*International Journal of Research in Engineering and Science (IJRES)*
*ISSN (Online): 2320-9364, ISSN (Print): 2320-9356*
*www.ijres.org Volume 10 Issue 7 ǁ July 2022 ǁ PP. 23-31*

# Chemical and Mechanical Properties of Aluminium and Palm SeedShell Metal Matrix Composite Using Compaction Technique

Dr. G.Punithakumari[1]*, S.Sowmiya[1], P.Karthika[1], R. Priyadharsini[1] & P.Saranya[1]
*Department of Chemistry, Theivanai Ammal College For Women (A), Villupuram, Tamilnadu, India*

***ABSTRACT***
*This investigation presents the development of metal matrix composite using palm seed shell ash as the reinforcement for automobile applications. Test samples were produced of determine physical, mechanical and wear properties and microstructure analysis. The metal matrix composites (MMC's) were prepared by addition of 3, 6, 9 and 12 wt% of PSSA particulates. The resultsof the Micro structural analysis of the composites revealed the uniform distribution of the palm seed shell ash particles. The increase in reinforcement volume fraction resulted in the decrease of matrix grain size in the composites. The result obtained also showed that additions of the palm seed shell ash particlesreinforcement to Aluminum increased the hardness value of composite; it is also observed that, as the applied load increases, the wear rate also increases. This is because, whenever applied load increases, fraction at the rotation disc obviously increases. For optimum service performance of this matrix, palm seed shell ash particles addition should be 15% by weight of PSSA particulates to develop better necessary properties. The research will reduce the cost of reinforcement in metalmatrix composite since palm seed shell are available in large quantities and can be regarded as renewable products. The results that will be obtained in this research can act as a starting point for both industrial designers and researchers to design and develop MMC components using this agricultural waste in the productions of automotive components, which will be a great benefit the world atlarge.*
***Keywords:*** *Matrix, coconut shell, mechanical properties, stir castings, particulate, reinforcement.*

---

Date of Submission: 18-06-2022 Date of acceptance: 02-07-2022

---

## I. INTRODUCTION

Recently, the material scientists are heavily indulged in developing new and advanced material matrix composites all around the globe. Due to exposure of harsh engineering environment a single metal/alloys are failing to achieve the requirements. This initiates the need of fabrication of metal matrix composites with certain specific properties to meet future engineering challenges.

In the last few decades, metal matrix composites have found potential application in aerospace, automobiles, space, defense and structural sectors because of higher specific strength, good wear resistance, higher thermal conductivity than ceramic materials and lower co efficient of thermal expansion etc.

The target properties of composites depend upon combined effect of reinforced particle and fabrication technique. As far as fabrication technique is concerned several techniques are available such as spray deposition, squeeze casting, compo-casting, stir casting and powder metallurgy. The conventional stir casting process involves some major drawbacks like inadequate wet ability between reinforcement and matrix, non-homogeneous distribution, and information of brittle inter metallic compound at the reinforcement and matrix interface.

To overcome these serious draw backs, powder metallurgy can be used because of the following advantages:
(a) Low processing temperature
(b) Homogeneous distribution of reinforcement and matrix particle
(c) Fabrication of near net shaped product

At present, aluminium matrix hybrid composites reinforced with micro and nano particles have gained increased application because of enhanced mechanical and trio biological properties.
The reason of enhancement in properties could be attributed due to the following reasons:

- Incorporation of uniformly dispersed nano particles improves the performance of matrix due to strengthening mechanism.
- Bettermicrostructureandmechanicalpropertiescanbeachievedbychanging particle size from micro to nano level

- Micro particle works as eleton for aluminium matrix and enhances the hardness and wear properties.

However, aluminium reinforced with single ceramic micro particles deteriorates the ductility of composite because of their tendency to crack during loading condition, when their concentration is high in the matrix. Further, in corporating nano-particles enhances the mechanical properties of composites by obstructing dislocation movement and promoting fine grain structure. Therefore, overall enhancement in the performance of composites can be achieved by reducing the concentration of micro particles and increasing the number of nano particles to get synergistic improvement in mechanical and ribological properties. Thus, the main objective of this research work is to fabricate aluminum matrix composite through conventional and non-conventional sintering process, when they are reinforced with combinations of micro nano silicon carbide, micro silicon carbide and nanozirconia,and zirconia and micro graphite particles. For all the fabricated combinations the morphological, physical, and wear properties of the composites were studied. The wear behavior of the composites was performed using pin-on-disc wear tester.

