A review on Effects of reinforcements on properties and wear behaviour of aluminium metal matrix material.

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Abstract

Mechanical properties are the main cocern of today's aerospace ,automotive and general engineering applications. The failure caused due to the poor mechanical properties and wear of aluminum and its alloys is one of the main problems in aluminum industry. The addition of reinforements taken a solution for this problem.The mechanical properties of matrix are strengthened by reinforcing particles, fibers and whiskers. Wear is one of the predominant factors and wear resistance can be improved by increasing the hardness of matrix material with reinforcement additions. addition of reinforcements, either single or multiple which improves properties of matrix. Aluminium based metal matrix composites have been widely used in various applications such as automotive, defense, marine, electronics and automobile sectors because of its excellent mechanical properties and better resistance to wear and corrosion. This paper presents a review on the effect of single as well as multiple reinforcement addition on mechanical and wear properties of aluminium based metal matrix composites.In this paper fabricating methods of Al-MMCs like sqeeze casting,stir casting,metal metallurgy were mentioned.The summary on limitation and findings are stated in the table form.research gaps and future trends of Al-MMCs are also discussed.

Key words: Aluminium metal matrix, composite,Hybrid composite,Reinforcement,Metal matrix composites,Aluminium alloy,wear,mechanical properties.

1.Introduction

Composite is defined as a material which consists of two or more physically and chemically distinct parts which are suitably arranged and are having different properties with respect to those of each constituent part[1]. Composites can be catagorized into, Metal-Matrix Composites (MMC),Ceramic Matrix Composites (CMC) and Polymer-Matrix Composites (PMC). Among these, MMCs has an advantage over other composites because of their ability to resist high temperatures, moisture, radiation and zero outgassing at vacuum, thermal and electrical conductivities, enhanced mechanical properties[2],[3].

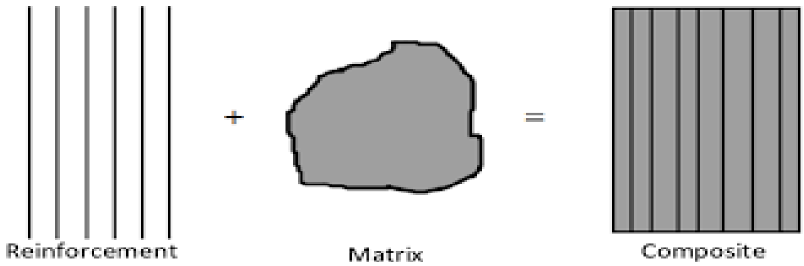


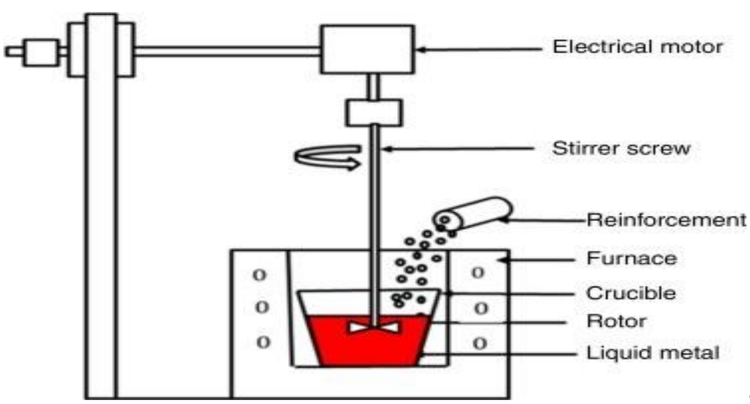
Fig 1.0 scheme of reaction between matrix and reinforcement

In today's time, MMCs became one of the most significant advanced materials utilized for defence, automotive, aerospace and general engineering applications. Matrix is a continuous phase of a composite which holds the reinforcement together and enhance the properties of resulting composite.There are various matrix materials (Al,Ti, Mg, Cu and Fe) available for MMCs. Among this matrix materials, aluminium and its alloys are widely used to produce MMCs.

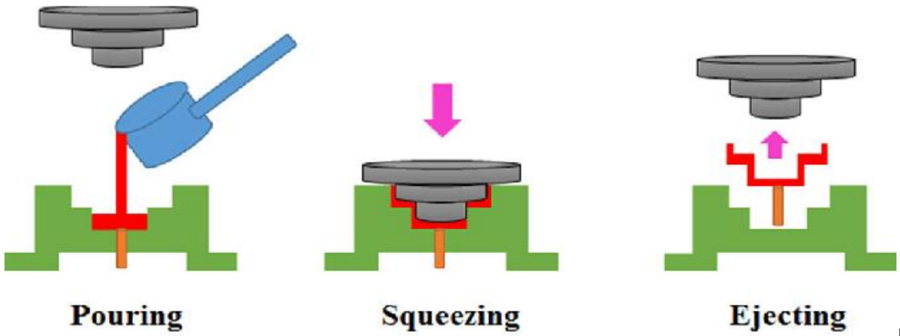
Aluminium metal matrix composites (Al MMCs) account for about 70% by mass of metal matrix composites (MMCs) produced annually and used for industrial purposes. This is so as a result of their outstanding physical, mechanical and tribological properties [4].

