Development of Green Hybrid Metal Matrix Composite using Agricultural Waste Bagasse as Reinforcement- A Review

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Abstract: Bagasse is a waste product which was produced from the sugar industry. These wastes produce lots of environment pollution in development. Effective utilization of these wastes can reduce lots of environment pollution. In this study, a literature review is carried out to observe the bagasse as reinforcement in the development of composite. From the literature, it was notified that bagasse can be used in the development of composite.

Keywords: Waste Bagasse, Density, Mechanical Properties, Corrosion

1. Introduction
Composite materials applications were observed since 1000 years before. From past to the present, different types of composites were developed and used for a wide variety of applications. Composite materials applications and their uses discuss one by one as given below [1-3]
- Composite describe by ancient people in the ancient period. In that time they just glued two plywood in many angles to form any shape.
- In 1500 B.C. engineers and artisans used straws as a reinforcement to make brick and boat.
- These seem that cement is described in that prouder only and Portland cement is the same. In ancient time builders and engineers do the same to form or work on the composite to describe sophisticated materials.

In this time Mongols found the bow by using the composite method. They just used wood, rock and many things to form a bow by using composite prouder. But it can’t so accurate. But at 1400 century when the firearm is introduced then it forms or built in the accurate form [4-6].
In this time we use chemical for composite. Mainly the chemical is converted into the solid-state is defined in this period only. The process which converts liquid to solid state is known as polymerization. The main resin is formed is Bakelite.
In this period chemical composition made a huge group to form a plastic such as vinyl, polystyrene. Now to make them strong means to increase the mechanical strength we use reinforcement. Without using reinforcement we can’t increase the mechanical strength. This period of time or century is the most important time or dominant for the composite industry which is used nowadays. In this period Owens corning introduce the first glass fiber or launched fiber resistant plastic (FRP). After that, it was patented also. Due to its curing properties, the unsaturated polyester is the most powerful composite due to which it is used till now. But for upcoming times we have to use more powerful reinforcement so that we can increase the mechanical properties or strength of composite [7]. In the 1940’s the use of FRP is increased. In World War II it’s necessary to focus on FRP production rather than research. The FRP was used in the radar system so that frequency was used in a better way without any disturbance [8]. In 1947 composite plays a vital role in the automobile sector. Due to composite automobile prototype is made for testing purpose. Fiberglass performs in classic cars. More resin is used in fiberglass for better performance in classic cars. At that period automobile brings new methods in which two methods are very used in that time. Simple molding composite (SMC) and bulk molding composite (BMC) brings revolutionary in the automobile sector at that time [9].

Pure aluminium has some basic properties like it is soft, ductile, and corrosion-resistant and has a high electrical conductivity. It is widely used in many manners but basically, it is used for foil and conductor cables, but when alloying is used with other elements it is necessary to provide the higher strengths needed for other applications. Aluminium is superior to steel but it is light in weight with having great strength. Aluminium is used in various applications because it has certain properties like recyclability, formability, re-melted, corrosion-resistant due to which it is available in various form [10-14]. Aluminium has a density about one third in comparison to steel or copper. It helps for making one of the lightest commercially available metals. The resultant of aluminium has a high strength to weight ratio which plays a vital role in making of structural material which allows increasing payloads or fuel savings for transport industries in particular. Pure aluminium has not enough tensile strength. So to increase the tensile strength some other metal is introduced in it like manganese, metal, magnesium alloy. Aluminium is very suitable for cold temperature. Its tensile strength is increasing with decreasing temperature. While decreasing in temperature toughness of aluminium is same there is no effect comes over it. In comparison to steel, aluminium is very good at decreasing temperature. The tensile strength of pure aluminium is around 90 MPa but it should be increased due to some availability of other alloys and after that, it should be increased up to 690 MPa [15-20]. Aluminium has better resistance to corrosion quality. When it is exposed in the air then immediately it forms a corrosion resistance layer which helps in no forming of corrosion on the surface. Due to all of above, it is better in acids. Due that it can’t harm the surface of aluminium at all. Above all this, it shows that it very good corrosion resistance in comparison to steel [21].

