Wear Behavior of Al-Si Alloy Matrix Composites Reinforced with SiC Particles

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Abstract:-

The aim of the present work is to study a dry sliding wear behavior of (Al – 12wt % Si) alloy reinforced with 5wt% SiC particles. Metal matrix composite samples were prepared by stir casting using vortex technique and squeeze casting under varying casting pressures from 7.5 to 53MPa , and mold preheated at temperature (200°C). Pin-on-Disk wear tests were conducted at varying loads from 5 to 20 N under a constant sliding speed of 2.7 m / sec. The results showed microstructure refinement with increasing the squeeze pressure. This correlated with increased hardness and reduced wear rate. It was also determined that the composites produced by squeeze casting had better wear resistance than of stir casting.

Keywords: Al–Si alloy; composite; wear ; microstructure ; squeeze casting

1. Introduction:-

Aluminum alloys are attractive in aerospace and automobile applications due to their low density, good corrosion resistance, high thermal and electrical conductivity and high damping capacity [21], but they lack sufficient wear resistance. The reinforcement the fibers or particles to aluminum matrix improved the mechanical properties that are highly desirable in various applications. Al-Si metal matrix composites (MMC) have attracted much attention due to their excellent mechanical properties, high wear resistance and low coefficient of thermal expansion [25].

Squeeze casting, also known as liquid metal forming was selected because it produces dense, fine equiaxed grain structures even with alloys compositions normally restricted to use in the wrought form. It is a combination of casting and forging processes where molten metal is poured into a die that is pressurized as the material solidified [5].The resulting microstructure can improve the properties of the resulting material. Other similar processes, such as high pressure die casting, and hot isostatic pressing do not improve the mechanical properties of Al-Si alloy as greatly as squeeze casting which has the added benefit of producing components with high efficiency [23]. Pressurized casting has a number of advantages which include the elimination of gas and shrinkage porosities, the reduction or elimination of metal wastage due to absence of feeders or risers and the ability to cast both cast and wrought alloys[12].

Several processes have been developed to prepare metal matrix Al/Sip composites reinforced with particles or fiber reinforcement, including melt infiltration [7],squeeze casting [22], spray deposition[8] and powder metallurgy....etc[17]. Ehsani and Seyed Reihani [9] produced Al 6061 /SiC composites using a squeeze casting method.SiC preforms were manufactured by mixing SiC powder having a 16 and 22μm particles size ,with colloidal silica as a binder. 6061 Al melt was squeeze cast into the pores of the SiC perform to manufacture a composite containing 30 vol. % reinforcement. The results show that the hardness, yield point and tensile strength increase with addition of SiC particles to 6061 Al alloy. Basavarjappa *et al*.[3]investigated dry sliding wear behavior of the Al 2219 alloy reinforced with SiC particles in 0-15 wt% in three steps, at different loads and speeds. The liquid metallurgy technique, with creating a vortex in the melt, was used to fabricate the composite specimens. The results show that the wear rates of the composites are lower than that of the matrix alloy, and further decrease with increasing SiC content. Chen Zhenhua *et al*. [6] investigated the wear behaviors of spray-deposited Al–Si/SiC composites, with Si contents between 9 and 20% and 15 vol. % SiC particles, by using a ring-on-ring test at room temperature under dry conditions. It has been found that the wear rate decreases with the increase in hardness of composites due to silicon content increasing. Hajjari *et al.* [10]produced carbon fiber reinforced 2024 aluminum alloy composites by squeeze casting method, under applied pressures of 30, 50,and 70MPato infiltrate the melt into the carbon fiber bundles. They were used for production of composites samples, nickel coated and uncoated carbon fibers with a mean volume fraction of 40%. They were concluded that applying nickel coating on carbon fibers improves the infiltration of molten aluminum into the carbon fiber bundles and thus reduces the pressure required for infiltration significantly. In the present study, Al-12%Si alloy matrix composites reinforced with SiC particles were prepared using the squeeze casting method. This method allows incorporate ceramic particles into composite and the microstructure exhibit uniform distribution of ceramic particles and good bonding between the matrix and reinforcement. The effect of squeeze casting pressure on microstructure and on dry sliding wear behavior of composites reinforced with SiC particles are investigated and compared with those produced by stir casting.

