Effect of Microstructure and Hardness of Brass Alloys on the Wear Resistance of Impeller pump

تاثير كل من البنية المجهرية والصلادة لسبائك النحاس على مقاومة البلى للعضو الدوار بالمضخات

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ملخص البحث

تم ادراج التاكل (النحر) بأعتباره مشكلة هندسية لمضخات المياه ,حيث تلعب دورا هاما في تصميم وتشغيل الانظمة نقل المياه.السؤال ليس هو ماذا اذا كان الجزء الدواربالمضخة سوف تبلى ومتى , في معظم التطبيقات لمضخات المياه الخسارة المادية بسبب الفشل تتكون نتيجة فقدان الانتاج بدلا من تكلفة المضخة . اذا لابد من معالجة هذا الفشل بالمضخة, اذا يمكن تقدير معدل النحر للجزء الدوار بالمضخة (المصنوعة من النحاس الاصفر) والوقت المناسب لتغيرها من خلال الصيانة الدورية. تقارير العمل الحالي والنتائج تشير ان التاكل النحاس الاصفر نتيجة الرمال الموجودة بالمياه (الطين). وقد تم تنفيذ الدراسة التفصيلية الجزء الدواربالمضخات الري من خلال الماسح الضوئي الالكتروني من اجل توضيح اليات التاكل. واظهرت النتائج فقدان الوزن الجزء الدوار نتيجة اصطدام الجسيمات السائلة أو الصلبة بسطحها وبشكل مستمر، تتولد أجهادات من هذهِ الجسيمات مما تسبب في تكوين نقر على السطح نتيجة بلى النحر . في هذا التحقيق اجريت تجارب لتقيم مقاومة بلى النحر باستخدام اختبار البلى , تم تصميمها وتصنيعها لهذا الغرض. استخدمت ثلاثة عينات من سبائك نحاس المختلفة (B1.CuZn2Ge,B2.CuZn4Ge, B3.CuZn6Ge) على شكل اقراص مصنوعة من هذه السبائك المختلفة وتم قياس الوزن المفقود المتراكم وتحديد معدل البلى للمواد مع حمل ثابت مقداره 20 كيلو غرام مع عدد من السرعات(1000-1450-2000) دورة بالدقيقة. وتم اختبار المواد الثلاثة على التوالي اختبار البلى وفقدان الوزن المتراكم مع عدداللفات المستخدمة خلال الاختبار وتم حساب معدل البلى وتاثيرالصلادة والبنية المجهرية لسبائك النحاس. فكانت النتائج معدل البلى لسبيكة (B3.CuZn6Ge) هو اقل معدل بلى من سبيكة (B2- CuZn4Ge) اقل معدل بلى من سبيكة (B1- CuZn2Ge) تحت نفس ظروف.

Abstract

Corrosion (Erosion) it is inserted as an engineering problem for Centrifugal slurry pumps it plays an important role in design and operation of slurry transportation systems. In most slurry pump applications the monetary loss due to pump failure consists of loss of production rather than the cost of the pump, since the process must be when the pump fails. If the erosion rate can be estimated, the pump impeller (manufactured from brass) can be changed out in time, during scheduled maintenance, the present work reports experimental investigations on dependence of erosion wear of brass alloy in sand - water slurry. Systematic study on the failing impeller of a slurry pump used in irrigation has been carried out by means of scanning electron microscopy in order to clarify the Corrosion mechanisms. The results show, the weight loss of the impeller result of the collision of particles of liquid or solid surface-and continuously, generated stresses by the particles probably caused configure mortise on the surface as aresult of erosion wear. In this investigation, experiments were carried out to evaluate the wear resistance using wear test rig designed and manufactured for this purpose. Three specimens of different brass alloys were used, namely (CuZn2Ge-CuZn4Ge-CuZn6Ge) Discs manufactured from. The accumulated loss of weight was measured and the wear rates were determined for each Case material at constant normal test load of 20kg. Number of revolutions of tests equals (1000- 1500-2000) rpm. were selected for the three test materials respectively during wear tests .The accumulated loss of weight was measured as a function of the number of revolutions, Wear rate was calculated, Effect of Microstructure and Hardness of Brass Alloys, The results show Wear rate for material B3 (CuZn6Ge) is less than that of the wear rate for B2 (CuZn4Ge), B1 (CuZn2Ge) under the same testing conditions.

