Volume 8, Issue 9, pp. 52-59, 2024.
International Journal of Scientific Engineering and Science
ISSN (Online): 2456-7361

Comparative Analysis of Mechanical Properties in Aluminum Casts Using Synthetic and Natural Moulding Sands

Amiebenomo Sebastian Oaihimire
Department of Mechanical Engineering, Ambrose Alli University, Ekpoma, Edo State, Nigeria
Email address: sebastianamiebenomo@gmail.com

Abstract— *This study was carried out to investigate the effect of synthetic and natural moulding sand on aluminum cast. In pursuit of the overall aim of this study, a sand characterization test which entails the determination of moisture content, permeability, porosity and sieve analysis of the sand were done on the synthetic and natural moulding sand. The results of the moisture content test show that moisture absorption is higher in natuaral sand (37.25%) when compared to synthetic sand (27.17%); the result of the permeability test reveals that the gas emission rate is higher for natural sand (7.63ml/min) when compared to synthetic sand (6.17ml/min); the result of the porosity reveals that the pore spaces for natural sand (44.4%) is higher when compared to synthetic sand (42.8%); the result of the sieve analysis reveals that the grain fineness number of synthetic sand was found to be (28.5) when compared to natural sand value of (39.18). This contributes to the surface quality of the aluminum alloy. In furtherance of the investigation, a number of mechanical tests were carried on the aluminium cast samples obtained from synthetic and natural sand moulding respectively. The hardness test result reveal that aluminium cast from natural sand (77.35HRC) show a better hardness quality when compared to synthetic sand (73.35HRC); the compression test result show that the aluminium cast from synthetic sand fracture at a value 23.30mm, while that of natural sand cast sample fracture at a value 0.61mm under the same apply load; tensile test results reveals that aluminium cast from natural sand had a higher tensile strength at maximum load of (27.8KN) at breaking point, when compare to the aluminium cast of synthetic sand having a maximum load of (18.7KN) at breaking point. Finally, a microstructural test was carried out and the results of the optical image obtained show that aluminium cast from synthetic sand had better surface layer when compared with that of natural sand aluminium cast on the basis of a closely packed structure with less dark pores. Arising from these study, it can be deduced that aluminium cast from natural sand is suitable for applications where hardness and tensile strength are important, while aluminium from synthetic sand is suitable for applications where compression properties are crucial.*

Keywords— *Synthetic sand, Natural sand, Microstructural test, Mechanical test, Aluminium cast.*

I. INTRODUCTION

Casting is a metal casting process whereby sand is used as the mould material. It is relatively cheap and sufficiently refractory for steel foundry use. Khan (2005) identifies sand casting as the most widely used casting method in the construction industry worldwide. The high utilization of sand casting, is due to the particle size of sand which is packed finely and tightly together providing an excellent surface for the mould (Aweda and Jimoh 2009). A large variety of moulding materials is used in foundries for manufacturing of moulds and cores. Moulding sand is classified as either natural or synthetic sand. The natural moulding sand is taken from river bed or dug out from pits, and it contains the binder which is used in the as-received condition with water added. It contains from 5-20% binder and about 5-8% water may be added. The synthetic moulding sand on the other hand, is made in the foundry by mixing a relatively clay free sand with a selected clay binder like bentonite. Water and other additives may be added as may be required.

Aluminium alloys are widely used in various industries, including automotive, aerospace, and construction, due to their favourable properties such as light weight, high strength, and corrosion resistance (Davis, 1993). Among these alloys, Al-Si7Mg is particularly notable for its excellent casting characteristics, making it a preferred choice for complex components (Campbell, 2003). The sand casting process, a versatile and cost-effective method for producing aluminium parts, involves pouring molten metal into a sand mould to create a desired shape (ASM International, 2008). The quality of sand used in the casting mould plays a crucial role in determining the final properties of the cast aluminium. Green sand and natural sand are two commonly used types of sand moulds in the casting process. Green sand, a mixture of silica sand, clay, and water, offers good moldability and reusability, making it a popular choice in the foundry industry (Beardsley & Ormerod, 2017). On the other hand, natural sand, composed primarily of silica, provides better surface finish and dimensional accuracy but is less environmentally friendly due to its lower reusability (Brown, 2000). The choice of moulding materials is based on their processing properties. The properties that are generally required in moulding materials are permeability, refractoriness, Sieve analysis moisture content, and green shear strength. (Bala and Khan 2013). The growing desire for increase in local content in the production industries and the quest for rapid industrialization in Nigeria necessitates that more and more local materials be sought to replace imported materials. Previous studies have indicated that the type of sand used in the mould can significantly affect the thermal conductivity, cooling rate, and ultimately the microstructure and mechanical properties of the cast metal (Murphy & Siebert, 1998; Stefanescu, 2015). However, detailed comparative studies focusing specifically on the effects of green and natural sand on aluminium casting are limited. Understanding these effects is