Aluminium has an electrical conductivity but not much as compare to other metals. But to increase the electrical conductivity it involves copper. Due to copper, the electrical conductivity of aluminium is increased up to 62%. The thin layer of copper is mixed with aluminium is just increased the electrical conductivity of aluminium. Composites are very important in today’s engineering point of view. Composites were used when a single material is not able to fulfill the requirements. The composite material is a mixture of two or more materials having different physical and chemical properties due to which new material is formed. However, the properties of the composite are constituent rails which remain distinct and separate in the composite. The performance of a composite is much superior to those of it. Composite requires two categories of intermediary materials known as matrix and reinforcement. For the fabrication of a composite, at least one portion of each constituent is required. Due to reinforcements the matrix materials enhance their physical and mechanical properties [22]. A simple method to classify composite materials shown below
Composite is very strong by other metals. We can say that the main advantage of composite is there mechanical properties were very strong in comparison to others. Composite is depending on the judicious matrix. If two metal matrixes are reliable then it can match the exact form of matrix properties. Reinforcement is applicable with aluminium at a certain position of the matrix represent better properties in comparison to resin and aluminium. While manufacturing of composite a product design is decided earlier because of flexibility issues. Some characteristics of these composite materials are as follows [30] Fiber Reinforced Plastics (FRC) are made by using reinforcing material fibers of glass, graphite, armed or boron in a matrix of epoxy The matrix is plastic and the reinforcement is glass in the tie threads, or often in a form woven into a cloth. Fiber Reinforced Composite has very high toughness and stiffness to weight ratio [31-32]. Ceramic-Matrix Composites are those composites which have a ceramic matrix, such as silicon carbide, silicon nitride, aluminium oxide, etc., and have higher resistance at high temperature and corrosive environment [33]. Laminated Composites are those composites which formed by bonding alternate layers of materials at different orientations and have high strength. Fiber-reinforced composites are widely used for making boat hulls, sports equipment, building panels, and many car bodies such as carbon-reinforced composites are used in expensive sports equipment, aircraft structures and, such as golf clubs. Composite materials are used in making of world’s largest Airbus 360 in which 20% of composite materials are used. The design primarily uses glass fiber reinforced aluminium, a newly developed composite that is 25 per cent stronger than conventional airframe aluminium but is lighter by 20 per cent [34].

2. Literature Review
Soorya Prakash Kumarasamy et al. in 2017 observed that description of a novel hybrid Aluminum Metal Matrix Composite (AMMC) urbanized through two-step compo casting technique by reinforcing steady quantity of fly ash chemosphere (10%) and unreliable amount of graphite (2%, 4% and 6%). Morphological study result shows the attendance of dendrite arms and identical sharing of the chemosphere and graphite in Al 7075 matrix. The hardness and tensile strength up turn with the supplement of chemosphere and vice versa for the supplement of graphite. The reinforcement particles have improved the tensile strength of aluminum matrix from 178 N/mm to 213 N/mm as of the composite is worried. Addition of chemosphere improves the bear resistance significantly and wears rate decreases additional with graphite supplement due to its self-lubricating character. Machine power (turning)
individuality of the urbanized hybrid composite was deliberate in feature moreover optimizing the machining parameters employing Artificial Neural Network (ANN) method. Based on the ANOVA consequences it was established that wounding pace and % of graphite supplement have the main donation in minimizing the surface roughness of urbanized composite [35]. Vipin K. Sharma et al. in 2017 showed that production and tri biological testing of an aluminum fly ash composite. The metal matrix chosen was aluminum and fly ash contents in dissimilar percentages were reinforced in it to produce the necessary metal matrix composite (MMC). Stir casting technique was used to produce the MMC with 2–4–6% mass of fly ash inside in aluminum. Tri biological examination of the tribe pairs shaped connecting the soft surfaces of cast iron disc and flat MMC pin has been careful and friction force and bear of the MMC were examined by using a Pin-on-disc setup. It was experiential that the MMC with 6% influence of fly ash content in aluminum matrix consequences in a smaller amount bear (0.32 g) and 4% mass of Fly ash substance gives the short coefficient of resistance (0.12) connecting the tribe pairs of cast iron surface and MMC surface [36]. However, some researcher works on composite and following work were carried out by them as shown in Table 1.