Keywords

Microstructure examination, wear test, Wear rate, hardness test, and worn surfaces by optical microscope

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Received: 31 August, 2015 – Revised – 25 October, 2015 - Accepted: 3 November, 2015

1. Introduction

Centrifugal slurry pumps are being used extensively for short and medium distance transportation of homogeneous and heterogeneous mixtures slurry The pump characteristics play a key role in the reliability of the transportation system considered pumps Calendar Irrigation of very necessary and important equipment which are used in a wide areas and there was a need to study so that we can choose the appropriate pump for a particular performance as well as the possibility to run different speeds And the impact on its performance in use irrigation pumps efficiently and take advantage of the increase Productivity[1] Erosive Wear is defined as 'progressive volume loss of material from a solid surface due to corrosion, abrasion and erosion'. Wear is one of the most common problemsenco unuttered in industrial applications. Wear, along with other aging processes such as fatigue, creep and fracture toughness, causes progressive degradation of materials with time leading to failure of material at an advanced stage [2]. Wear can generally be divided into two main types that are mechanical wear and chemical wear [3]. It is generally held that the most common types of wear mechanism are the adhesive wear, abrasive wear, cavitation wear, corrosive wear, erosive wear, fatigue wear and fretting wear. Infect, more than a single mechanism can occur at the same time [4]. However, there is always a primary mechanism that determines the material removal rate. Corrosion pump impeller can be general in nature, affecting all wetted surfaces or highly localized affecting only a small portion of a single component. Pump useful life in these applications can range from a few weeks to a few years depending on the type of slurries handled. Localized corrosion is not easily identified during visual inspection and may be confined to a very small area making the probability of discovery very low unless the examiner is highly experienced [5].The term “erosive wear” refers to an unspecified number of wear mechanisms which occur when relatively small particles impact against mechanical components The major type of erosion wear in a slurry pump impeller is due to the Particle impingement[6].Where the particles contact of the solid particles with the material surface causes its erosion substantially to the surface .The main cause of the erosion wear is impact The magnitude of loss depends on three primary factors, properties of the material exposed to erosion, abrasive material, and the environment in which the erosion takes place [7]. Particles impacting directly onto a surface can generate very high specific contact pressures. The actual value of the contact stress depends on the particle velocity, the mass, and the particle shape. Particles with sharp edges wear the surface faster because of their smaller contact area. Material is removed by a process of cutting and/or pouching [8]. Pouching Erosion wear: is a two stage process involving localized plastic deformation of the surface from rounded particle impacts [9].Cutting Erosion wear: occurs when the particles are very sharp and interaction with the material surface causes a micromachining action [10]. Deformation and Cracking: When cyclic forces are applied to parts found in the pump, a crack may appear over a period of time, in a target surface. A blunt particle striking the target surface at high velocity causes localized plastic deformation at the point of contact, which develops cracks leading to wear by brittle fracture. This type of wear mechanism is known as subsurface deformation and cracking [11].Elemental analysis of the failed impeller blades, as well as the middle of blades, shows that the base alloy used for this impeller is Brass. Physical examinations, that the leading edge of the impeller had undergone active corrosion with rough surface and visible pit like features. Chemical analysis of the blade surface at various locations indicated at the surface. This confirms that the erosion wear of surface has occurred on these alloys in the environment to which this impeller was exposed. To verify further the effect of Microstructure and Hardness's on the erosion wear of an impeller, simulated erosive wear tests were performed on a rotating disk on disk with of tested materials used in this investigation and samples from the failing impeller. Three speeds were used. The first is (1000) r. p. m is the second is (1450) r. p. m. The third (2000),To improve erosion resistance of alpha brass alloy (70Cu/30Zn) used in pump impeller by adding a alloying elements such as Germanium, and studying its effect on the microstructure and wear resistance of brass alloy (70Cu/30Zn)to increase impeller service life.

2. Experimental Work

2.1. Test Specimens

2.1.1. Materials:

The material Used in this investigation for impeller pump production in are as follows: B1. (CuZn2Ge), B2 (CuZn4Ge), B3.(CuZn6Ge).The chemical composition for materials used in this investigation is given in table (1).