2. Experimental Works

2.1 Casting methods

AlSi12 standard alloy (Al-12%Si) ingots were prealloyed combined with 53-75µm SiC as reinforcing particles in weight percentage of 5wt%. Gravity die castingwas performed by melting the alloy at 750ºC in a graphite crucible in an electric resistance furnace and then the melt was pouring in a steel mold held at 200ºC. SiC particles were held at 300◦C for 60min prior to being introduced to the molten AlSi12 alloy. The molten AlSi12 was stirred at speed 500rpm for 5min after the SiC particles were introduced followed by solidification in a die at 200◦C. The squeeze casting system used in this work includes: hydraulic press, squeeze punch and squeeze die. A vertical hydraulic press is used (with a ram 70 mm in diameter) to apply the pressure in a perpendicular direction to the squeeze casting die. The press can apply a hydraulic pressure of (1-70) Kg/cm^2, at a constant ram speed of 25 cm/min. The die is cylindrical in shape with dimensions of 25mm in height and 41.5mm in diameter. This lower part is used to squeeze the molten alloy. This design allows the final squeezed composite casting to be removed from the die easily.

Procedures similar to those mentioned in the preparation of samples by gravity die casting, were carried out. The molten Al-Si alloy with SiC particles was stirred and poured into the bottom half of the squeeze die (i.e die cavity). As the molten metal started solidifying, the upper half closed the die and applied pressure during the solidification process. The casting pressures that were used for all castings were (7.5, 23, 38 & 53) MPa. The required squeeze pressure was applied for 30 seconds at a delay time of 5 seconds for solidification. The solidified composite casting was removed from the die.

2.2 Tests and measurements

Specimens of base alloy (A1 and A2) and cast composites (C0, C10, C30, C50 &C70) were prepared by grinding operation with water was done by using emery paper of SiC, and then polishing process was done to the specimens by using diamond paste of size (1µm) with special polishing cloth and lubricant and then etching process was done to the specimens by using etching solution which is composed of (99% H_2O+1%HF). Vickers hardness test was made by using Vickers hardness tester type (Einsingenbei U/M, Model Z323) and the specimen being tested under a static load of 300 gm for10-15sec.

The Archimedes technique was used to measure the density of base alloy and composites samples. The porosity percentage (P%) was measured for the squeeze and stir cast composites samples by using both the actual density(ρ_{ac}) and theoretical density of reference (ρ_{th}) [13].

Wear specimens were machined from ingots and cut according to ASTMG99 specification into 20mm length and 10mm diameter[16]. Then one surface of each specimen was ground and polished to obtain clean and smooth surface. Dry sliding wear tests were conducted at room temperature using a conventional Pin- on-Disk testing machine. The hardness of steel disk was 35 HRC. The applied loads were 5, 10, 15 and 20N, the sliding speed was 2.7m/sec and the revolution speed of motor was 510 rpm. Weight loss method of disk specimens was measured using an electronic balance (DENVER-Max-210gm) with an accuracy of 0.1mg. Wear rate of the specimens were calculated through weight loss divided by sliding distance according to equation (1) [19].

Where:

$$\text{Wear rate} = \Delta w/S_D \quad (1)$$

$$S_D = S_S{*}t = \pi D.N.t \quad (2)$$

Therefore,

$$\text{Wear rate (W.R)} = \Delta W/\ \pi D.N.t \quad (3)$$

Where:

S_D = linear sliding speed (m/sec)

D = sliding circle diameter (cm)

t = sliding time (min)
N = steel disk speed (rpm)

3 Results and Discussion

3.1 Microstructure results

Fig. 1 shows the microstructure of gravity cast sample (A1)which consists of primary phase (α-Al) as dendritic structure which represents the matrix of the microstructure and a black color of silicon phase (as flakes). A part of primary silicon phase is shown as a block or mass of silicon (Grey color) in some regions of matrix microstructure. As applied pressure increases the refinement of eutectic phase increases and in comparison with squeeze cast sample (sample A2), the α-dendrites are much bigger than those of gravity cast sample as shown in Fig. 2.

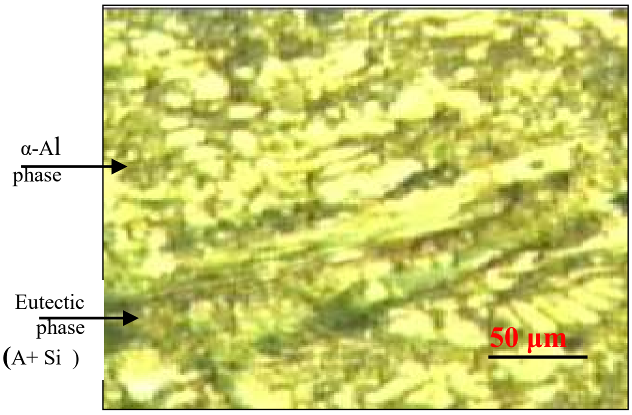


Fig 1. The microstructure of gravity Die cast sample (sample A1)

