International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2016): 79.57 | Impact Factor (2017): 7.296

Study of Some Physical and Mechanical Properties of Silver - Based Hybrid Composites

Mu'tazaballah Ibrahim Abdullah[1], Adnan Raad Ahmed[2], Shehab Ahmed Zidan[3]

[1]College of Education for Pure Sciences, Department of Physics, University of Tikrit, Salahuddin, Iraq

[2]College of Education for Pure Sciences, Department of Physics, University of Tikrit, Salah al-Din, Iraq

[3]Department of Applied Science, University of Technology, Baghdad, Iraq

Abstract: ***The objective of the research is to manufacture a hybrid material with a silver base and its strength with Zro2 and a fixed volume fraction equal to 3%. It contains variable volume fractions of the graphite (Gr) 0, 0.75, 1.5, 2.25 and 3% Powder metallurgy and its impact on the physical, mechanical and wear properties of silver. The mixture was mixed for 10 minutes, after which the cold mixture was pressured by pressing Mpa (700) to obtain the green pickles and then sintering at a temperature of 770 ° C for three hours. The mechanical properties of the compounds were investigated. Physical properties of volumetric and virtual density and water absorption as well as microscopic and thermal conductivity. The results of the study showed that the hardness decreased by 19.15% with the increase of the volume fracture of the graphite, while the wear rate was obtained at the lowest rate of wear at the content of graphite 1.5, 2.25% and then rise. The results also showed a soft relationship between the volumetric and virtual density, which decreases with the increase of the graphite content, in contrast to the total porosity and porosity, which increases with the increase in the content of the graphite, causing the increase of water absorption of the hybrid complexes. The decrease in thermal conductivity is consistent with the increase in Total porosity***.

Keywords: hybrid overlays, powder metallurgy, mechanical properties, physical properties, wear rate

1. Introduction

Silver composite materials with various additives have effective properties and properties that have been widely used in the manufacture of electrical contacts. Silver-graphite materials have long been used as electrical contacts in low-voltage transformers, radar or trackers and other sliding conditions [2.1].

The materials used in these applications shall contain a good combination of electrical conductivity, wear and tear, wear resistance and welding. It is known that electric slip connections are a mobile group that cannot be used as a traditional lubricant. Overlapping lubricants are the most effective ways to solve aggregation and corrosion resistance. Therefore, silver-graphite compounds are typical electrical contact materials and are used in many engineering applications [4, 3].

Due to the use of electrical contacts in a variety of conditions, various types of silver contact materials have been developed to meet the requirements of different applications. The usefulness of the electrical contact material is determined by a variety of electrical, mechanical, For economic reasons, the basic characteristics of these materials from the point of view of performance are electrical conductivity, high thermal and good mechanical properties [5].

Silver-based composites are widely used due to their high electrical and thermal conductivity, higher than all metals, good resistance to properties, corrosion and high hardness [6].

Graphite is one of the most widely used lubricants because of its effectiveness in the final conditions where lubricating oil and grease cannot work. Graphite has unique anti-friction and wear characteristics, but it has imperfections such as fragility, low power in carrying current, electrical conductivity, With increased graphite content [8, 7].

The addition of particles of ceramic materials to strengthen metal-based composites helps to improve the trapositional properties of overlays, increasing the hardness of the composites, as well as increasing the resistance of the coatings to the wear. Sometimes hybrid materials are used, adding more than a strengthening material to obtain greater diversity in properties [9].

The most common methods used in the preparation of overlapping materials are powder metallurgy technology, which is widely used to obtain self-lubricating composites, which have the potential to produce a variety of microscopic structures, in addition to the possibility of obtaining materials that have a collection of properties that can not be obtained from Metals, alloyed or hot cast alloys, as well as the possibility of manufacturing products of almost all metals, as well as the possibility of controlling the particle size, and the structure of the microstructure is homogeneous and relatively regular and this method is economical and high productivity [10.9].

The aim of the study is to prepare a hybrid composite material by adding a fixed volume fraction of 3% zirconia oxide minutes, as well as variable volume fractions of 0, 75, 1.5, 2.25 and 3% graphite for silver and then studying the mechanical properties of hardness and wear rate. On physical properties and thermal conductivity

2. Experimental

2.1 Manufacture of models

The samples used in this study were prepared using powder metallurgy technology, which can be divided into three main sections for the production of overlays:

2.1.1 Powder preparation

Use silver powder as a 99.9% pure base material and granular size 7575 micrometer, and use of Zirconia and graphite powder as a 99% booster and 99% granular volume. The weight of each component was determined using the volumetric ratios shown in Table 1. The weight of the powders was calculated using a sensitive electrical balance of 0.1 mg and then manually mixed for 10 min. The volumetric ratios were adopted due to the large difference in the density between the silver powder and the rest of the powders.

