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Experimental Analysis of Mechanical Characteristics of Aluminium Matrix Hybrid Composite Using Seashell Powder And Coconut Shell Powder

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Abstract

The purpose of this study is to investigate the manufacturing processes and mechanical properties of composites made of marine shell powder, coconut shell powder, and aluminium. In our project, the MMC was made of aluminium with seashell powder and aluminium with coconut shell powder. A stir casting process fabricated the Composite. The composition of aluminium, seashell powder and coconut shell powder varies. According to the criteria established by the American Society for Testing and Materials (ASTM), a morphological and mechanical behaviour examination of the material was carried out. The microstructure exhibits a relatively uniform dispersion of reinforcement particles inside the matrix alloy, with a reduced number of visible remaining pores. The maximum tensile strength of composite material is 176.34 kN in Al- reinforced 10% seashell powder; the composite materials have a higher yield strength of 146.38 kN in Al + 5% coconut shell powder. The matrix dislocation density and elastic modulus fluctuations are both increased, resulting in 205.46 kN at Al + 5% coconut shell powder shows an increase in the flexural strength of the material. As a consequence of the improved grain refinement and decreased porosity, the impact strength of the material increased by 61.60 kN at Al + 10 % Seashell powder. Max Hardness is achieved at Al + 5% coconut shell powder is 65.75 HBW. Corrosion test proves that material is withstanding upto 16 hours in salt water without white rust fornmation.

Keywords: Aluminium, Metal matrix composite, Mechanical testing, seashell powder, and coconut shell powder

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INTRODUCTION

In recent years, MMCs have become a prominent material family for use in various industries, including construction, wear, thermal, transportation, and electricity [1, 2]. This is because their strength-to-cost and strength-to-weight ratios are much higher than those of comparable monolithic commercial alloys [3, 4]. Due to their excellent wear resistance, low thermal expansion, and low coefficient of expansion, Al hybrids are being evaluated as a new class of sophisticated materials [5]. In metal matrix composites, the reinforcement is responsible for bearing the bulk of the applied load. In contrast, the matrix holds the reinforcements together, transfers external loads, and distributes those loads uniformly across the reinforcements. Because of the incorporation of micro-sized reinforcing powders into the matrix, MMCs are among the most promising substances for increasing mechanical qualities like yield strength, Young's modulus, ultimate tensile strength, and hardness [6]. The al alloy hybrids are created by mixing the particles in a molten alloy. The composites were stronger, stiff, tougher, and more abrasion and wear vulnerable [7, 8]. MMC materials offer higher thermal conductivity, lower density, relatively low thermal expansion, higher thermal diffusivity, and enhanced corrosion resistance are only some of the advantages over cast iron based on extensive research on their attributes [9, 10]. Casting the resultant Metal matrix composite is accomplished after the ceramic particles have been melted into a metallic matrix in a liquid state process[11, 12]. With mechanical stirring, ceramic particles can be incorporated into a matrix of molten metal during the Stir Casting process, a liquid state technique for fabricating composite materials. Traditional casting techniques are then used to mould the liquid composite material [13]. Numerous fabrication methods are now used to create MMC materials depending on the type of reinforcement utilized, including liquid metal penetration, squeeze casting, stir casting, and spray co-deposition. [14, 15].

In this paper, the aluminium-based MMCs are manufactured by using the stir casting process with seashell powder and coconut shell powder. The mechanical attributes of fabricated aluminum MMC were investigated by experimental investigation, and the corrosion properties were also found.

MATERIALS AND METHODOLOGY

Two different particles, seashell powder and coconut shell powder (shown in Figure 1a, Figure 1b) were used as reinforcement in the pure aluminium matrix.

Figure 1. (a) Seashell Powder, (b)Coconut Shell Powder.

A seashell is generally made of calcium carbonate or chitin and is the exterior of an invertebrate (an organism without a backbone).

- Clean the mussel shells by washing them and discarding any leftover debris.
- Bake the shells in a preheated oven for an hour at 200 degrees. The shells will become more fragile as a result.
- Get a powder out of the shells by grinding them.
- Sieve the ground shells to procure a powder with 40 micron particle size.

The excellent thermal conductivity, moderate thermal expansion, and high strength offer this substance exceptional thermal shock resistance.

Figure 2. Pure Aluminium Rod.

