ELEVATION OF MECHANICAL PROPERTIES OF ALUMINIUM ALLOY (AL-2024) REINFORCED WITH SILICON CARBIDE AND ANACARDIUM OCCIDENTAL

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ABSTRACT:

In present scenario Aluminium metal Matrix hybrid composites are widely using for aerospace applications, transport applications and structural applications due to their desirable properties .In view of this the present investigation was aimed to synthesis aluminium –silicon-agro waste based hybrid metal matrix composites. The present experimentation was carried out to examine fabrication characteristics and mechanical properties of Aluminium hybrid metal matrix composite. In the present investigation Al 2024 reinforced with silicon carbide and (SiC) and Anacardium occidentale ash for developing the mechanical properties. The composites were synthesized by the stir casting technique. The composites were synthesized by varying Anacardium occidentale percentage of weight as 0%, 2%, 4%, and 6% .The mechanical properties like Tensile strength, Yield strength, percentage of elongation, hardness were performed. The micro structural study was carried out by SEM examination.

INTRODUCTION:

The demands made on materials for better overall performance are so great and diverse that no one material can satisfy them. This led to a resurgence of the ancient concept of combining different materials in an integral composite material system that results in a performance unattainable by the individual constituent, and offers great advantages. Composites are materials in which two phases are combined, usually with strong interfaces between them. Aluminum is adopted for the fabrication of modern ships, due to its low density, high strength to weight ratio, good Weld ability, corrosion resistance and better mechanical properties. Aluminum is the most second plentiful mechanical equipment on earth and became an economic competitor in engineering applications as recently at the end of 19th century. It was to become a metal for its time. Further most important industrial development would by demanding material characteristics consistent with the unique Qualities of Aluminum and its alloy. Aluminum is the most abundant metal and the third most abundant chemical element in the earth's crust, comprising over 8% of its weight. Aluminum alloys are broadly used as a main matrix element in composite materials. Aluminum alloys for its light weight, has been in the net o researchers for enhancing the Technology. The broad use of Aluminum alloys is dictated by a very desirable combination of properties, combined with the

case with which they may be produced in a great. The increase in strength during precipitation hardening heat treatment is due to precipitation of different types of mean stable phases forming in Aluminum solid solution. The corrosion resistance of Aluminum alloys depends on oxide film formation. This oxide film is non-uniform, thin and non-coherent, however it is naturally self-renewing and accidental abrasion or other mechanical damage of the surface film is rapidly repaired. Therefore, it imparts a certain level of protection under normal conditions.

Corrosion resistance of this alloy depends on the rate of formation and breakdown of oxide film. Intensity of corrosion attack depends on chemical composition of both exposed alloy and corroding. Inclusions, second phase particles, their size and grain structure also affects corrosion of alloy. In the marine environment Intended service life depends on composition of sea water. PH, velocity, temperature, time of exposure, aeration also effects corrosion rate. Effect of in-solution heat treatment and aging time on Mechanical Properties of specimen has been evaluated. Corrosion behavior of alloy is studied in still water condition at room temperature. Also effect of second phase particles formed, due to precipitation hardening heat treatment on Mechanical properties and corrosion rate is studied. Mechanical Properties, Weld ability and corrosion resistance are found to be primarily dependent on composition and gain structure of alloy.A356 has high strength in cast alloys, which can be further increased by precipitation hardening heat treatment. A356 alloy used in this study is eutectic Aluminum.

The liquids temperature of the alloy is 628c and the solidus temperature is 557C. One of the most promising approaches to improve the mechanical properties of Aluminum alloys is based on the addition of alloying elements either with low solubility or totally insoluble in Aluminum. Among the range of possible elements, chromium is the most effective precipitation hardener element in Al alloys Chromium addition has a strong influence on the properties of Aluminum and Aluminum alloys. Aluminum alloys doped with Chromium have shown improved mechanical strength, hot cracking resistance, weld strength and age hardening in AL (Cr) alloys with Cr content up to 0.3 wt%. The high response to hardening mechanism is a consequence of the fine homogenous dispersion of Al3Cr particles, formed during decomposition of the c-Al supersaturated solid solution, which nucleates in Aluminum matrix and grain boundaries, thus blocking the dislocations motion.

The increase in hardness of Cr added A356 alloys is attributed to grain refining and change in the morphology of dendritie Si in to nodular form. In age hardened condition, the hardness increases with increasing ageing time and thus falls with further ageing time. This can be revealed that the precipitated particles (A356-Cr alloys) grow to critical size by maintaining the coherency with the Matrix leads to increase of the hardness to peak value.