![Table 1: Some investigation carried out by researchers](chart.png)

### 2.1 Research Gap

The following research gaps identified from the literature review

- Very few researchers used bagasse ash reinforcement with pure Aluminium.
- Very few researchers used bagasse ash and magnesium oxide reinforcement with pure aluminium to develop hybrid metal matrix composite.
- Very few researchers identify the specific strength and thermal expansion of bagasse reinforced composite.
- Very few researchers compare mechanical properties of pure Aluminium/Bagasse composite before carbonized and after carbonized bagasse powder.

### 2.2 Problem Formulation

From the literature, it was observed that bagasse waste from the sugar factory is one of the most environmental problems in India as well as in all over the world. By utilizing this waste product, in the development of composite, this environment problem can be reduced. By utilizing this waste product, the mechanical properties of Aluminium base composite can be increased. By using MgO as secondary reinforcement material, mechanical properties can be further improved.
3. Microstructure and Mechanical Characterization of Composite
The analysis of microstructure determines the point of crystal, reinforcement and a lot of extra structural properties. By investigation of microstructure characteristic and atypical micrographs is obtainable. Many further changes develop into obvious with the assessment of aluminum macrostructure and microstructure which happen concurrently with the icy, homogenization, preheat, hot or cold reduction, annealing, or solution or precipitation heat treatment of the aluminum alloy. Although, it’s not achievable always to get extra in sequence while explanation. Comparative samples with recognized histories are much extra useful in any given understanding. Clarify should begin at usual apparition point and continue to advanced magnification, according to the necessity for an extra comprehensive examination. If the sample region is very tiny then the effect of the microstructure is improved and essentially the position of sample on the microstructure is plays a very significant position. Cost makes visual methods of macro and micro investigation the generally helpful. By microstructure the depth of crystal visions with an electron. Some time it dictates the electron in depth. Electron techniques enhancement and in several cases put back the discriminating use of etchants, and they allow the purpose of micro chemical study, which contributes to extra decisive answers. Examine of breakage surfaces is necessary to decide the form and way of fracture spread. Major graphic description is regularly not observable with the nude eye and it can be seen obviously when it overblown. For an enhanced consequence, the fracture sample should be handled with extremely high-quality care as assessment. Mechanical characterization such as tensile strength, hardness and toughness can be also observed to see the effect of bagasse addition in aluminium alloys.

