

A Review on Mechanical Properties of Al-Alloy with B4C and Fly ash Reinforced Metal Matrix Composite

Prof. Sanjay G. Patel¹, Prof. Himanshu R. Sathavara², Prof. Mehul B Patel³, Prof. Amit R Patel⁴

^{1,3,4} Assistant Professor, B S Patel Polytechnic, Ganpat University
² Assistant Professor, U V Patel College Of Engineering, Ganpat University

Abstract - Most of the style of production strategies available for discontinuous metallic matrix composites, stir casting is generally regularly occurring as an especially promising route, presently practiced commercially. Its benefits lie in its simplicity, flexibility and applicability to massive amount production with value benefit. The major trouble of this manner is to reap sufficient wetting of particle with the aid of liquid metallic and to get a homogenous dispersion of the particulates. the present assessment is at the technique employed in stir casting which include, how the base steel is melted, at what temperature and kingdom it's miles to be maintained, what conditions the particulates are brought and how the stirring time and stirring speed have an effect on the final composite cloth. The effect of stirrer design and feeding mechanism has additionally been discussed. The variation in the type of mixing the particulates into the metallic matrix has additionally been handled within the paper. in the introductory component the stir casting method with a diagram has been laid out to present an overview of the general system of casting of steel matrix composites. the limitations of the process also are listed in the paper.

Key Words: Metal matrix composites; Particulates, reinforcement, stir casting

1. INTRODUCTION

Stir casting manner is specifically used for production of particulate strengthened metal matrix composite (PMMC). it's miles a primary procedure of composite production wherein the reinforcement component fabric is integrated into the molten steel through stirring. The stir casting of steel matrix composites entails generating a soften of the chosen matrix fabric accompanied with the aid of the advent of a reinforcement material into the melt earlier than including the reinforcement cloth the soften ought to be subjected to degasing by means of a suitable medium, because the molten steel reacts with atmospheric oxides and undergoes oxidation with the aid of degrading the homes of the base material.

The subsequent step is the solidification of the soften containing suspended dispersions below selected conditions to gain the favored distribution of the dispersed phase in the forged matrix. Within the stir casting with backside pouring technique, the mould is saved just below the furnace with an opening at the lowest for pouring. This kind of arrangement enhances the incorporation of particulates and reduces the time of pouring. The discount in time of pouring and due to a better particulate introduction to the mildew the composite properties are greater nearer to development.

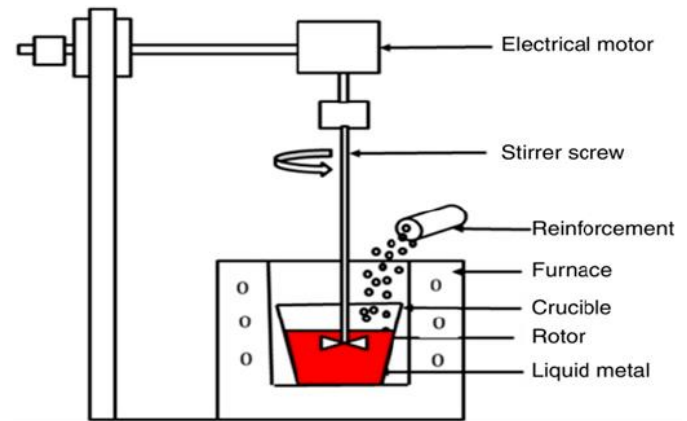


Fig. 1, Basic Process of Stir Casting

Fig.1 suggests the matrix cloth melted in a crucible via heating it in a crucible furnace. The stirring is activated by means of a motor at the pinnacle of the stirrer. The stirrer can be moved up and down through a rack and pinion association. Reinforcement is delivered to the matrix after stirring the matrix material for a sure amount time. Preheating is likewise accomplished to avoid thermal distortion of the composite material.

mixing strategies are used for introducing and homogeneously dispersing the discontinuous segment considering maximum of the ceramic reinforcement substances are denser as compared to matrix alloy, in any other case the reinforcement fabric may additionally settle at the lowest of the crucible if now not agitated properly. blending strategies generally used for mixing of ceramic reinforcement into a soften are:

- adding particles to a vigorously agitated molten alloy
- Injection of the discontinuous phase into the soften with an injection gun
- Dispersion of pellets or briquettes of a discontinuous section [2]

Stir casting is attractive due to the fact a traditional steel processing route is used and is the most in your price range course of all the to be had routes of metal matrix composite production. The value of making ready composite fabric the usage of this approach is about one third to half of the opposite competitive strategies, and for high quantity manufacturing, it is projected that the fee will fall to at least one tenth [3]. a number of the important factors that want attention at some stage in stir casting are:

- The issue of reaching a uniform distribution of the reinforcement material.
- Wettability among two fundamental materials (matrix and reinforcement materials).
- Porosity within the forged steel matrix composites.
- Chemical reactions among the reinforcement material and matrix alloy [4].

