EFFECT OF REINFORCEMENT OF NANO Al_2O_3 ON MECHANICAL PROPERTIES OF MAGNESIUM METAL MATRIX NANO COMPOSITE- A REVIEW

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ABSTRACT: In the present scenario, a considerable importance is being given to find newer material for structural and functional applications. In the recent demands of advanced engineering application, magnesium based nano composites are a new generation of metal. Researchers have been observed that the addition of nano sized alumina particle with magnesium metal matrix leads to wards superior mechanical and physical properties and interfacial characteristics of nano composites. The images of scanning electron microscope of the magnesium metal matrix nano composite indicate that the nano alumina reinforcing particles are uniformly distributed in metal matrix. This paper attempts to review the fabrication technique and mechanical properties of magnesium/Al_2O_3 based metal matrix nano composites.

KEYWORDS Magnesium metal matrix nano composite, Fabrication technique, Scanning electron microscope, Mechanical properties

INTRODUCTION

Magnesium metal matrix composite filled with nano particles featuring physical and mechanical properties very different from conventional metal. The nano particles can improve the base material in terms of wear resistance, damping properties, porosity, corrosion resistance and mechanical properties. Different kind of metals predominantly Mg, Al, and copper have been employed for production of composite through the different nano particles such carbide, nitride and oxide. Magnesium based composite have been attracting much attention as their lower weight to strength ratio because of low weight magnesium metal. Aerospace, automobile, electronic, bio-implant and consumer product related industry seeking for magnesium metal composite for critical performance. The huge quantity (8^{th} most common element in earth crust and 3^{rd} most common element in dissolved sea water) of magnesium on earth is considered to be lightest metal with good cast ability, machinability, dimensional stability, electromagnetic radiation resistance and low power consumption. Exploitation of reinforcement of nano particles on metal matrix depends on the type of primary and secondary processing, matrix composition, size, volume fraction, morphology of reinforcement and heat treatment. Among all the investigated nano particles reinforcement with alumina was found to be most effective in enhancing the strength properties of magnesium when incorporated via ingot metallurgy process. Fabrication methods can be broadly classified into 2 types solid state processing and liquid state processing. In liquid state processing mechanical and electromagnetic stirring and ultrasonic based dispersion is uses for the proper distribution of nano particle that have some advantages than solid state of processing that are high productivity, flexibility, easy to control on matrix structure and better bonding between matrix and particles etc. In solid state of processing mostly preferred method is powder metallurgy in which, the main drawback of liquid state processing technique can be overcome that is non-uniform dispersion of nano particles but this uniform dispersion of nano particles makes it costly and lengthy process

FABRICATION TECHNIQUE

Processing of Magnesium metal matrix nano composite (Mg-MMNC's) are classified into solid state and liquid state. In solid state Diffusion Bonding, Electroplating, Powder Metallurgy, Spray Deposition, Immersion Plating, etc. Liquid state processing includes Stir Casting, Squeeze Casting, Melt Infiltration, Compo Casting and Melt Oxidation processing etc. But Powder Metallurgy, Stir Casting , High Energy Ball Milling, Squeeze Casting, Mechanical Alloying , Spark Plasma, Ultra sonic cavitation based solidification and Laser Deposition mostly used. The nano particles have tendency of agglomeration and clustering because of electrostatic, high surface energy, adhesiveness due to the moisture present. Out of these fabrication technique some are discuss below that are mostly prefer for reinforcement of ceramic nano particles on metal matrix.

1:- STIR CASTING

Conventional stir casting process has been employed for producing discontinuous metal matrix nano composite. The major problem of this process is to obtain proper mixing of nano particle with the liquid metal and to obtain homogenous dispersion of particles. But this method is mostly use because of their simplicity, low cast and less time consuming process. From micro structural characterization, it is concluded that the shorter stirring period is required for ceramic incorporation to achieve metal/ceramic bonding at the interface.