A parietal, has studied the effect off Al-Fe-Si reinforced with coconut shell ash using stir casting method and found that presence of reinforced particles increases the hardness by increasing the percentage of reinforcement particles and increase in the wear resistance of the material.[1].

Alanemeetal.investigatedthefabricationcharacteristicsandmechanicalbehaviourofAl-Mg-Sialloy matrix composites reinforced with alumina (Al2O3) and RHA [2].This was aimed of developing high performance All matrix composites at reduced cost. The results shown that the less dense Al-Mg-Si/RHA/Al2O3hybrid composites have estimated percent porosity levels as low as the single Al2O3 reinforced grade <2.86%porosity.reported that the RHA is an important source of silica and it can be added in Aluminium metal. [3].The author further observed that by successful addition of rice husk ash in molten metal the mechanical properties of composites can be improved. Investigated the micro structural characteristics ,mechanical and wear behavior of Aluminium matrix hybrid composites reinforced with alumina, rice husk ash and graphite. [4].Hardness decreased with increase in the weight ratio of RHA and graphite in the composites and with RHA content greater than50% ,the effect of graphite on the hardness became less significant.The tensile strength for the composites containing 0.5 wt .% graphite and upto50% RHA was observed to be higher than that of the composites without graphite. However, the wear resistance decreased with increase in the graphite content from 0.5 to 1.5. VijayaKumar Rajuetal. Investigated the tribological behavior of an Al–5-wt.%Cu alloy, Al–10 -wt. % Cu alloy (hypo eutectic alloy),and an innovative composite combination of an Al–5-wt % Cu alloy as the matrix and a 5-wt% Cu powder as the reinforcement fabricated using stircasting method. [5].The wear and frictional properties of the metal matrix composites was studied by performing dry sliding wear test using a pin-on-disc wear tester and Taguchi's L9 Orthogonal array was selected for analysis of the data.Wear rate of the composite was found lower when compared to both the alloys.

