ketone peroxide (MEKP) hardener. In this work, NaOH in flakes form was used for the treatment of bagasse fibers and it was purchased from local suppliers.

Unsaturated polyester resin and hardener were purchased from the local supplier World Fiber Glass and Water Proofing Engineering in Addis Ababa, Ethiopia. Sodium Hydroxide in flakes form was used for the treatment of bagasse fibers and it was purchased from local suppliers. NaOH treatment helps to remove lignin and hemicellulose from the surface of bagasse fibers and it has the advantages of activating the hydroxyl groups attached to cellulose and lignin.

\[
\text{Fiber-OH} + \text{NaOH} \rightarrow \text{Fiber-O}, \text{Na}^+ + \text{H}_2\text{O}
\]

For this study, the bagasse fibers were washed with clean water and dried in sunlight for 2 days. Then bagasse fibers were soaked to take a chemical treatment of bagasse fiber at a 3% concentration of NaOH. That means the bagasse fibers were soaked in 150 grams of sodium hydroxide mixed in five liters of distilled water at room temperature for 1hr. after that washed with clean water several times. Finally, the fibers were allowed to dry in bright sunlight for 3 days.

### 2.2. Methods

Based on L9 orthogonal design of experiment nine samples of samples were used based on ASTM standard of performed test.

#### 2.2.1. Design of Experiment

#### 2.2.2. Hand lay-up Technique

Composites were fabricated by hand lay-up technique. The composites with 10, 15, and 20 wt.% of bagasse fibers, alumina and silicon carbide with 6, 8, and 10 wt.% were used for composites fabrication. The polyester resin and its hardener are also used as matrix materials. The fabrication process was conducted at room temperature. The mold plates were HDF or hardboard with 300 mm x 300 mm. The mold plates were covered with mold release wax and the mixture was poured into the mold plate. Then level the mixture to have a uniform thickness. Finally closing the mold plates by applying for the upper plate and fixed the two plates with four C-clamp at four corners.

### Table 4: Process Parameters and Levels

| S. No | Factors             | Parameter’s designation | Level 1 | Level 2 | Level 3 |
|-------|---------------------|-------------------------|---------|---------|---------|
| 1     | Al$_2$O$_3$ content | A                       | 6       | 8       | 10      |
| 2     | Bagasse fiber content | B                      | 10      | 15      | 20      |
| 3     | Silicon carbide content | C                     | 6       | 8       | 10      |

### Table 5: Composition and Mass of each Sample of Composites

| Samples | Composition (wt.%) | Mass (g) |
|---------|--------------------|----------|
|         | Polyester | Al$_2$O$_3$ | SiC | Bagasse Fiber | Polyester | Al$_2$O$_3$ | SiC | Bagasse Fiber | Total |
| S1      | 78        | 6         | 6   | 10          | 353.80    | 27.20     | 27.20 | 45.36      | 453.60 |
| S2      | 71        | 6         | 8   | 15          | 328.73    | 27.78     | 37   | 69.45      | 463    |
| S3      | 64        | 6         | 10  | 20          | 301.80    | 28.30     | 47.16 | 94.32      | 471.60 |
| S4      | 74        | 8         | 8   | 10          | 345.78    | 37.40     | 37.40 | 46.73      | 467.28 |
| S5      | 67        | 8         | 10  | 15          | 319.10    | 38.10     | 47.62 | 71.44      | 476.28 |
| S6      | 66        | 8         | 6   | 20          | 306.50    | 37.15     | 27.86 | 92.88      | 464.40 |
| S7      | 70        | 10        | 10  | 10          | 337.40    | 48.20     | 48.20 | 48.20      | 482    |
| S8      | 69        | 10        | 6   | 15          | 323       | 46.80     | 28   | 70.20      | 486    |
| S9      | 62        | 10        | 8   | 20          | 296.80    | 47.88     | 38.30 | 95.76      | 478.80 |
| Total   |           |           |     |             | 2913      | 338.81    | 338.74 | 634.34     |        |
curing process takes 24 hr and nine experimental runs were finished in the same ways.