Al MMCs have been given preference over other frequently used aluminium alloys in recent times as a result of their excellent strength-to-weight ratio,better mechanical properties.

Aluminium matrix composites have been fabricated using many casting and other processes. Among all these manufacturing process, casting is the most economical and viable method to produce to composites [5]. Among casting processes, stir casting and squeeze casting are the most economical methods to produce near net shaped components with good surface finish,minimum porosity, superior mechanical properties with minimal post processing operations[6].



a)



b)

Fig 1.2:A schematic of a) stir casting process b) squeeze casting process

In the stir casting process of composite manufacturing the reinforcement is introduced into molten metal by stirring. Stir casting process generally involves producing a melt of the selected matrix material, followed by the introduction of a reinforcing material into the melt and obtaining a suitable dispersion through stirring.finally mixture is solidified and composite is resulted.

Squeeze casting is a process that combines gravity and pressurized casting. In general, molten metal is poured into a pre-heated die. When filling is complete, a ram is used to slowly apply high pressure to the molten metal head. This pressurization helps ensure that metal flows throughout the solidifying casting, minimizing shrinkage and microshrinkage porosity. When combined with a controlled cooling step, this process can produce a very fine microstructure.after cooling completed upper die is open and the desired shape is out.

2.Effect of reinforcements on mechanical properties of Al-MMCs

Reinforcement is a discontinuous phases of composite materials that are embedded in a continuous phase (matrix) of composite. It may be particle, fiber or whisker form[7].Mechanical properties are the main cocern of today's aerospace ,automotive and general engineering applications.So,the mechanical properties of aluminium based metal matrix composites are enhanced by using reinforcements.reinforcements are usually non-metallic and are commonly ceramic. The type, nature, volume (%),weight(%), shape and size of reinforcements are critical factors in the enhancement of mechanical properties of Al MMCs.

And also fabrication temperature,pressure,speed (RPM),and duration of time are factors that should be considered during fabrication method.the reinforcements which are added to the matrix (aluminium or its alloy) may be single or multible reinforcements[8].

A single reinforced Al-MMC is formed when only one ceramic particles are reinforced with aluminum.Single reinforcements like Al_2O_3,Mgo ,SiC,TiC,B_4C,AlC,e.t.c [9],[10]. When minimum two reinforcements exist within the matrix,multiple-reinforced AMCs are formed.Multiple reinforcements like Al_2O_3-Gr, TiO_2-CuO, Ti-SiC, e.t.c [11], Miranda, Buciumeanu [12].

Table 1: Mechanical properties of aluminium based metal matrix composites [2]

Base alloy	Reinforcement	Reinforcement wt% (or) vol%	Manufacturing proces	Hardness	Ultimate Tensile strength
LM6	Steel fibers	0, 2.5, 5 and 10 wt%	Squeeze casting	72BHN	164 MPa
A356	Al2O3particles	1.5 vol%	Stir casting	120–135 BHN	265 MPa
2020 Al alloy	Al2O3particles	30 wt%	Stir casting	120–140 BHN	100–120 MPa
Al	AlN particles	50% vol%	Squeeze casting	120-130BHN	154 MPa
Al6061	WC particles	3 wt%	Stir casting	71VHN	615 MP
Al6063	Wet grinder stone	10 and 20 wt%	Stir casting	44 – 48 VHN	145–160 MPa
Al	Stainless steel wires	40 vol%	Squeeze casting	140 to 1090 VHN	450 – 500 MPa
AA6061	Fly ash	4, 8 and 12 wt%	Compocasting	100–120 VHN	210 – 250 MPa
Al2024	B4C particles	3,5,7 and 10 vol%	Stir casting	93.070 BHN	200 – 250 MPa

Mechanical properties are physical properties that a material exhibits upon the application of forces. Examples of mechanical properties are the modulus of elasticity ,stiffness,toughness, tensile strength, elongation, hardness and fatigue limit. when we see the shape of reinforcement particles mostly rectangular shaped particle reinforcements are better in strain hardening and stiffness than other shapes.square shape is preferred next to rectangular and and it is followed by triangular and round or circular shaped respectively[13],[14].

Lu et al.[15]investigate effect of the metallic powder (Zr and Fe) and SiC particles on 7075Al.The result of researchers shows that mechanical properties of the SiC/7075Al hybrid composite improved significantly with the addition of Zr particles. The ultimate tensile strength, fracture failure and Young's modulus of the AMC-Zr composite are 564 MPa, 1.05% and 151.3 GPa, respectively. However, the addition of Fe particles have an opposite influence on the mechanical properties of the composites. By contrast, the hard and brittle Fe-Al interfacial layers in the AMC-Fe composites tend to provide sites for crack nucleation and propagation, which is harmful for the mechanical properties of the composites.

