The Iraqi Journal For Mechanical And Material Engineering, Vol.17, No1, March.. 2017

STUDYING MAGNESIUM ADDITION ON MECHANICAL PROPERTIES FOR COMPOSIT HYPEREUTECTIC Alloys 18% SILICONE USING ADHESIVE WEAR .

PHD Abdul Mohsin Naji ALMohaisen
Middle Technical University
E-mail moh Naj56@yahoo.com

ABSTRACT :-

The impact of time ,speed of sliding and load on wear qualities of hypereutectic aluminum 18% silicon alloys by pin on disc apparatus is actualize. silicon alloys are most prosperous materials due to include hardness and resistance of wear compared to other alloys or any other composites and by using die-casting, many alloys are prepare at diverse of magnesium additions (2.5, 3.5, 4.5)wt% to the Al-18%Si- alloy in order to study the effect of magnesium additions on the wear rate The microstructure of prepared alloys is examine by optical microscope.. The experiments of the wear are carry out on a set of specimens under different times ranging from (10 to 40) minutes, and loads (0.5 to 2) kg, and diverse sliding speeds (2.5 to9) m /sec the results of microstructural show the existence of primary silicon (Si) and phases of eutectic silicon and adhesion wear properties decrease when magnesium was added to aluminum at all percentages. It was concluded that decrease in hardness and increase in ductility contributed to decreasing in wear properties in the range of these values.

KEY WORDS : hypereutectic Al-Si alloys; wear rate; sliding distance, element alloy.

دراسة اضافة المغنيسيوم على الخواص الميكانيكية لسبيكة من مركب المنيوم %18 سيليكون .

أ.م. د. عبد المحسن ناجي المحيسن
الجامعة التقنية الوسطى

الخلاصة :-

تم دراسة تاثير كل من الزمن ،الحمل، السرعة الانزلاقية على خواص البلى الالتصاقي بطريقة pin on disc لسبيكة المنيوم %-18 سيليكون والذي له اهمية في سبائك الالمنيوم لما يملك من خواص منها الصلادة ومقاومة البلى مقارنة بعناصر السبك والمواد الاخرى .تم تحضير عدد من السبائك بطريقة السباكة في قوالب معدنية باضافة عنصر المغنيسيوم بنسب مختلفة wt % (2.5,3.5,4.5) لسبيكة المنيوم %-18 سيليكون لدراسة تاثير اضافة المغنيسيوم على معدل البلى حيث اجري اختبار البلى وفق المتغيرات من زمن اذ طبق من (10 to 40) دقيقة وعند حمل (0.5 to 2 kg) وسرعة انزلاقية من(2.5to 9 m/sec) واوضحت نتائج البنية المجهرية التي تم فحصها بواسطة المجهر الضوئي وجود سيلكون مباشر مع سيلكون بطور اليوتكتك وان نتائج اختبار البلى شهدت زيادة في معدل البلى عند اضافة المغنيسيوم وبالنسب التي تم ذكرها لدوره في تقليل الصلادة وزيادة المطيلية .

Received : 6 – 12 - 2016
Accepted : 25 – 1 – 2017

1-INTRODUCTION :-

It is known that casting aluminum which reinforces composite alloys enjoy specific strength, specific modulus, hardness and good wear resistance as compared to unreinforced alloys. [**Deepak Singla1, S.R. Mediratta, 2013**] Hypereutectic alloys comprise Al-Si alloys which have silicon greater than 12% and these composites fine resistance of wear, decent features of casting and a lesser coefficient of thermal expansion. Also they enjoy fluidity which is noticeable and machinability which is fine in terms of finish of the surface and characteristics of chip. The aluminum alloy (18% silicon) is utilized in small engines, components in automatic transmission and pumps, master brake cylinders pistons for Air conditioning compressors **[Sunil Kumar, 2Anoop Aggarwal ,2014] .**

We can increase the modulus of elasticity, thermal stability for dimensional and thermal conductivity and strength of bending for aluminum by increasing Si content until 12% Si of the composites and reducing the thermal expansion coefficient (CTE) of the composites and Magnesium (Mg) thus supplying great strengthening and improvement of the characteristics of work-hardening of aluminum. It can offer good resistance of corrosion and weld ability or extremely high Strength .Silicon combines with magnesium to make the hardening phase Mg_2Si (Fig.1)that gives the strengthening property**[Hemant kumar Neopaney 2014].**