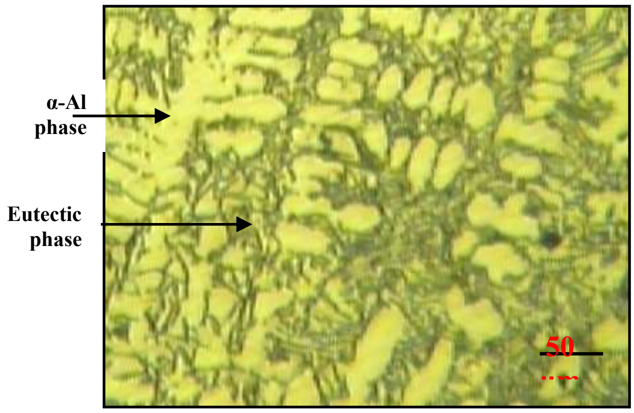


Fig 2. Microsturcture of squeeze cast sample at applied pressure 53 MPa (sample A2)

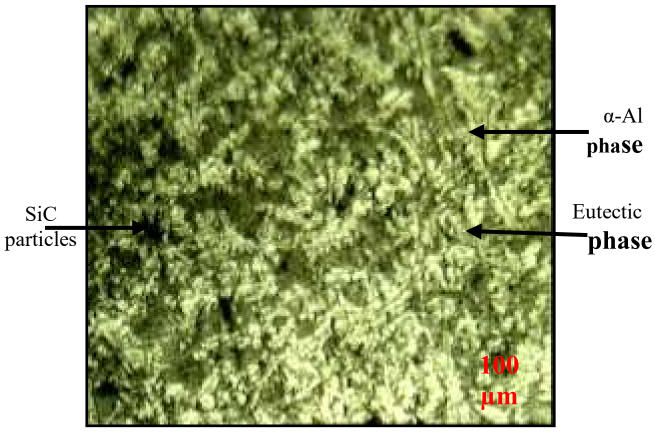


Fig 3. The microsturcture of stir cast sample (composite sample C0)

Fig. 3 shows the microstructure of the composite sample (sample C0) made by stir casting method. It is seen that the distribution of SiC particles is relatively uniform and good bonding between reinforcements and matrix alloy is observed. The segregation of some reinforcements (SiC particles) into eutectic regions as a solidification effect is seen in this figure. These results have been pointed out by several researchers [6, 2].

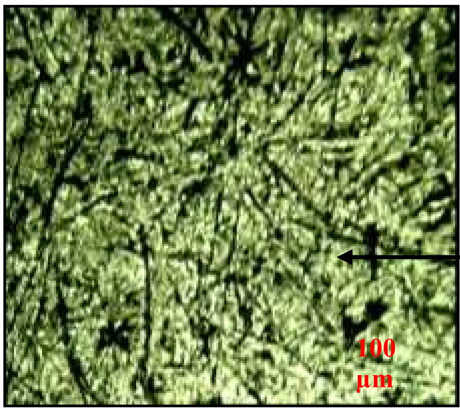


Fig 4. The microstructure of squeeze cast sample at applied pressure 7.5 MPa (composite sample C10)

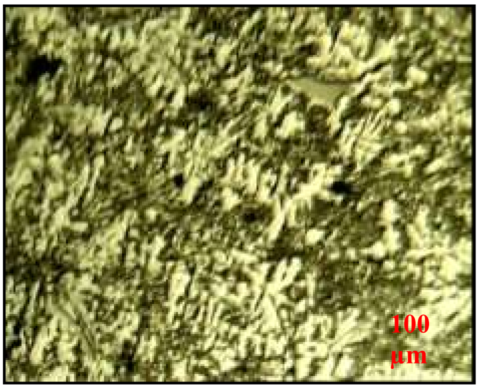


Fig 5. The microstructure of squeeze cast sample at applied Pressure 53 MPa (composite sample C70)

Figs. 4 and 5 show the microstructures of composites (samples C10 and C70) respectively which were prepared by squeeze casting method with variation in applied casting pressures o f 7.5 and 53MPa respectively. It is obvious that each of the composites has a relatively uniform distribution of SiC particles, primary α-Al grains, eutectic phase and massive primary Si phase in the interdentritic regions. The α-Al grains and eutectic phase greatly refined and modified with increasing the squeeze casting pressure. This is due to the high cooling rate associated with the rapid solidification processes during the squeeze casting in which the pressure is applied to the molten metal in the die cavity [9, 2]. In addition the dendritic structure is changed gradually to equiaxed grains as a result of the applied casting pressure increase from 7.5MPa to 53MPa.

3.2 Hardness results

Vickers hardness results are given in Tables. 1 and 2. It is observed that the hardness of squeeze cast sample of base alloy (Al-12%Si) is higher than that of gravity die cast sample. It is also seen that the squeeze cast composite samples have higher hardness values than stir cast composite samples. This is due to rapid solidification and high cooling rate of molten metal under applied pressure which gives smaller grain size and more refine of eutectic phase (Al-12%Si) than that of stir cast and gravity die cast. From Table 2 it is seen that the hardness values of the squeeze composite samples increase from 84 HV to 128 HV at pressures 7.5 MPa to 53 MPa respectively. It was thought the microstructural changes played important role in the increase in the hardness value of the squeeze cast.