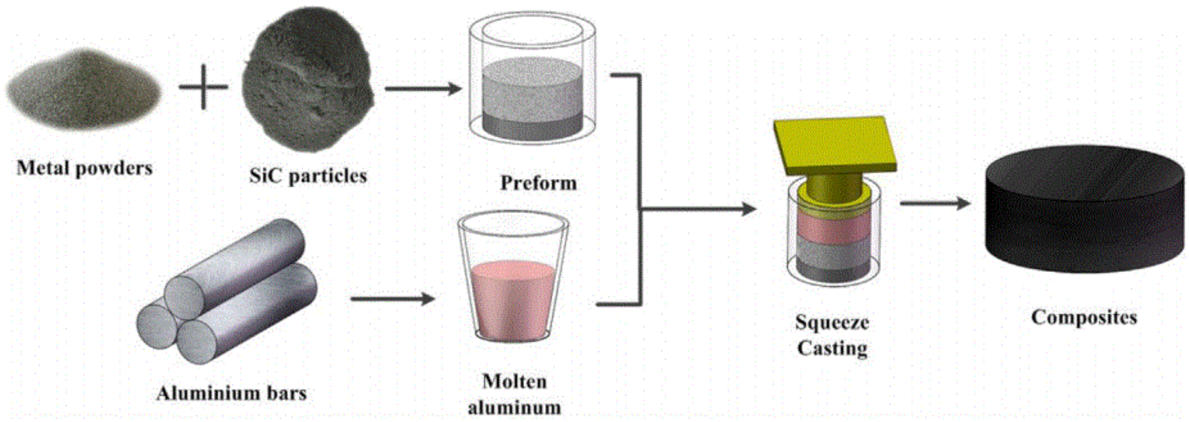


Fig 1.3: Schematic diagram of fabricating process for 7075Al hybrid composites.

The authors use digital microhardness nanoindenter, tensile testing machine,and transmission electron microscope(TEM) to test mechanical properties. but the authors didn't noticed that the negative impact behind Fe particle on hybrid composite and the mechanical tests were at constant strain and room temperature,so temperature effect didn't considered.An other gabs of the authors is that optimization of parameters like die coat material(lubricant),delay time to achieve maximum pressure during squeezing, punch temperature, duration of pressure application are not considered.This missed parameters leads to wrong result and conclusion and also have significant effect on the investigation.

2.1 Hardness

Hardness is a measure of the resistance to localized plastic deformation induced by either mechanical indentation or abrasion. Hardness of the composite depends on the particulate reinforcements.The hardness of the MMCs is measured on the polished sample using Zick/Roll Micro hardness tester.

The hardness test can be conducted on Brinell hardness machine,Rockwell hardness machine or vicker hardness machine.the indenter which transmits the load to the test piece ,varies in size and shape for different tests.common indenters are made of hardened steel or diamond.The specimen may be cylinder ,cube ,thick or thin metal sheet.by calculating hardness value we can get hardness of Al-MMCs.The formula to calculate hardness value is expressed as bellow.

$$HB = \frac{2P}{\pi D\left(D - \sqrt{D^2 - d^2}\right)}$$

where,HB= Brinell Hardness Number (kg/mm^2)

P=applied load in kilogram-force (kgf)

D=diameter of indenter (mm)

d=diameter of indentation (mm), pi=3.14

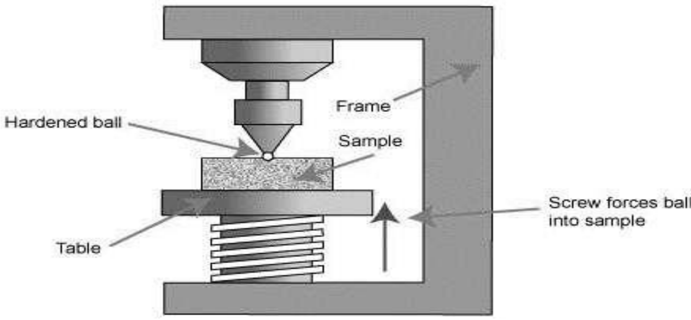


fig 1.4 schematic of Brinell Hardness testing machine

Inserting the specimen of the resulted composite between the supported table and hardened ball and apply the load of indenter by rotating the jack screw adjustable wheel,and remove the specimen and look the indentation with microscope,measure diameter,d by micrometer fitted on microscope.

According to the rule of mixtures (ROMs) the hardness of the composite calculated as

$H_c=H_m.f_m+H_r.f_r$..............................[16]

Where **H_c**, **H_m** ,and **Hr** stand for hardness of the composite, matrix, and reinforcement,respectively ,and **f_m** and **f_r** represent the volume fraction of The matrix and reinforcement,respectively.

But as the researchers show on their paper when they use this formula only nano size and very small volume fraction is analyzed.

Kok [17]Studied the effect of particle size and weight fractions of Al2O3 reinforced 2024 aluminium alloy processed by stir casting and squeeze casting process. Particle size (16, 32 and 66µm) and wt% (10, 20 and 30) of reinforcement were varied in experimental work. The author's results revealed that reinforcement of hard Al2O3 particles improved the hardness and tensile strength of composites compared to matrix.Hardness and tensile strength of composites increased with increasing wt% of reinforcement and decreasing particle size.

The author uses Brinell Hardness testing machine for measuring hardness value of the resulted composite.but the author did't consider the optimization of temperature effect(up to what extent positive result is revealed) and the effect of stiring or mixing speed during fabrication process.This missed parameters have a significant effect on final result.And an other limitation of the author's investigation is that expiremental density measurement is based on archimedian principle by cutting small pieces of cylindrical composite and trial methods which results less accuracy and wrong coclusion.