4. Physical Properties of Composite
Physical properties such as density, porosity and corrosion behaviour of the composite are usually observed. Corrosion of aluminum is usually connected with the stream of electrons flanked by the anode and cathode regions of the material in an electrolyte, as it typically is in electrochemical corrosion of previous ordinary metals. Strength of corrosion depends on the variation of potential of the two regions, which is due to micro and macro structural defects caused by fabrication, welding and other combination methods. The consequence is just enlarging by the dissimilarity in the electrical possible of the alloying materials (alloy is certainly not superlatively homogeneous, so there are micro regions where the alloying material can be originated in little well-built quantities). Due to the anti-corrosion result of the oxide pictures, it is uncommon for consistent corrosion to appearance, and it is extra possible that a number of appearances of localized corrosion occasion are going to happen, typically due to a mixture of electrochemical and mechanical factors. This mainly usually happens in the appearance of mechanically assisted squalor, in which the corrosion procedure is greater than before by pitting, cavitations, erosion and fretting. Localized corrosion can also be caused by stress corrosion cracking (SCC), where we have stationary tension stress in a violent environment, or corrosion fatigue, if many (and stresses) are dynamic. On the previous dispense, while consistent corrosion of aluminum is uncommon, it can happen in extremely acidic or alkaline environments (thus pH values under 4 or over 9 should be avoided). In environments where the oxide pictures can be smashed downwards, such as sodium hydroxide or phosphoric acid, aluminum breaks behind at a permanent rate, depending on the special treatment and warmth of the solution. Depending on
these factors, decay can variety from external surface injure to comprehensive and finish. Consistent corrosion can mainly effortlessly be estimated by measuring the weight or thickness defeat. It’s mostly found that pure aluminum, reduce alloys and non-heat-treatable alloys are mainly ordinary for aluminium alloys. Surface roughness, thickness variations and dissimilar concentrations of alloying elements can alter the material’s surface and make hold back regions of positive and negative ions, which guide to extra limit forms of corrosion. In addendum, if the plane oxide layer is irresolvable in the environment, it leads to limit of weak spots in the pictures where the probability of corrosion is superior to the former regions. As previously stated, these weak are auxiliary partial by the mechanical act. Equally standardized and contained corrosion are electrochemical in the environment, and in the folder of localized corrosion (which is more common), it is caused by a change in the electric potential of the localized area. The main ordinary culprits for this discrepance in possible are cathodic micro constituents establish in the surface coating, such as CuAl₂, FeAl₃ and Si. There are other mechanisms, mainly caused by impurities, inclusions or discrepancy aeration cells. The only category of restricted corrosion that can happen in aluminum that is not electrochemical in life is fretting corrosion, which is a figure of dry corrosion. The main manufactured goods of corrosion are approximately entirely aluminum tri hydroxide (bay rite). While mainly types of corrosion happen in the occurrence of an electrolyte (mainly water), localized corrosion of aluminum typically does not happen in very clean water at ambient temperature. Generally ordinary use of the word, this resources electrochemical oxidation of metal in reaction with an oxidant such as oxygen or sulfur. Rusting, the configuration of iron oxides is a well-known example of electrochemical corrosion. This kind of injuries normally produces oxide(s) or salt(s) of the unique metal and results in a characteristic orange bloom. Corrosion can also happen in materials previous than metals, such as ceramics or polymers, even though in this circumstance, the term "degradation" is extraordinary. Corrosion degrades the helpful properties of materials and structures as well as strength, appearance and permeability to liquids and gases.

5. Conclusions
From the exhaust literature following conclusions can be drawn.
1. Bagasse is a waste product which can be utilized in the development of aluminium based composite.
2. By utilizing bagasse as reinforcement material, mechanical properties can be improved.
3. By utilizing bagasse as reinforcement material, corrosion loss can be reduced.

References
[1] Dora Siva Prasad, Chintada Shoba, Nallu Ramanaiah, “Investigations on mechanical properties of aluminum hybrid composites”, journal of materials research and technology, volume 3 (2013), 79–85.
[2] M. Dhanashkekar, V. S. Senthil Kumar, “Squeeze Casting of Aluminium Metal Matrix Composites- An Overview”, 12th Global congress on manufacturing and management, gcmm, Volume 97 (2014), 412 – 420.

[3] K.R.Padmavathi, Dr. R.Ramakrishnan, “Tribological behavior of Aluminium Hybrid Metal Matrix Composite”, 12th Global congress on manufacturing and management, gcmm, Volume 97, (2014), 660 – 667.

[4] Md. Habibur Rahman, H. M. Mamun Al Rashed, “Characterization of silicon carbide reinforced aluminium matrix composites”, 10th International Conference on Mechanical Engineering, Volume 90, (2013), 103 – 109.

[5] Himanshu Kala, K.K.S Mer, Sandeep Kumar, “A Review on Mechanical and Tribological Behaviors of Stir Cast Aluminium Matrix Composites”, 3rd International Conference on Materials Processing and Characterization, Volume 6, (2014), 1951 – 1960.