It was found 4–8 wt. %, was the optimum content of Mg to aluminum at which the composites reverse good thermo-mechanical properties. However, as the Mg content was enhanced beyond 8 wt. %, the higher porosity in the composites which results from the lower pressure of the magnesium caused lower thermo-mechanical properties. **[Rana. R. S., Rajesh Purohit ,2012].**

Adhesive Wear is a sort of wear alternator by moving of one solid surface against another., clearly sliding wear is a kind of wear which is “enduring” when all other kinds of wear have been examined under separate headings**[B.K. Kardasheva, L.L. Regelb, W.R. Wilco**,**2005].**

A number of studies have examined aluminum – silicon composite strengthens using different percentages of metals and wears behavior such as:-

[Deepak Singla,2013] study the effects of sliding speed ,load on wear belongings and the friction coefficient using Pin on Disc apparatus. The sample is prepare of Al 7075-Fly Ash composite material .this metal composite is used to modify special characteristics including hardness and resistance of wear compared to alloys or any other metal. He made it clear that composites with fly ash with Al 7075 as reinforcement is optimize the differently in physical and mechanical features. They are used on a large scale in the automotive and space craft industries.

[Sunil Kumar,2014] study the tribological properties of alloys made from aluminum-silicon. Which increases resistance of wear when addition of silicon to aluminum increases but decreases the coefficient of thermal expansion as well as high strength to eight ratio. Then he observed that wear is increase with velocity increase and also with increased normal load. But he also observed decreasing Silicon content under lubricated condition gives increase in wear resistance because of the interaction of Silicon platelets at the Al-Si boundary.

[kumar Neopaney ,2014] studied the mechanical & tribological properties of five alloy samples(9,12,14,17and 21)wt%Si.Many physical tests were done such as composition analysis to investigate the weight% of Silicon & Aluminum in the Al-Si alloy. Density test was made by measuring mass and volume of the alloy samples.. Porosity of the samples is evaluated by considering the density of the component (γp) and the density of the solid alloy material (γs) is evaluate also mechanical test such as hardness by Brinel method is carry out . Tests of wear are performs using pin on-disc method by machine type (DUCOM monitor of wear and friction) and sliding velocity , applied load and time are taken as the parameters .Results show that when silicon percentage increases it causes an increase wear resistance due to increase in hardness .

[Ravindra Babu G1, Dr Girish D P2,2015] Al-Si alloy A356 is improved by modify and refined the grain using Al-5Ti-1B and Al-10Sr re Ravindra Babu G1, Dr Girish D P2spectively pre-heated template was used to cast these alloy using liquid metallurgy route. Then solution heat treatment included heating the alloys to 540C°, water quenched and aged for 5 hours at 180°C. Hardness and wear resistance were tested agreeing to ASTM standards he points out increasing in wear resistance by Grain refined, Modified and heat treated A356 compared to as cast A356, Grain refined and modified A356. The result appear that the improvement in wear resistance may be due to grain refinement and modification of the microstructure and improving hardness by heat treatment .

In this study the effect of magnesium addition at different amount on wear behavior of hypereutectic Al-18%wtSi cast alloys is investigate using a Pin-On-Disc testing machine

2-EXPERIMENTAL SETUP :-

2-1Materials

(Al-alloy18% Si) was used which has many applications in industry in making parts such as pistons liner-less engine blocks and compressor .The chemical composition analysis was carried out using ARL spectrometer instrument in Institute of specialized Mechanical Industrial and the indicate result shows in Table(1) .

2-2Preparation of Materials

The base alloys of Al- 18%Si was melted in crucible made of graphite using an electric furnace at temperature of 750º C and the melt was poured and cast in the preheated cylindrical steel mold with dimensions of 12mm diameter and 100mm height. The materials were prepared by dispersing the hard Mg particles in aluminum alloys matrix (Al -18% Si using the technique.of stir-casting The steps involved in preparing material cover melting the base alloy, stirring the melt using a mechanical stirrer, dispersing the 2.5%Mg in the melt with stirring at speed of 600 rpm for 6 min and the melt was poured in the steel mold. The same procedures were performed for preparation the composite material containing the addition of the magnesium particles in the matrix alloy using sequences percentage 2.5%,3.5% ,4.5% .