Table 1. The actual density, theoretical density, VHN and P%, determination for base alloy (Al-12%Si) samples prepared by gravity die casting and squeeze casting

Sample Symbol	P_a(MPa)	Tp(°C)	T_D(°C)	ρ_{ac} (g/cm^3)	ρ_{th} g/cm^3)	P%	VHN Kg/mm^2
C0	Stir casting	700	200	2.604	2.706	3.76	84
C10	7.5	700	200	2.626	2.706	2.95	96
C30	23	700	200	2.628	2.706	2.88	118
C50	38	700	200	2.659	2.706	1.73	123
C70	53	700	200	2.620	2.706	1.62	128

Table 2. The actual density, theoretical density, VHN and P%, determination for composite samples prepared by squeeze casting under different applied pressures

Sample Symbol	P_a(MPa)	Tp(°C)	T_D(°C)	ρ_{ac}(g/cm^3)	ρ_{th} (g/cm^3)	P%	VHN Kg/mm^2
A1	Gravity dieCasti	700	200	-	2.68	-	68
A2	Squeeze casting	700	200	2.674	2.68	0.22	120

ρ_{ac}: Actual density, g/cm^3
Tp : Pouring temperature ,ºC
ρ_{th}: Theoretical density, g/cm^3
T_D : Die (Mold) temperature ,ºC
P%: Porosity percentage
Pa: Applied casting pressure, MPa
VHN: Vickers Hardness Number

3.3 Density and porosity measurements results

The effect of squeeze pressure on density and porosity is illustrated in **table 2.** The density is increased continuously with increasing the applied pressure in squeeze casting; it shows a rise at the used pressure from 7.5 MPa to 53MPa. This is attributed to the existence and segregation of porosities at the center of sample. The main part of shrinkage for the samples solidified under atmospheric pressure has been accommodated by formation of a large shrinkage pipe on the top surface of the cast. Upon the application of squeeze pressure, such shrinkage pipe and cavities are pushed down toward the bulk of the samples. Consequently, if the applied pressure is not large enough to eliminate such cavities, smaller density values may be attained. With further increase in the applied pressure up to 53 MPa, gas and shrinkage porosities decrease and hence density increases. These results are in agreement with those of other researchers [24, 14].

3.4 Wear test results

3.4.1 Wear behavior of the Al-12%Si Alloy

Fig. 6 shows the variation in mass wear rate with applied normal load during wear test for both samples (A1 and A2) of the base alloy(Al-12%Si) which were prepared by gravity die and squeeze casting respectively, under dry sliding conditions at a sliding time of 20min and sliding speed of 2.7m/sec.

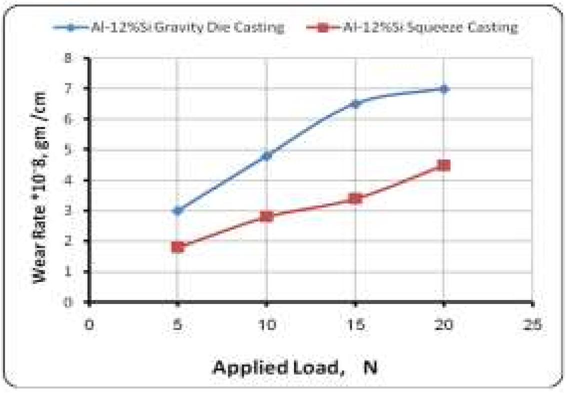


Fig 6. Wear rate versus applied load diagram in different casting methods for the Al- 12%Si alloy at constant sliding speed of (2.7 m/sec) and constant sliding time of (20min)

It is noticed that the wear rate increases as the applied load increases for both samples A1 and A2. This is due to the fact that when the load on the pin specimen is increased, the actual area of contact would increase towards the nominal area, resulting in increased frictional force between two sliding surfaces. The increased frictional force and real surface area in contact will bring about higher wear rate. Similar observations were made by Basavakumar *et al*. [4]. They studied the influence of grain refinement and/or modification and combined addition of both on the sliding wear behavior of Al–7Si and Al–7Si–2.5Cu cast alloys under different loads (10-100N) at constant sliding speed of (1.0 m/sec) and constant sliding distance. In this work, it is noticed that the wear behavior of sample A1 is similar to that of sample A2.It is mild wear (oxidative wear) at low loads of (5-10) N, and when the load increases the wear rate increases and transforms to metallic wear at high loads of (10-20) N. The wear rate of the squeeze cast sample (sample A2) is less than that of the gravity die cast sample (sample A1) at all applied loads (5-20N). These results are in agreement with those of other researchers [14, 1].