**Testing Methods**

Tensile strength test performed according to the ASTM D3039 on the computerized USM with a capacity of up to 2000KN. The specimen size tensile strength test was 300 mm × 30 mm × 5 mm. Tensile test was conducted in Ethiopian Conformity Assessment Enterprise (ECAE) in Addis Ababa, Ethiopia. Flexural Strength Test performed with ASTM D790-2010. Specimen’s dimension of 170 mm × 25 mm × 5 mm. this test was done in Defense University, of Engineering College in Bishoftu, Ethiopia by using Computer Controlled universal testing machine which has a capacity of up to 50 KN. For Vickers hardness the Specimen’s dimension of 30 mm × 30 mm × 5 mm. This test was performed in Adama Science and Technology University at Material Science Engineering laboratory, Adama, Ethiopia. Impact strength test of the composite was prepared as per ASTM D (prepared to a size of 55 ×13 mm × 5 mm. A notch has been prepared with a depth of 2.5 mm at 45° inclination. Impact strength test performed in Defence University of Engineering College, Bishoftu, Ethiopia.

**3. RESULTS AND DISCUSSION**

**3.1. Tensile Strength Test**

From experimental work result for the tensile strength of hybrid composite made from alumina and silicon carbide reinforced bagasse fiber and polyester material was obtained as follows. Figure 2 shows the tensile strength test results for all specimens. Specimen 1 has a tensile strength result of 35.3 MPa. This specimen was fabricated from 6 wt.% of alumina, 10 wt.% of bagasse fiber, and 6 wt.% of silicon carbide. Specimen 2 has a tensile strength result of 36.9 MPa. This specimen was fabricated from 6 wt.% of alumina, 15 wt.% of bagasse fiber, and 8 wt.% of silicon carbide. Specimen 3 has a tensile strength result of 33.5 MPa. This specimen was fabricated from 6 wt.% of alumina, 15 wt.% of bagasse fiber, and 8 wt.% of silicon carbide. Specimen 4 has a tensile strength of 36.6 MPa. This specimen was fabricated from 8 wt.% of alumina, 15 wt.% of bagasse fiber, and 10 wt.% of silicon carbide. Specimen 5 has a tensile strength of 35.6 MPa. This specimen was fabricated from 8 wt.% of alumina, 15 wt.% of bagasse fiber, and 10 wt.% of silicon carbide. Specimen 6 has a tensile strength of 29.5 MPa. Specimen 7 has a tensile strength of 37.2 MPa. This specimen was fabricated from 10 wt.% of alumina, 10 wt.% of bagasse fiber, and 10 wt.% of silicon carbide. Specimen 8 has a tensile strength of 35.1 MPa. This specimen was fabricated from 10 wt.% of alumina, 15 wt.% of bagasse fiber, and 6 wt.% of silicon carbide. Specimen 9 has a tensile strength of 39.9 MPa. This specimen was fabricated from 10 wt.% of alumina, 20 wt.% of bagasse fiber, and 8 wt.% of silicon carbide. From this, the specimen 9 shows maximum tensile strength.

Figure 2: Tensile strength test results.

This specimen was fabricated from 8 wt.% of alumina, 20 wt.% of bagasse fiber, and 6 wt. % of silicon carbide. Specimen 7 has a tensile strength of 37.2 MPa. This specimen was fabricated from 10 wt.% of alumina, 10 wt.% of bagasse fiber, and 10 wt.% of silicon carbide. Specimen 8 has a tensile strength of 35.1 MPa. This specimen was fabricated from 10 wt.% of alumina, 15 wt.% of bagasse fiber, and 6 wt.% of silicon carbide. Specimen 9 has a tensile strength of 39.9 MPa. This specimen was fabricated from 10 wt.% of alumina, 20 wt.% of bagasse fiber, and 6 wt.% of silicon carbide. From this, the specimen 9 shows maximum tensile strength. Stress versus strain diagram for tensile strength given as below.