Volume 8, Issue 9, pp. 52-59, 2024.
ISSN (Online): 2456-7361

essential for optimizing the casting process to achieve superior material properties and performance in industrial applications

II. Literature Review

Aluminium alloys are pivotal in various engineering applications due to their unique combination of properties, including low density, high strength-to-weight ratio, excellent corrosion resistance, and good thermal and electrical conductivity. These characteristics make aluminium alloys ideal for the automotive, aerospace, and construction industries (Davis, 1993). The Al-Si7Mg alloy, in particular, is renowned for its excellent casting properties, including good fluidity, low shrinkage, and high mechanical strength (Campbell, 2003). These attributes make Al-Si7Mg a preferred material for complex and high-performance castings. Sand casting is one of the oldest and most widely used metal casting processes, primarily due to its versatility and cost-effectiveness. The process involves creating a mould from a sand mixture, pouring molten metal into the mould, and allowing it to solidify. After drying, the mold is removed to reveal the casting (ASM International, 2008). The quality of the final casting significantly depends on the type of sand used in the mould. Green sand and natural sand are the two types of sand used in the construction industry. Green sand is a mixture of silica sand, bentonite clay, and water, providing good moldability and reusability (Beardsley & Ormerod, 2017). Natural sand, composed mainly of silica, offers a better surface finish and dimensional accuracy but is less environmentally friendly due to its lower reusability (Brown, 2000).

Types of Molding Sands

Greensand is widely used in the construction industry because of its simplicity, reusability and affordability. The mixture of silica sand, clay, and water creates a mould that is easy to shape and can withstand the high temperatures of molten metal (Brown, 2000). The presence of clay in green sand enhances its binding properties, allowing for better mold strength and durability (Beardsley & Ormerod, 2017). However, the moisture content in green sand can sometimes lead to defects such as gas porosity and poor surface finish (Murphy & Siebert, 1998).

Natural Sand

Natural sand, typically composed of pure silica, is preferred for applications requiring high surface finish and dimensional accuracy. Unlike green sand, natural sand does not contain clay or moisture, reducing the risk of gas-related defects in the final casting (Brown, 2000). However, the lack of binding agents in natural sand can make the mould more fragile and less reusable, leading to higher costs and environmental concerns (ASM International, 2008).

Sand Effects on Casting

Previous research has extensively explored the impact of different moulding sands on the quality of cast metal. Murphy and Siebert (1998) highlighted that the type of sand affects the thermal conductivity and cooling rate of the mould, which in turn influences the microstructure and mechanical properties of the casting. Stefanescu (2015) emphasized the importance of cooling rates, noting that faster cooling typically results in finer microstructures and improved mechanical properties. Studies comparing green sand and natural sand have mixed results. Green sand moulds often produce castings with higher porosity and rougher surface finishes due to the presence of moisture and organic binders (Beardsley & Ormerod, 2017). On the other hand, natural sand moulds provide better surface finish and lower porosity but at a higher cost and environmental impact (Brown, 2000). Khurmi and Gupta (2005) investigated the mechanical properties of aluminum castings produced using different moulding sands. Their study revealed that castings from natural sand moulds exhibited higher tensile strength and hardness compared to those from green sand moulds. This was attributed to the finer grain structure and reduced porosity in natural sand castings.

Microstructural Analysis

The microstructure of a casting plays a critical role in determining its mechanical properties. Factors such as grain size, shape, and distribution, as well as the presence of defects like porosity and inclusions, significantly affect the strength, hardness, and ductility of the material (Campbell, 2015). The type of sand used in the mould influences the thermal gradient during solidification, which in turn affects the microstructural development of the casting. Microstructural analysis typically involves optical microscopy and scanning electron microscopy (SEM) to observe and characterize the grain structure, porosity, and other defects. Murphy and Siebert (1998) demonstrated that faster cooling rates, often associated with natural sand moulds, lead to finer grain structures and fewer defects compared to slower cooling rates typical of green sand moulds.

Mechanical Properties

Mechanical properties such as tensile strength, hardness, and impact toughness are crucial for evaluating the performance of aluminum castings. These properties are directly influenced by the microstructure of the casting. For instance, finer grain structures generally result in higher tensile strength and hardness due to the Hall-Petch effect, which states that smaller grains inhibit dislocation movement, thereby increasing strength (Khurmi & Gupta, 2005). Green sand castings often exhibit lower mechanical properties due to the presence of defects like porosity and coarse grain structures. In contrast, natural sand castings, with their finer microstructures and lower porosity, typically demonstrate superior mechanical properties (Brown, 2000). However, the higher cost and environmental impact of natural sand molds pose challenges for widespread adoption.

Environmental and Economic Considerations

The choice of moulding sand also has significant environmental and economic implications. Green sand moulds are more environmentally friendly due to their high reusability, reducing waste and lowering production costs (Beardsley & Ormerod, 2017). However, the energy and resources required to manage and regenerate green sand can offset some of these benefits. Natural sand moulds, while providing better casting quality, are less sustainable due to their lower reusability. The extraction and processing of natural sand also contribute to

International Journal of Scientific Engineering and Science
Volume 8, Issue 9, pp. 52-59, 2024. ISSN (Online): 2456-7361

environmental degradation and increased costs (ASM International, 2008). Therefore, balancing the trade-offs between quality, cost, and environmental impact is crucial for the foundry industry.