Dora.et.al.investigated he mechanical properties of aluminium hybrid composites reinforced with various volume fractions of 2,4,6,and 8 wt % RHA and SiC particulates in equal proportions. [6].Properties such as hardness,density,porosity and mechanical behaviour of the unreinforced and Al/x % RHA/ x % SiC (x=2,4,6,and8wt%) reinforced hybrid composites were examined. It was observed that the hardness and porosity of the hybrid composite increased with in creasingre in forcement volume fraction and density decreased with increasing particle content.It was also observed that the ultimate tensiles trength and yield strength increase with an increase in the percent weight fraction of there inforcement particles,where as elongation decreases with the increase in reinforcement. Lakshmi kanthan and Prabu investigated the mechanical and tri-biological properties of aluminium alloy Al-Coconut Shell Ash (CSA) MMC synthe sized by stir casting. [7].Using this method, varied weight percentage 3%, 6%, 9%, 12%and 15% of CSA particles are successfully introduced in the aluminium alloy to produce different mixtures of composite. The characterization of the composites was carried out using scanning electron microscopy, EDAX, tensile test, hardness test and wear test .The results showed the good dispersion of CSA particles in the aluminium alloy matrix and that mechanical and tribological properties of composites are better at alower amount of CSA reinforcement. Alanemeetal. Investigated the fabrication characteristics and mechanical behavior ofAl-Mg-Si alloy matrix composites reinforced with alumina(Al2O3)and RHA [8]. This was aimed of developing high performance Almatrix composites at reduced cost. The results shown that the less dense Al-Mg-Si/RHA/Al2O3hybrid composites have estimated percent porosity levels as low as the single Al2O3reinforced grade. Lakshmikanthan and Prabu investigate the wear and electrochemical corrosion behavior of Al-CSA composites with varying weight percentages of CSA reinforcement have been investigated . [9]. A pin on disc apparatus was used to characterize the wear resistance of the prepared composite specimens. Open-circuit corrosion potential(OCP) and potentio dynamic polarization measurements (PDP). were used to study the corrosion behavior of preparedAl-CSAcompositesin3.5%NaClsolution.ThecharacterizationwasperformedthroughEDSandSEM.The wear rate of the composites decreased with increase in wt.-% of the CSA. It was observed that with an increase in CSA, the coefficient of friction and friction force of the composites increased. The composites produced have better corrosion resistance than the base matrix aluminum alloy Al. Yekinni et al studied; rice husk ash/alumina, rice husk ash/silicon carbide, ricehusk ash/fly ash and rice husk ash/bagasse . [10]Based on the database for material properties, the application area of HAMCs has been proposed in the present review. It has been concluded that the hybrid composites offer more flexibility and reliability in the design of possible automotive components depending upon there inforcement's combination and composition.As a result of some observables in the properties of rice husk ash, it is recommended that low concentration rice husk ash reinforcement could be used to solve the dispersion challenges of graphene in molten aluminium to produce hybrid composites free of harmful in term etallic compound like aluminium carbide[11]. Management of most agro wastes could be overwhelming and the best approach remains to explore more recycling techniques and then applications where recycled wastes can be productively utilized[12]. This work is part of current efforts. aimed at considering the potentials of a wide range of agro waste ashes for thedevelopmentoflowcost-highperformanceAluminiumbasedcomposites[13].These low-cost composites could have potentials for use in stress bearing and wear applications among others[14]. PSSA is silica enriched agricultural waste. The Objective of the present work is to develop low cost and high-performance Almatrix composites with the use of PSSA as reinforcements and mgasacouplingagent.[15] Microstructural characteristics of PSSA and mechanical properties off abricated Al matrix composites were investigated[16].

## II. MATERIALS AND EXPERIMENTAL

In this work, different aluminium matrix composites have been fabricated through powder metallurgy technique. Natural reinforcement particles namely palm seedshell ash (PSSA) used as reinforced in aluminium matrix.

### MATERIALS ALUMINIUM POWDER

Aluminium powder (99.9% pure) was procured from Otto Chemicals ltd. Mumbai (India).The average particles size (APS) range was10μm.The photocopy of Aluminium powder is shown in Figure.


**Figure 1. The photocopy of Aluminium powder**

### PALM SEED SHELL ASH

Palm seed shell ash was used as reinforcement, the photocopy image shows produced PSSA particles and SEM of as-received particles are shown in **Figure 2 (a&b)**

**Figure 2. The photocopy of Aluminium powder**

**PREPARATION OF PSSA**

The coconut shell ashes are prepared by this following step:

1. The Palm seed shells are collected from the nearer village

**Figure 3. Palm seed shells**

2. The fibers of Palm seed are cleaned by using emery sheet
3. Cleaned Palm seed shells are dried in sunlight for 48 hours
4. Dried Palm seed shells should be burned in the fire at clean space and open atmosphere
5. Palm seed ashes are collected after the complete burning
6. The collected ash is sieved by using different size sieve to get a particlesize of less 125 micron.

**SAMPLE PREPARATION**

The size distribution of the reinforcing particles was measured using particle size analyser and shown in Fig.2.1. For the analysis, the following combination of composites were fabricated.

1. Pure Al
2. Al+ 3% PSSA
3. Al+ 3% PSSA
4. Al+ 3% PSSA
5. Al+ 3% PSSA

The composites were fabricated through powder metallurgy technique. Firstly, the predetermined amount of elemental powders was weighed by using a digital weighing machine) having a least count 0.0001 g. The powders were thoroughlymixed using a ball mill stainless steel balls with a ball to powder weight ratio of 10:1 to achieve homogenization and to reduce the agglomeration of particles. Themilling time and speed were 15 min and 100 rpm, respectively. In the next stage,the mixture of powders was compressed in a uniaxial hydraulic pallet press at 585MPa to obtain green compacts of 10 mm diameter and a height of 10 mm. The die wall was lubricated manually using zinc stearate before every compaction process. The compacted samples were sintered at 450-470 0C for 60 min. in a tubular furnace over argon atmosphere (flow rate = 1.0 liter/min.), to avoid oxidation of aluminium matrix. The sintered samples could cool to the room temperature in the furnace itself.