Pure aluminium metal is used in solid metal form. It is melted ad mixed with ceramic which is in powder form. The aluminium rod is shown in Figure 2. For the spreading of particles into a molten aluminum alloy, an electric heating furnace with a stirring mechanism has been used. Seashell powder and coconut shell powder were preheated at 300°C in the air to improve their surface reactivity to remove moisture. The compositions of different specimens are listed in Table.1. The particles were heated and poured into the vortex's melting mass. Next, the molten material was poured into a graphite cylinder mould with a predetermined internal diameter. Heat treatment was used on the cast composites to lessen their porosity and to disperse the particles inside the Al matrix better.

Table 1. Specimens Compositions with Varying wt% of Composites.

Sample number	**Sample 1**	**Sample 2**	**Sample 3**	**Sample 4**
Com position	Al + Seashell powder 10%	Al + Coconut shell powder 10%	Al + Seashell powder 5%	Al + Coconut shell powder 5%

RESULTS AND DISCUSSION

Tensile Test

The material's monotonic characteristics and stress-strain curves were gathered by tensile testing is shown in Figure 3. All experimental observations were carried out under the ASTM Standard B 557. The experiment was done outside, in natural conditions.

Figure 3. Electrical Resistance Furnaces with a Stirring Assembly.

The experimental results show that the AL with 10% Seashell powder has higher tensile strength than other specimens. The tensile test results for the four samples are illustrated in Figure 4.

From the Experimental results, aluminium reinforcement with 10 % Seashell powder Tensile Strength is 176.34 KN, aluminium reinforcement with 10 % coconut shell powder Tensile Strength is 135.86 KN, aluminium reinforcement with 5 % Seashell powder Tensile Strength is 141.33 KN, aluminium reinforcement with 5% coconut shell powder Tensile Strength is 163.42 KN, is shown in Table 2.

Table 2. Tensile Strength of Al with Various wt% of Sea Shell powder and Coconut Shell Powder Composites.

S.N.	**Sample name**	**Tensile strength**
1	Al + 10 % Seashell powder	176.34 KN
2	Al + 10 % coconut shell powder	135.86 KN
3	Al + 5% Seashell powder	141.33 KN
4	Al + 5% coconut shell powder	163.42 KN

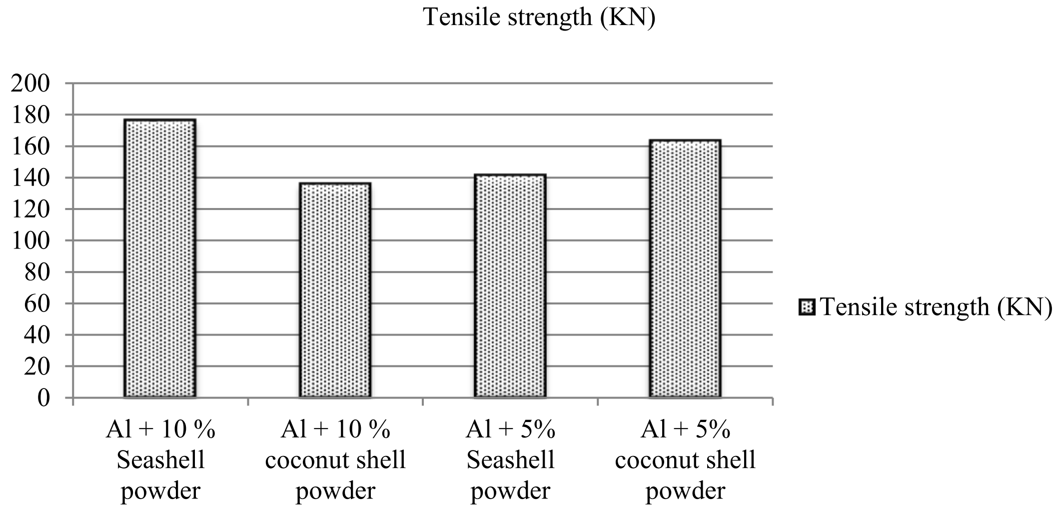

Figure 4. Tensile Strength of Al – Sea Shell Powder and Coconut shell Powder Composites.

The yield strength test was conducted in UTM as per the IS 11500, and tensile was conducted from ASTM E8. From the Experimental results, aluminium reinforcement with 5 % coconut shell powder has a higher yield value than other specimens. The results are illustrated in Table.3.

Table 3. Yield Strength of Al – Coconut Shell Powder and Sea Shell Powder Composites.

S.N.	Sample name	Yield strength
1	Al + 10 % Seashell powder	139.46 KN
2	Al + 10 % coconut shell powder	109.85 KN
3	Al + 5% Seashell powder	131.42 KN
4	Al + 5% coconut shell powder	146.38 KN

From the Experimental results shown in Figure 5, aluminium reinforcement with 10 % Seashell powder Yield strength was 139.46 KN, aluminium reinforcement with 10 % coconut shell powder Yield strength is 109.85 KN, aluminium reinforcement with 5 % Seashell powder Yield strength is 131.42KN, aluminium reinforcement with 5% coconut shell powder Yield strength is 146.38 KN.