Figure 3 shows the stress-strain diagram of the tensile strength test. Specimen 1 has 1.6% strain. Specimen 2 has 1.67% strain. Specimen 3 has 1.7% strain. Specimen 4 has 0.598% strain. Specimen 5 has 0.82% strain. Specimen 6 has 1% strain. Specimen 7 has 0.977% strain. Specimen 8 has 0.79% strain. Specimen 9 has 1.2% strain.

Figure 3: Stress vs strain for tensile test.
3.2. Flexural Strength Test

From experimental work result for the flexural strength of hybrid composite made from alumina and silicon carbide reinforced bagasse fiber and polyester material was obtained as below what? Figure 4 shows the flexural strength for all specimens. Specimens 1, 2, and 3 were 56.1, 54.79, and 28.33 MPa respectively. Specimens 4, 5, and 6 were check it and 33.2 MPa respectively. Specimens 7, 8, and 9 were 45.27, 42.5, and 46.04 MPa respectively. From this, specimen 1 shows maximum flexural strength.

3.3. Hardness Test

Hardness is the confrontation of a material to deform, indentation or scratching the basic goal of hardness is to enumerate the resistance of a material to plastic deformation. Load during hardness test is 10 kg (99.1 N) on two trials on the specimens. For each test, two reputations are followed and an average value was taken. Figure 5 shows the Comparisons of hardness for all specimens. Specimens 1, 2, and 3 were 49.75, 58.55, and 55.55 HV respectively. Specimens 4, 5, and 6 were 66.3, 56.85, and 62.4 HV respectively. Specimens 7, 8, and 9 were 33.95, 48.4, and 75.05 HV respectively. From all specimens, the specimen 9 shows maximum hardness value and

Table 6: Analysis of Variance for S/N Ratios of Tensile Strength

| Source         | DOF | Seq SS   | Adj SS   | Adj MS   | F     | P     |
|----------------|-----|----------|----------|----------|-------|-------|
| Alumina        | 2   | 0.09367  | 0.09367  | 0.04683  | 1.91  | 0.344 |
| Bagasse fiber  | 2   | 0.04631  | 0.04631  | 0.02316  | 0.94  | 0.514 |
| Silicon carbide| 2   | 0.15084  | 0.15084  | 0.07542  | 3.08  | 0.245 |
| Residual Error | 2   | 0.04902  | 0.04902  | 0.02451  |       |       |
| Total          | 8   | 0.33985  |          |          |       |       |

Table 7: Analysis of Variance for S/N Ratios of Flexural Strength

| Source         | DOF | Seq SS   | Adj SS   | Adj MS   | F     | P     |
|----------------|-----|----------|----------|----------|-------|-------|
| Alumina        | 2   | 0.00313  | 0.00313  | 0.001567 | 0.01  | 0.994 |
| Bagasse fiber  | 2   | 1.37602  | 1.37602  | 0.688009 | 2.51  | 0.285 |
| Silicon carbide| 2   | 0.45276  | 0.45276  | 0.226379 | 0.83  | 0.547 |
| Residual Error | 2   | 0.54733  | 0.54733  | 0.273664 |       |       |
| Total          | 8   | 2.37924  |          |          |       |       |
Figure 5 shows the hardness test values and deformation area of specimen 9 during the test.

### 3.4. Impact Strength Test

Figure 6 shows the impact test results. From this, the specimens 1, 5, and 9 have impact values 5J. Specimens 2 and 3 have impact values 14 and 6.5 J. Specimens 4 and 6 have impact values 8.5 and 10 J. Specimens 7 and 8 have impact values 5.5 and 7.5 J. Specimens 7 and 8 have impact values 5.5 and 7.5 J. The maximum impact strength was obtained at specimen 2 with 14J.