Despite the extensive research on sand casting, there remains a gap in detailed comparative studies specifically focusing on the effects of green sand and natural sand on the microstructure and mechanical properties of aluminium alloys, particularly Al-Si7Mg. Most studies have either concentrated on other alloys or have not provided a comprehensive analysis of both microstructural and mechanical properties. This study aims to fill this gap by providing empirical data and a thorough analysis of the effects of these two types of moulding sands on aluminium castings.

III. Materials and Methods

Materials

Aluminum Alloy: Al-Si7Mg alloy was used with the following composition:

TABLE 1. Aluminium alloy composition

Aluminium Alloy (Al-Si7Mg)	**Aluminum (Al)**	**Silicon (Si)**	**Magnesium (Mg)**	**Iron (Fe)**	**Manganese (Mn)**	**Zinc (Zn)**	**Titanium (Ti)**
Percentage composition	92.15%	7.0%	0.4%	0.15%	0.05%	0.1%	0.15%

Moulding Sands
Synthetic Sand: Silica sand (90%), bentonite (8%), water (2%).
Natural Sand: Pure silica sand used for this research was obtained from the Uhomorah beach sand.

Electric furnace, crucible pot, mould, pattern, rammer, compression machine, tensile machine, hardness machine, sieve analyzer, digital measuring machine, and microstructural test machine.

Methods

Preparation of Moulds

Synthetic Sand Moulds: Mixed silica sand with bentonite and water, packed around a pattern, compacted. Natural Sand Moulds: Filled mould box with silica sand, compacted

Aluminium Casting Process

Melting: Al-Si7Mg melted at 750°C, degassed with argon.
Pouring: Smooth, continuous pour into moulds.
Cooling: Monitored with thermocouples, recorded cooling curves.
Mould Removal: Moulds broken to retrieve castings, cleaned.

Tests entail chemical analysis of natural sand obtained at Uhomorah beach, sieve analysis, moisture content, refractoriness and permeability tests.

Chemical Analysis Test: The chemical analysis of the sample of natural and synthetic sand was determined using X-ray florescence (XRF) spectroscopy technique.

Sieve Analysis Test: The sieve analysis test, was done on samples of natural and green sand to determine the distribution of aggregate particles by size within a the given samples.

Permeability Test: Permeability test was carried out on each samples of natural and synthetic sand to determine how well the sand can vent. This was evaluated using air permeability metre.

Refractoriness: The sand samples for the refractory test was mixed with the desired quantities of binders and water. The mixture was moulded into cone shape and then dried in oven at 1100degree centigrade

Moisture Content Test: The moisture content of the samples of natural and synthetic sand were determine by drying a weighed amount of each sample to a temperature up to 100°C in a oven for about one hour. Maintaining proper moisture levels when producing sand moulds guarantees bonding takes place between materials to create the right cohesiveness, surface finish, flowability and chemical inertness.

Mechanical test sample

The various aluminum test samples used for this study are outlined below:

Tensile Test: the sample for the tensile test is cylindrical with dimension of 1.6cm thickness and 20cm length.

Compression Test: the sample is a cylindrical bar with dimension 25mm thickness and 150mm length.

Hardness Test: the sample is a cylindrical work piece with dimension 20mm length and 25mm diameter.

Tensile Test Procedure

Tensile test was carried out using the Universal Testing Machine at the civil engineering laboratory at Ambrose Alli University.

Hardness Test Procedure

Hardness test is carried out to ascertain the level or degree of resistance of material to wear, cutting, crushing when the material is under loading. Hardness test was carried out using a BrinelI Hardness testing machine

Compression Test

Compressive testing gives information about the Compressive strength and brittleness of aluminum alloys. It determines the characteristics of materials under crushing loads. The Universal testing machine (UTM) model WAW-600B was used. A total of three synthetic sand aluminium cast samples and three natural sand aluminium cast samples was tested.

Metallographic Test Procedure

The microstructure or metallographic test was carried out at the Metallurgical and Materials Engineering AAU. The cast aluminium test piece was cut and polished to a good smooth surface using a Belt Grinder (B.G-20) with fine grades of abrasive papers to ensure better surface finish.

IV. Results and Discussion

This section presents the results of the experimental investigation into the effects of synthetic and natural sand moulds on the microstructure and mechanical properties of Al-Si7Mg aluminium alloy castings. The results are analysed and discussed to elucidate the impact of the moulding sands on the casting quality. The analysis includes tensile strength, hardness, and compressive strength data, as well as microstructural observations.