Specimens were prepared from Base metal alloy (CuZn), (CuZn2Ge), (CuZn4Ge), (CuZn6Ge),the microstructure examined, hardness test (Vickers hardness) and Topography optical microscope Study.

2.1.2. Test specimens for wear:

Specimens were prepared from Base metal (brass) and (CuZn2Ge), (CuZn4Ge), (CuZn6Ge), 80mm diameter & 15 mm length thickness as shown in Fig (1,a), which were turned, shown in Fig (1,b), In this work 24 discs were used, 6 discs from each tested materials divided into 4 groups, shown in Table (2). The wear tests were carried tests at Speed (1000, 1450, 2000 rpm), 18 discs, 2 samples were test for each.

Table (1) Chemical composition

No.	Zn%	Ge%	Fe%	P%	S%	Cu%
B1	29.989	2.017	0.0018	0.006	0.003	Rem
B2	29.987	4.014	0.002	0.001	0.001	Rem
B3	29.975	6.011	0.001	0.004	0.002	Rem
D	29.862	0.0	0.0022	0.0015	0.009	Rem

Table (2) Test Specimens Materials for wear

Speed (r.p.m)	B1 (2%Ge)	B2 (4%Ge)	B3 (6%Ge)	Base metal (D)
1000 (r.p.m)	B11/B11-	B21/21-	B31/B31-	D1/D1-
1450 (r.p.m)	B12/B12-	B22/B22-	B32/32-	D2/D2-
2000 (r.p.m)	B13/B13-	B23/B23-	B33/B33-	D3/D3-

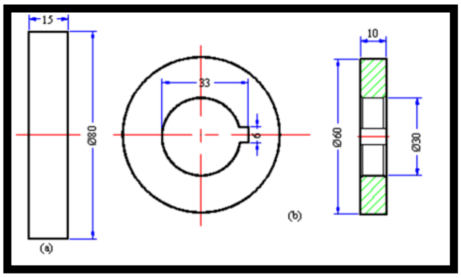


Fig (1) The shape and dimensions of test discs

3. Experimental Tests

3.1. Wear Test

Wear is usually measured by one of two methods either by measuring dimensional changes or by weight loss. In this study, wear was estimated and measured by weight loss. Precise digital balance type of Sartorius BP 210 S was used. The accuracy (+/-) of the balance is 1*10-4 g and its capacity is 240g. By weighting the specimens before and after each run, it was possible to calculate the weight loss due to wear. Thus the accumulated wear as a function of rolling distance can easily be investigated and plotted. From the plots and knowing the density of the material, it was possible to calculate the wear rate of tested materials. [13].

Wear rate = W (loss) / time

W: Accumulated weight of removed metal (g).

3.2. Wear Testing Machine Disc machine:

In the two-disc machine, one disc is mounted in a bearing supported by a swinging drive shaft while the other is carried on a rigid bearing .The disc carried by a swinging driven shaft is pressed against the other by a loaded lever. Wear machine manufactured in Gears laboratory in department production engineering and mechanical design Wear machine manufactured in Gears laboratory in department production engineering and mechanical design: The machine consists of upper casing part (1) cast iron boxes and their housing (3) to carry the bearings support driven discs specimens, lower casing part (2) cast iron boxes and their housing (4) to carry the bearings support driver discs specimens. Bearing housing (3,4) to support the single row deep groove ball bearings (11) 6003zz . Driven and drive shaft (5,6) to carry the driven and drive discs (7) , spacing sleeve (8) to adjust the distance between the discs and ball bearing , key (9) to fix the discs with the shafts , Snap ring Φ 17 mm (10) to locate the bearing inner race with the shafts , spacer sleeve (12) , to adjust the distance between the ball bearing and the driven pulley (13) which fix by key (16) , the washer (14) and the bolt (15) to fixed the pulley. Base (17) Dimensions, 400 * 600 mm, the base is supported on four angles (legs) 50 * 50 * 300 mm (25). Driving motor (24) three phase, 2 horse powers, 1450 r.p.m and 380 volts was used to drive the machine. A calibrated two springs (21) supported by two studs (18) and four bases (20, 22) to apply the required load between the drive and driven discs by the tightening nuts (19) to deflect the springs. Two dial gauges measurements range from 0 to 50 mm and accuracy 0.01 mm (23) were mounted to measure the deflection of the springs; this deflection represents the exerted load. Figures (2) represent a schematic layout of the machine.