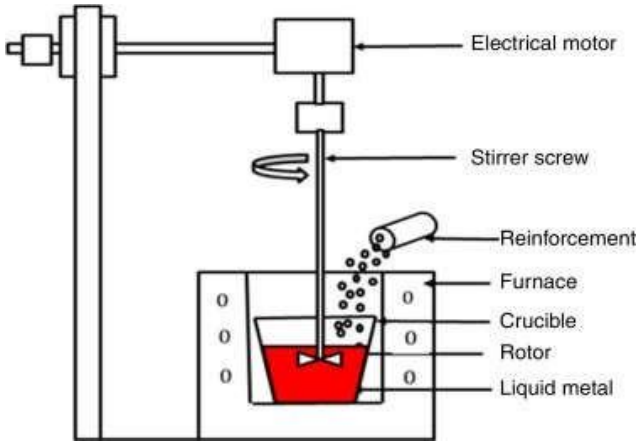
ALUMINUM AND ALUMINUM ALLOYS

Aluminum is the third most abundant element (after oxygen and silicon), and the most abundant metal in the Earth’s Crust. It makes up about 8% by weight of the Earth’s solid surface. Al is a silvery white and ductile metal with face centered cubic structure. It has excellent electrical and thermal conductivity (next only to copper and silver). It has low density (2.7 g/cc) which gives it a very high specific modulus and strength. The versatility of Al makes it the most widely used metal after steel. Aluminum metal is so chemically reactive that specimens are rare and limited to extreme reducing environments. Aluminum is remarkable for the

metal's low density and for its ability to resistant and has a high electrical conductivity. In addition, Al alloys have excellent mechanical and technological properties like high strength to weight ratio, cast ability, weldability and machinability. Structural components made from Aluminium and its alloys are vital to the aerospace industry and are important in other areas of transportation and structured materials. The most useful compounds of Aluminum, at least on a weight basis, are the oxides and sulphates.

STIRR CASTING:

In a stir casting process, the reinforcing phases (usually in powder form) are distributed into molten Aluminum by mechanical stirring. Stir casting of metal matrix composites was initiated in 1968, when S. Ray introduced alumina particles into an aluminum melt by stirring molten aluminum alloys containing the ceramic powders typical stir casting process of Aluminum alloy matrix composite is illustrated in Fig. Mechanical stirring in the furnace is a key element of this process. The resultant molten alloy, with ceramic particles, can then be used for die casting, permanent mold casting, or sand casting. Stir casting is suitable for manufacturing composites with up to 30% volume fractions of reinforcement. The cast composites are sometimes further extruded to reduce porosity,refine the microstructure, and homogenize the distribution of the reinforcement. A major concern associated with the stir casting process is the segregation of reinforcing particles which is caused by the surfacing or settling of the reinforcement particles during the melting and casting processes. The final distribution of the particles in the solid depends on material properties and process parameters such as the wetting condition of the particles with the melt, strength of mixing, relative density, and rate of solidification .The distribution of the particles in the molten matrix depends on the geometry of the mechanical stirrer, stirring parameters, placement of the mechanical stirrer in the melt, melting temperature, and the characteristics of the particles added.



Stir casting equipment

An interesting recent development in stir casting is a two-step mixing process . In this process, the matrix material is heated to above its liquids temperature so that the metal is totally melted. The melt is then cooled down to a temperature between the liquids and solidus points and kept in a semi-solid state. At this stage, the preheated particles are added and mixed. The slurry is again heated to a fully liquid state and mixed thoroughly. Stir casting characterized by following features:

1. Content of dispersed phase limited (usually not more than 30% vol)

2. Distribution of dispersed phase throughout the matrix is not perfectly homogeneous:

(a) There are local clouds (clusters) of the dispersed particle (fibers);

(b) There's gravity segregation to the dispersed phase due to difference in the Densities of dispersed and matrix phase.

3. The technology is relatively simple and low cost For Production of AMC by stir casting the two main ingredient required are Matrix and Reinforcement.

CRUCIBLE FURNACE:-

Crucible furnaces are small capacity typically used for small melting applications. Crucible furnace is suitable for the batch type foundries where the metal requirement is intermittent .The metal is placed in a crucible which is made of clay and graphite.The energy is applied in directly.

