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Investigation on Sand and Cement Particles Reinforcement in Aluminium Matrix Composite (AMC)

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Abstract: The aerospace, automotive, nuclear, biotechnology, electrical, and sports goods sectors may all benefit from the usage of metal matrix composites (MMCs), a class of sophisticated materials. The main objective of this study is determining the physical and mechanical behaviour of sand and cement reinforced AMC and to examine the effect of reinforcements composition of sand and cement in AMC. Through a series of tests including mechanical and physical testing, that the sample of aluminium matrix composite (AMC) has the appropriate chemical makeup and has been cured for the appropriate number of days.

Keywords: Aluminium matrix composite (AMC), Physical properties, Mechanical properties

1. Introduction

The most prevalent kind of metal matrix composites are metal/ceramic composites that have a high percentage of ceramic material ("cermets" was a term that was used roughly 40 years ago to refer to metal/ceramic composites that had a high percentage of ceramic content). However, there are many other possible combinations. MMCs have been developed using a variety of processes, including casting, high-pressure diffusion bonding, and powder metallurgy, among others. The methods of diffusion bonding and casting were used in the production of MMCs with continuous-fiber reinforcement. Powder metallurgy and pressure-assist casting were the processes used in the production of discontinuously reinforced matrix metal matrix composites (MMCs). MMCs like as B/Al, Gr/Al, Gr/Mg, and Gr/Cu have been created by the process of diffusion bonding for use in the construction of prototype spacecraft components such tubes, plates, and panels (Miracle, D. B.) (2005). The sand and cement are both ground into a powder in a mill. In order to acquire the desired particle size of 63 micrometres, the powder must first go through the sieving procedure. During this time, the XRF test is being carried out so that the elemental compositions of the powder concrete may be characterized.

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Depending on how the fibres are distributed and oriented within the cement matrix, the introduction of fibres makes the cementitious material more isotropic and transforms it from brittle to quasi-ductile. The post-cracking era is when fibres added to concrete really show their genuine value. The fibre had no impact on the mechanical properties of concrete before. In nutshell, from the background study it can relates to our objectives that is to investigate about the enhancement of properties sand and cement particles reinforcement in Aluminium matrix composite (AMC). Through experimental study, the primary goal is to raise the tensile strength of the material so that it may be used in a variety of applications.

First, aluminium has only been a major industrial metal since 1886, the year in which the current smelting technique was created. In comparison to the thousands of years that bronze, copper, lead, iron, and other metals have been accessible, it has only been available for a brief period. It now easily outnumbers non-ferrous metals in terms of volume consumption. It is preferred over steel in regions where its unique features (light and brilliant) make it worthwhile to invest in. Many applications have found their true place for aluminium, while others are still on their way in. Global usage is currently over 20 million tons per year (Dwight, John, 1998). Organic materials that have been foamed have a low specific weight, but since polymer foams are weak, their energy amounts that can be converted to deformation energy are also weak. Aluminium foams may be used to produce energy-absorbing devices with a higher energy level (J. Baumeister, J. Banhart, M. Weber) (1997).

Foundry sand is a superior silica sand with uniform physical characteristics. Sand has been used asa moulding material for millennia because of its heat conductivity in the ferrous and non-ferrous metal casting industries, where it is a byproduct. Sand is repeatedly recycled and used in foundries with success. Foundry sand is removed when the sand can no longer be used in the foundry and is then used elsewhere. Foundry sand is silica sand of superior quality and consistency (Rafat Siddique et al., 2011). Cement is often regarded as one of the most essential components of any structure. The primary application for its utilisation is in the manufacturing of concrete. Sand, gravel, broken stones, and other inert mineral aggregates, together with cement, are the primary components of concrete. (Worrell, Ernst, et al. "Carbon dioxide emissions from the global cement industry." Annual review of energy and the environment 26.1 (2001).

2. Materials and Methods

The methodology of the study, which comprises the experiment and testing methods, is discussed in this chapter. The aluminium alloy employed in this study was AA7075. Milling, sieving, sintering, mixing, drying, cleaning, and compaction will all be performed by AA7075 during the trial. Mechanical and physical tests were also performed on the completed product.

2.1 Raw Materials

The three major raw materials used in this investigation were aluminium alloy AA7075, cement, sand and aluminium alloy zinc stearate (C36H7004Zn). The matrix of the composite is constructed of AA7075 aluminium alloy, with zinc stearate as a binder and cement and sand as reinforcement.