IJSES
International Journal of Scientific Engineering and Science
Volume 8, Issue 9, pp. 52-59, 2024.
ISSN (Online): 2456-7361

Natural and Synthetic Sand Characterization

Chemical Analysis Test

The results of the tests conducted are presented in Table 2 and it shows the result of the chemical analysis of the natural sand of Uhomorah beach.

TABLE 2. Results Of Chemical Analysis Test

Compound	Sio_2	K_2o	Cao	Tio_2	V_2o_3	Mno	Fe_2o_3	Nio	Cuo
%Concentration	95.934	1.35	0.35	0.25	0.012	0.028	1.54	0.030	0.014

From Table 2, it is observed that the natural sand of Uhomorah beach contains 95.934% SiO_2, 1.35% K_2O and 1.54% Fe_2O_3 as the major components. The silica content of 95.49% compared very well with the accepted standard values of between 80% and 97% recommended for moulding sand (Jain, 2008).

Sieve Analysis Test

The measured results for sieve analysis of natural sand and synthetic sand are shown in Tables 3 and 4.

TABLE 3. Sieve analysis and grain fineness number for natural sand

S.No	Sieve Aperture	% Sand Retained	BS Sieve No	Product	% Parsing
1	4.75mm	0	3.5	0	100
2	2.36mm	0	7	0	100
3	1.18mm	9	14	63	91
4	600µm	34	25	476	66
5	425µm	23	36	527	77
6	300µm	16	52	576	84
7	212µm	10	70	520	90
8	150µm	4	100	288	96
9	Pan	4	-	400	96
Total		100		2850	

Grain fineness number (GFN) = $\frac{total\ product}{total\,\%\,sand\ retained} = \frac{2850}{100} =$ 28.5

TABLE 4. Sieve analysis and grain fineness number for synthetic sand

S.No	Sieve Aperture	% Sand Retained	BS Sieve No	Product	% Parsing
1	4.75mm	0	3.5	0	100
2	2.36mm	0	7	0	100
3	1.18mm	1	14	7	99
4	600µm	5	25	70	95
5	425µm	25	36	625	75
6	300µm	38	52	1368	62
7	212µm	22	70	1144	78
8	150µm	7	100	504	93
9	Pan	2	-	200	98
Total		100		3918	

Grain fineness number (GFN) = $\frac{total\ product}{total\,\%\,sand\ retained} = \frac{3918}{100} =$ 39.18

The grain fineness number (GFN) for natural sand and synthetic sand are 28.5 and 39.18 respectively. This grade of fineness number is suitable for most alloy steels and nonferrous metals as this belongs to the group of fineness number that has a wide range of application in sand casting based on American Foundry Society (AFS) standard. It should be noted that as the grain fineness number is a useful parameter, choice of sand should be based on particle size distribution as the size distribution affects the quality and property of the casting produced (Edoziuno, Oyibo and Nwaeju, 2017).

Moisture Content Test results

TABLE 5. Moisture content result for natural and synthetic sand

Specimen reference	Unit	Natural		Synthetic	
Container number		1	2	3	4
Mass of wet soil + container (m_2)	G	11.68	10.91	10.95	9.35
Mass of dry soil + container (m_3)	G	10.35	9.28	10.05	8.41
Mass of container (m_1)	G	6.86	4.91	6.68	5.01
Mass of moisture ($m_2 - m_3$)	G	1.28	1.63	9	9.4
Mass of dry soil ($m_3 - m_1$)	G	3.49	4.37	3.37	3.4
Moisture content $w = \frac{m_2 - m_3}{m_3 - m_1}(100)$	%	3.667	3.782	2.670	2.764

Moisture content for natural sand = $\frac{3.667 + 3.782}{2}$ = 3.725%

Moisture content for green sand = $\frac{2.670 + 2.764}{2}$ = 2.717%

The results of the moisture content showed that natural sand possessed a moisture content of 3.725% while synthetic sand possessed a moisture content of 2.717%. The results are within AFS standard moisture content range of 2% to 8%.

Permeability Test

This test was conducted to determine how well the sand can vent, i.e. allow gases to pass through it. This test determines whether the sand is suitable for the casting conditions. The test results are shown in the Tables 6

TABLE 6. Permeability of moulding sand

Natural Sand	7.63 ml/min
Synthetic Sand	6.17 ml/min

Porosity test

This test was conducted to determine the measure at which the pore spaces are distributed and how it affects the metal to be cast. It is usually expressed as a percentage. The test results are shown in Table 7

TABLE 7. Porosity of moulding sand

Natural Sand	44.4%
Synthetic Sand	42.8%

Mechanical Test Results

The mechanical tests results for the aluminium casts from the three different sand samples tested include, hardness test, tensile strength and compression test.

Hardness Test Results

TABLE 8. Hardness test results for synthetic sand aluminium cast samples

Samples	Indentation (HRC)
A	67.3
B	68.35
C	73.4

International Journal of Scientific Engineering and Science
Volume 8, Issue 9, pp. 52-59, 2024.
ISSN (Online): 2456-7361

TABLE 9. Hardness test result for natural sand aluminium samples

Samples	Indentation (HRC)
A	75.9
B	73
C	77.35

Compression Test Result

The compression test results reveal a significant difference between the aluminium samples whereby, the natural sand samples fractured upon application of lesser load while the synthetic sand aluminium cast samples required a greater load for it to break.