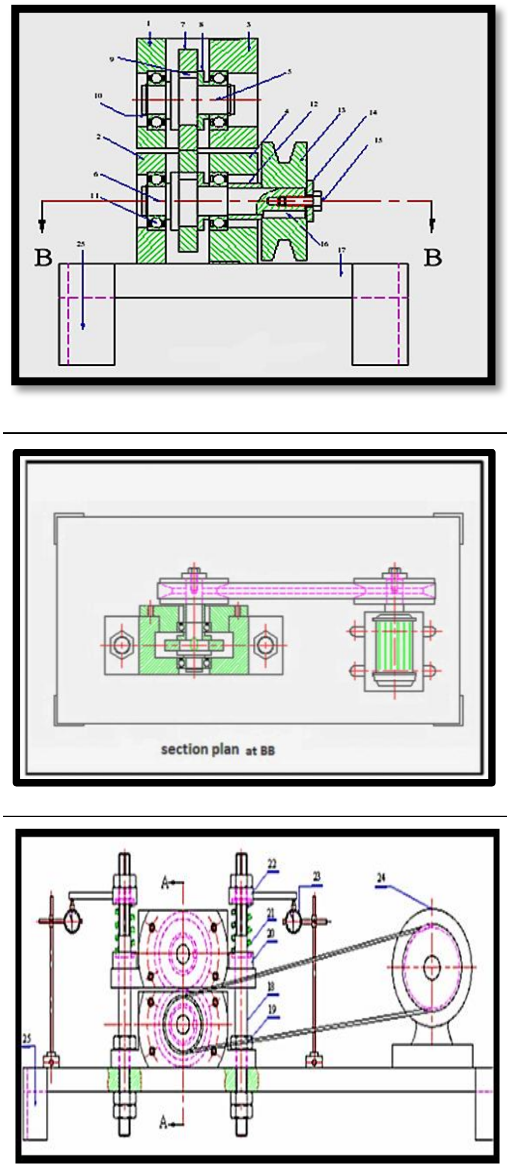


Fig (2) schematic layout of the machine test

3.3. Wear Test Procedure

The procedure for wear test experiments can be summarized in the following steps: (1) Before each test, the discs were carefully cleaned.(2) Load: Tests were carried out at constant load of 20kg, the normal loads which were applied through two springs, were maintained constant during the period of test .(3) Speed : Speed designed rollers used for the purpose of converting speeds to obtain the required speeds and by country and energies of the electric motor from to(1000 -1450-2000rpm).(4) The machine was stopped at time intervals for weighing the discs . Any loose debris at the surface of the disc specimens were removed by cleaning before weighing the specimens. (5) On restarting the wear tests, the discs were located in their supports in exactly the same orientation as before stopping the tests, in order to ensure that the wear in discs has occurred in the same direction throughout the test (6) At the end of the test, the accumulated wear of the discs, expressed in mg. was plotted against the number of revolutions and the wear rate were calculated for each test material.

4. Results and discussion

4.1. Hardness test

Fig. (3) represents the relationship between hardness and the percentage by additive of germanium, the he increased hardness with the increase in the percentage of germanium and by at adding up 6% can be explain of as the work of element germanium is to impede the movement of dislocations, and impeding the plastic deformation of the alloy, leading to increased hardness.

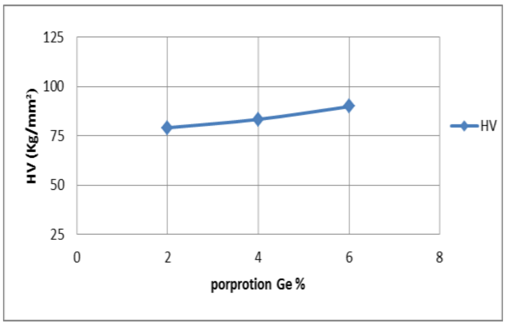


Fig (3) the hardness for alloys with different percentage of germanium.