2-3Categorization of cast ingot

Cast ingots which were prepared by stir-casting technique were classified and put into groups as shown in table(2) .

2-4Microstructure Test

Specimens were taken from ingot which is listed in table (2) were prepared for microstructure test involving grinding, polishing, etching and they were observed under optical microscope in sequences steps. Wet grinding operation with water was done by emery paper of SiC with the diverse grits of (240,320,600,and 1000). Polishing process was done to the samples by diamond paste of size (1μm) with special polishing cloth and lubricant. Etching process was done to the samples by etching solution which is made of (99% H2O+1%HF). Then the samples were washed with water and alcohol and dried. Optical examination of samples was carried out by optical microscope supplied with camera and connected to a computer.

2-5Hardness test

The specimens in table (2) are subjected to Macro Hardness test using a Rockwell Hardness Testing Machine. On B-Scale .The hardness values as gained are noted in table (3).

2-6Wear test

Wear test is carrying out uing pin on disc method according to the following steps.

1-A digital sensitive balance, with accuracy 0.0001g of type XB 220 a Precise was used to Wight the test specimen's before and after test.

2- We chose the variables which we want to know their effect on the wear rate like time and other variables (load , sliding speed) were kept constant.

3- the specimen was Putting by the bearer in vertical location on disc.

4-The operation time was chosen(10,20,30,40)minute .

5- The cleanness of the disc was examined before the test started.

6- Operate the apparatus with select specified times keeping other variables constant

.7- The apparatus was stopped and the specimen was weighed

8- Repeat the process with constant time(10)minute ,changing other variables as Load was taken (0.5,1,1.5,2)Kg and sliding speed was taken (2.5,5,7,9)m/s.

We calculated the wear rate from the following equation:

$$Wr = \frac{\Delta w}{2\pi rnt} \quad (1)$$

where 2πrnt is the sliding distance (cm) , $\Delta w = w1 - w2$ and n= 940 rpm

3-RESULT AND DISCUSSION :-

3-1 Microstructure

The results of microstructure are shown in **Figure (**1) while in **Figure** (2) the micrograph of SEM for specimens (B,C)

(**Figure 1A**) demonstration the microstructure of Hypereutectic Al–18 Si alloys which observed the existence of primary silicon (Si) and eutectic silicon phase's .The primary Si has the blocky shape while the eutectic silicon has needle shape with size comparatively large. In(**Figure B,C,D**) when silicon or other elements are alloyed to aluminum, dendrites shape is seem but in specimen(B) The arms of the dendrite branches are fine, the dendrites are growing freely into the liquid metal. They are still small and do not get in contact with neighboring grains at some point, however, in specimens (C,D) the 'trunks' of the dendrites come in contact with neighboring grains. (This time of contact is called dendrite coherency) After this time any further solidification (and growth of dendrites) can occur only by thickening with the snow flake analogy, the growing of aluminum grain by a snow plow is represented in **Figure** (1C,D) and this behavior of solidification is agree with[**Geoffrey K. Sigworth 2014].** **Figure (2)** shows SEM micrographs of Al-18%Si alloy and

With addition of Mg. It was seen Mg_2si at orientations phase due to distributed of solid solution (α and eutectic phase) and micro porosity due to magnesium oxidation through solidification and this defect is treated by **[M. Gupta*, S. Ling 1999**] using extrusion method

3-2Hardens Result

As shown in table (3)

Table (3) show the hardens values ,the amount of Mg addition is good to improve the physical and mechanical properties of aluminum matrix. Rise in Magnesium amount cause increases the ability of soft aluminum matrix which accommodate the hard and brittle as Silicon addition, properties rely on several element through alloys solidification the extreme of the concentration relies on of the mechanical qualities happened for the fine-grained structure arisen from coupled eutectic-as growth**[S.P. Nikanorova,∗, M.P. Volkova2005**].