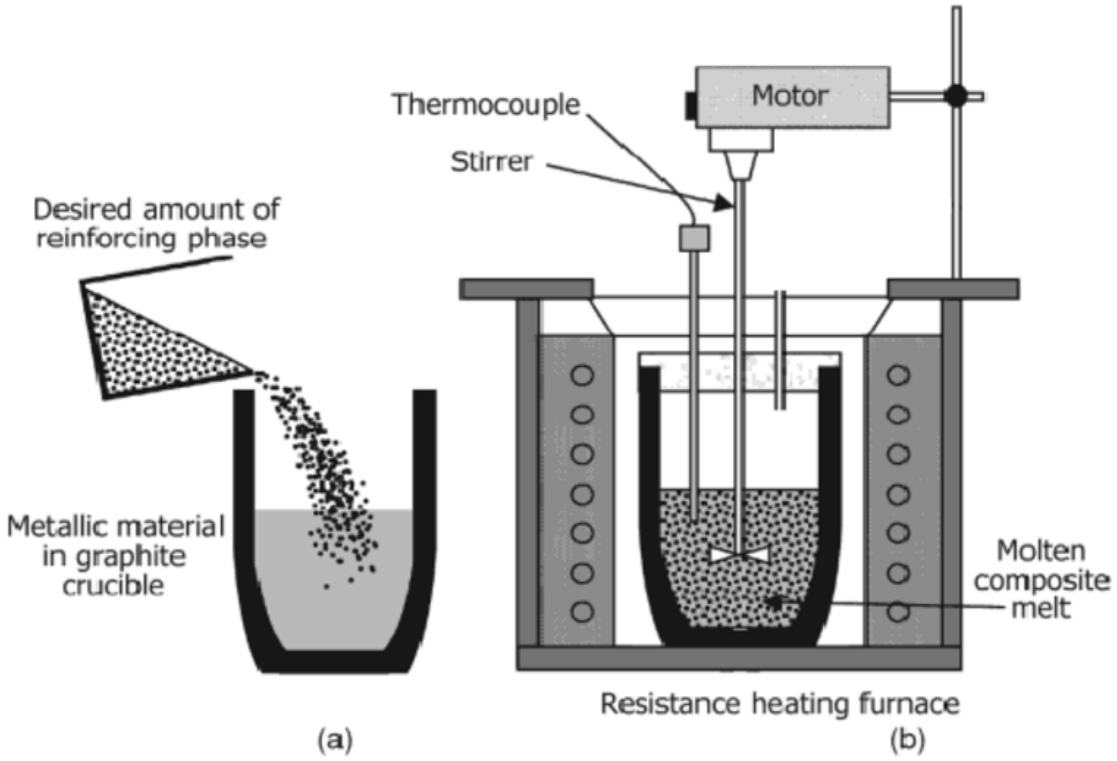

Fig:-1 schematic dia. Of stir casting

2:- POWDER METALLURGY

Powder metallurgy has a great advantages comparison to the other processes such as casting, forging, and machining particularly for complex part made of high strength and hard alloy. Powder metallurgy has a 5 step blending, compacting, sintering, finishing. First step to form a powder by the various process such as reduction, atomization, electrolytic deposition, mechanical pulverization and grinding etc. second step is blending, blending is a process of mixing of the powder of metal in a inert gas atmosphere to avoid oxidation. Lubricants and additives can be added to improve their flow characteristics. Third step is compaction of metal powder that is a process of reducing the porosity and increasing the density by the help dies for required shape and size of the metal powder. Fourth step is sintering in which compact powder is heated to a temperature below the melting point temperature in controlled atmospheric condition but temperature must be sufficient to allow bonding between the particles. Generally sintering is done at a .7 to .9 of their melting point temperature. Sintering is done for the improving the mechanical strength.