The core hardness for alloys CuZn6Ge, brass (Cu Zn) were measured and found 89.842 and 70.685 HV respectively. During the test the hardness of different alloy depth of (0.5, 1.0 1.5 mm) show table (3and4), which found that the hardness is increased with the depth of cut samples of alloy. This is was found through tests of these material give greater resistance to wear at different speeds .And the alloy basis, the hardness decreases with cutting depth, which give wear large and this through laboratory tests.

Table (3) the hardness distribution with subsurface depth for (CuZn6%Ge)

Subsurface depth(mm)	HV
Surface hardness	**89.8397**
0.5	**90.135**
1.0	**92.862**
1.5	**94.798**

Table (4) the hardness distribution with subsurface depth for (CuZn)

subsurface depth(mm)	HV
Surface hardness	**70.684**
0.5	**69.6236**
1.0	**67.812**
1.5	**66.901**

4.2. Effect of percentage added germanium on brass alloy (70/30):

As wear test the major type of wear that take place in this experimental work is erosion. The weight loss of the impeller is due to the material removal from the impeller as a result of erosion wear. The entire testing was divided in three phases. The details of all three phases are mentioned below: First Phase: 1000 rpm, load 20kg as in Figure (4).Second Phase: 1450 rpm, load 20kg as in Figure (5), Third phase: 2000 rpm, load 20kg as in Figure (6).The duration of each test was three hours’ time. Germanium has been studied weight ratios on the basis alloys and other alloys loss rate when the load (20kg) and different speeds (1000.1450.2000) rpm. the fig (4, 5, 6) note the relationship between the number of revolutions and weight loss to each of the basis slug and fig (4, 5 and6) show that the increase in germanium percentage up to 6% led to decrease the weight loss for driving and driven disc alloys other and note that the basis slug have a loss larger than the other alloys weight rate and note less loss rate by weight in the alloy (B3_6%Ge). This is due to increase of the percentage of the added germanium element increases the hardness and as described in the hardness test where the hardness is inversely proportional to the rate of weight loss as reduce the (Plastic deformation).

In the early stages of the sliding wear rate is than the closing stages. In flattening the bumps in both adjacent surfaces are obtained on the surface outcrops in which the proportion of a few, in addition to continuing to slide lead to a declamatory hardening of the surface of the sample and thus lower metal loss rate.

It is noted that the basis slug more affected by a time of sliding of overlapping material where noted that the metal loss rate decreases with the increase of the at germanium 6% and be less loss rate by weight and this goes back to the role of germanium element to increase the hardness of the sample and to reduce contact between surfaces adjacent and reduce the rate of loss by Weight.

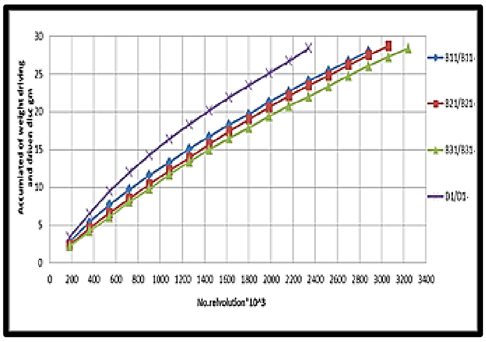


Fig (4) the variation of accumulated loss of weight of driving and driven discs versus the number of revolutions at different materials, (B11/B11"), (B21/B21"), (B31/B31"), at velocity (1000) r. p. m.

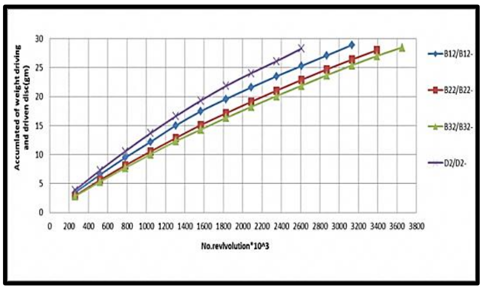


Fig (5) The variation of accumulated loss of weight of driving and driven discs versus the number of revolutions at different materials, (B12/12") (B22/B22") (B32/B32") at velocity (1450) rpm.