3-3Wear result

The wear result was shown in **Figure** (4,5,6)

Figure (4,5,6) shows the relationship between wear rate and its effected factors (Time, Load ,Sliding speed,) wear rate increases when time, load, sliding speed increase and this was clear in all specimens group A, B,C ,D. Since wear resistance is rely on hardness then when hardness as shown in Table (3) decreases after magnesium addition the wear rate will increase. in **Figure** (4) which represents the relationship between time and wear rate shows that specimen (A) gives the lowest wear rate while specimen (D)gives the highest for the reason which mentioned before due the effect of magnesium addition on hardness **Figure** (5) shows the effect of second parameter (load) and wear rate causes an increase in the plastic deformation in surface tips peaks between two sliding surfaces, the adhesive process of the two tips surfaces is based on applied load, if the load is low the contact appears in upper bit and this is very thin during sliding operation that causes a thin layer of oxide to work as a protective surface film which limits the contact between the two sliding surfaces and stops the direct metallic connection between the surfaces tips thus the required force to cut the connection between the two surfaces tips is less than the force between the metal atoms itself and that will create a decrease in wear rate [**Geoffrey K. Sigworth 2014**],[**RemeltingWislei R. Osório *, Noé Cheung, Leandro1999**] On the other hand an increasing in applied load will decompose the oxide film because of its brittleness because its shoots out the friction sliding surfaces for both the discs and specimen during the sliding process which makes a strong metal contact between them making the required force to shear its contact tips more than the force between the metal atoms itself.During the test, when the applied load on the pin is increased, the actual contact area would increase towards the nominal area which improves the frictional force between two sliding surfaces. The enhanced frictional force gives high wear . the effect of wear parameters are connected with microstructure of the alloys which have change due to magnesium addition which contributed in degreasing hardens that wear rely on its .

4-CONCLUSION :-

1-The increase in Mg content in Al-18%Si has provided a dendritic refinement of α- solid solution and silicon needle phase

2- The addition of Mg leads to more extensive distribution of the Mg_2Si in aluminum matrix which has improved microstructure.

3-Wear rate decreases when addition of magnesium increases.

4- Load parameter has the main effect on wear rate

Table (1) Chemical composition of Al-Si alloy

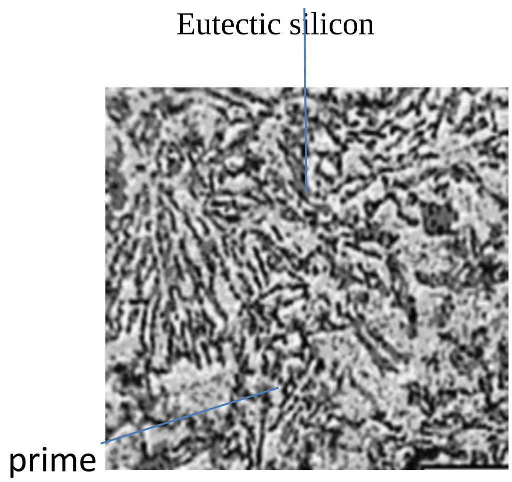
Element wt%	Si%	Fe%	Cu%	Mn%	Mg%	Cr%	Ni%	Zn%	Sn%	Pb%	Al%
Actual	15.7	1.6	1.81	0.252	0.184	0.026	0.36	2.28	0.059	0.214	Bal.
Standard	17	1.0	1.3	-	1.0	0.1	1.3	0.25	-	-	Bal

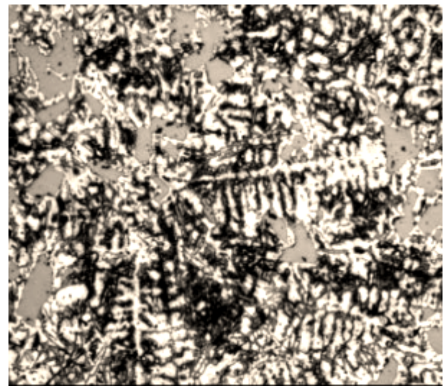
Table(2) :- Categorization of Specimens for Al-Si alloy

Specimen's symbol	**State of specimens**
A	Alloy without addition
B	Composite with addition of Mg(2.5wt%)
C	Composite with addition of Mg(3.5wt%)
D	Composite with addition of Mg(4.5%wt)