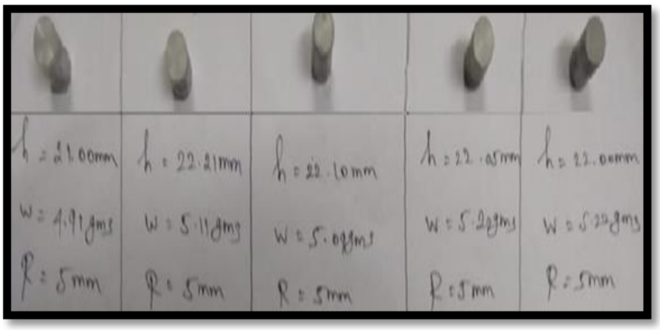



**Figure 4. Prepared Al and Al-PSSA composite specimens**

The density of the samples was measured using Archimedes principle. The measured density was compared to the value obtained using rule-of-mixture to find out the porosity. The samples were weighed by using a digital weighing machine (Precisa, Swiss Made, ES 225SM-DR) having a least count 0.001g. The hardness of sintered composites were carried out by using a Digital Rockwell hardness tester (TRB-250 DM) with a steel ball of diameter of 1/8” and a load of600 N (Scale H). The tests were performed at room temperature (i.e. 30 0C) andreadings of hardness were taken at five different locations on every sintered sample to find the mean hardness value. The EDS analysis of all the sintered composites was performed.

## III. RESULT AND DISCUSSION

The primary aim of this research was to evaluate the possibilities of developing aluminium based composites material for automobile application from palm seed shell ash particles using powder metallurgy method.
The following conclusion can be drawn from the study:
1. Preparation of Al-PSSA composites by powder metallurgy techniques is successful during the research work. Composite are produced by varying thecomposition of the reinforcement material. The composition of prepared composites is: Al, Al + 3 % PSSA, Al + 6 % PSSA, Al +9 % PSSA, Al+123 % PSSA.
2. Hardness is enhanced for Al -PSSA composite due to the presence of hard ceramic and oxides particles in the reinforcement.
3. The wear of the composites increases gradually with the increase in amountof reinforcement. The reason for this trend may be due to increase in the amount of debris for the composites during the also abrasive in nature. EDS analysis confirms the presence of silicon carbide particles in composites prepared by both
The technique and uniform distribution of reinforcement material can be seen from the micro structural analysis.

**DENSITY**

Figure 5 and Table.1 shows the variation of density measurements. The density experiment has been carried out using Archimedes principles, from the result it has been observed that density of composites increases by the addition of PSSA particles. The reason of enhancement in the density is due to the addition of higher density reinforcements in the aluminium matrix.