2.2 Process overall project

Chip preparation is the initial part of this investigation. Chip cleaning is the next step, and it is critical to the project's success since it eliminates the oil and contaminants that have attached to the aluminium chip. The chip drying method was carried out after the cleaning procedure. Next, the original foundry sand and cement was used as the second raw material. The exact particle sizes are 63m of cement and sand were determined using a sieve method after the burning process. The mixing procedure and the cold compaction process were both used to prepare the specimens. The mixing process was carried out with the help of a ball mill. Besides that, the cold compaction procedure was carried out using a uniaxial hydraulic machine, commonly known as a press machine, with a 9-ton operating pressure and a 20-minute holding duration at room temperature. Then, the sintering procedure was utilized to minimize the specimen's porosity and increase properties like strength. After that, several physical tests, including density, porosity, and water uptake, were carried out and analyzed. In addition, an optical microscopic examination of the microstructure of the selected specimen was performed. The final step in specimen testing is the mechanical test, which determines the mechanical properties of sand and cement with different compositions. Mechanical tests were included compression and micro-hardness tests.

The equation used to calculate the compressive strength of the sample in the test is:

$$C = \frac{W}{A} \quad \text{Eq. 1}$$

The equation for modulus young is:

$$E = \frac{\sigma}{\epsilon} \quad \text{Eq.2}$$

3. Results and Discussion

The findings and subsequent discussion of an examination into the effects of sand and cement particles used as reinforcement in aluminium matrix composites (AMC) on the mechanical and physical characteristics of AMC were the primary focuses of this chapter. In order to investigate the mechanical characteristics of the sample, both a micro-hardness test and a compression test have been carried out.

3.1 Physical properties

The findings were compared to Sample 1 that consisted entirely of aluminium chips. Sample 6 had a density that was greater than Sample 2, coming in at 2.488 g/cm3, while Sample 2 had a density that was lower, at 2.250 g/cm3. In addition to this, its density was greater than that of Sample 1, which contained 100 wt. percent of AA7075 and had a density of 2.054 g/cm3. Figure 1 shows the density graph of physical properties of metal matrix composites reinforced with cement.

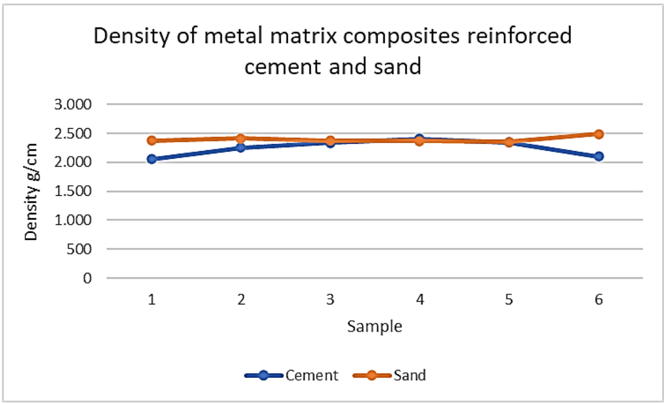

Figure 1: The density graph of physical properties of metal matrix composites reinforced with cement.

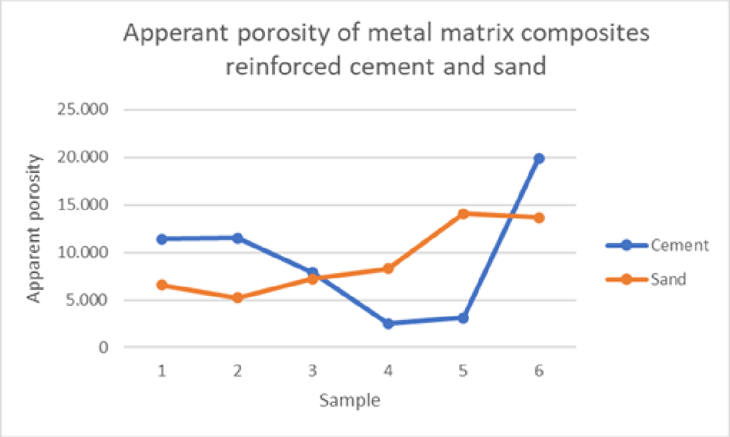

Figure 2: The apparent porosity graph of physical properties of metal matrix composites reinforced with cement

Figure 2 shows the apparent porosity (%) decreases from sample 1 all the way through sample 4 and is represented by the value 11.409 to 2.509. In addition, the apparent porosity increases from sample 4 to sample 5, going from 2.509 to 14.083, but then it falls from sample 5 to sample 6, going from 14.083 to 13.675, which is a disappointing result. Meanwhile in figure 3, shows the water absorption results were as well decreasing from sample 1 to sample 4 which is from 9.765 to 1.756. Next, the water absorption increases from sample 4 to 5 and then decrease again from sample 5 to 6 which is 1.756 to 9.460 and 9.460 to 9.340.