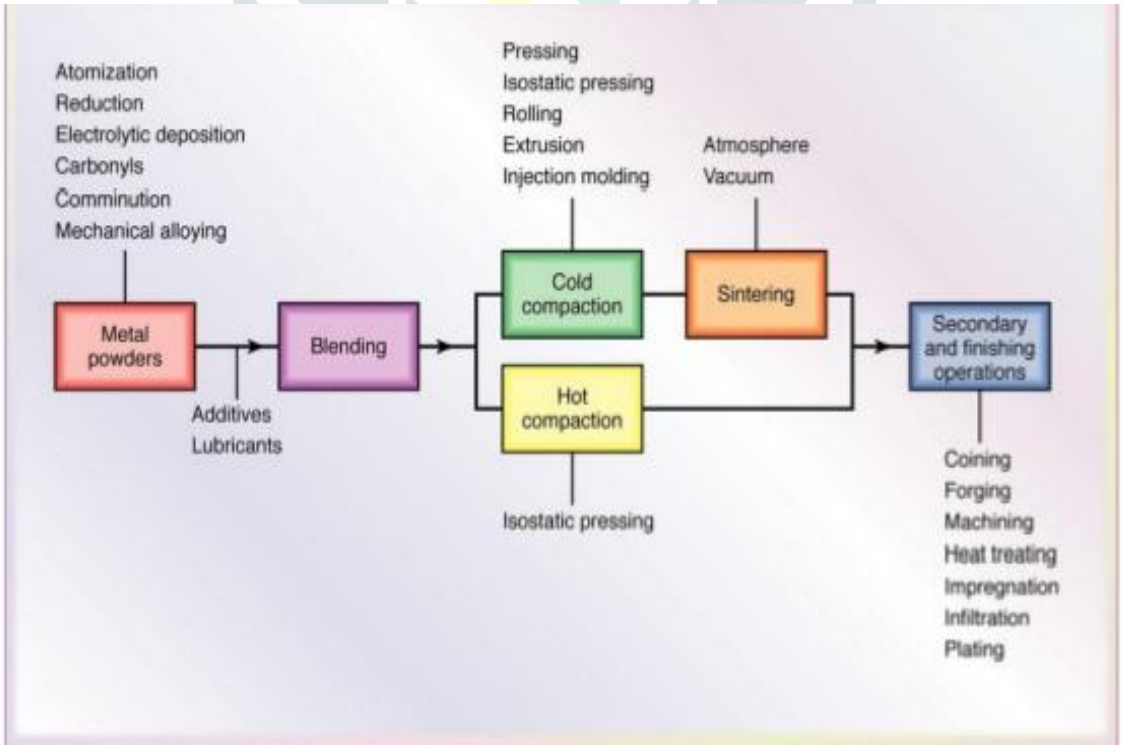

Fig.:- 2 Schematic dia. powder metallurgy process

3:- SPARK PLASMA SINTERING

In spark plasma sintering the release of electrical energy through a porous powder and then breakdown of surface film take place. The basic theory of spark plasma sintering process is based on the generation electrical spark. Low voltage pulse current momentarily generates spark plasma in fine local areas between the particles at high energy. Spark plasma is advanced technique which takes less time to complete sintering process comparison to the conventional sintering process. In conventional sintering usually a green compact needs to be prepared during the compaction before the process but in the spark plasma sintering it is not necessary to green compaction in this process directly fed in to the graphite dies and dies closed in suitable punch. When spark discharge generate in the gap between the particles of a material, a local high temperature state appears. This cause vaporization and melting of the surface of the powder particles takes place in spark plasma sintering. Constricted shape or necks are formed around the contact between the particles.