![Figure 6: Impact test result.](image)

**Table 8:** Analysis of Variance for S/N Ratios for Hardness

| Source            | DOF | Seq SS | Adj SS | Adj MS | F   | P   |
|-------------------|-----|--------|--------|--------|-----|-----|
| Alumina           | 2   | 0.3676 | 0.3676 | 0.1838 | 1.43| 0.412|
| Bagasse fiber     | 2   | 0.5893 | 0.5893 | 0.2947 | 2.29| 0.304|
| Silicon carbide   | 2   | 0.8286 | 0.8286 | 0.4143 | 3.22| 0.237|
| Residual Error    | 2   | 0.2571 | 0.2571 | 0.1285 |     |     |
| Total             | 8   | 2.0426 |        |        |     |     |

**Table 9:** Analysis of Variance for S/N Ratios for Impact Strength

| Source            | DOF | Seq SS | Adj SS | Adj MS | F   | P   |
|-------------------|-----|--------|--------|--------|-----|-----|
| Alumina           | 2   | 2.198  | 2.198  | 1.0992 | 0.20 | 0.835|
| Bagasse fiber     | 2   | 1.793  | 1.793  | 0.8963 | 0.16 | 0.861|
| Silicon carbide   | 2   | 4.231  | 4.231  | 2.1155 | 0.38 | 0.724|
| Residual Error    | 2   | 11.126 | 11.126 | 5.5630 |     |     |
| Total             | 8   | 19.348 |        |        |     |     |

![Figure 7: SEM Image (a) specimen 1 (b) specimen 9.](image)
Table 10: Comparison with the Previous Work

| No | Authors | Matrix Type | Fiber Type and Filler | Methods | Results |
|---|---------|-------------|----------------------|---------|---------|
| 1 | Dhibar et al., (2018) | Polyester | Bagasse fiber | Hand lay-up technique | Tensile and compression strength were 12.73 and 2.315 MPa respectively. water absorption was 27.66% |
| 2 | Ramlee et al., (2019) | Phenolic | OPEFB and bagasse fiber | Hand lay-up technique | Tensile strength was 5.56 MPa, water absorption was 15.4%, density was 0.521g/cm³ and void content was 6.45% |
| 3 | Cao et al., (2006) | Polyester | Bagasse fiber | Hot mounting Press | Tensile and flexural strength were 26.77 and 50.86 MPa respectively. Impact strength was 11.27KJ/m² |
| 4 | Subramonian et al., (2016) | Polypropylene | Bagasse fiber | Hot pressed | Tensile and flexural strength were 19.6 and 57 MPa respectively. Hardness was 104.7 HRC |
| 5 | Zakaria et al., (2020) | Polyester | Bagasse fiber | Hot pressed | Tensile and flexural strength were 18 and 38 MPa |
| 6 | Mathur et al., (2018) | Epoxy | Bagasse fiber | Hand lay-up technique | Tensile and flexural strength were 22.085 and 36.62 MPa respectively |
| 7 | Current work | Polyester | Bagasse fiber and Al₂O₃ and SiC | Hand lay-up technique | Tensile and flexural were 39.9 and 56.1 MPa respectively. Hardness was 75.05 HV. Impact was 14J. |

3.5. Morphology Analysis

Figure 7 shows SEM morphology used to check the bonding and filler material distribution in the matrix. SEM images were taken for the specimens to observe the microstructure. The images were taken for the hybrid composite made from alumina and silicon carbide reinforced with bagasse fiber and polyester and the images were analyzed in the scanning electron microscope. The Scanning electron microscope image shows the dispersion of the bagasse fiber and filler materials alumina and silicon carbide with the polyester matrix.

Comparison with the Previous Works

This study was compared with the previous work by different properties of composite materials were given in Table 10. From this filling alumina and silicon carbide in bagasse fiber was improved the properties of hybrid composite.

4. CONCLUSION

The following conclusions can be made based on the study carried out:

The results indicated that the increased Al₂O₃ wt.% tensile strength was increased. It decreased after adding more than 8 wt.% of SiC and 10 wt.% of bagasse fiber. When Al₂O₃ wt.% was increased, its flexural strength was also increased. While it was decreased when more than 10 wt.% of bagasse fiber, and 8 wt.% of SiC were added. As wt.% bagasse fiber of increased the hardness of composite was increased. More than 8 wt.% of Al₂O₃ and the SiC hardness of the composites were decreased. More than 6 wt.% of Al₂O₃, 15 wt.% of bagasse fiber and 8 wt.% of SiC impact strength of composite was decreased.

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