Crusible Furnace

Silicon carbide:-

It also known as carborundum ,is a semiconductor containing silicon and carbon with chemical formula SIC it occurs in nature as extremely rare mineral moissanite synthetic silicon carbide powder has been mass-produced since 1893 for use as an abrasive . Grains of silicon carbide can be bonded together by sintering to form very hard ceramics that are widely used in applications requiring high endurance such as car brakes, car clutches and ceramic plates in bulletproof vests. Electronic applications of silicon carbide such as light emitting diodes (LED) and detectors in early radios were first demonstrated around 1907. Sic

is used in semiconductor electronics devices that operate at high temperatures or high voltages, or both .large single crystals of silicon carbide can be grown by Lely method they can be cut into gems known as synthetic moissanite. Silicon carbide with high surface area can be produced from sio2 contained in plant material

Silicon carbide is an important non-oxide ceramic which has diverse industrial applications. In fact, it has exclusive properties such as high hardness and strength, chemical and thermal stability, high melting point, oxidation resistance, high erosion resistance, etc. All of these qualities make SiC a perfect candidate for high power, high temperature electronic devices as well as abrasion and cutting applications. Quite a lot of works were reported on SiC synthesis since the manufacturing process initiated by Acheson in 1892.

Silicon Carbide

Silicon Carbide is the only chemical compound of carbon and silicon. It was originally produced by a high temperature electro-chemical reaction of sand and carbon. Silicon carbide is an excellent abrasive and has been produced and made into grinding wheels and other abrasive products for over one hundred years. Today the material has been developed into a high quality technical grade ceramic with very good mechanical properties.

It is used in abrasives, refractories, ceramics, and numerous high-performance applications. The material can also be made an electrical conductor and has applications in resistance heating, flame igniters and electronic components.

Structural and wear applications are constantly developing. Silicon carbide (Sic), also known as carborundum is a semiconductor containing silicon and carbon with chemical formula SiC. It occurs in nature as the extremely rare mineral moissanite. Synthetic silicon carbide powder has been mass-produced since 1893 for use as an abrasive. Grains of silicon carbide can be bonded together by sintering to form very hard ceramics that are widely used in applications requiring high endurance, such as car brakes, car clutches and ceramic plates in bulletproof vests. Electronic applications of silicon carbide such as light-emitting diodes (LEDs) and detectors in early radios were first demonstrated around 1907. SiC is used in semiconductor electronics devices that operate at high temperatures or high voltages, or both. Large single crystals of silicon carbide can be grown by the Lely method; they can be cut into gems known as synthetic moissanite. Silicon carbide with high surface area can be produced from SiO2 contained in plant material.

Silicon carbide is composed of tetrahedra of carbon and silicon atoms with strong bonds in the crystal lattice. This produces a very hard and strong material. Silicon carbide is not attacked by any acids or alkalis or molten salts up to 800°C. In air, SiC forms a protective silicon oxide coating at 1200°C and is able to be used up to 1600°C. The high thermal

conductivity coupled with low thermal expansion and high strength give this material exceptional thermal shock resistant qualities. Silicon carbide ceramics with little or no grain boundary impurities maintain their strength to very high temperatures, approaching 1600°C with no strength loss. Chemical purity, resistance to chemical attack at temperature, and strength retention at high temperatures has made this material very popular as wafer tray supports and paddles in semiconductor furnaces. The electrical conduction of the material has lead to its use in resistance heating elements for electric furnaces, and as a key component in thermistors (temperature variable resistors) and in varistors (voltage variable resistors).

Typical silicon carbide characteristics include:

- Low density
- High strength.
- Good high temperature strength (Reaction bonded)
- Oxidation resistance (Reaction bonded)
- Excellent thermal shock resistance.
- High hardness and wear resistance.
- Excellent chemical resistance.
- Low thermal expansion and high thermal conductivity.

Silicon Carbide Typical Uses:

- Fixed and moving turbine components
- Suction box covers
- Seals, bearings
- Ball valve parts
- Hot gas flow liners
- Heat exchangers
- Semiconductor process equipment
- General Silicon Carbide Information