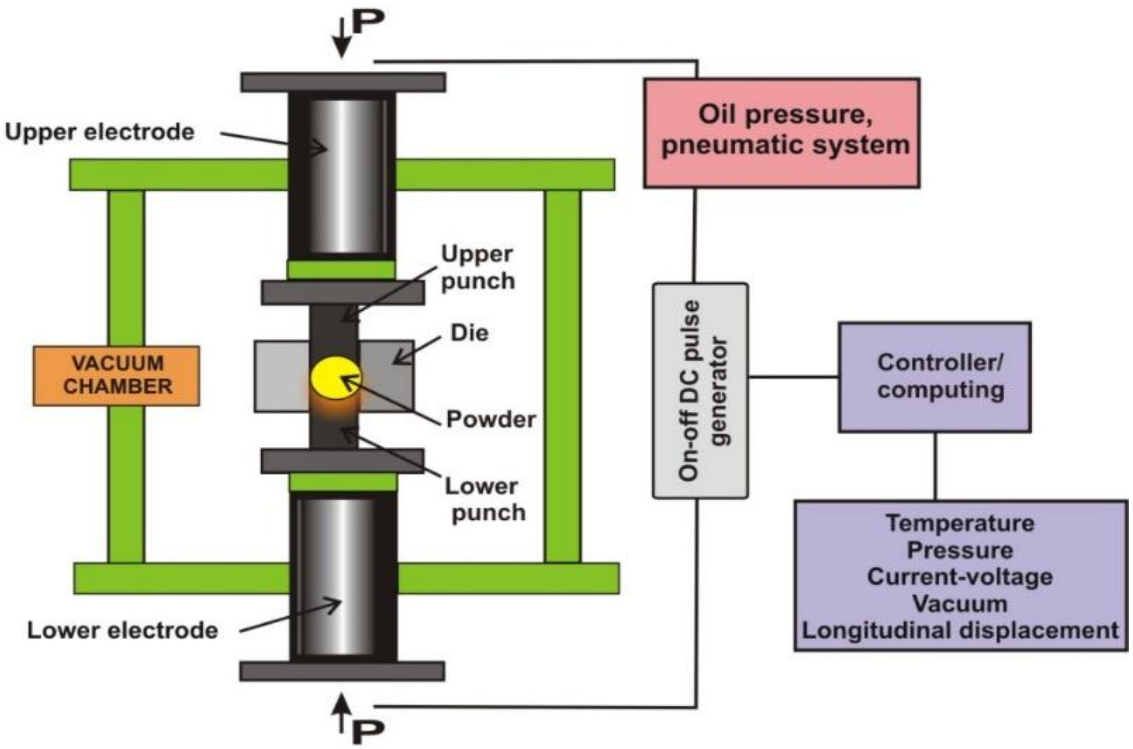

Fig:-3 schematic dia. Of spark plasma

LITERATURE REVIEW

V. Sridhar [1]

V. Sridhar presents the synthesis and mechanical study of magnesium reinforcement nano alumina powder with variation in volume percentages of alumina. The magnesium metal matrix nano composite develop by varying 3 amount of nano particle (i.e. .35, .7 and 1.4 volume percentage) by the powder metallurgy method. The compaction is done on UTM and sintering is done at a temperature range of 600 to 620^0C in presence of inert argon gas with the flow pressure of 15L/min of argon. After the sintering it is observed that the density of the powder composite is improved. By the use of X-ray diffraction micro structural characterization is determine. The hardness value and the SEM graph are plotted between the various compositions and comparison between these various amount is done. By mechanical testing is observed that the hardness of the nano composite is improved.

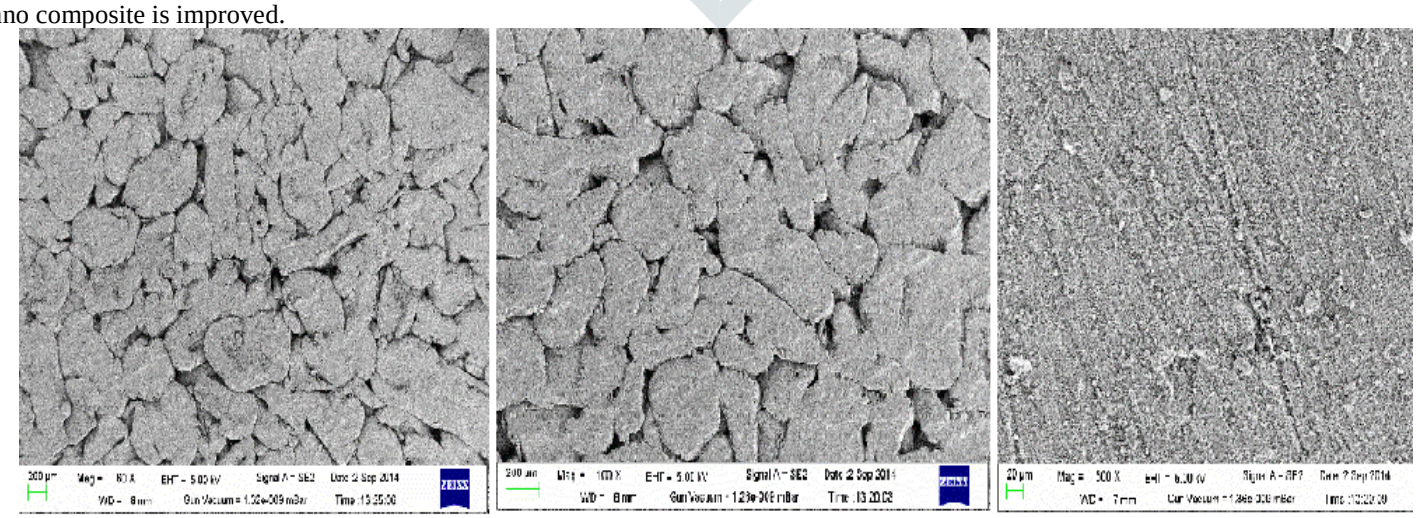

Fig. 4 SEM photo graphs of .35%, .7%, 1.4 % volume of AL_2O_3 in Magnesium

S. Fiada Hassan [2]

S. Faida Hassan fine element of nickel particles were mixed into pre magnesium metal matrix using blend-press-sinter powder metallurgy technique voiding ball milling. The nickel reinforcement particles dispersion was uniform with metal matrix.