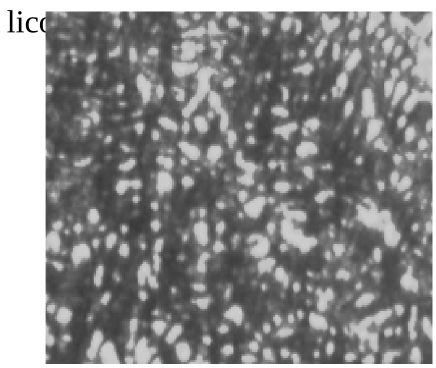
Table(3) :- show hardens Result for all specimens

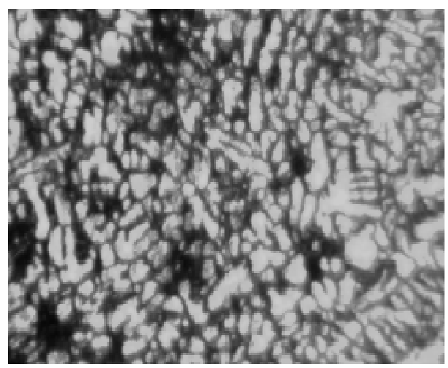
Specimens Symbol	Hardness Kg/ mm^2
A	87
B	83
C	72
D	68



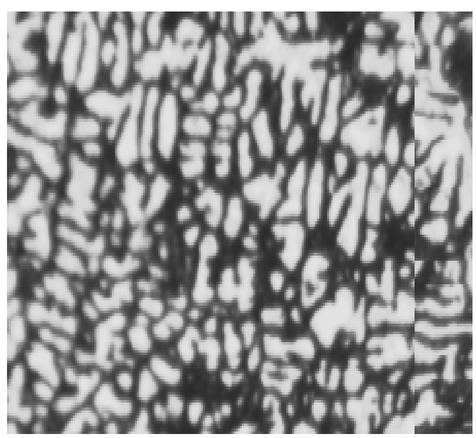


A(base alloy)   **A(base alloy as cast)**



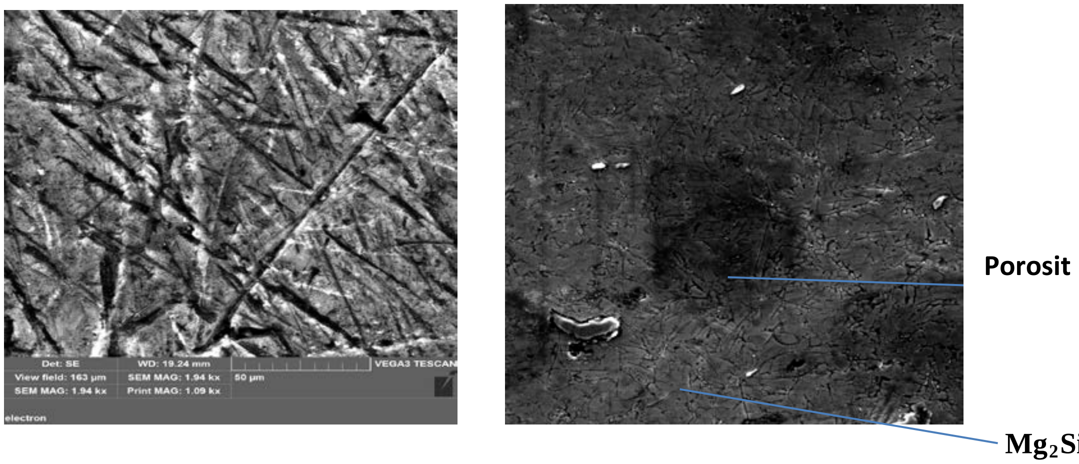


B   **C**



D

Figure:(1) Microstructure of all specimens at magnification of 400x



B C

Figure (2) :micrograph of SEM for specimen (B,C)