2.2 fracture toughness

Fracture toughness of a composite material is a property which describes the ability of a material containing a crack to resist fracture, and is one of the most important properties of any material for many design applications.

It has been reported from various researches that the presence of the Bamboo leaf ash (BLA) and Rice husk ash (RHA) in the aluminium matrix composites(AMCs) and hybrid aluminium matrix composites(HAMCs) increase the fracture toughness properties of the composites; it might be due to the presence of silica (SiO2) particles in these compounds.

The crack propagation resistance (fracture toughness) of the composites was determined using a simplified fracture mechanics approach based on uniaxial tensile testing of circumferential notch tensile (CNT) specimens. The specimens were then subjected to tensile loading to fracture using an instron universal testing machine. fracture toughness (KIC) evaluated using the relation.

$$K_{IC} = \frac{P_f}{(D)^{\frac{3}{2}}\left[1.72\left(\frac{D}{d}\right) - 1.27\right]}$$ ....[18]

Where ,D=specimen diameter,

d=notch diameter,

p_f=fracture load

in this study researchers didn't consider the effect of each variable during the test rather they set the value of variable at once and performed the test.This may leads to wrong coclusion.And also researchers didn't use optimization of the variables(up to what value of variables the positive result is revealed).

Alaneme, Bodunrin [18] in their research on hybrid aluminum based composites observed that the fracture toughness can be enhanced by increasing the content of bamboo leaf ash(BLA) in the Al/SiC/BLA hybrid Composite.

The authors result show that the fracture toughness of the composite is increased as compared to Al matrix alone due to the chemical composition of bamboo leaf ash(BLA) that contains refractory oxides such as,aluminium oxide,iron oxides,and silicon oxides that are better and attractive reinforcements for fracture toughness. But the authors didn't reveal how the bamboo leaf ash prepared specifically for this matrix materials and how much amount of ash is added to the Al matrix to enhance fracture toughness.and an other limitation of the authors is that they didn't consider temperature effect at each stage of composite fabrication such as pouring stage. and the authors also did't show the effect of each component of ash composition (oxides).

This limitations are leads to wrong conclusion of the result.

Ravesh and Garg [19] in their research reported that there is an increase in the fracture toughness of the Al/SiC/Flyash composite with the increase in the weight percentage of reinforcements. They observed that the maximum value for toughness was obtained for the composite containing 10 wt% SiC and 5 wt% Flyash content.

The authors result show that Flyash is residues generated in combusition of coal and it contains SiO2,Al2O3,FeO3, and CaO as its composition.the authors found that the the fracture toughness of Al/SiC/Flyash composite were improved.but the authors didn't consider optimization of weight % of the ash reinforcement (up to what amount the fracture toughness is increased) and they didn't reveal the effect of each component of the the composition of the Flyash.

And other limitations of the authors were they didn't analysis the effect of change of speed of stiring during stir casting fabrication of the composite.

2.3 bending, tensile strength

The **tensile strength** of a material is the maximum amount of **tensile stress** that it can take before failure. strengthening can be achieved by the addition of hard and stiff reinforcement in the soft matrix.the tensile strength of composite is determine by using different testing machine.in order to remove all materials that are not part of finished casting of composite machining of composite is required before apply tensile testing.

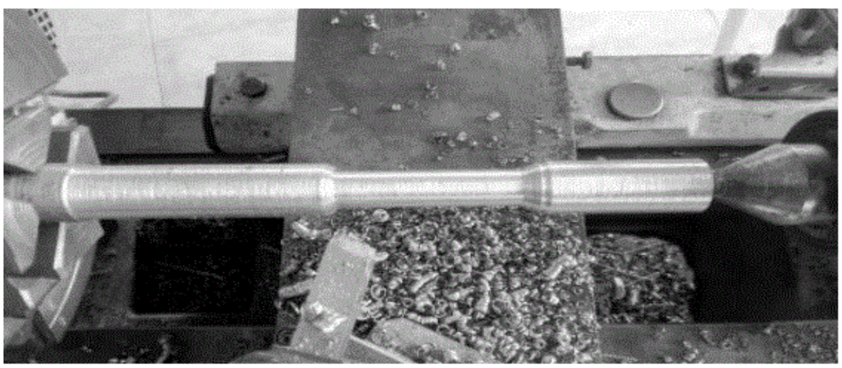


fig 1.5 Dies for tensile testing specimens.

a) b) c)