3.4.2 Wear behavior of the Al-12%Si-5%SiC composites

From **fig. 7** it is observed that the wear rate of the stir cast composite (sample C0) is more than that of the squeeze cast composites(samplesC10,C30, C50 & C70) under dry sliding conditions at loads of (5-20N)and at a sliding time of 20min and sliding speed of 2.7m/sec.

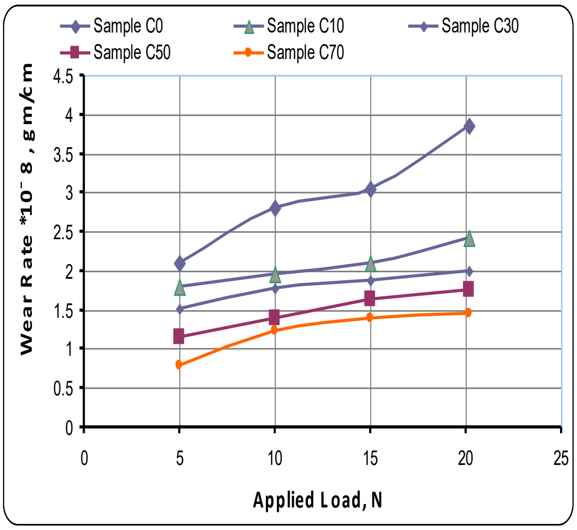


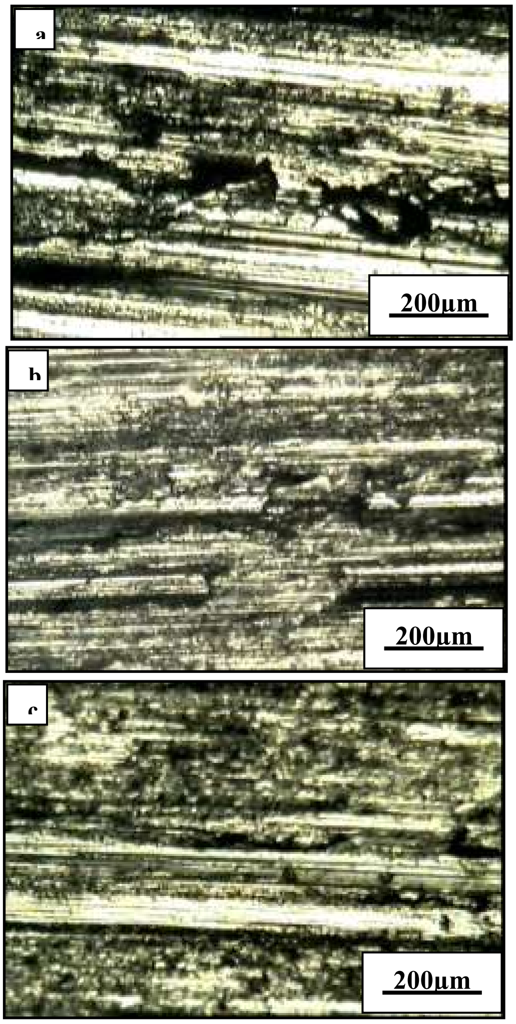
Fig 7. Wear rate versus applied load diagram in different squeeze casting pressures for the Al-12%Si -5% SiC composite at constant sliding speed of (2.7 m/sec) and constant sliding time (20min

It was seen that the wear behavior of composite (sample C0) is different from that of composites (samples C10, C30, C50 &C70). It is mild wear (oxidative wear) at low loads (5-10) N, and changes or transforms to metallic (severe) wear at high loads of (10-20) N. Both composites materials display transitions from mild to severe wear at specific load and at a constant sliding speed. The mild wear region for the squeeze cast composite extends to a higher range of loads in comparison with stir cast composite. Within the mild region, two sub-regions exist for squeeze cast composites, namely where mixing/oxidation occurred at low loads to produce a thermally insulating surface layer, and another at higher loads where this layer was removed. Both composite wear transitions, i.e. from mild to metallic region, occurred at load range of 5-20N where the wear rates of the composites were lower than those of unreinforced standard alloy (Al-