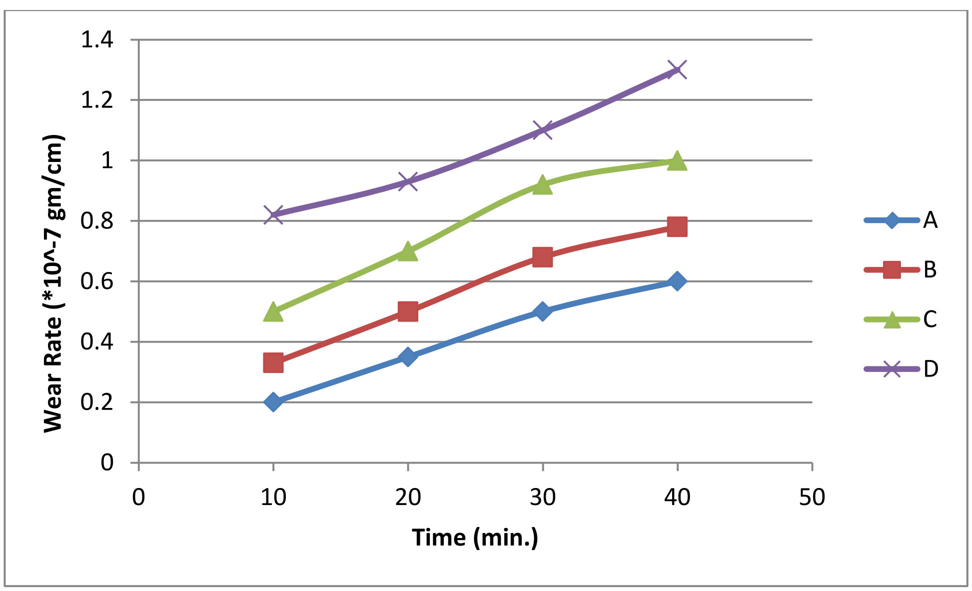
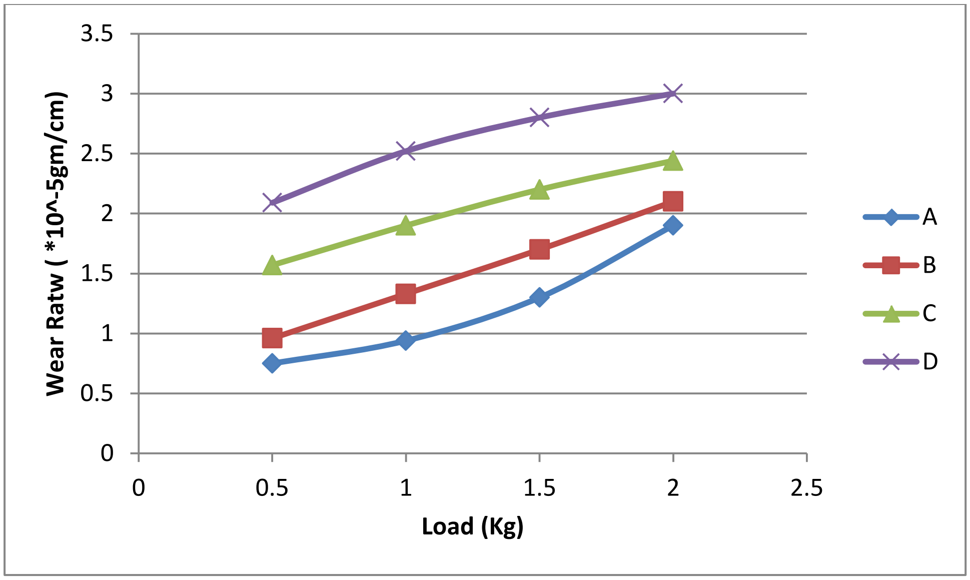


Figure (4): Relationship between Time and wear rateat constant load (1 kg)and sliding Speed (5m/s)



Figure(5): Relationship between Load and wear rate at constant time(10)min and sliding speed of (5)m/s