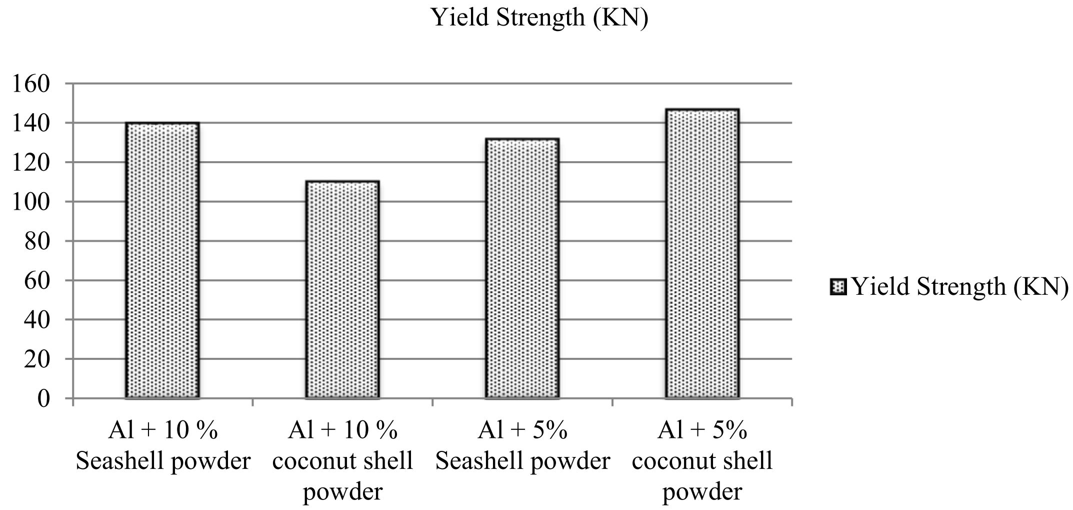

Figure 5. Yield Strength of Al with Different wt% of Coconut Shell and Sea Shell Powder Composites.

Flexural Test

The testing procedure typically entails using a designated test fixture mounted on universal testing equipment. The test outcomes are sensitive to the test's setup, conditioning, and administration. Values for the elastic modulus during bending flexural strain and stress, as well as the flexural stress-strain response of such sample obtained via a three-point bending flexural test. Flexural characteristics of aluminium MMC hybrids have been measured under the requirements of ASTM D790. An easy sample preparation and testing process is the primary benefit of the three-point flexural test. A universal testing machine gradually loads specimens in tension while recording measured values. Maximum load sustained before failure and various failure modes have been investigated to establish the ultimate material strength.

Table.4. Flexural Strength of Al With Various Composition of Sea Shell and Coconut Shell Powder Composites.

S.N.	Sample name	Flexural strength
1	Al + 10 % Seashell powder	194.87 KN
2	Al + 10 % coconut shell powder	195.15 KN
3	Al + 5% Seashell powder	194.59 KN
4	Al + 5% coconut shell powder	205.46 KN