12wt%Si)as shown in Fig. 6. Similar observations were made by Wilson and Alpas [20]for the A356 Al alloy and A356AI-20% SiC in sliding contact with tool steel at different sliding speeds and loads Here large decreases in electrical contact resistance between sliders were seen when non-conducting surface oxide layers were removed by changing the wear conditions. It was found that the addition of SiC particles to A356 Al expanded the mild wear region to higher speeds and loads, thereby inhibiting severe wear. SiC particles assist with the retention of an oxide transfer layer on composite sliding surfaces which prevent metal-metal contact and keep wear behavior within the mild wear region. Fig. 7 shows also the effect of applied casting pressure on the wear rate of different samples. The sliding wear rate reduces or wears resistance increases with increasing the applied casting pressure which was used to press the molten alloy in the die cavity during squeeze casting of Al-12%Si alloy. This is due to an increase in the hardness value as the applied pressure increases, because the applied pressure during solidification reduces or prevents the formation of both shrinkage and gas porosity in the solidifying alloy. This reduction in shrinkage porosity comes as a result of bulk deformation and improving of filtration feeding action during solidification under pressure in squeeze casting [11, 15]. The composite samples (C10, C30, and C50 & C70) exhibit better wear resistance in the squeeze cast condition compared with the same composite in the stir cast condition. The improved wear resistance of squeeze cast Al–12%Si alloy and composites is related to the refinement of the aluminum grain size, uniform distribution of eutectic Al-silicon and fine Si phase in the eutectic region resulting from combined refinement and modification, in addition to the uniform distribution of SiC particles in the alloy matrix.

3-4-3 Worn surface analysis results

Wear surface analysis of base alloy and composites samples were examined by optical and SEM microscope (Type TESCAN VEGA II). Fig. 8(a, b, c, d & e) shows optical micrographs of the worn surfaces of different samples, gravity die cast sample(A1) and squeeze cast of base alloy(A2), and composite samples (C0,C10 & C70) which were prepared by stir cast and squeeze cast respectively. Wear test was carried out at a sliding speed of 2.7m/sec and a load of 20N, and for sliding time of 20min. The worn surfaces show grooves parallel to the sliding direction and cracking of long wear track. In some places ,some plastic deformation, together with presence of fine oxides debris particles are also observed in case of gravity die cast sample. On the other hand, it a smooth and glassy finish and faint wear lines are seen in the direction of sliding on worn surfaces of composites samples. That indicates a mild wear mode is present in composites samples which were squeezed at applied pressures (7.5-53 MPa).



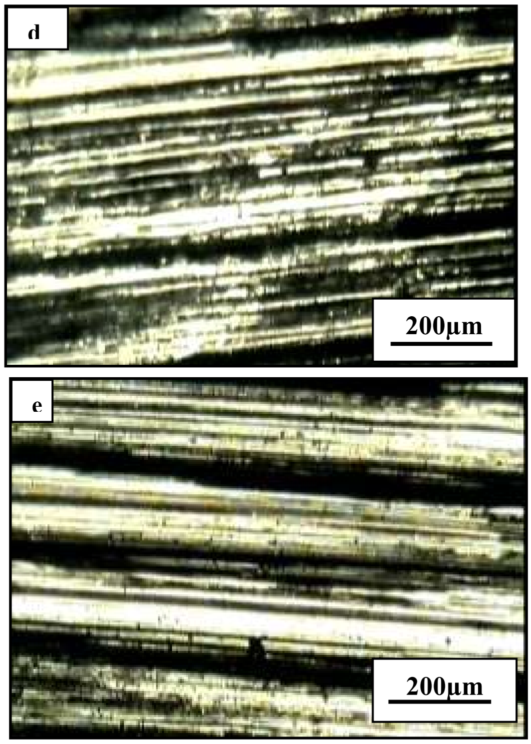


Fig 8. Micrographs of the worn surfaces of the base alloy (Al-12%Si) and composites at a sliding speed of 2.7m/sec, load of 20N and sliding time of 20min

(a) Base alloy -gravity die cast
(b) Base alloy- squeeze cast at applied pressure 53 MPa
(c) Composite sample-stir cast
(d) Composite sample - squeeze cast at applied pressure 7.5 MPa
(e) Composite sample- squeeze cast at applied pressure 53 MPa