Table 1: Shows the volume ratios of materials

Gr%	Zro_2%	Ag %
0	3	97
0.75	3	96.25
1.5	3	95.5
2.25	3	94.75
3	3	94

2.1.2 Press of powders

After obtaining a homogeneous powder, Uniaxial was molded and molded into a solid steel mold with a 60 HRC and 10 mm diameter. The mixed mixture was then placed in the capsule and a pressure of 700 Mpa for half a minute to avoid the possibility of flexible return using the Universal Testing Machine Testing Machine with a capacity of 170 KN to obtain cylindrical samples with a diameter of 10 mm and a height of 5.6 mm Figure (1) shows the samples after the clamping.

Figure 1: Image of the specimen before the frying

2.1.3 Sintering of samples

The sintering process was carried out inside an electric oven with a maximum temperature of 1050 ° C after the clamping process, because the samples are not ready for the tests and have weak resistance is the green resistance. In order to prevent the oxidation of the samples, the sintering process was carried out in a reduced atmosphere by covering the samples with silica powder SiO2 and the iron cast iron inside a special ceramic container to prevent oxygen from reaching the sample surface. A layer of cast iron was placed in the bottom of the container and 1cm thick, 1.5cm The samples are then paired with a double K type thermocouple installation near the samples for temperature control and control. The samples were then covered with another layer of silica powder 1.5 cm thick and then another layer of iron cast iron thickness of 1 cm finally, the ceramic container was sealed with a layer of thermal clay after the mud dried and the container was placed inside the oven. The temperature inside the furnace was raised to a temperature of 770 ° C and at 9 ° C / min and the charge was kept at that temperature for 3 h. The samples were then cooled inside the oven to room temperature. The following equation represents the temperature of the fogging [11]

$$Ts = (0.7 - 0.9)Tm \dots\dots\dots\dots\dots\dots\dots (1)$$

whereas:
Ts: Sintering temperature (K °).
Tm: melting temperature of base metal (k °).

2.2 Preparation of samples for microscopic examination and measurement of hardness

The samples used in the research were prepared for microscopic examination and hardness measurements by wetting the water with water and using papers of different thicknesses (2500, 2000, 1800, 1500, 1200, 1000, 800, 600, 400). The polishing process was done using a special polishing cloth with alumina solution. Microscopy was performed using an SEM scanner. The hardness test was then performed using a Micro Vickers Hardness Test. The hardness was calculated by taking a mean of 5 readings per sample.

2.3 Examination of density, porosity and water absorption

Physical properties were studied, both volumetric and virtual density and total and porous porosity, as well as water absorption using the Archimedes base according to ASTM C373 [12]. The samples are weighed using a sensitive electrical balance of 0.1 gm where the dry weight is Md. The samples are then suspended and immersed in distilled water with a density of 1 gm / cm3 by a suspension balance. This weight is Mi, Boiled for 5 hours and then immersed in distilled water also at room temperature for 24 hours after the samples are removed and removed surface water suspended only and weigh samples, which represents the saturated weight.

1) Bulk Density (B.D): - The ratio between the mass and the total size of the sample (the size of the particles of the material + the volume of closed and open pores) and calculated from the following relationship [13, 12, 11]:

$$\boldsymbol{B.D.} = \frac{\boldsymbol{Md}}{\boldsymbol{Ms - Mi}} \times \boldsymbol{\rho w} \dots\dots\dots\dots\dots\dots\dots (2)$$

2) Density (A.D): - The ratio between the mass and the apparent size of the sample (the size of the particles of the substance + the volume of the closed pores), calculated from the following relationship [13, 12]:

$$\boldsymbol{A.D.} = \frac{\boldsymbol{Md}}{\boldsymbol{Md - Mi}} \times \boldsymbol{\rho w} \dots\dots\dots\dots\dots\dots\dots (3)$$

3) Pore Porosity (A.P.): - The ratio between the size of open pores to the total size (size of the particles of the

Paper ID: ART20183189 DOI: 10.21275/ART20183189

substance + the size of the total pores), calculated using the following relationship

$$A.P. = \frac{Ms - Md}{Ms - Mi} \times 100\% \ldots\ldots\ldots\ldots (4)$$

4) Total Porosity (T.P): - The ratio between the total open and closed pore sizes to the total volume (particle size + total pores size), calculated using the following relationship

$$T.P. = \frac{T.D. - B.D.}{T.D.} \times 100\% \ldots\ldots\ldots (5)$$

whereas:
T.D.: The theoretical density of the samples is calculated through the relationship

$$T.D. = \sum_{i=1}^{n} (\rho i \times Xi) \ldots\ldots\ldots\ldots\ldots\ldots (6)$$

whereas:
: ρi The theoretical density of the constituent elements of the sample.
: Xi Ratio of each element in the sample.