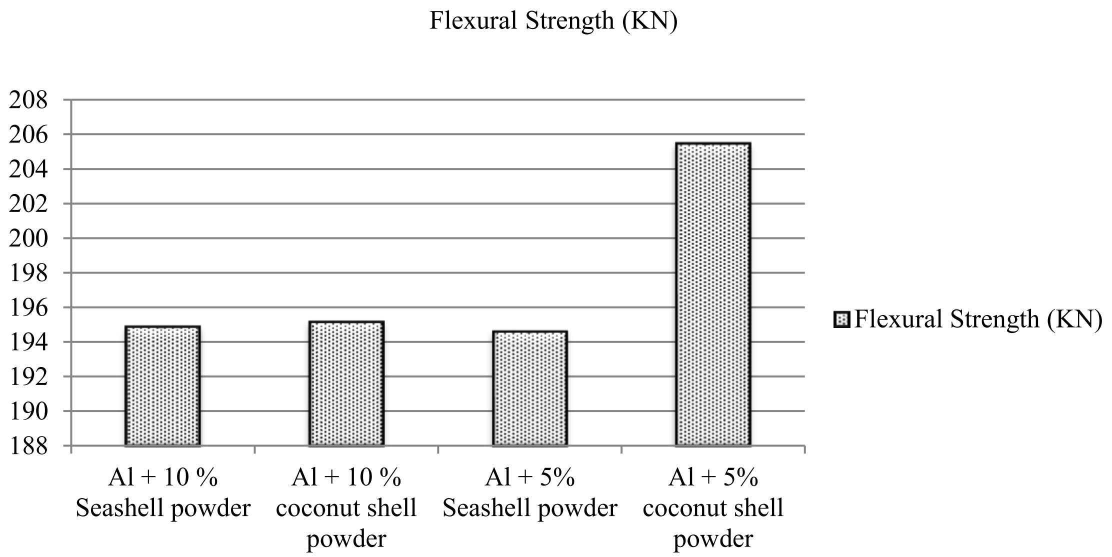

Figure 6. Flexural Strength of Al Reinforced Sea shell and Coconut Shell Powder Composites.

The experimental results show that the AL with 5% coconut shell powder has higher flexural strength than other specimens. The flexural test results for the four models are shown in Table.4. From the Experimental results, aluminium reinforcement with 10 % Seashell powder Flexural Strength is 194.87 KN, aluminium reinforcement with 10 % coconut shell powder Flexural Strength is 195.15 KN, aluminium reinforcement with 5 % Seashell powder Flexural Strength is 194.59 KN, aluminium reinforcement with 5% coconut shell powder Flexural Strength is 205.46 KN are shown in the Figure 6.

Impact Test

The impact test aims to ascertain how a material responds to rapid and intense stress. The impact test measures the material's toughness under dynamic load and its resistance to shock loads. Non-impact testing methods are based on the premise that a material can take in only so much energy before cracking or breaking. From the experimental results, the AL with 10% coconut shell powder had higher impact strength than other specimens. The impact test results for the four samples are illustrated in Table.5.

Table 5. Impact Strength of Al Reinforced Sea shell and Coconut Shell Powder Composites.

S.N.	Sample name	Impact strength
1	Al + 10 % Seashell powder	61.60 KN
2	Al + 10 % coconut shell powder	64.75 KN
3	Al + 5% Seashell powder	37.21 KN
4	Al + 5% coconut shell powder	42.35 KN

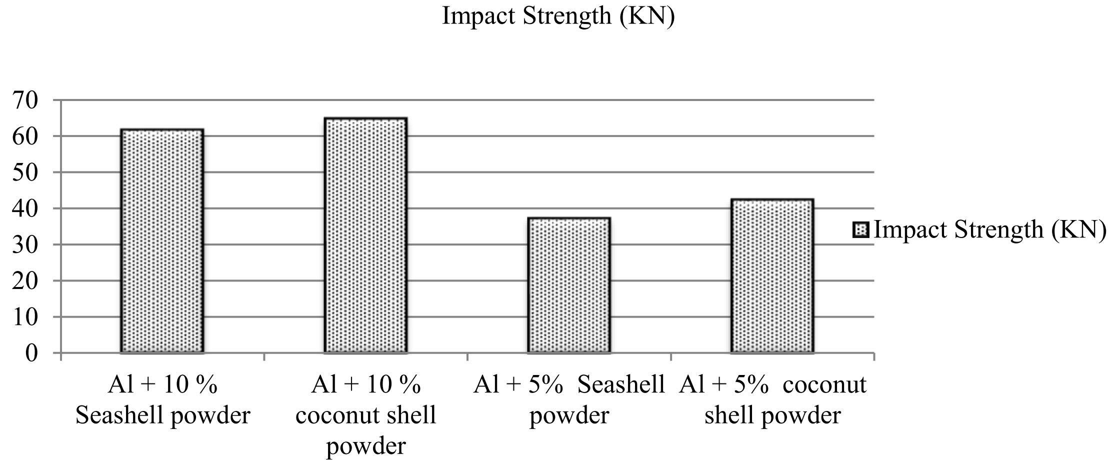

Figure 7. Impact Strength of Various Compositions of Seashell Powder and Coconut Shell Powder Reinforced Aluminium Composites.

From the Experimental results, aluminium reinforcement with 10 % Seashell powder Impact Strength is 61.60 KN, aluminium reinforcement with 10 % coconut shell powder Impact Strength is 64.75 KN, aluminium reinforcement with 5 % Seashell powder Impact Strength is 37.21 KN, aluminium reinforcement with 5% coconut shell powder Impact Strength is 42.35 KN is shown in the Figure 7.

Corrosion Test

The chamber contains a temperature range of 32.5°C to 34.7°C with an air pressure of 16psi. The specimen was cleaned in running water gently before loading. The specimen was located continuously for 24 hours in the 7 PH salt solution. 5.1 to 5.2% NaCl solution was used for the corrosion test. Figure 8 shows the corrosion Test Specimens. The test result is monitored periodically. The test results are illustrated in Table 6 as per the ASTM B117-11. In the corrosion test, the specimens start to corrode white rust at 24 hours. From the corrosion Test results, At 8 & 16 Hours time period there is no corrosion in specimen, When time period reaches 24 Hours, White rust appeared on the specimen.