Anacardium Occidental:-

The cashew (Anacardium occidentaleL.) is an important tropical nut tree native to Centre and Southern America Behrens (1998). It belongs to Anacardiaceae family which includes about 75 genera and 700 species among which the well economically known ones are mango and pistachio (Nakasone & Paull, 1998). According to Azam-Ali & Judge(2001), cashew is widely cultivated in many tropical countries and has been introduced in India, Asia and Africa between the15thand 16th centuries Ohler, (1979). In South Saharan Africa, cashew is cultivated in agricultural areas degraded by extensive farming such as that of cotton, yams or other cash crops destructive of forest lands Tandjiekpon, (2005). The agro forestry system based on cashew, as practiced in many countries of Africa (Tanzania, Mozambique, Nigeria, Guinea Bissau, Côte d'Ivoire and Benin), enable to solve important problems of development in economic, social and environmental levels Tandjiekpon (2005). Besides its interest for forest plan, cashew is mainly grown for nuts and apples. It provides food, employment and additional incomes to producers. The cashew apples are eaten fresh or processed into alcohol or food products; Morton (1987) while the kernel of the cashew nut is consumed in roasted form. The cashew wood is used for carpentry mainly, firewood or turned into charcoal Akinwale (2000). Cashew resins are used in the manufacture of natural insect repellents and insecticides and the different tree parts have medicinal value because they are used to treat various diseases Cavalcanteet al. (2003). Nowadays, the growing interest of cashew is increasing because of the high commercial value of its nuts at international market level. In Benin, the cashew production system (cultivation, processing and marketing of the products) and the socio economic impacts on the local populations have been well described and jiekpon (2005). Research on traditional knowledge in Côte d'Ivoire showed the effectiveness of these methods in the management of she a genetic resources Diarrassouba et al. (2008). Knowledge of local communities on the management of some

perennial trees such as shea, baobab, jatropha, was assessed in Benin by Assogbadjo et al.(2009). But little data exist on the ethno-botanical knowledge of cashew and the management of its genetic resources. The objective of this study was then to document the indigenous knowledge of local people related to the production of cashew, its use and how the genetic resources of this important species are traditionally managed by farmers in local agriculture system in Benin.

Cashew Nut Shells

From the information gathered from cashew producers, the tree has been introduced in the surveyed areas since 1960s just after independence of the country. Diverse opinions have been received on the introduction of this species in the study area. In the Centre and North-West for instance, cashew was introduced in these areas for reforestation and economic reasons while in the North-East, along with these two reasons, this fruit tree has been introduced as an alternative for cotton and groundnut.

Most of the respondents recognized the increase of the total areas devoted to cashew cultivation compared to the previous years. Several factors have been reported to be in favor of this fact. Indeed in previous year, approximately 35% of the respondents showed poor knowledge about the plant, especially in Centre and North-West. In the North-East, 52.81% of farmers believed about their lack of knowledge on the benefices provided by the cashew tree. On the other hand, about 5% of the producers also indicated that the decrease of cotton production promoted the cashew plantations. Finally, according to 27% of the investigated farmers, the awareness of the producers on the production techniques by the NGOs played an important role in the development of cashew plantations. Cashew played an important role in the development of socio economic status of local populations in Benin. In the surveyed area, many ethnic groups are involved in the cultivation of the cashew tree.

A total of seven major ethnic groups are involved in the production. Similar type of study was conducted by Tandjiekpon (2005) and reported that five ethnic groups were mostly involved cashew production in Benin. But in present study the involvement of seven ethnic groups was reported this indicates the increased interest of local populations in the production of this tree. Moreover, although cashew planting is still dominated by men, the present study revealed the involvement of women owning cashew plantations, suggesting a broad development of the actors involved in cashew production in the country. The lack of women in cashew cultivation until now can be explained by the fact that they are not landowners. Indeed, in the study area, only men can inherit land from their parents.The few women farmers involved in cashew production have acquired the land from their husbands. The same observation about the low proportion of women as leaders operating cashew plantations has been reported by Topper and Kasuga (2003) in Tanzania.

Ash of Cashew Nut Shells

SANDSEVIER:-

Sandsevier

Mechanism: Consists of Sieving mechanism, to accommodate 10 nos. of sieves of 200mm Dia. & 35mm Ht.,

Misc Spec. : Please inform supply specifications to adapt equipment accordingly (Default: 230v AC , 50Hz).

Set of sieves 200 mm. Dia & 35 mm. Height of each standard sieve.

Sieve set consists of sieves with ISS No. in **microns** 1700, 850, 600, 425, 300, 212, 150, 106, 75, 53 with lid & receiving pan.

Sand Type: Raw sand/ Resin coated sand/ Base sand

Test:AFS Number OR Grain fineness number

Application: To determine the Grain fineness number of the foundry sand.

5.6 Specifications

Width: 470
Depth: 330
Height: 630
Weight: 44
Utility: ..
Range: 100 gms

Testing*:*

The fabricated specimens were proposed to test for mechanical properties like hardness and tensile strength. The SEM analysis and XRD analyses were proposed to be done to know the dispersion of the reinforcement in the metal matrix.