5) Water Absorption (W.A.): The ratio between the weight of water absorbed to the sample weight is dry, calculated using the following relationship:

$$W.A. = \frac{Ms - Md}{Md} \times 100\% \ldots\ldots\ldots\ldots (7)$$

2.4 Measurement of thermal conductivity

Thermal conductivity of the samples was measured using the Lee's method [14]. The Li-disk method is used to find the thermal conductivity of samples whose thickness is small relative to its diameter. A Li-disk device made of Polish wood consists of A, B, C, heating disk, and sample space to be selected for thermal conductivity, The thermometer is placed in it. A, B and C are of the same diameter and thickness, while the heating disc is of the same diameter but with a smaller thickness. The disc and samples were cleared and cleared from the dirt and placed in order. The heating disc is connected to a 6v power source. I took the final reading in each case after 20min minutes of taking the initial reading. Repeat the same procedure for all samples.

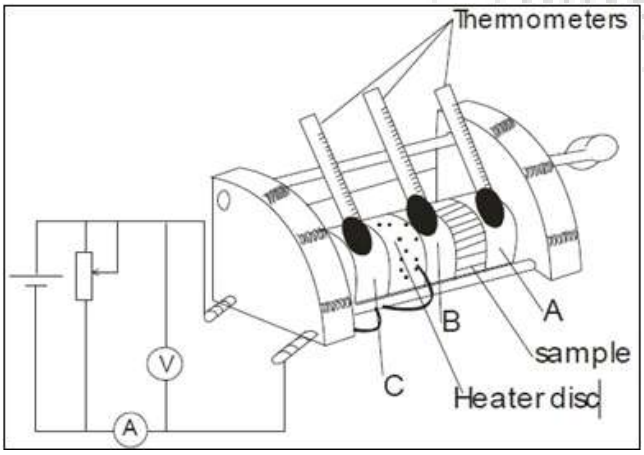

Figure 2: My experiment to measure thermal conductivity

2.5 Test of sliding dry wear

The Sliding dry wear test was carried out in accordance with ASTM G99 [15] with the use of an Indian-based wear and friction checker from Duque (Wear and Friction Monitor ED.201) and Pin on Disc as shown in Figure 3). The device contains a timer to measure the duration of the test accurately and stop at the end of the pre-determined period of 20 min, and the device contains a load of weights used during the duration of the test where different loads were put (20, 15, 10, 5 N). The hardness of the disc installed in the machine is 62 HRC and 60 mm diameter, and the rotational speed is 480 r.p.m. The surface of the disc and the sample to be examined were designed by smoothing it with 1000-sheet paper. The weight loss was measured during the test period using a sensitive electrical balance. The Wear Rate (WR) was calculated using the following equation [15, 9].

WR=ΔW/SD=ΔW/2πRNT……………………….(8)

whereas:
SD: Sliding distance (m).
R: Radius of the sample center (30mm).
N: Rotational speed of disk (480 r.p.m).
T: Test duration (20 min).


Figure 3: The wear and tear device used in the research

3. Results and discussion

Figure 4 shows the images of the electron microscopy (SEM) of silver-based composites containing a fixed volume fraction of zirconium oxide particles (3%), as well as variable volume fractions of graphite (0-3%). The uniform distribution and dispersion of the reinforcement particles improves the contact properties of the silver-based composites, giving homogeneous distribution of properties to all parts of the overlay and ensuring good self-lubrication. [16]