Invariably speaking, the failure of the natural sand samples occurred at lower strain while failure for the synthetic sand aluminium cast samples occurred at a higher strain.

This result shows that the synthetic sand used possesses a higher brittleness than the natural sand casting.

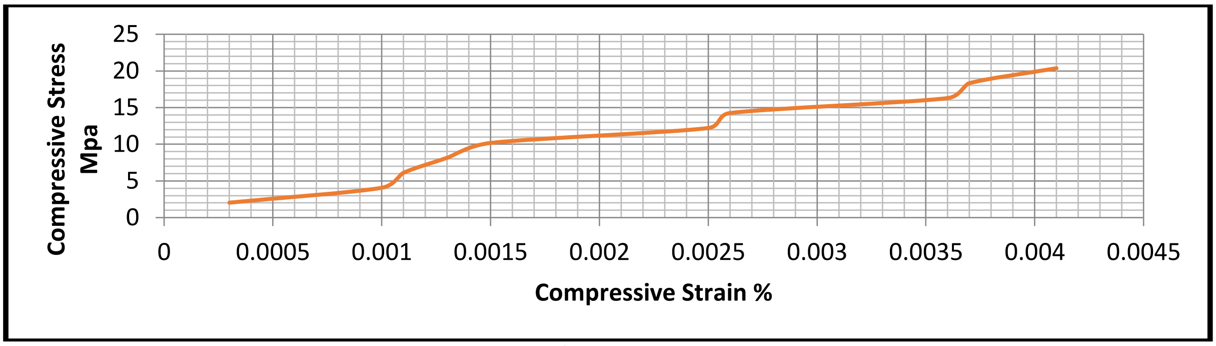

Figure 1. Stress-strain curve for natural sand aluminium cast samples

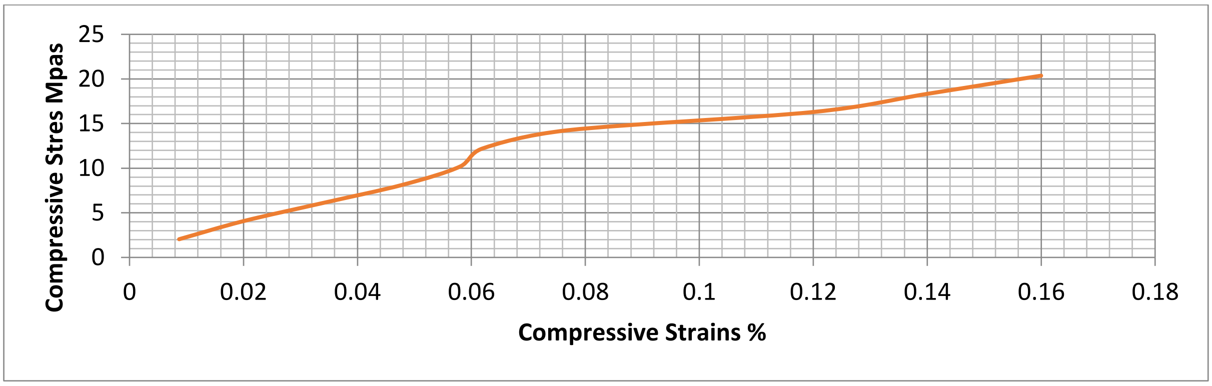

Figure 2. Stress-strain curves for synthetic sand aluminium cast samples

Tensile Test Results

The stress-strain curves for two aluminum samples, Sample A and Sample B, developed using a natural sand mould are depicted in two graphs. Sample B exhibits a peak stress of 384 megapascals (MPa) and a strain of 38% at maximal stress. The specimen exhibits a fracture point and excellent ductility. Sample A exhibits a superior ultimate tensile strength of around 460 MPa, indicating its ability to endure greater loads before experiencing failure. Both specimens demonstrate comparable ductility, while Sample B has a little greater strain upon fracture. The strain behaviour exhibits an early period of linear elasticity, which is then followed by yielding and strain hardening until it reaches the ultimate tensile strength. Potential causes for the disparities in tensile strength and ductility may include changes in casting circumstances or microstructural composition.