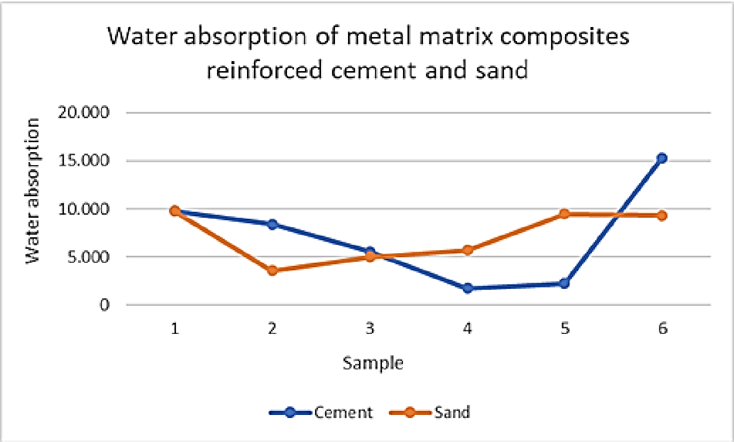

Figure 3: The water absorption graph of physical properties of metal matrix composites reinforced with cement.

3.2 Micro-Hardness test

First, the addition composition Al (90.5%) +10 wt.% of cement was added to mix of metal matrix composites shows that increment of hardness results from 64.689 Hv to 119.795 Hv for Al (92.5%) + (7.5%). Furthermore, it decreases from 119.795 for Al (92.5%) + (7.5%) to 32.654 for Al (92.5%) + (7.5%). From the experiment, the results show that the higher the content of cement can rapid the hardness, meanwhile it can lose the hardness as the amount of composition are higher and can make the hardness decreasing.

Next, the addition composition Al with sand shows the decreasing of hardness from 55.40 Hv to 34.452 Hv and it shows the decreasing from first element until the last element. According to the findings of the earlier research conducted by Te-Hua Fang et al., 2007, the composition of that material is more solid when it has a higher value for its hardness. Both the micro hardness test and the Nano indentation test differ greatly from one another in two areas: the maximum load that is applied during the micro hardness test and the greatest depth that is applied during the Nano indentation test. Figure 4 illustrates the graph of micro hardness Vickers test results in Table 1.

Table 1: Micro-Hardness Vickers test results (HV)

Element composite	**Composition**	**Hardness, HV (cement)**	**Hardness, HV (sand)**
A	Al 100%	64.689	55.540
B	Al (90.5%) + (10%)	83.063	53.256
C	Al (95%) + (5%)	89.428	50.079
D	Al (92.5%) + (7.5%)	119.795	38.098
E	Al (90.5%) + (10%)	38.121	38.016
F	Al (92.5%) + (7.5%)	32.654	34.452

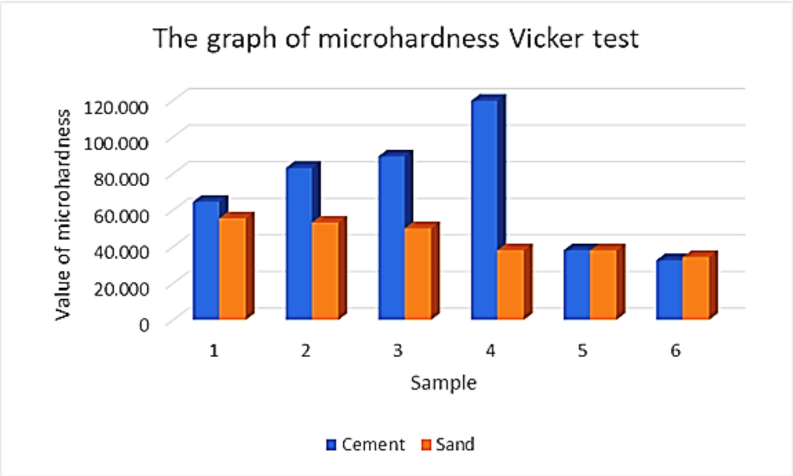

Figure 4: The graph of micro hardness Vickers test results

3.3 Compression test

The value of Young's Modulus for cement and sand is shown in Table 2 and Table 3, respectively. Based on Figure 5, Young's Modulus and stiffness strength of AMC were dominated by Aluminium chip AA7075 (95%) + cement (55%) + Zinc Stearate (1%), which is 11.952 owing to the mechanism of reinforcement that roughly matched with the addition composition of cement. Next, Aluminum chip AA7075 (95%) plus sand (5%) plus Zinc Stearate (1%) has the maximum Young's Modulus and stiffness, which is 13.352, suggesting that the reinforcement is approximately balanced, with the addition of sand.