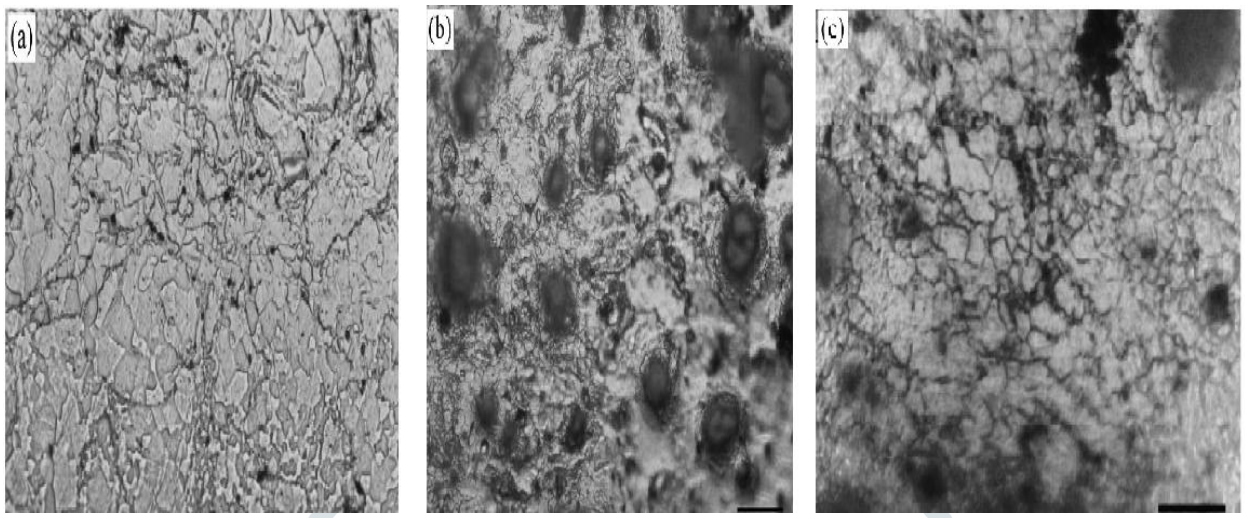

Fig: 5 Optical micrographs showing grain morphology in: (a) monolithic magnesium And (b) and (c) elemental nickel reinforced magnesium, respectively

The small volume fraction of element nickel particles reinforcement refined grain morphology and significantly improved the hardness and tensile strength of the magnesium metal matrix without affecting the yield strength. The reinforcement of nickel particles changed fracture mode of magnesium metal matrix from pseudo ductile to brittle mode dominated by nickel particles.

M. Habibnejad-Korayema [3]

M. Habibnejad-Korayema present .5% , 1% , 2% of weight of alumina nano particles were added to pure magnesium and AZ31 magnesium alloy via stir casting method. A uniform distribution of the AL_2O_3 nanoparticles with an average diameter of 100nm Refined the grain structure of cast and decrease the coefficient of thermal expansion, thus improving the dimensional stability of both pure magnesium and AZ31 alloy.