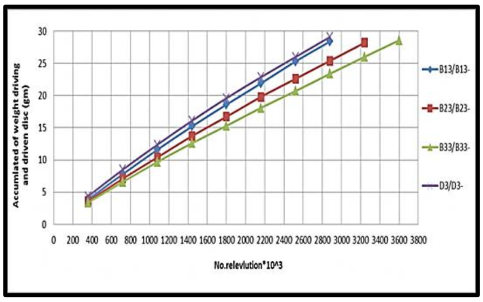


Fig (6) The variation of accumulated loss of weight of driving and driven discs versus the number of revolutions at different materials, (B13/B13")(B23/B23")(B33/B33") at velocity (2000) r. p. m.

4.3. Effect of of Adding Ge% on the wear rate:

Effect adding different percentage of germanium on the wear rate of the basis alloy and other alloys at different speeds (1000-1450-2000) rpm and prove used load (20 kg). is show Fig (7) relationship between the ratios added and the wear rate is where the relationship is inverse it can noticed that the basis alloy have the wear rate high and the rate wear is lower in the alloy (B3_6% Ge).

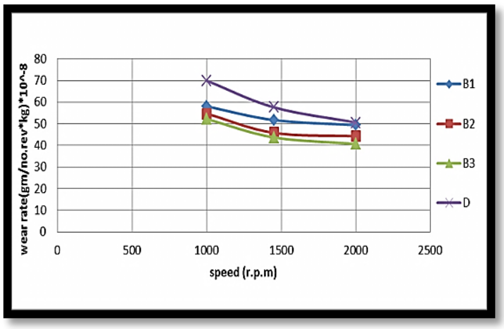


Fig (7) Effect of the adding of germanium on the wear rate at different speed.

4.4. Microstructure examination:

The microscopic structures of brass when cast in sand .is show the marked dendritic structure indicating the gradation in composition in the crystals as they formed. If this casting annealed for a long time, the structure should become homogeneous. Fig(8,9and10),which shows the microscopic structure of the alloy after the addition of germanium element and different percentage as(Ge%2to%6).The led to Change and improvement in microstructure because of the element germanium is distributed almost other inside the alloys. Leading to refine the grain and twining forms of crystal structure of as observed .We also note that there is a light-colored area, which represent ground which is the solution solid such as copper and zinc.

Fig. (8) Microstructure of CuZn,250X.

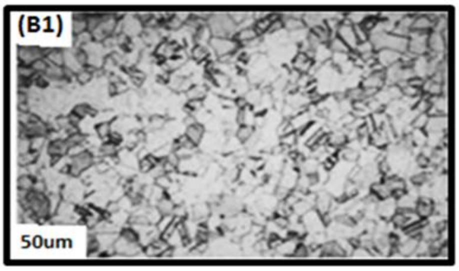


Fig (9) Microstructure of CuZn2Ge, 100X.

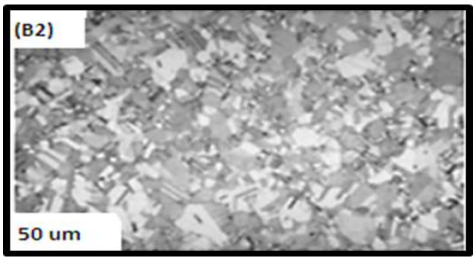
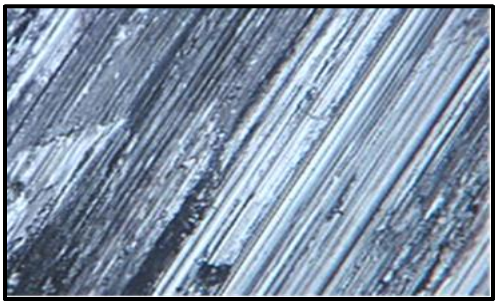


Fig (10) Microstructure of CuZn4Ge, 100X

Fig (11) Microstructure of CuZn6Ge, 100X

4.5. To pograghy optical microscope Study:

Optical microscope of the type (VEGA II / TESCAN) in the Nano Research Center / was used to study the topography of the worn surfaces of the samples exposed to wear. Figures show (12, 13, 14, 15, 16and 17) the impact and speed on the surface of samples of the alloy base and alloys other wear after tests by using an optical microscope.it has been noticed that the worn surface of alloy and scratches and increases specially at speed 2000 rpm.