Table 2: Young's Modulus composition aluminium with cement

Element composition	Composition	Young Modulus
A	Al 100%	11.297
B	Al (90.5%) + cement (10%)	11.312
C	Al (95%) + cement (5%)	11.952
D	Al (92.5%) + cement (7.5%)	11.478
E	Al (90.5%) + cement (10%)	10.328
F	Al (92.5%) + cement (7.5%)	10.176

Table 3: Young's Modulus composition aluminium with sand

Element composition	Composition	Young Modulus
A	Al 100%	11.288
B	Al (90.5%) + sand (10%)	12.736
C	Al (95%) + sand (5%)	13.352
D	Al (92.5%) + sand (7.5%)	12.478
E	Al (90.5%) + sand (10%)	10.323
F	Al (92.5%) + sand (7.5%)	10.176

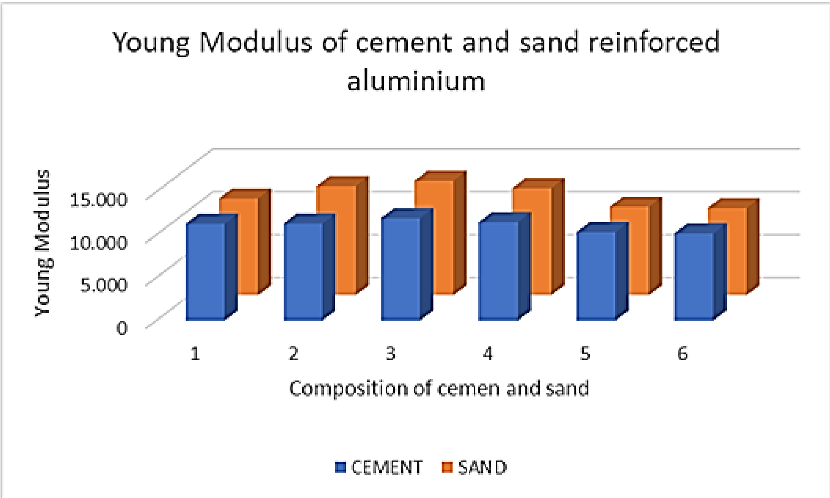

Figure 5: Young's Modulus graph

4. Conclusion

This project's recycling procedure was carried out by employing machining chip blocks as well as samples that went through the cold compaction process and sintering process using argon gas. This method of remelting was selected as an alternative. Rather than the traditional recycling procedure, a cold compaction hydraulic machine is used to compress the metal matrix composite with reinforcement.

Furthermore, this project achieves the objective which is to determine the physical and mechanical behaviour of sand and cement reinforced AMC and to examine the effect of reinforcements composition of sand and cement in AMC. In a nutshell, for recommendation for future work is add other types of reinforcing materials to metal matrix composites, such as concrete, coir fiber, rice husk silica and others.

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References

[1] Hooker, J.A.; Doorbar, P.J. Metal matrix composites for aeroengines. Materials Science and Technology, 16(7-8), 725–731, 2000.

[2] Varshney, Deekshant; Kumar, Kaushal, Application and use of different aluminium alloys with respect to workability, strength and welding parameter optimization. Ain Shams Engineering Journal, (), S2090447920301295, 2020.

[3] Gavin Reynolds; Rohit Ingale; Ron Roberts; Sanjeev Kothari; Bindhu Gururajan, Practical application of roller compaction process modeling., 34(7), 1049–1057.), 2010.

[4] Olle Skrinjar; Per-Lennart Larsson, Cold compaction of composite powders with size ratio., 52(7), 1871–1884, 2004.

[5] Rafat Siddique; Yogesh Aggarwal; Paratibha Aggarwal; El-Hadj Kadri; Rachid Bennacer, Strength, durability, and micro-structural properties of concrete made with used- foundry sand (UFS)., 25(4), 1916–1925. 2011.

[6] Rakesh Kumar; B Bhattacharjee. Porosity, pore size distribution and in situ strength of concrete, 33(1), 155–164. 2003.

[7] Lee, G. C., and H. B. Choi. "Study on interfacial transition zone properties of recycled aggregate by micro-hardness test." Construction and Building Materials 40: 455-460. 2013.

[8] Tuncay, Ergün, and Nilsun Hasancebi. "The effect of length to diameter ratio of test specimens on the uniaxial compressive strength of rock." Bulletin of engineering geology and the environment 68.4: 491-497. 20096.

[9] Arenal, Raul, et al. "Young modulus, mechanical and electrical properties of isolated individual and bundled single-walled boron nitride nanotubes." Nanotechnology 22.26: 265704. 2011.

[10] F Findik; R Yilmaz; T Köksal. Investigation of mechanical and physical properties of several industrial rubbers., 25(4), 269–276. 2004.