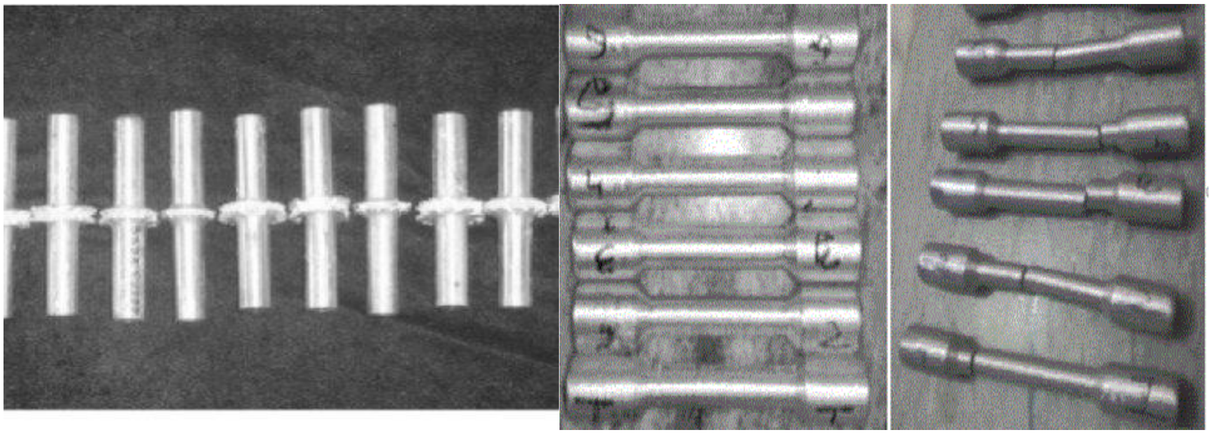


Fig 1.6 (a) tensile test results of Al-MMCs (b) specimens before tensile test (c) specimens after tensile test

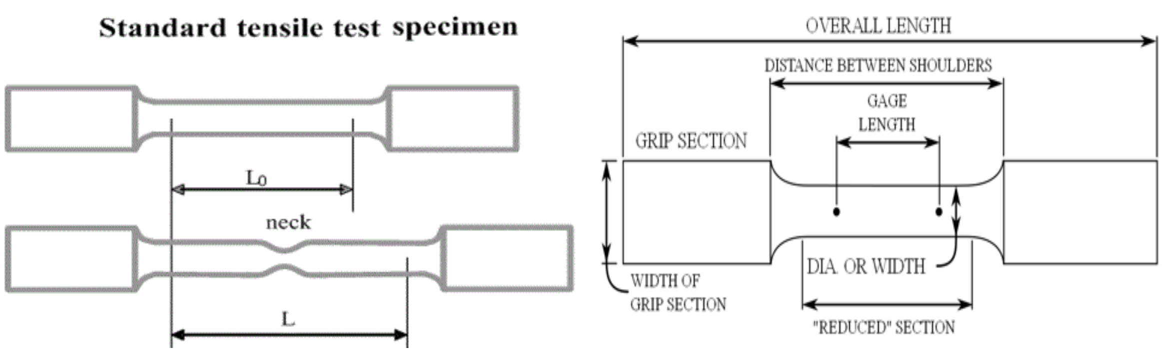


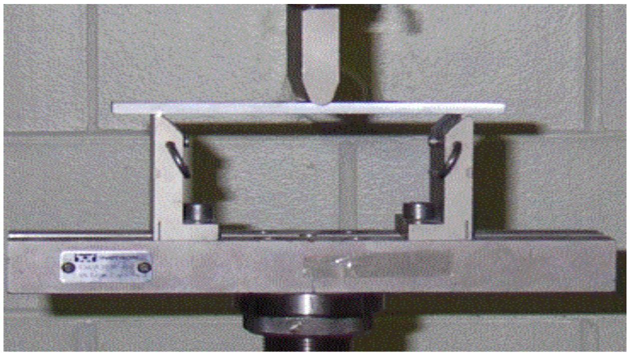
Fig 1.7 tensile test specimen as per-ASTM standard

After tensile test is performed on testing machine we get final diameter,final gauge length and final area based on intial value. Based on this load versus elongation and stress versus strain can be calculated and drawn based on the following formula.

σ_t=p/A where, σ_t=tensile stess, ε=strain , ΔL and L are change in length and final length.

ε =ΔL/L

bending strength is defined as the maximum stress that a material exhibits at failure due to a three or four-points flexural load

.  fig 1.8 Three-point bend testing

Bending strength was calculated according to the following equation:

$$\sigma_{bending} = 3PL^2wh^2$$

Where P is the maximal load, L is the span, w is the width of Specimen and h is the thickness of specimen.

Zhang, Chen [20]Studied the effect of aluminium nitride (AlN) reinforcement in aluminium fabricated by squeeze casting process.Average particle size of 4µm, 50 vol% of AlN was reinforced in aluminium alloy and the micrographs showed homogeneous distribution of AlN in matrix.

The authors found that Addition of AlN particles in matrix improved the ultimate tensile strength and yield strength. However tensile strength of composites decreases with increasing pouring temperature.

The authors use 3 point bending test using ISTRON5569 universal test machine and tensile tests on DSS-10T-S electron tension testing system to anayze tensile strength.

But the authors performed the bending and tensile test on room temperature which can be hidden the effect of the temperature on tensile strength and also the authors take several theoretical model,predictions which leads to less accuracy result.the other limitation of the authors is that the parameters of squeeze casting like delay time to achieve maximum pressure,die coat materials(lubricant),and effect of temperature at each stage of squeeze casting and also on testing stage not considered.on the authors result there is mismatch expansion of Al matrix and AlN reinforcement and leds to complicated expansion on Al/AlN composite which may be result of missed parameters.