Fig(12) Speed at (1000 rpm) of B3(X100)

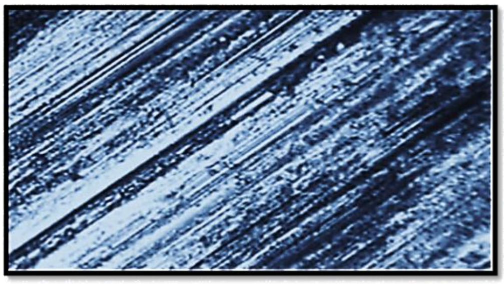


Fig (12) Speed at (1450 rpm) of B3(X100)

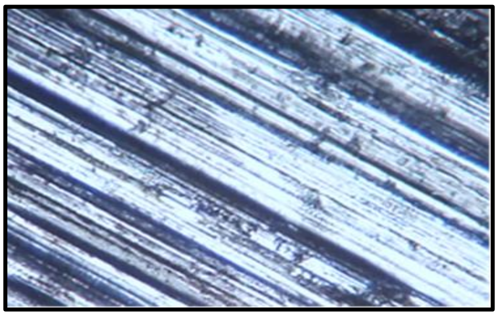


Fig (14) Speed at (2000 rpm) of B3-(X100)

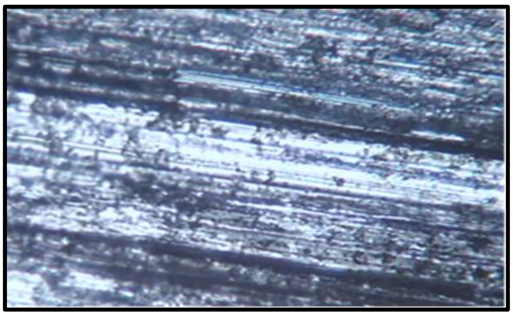


Fig (15) Speed at (1000 rpm) of D-(X100)

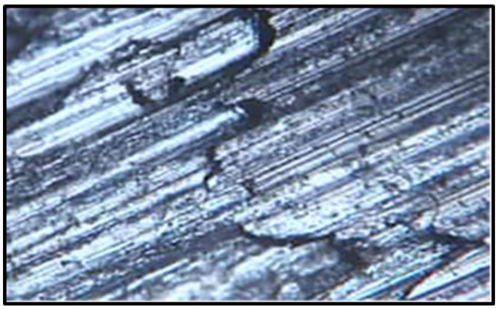


Fig (16) Speed at (1450 rpm) of D-(X100)

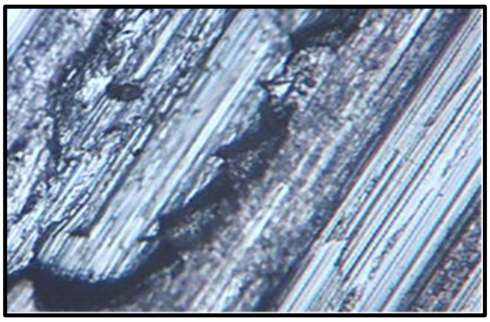


Fig (17) Speed at (2000 rpm) of D-(X100)

5. Co nclusions

[1.] Wear rate for all materials under investigation decreases with the increase of their case hardness. Minimum wear rate was obtained at hardness 89.8397HV.

[2.] Wear rate for all tested materials decreases with the increase of germanium. The addition of germanium to reduce the wear if the alloys and the wear rate decrease with increases added lineage of germanium element and less wear rate was found when the additing at 6%Ge.

[3.] the that increase of the element germanium leads to the gradually reduce the rate of wear due to the increase of germanium element which increases the hardness and reduce the wear of the material.

[4.] Improved microscopic structure of the brass alloy after the addition of element germanium, where changes the dendritic structure approximately into equi-axis structure and improve wear erosion resistance of alpha brass alloy.

[5.] 5.Best alloy through the results that have been reached are B3(6%GeCuZn) at different speeds, which gives better resistance to wear and erosion that can through these specifications manufacturing pumps impeller.

[6.] 6.Through the results obtained B3(6%GeCuZn) can be designed to impeller pump, which gives less impeller wear erosion rate, maintenance less -and a reduce the economic cost and long life impeller.

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