5. Reaction of matrix and reinforcement substances with atmospheric elements.

2. Literature Review

Dr. Jameel Habeeb Ghazi et al., cut the Al alloy into small portions for the motive of weighing and calculating weight fraction of silicon carbide by way of five percentage, and then the weighed portions had been located in crucible inside electric furnace at constant temperature at (750 °C) to make certain full melting of ingot, then the Silicon carbide ceramic he body of the paper consists of numbered sections that present the main findings. These sections should be organized to best present the material.

Debris enveloped by using aluminum foils have been introduced to the molten fabric after pre-heating to 250 °C for you to get rid of moisture, to keep away from thermal mismatch and to enhancing the dispersion of debris within the soften. A small quantity of Magnesium becomes added to make sure good wettability of particles with molten steel. the electric mixer enters in crucible furnace which spun unexpectedly at a pace of 900 rpm to enhance homogenizing molten cloth for 3-five min, after which the molten cloth is poured into the pre-heated steel mold. The authors concluded that the hardness, last tensile electricity and yield energy of composites accelerated with elevated addition of reinforcements within the composites up to 20 weight percentage. The effect electricity decreased with increase similarly of reinforcement. there has been uniform distribution of particulates as discovered from the microstructural take a look at. The unique purpose for this to manifest become the addition of reinforcement covered by aluminum foils and also the addition of magnesium within the molten steel [5].

S. Balasivanandha Prabu et al., used moderate steel impeller at a velocity 500–700 rpm to stir molten metallic and create the vortex (vortex generates centrifugal forces through, because of which the secondary section is thrown at the partitions of the crucible making sure uniform distribution of particulates inside the matrix) . The impeller blades were designed to create vortex to reap the particle blending. Zirconium-primarily based coating turned into applied to the impeller to minimize blade dissolution in molten metallic (in addition to avoid metal pick out-up also to keep away from reaction among molten steel and stirrer). The molten steel changed into nicely agitated with the aid of a mechanical stirrer to create turbulence motion at some stage in the process. Immersed impeller changed into at a depth of approximately 2/three of the peak of the molten metallic from the bottom of the crucible and the velocity of the stirrer become set at 500/600/seven hundred rpm. common size of 60µm of Silicon carbide powder turned into taken for this observe and the calculated quantity of Silicon carbide became heated in atmospheric air at 800 °C for 2 hours and become then fed at a consistent fee into the foundation of the vortex. that allows you to shape a layer of SiO₂ at the Silicon carbide, warmness remedy changed into achieved, and it improved the incorporation of the Silicon carbide particulates into the molten melt. The molten steel–Silicon carbide slurry became stirred constantly for the one of a kind mixture of processing conditions with the aid of varying the stirring speed and stirring time. The stirring time had been cited at 5, 10 and 15 min after the addition of Silicon carbide at some stage in the procedure. The molten metallic became poured right into a mild metallic die, which become preheated to approximately three hundred °C. They discovered from the microstructural

look at that with decrease stirring pace and stirring time there has been clustering and some places have been determined without particulate inclusion however with the boom of stirring time and velocity the distribution changed into extra homogeneous. higher stirring pace and time gave a higher hardness of the composite [6].