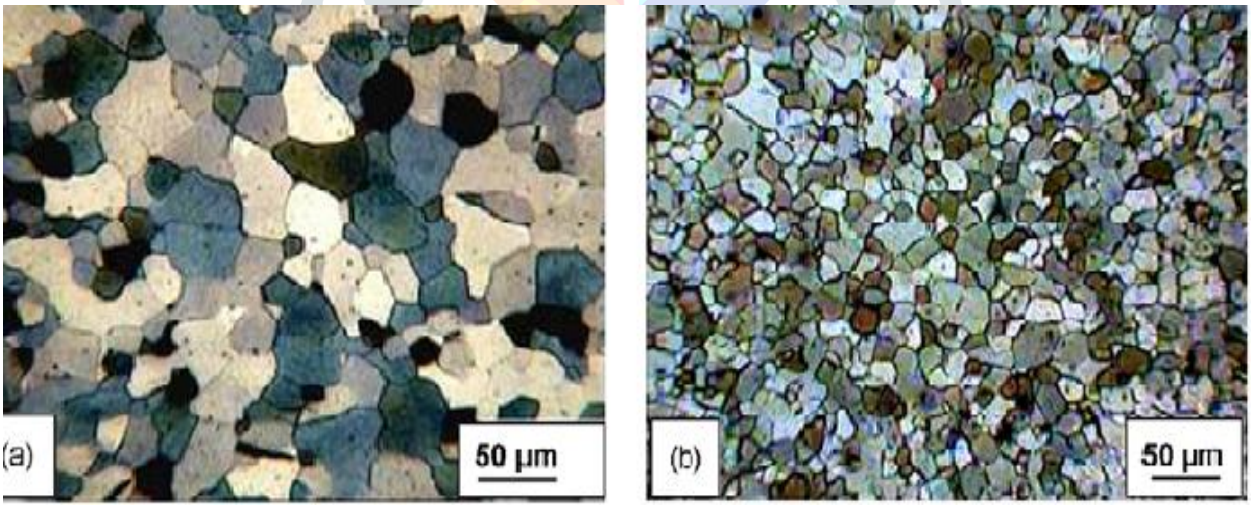

Fig:6 SEM micro graphs of structure of pure Mg and Mg/Al_2O_3

The addition of 2wt% nano AL_2O_3 particles have great potential in the reduction of coefficient of thermal expansion from 27.9 to 25.9 10^{-6} K^{-1} in pure magnesium and from 26.4 to 25.2 10^{-6} k^{-1} in AZ31. The nano particles improved the yield strength and the tensile strength but the ductility of the both pure magnesium and AZ31 magnesium alloy decreases. The yield and tensile strength of pure magnesium is improved by the 40 mpa and by the 60 mpa for the AZ31 magnesium alloy.

J. Safari [4]

J. Safari present the study of milling time on microstructure and mechanical properties of Al and Al -10% weight of magnesium matrix with the reinforcement with the 5% weight of AL_2O_3 nano particles the mechanical properties are investigated. Steady state situation was occurred in Al-10Mg/5 Al_2O_3 in 20 hour but in the $Al/5Al_2O_3$ this situation was not occurred this due to the solution of Mg in to Al matrix . nano composite after 20 h, due to solution of Mg in to Al matrix. For the binary Al-Mg matrix up to 10 h lattice strain increased to about .4 and .66% for Al and Mg matrix with average crystalline size 34 nm.

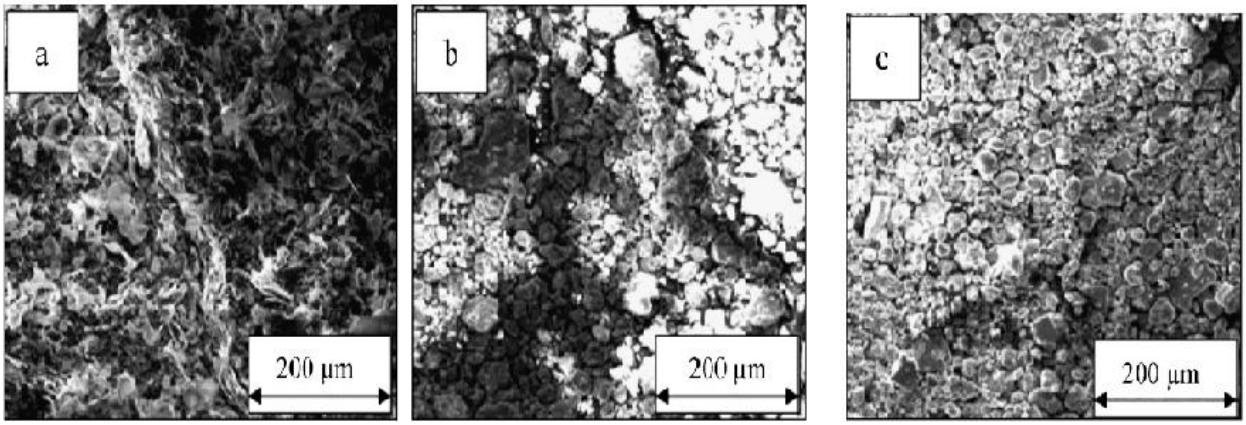

Fig: 7 SEM micrograph of AL-10Mg/5Al_2O_3 powder milled for different times (a) 2 h , (b) 5 h, (c) 10 h

M. Ramchandra [5]

In this work aluminum metal matrix reinforced by the zirconium dioxide nano particles, zirconium dioxide nano particles produced by the solution combustion method. Urea is used as the fuel for solution combustion method and nano particles reinforced with different percentage of weight in to the aluminum by using the powder metallurgy process.

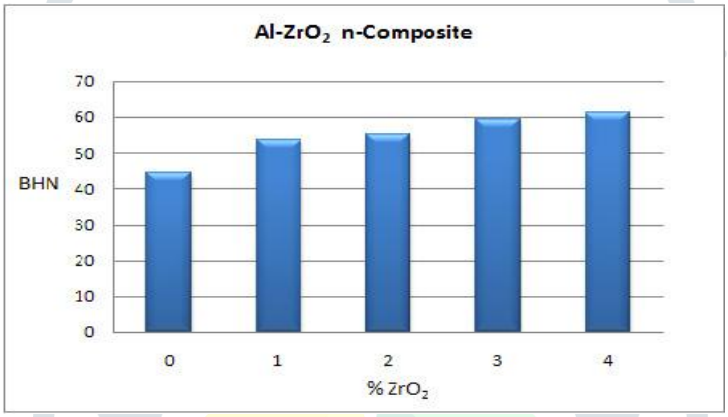

Fig:8 Hardness (BHN) value of Al-Zro_2 composite

The prepared specimen is tested for the hardness test and microstructure characterization. The metal matrix nano composite are tested for wear resistance by using the disc wear technique. Reinforcement of n-Zro_2 particles in aluminum metal matrix improved the hardness and the wear resistance.