**DENSITY (g/cm3)**

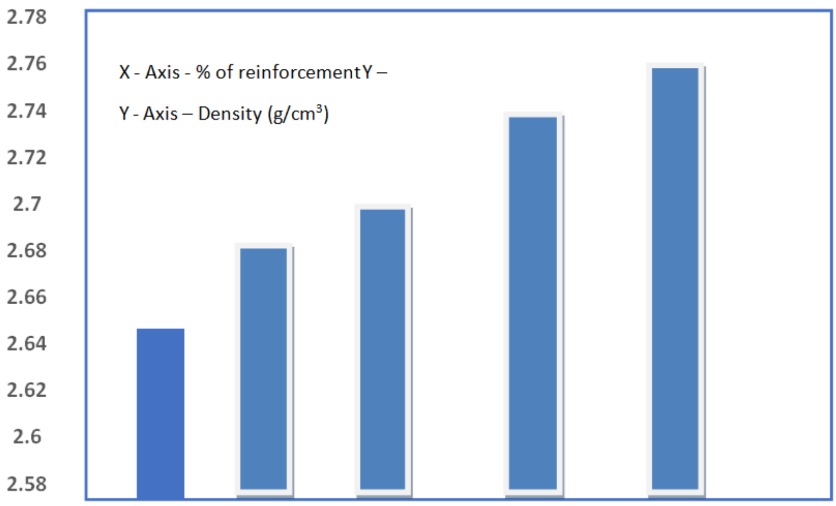



Figure 5. shows density measurements of Al and Al-PSSA composite

| Si.No | Al | Al- 3%PSSA | Al- 6%PSSA | Al- 9%PSSA | Al- 12%PSSA |
|---|---|---|---|---|---|
| Density(g/cm3) | 2.65 | 2.68 | 2.7 | 2.73 | 2.76 |

Table .1 shows density measurements of Al and Al-PSSA composite

**HARDNESS MEASUREMENT**

**(ROCKWELL HARDNESS NO)**

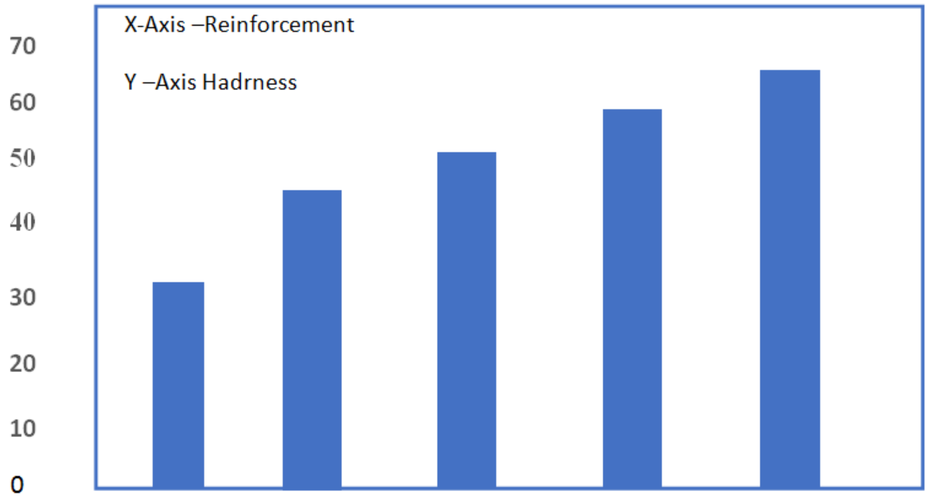



Figure 6. shows density measurements of Al and Al-PSSA composite

| SI.No | Al | Al-3%PSSA | Al-6%PSSA | Al- 9% PSSA | Al-12%PSSA |
|---|---|---|---|---|---|
| Rockwell hardness no. | 30 | 46 | 5<br>2 | 56 | 62 |

Table. 2 show hardness measurements of Al and Al-PSSA composite.

The Figure 6 and Table.2 represent the hardness measurement of the prepared Al and Al-PSSA composite. From the obtained data, the fabricated composite has better hardness value than the base Aluminum (Al). The hardnessof the composite increases linearly in hardness up to 12% and the specimen Al- 12% PSSA have more hardness compared to other Al-PSSA composite specimen