[6] Amal E. Nassar, Eman E. Nassar, “Properties of aluminum matrix Nano composites prepared by powder metallurgy processing”, Journal of King Saud University – Engineering Sciences, Volume 29, (2015), 295–299.

[7] Muhammad Rashad, Fusheng Pan, Zhengwen Yu, Muhammad Asif, Han Lin, RongjianPan, “Investigation on micro structural, mechanical and electrochemical properties of aluminum composites reinforced with graphene nanoplatelets”, Progress in Natural Science Materials International, volume 25, (2015), 460–470.

[8] Jaswinder Singh, Amit Chauhan, “Characterization of hybrid aluminum matrix composites for advanced applications”, journal of materials research and technology, volume 5, (2015), 159–169.

[9] Omar S. Salih, Hengan Ou, W. Sun, D.G. McCartney, “A review of friction stir welding of aluminium matrix composites”, Materials and Design, volume 86, (2015), 61–71.

[10] Pardeep Sharma, Satpal Sharma, Dinesh Khanduja, “A study on microstructure of aluminium matrix composites”, Journal of Asian Ceramic Societies, volume 3, (2015), 240–244.

[11] Sefiu Adekunle Bello, Isiaka Ayobi Raheem, Nasir Kolawole Raji, “Study of tensile properties, fractography and morphology of aluminium (1xxx)/coconut shell micro particle composites”, Journal of King Saud University – Engineering Sciences, volume 29, (2015), 269–277.

[12] Pierre-Louis Hereil, Jerome Mespoulet, Fabien Plassard, “Hypervelocity Impact of Aluminum Projectiles against Pressurized Aluminum-Composite Vessel”, Procedia Engineering, volume 103, (2015), 181 – 188.

[13] S. Szczepanik, “Composites of aluminium alloy matrix reinforced by a steel mesh”, Materials Today Proceedings, volume 2S, (2015), S9 – S18.

[14] Ranjib Biswas, Arunanshu S. Kuar, Souren Mitra, “Process optimization in Nd : YAG laser micro drilling of alumina–aluminium interpenetrating phase composite, journal of materials research and technology, volume 4(3), (2015), 323–332.

[15] Ehsan Ghasali, Masoud Alizadeh, Touraj Ebadzadeh, Amir Hossein Pakseresht, Ali Rahbari, “Investigation on micro structural and mechanical properties of B4c–aluminum matrix composites prepared by microwave sintering”, Journal of materials research and technology, Volume 4(4), (2015), 411–415.

[16] Jerome Mespoulet, Fabien Plassard, Pierre-Louis Hereil, Patrick Thiot, “Numerical Investigations of Hypervelocity Impacts on Pressurized Aluminum-Composite Vessels”, Procedia Engineering, volume 103, (2015), 373 – 380.

[17] Sijo M T, K R Jayadevan, “Analysis of stir cast aluminium silicon carbide metal matrix composite A comprehensive review”, Procedia Technology, volume 24, (2016), 379 – 385.

[18] Muhammad Mansoor, Muhammad Shahid, “Carbon nanotube-reinforced aluminum composite produced by induction melting”, Journal of Applied Research and Technology, volume 14, (2016), 215–224.

[19] Sumesh Narayan, Ananthanarayanan Rajeshkannan, “Studies on formability of sintered aluminum composites during hot deformation using strain hardening parameters”, Journal of materials research and technology, Volume 6(2), (2017), 101–107.
[20] Sumesh Narayan, Ananthanarayanan Rajeshkannan, “Hardness, tensile and impact behavior of hot forged aluminium metal matrix composites”, Journal of materials research and technology, Volume 6(3), (2017), 213–219.

[21] Kenneth Kanayo Alaneme, Joshua Ogheneakporobo Ekperusi, Samuel Ranti Oke, “Corrosion behavior of thermal cycled aluminium hybrid composites reinforced with rice husk ash and silicon carbide”, Journal of King Saud University – Engineering Sciences, (2016).

