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Original Research

RETRACTED: ALLOCATION OF HYBRID COMPOSITE MATERIALS IN FRICTION DISC CLUTCHES

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Abstract: This study explains the design of a single-plate clutch using experimental measurements. The ratios of materials used to make the samples were 34g of Kevlar fiber (aramid 49 type), 150g of epoxy-type Sikadur-52, 10g of iron powder, and 10g of graphite powder. The three different sample types were made as laminates and cut using water cutter machinery according to the ASTM standard for each test. The following procedures were taken: The prepared mold was created first. Epoxy and the hardener were mixed in a 2:1 ratio. After that, the mixture was stirred well for a sufficient period of time. Then a quantity of the epoxy mixture was placed in the mold, and Kevlar fibers were placed in layers. The following ratios were used to create three samples: Sample 1 (34 g of Kevlar fiber, 150 g of epoxy), Sample 2 (34 g of Kevlar fiber, 150 g of epoxy, 10 g Fe), and Sample 3: Kevlar fiber (34 g), graphite (10 g), epoxy (150 g), and iron (10 g). The following facts have been found: When Kevlar fiber (aramid 49 type) was used at a weight of 34g for all samples, the best performance was achieved by hybrid composite sample3, which has the highest values (modulus of elasticity and higher wear resistance) in comparison to the other two composite samples (sample2 and sample1). In comparison to composite sample 1, the hybrid composite samples 2, and 3 have the highest value. (Tests for hardness).

Keywords: *Clutch; coefficient of friction; composite; hardness; pin-on-disc; reinforcing; wear.*

1. Introduction

A clutch connects the driven and driving mechanisms to provide driving force. A brake inhibits motion and is its opposite. Two-shaft devices need clutches. One shaft (the driving member) is attached to a motor or other power unit, and the other shaft (the driven member) provides output power [1, 2]. In the automotive industry, fiber-reinforced hybrid composites are the most commonly used dry-friction materials. This research gives us a useful reference as well as new rules for how to work with complex materials like these [3]. Fiber-reinforced hybrid composite dry friction clutch facings are shown after real-world automotive tests. Mileage and test conditions caused clutch killer tests to wear more than 0.1 mm at inner diameters. With some exceptions, facing size, friction diameter, and directions affected surface roughness trends [4]. Naemah et al. [5] examine the wear characteristics of an aluminum-based composite material. Increasing the sliding speed and applied load affects the highest wear rate in the aluminum alloy, while the wear rate reduces as the SiC percentage in the Al/SiC composite. It was discovered that as SiC percentage age increases, so does hardness. Kadhim et al. [6] investigated the wear and compressive strength of a polymer hybrid composite. Sample 4 has the

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highest stress and lowest strain. Sample (3) had a good stress-to-strain ratio. The study found that reinforcing the base material (Novelac) decreases wear and tear, which increases wear resistance, especially with an increase in the percent of Kevlar fiber (aramid 49 type) to (40%-50%), where the lowest wear rates were in the sample (4). In the current application trend, conductive composite polymers are created by filling polymer matrices with various carbon blacks. The best example of carbon black is particulate filler, which is widely used as a reinforced filler in the polymer industry. As a result, created a polymer matrix composite with coconut shell char that contains up to 70.5% carbon, 0.99% ash, 31.75% lignin, 19.5% cellulose, and 70% hemicelluloses. The material was created by carburizing the coconut shell as the primary raw material [7]. The friction and wear characteristics of Al-7075 and Basalt fiber metal matrix composite materials were investigated in experiments with a range of sliding velocities and contact loads. Asbest is currently used as a primary component of the clutch facing for Multi Utility Vehicles (MUV) [8]. Kadhim et al. [9] conducted a mechanical performance comparison study of traditional disc clutches and hybrid composites. conducted a mechanical performance comparison study of traditional disc clutches and hybrid composites. The hardness and damping ratio test results revealed an increase in damping ratio when the traditional disc clutch was replaced with a hybrid composite. The use of this composite material in crucial applications like clutch pressure and face plate assembly is made possible by its good mechanical, wear, and physical properties. The composites with 20% SiC and 10% Al2O3 reinforcement have been found to work best as clutch pressure/face plates [10]. In single plate dry friction clutches, Kevlar, Ceramic, Feramic, and Feram Alloy have replaced asbestos as friction materials. Asbestos clutch facing is still available in the spare parts market and is employed to recondition old clutch plates. A new environmentally friendly and non-hazardous clutch-facing material is urgently needed [11]. Structured jute fibers (SJF) had the ability to increase the friction composites' impact strength, but they had no effect on the friction composites' density or hardness. This could be useful in a wide variety of applications, such as friction gearing and automotive braking systems [12]. As a friction material in clutches, functionally graded aluminum matrix composite (FGAMC) with silicon carbide is utilized because of its suitable friction coefficient and high resistance to wear. According to the analysis, the FGAMC is experiencing a greater amount of strain [13]. The utilization of fly ash in metal matrix composites reinforced leads to a general decrease in weight as well as the quantity of filler material, which ultimately results in a change in the composition of the aluminum alloy [14]. Analyses are performed on the composite's static, dynamic, thermal, and wear behaviors, and the composite is functionally graded. According to the results of the static analysis, the FGAMC clutch performed exceptionally well, exhibiting the lowest amount of deformation out of the three different materials [15].