**WEAR MEASUREMENTS**

**WEAR (gm)**

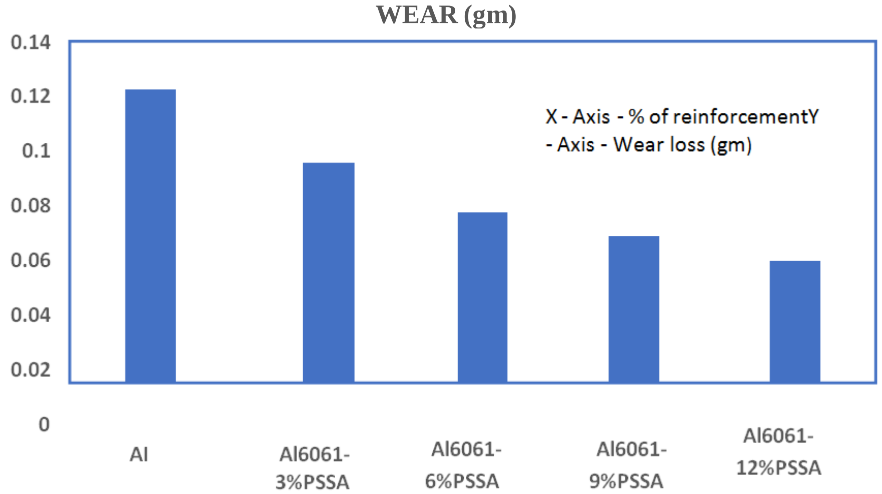



Figure 7 shows wear loss of Al and Al-PSSA composite

The variation of wear loss of the pure aluminium along with synthesized composites is shown in Figure. 6.3. The wear loss decreases by the increase in PSSA addition. The wear loss of produced composites is lower than the pure aluminium. The considerable improvement in the wear properties can be attributed to the hardness provided by reinforcement particles.

From the graph it can be concluded that at high load the wear loss is greaterand vice versa. Furthermore, composites reinforced with 12% PSSA shows higher wear resistance than other composites. This can be attributed because of hard ceramic and oxide particles presence in PSSA is acting as a load bearing element. During sliding condition oxidation of specimen surface cannot beavoided and these oxide layer forms a layer on the specimen surface. In this developed oxide layer distortion, spelling and fracture takes place during sliding condition.

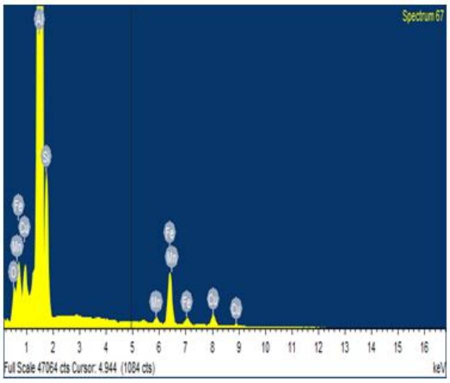
When the load increases all the oxide layers are not completely. removed from the rubbing surface, some amounts present between the mating surfaces offers wear resistance due to the dilution of metallic contact of the surface. But as the load exceeded a certain value severe wear loss is observed in all composites because gross damage occurs at rubbing surface.

**MORPHOLOGICAL STUDY**

Figure.8(a) and 8(b) shows the energy dispersive spectroscopy (EDS) analysis andthe corresponding microstructure of the synthesized composite. Al, Si, Fe, Mg,cuZr,C and O peaks are observed in the EDS analysis. So, EDS analysis confirms that PSAA particles consist of hard ceramic and oxide in the synthesized composites.

Figure 7(a) and 7(b)shows EDS analysis ofAl-6%PSSAandAl-12%PSSAcomposite

**SCANNINGELECTRONMICROSCOPEANALYSIS**



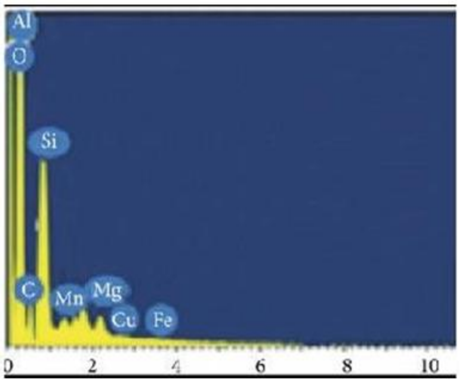
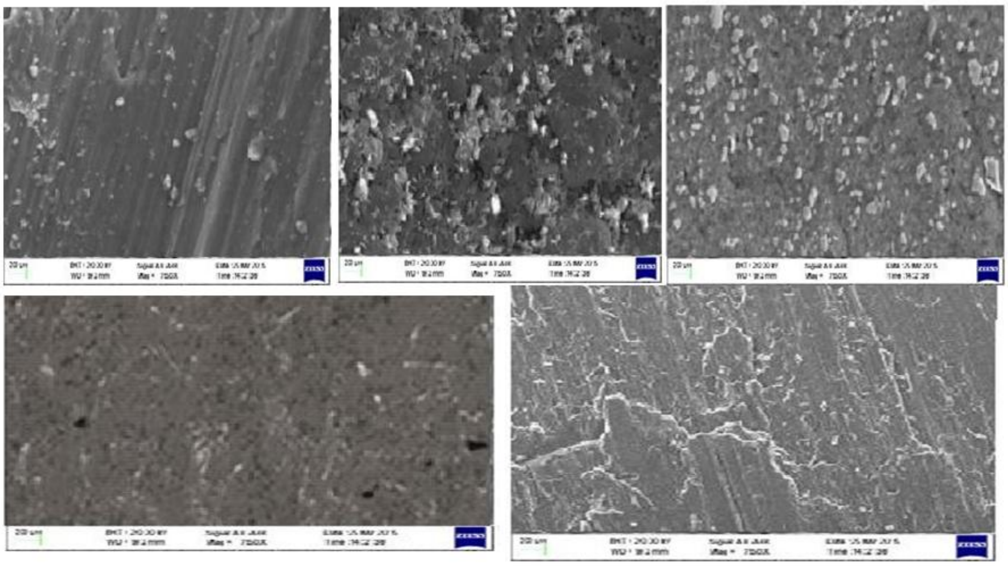