Bharath V et al., superheated the Al6061 alloy to a temperature of 800 °C in a Silicon carbide crucible. With the help of a digital temperature controller the furnace temperature became managed to an accuracy of ± 50 °C. A 3 level blending with preheating was accompanied. Ceramic Al₂O₃ particulates have been preheated to 2 hundred °C in an oven to get rid of the gases and avoid temperature drop whilst delivered into the molten fabric. A vortex changed into generated the use of a Zirconia lined steel impeller. the entire amount of reinforcement became calculated and delivered to the soften in three steps. Ten minutes of stirring turned into carried. The stirrer became also preheated and it became at a intensity of two/3 from the bottom of the crucible. The stirrer changed into stirred at 2 hundred rpm. It become concluded that a fairly uniform distribution of Al₂O₃ particulates was obtained. The hardness, tensile and yield electricity increased with increase in addition of reinforcement up to certain weight percentage at the same time as the ductility reduced for the reinforcement under observe [7].

k.ok. Alaneme et al., dehydrated Borax by heating it to 250 °C for 20 minutes which served as a wetting agent and blended with calculated quantities of Silicon carbide inside the ratio 1:2. Furnace become charged with Al6063 scrap billets and melting changed into allowed to progress at a temperature of 750 °C which become above the liquidus temperature after which it turned into cooled to 600 °C that is beneath the liquidus temperature to a semisolid nation. At this point of time the borax blended with Silicon carbide was poured into the melt and became stirred manually for 20 minutes. After manual stirring the melt was once more reheated to 750 \pm 10 °C and changed into automatically stirred. The stirring become carried out for length of 20 minutes at a velocity of 300 rpm. It turned into concluded that the electricity of the Al6063 matrix with nine to 12 quantity percent of Silicon carbide improved and there was additionally now not tons exchange within the ductility of the composite [8].

S. Suresh et al., heated the blower furnace by coal and charged Al6061 into it which became at a temperature of 750 °C and melted the cloth which was held at that state for a length of 20 minutes. The furnace temperature changed into cooled below the liquidus temperature to maintain the slurry inside the semi-strong kingdom. Drilling system become employed to carry out stirring at a pace of 450 rpm. At this point of time, the particulates TiB₂ have been brought manually to the vortex. during final blending, the furnace temperature turned into maintained at seven-hundred \pm 10 °C and then the aggregate became poured into the mold to get the specimens for trying out. They in addition concluded that, the micro hardness progressed with addition of reinforcement and there was an improvement within the wear resistance [9].

Tony et al., concluded that with proper change in the stirrer layout, like enhancing the geometry of stirrer and increasing the stirring pressure should achieve uniform distribution of particulates and decrease cluster formation respectively. The modification inside the feeding mechanism brought about an development within the uniform and managed spray of particulates for this reason improved houses of metal matrix composites [10].

k.Umanath et al., melted the base material with the aid of stirring forcefully with the help of an automatic agitator to shape a whirlpool. The temperature maintained changed into 725 °C. eventually after melting the fabric, degassing was carried out with the help of nitrogen. Alumina lined stainless steel stirrer changed into used to stir at 600 rpm for 20 mins. The preheated particulates have been delivered and the molten material was poured to a mold which became preheated to 250 °C, within the place of vortex to manufacture specimen after casting. They eventually concluded that the optical micrographs confirmed the homogeneous distribution of silicon carbide and aluminum oxide particulates within the Al6061 matrix material [11].

Kenneth Kanayo Alaneme et al., charged the gasoline fired crucible furnace geared up with a temperature probe with aluminum billets and heated to temperature of 670 °C till the soften was shaped. Zinc was added after decreasing the temperature of the furnace to 500 °C. The soften turned into cooled to a semi-strong nation as soon as the zinc had melted completely (approximately 450 °C). The melt changed into stirred at 200 rpm for 5 minutes to achieve homogeneity. The husk, Silicon carbide and Graphite debris which were preheated have been added and the stirring become done manually for 5-10 minutes. The semi-strong composite slurry changed into heated returned to 530 °C (superheated) and automatically stirred for 10 minutes at four hundred rpm. The molten material become poured into the mould for casting. They concluded that the microstructure of 7 weight% - 10weight% of husk, Silicon carbide and graphite had been similar. With boom in rice husk ash reinforcement the hardness turned into observed to lower. A comparable trend become located for the tensile power and yield power of the composite. considering rice husk ash is a softer reinforcement than Silicon carbide, and consequently the presence of improved amount of softer reinforcing particles, reduces the strengthening derivable from load switch from the matrix to the reinforcements [12].