G. Sivakumar [6]

In this work synthesized nano sic particles reinforced in to the Ti-6Al-4V alloy with different mass fraction 0, 5%, 10% and 15% by the powder metallurgy process. The effect of reinforcement of sic particles on the mechanical properties such as hardness and compressive strength of the alloy of titanium are determined.

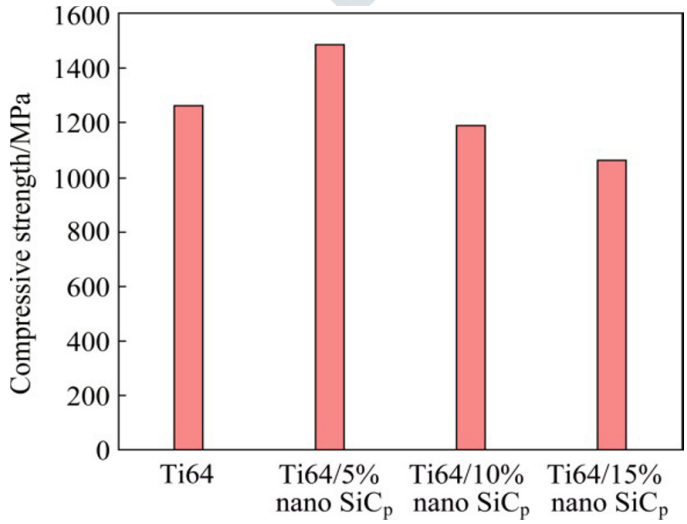

Fig:8 compressive strength of Ti64 alloy and Ti64alloy/sic nano particles

The optimum density 93.33% was obtained at the compaction pressure of 6.035 Mpa. The effect of reinforcement of nano sic particles in Ti64 alloy matrix composite on the phase formation are observed by the X-ray diffraction. After testing mechanical properties it shows that the compressive strength and hardness of Ti64 alloy improved by reinforcement of sic nano particles.

Yong yang [7]:-

In this work, ultrasonic dispersion method is used for an inexpensive fabrication of bulk lightweight MMNCs with reproducible microstructures and superior properties by use of ultrasonic nonlinear effects, namely transient cavitation and acoustic streaming, to achieve uniform dispersion of nano-sized Sic particles in molten aluminum alloy. And then Microstructural study was carried out with the help of optical microscope, Scanning electron microscope and XPS. From the micro level study it is found that the Sic nano-particles uniformly distributed with slight clustering that is shown below and some of the particles oxidized and formation of SiO_2 take place. After the analyzing the composite material it is found that the strength of composite increases 50% with the addition of 2% of Sic nanoparticles with the aluminum alloy.