To make high-quality friction linings for the Hyundai system, the research aimed to improve friction and strengthen fillers and fibers. This would keep the system running at its best performance even in high temperatures. Kevlar fiber (aramid 49 type), which dampens vibrations, is hoped to help. The study examines hardness and compressive stress resistance.

Composite properties are proxied by the mixing rule. [16, 17].

2. Weight loss method

Wear is the process by which material is gradually lost from one or both on a moving surface's surfaces. Wear could also be caused by the transfer of material [18]. This method was selected because it is easy to understand and because it can be used to calculate wear rates thanks to the information that it provides regarding the amount of wear debris. To summarize this procedure, the weight of the sample before and after the test is used, and the difference between the two weights indicates the amount of wear debris [19].

When A. Mouton announced that he had discovered these laws, they were given the name A mouton's three laws of dry friction. Not long after that, a number of other researchers made further discoveries about friction that were on par with the traditional empirical model. In this model, friction can either be static or kinetic, or it can even be rolling. The first step that the researchers took was to differentiate between kinetic and static friction. In 1734, John Theophilus Desaguliers made the discovery that friction is a force powerful enough to rip apart surfaces that have been adhered together. In the year 1833, Arthur Jules Martin provided a description of the difference between sliding friction and rolling friction. They established the principles that govern friction, which are still considered valid today. The Archard wear equation, which is founded on the asperity contact theory, is a simple model that can be used to describe the sliding wear that occurs. He reaches the conclusion that the amount of work done by frictional forces is directly proportional to the number of wear-related debris that is removed from the system.

3. Coefficient of Friction

The ratio of the force caused by friction to the vertical reaction of the surface is what's meant to be understood by the term "coefficient of friction." Its value is proportional to the load, and it is a function of both surfaces at the same time. When the load increases, the coefficient of friction also increases. There are two different kinds of friction coefficients; they are the coefficient of static friction and the coefficient of kinetic friction. Coefficient of friction (COF) testing is testing is used to determine the frictional properties of various materials. The smoothness of the surfaces is indicated by a low COF.

4. Experimental Part

This part is referred to as the experimental work section. It defines the components that are used in the production of hybrid polymeric composite materials, as well as the powders and samples that are produced with the help of the thermal compression device. The use of mechanical testing equipment for samples was made available.

4.1. Materials Used

Materials such as fiber filler, epoxy of type Sikadur-52, graphite powder, and iron powder were used to create samples for this investigation using the various types of powders.

4.2.Fiber Reinforcement

Kevlar fiber was chosen to serve as the reinforcing material for the matrix, and it was used to make the matrix stronger. It was utilized in a number of different weight ratios throughout the process. In the process of reinforcing the clutch, Kevlar fiber thin layers with dimensions of 6 cm x 4 cm have been used, resulting in increased durability and longevity. The construction of Kevlar fiber is illustrated in Figure 1, which also includes its production.

Figure 1. The design and manufacturing of Kevlar fiber.

The Kevlar fiber (aramid 49 type) properties are shown in Table 1.

Table 1. Kevlar fiber (aramid 49 type) properties

Property	Value
Density	$1440 kg/m^3$
Young's Modulus	$12x10^{11}$pa
Poisson's Ratio	0.36
Bulk Modulus	$1.333 x10^{11}$ pa
Shear Modulus	$4.1176x10^{10}$pa
Specific heat Capacity	$1420 J\cdot kg^{-1}\cdot c^{-1}$
Isotropic Thermal Conductivity	$0.04\ wm^{-1}C^{-1}$

Figure 2 shows pure iron powder, which is combined with graphite powder and cast together to create the rough surface of the sample shown in Figure 3. The final product of crushing clutch material into powder can be seen in Figure 4, which illustrates commercial clutch powder.

Figure 2. Pure iron powder used to make castings.

Figure 3. Graphite powder that gives the sample surface some roughness.

Figure 4. commercial clutch powder.