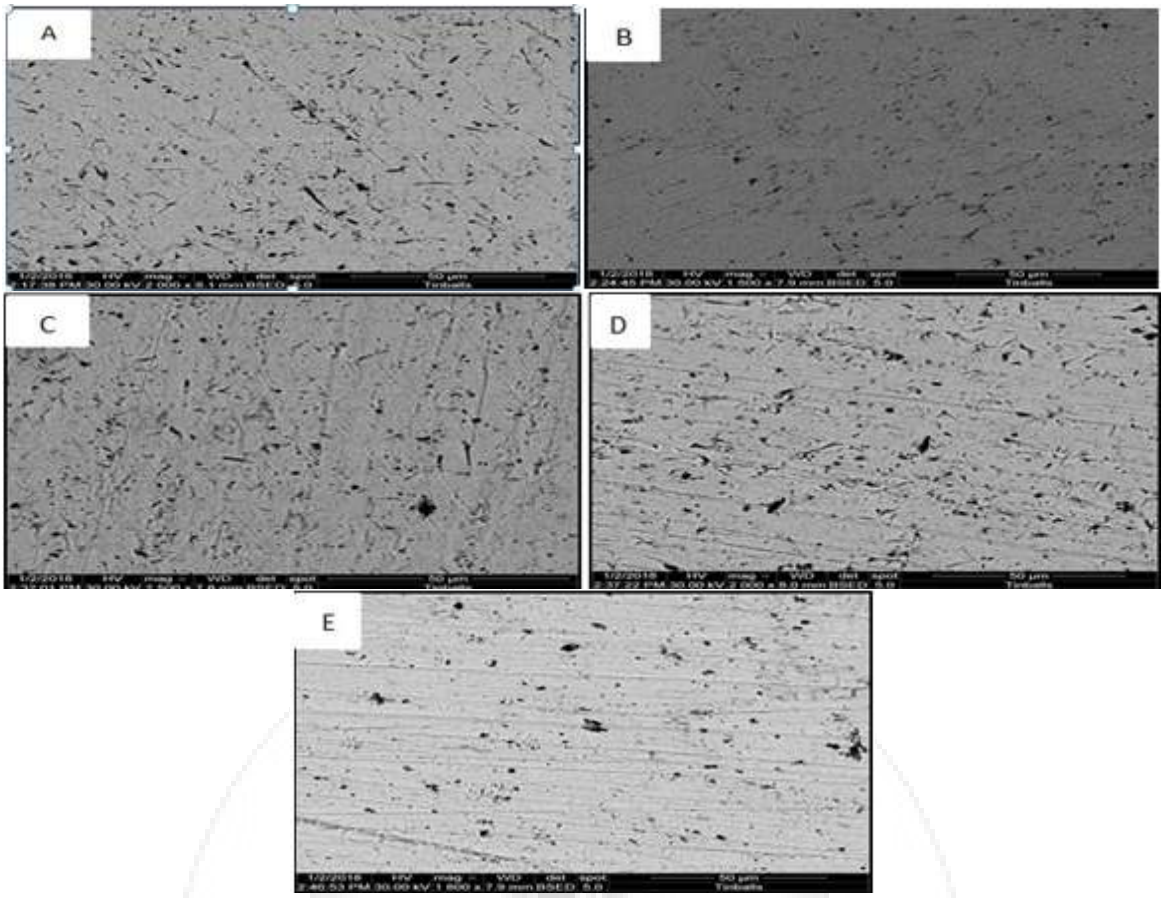

Figure 4: Shows the images of the electron microscopy SEM scanner for the samples according to the ratios of the relay respectively

A-Ag + 3% Zro_2 + 0% Gr
B-Ag + 3% Zro_2 + 0.75 Gr
C-Ag + 3% Zro_2 + 1.5% Gr
D-Ag + 3% Zro_2 + 2.25% Gr
E-Ag + 3% Zro_2 + 3% Gr

3.1 Hardness Test

Figure (5) shows the relationship between the volume fracture of the graphite and the hardness of the microwaved Vickers. Hardness is reduced from 50.325 to 42.3 when the graphite content increases from 0-3%. The lower the hardness of the hybrid overlay, the higher the percentage of graphite is the lower the expected for several reasons, which comes in the forefront of the low hardness of the graphite compared to the rest of the materials of the overlays, as the graphite is more soft than the rest of the overlapping materials and the fragile nature of the graphite and its content increase the increase of the ease of the plastic deformation) By the effector (stitching tool). Moreover, increasing the graphite content will increase the spread and generation of cracks between the surfaces of the graphite and the other materials of the hybrid overlapping, causing a weak bond between them.