Figure8 shows the micro structural analysis of the micro structural analysis composite prepared by compaction methods. A homogeneous dispersal of PSSAis noticed visibly in Figure 8 without cavities and gaps [19]. Figure 6(b) shows the presence of eutectic silicon $\alpha$-Al phase precipitation and stated that prospective ceramic sparticles have an intensity to cause consistent growth due to then ucleation system as seen in Figure 8(b, c). The addition of reinforcing agent ledto the building of the silica-rich layer at the matrix margin.

Fig.8 (a)Al(b)Al -3%PSSA (c) Al -6% PSSA (d) Al -9% PSSA and (e) Al-12% PSSA composite



## IV. CONCLUSION

The primary aim of this research was to evaluate the possibilities of developing aluminium based composites material for automobile application from palm seed shell ash particles using powder metallurgy method. The following conclusion can be drawn from the study: Preparation of Al-PSSA composites by powder metallurgy techniques is successful during the research work. Composite are produced by varying the composition of the reinforcement material. The composition of prepared composites are: Al, Al + 3 % PSSA, Al + 6 % PSSA, Al +9 % PSSA, Al+123 % PSSA. Hardness is enhanced for Al -PSSA composite due to the presence of hard ceramic and oxides particles in the reinforcement. The wear of the composites increases gradually with the increase in amountof reinforcement. The reason for this trend may be due to increase in the amount of debris for the composites during the also abrasive in nature. EDS analysis confirms the presence of silicon carbide particles in composites prepared by both the technique and uniform distribution of reinforcement material can be seen from the microstructural analysis.

## REFERENCES


[1]. Apasi, A.,D. S. Yawas, S. Abdulkareem, and M. Y. Kolawole."Improving mechanica lproperties of aluminium alloy through addition of coconutshell-ash."Journal of Science and Technology (Ghana)36,no.3(2016):34-43.

[2]. Alaneme, Kenneth Kanayo, and Kazeem Oladiti Sanusi."Microstructural characteristics, mechanical and wear behaviour of aluminium matrix hybrid composites reinforced with alumina, ricehuskash and graphite." Engineering Science and Technology, an InternationalJournal18,no.3 (2015):416-422.

[3]. Pydi, P. H., Prasad, H. K. R., Abburi, M. R., Murthy, B. S. N.,Sivaparsad, D. (2012) "Scanning Electron Microscope Studies On Dry Sliding Wear Behavior Of Metal Matrix Composites With Aluminium And Rice HuskAsh",International Journal of Integrative sciences, Innovation and Technology. Sec. B,Vol. 1,Issue2,pp1-51

[4]. AlanemeKK,Akintunde IB, Olubambi PA,AdewaleTM,(2013),"Fabrication characteristics and mechanical behaviour of rice husk ash – AluminareinforcedAl-MgSi alloy matrix hybrid composites",JournalofMaterialsresearchand Technology,Vol2,Issue1,pp 60-67.