Abhilash Viswanath et al., charged the AZ91 in a metallic crucible which become a resistance heating furnace. The furnace become maintained beneath a protecting atmosphere of argon gas since the gasoline is inert. A metal impeller rotating at 750 rpm was used to soften the alloy which turned into maintained at a temperature of 750 °C. Silicon carbide particulates having a length of ~23µm which were preheated to a temperature of 600 °C were delivered into the center of the vortex while stirring. The distinct weight probabilities of particulates were delivered and stirring changed into carried out for 10 mins to make sure entire mixing of reinforcement within the matrix. sooner or later, the soften become poured right into a mildew which became preheated to three hundred °C to cast. The authors concluded that the technique turned into effective up to twenty-five weight % content of the reinforcement and there has been a uniform distribution of particulates within the matrix with less agglomeration and had a purifier interface where agglomeration is the undesirable increase or lumping of powder reinforcement to one another [13].

M S Raviraj et al., charged the Al6061 in a circular furnace which turned into maintained in a temperature variety of 900 °C – 950 °C. The crucible was constituted of steel and the reinforcement powder changed into combined with the best quantity of flux (alkaline okay-Al-F, scum powder) to make sure intimate dispersion prior to including it as much as the matrix melt. in order to keep away from defects within the solid, degas tablet Hexachloro ethane (C2Cl6) become introduced into the soften. The mixture was left unstirred for 2-

5 minutes which fashioned a liquid flux and floated at the floor of the melt. This changed into eliminated the use of a ladle. It became then stirred at a pace of seven-hundred rpm after cleansing out the slag to homogenize and cast. The authors concluded that the fluxing promoted the contact among easy wetting surfaces on account that all the slag changed into removed from the molten aggregate [14].

Himanshu Kala et al., speak approximately a two-step mixing technique, wherein in, the matrix material is heated above liquidus temperature after which the melt is cooled down inside the range of liquidus and solidus temperature to a semi-strong kingdom, At this point the preheated particulates are delivered and once more the problem is heated to above liquidus temperature and blended very well to ultimately solid by way of pouring within the mould. The authors of their review also point out that the two-step mixing breaks the gasoline layer around the particulates and hence promotes wetting between matrix melt and particulates [15].

Pardeep Sharma et al., charged 1000 grams of aluminum alloy in an electric powered furnace with graphite crucible in which the temperature became 900 °C. A mechanical stirrer was used to shape fine vortex. The Si3N4 particulates have been preheated with a purpose to oxidize the surface of the reinforcement and have been fed into the melt at a uniform feed charge. An inert ecosystem became maintained the usage of argon fuel and the aggregate became stirred. The inert gasoline became provided till the soften changed into poured into the preheated mildew. The authors concluded that the density of composite elevated from 2.sixty nine to 2.seventy five g/cm3 after locating out the presence of Si3N4 particulates the use of SEM pics and XRD analysis [16].

okay.L. Tee et al., charged the aluminum to the graphite crucible. The crucible changed into brush lined with alcohol based totally zirconium oxide. The furnace became vertical chamber and operating below regular atmospheric conditions. The Al+Ti+B aggregate become preheated and manually stirred at 1060 °C and then ramped the temperature to 1080 °C. The temperature become maintained for the reaction to occur absolutely. Argon became used to do away with trapped hydrogen. Dross changed into removed twice from the melt floor, as soon as throughout holding and again just before casting. The composite soften was forged within the graphite mildew. A end turned into made that there was a uniform distribution of the particulates in the matrix [17].

J. Hashim et al., wrote that the stirring pace have to not be too high and needs to be continuous for couple of minutes until the melt is poured into the mildew by using bottom pouring approach. backside pouring avoids impurities at the surface of melt being solid into mold. The thoroughness of stirring is dependent on form of agitator, velocity of stirrer and additionally the placement with reference to the bottom and the aspect walls of the crucible. The authors additionally say that the vortex advent at some stage in melting will entrap fuel and as a result the reinforcement debris need to be delivered with the aid of injection with the help of a carrier gasoline that is inert accordingly supporting lessen defects in composites. The wettability can be advanced by means of a few regarded strategies consisting of coating the particulates, addition of alloying elements inside the melt, irradiation of melt and remedy of particulates [18].