2.4 coefficient of thermal expansion (CTE)

The **coefficient of thermal expansion** describes how the size of an object changes with a change in temperature.low coefficient of thermal expansion is often necessary for electronic packaging application.this is enhanced by using adding of reinforcement to matrix Al and its alloy.The formula to calculate the coefficient of thermal expansion of the composite by using rule of mixture (ROM) of Al based MMCs is expressed as bellow[21].

$$\alpha_c = \alpha_m.V_m + \alpha_p.V_p$$

where α is the CTE, V is the volume fraction, and subscripts c,m,p refer to the composite, matrix and particle, respectively .and

Turner [22] considered the effect of uniform hydrostatic stresses on Adjacent phases, and gave the CTE of the composite:

$\alpha_c=\alpha_m V_m K_m+\alpha_p V_p K_p V_m K_m+V_p K_p$ where K is the bulk modulus.

Kerner [23] model included the shear strainin particulate composite,and the CTE was given by:

$$\alpha_c=\alpha_m V_m+\alpha_p V_p+V_p V_m(\alpha_p-\alpha_m)\times K_p-K_m V_m K_m+V_p K_p+(3K_p K_m/4G_m)$$

where G is shear modulus.

In this study researchers didn't show that how bulk modulus and shear modulus of the composite were found.nd also the researchers didn't reveal about the volume fraction scale and its optimization ,and also volume fraction of each matrix and reinforcement effect didn't consider.

3. Effect of reinforcements on wear behavior of Al-MMCs:

The gradual removal of material from solids surface is termed as wear. Wear is failure or loss of materials in volume or weight due to various reasons. Wear may be due to micro-cracks or by localized plastic deformation [24]. It is difficult to completely nullify the effect of wear, but we can reduce wear by means modification of components material,so this is enhanced by using reinforcements to modify properties of Al-MMCs. wear is one of the main problem in pure aluminium and its alloys in aluminium industry. Al-based metal matrix have better wear resistance behavior than pure aluminium and its alloys by modified their mechanical properties like hardness.Hardness is the measure of wear resistance of materials. If hardness is high the wear resistance of Al-MMCs is better, this hardness is enhanced by small sized particles of reinforcement to the matrix of aluminium or its alloy [25].

Many researchers studied the wear behavior aluminium alloy based metal matrix composites by using different reinforcements.The researchers varied the wear process parameters like, load, velocity and sliding distance and observed the weight loss, wear rate and coefficient of friction.

Wear test is can be performed by dry wear testing according to American Society for Testing and Materials (ASTM) standard G99 [26]. by unidirectional pin-on-disk apparatus with a counter Face of AISI52100 steel which was hardened. Worn samples were cleaned after the tests and then Weighed to determine the wear weight loss using an electronic balance (GR200-AND). Normal load,velocity and wear distance (sliding distance) were set at the machine.density of composite is determined by Archimedes principle.

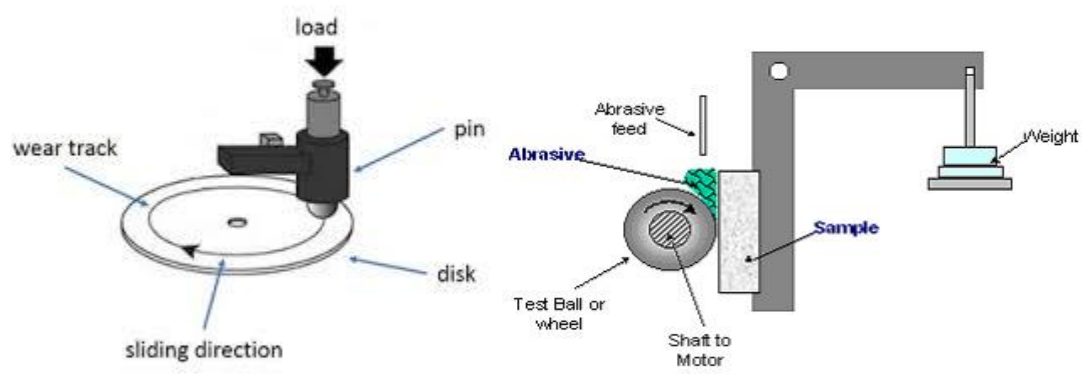


Fig 1.9

a) Pin-on-disk test b) wear testing and measurement

The material loss (in volume) and wear rate of composite is calculated by the following formula.

$$Volume\ \ loss\ (mm^3) = \frac{weight\ loss\ (g)}{density\left(\frac{g}{cm^3}\right)} \times 1000$$

$$Wear\ \ rate\left(\frac{mm^3}{km}\right) = \frac{Volume\ \ loss(mm^3)}{sliding\ \ distance(km)} \times 1000$$

Or **Q = V/ FN˙S** were: Q– wear rate; FN– normal force,S=sliding distance

In this study the researchers set the variables like normal load,sliding velocity,sliding distance at once or make constant.but this may leads to wrong conclusion as researchers didn't consider these variables effect one by one by changing their value during the test.

Ahmadi, Siadati [27] investigated wear behavior of addition of TiO2 and CuO particles in pure Al by powder metallurgy method. The researchers found that XRD (X-Ray powder Diffraction),SEM (scanning electron microscope) examinations revealed that the ceramic particles were distributed uniformly in the Al matrix. TiO2and CuO particles additions provided better wear resistance than that of pure Al.