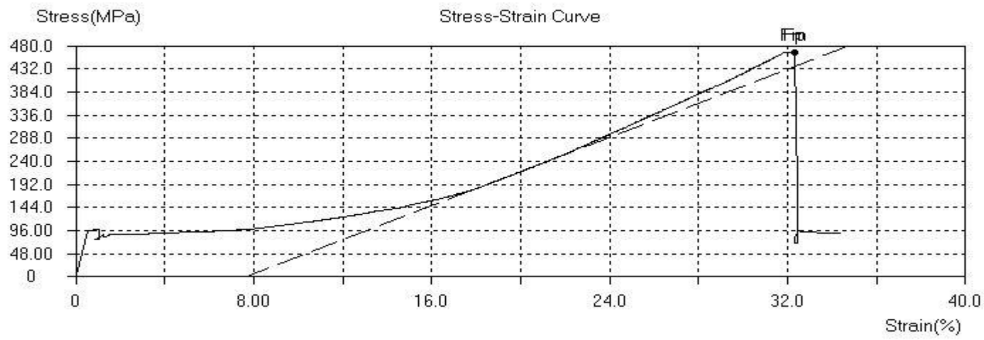

Figure 4. Stress-strain curve for natural sand aluminium cast sample A

International Journal of Scientific Engineering and Science
Volume 8, Issue 9, pp. 52-59, 2024. ISSN (Online): 2456-7361