A. R. Kennedy et al., heated the metal costs in a tube furnace within the temperature variety of 750 °C – 800 °C in Silicon carbide crucible which was clay bonded. With the right

quantity of flux the reinforcement powders were tumble blended to ensure intimate distribution prior to sprinkling the combination at the surface of melt. The rate become no longer stirred for two-5 minutes so that the flux formed a liquid and the reinforcement were given transferred to the soften. the usage of a ladle the liquid flux which floated on surface changed into removed. The combination turned into then stirred for homogeneous dispersion of the reinforcement inside the soften after cleansing. finally the melt changed into poured into mold and cast. The whole fabrication process become completed in 15 mins. The particulates got transferred to the melt because the flux fashioned a liquid which rapidly enveloped the reinforcement. The oxide layer on the floor of the soften is dissolved through the addition of the ok-Al-F, cryolite type flux. The elimination of the oxide layer guarantees the removal of mechanical impediment for the particle entry [19].

S. Gopalakrishnan et al., developed Al-TiC composite by means of improved stir casting method to minimize the manufacturing associated hassle associated with traditional stir casting method. The temperature in the furnace was set to 30 °C above the melting point of AA6061 and wiped clean matrix fabric was located in the crucible to soften. With entire melting of the cloth, the temperature turned into further raised up by 50 °C to make amends for cooling effect due to stirring. The reinforcement TiC was mixed with the soften in the form of a pill (protected by means of aluminum foil). The method of step mixing changed into adopted to sell thorough mixing of the reinforcement. One percentage of Magnesium turned into delivered to the combination to promote the Wettability of TiC with aluminum. The inert gasoline argon become additionally brought at the same time as blending Magnesium to the combination so one can avoid molten aluminum reacting with atmosphere. Preheated cast iron molds had been located at the bottom of the furnace to pour with a purpose to keep away from the problem associated with the pouring of the molten cloth. manual stirring become completed at some point of pouring as well. The authors concluded that defect unfastened composite became produced with excellent distribution of particulates after reading the SEM photographs [20].

Mahendra Boopathi et al., focuses on Al2024 – SiC- Flyash hybrid steel matrix composite fabricated by way of stir casting approach and reports that particulates were no longer uniformly dispensed in unmarried reinforced composites and segregation of composites turned into really visible which they attribute to the gravity regulated segregation of particulates. This changed into avoided with reinforcements in preference to one of their take a look at which they clearly file within the paper as they look at by means of observations thru micrographs [21].

D.Siva Prasad et al., similarly upload up that hybrid composites reinforced by using Silicon carbide and rice husk ash particulates display uniform distribution as compared to single bolstered composites by way of stir casting technique and display up isotropic set of residences [22].

3. CONCLUSIONS

The stir casting technique commonly involves the heating of the matrix fabric to a melting temperature in a crucible that's chemically inert to the materials which are going to be charged into it. The crucible may be of diverse types and the

maximum simple kind being the coke fired. The furnace commonly being used is the electric resistance furnace. The particulates are preheated on the way to enhance its mixing with the matrix fabric additionally to keep away from thermal mis-healthy. The soften may or won't be stirred prior to blending the particulates. The temperature of the crucible depends at the alloy cloth being melted. the combination of the particulates may be -step or 3-step that's a variation depending on the weight probabilities of the reinforcement. the integration may be in semi-stable nation or above liquids country. There ought to be variations in the geometry of the stirrer and feeding mechanism to get a homogenized material. An inert surroundings may be maintained during stirring and pouring the melt into the mould that allows you to avoid defects in the cast product. The problem of fuel entrapment because of vortex creation can be averted with the aid of introducing the particulates by means of an injection gun with an inert gas wearing it. The Wettability between the matrix and the reinforcement has to be appropriate with a view to get a homogenized composite. the general conclusion is that the microstructure of the so produced composite has a fairly properly distribution of the particulates inside the matrix material. The properties received have performed the tailor able function of the composite fabric.

similarly from the literature it may be concluded that the fabrication approach, manner followed to shape MMCs, particulates temperature, degassing, stirring velocity and length, and pouring temperature of the mixture and ultimately the distribution of particulates etc. all have a large have an impact on on the final properties of the steel matrix composites.