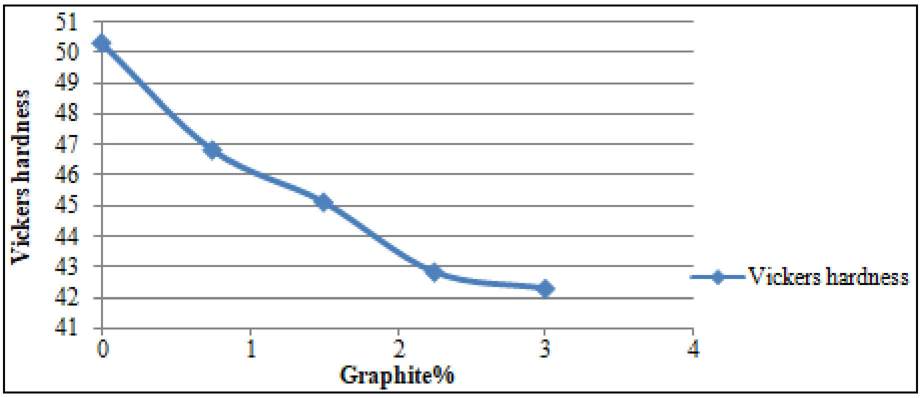

Figure 5: Effect of the graphite fracture on the microsatellite vickers hardness

3.2 Bulk and Apparent density

Figure (6) shows the relationship between volumetric, virtual and theoretical density with graphite content respectively. It was found in the relationship that increasing the graphite content resulted in decreasing both the volumetric density and the spectral density of the hybrid spectra where the volumetric density decreases from 9.2963 gm / cm3 to 8.4677 gm / cm3). The main reason for the decrease in density, both volumetric and virtual, by increasing the content of graphite is the low density of graphite (2.1 gm / cm3) compared to the density of the rest of the overlapping materials. The graphite particles also inhibit the integration of silver particles and the spread of solid state (impede the process of condensation and shrinkage) Volumetric phase during sintering). In addition, both zirconia and graphite oxide are weak phases and do not react completely to silver and other compounds. Increasing the graphite content leads to the collection of closed and open pores between them and keeping them in their positions. As shown in the figure, both the volumetric and virtual densities of all overlays were higher than (8 gm / cm3) indicating that the overlays were rather thick. The figure shows that the deviation from the theoretical density increases with the increase of graphite content, Using [17, 7] using different addition ratios.

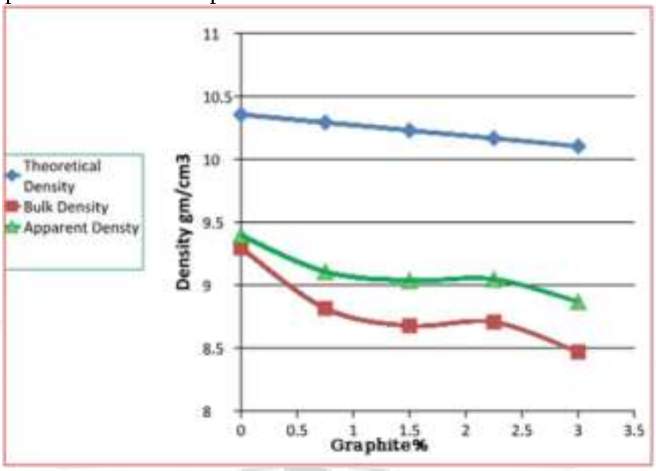

Figure 6: The relationship between the volume fraction of the graphite and the densities

3.3 Total Porosity

Figure (7) shows the relationship between total porosity and graphite content. The ratio of total porosity with the increase in graphite content is increased. The total porosity increases from 10.23% to 16.19%. The graphite content is increased from 0% to 3%. The reasons that led to the reduction of the volumetric and virtual density, which is the increase in the content of the graphite, inhibits the partial integration and prevents the complete integration of the silver particles, ie, the isolation of the particles during the sintering process, as well as the obstruction or prevention of volumetric contraction, leaving the pores closed and open in their potential and difficulty Content of Ravit.

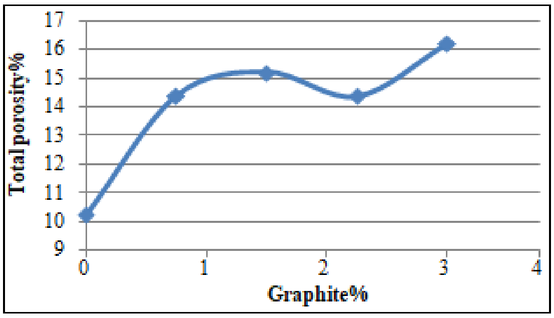

Figure 7: Shows the relationship between the volume fracture of the graphite and the total porosity

3.4 Apparent porosity and water Absorption

Figure (8) shows the relationship between the apparent porosity and the water absorption with the graphite content. It is observed that there is a positive relationship between the porosity and the water absorption with the increase of the graphite content. The percentage of the apparent porosity from 1.05% to 4.51% The percentage of water absorption increases from (0.11% to 0.30%) with the addition of graphite content as well. The positive relationship between the apparent porosity and the absorption of water is a logical relationship because the increase of the porosity means the increase of open pores percentage and therefore inevitably increase the percentage of water absorption of the hybrid over any increase pores through which the water can be implemented within the overlapping, With total porosity behavior by increasing the graphite content shown in Figure (7) and the opposite of the behavior of the density is completely virtual increase graphite content shown in Figure (6), which indicates that the nature of the effect of increasing the content of the graphite on both open and open porosity is one nature and the factors that control the closed porosity are the same that control open porosity, and Mechanisms are the two types of porosity one.