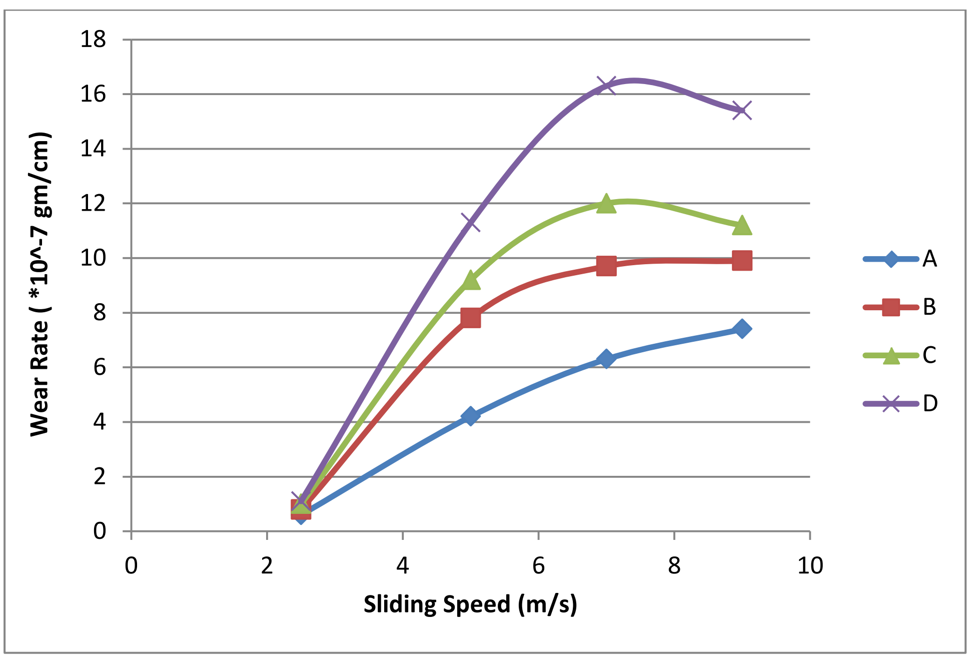


Figure (6): Relationship between ,Sliding Speed and wear rate at constant time (10)min and load (1 kg)

5 – REFERENCE :-

B.K. Kardasheva, L.L. Regelb, W.R. Wilco “Structural and Mechanical Properties of Al–Si alloys obtained by fast cooling of a levitated melt” Materials Science and Engineering A 390 (2005)pp 63–69

Deepak Singla1**,** S.R. Mediratta “ Effect of Load and Speed on Wear Properties of aL 7075-Fly Ash Composite Material” International Journal of Innovative Research in Science, Engineering and TechnologyVol. 2, Issue 5, May 2013

Hemant kumar Neopaney, Study of Mechanical and Tribological Properties of Al-Si alloy Prepared by Powder Metallurgical Technology Journal of Mechanical and Civil Engineering, Volume 11, Issue 5 Ver. III (Sep- Oct. 2014), PP 54-63

Rana. R. S., Rajesh Purohit, and S Das Reviews on the “ of Alloying Elements on the Microstructure and Mechanical Properties of Aluminum alloys and aluminum alloys composites” International Journal of Scientific and Research Publications, Volume 2, issue 6, June 2012

Ravindra Babu G1, Dr Girish D P2”The Effect of Heat Treatment on the Dry sliding Wear Behaviors of as Cast and Grain Refined and Modified, Gravity Cast A356” International Journal of Innovative Research in Science,Engineering and TechnologyVol. 4, Issue 3, March 2015pp 928-939

Geoffrey K. Sigworth “ Fundamentals of Solidification in Aluminum Castings” International Journal of Metal casting /Volume 8, Issue 1, 2014

RemeltingWislei R. Osório *, Noé Cheung, Leandro” Corrosion Resistance and Mechanical Properties of an Al 9wt%Si Alloy Treated by Laser Surface” *Int. J. Electrochem. Sci.,* 4 **(2009)** 820 - 831

M. Gupta*, S. Ling” Microstructure and mechanical properties of hypo/ hyper-eutectic Al–Si alloys synthesized using a near-net shape forming technique” Journal of Alloys and Compounds 287 (1999) 284–294

Sunil Kumar, 2Anoop Aggarwal” Wear Studies of Aluminum-Silicon Alloys” International Journal of Research in Mechanical Engineering & Technology Vol. 4, Issue 2, Spl- 2 May - October 2014

S.P. Nikanorova,∗, M.P. Volkova” Structural and mechanical properties of Al–Si alloys obtained by fast cooling of a levitated melt” Materials Science and Engineering A 390 (2005) 63–69

Naglaa Fathy1” Microstructural Evolution of Hyper-Eutectic Al-18% Si Alloy during Semi-Solid Isothermal Heat Treatment IntJournal of Research in Chemical,Metallurgical and Civil Engg. (IJRCMCE)Vol. 1, Issue 1(2014) ISSN 2349-1442 .