The authors used to Vickers microhardness tester to determine the hardness of composite that is measure of wear resistance according to ASTM standard [28].The authors result show that microhardness and wear resistance of the Al/TiO2+CuO composite were improved.but This study only focused on investigating the effect of Nanoparticles on wear mechanism,while maintaining other factors constant.and other limitations of the authors is that the small number of indentation trial were taken which couldn't leads to precise and accurate result.The effect of change in sliding velocity during wear test is not considered.

Iacob, Ghica [29] Studied the wear behavior and microhardness of aluminium hybrid composite reinforced with of Al2O3(10, 15,20 wt%) and of Gr (1, 2, 3 wt). They fabricated the hybrid composites by powder metallurgy process.

The researchers found that Micro-structural characterization of the hybrid composites has revealed fairly uniform distribution and some amount of grain refinement in the cast specimens. They also observed that the micro-hardness has been improved when increasing the milling time and the reinforcement content due to presence of hard Al2O3 particles.

Summary of research works on Effects of reinforcements on properties and wear behaviour of aluminium based metal matrix matrix.

Table 1:summary on Effect reinforcement addition on Al-MMCs:

Authors name	Methods	Materials		Considered Parameters	Findings Or results	Remark
		matrix	reinforcement			
T.lu et al.[15]	squeeze casting	7075Al hybrid	Zr-Fe-SiC	Squeeze pressure,percentage content of reinforcement	Ultimate tensile strength,fracture resistance,young's modulus were improved.	Other parameters like temperature,size of reinforcement, effect were not analyzed,negative impact behind Fe is not looked,mechanical test were performed at constant strain and room temperature(effect of temperature did not considered)
M.Kok [17]	Stir casting,squeeze casting	Al2024	Al2O3	Weight %,size of reinforcement, pressure	Hardness,tensile strength,wettability force between aluminium and Al2O3 were enhanced.	Duration of time of stiring,speed, ,temperature effect not considered,no optimization of parameters(up to what value size,wt% the result is positive),expirmental density is based on try and error of archimedian rule.
Alaneme et al.[18]	Stir casting	Al	SiC-bamboo leaf ash(BLA)	Wt%,size of reinforcement,temperature,speed RPM,time	Fracture toughness of composite is increased as	Effect of temperature did not revealed,effect of ash compositions

				duration of stiring	compared to Al matrix	(Al2O3,FeO3 and SiO2) are not analyzed.
Ravesh and garg[19]	Stir casting	Al	SiC-Flyash	Speed RPM,temperature,wt%,size,time duration of stiring	Fracture toughness of Al/SiC- flyash composite is enhanced.	No optimization of wt%,effect of compositions(SiO2,Al2O3, FeO3 and CaO) of Flyash did not considered,effect of change of speed during stiring is not noticed.
Q.Zhang et al.[20]	Squeeze casting	Al	AlN	Size of reinforcement,volume % of reinforcement,squeeze pressure,stiring temperature	Ultimate tensile strength,yield strength,coefficient of thermal expansion of matrix were improved	Effect of optimization(up to what extent positive result is revealed) not considered,tensile test is performed on room temperature,more prediction and theoretical model are there.
M.Ahmadi, M.H.Siadati [27]	Powder metallurgy (PM)	Pure Al	TiO2-CUO	-	Yield strength,hardness,wear resistance were improved.	Parameters (temperature,time,wt%,volume%,) not mentioned.
G.laco et al.[29]	Powder metallurgy	Aluminium hybrid	Al2O3-Gr	Weight % of reinforcement, milling time,content of reinforcement	Wear resistance,micro hardness,hardness were improved.	pressure,size of reinforcement effect were not considered,optimization is not considered.

Generally ,as we understand from above table summarization on effect of reinforcement on mechanical properties and wear behaviour by different authors and fabricating methods almost many researcher's work doesn't reveal optimization of parameters (up to what extent the positive result is revealed).and also some researchers didn't consider effect of some parameters on fabrication methods of composite of reinforcement and matrix materials.

Conclusion

From the above literature, it is concluded that Al-based metal matrix mechanical properties and wear resistance can be improved by addition of hard reinforcements in matrix.Stir casting is the most economical method to produce particulate and fiber reinforced metal matrix composites. It is observed that stirring speed is one of the major influencing parameter which affects the dispersion of particles / fibers in matrix. Weight loss, coefficient of friction and wear rate of composites decreases with increasing volume fraction of reinforcements.wear volume,sliding distance,normal load during wear test,hardness are fundamental wear parameters.Wear resistance and hardness is related directly.If hardness is increased wear resistance also increased.

Identification of the research Gaps in literature review

After reviewing different research works conducted in the recent past,the following gaps have been observed on effect of reinforcement on mechanical properties and wear resistance Behaviour of Al-MMCs.