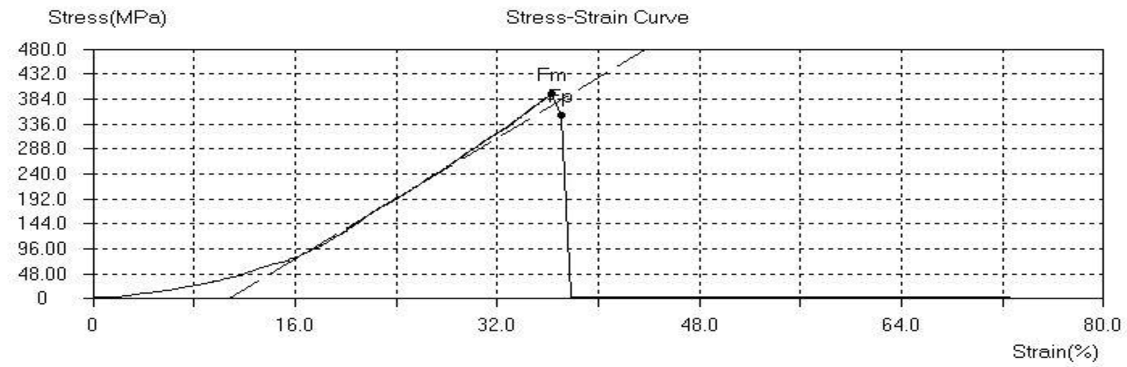

Figure 5. Stress-strain curve for natural sand aluminium cast sample B

TABLE 10. Tensile test results for natural sand aluminium cast samples

Samples	Maximum Load (kN)
A	30.16
B	25.48

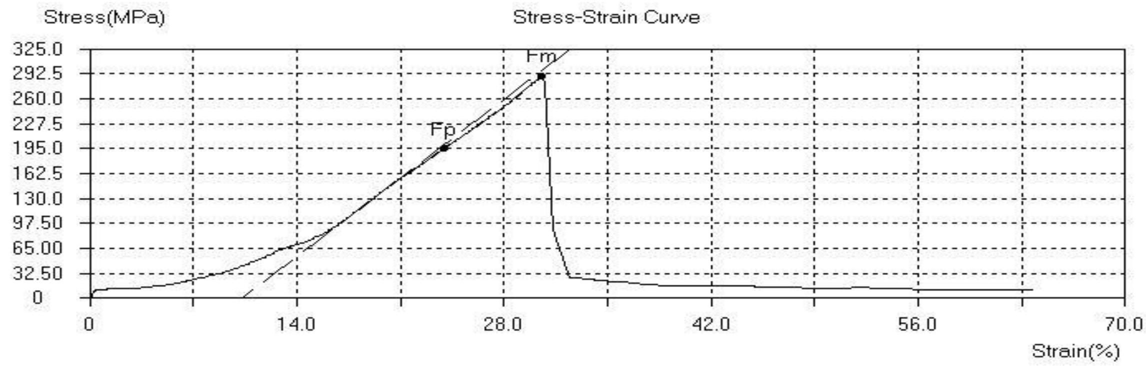

Figure 6. Stress-strain curve for synthetic sand aluminium cast sample A

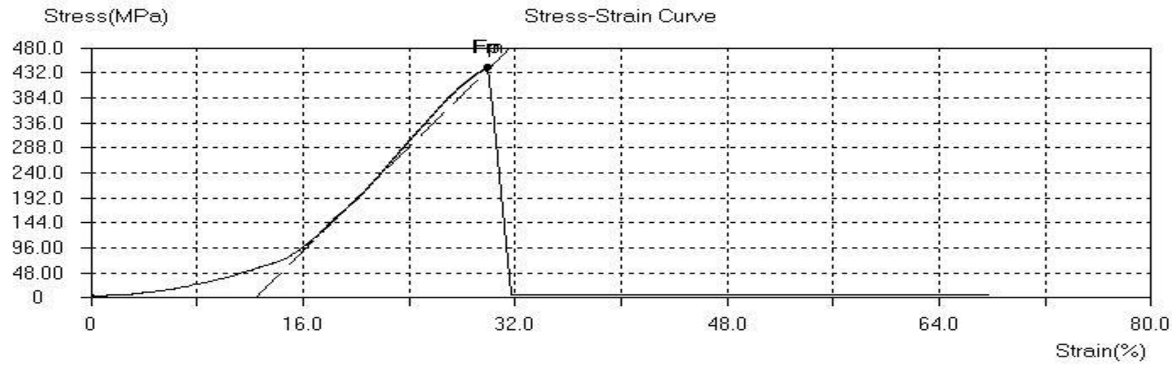

Figure 7. Stress-strain curve for synthetic sand aluminium cast sample B

The stress-strain curves of two aluminum samples of synthetic sand mould A and B are depicted in Figures 6 and 7; sample A exhibit a precipitous increase in yield strength, reaching its maximum point at 315 MPa, and a strain of 28%. The material demonstrates a moderate level of ductility, which decreases significantly after peaking at the ultimate tensile strength, suggesting the occurrence of necking and fracture. In contrast, Sample B has a greater ultimate tensile strength of 435 MPa and a strain at UTS of 32%, therefore demonstrating both structural strength and ductility. Possibly owing to variations in microstructure or manufacturing circumstances, Sample B seems to exhibit greater strength and ductility compared to Sample A.

TABLE 11. Tensile test results for synthetic sand aluminium cast samples

Samples	Maximum Load (kN)
A	18.74
B	18.66

The tensile test result shown in figure 4, 5, 6 and 7 is better explained by looking through the stress-strain diagram. This highlights the maximum load required to break the samples and it also shows the behaviour of the aluminium samples through the curve.It was also observed that natural sand aluminium cast samples (Sample B has a peak stress of 384 MPa and strain of 38%, while Sample A has a superior ultimate tensile strength of 460 MPa) possessed greater tensile strength than the corresponding synthetic sand aluminium cast samples (Sample A shows a significant increase in yield strength, reaching 315 MPa and strain of 28%,while Sample B shows greater ultimate tensile strength of 435 MPa and strain at UTS of 32%.)

Microstructural Test Results

The microstructure test carried-out as depicted in Figure 8 and 9 shows particle matrix interfaces of natural and synthetic sand aluminium cast samples respectively. Both samples exhibited signs of homogeneity but close observation of Figure 8 (natural samples) shows a greater number of black spots (Ferrite) which explains the increase in hardness of the material. The grain sizes in Figure 8 which are small shows the increase in hardness of the material.

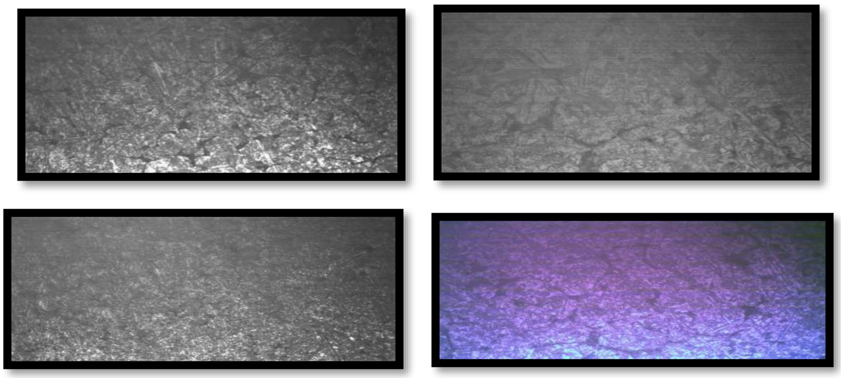

Figure 8 optical microstructure of natural sand aluminium cast samples

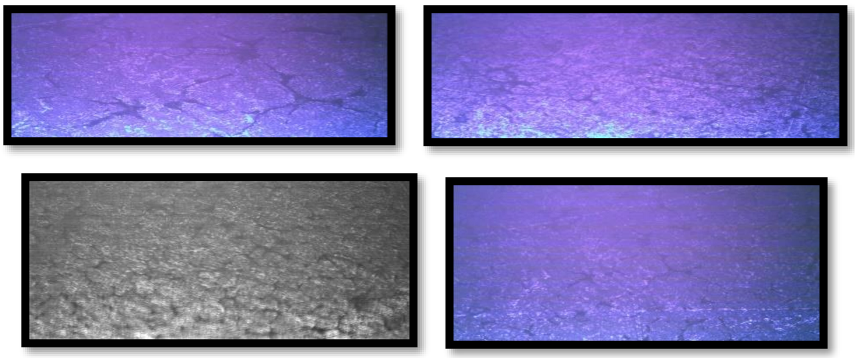

Figure 9. Optical microstructure of synthetic sand aluminium cast samples

V. Conclusion

Aluminium alloys are widely used in various industries due to their properties such as light weight, high strength, and corrosion resistance. Sand casting is a versatile and cost-effective method for producing aluminium parts, and the quality of sand used in the mould plays a crucial role in determining the final properties of the cast aluminium. Synthetic and natural sand are two commonly used types of sand moulds in the casting process. Understanding these effects is essential for optimizing the casting process to achieve superior material properties and performance in industrial applications.