Hardness Test:

Bulk hardness measurements were carried out on the base metal and composite samples by using standard Rockwell hardness test machine. Rockwell hardness measurements were carried out in order to investigate the influence of particulate weight fraction on the matrix hardness. Load applied was 100 kg and indenter used was 1/16'.

Tensile testing*:*

The specimens were machined to get dog boned structure as per ASTM E-8 standards. Test was carried out on a computerized UTM (TUE-C-600 Model Machine). Tensile test specimens are shown in the figure.

Tensile Test Specimens

Result and Conclusion

Hardness

A basic Brinell hardness tester with semi-automatic operation. NB3010 is a cost-effective Brinell tester using deadweights with a pneumatic load system to apply and remove the loads. Operates in most all Brinell scales. This tester is used for determining the Brinell hardness of un-quenched steel, cast iron, nonferrous metals and soft bearing alloys. The NB-3010 measuring range is 8 – 650 HBW using atungsten carbide ball indenter.

The NB-3010 applies precise loads using a deadweight design. A pneumatic cylinder ensures that the load descends smoothly without an impact effect, and that the deadweights return after the test. A 60 psig air regulator using clean, dry air is required. Deadweights are used for applying up to eight different loads from 187.5 kgf to 3000 kgf. The NB-3010 also features a semi-automatic test procedure which is easy for the operator. The operator simply raises the elevating screw until the specimen makes contact with the indenter. At the press of a button, the load is applied and removed after a pre-defined dwell time. Time-at-loads of 12, 30, and 60 seconds are permitted and each time period has a dedicated pushbutton further simplifying operation. This computer-based system displays tests on your computer, stores your test results electronically and can print SPC reports. This automated system reduces operator influence on test results.

NB3010 Series Features and Benefits

Simple-to-Use, Semi-Automatic Control

Pushbutton controls ensure proper loading and dwell time.

High Accuracy Dead Weight Design

Precision dead weights apply load automatically without impact effect. Requires minimum operator monitoring.

Economical

Economically priced, yet rugged. High-quality materials and construction.

S No.	Samples Designation	Hardness (BHN)
1	As Cast Al	58.31
2	Al+15%Si+2%AO	67.05
3	Al+15%Si+4%AO	70.09
4	Al+15%Si+6%AO	85.95

Tensile properties Composites

The tensile test results are given in the table 3. The tests revealed that, the ultimate tensile strength gradually increased by the increase in wt. % of the reinforcement added to the metal matrix. The maximum Tensile strength was observed at 4% anacardium occidental When the reinforcements are added, the particulate reinforcements form nuclei which results in

greater number of grain formation. Thus the movement is restricted further, which results in greater strength P.K.Rohatgi etal (2004). Thus the observation in the overall increase of the tensile strength is aptly justified and explainable. It can be predicted from the micrographs that the fracture is a ductile fracture.

S No.	Samples Designation	Hardness (BHN)	U.T.S. (Mpa)	% of Elongation
1	Al+2%AO	67.05	129	4
2	Al+15%Si+4%AO	70.09	145	3
3	Al+15%Si+6%AO	85.95	159	2

CONCLUSIONS

- ensile strength reductions of

The fabrication characteristics and mechanical behavior of Al-Si -Cashew Nut Shells Ash alloy matrix composites containing 0, 2, 4, and 6% Cashew Nut Shells Ash and Al2O3 as reinforcement was investigated. The results show that:

- The less dense Al-Si/Cashew Nut Shells Ash/Al2O3 hybrid composites have estimated percent porosity levels as low as the single Al2O3 reinforced grade (< 2.3% porosity).
- The hardness of the hybrid composites decreases slightly with increase in Cashew Nut Shells Ash content with a maximum reduction. Of less than 11% observed for the Al-4 wt.% Cashew Nut Shells Ash-6 wt.% Al2O3 composition (in comparison with the Al-10 wt% Al2O3 single reinforced composition). 8% and 13% and specific strengths which were 3.56% and 7.7% lower were respectively observed for the 3 and 4 wt %Cashew Nut Shells Ash containing hybrid composites.
- The specific strength, percent elongation and fracture toughness of the 2%Cashew Nut Shells Ash containing hybrid composite was higher than that of the single Al2O3 reinforced and other hybrid composite compositions worked on.
- Cashew Nut Shells Ash as great promise to serve as a complementing reinforcement for the development of low cost-high performance aluminium hybrid composites.

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