[22] I. Dinaharan, N. Murugan, A. Thangarasu, “Development of empirical relationships for prediction of mechanical and wear properties of AA6082 aluminium matrix composites produced using friction stir processing”, Engineering Science and Technology, an International journal, volume 19, (2016), 1132–1144.

[23] S. Joyson Abrahama, S.Chandra Rao Madane, I. Dinaharan, L. John Baruch, “Development of quartz particulate reinforced AA6063 aluminium matrix composites via friction stir processing”, Journal of Asian Ceramic Societies, volume 4, (2016), 381–389.

[24] V.V. Monikandan, M.A. Joseph, P.K. Rajendra kumar, “Dry sliding wear studies of aluminum matrix hybrid composites”, Resource-Efficient Technologies, volume 2, (2016), S12–S24.

[25] Puneet Bansal, Lokesh Upadhyay, “Effect of Turning Parameters on Tool Wear, Surface Roughness and Metal Removal Rate of Alumina Reinforced Aluminum Composite”, Procedia Technology, volume 23, (2016), 304 – 310.

[26] Matthias Hackert-Oschatzchena, Norbert Lehnert, Andre Martin, Gunnar Meichsner, Andreas Schubert, “Surface Characterization of Particle Reinforced Aluminum-Matrix Composites Finished by Pulsed Electrochemical Machining”, Procedia CIRP, volume 45, (2016), 351 – 354.

[27] J. David Raja Selvam, I. Dinaharan, “In situ formation of ZrB2 particulates and their influence on microstructure and tensile behavior of AA7075 aluminum matrix composites”, Engineering Science and Technology, an International Journal, volume 20, (2017), 187–196.

[28] Zilong Zhao, Qiang Gao, Junfeng Hou, Ziwei Sun, Fei Chen, “Determining the microstructure and properties of magnesium aluminum composite panels by hot rolling and annealing”, Journal of Magnesium and Alloys, volume 4, (2016), 242–248.

[29] J. Allwyn Kingsly Gladston, I. Dinaharan, N. Mohamed Sheriff, J. David Raja Selvam, “Dry sliding wear behavior of AA6061 aluminum alloy composites reinforced rice husk ash particulates produced using compo casting”, Journal of Asian Ceramic Societies, volume 5, (2017), 127–135.

[30] Y.D. Boon, S.C Joshi, L.S. Ong, “Effects of Mechanical Surface Treatment on Bonding between Aluminum and Carbon/Epoxy Composites”, Procedia Engineering, volume 184, (2017), 552 – 559.

[31] Fanghui Jia, Jingwei Zhao, Liang Luo, Haibo Xie, Zhengyi Jiang, “Experimental and numerical study on micro deep drawing with aluminium-copper composite material”, Procedia Engineering, volume 207, (2017), 1051–1056.

[32] A.A. Agbeleye, D.E. Esezobor, S.A. Balogun, J.O. Agunsoye, J. Solis, A. Neville, “Tribological properties of aluminium-clay composites for brake disc rotor applications”, Journal of King Saud University – Science, (2017).

[33] S. Suleiman, Z. Marjom, M.I.S.Ismail, M.K.A.Ariffin, N. Ashrafi, “Effect of Modifier on Mechanical Properties of Aluminium Silicon Carbide (Al-Sic) Composites”, Procedia Engineering, volume 184, (2017), 773 – 777.

[34] Soorya Prakash Kumarasamy, Kavimani Vijayananth, Titus Thankachan, Gopal Pudupulayam Muthukuttib, “Investigations on mechanical and machinability behavior of aluminum/flyashcensosphere/Gr hybrid composites processed through compo casting”, Journal of Applied Research and Technology, volume 15, (2017), 430–441.

[35] Vipin K. Sharma, R.C. Singh, Rajiv Chaudhary, “Effect of fly ash particles with aluminium melt on the wear of aluminium metal matrix composites”, Engineering Science and Technology, an International Journal, volume 20, (2017), 1318–1323.