Figure 8. Corrosion Test Specimens.

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Table 6. Specimen Properties of Corrosion Test at Different Periods.

S.N.	Time	Observation
1	At 8 Hours	No Corrosion
2	At 16 Hours	No Corrosion
3	At 24 Hours	White rust appeared

Hardness Test

The specimens' hardness varies with the addition of seashell powder and coconut shell powder. The addition of 5 % of any of the two constitutions has similar hardness values. At the same time, adding 10 % of seashell powder also has the same hardness value, and the 10 % addition of coconut shell powder reduces the hardness value to lower hardness. This is due to the volume fraction reduction in that particular specimen.

Table 7. Hardness of Al – Seashell and Coconut Shell Powder Reinforcement.

S.N.	Specimen name	Hardness
1	Al + 10 % Seashell powder	65.50 HBW
2	Al + 10 % coconut shell powder	39.50 HBW
3	Al + 5% Seashell powder	65.50 HBW
4	Al + 5% coconut shell powder	65.75 HBW

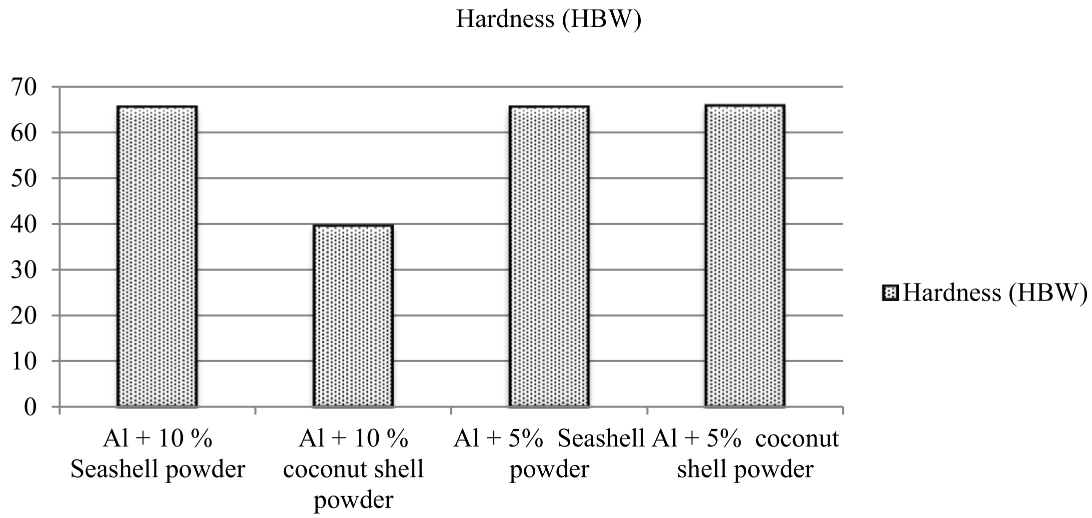

Figure 9. Hardness of Al- Sea Shell Powder and Coconut Shell Powder Reinforced Composites.

From the Experimental results, aluminium reinforcement with 10 % Seashell powder Hardness is 65.50 HBW, aluminium reinforcement with 10 % coconut shell powder Hardness is 39.50 HBW, aluminium reinforcement with 5 % Seashell powder Hardness is 65.50 HBW, aluminium reinforcement with 5% coconut shell powder Hardness is 65.75 HBW is shown in Table 7 and consecutively graph drawn is shown in Figure 9.

CONCLUSION

This study is the key to knowing the ability of the tested composition in aluminium metal matrix composite. The presence of 10 % of seashell powder with aluminium improves tensile strength, but the addition of coconut shell powder makes the tensile property lower when compared to other specimens. Moreover, adding 5 % in coconut shell powder improves the tensile properties much nearer to seashell powder with aluminium. Yield strength is high in the composition of 5 % coconut shell powder with Aluminium compared with other specimens. The impact strength of the specimen is increased in addition to a 10 % composition of Seashell powder and 10 % coconut shell powder. Further, adding 5 % of seashell powder and coconut shell powder decreases the impact strength. On the other hand, the flexural strength of the aluminium metal matrix composite has improved in aluminium reinforcement with coconut shell powder, both at 10% and 5 %. In addition, the higher hardness value appeared in aluminium with 5% coconut shell powder.

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