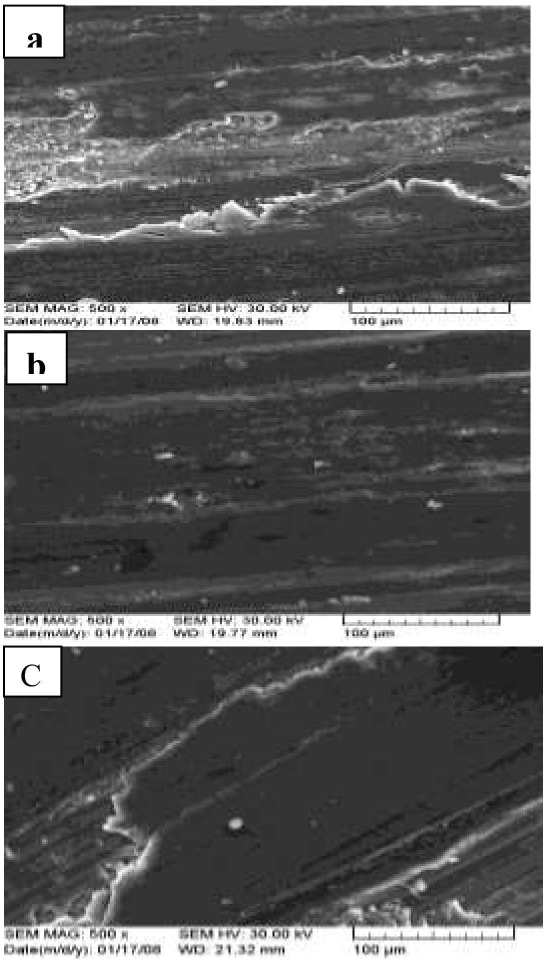


Fig 9. SEM micrographs of the worn surfaces of the base alloy(Al-12%Si) and composites at a sliding speed of 2.7m/sec , load of 20N and sliding time of 20min

(a) Base alloy- squeeze cast at applied pressure 53 MPa
(b) Composite sample-stir cast
(c) Composite sample- squeeze cast at applied pressure 53 MPa

Fig. 9 (a, b and c) shows SEM Micrographs of the worn surfaces of the base alloy(Al-12%Si) and composites samples at a sliding speed of 2.7m/sec , load of 20N and sliding time of 20min.

It was observed that the wear surface consists craters and cracks which are formed when the materials is removed from some regions as wear debris during wear test. Also the worn surface shows plastic deformation and grooves parallel to the sliding direction as in Fig. 9a. This due to plowing actions at the wear surface. Plowing is deformation-induced materialremoval phenomenon [18], and consequently the wear rate is governed by mechanical properties of the sample and consequently the wear behavior. While in case of composites samples the possibility of fracture and worn surface is low due to presence of hard particles of SiC which protrudes to composite surface that will retard the wear process compared to as-cast samples leading to the improvement of wear resistance, as seen in the form of smooth worn surface (see Figs. b and c).

4- Conclusions

1- The results show a refinement and modification in the microstructure of standard alloy(Al-12%Si) and composite samples which were prepared by squeeze casting method

2- The samples which were prepared by squeeze casting method have higher hardness values and wear resistance than those of the gravity die casting.
3- The composites prepared by squeeze casting method have higher hardness values and wear resistance than those of the stir casting.
4- As the applied casting pressures increases the hardness values and wear resistance increase. for squeeze cast samples which included the standard alloy and composites
5- The actual density of squeeze cast samples is improved and approaches the theoretical density because of the reduction in shrinkage porosity as applied pressure increases during solidification in squeeze casting.
6- It has been found that the wear rate decreases with the increase in the hardness of composites due to squeeze pressure increasing.
7- The composites exhibit better wear resistance in the squeeze cast condition compared with the same composite in the stir cast condition.
8- The mild wear region of the squeeze cast composite is extended to a higher range of loads in comparison with unreinforced standard alloy.

5- References

[1] Abbas M.K.: Study of dry sliding wear behavior of Al-12%Si alloy produced by squeeze casting. The Iraqi Journal for Mechanical and Materials Engineering, Babylon University, College of Engineering, Babel Country, Iraq, 69-382(2009)

[2] Akbulut H., M. Durmam M. , Yilmaz F.: Dry wear and friction properties of δ-Al2O3 short fiber reinforced AI-Si (LM13) alloy metal matrix composites. Wear 215, 170-179(1998)

[3] Basararjappa S., Subramanian G., Choudrasakar A.: Dry sliding wear behavior of Al-2219/ SiC metal matrix composites. Materials Science, Poland 24, 357-366(2006)

[4] Basavakumar K.G., Mukunda P.G., Chakraborty M.: Influence of melt treatments on sliding wear behavior of Al–7Si and Al–7Si–2.5Cu cast alloys. J. Mater. Sci. 42, 7882–7893(2007)

[5] Chen Y. ,Chung D.D.L.: Aluminum- matrix silicon carbide whisker composites fabricated by pressureless infiltration. J. Mat. Sci., 407-412 (1996)

[6] Chen Zhenhua, Teng Jie, Chen Gang, Fu Dingfa, Yan Hongge: Effect of the silicon content and thermomechanical treatment on the dry sliding wear behavior of spray-deposited Al–Si/SiCp composites. Wear 262, 362–368(2007)

[7] Chien CW, Lee SL, Lin JC and, Jahn MT: Effect of Sip/Al size and volume fraction on properties of Al/Sip composites. Mater Lett. 52, 334-41(2002).