The type of sand affects the thermal conductivity and cooling rate of the mould, which in turn influences the microstructure and mechanical properties of the casting. Studies comparing synthetic sand and natural sand have shown varying results, with green sand moulds often producing castings with higher porosity and rougher surface finishes due to moisture and organic binders. Natural sand castings typically demonstrate superior mechanical properties, but their higher cost and environmental impact pose challenges for widespread adoption. This study investigates the effect of synthetic and natural moulding sand on aluminum cast.

Tests entail chemical analysis of natural sand, sieve analysis, moisture content, refractoriness, and permeability tests. Mechanical test samples used include tensile, compression, and hardness tests. Compressive testing provides information about the compressive strength and brittleness of aluminum alloys. The microstructure or metallographic test is carried out at the Metallurgical and Materials Engineering Ambrose Alli University. The experimental investigation into the effects of synthetic and natural sand moulds on the microstructure and mechanical properties of Al-Si7Mg aluminium alloy castings was conducted. The results showed that the natural sand of Uhomorah beach contains 95.934% SiO_2, 1.35% K_2O, and 1.54% Fe_2O_3, with a silica content of 95.49%. The sieve analysis test for natural sand and synthetic sand showed grain fineness numbers of 28.5 and 39.18, respectively, which are suitable for most alloy steels and nonferrous metals. The choice of sand should be based on

Volume 8, Issue 9, pp. 52-59, 2024.
ISSN (Online): 2456-7361

particle size distribution, as the size distribution affects the quality and property of the casting produced. The moisture content test results showed that natural sand had a moisture content of 3.725%, while synthetic sand had a moisture content of 2.717%, within the AFS standard moisture content range of 2% to 8%. The results provide valuable insights into the impact of moulding sands on the quality of Al-Si7Mg aluminium alloy castings. The study focuses on the performance of aluminium casts from three different sand samples, including natural sand, synthetic sand, and natural sand moulding sand. The permeability test measures the sand's ability to vent gases, while the porosity test measures the distribution of pore spaces and their impact on the cast metal. Mechanical tests for aluminium casts from these samples include hardness, tensile strength, and compression tests. The results show that natural sand samples fractured under lesser loads, while synthetic sand required a greater load for it to break. This indicates that the synthetic sand used has higher brittleness than natural sand casting.

Results showed that natural sand cast had better hardness quality (77.35HRC), higher compression strength (23.30mm) under the same load, and higher tensile strength (27.8KN) at the breaking point compared to synthetic sand (18.7KN).

Tensile test results show that natural sand aluminum cast samples have a higher peak stress and strain, while synthetic sand aluminum cast samples have a higher ultimate tensile strength. The microstructure test reveals that both natural and synthetic sand aluminium cast samples exhibit signs of homogeneity, but the natural samples have a greater number of black spots (Ferrite) which explains the increase in hardness. In conclusion, the study provides valuable insights into the performance of aluminium casts from different sand samples and their potential applications in various industries.

References

[1]. Aweda, J. O., & Jimoh, Y. A. (2009). Assessment of properties of natural moulding sands in Ilorin and Ilesha, Nigeria. USEP: Journal of Research Information in Civil Engineering, 6(2), 68-77.
[2]. Bala, K. C., & Khan, R. H. (2013). Characterization of beach/river sand for foundry application. Leonardo Journal of Sciences, 77-83.
[3]. Beardsley, A., & Ormerod, A. (2017). Sand casting. In J. R. Davis (Ed.), ASM Handbook (Vol. 15, pp. 455-467). ASM International.
[4]. Brown, J. R. (2000). Foseco Ferrous Foundryman's Handbook. Butterworth-Heinemann.
[5]. Campbell, J. (2003). Castings (2nd ed.). Butterworth-Heinemann.
[6]. Campbell, J. (2015). Complete Casting Handbook. Butterworth-Heinemann.
[7]. Davis, J. R. (Ed.). (1993). Aluminum and Aluminum Alloys. ASM International.
[8]. Edoziuno F. O., Oyibo A. O. and Nwaeju C. C. (2017). Preparation of synthetic moulding sand using local raw materials. International Journal of Advanced Engineering and Technology, 1(1)28-31.
[9]. Khan, R. H. (2005). Metal Casting Technology in Nigeria-Present Status and Future Prospects*. Minna: KingsPlaza.
[10]. Khurmi, R. S., & Gupta, J. K. (2005). A Textbook of Machine Design. Eurasia Publishing House.
[11]. Murphy, J. A., & Siebert, A. R. (1998). *Principles of Metal Casting. McGraw-Hill.
[12]. Stefanescu, D. M. (2015). Science and Engineering of Casting Solidification. Springer.
[13]. ASM International. (2008). Casting. ASM International.
[14]. ASM Specialty Handbook: Aluminum and Aluminum Alloys, J.R. Davis, Ed., ASM International, 1993