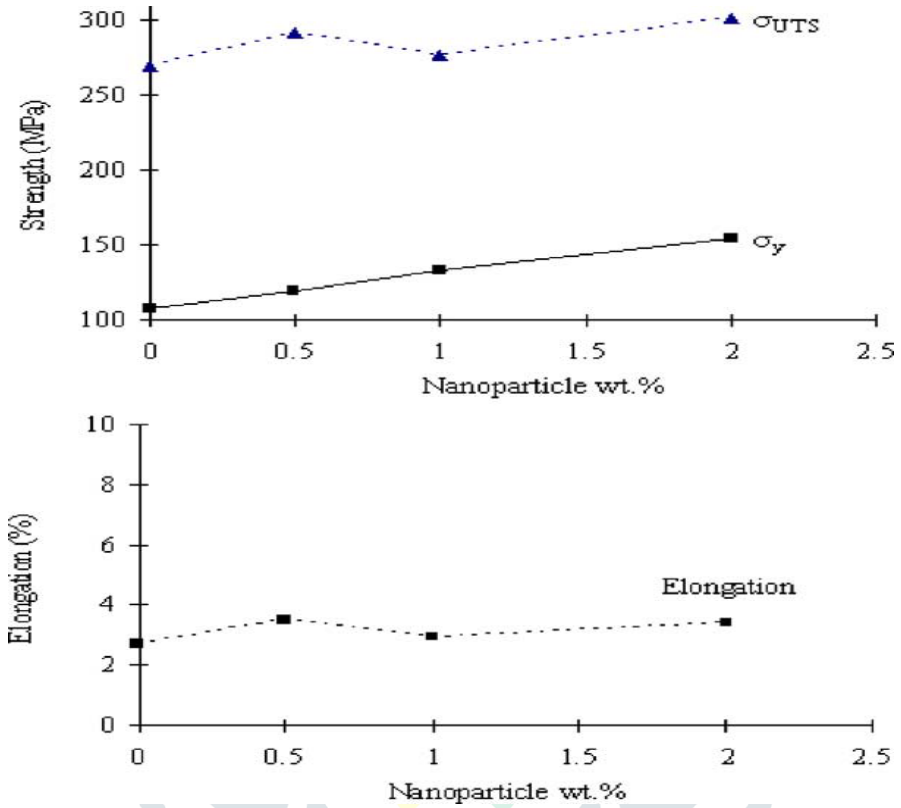

Fig 9 :- change in tensile strength and elongation of composite with increase in percentage of Sicnanoparticles

A.Fathy:[8]

In this work, Effect of Mg content on microstructure and mechanical properties of Al–Al2O3 (10%) composite. magnesium mixed with the aluminum powder by varying wt.% of 0% to 20% with step size of 5% during milling and then characteristic of composite was investigated. The results show that with the increment of Mg to 15% of wt. the crystallite sizes of 20 h milled powders diminish from 44 to 26 nm and lattice strains increased from 0.22% to 0.32% caused by Mg atomic penetration into the substitution sites of the Al lattice. With up to 15% of wt. Mg (for 20 h milled composites) hardness increases from 120 to230 HV caused by the increment of the Mg concentration

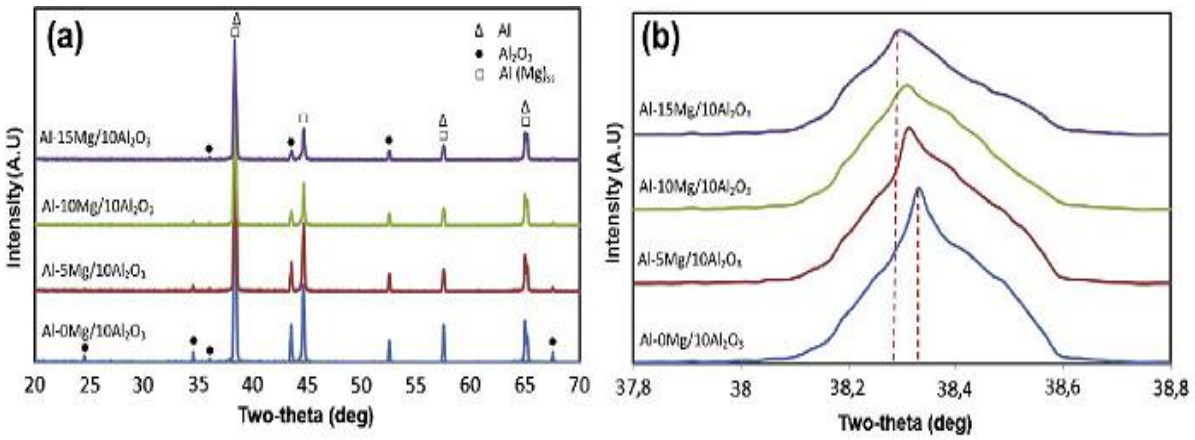

Fig:-6 X-ray diffraction patterns of Al–x $Mg/10Al_2O_3$ powder mixture milled for 20 hours

B. Teja Ganapathi Verma:[9]

The energy crisis and the global inclination to reduce the green-house gas emission has attention the scientist for developing the low weight material. Magnesium based alloy have been attracting much attention as light weight material. Also because of their high specific strength, good cast ability, high damping capacity of magnesium metal used. Nano particles with magnesium metal matrix by powder metallurgy process and after testing it found that density of metal matrix nano composite improved.

CONCLUSION

In this work present there are the various type of the fabrication technique for the reinforcement of nano particles on metal matrix. Mostly used fabrication method are stir casting, spark plasma, ultra sonic assisted casting, powder metallurgy but stir casting most suitable due to their simplicity and low cast. The uniform dispersion of nano particles on metal matrix are shows by the scanning electron microscope. And by the X-ray diffraction the intensity of composite are determine. Through the reinforcement of nano particles on metal matrix the mechanical properties of composite metal matrix nano composite such tensile strength, hardness, compressive strength, wear resistance are improved comparison to the conventional metal matrix.

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