Paper ID: ART20183189 DOI: 10.21275/ART20183189

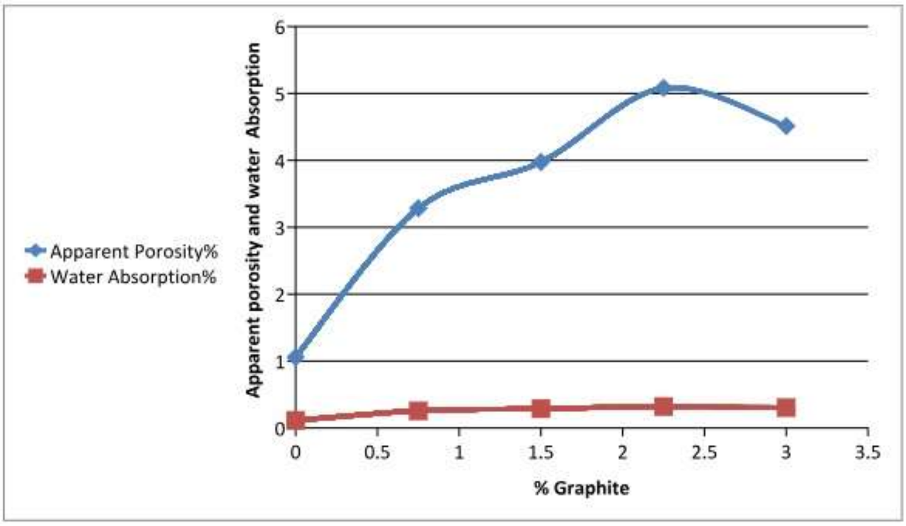

Figure 8: The relationship between the fraction of the volume of the graphite% and the apparent porosity and water absorption%

3.5 Thermal conductivity

Figure (9) shows the effect of graphite content on the thermal conductivity of the hybrid based on silver and contains a fixed volume fraction of zirconia oxide (3%) and variable volume fractions of graphite by 0-3%, respectively. Graphite content reduces thermal conductivity as thermal conductivity decreases from 387 w / mk to 293 w / mk. The main reason for low thermal conductivity by increasing graphite content is the low thermal conductivity of graphite (23.9 w / mk) The main material is silver (429 w / mk). The reason for the decrease in thermal conductivity and the increase in the volume fraction of graphite can be understood to increase the total porosity ratio by increasing the graphite content as shown in Fig. 7. Porous works as insulators within the overlapping body and any increase in its proportion necessarily reduces thermal conductivity, Pores transform the heat transfer by conduction into Convection transmission and this necessarily reduces the thermal conductivity of the superconductor.

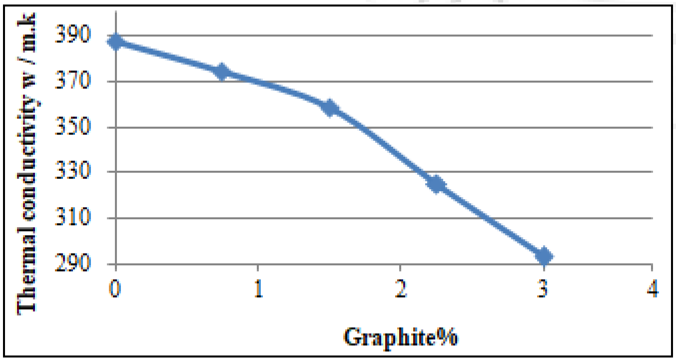

Figure 9: Shows the relationship between the volume fraction of graphite and the thermal conductivity

3.6 Wear rate

Figure (10) shows the relationship between the rate of wear and tear with the volumetric fracture of the graphite. The ratio of wear and tear with the increase of the fraction of the graphite from 0.75-0.0% (6), since the hardness is inversely proportional to the rate of wear and tear and follows the following formula [19]: -

$$W = K\frac{NS}{H} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots . (9)$$

whereas:
W: Wear rate (gm / cm).
K: The wear and tear coefficient.
N: Applied pregnancy (N).
S: Sliding distance (cm).
H: Overlying hardness (Mpa).

The increase in the rate of wear and tear can be attributed to low graphite content as the amount of graphite in the debris of wear and tear is insufficient to form the insulating oil layer between the two surfaces, which reduces the wear rate. This is consistent with [16, 9] Necessarily to a high rate of wear and tear.