REFERENCES

- [1] <https://juniperpublishers.com/ijoms/JOJMS.ID.555642.php>
- [2] Pradeep Rohatgi "Cast Aluminium – Matrix Composites for Automotive Applications" *JOM 1991 springer*
- [3] D.M. Skibo, D.M. Schuster, L. Jolla' Process for preparation of composite materials containing non-metallic particles in a metallic matrix, and composite materials made by, US Patent No. 4 786 467, 1988.
- [4] J. Hashim, L. Looney, M.S.J. Hashmi "Metal matrix composites: production by the stir casting method" *Journal of Materials Processing Technology* 1999; 92-93: 1-7
- [5] Dr.Jameel Habeeb Ghazi "Production and Properties of Silicon Carbide Particles Reinforced Aluminium Alloy Composites" *International Journal of Mining, Metallurgy and Mechanical Engineering* 2013; 1: 2320-4052
- [6] S. Balasivanandha Prabu, L. Karunamoorthy , S. Kathiresan , B. Mohan "Influence of stirring speed and stirring time on distribution of particles in cast metal matrix composite" *Journal of material processing technology* 171 2006: 268-273
- [7] Bharath V, Madhav Nagaral, V Auradi and S. A. Kori," Preparation of 6061Al-Al₂O₃ MMC's by Stir Casting and Evaluation of Mechanical and Wear Properties" *Procedia Material Science* 2014 ; 6 : 1658-1667
- [8] K.K. Alaneme, A.O. Aluko," Fracture toughness (K_{1C}) and tensile properties of as-cast and age-hardened aluminium (6063)-silicon carbide particulate composites" *Scientia Iranica A* 2012; 19(4): 992-996
- [9] S. Suresh, N. Shenbaga Vinayaga Moorthi, "Process development in stir casting and investigation on microstructures and wear behaviour of TiB₂ on Al6061 MMC" *Procedia Engineering* 64 2013: 1183-1190
- [10] Tony, Thomas.A, Parameshwaran.R, Muthukrishnan.A, Arvind Kumaran. M,"Development of feeding and stirring mechanisms for stir casting of Aluminium Metal Matrix Composites", *Procedia Materials Science* 2014; 5: 1182-1191
- [11] K.Umanath, S.T.Selvamani, K.Palanikumar K and D.Niranjana Varma," Metal to Metal Worn Surface of AA6061 Hybrid Composites Casted by Stir Casting Method", *Procedia Engineering* 2014: 703-712
- [12] Kenneth Kanayo Alaneme , Olusola Joseph Ajayi, "Microstructure and Mechanical behaviour of stir cast Zn-27Al based composites reinforced with rice husk ash, Silicon carbide and graphite", *Journal of king Saud University- Engineering Sciences* 2015

- [13] Abhilash Viswanath , H. Dieringa , K.K. Ajith Kumar , U.T.S. Pillai , B.C. Pai,” Investigation on Mechanical properties and creep behaviour of stir cast AZ91-SiCp composites”, *Journal of Magnesium and Alloys* 2015 ; 3 : 16-22
- [15] Himanshu Kala, K.K.S Mer, Sandeep Kumar,” A review on Mechanical and tribological Behaviours of Stir Cast Aluminium Matrix Composites”, *Procedia Materials Science* 2014; 6: 1951-1960
- [16] Pardeep Sharma, Satpal Sharma, Dinesh Khanduja,” Production and some properties of Si₃N₄ reinforced aluminium alloy composites”, *Journal of Asian Ceramic Societies* 2015; 3: 352-359
- [17] K.L. Tee , L. Lu , M.O. Lai,” In Situ Processing of Al-TiB₂ composite by stir casting technique”, *Journals of Materials Processing Technology* ,89-90 1999 : 513-519
- [18] J. Hashim, L. Looney, M.S.J. Hashmi,”Metal matrix composites: production by stir casting method”, *Journal of Material Processing Technology*, 92-93 1999: 1-7
- [19] A. R. KENNEDY, A. E. KARANTZALIS, S. M. WYATT,” The microstructure and mechanical properties of TiC and TiB₂-reinforced cast metal matrix composites” *Journal of Materials Science* 1999 ; 34 : 933- 940
- [20] S. Gopalakrishnan, N. Murugan “ Production and wear characterisation of AA6061 matrix titanium carbide particulate reinforced composite by enhanced stir casting method” *Composite : Part B* 43 2012 : 302-308
- [21] M. Boopathi, K.P. Arulshri, N. Iyandurai “Evaluation of mechanical properties of aluminium alloy 2024 reinforced with silicon carbide and fly ash hybrid metal matrix composites” *Am J Appl Sci*, 10 (3) (2013), pp. 219–229
- [22] D. Siva Prasad, C Shoba “ Hybrid composites – a better choice for wear resistant materials”, *J Mater Res Technol*, Volume 3 (2),2014,pp-172-178