1. Most of researchers do not consider lubrication or coolant effect during sliding test of wear resistance,but it has a significant effect when we use it.
2. Most of researchers examined or considered on influence of small number of process parameters on fabrication of Al-based metal matrix composites by different process methods,which lead to incorrect conclusion.since fabrication is result of a series of correct combination each parameters.
3. The number of researcher who investigates the effect of squeeze pressure during fabrication of Al-MMCs by squeeze casting is few, which has significant effect on mixing of reinforcement with matrix.
4. Most of researchers do not consider the effect of shapes of reinforcement particels like rectangular,square,triangular and round on mechanical properties of Al-based metal matrix composites,which has also significant effect.
5. The number of researchers who who considers effect of orientation of reinforcements like aligned, random, continuous, unidirection, bidirection, multi direction are very few, but orientation of reinforcement has a significant effect on mechanical properties of Al-MMCs.
6. Most of researchers also do not consider reaction condition of reinforcement and matrix during composite fabrication method.

Future trends in Al-MMCs

In the present scenario, much importance has been given in the direction of production of a quality-assured product by minimal impact on the environment. Methods for grain refinement and alignment of reinforcement particles in the matrix is a challenging task to control.it is still in developing stage and much attention is required for the control of particle alignments. assessment of material properties at nano scale regime requires more research study to understand the effect of interfacial bonding and role of reinforcement at nano level for the enhancement in the material properties. nano dynamic mechanical test and nano scratch test of Al-MMCs are still in fancy stage for the Al-MMCs.

Investigate the effect of change in rotational speed in fabrication processes that used to for better mixing of matrix and reinforcement materials.

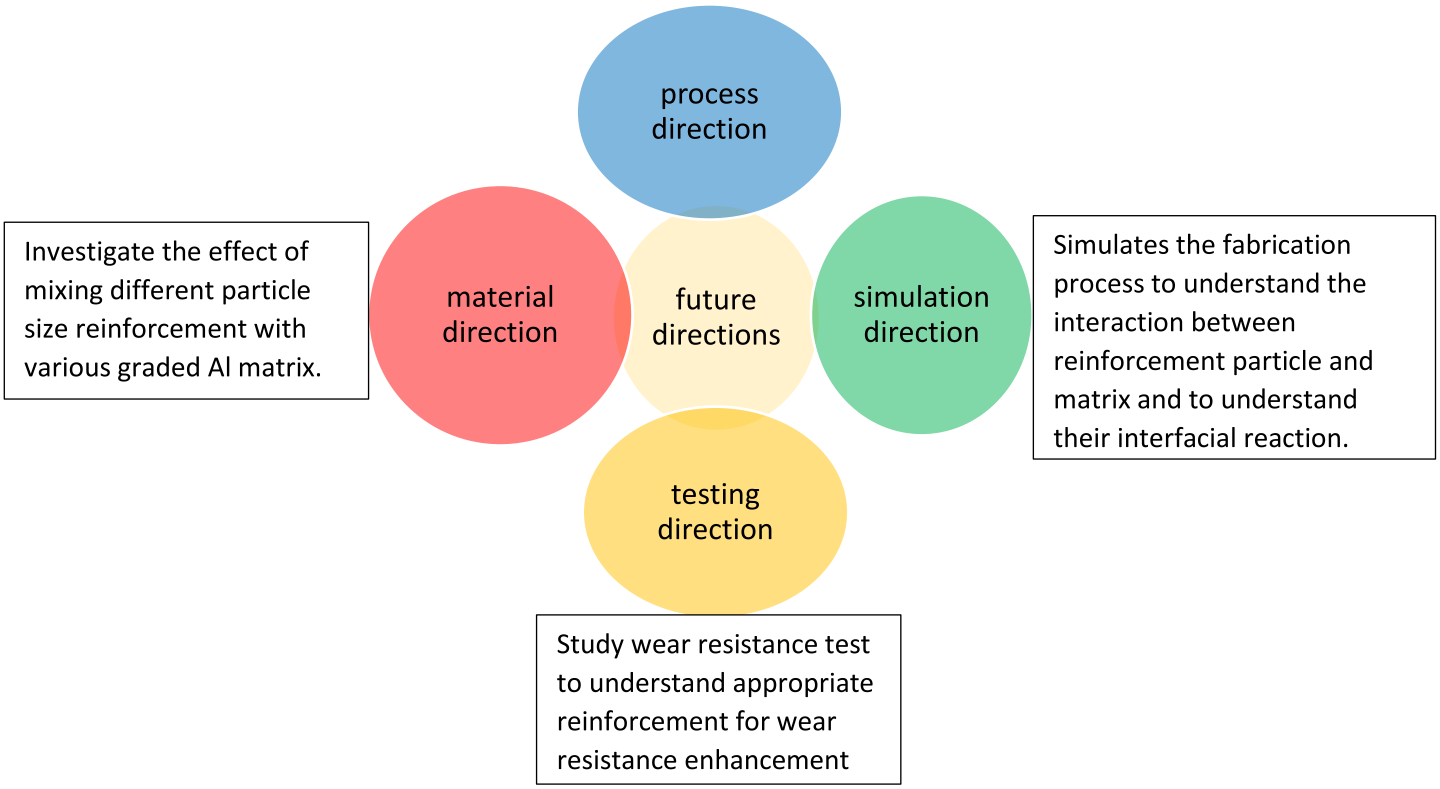


Fig 1:future trends in Al-MMCs

Recommendation

Researchers should involve on studying of mechanical properties enhancement methods to contribute their role in new advanced field of study.

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