We also notice in the figure (10) the decrease in wear and tear between the content of the graphite (2.25-0.75%) if this decrease can be attributed to the formation of the lubrication layer easily and reduce the wear and tear and thus the wear rate becomes less and this explains the low wear rate. Increasing the content of the graphite to (0.75 and 2.25%) makes the overlays more smooth during the wear and tear process, the lubricating layer formed prevents metal contact and delays the transmission of wear behavior from moderate to severe., 0.0037 gm) at the ratio of graphite (1.5) 2.25%, where the lubrication layer formed between the sliding surfaces acts as a solid oil due to the nature of the class graphite and the weak bond between those layers which are connected only by weak Vanderval forces, The presence of graphite will change the nature of machines The metal wire connection between the two surfaces Almenzgayn above each other (silver disc surface steel surface) to the case of contact between the two surfaces separated by a layer Kravite working Kmazit solid reduces stress sternoclavicular and improves the properties Turaabologer these surfaces and thus reduces wear and tear resulting from the sliding rate of movement.

The increase in the content of the graphite (2.25-3%) is due to the increase in the percentage of wear and tear. This increase is due to the presence of zirconia oxide minutes. Increasing the content of the graphite will increase the spread and cracks between the particles of the overlays due to disability In addition to the increase in the percentage of visible porosity and total porosity, all of them are easily separated for some minutes of the overlapping material. These are known as the debris of wear from the surface of the superconductor to the surface of the disc where the debris is rich in zirconia oxide. Aux Zirconia has a high hardness and its presence causes an increase in the operation of the surface of the sample and the high rate of wear and tear, and its effect between the surfaces is higher than the effect of increasing the composition of the graphite layer by increasing the content of the graphite, and increasing the rate of wear and tear with the increase of graphite content occurs due to increased plastic deformation occurring in protrusions and regions Near the surface due to increased wear debris rich in zirconia oxide. This increases the density of the particles by increasing deformation, which leads to the formation of precise cracks in the surface of the metal and then the intersection of these cracks with each other and with lines of wear and parallel to the surface of the separation, The increase in the wear rate can be attributed to the lower hardness of the overlapping (E). The increase in the wear and tear ratio with the increase in the content of the graphite is also due to the increase in the rate of wear and tear. That the graphite not only prevents wear and tear but also generates a large amount of debris, and this is consistent with [16.9].

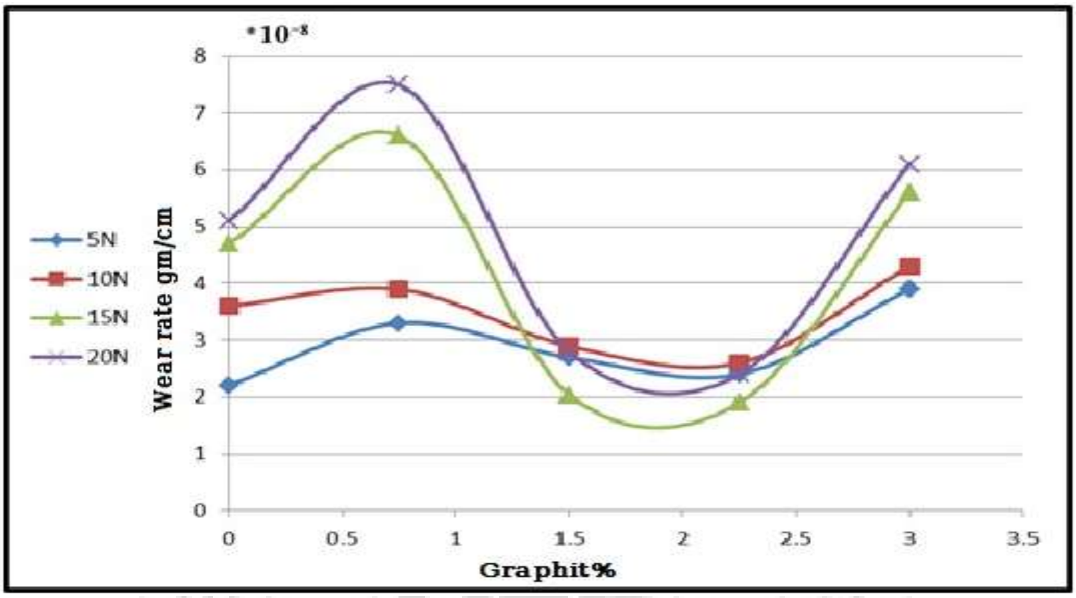

Figure 10: Shows the relationship between the volume fraction of the graphite% and the wear rate gm /cm

4. Conclusions

1) The increase in the content of graphite from 0 to 3% led to a decrease in the density of volume complexes by (8.91%).
2) The percentage of total porosity increased by (36.74%) with increasing the content of the graphite from (3-0)%.
3) The behavior of the apparent porosity with the behavior of the water absorption of the increase in the content of the graphite of all proportions.
4) Thermal conductivity decreases with increasing graphite content by (24.28%).
5) Hardness decreases with the addition of graphite and continues to decrease with increased graphite content.
6) The rate of wear and tear decreases to a minimum and increases by increasing the content of the graphite because the graphite not only impairs adhesion but also generates a large amount of debris. The study concluded that the wear and tear rate reaches the minimum value when the graphite content is about 2.25, 1.5%.