[5]. Vijaya Kumar Raju P, Rajesh S, Babu Rao J, Bhargava N.R.M.R.,(2018), " Tribological behavior of Al-Cu alloys and innovative Al-Cu metalmatrix composite fabricated using stir-casting technique" , Materials Today:Proceedings5,pp.885–896.

[6]. DoraSivaPrasad,ChintadaShoba,NalluRamanaiah,(2014),"Investigations on mechanical properties of Aluminium hybrid composites",journalofmaterialresearchand technology,Vol3,Issue1,pp 79–85.

[7]. P.Lakshmikanthan, Dr. B. Prabu ―Mechanical andTribologicalbehaviour of Aluminium Al-Coconut Shell Ash composite using Stir CastingPelletmethod‖,Journalofthe Balkan TribologicalAssociationVol.22.

[8]. KenethKanayo,AlanemeandKazeemOladitiSanusi,(2015),"Microstructural characteristics, mechanical and wear behaviour of Aluminiummatrix hybrid composites reinforced with alumina, rice husk ash and graphite",EngineeringscienceandTechnology,Vol18,pp 416- 422.

[9]. Purushothaman,Lakshmikanthan,andPrabuBalakrishnan."Wearandcorrosion behavior of coconut shell ash (CSA) reinforced Al6061 metal matrixcomposites."MaterialsTesting62,no.1 (2020):77-84.

[10]. Yekinni,A.A.,M.O.Durowoju,J.O.Agunsoye,andL.O.Mudashiru. "Effect of particle size of rice husk ash on aluminium/graphenecomposites." In IOP Conference Series: Materials Science and Engineering, vol.805,no.1,p.012012.IOP Publishing,2020.

[11]. J. Allwyn Kingsly Gladston, N Mohamed sheriff, I Dinaharan, J DavidRajaSelvam,(2015),"Productionandcharacterizationofrichhuskashparticulate reinforced AA6061 aluminium alloy composites by compocasting",Transactions of Nonferrous Metals Society of China, Volume 25, Issue 3, pp 683-691.

[12]. SiddabathulaMadhusudan,MohammedMoulanaMohiuddinSarcar,NarsipalliBhargavaRamaMohanRao,(2016),"Mechanicalpropertie sofAluminiumCopper(p)compositemetallicmaterials",JournalofAppliedResearchandTechnology,Vol14,pp293–299

[13]. Vipin K. Sharma, R.C. Singh , Rajiv Chaudhary, (2017), "Effect offlyash particles with aluminium melt on the wear of aluminium metal matrix composites", Engineering Science and Technology, an International Journal 20,pp.1318–1323.

[14]. Siddhartha Sarkar, Aniket Bhirangi, JoelMathew, R.Oyyaravelu, KuppanP, A.S.S.Balan,(2018),"Fabrication characteristics and

mechanical behavior of RiceHusk Ash-Silicon Carbide reinforcedAl-6061 alloy matrix hybrid composite",Materials today :Proceeding,Vol5,Issues5,part2,pp12706-12718.
[15]. KylmaJ,SeppalaJV.Synthesis and characterization of a bio degradable thermoplastic poly(ester-urethane)elastomer,Macromolecules1997,30,2876–82
[16]. Lodha P, Netravali AN,Characterization of stearic acid modified soyprotein isolate resin and ramie fiber reinforced 'green' composites, ComposSciTechnol2005,65,1211–25
[17]. WangS,Jane JL, Morphology and mechanical behavior of engineering soyplastics.
[18]. Wollerdorfer M, Bader H, Influence of natural fibres on the mechanical properties of biodegradable polymers,Ind Crop Prod 1998,8, 105–1
[19]. Yu T, Ren J, Li S, Yuan H, Li Y, Effect of fiber surface-treatments on the properties of poly (lacticacid)/ ramiecomposites,Compos,PartA: Appl Sci Manuf 2010, 41,499–505.
[20]. R. Siva Sankara Raju, M.K. Panigrahi, R.I. Ganguly, G. Srinivasa Rao, Tribological behaviour of al-1100-coconut shell ash (CSA) composite at elevated temperature, Tribology International129 (2019)55–66