[8] Cui C, Schulz A., Epp J., Zoch HW: Deformation behavior of spray-formed hypereutectic Al–Si alloys. J.Mater.Sci.45, 2798–807(2010)

[9] Ehsani R. and Seyed Reihani S.M.: Aging behavior and tensile properties of squeeze cast Al 6061/SiC metal matrix composites. Sharif University of Technology, Scientia Iranica 11, 392-397(2004)

[10] E. Hajjari E., M. Divandari M., Arabi H.: Effect of applied pressure and nickel coating on microstructural development in continuous carbon fiber-reinforced aluminum composites fabricated by squeeze casting. Materials and Manufacturing Processes, Taylor & Francis Group LLC 26, 599–603(2011)

[11] J.R. Franklin J.R. , Das A.A.: Squeeze casting – a review of the status. British Foundry Man Journal 77, 150-158(1984)

[12] Long S. , Beffort O., Moret G. Thevoz Ph.: Processing of Al-based MMCs by indirect squeeze infiltration of ceramic preforms on a shot-control high pressure die casting machine. J. Mat. Sci. Eng., 1-10(1999)

[13] Meclain S.T.: A study of porosity quantification techniques and pore morphology in aluminum alloy casting. MSc Thesis, Department of Mechanical Eng. Mississippi State University, Mississippi State, USA (1997)

[14] Najeeb S.A.: A study on squeeze casting parameters effects on improving the metallurgical and mechanical properties of aluminum alloys. PhD Thesis, Dept. of Production Engineering and Metallurgy, University of Technology, Baghdad(2007)

[15] Osama S.: Studying the parameters affecting the production of Al- alloy composite materials by squeeze casting. PhD Thesis ,Dept. of Production Engineering and Metallurgy, University of Technology, Baghdad(2008)

[16] Standard Test Method for wear testing with a Pin-on-Disk, Endo lab mechanical engineering GmbH,www.endolab.de ,www.astm.com, test equipment MT: wear tests "pin-on-disk" type- MICROTEST, S.A., 1-8(2010)

[17] Sub ZQ, Zhang D and Li GB: Evaluation of dry sliding wear behavior of silicon reinforced aluminum matrix composites. Mater. Des.26, 454–8(2005)

[18] Tahamtan S.., Emamy M. Halvaee A.: Effects of morphological characteristics of alumina particles and interfacial bonding strength on wear behavior of nano/micro alumina particulates reinforced Al/A206 matrix composites. Tribol.Lett.51,499-511(2013)

[19] U. N. I. D. O.: Advances in Material Tech., Monitor Vienna International Center, Austria, 9-11(1990).

[20] Wilson S. and A.T. Alpas A.T.: Wear mechanism maps for metal matrix composites. Wear 212 41-49(1997)

[21] Wenlai S., Chung D.D.L.: Fabrication of particulate aluminum matrix composites by liquid metal infiltration. J. Mat. Sci. 29, 3128-3150 (1994)

[22] Xiu ZY, Wu GH, Zhang Q, Song MH ,Tian SF: Microstructure and electric properties of Sip/Al composites for electronic packaging applications. Trans Nonferrous Metals Soc China 17, 1034–1038 (2007)

[23] Yue T.M.: Squeeze casting of high-strength aluminum wrought alloy AA7010. J. Mat. Proc. Tech. 66, 179-185 (1997)

[24] Zovko Brodarac Z., Mrvar P., Medved J., Fajfar P.: Local squeezing casting Influence on the compactness of AlSi10Mg alloy casting. Metalurgija Metabk 46 , 29-35(2007)

[25] Zhang X.X., Wang D.Z. , Geng L.: Coarsening of eutectic silicon in squeeze cast alumina fiber reinforced eutectic Al-Si aluminum composites. J. Mat. Sci. Lett. 22, 861-863 (2003)

سلوك البلى لمواد مركبة ذات ارضية من سبيكة الالمنيوم- سليكون المقواة بدقائق كاربيد السليكون

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قسم هندسه الانتاج والمعادن / الجامعه التكنولوجيه

الخلاصة:-

يهدف البحث الى دراسة سلوك البلى الانزلاقي الجاف لسبيكة الالمنيوم-12٪ سليكون المقواة بدقائق كاربيد السليكون بنسبة وزنية 5٪. وتم تحضير المواد المركبة بطريقة السباكة بالمزج باستعمال تقنية الدوامة وبطريقة السباكة بالعصر تحت ضغوط متغيرة من 7.5 -53 ميكاباسكال مع تسخين مسبق للقالب في درجة حرارة 200 م°. وقد اجريت اختبارات البلى من نوع المسمار على القرص مع تسليط احمال عمودية مختلفة من 5- 20 نيوتن عند سرعة انزلاق ثابتة (2.7 متر/ ثانية). وقد اظهرت النتائج تنعيم في البنية المجهرية مع زيادة ضغط العصر مما ادى الى زيادة الصلادة وتقليل معدل البلى. وقد وجد ايضا ان مقاومة البلى للمواد المركبة المنتجة بطريقة السباكة بالعصر افضل مما هو عليه من السباكة بالمزج.