References

[1] M.P.Afonin and A.V. Boiko "EFFECT OF STRUCTURAL ANISOTROPY ON CONTACT PROPERTIES IN A SILVER-GRAPHITE COMPOSITE". Powder Metallurgy and Metal Ceramics, vol. 44, Nos. 1-2, (2005).
[2] Jiang, Peng, Feng Li, and Yaping Wang. " Effect of different types of carbon on microstructure and arcing behavior of Ag/C contact Materials". IEEE transactions on components and Packaging technologies 29. 2 (2006): 420 – 423.
[3] Findik, Fehim, and HuseyinUzun. "Microstructure hardness and electrical properties of silver–based refractory contact materials".Materials&design vol (24). No.(7): pp 489 – 492 (2003).
[4] Feng, Yi, et al. " the influence of pressureon the electrical tribology of carbon nanotube – silver – graphite composite ".Journal of Materials Science 42. 23 (2007): 9700 – 9706.
[5] Ćosović, v., et al. "comparison of properties of silver – metal oxide electrical contact materials."Journal of Mining and Metallurgy B: Metallurgy 48.1 (2012): 131-141.
[6] Dutkiewicz, Jan, et al. "Structure of silver base composite for electric contact materials."ChemListy 105 (2011): s420-s423.
[7] Chen, F.Y. et al. "Tribological behavior of silver based self – lubricating composite". Powder metallurgy 56.5 (2013): 397 – 404.

[8] Feng, Yi, Hai Long Yuang, and min Zhang. " Fabrication and properties of silver – matrix composites reinforced by carbon nanotubes". Materials characterization 55.3: pp 211 - 218 (2005).
[9] Saif Sabah Arheem "The Effect of Adding Graphite / WC on the Physical, Mechanical and Wear Properties of Aluminum", Diyala Journal of Engineering Sciences, Volume 10, Issue 4, (86-72), December (2017)
[10] Chen, wu, et al. " Effect of Hot Extrusion on Mechanical and tribological behavior of Ag – cu/ Mos_2 composites". Tribology Tran Sactions 59. 2 (2016): 375 – 384.
[11] Ali MezherRassin, "The Effect of Adding Alumina Powder on Wear Resistance to Zn-4Al Alloy Made in Powder Metallurgy"Diyala Journal of Engineering Sciences, Volume 8, Issue 3, pp. 20-30 (2015).
[12] American Society for Testing and Materials, "Standard Test Method for water Absorption, Bulk Density, Apparent Porosity, and Apparent Specific Gravity of Fired White ware Products", ASTM C373-88, (2009).
[13] Farouk M. Mahdi, Raed N. Razooqi, Siaf S. Irhayyim, " Effect of Graphite content and Milling Time on Physical Properties of copper-Graphite composites prepared by powder Metallurgy Route". Australian Journal of Basic and Applied sciences, vol. 7, No.12, pp: 2445-255 (2013).
[14] OMOTOYINBO, Joseph Ajibade, IsiakaOluwole OLADELE, and WasiuSHOKOYA."Effect of the degree of Plastic deformation on the electrical resistance and Thermal conductivity of Al-Mg-Si allyo." Leonardo Electronic Journal of Practices & Technologies 24(2014): 37-50.
[15] American Society for Testing and Materials, " Standard Test Method for Wear Testing with a pin-on-Disk Apparatus". ASTM G99 – 04, (2009).
[16] Juan W. A. N. G. et al. "Influece of graphite content on sliding wear characteristics of CNTs – Ag – G electrical contact materials ". Transactions of nonferrous Metals society of china 19. 1 (2009): 113 – 118.
[17] Khanra G. P., et al. "studies on the Effect of Graphite content on Hardness and Electrical Resistivity of silver – Graphite composites ". Materials science Forum. vol. 710. Trans Tech publications, (2012).
[18] Wang, xianhui, et al." Investigation on proparation, macrostructure, and properties of $AgTiB_2$ composite". Journal of composite Materials 45. 12 (2011): 1285 – 1293.
[19] Zhang. Lei, Jinkun Xiao and Kechao Zhou. "Sliding wear behavior of silver – Molbdenum disulfide composite". Tribology Transactions 55.4: pp 473-480 (2012).