Table 2 lists the components of the clutch powder according to their chemical identities. The X-Ray Fluorescence Spectrometer that can be found in the Department of Nanotechnology of the

Ministry of Science and Technology provided the source for these particular data.

Table 2. Chemical composition of the clutch powder.

Element	Oxide	Oxide%	Oxide% Sigma	Number of Ions
O				2.00
Na	Na_2O	0.47	0.48	0.01
Mg	MgO	4.24	0.5	0.08
Al	Al_2O_2	12.01	0.66	0.17
Si	Sio_2	39.97	1.16	0.49
S	SO_3	11.21	0.79	0.10
K	K_2O	0.51	0.24	0.01
Ca	Cao	19.00	0.66	0.25
Ti	Tio_2	0.97	0.54	0.01
Fe	Feo	2.40	0.54	0.02
Ni	Nio	0.48	0.58	0.00
Cu	Cuo	6.61	0.85	0.06
Ba	Bao	2.13	0.85	0.01
Total:		100		1.22 (Cation sum)

4.3. Preparation of the Samples

4.3.1. Composite Material Preparation

During this stage, the preparation of the composite materials that will be used in the sample preparation will be explained. The laminations of each of the three different types of samples were created, and then the water cutter was used to cut them according to ASTM for each test. The hand layup technique is used for this work at room temperature. It was determined to proceed with the following procedures: First and foremost, the mold that would later be used was initially prepared. Following this step, the epoxy and the hardener were mixed in a ratio of two to one, and the resulting mixture was stirred thoroughly for a sufficient amount of time. After that, an amount of the epoxy mixture was put into the mold, the Kevlar fibers were layered in the mold, and three samples were created. They are designated as S1, S2, and S3, as shown in Table 3.

Table 3. the weight ratios of the various sample components.

Material	Sample's Component Weight (g)		
	Sample 1	Sample 2	Sample 3
Kevlar fiber	34	34	34
Graphite	-	-	10
Epoxy	150	150	150
Fe	-	10	10

4.3.2. *Preparing the examination samples:*

The samples were cut with a cutting machine (water jet) for the purpose of testing tensile strength, impact, and wear, as illustrated in Fig. 5. Each sample was cut in accordance with the ASTM standards for each test.

Figure 5. Demonstrates the creation of three samples.

4.4. Hardness Test

The samples' hardness was measured using a Digital Micro Hardness instrument. It was carried out at the control and measurements lab of the prosthetics and orthotics engineering college. The force applied was 0.981 N. To achieve excellent accuracy, hardness measurements were averaged over three readings. The Digital Micro Hardness equipment, shown in Fig. 6, is used to measure the samples.

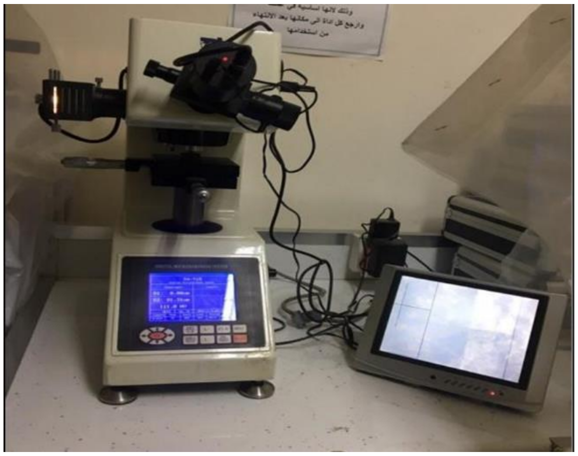


Figure 6. A Digital Micro Hardness Device.

4.5. Wear Test

At the University of Diyala, the Department of Mechanical Engineering maintains a Materials Lab that is equipped with a wear measurement instrument. In order to obtain contact between the sample and the disc rotor while the vertical load effect is being applied, a pin-on-disk device is a common piece of wear testing equipment. This device can be seen in Fig. 7. The disc completes 720 revolutions in one minute as it spins.

Figure 7. A pin-on-disk device is a common tool for wear testing.

The wear test sample is shown in Fig. 8. The sample had a diameter of 10 mm and a height of 20 mm.

Figure 8. The wear test sample is shown in the figure.

6. Results and Discussion

6.1. Compressive Strength Test Results

This test highly depends on the density of the reinforcement material. It is observed that the compressive strength gave good result at low density because high density is the primary factor in accelerating the failure process of samples. This indicates that materials with a low density have a high compressive strength resistance.

Fig. 9 displayed the stress to be 41.66 MPa and the Young's modulus to be 61.26 MPa. Compressive resistance decreased as composite material coherence and bending decreased. It is sufficient to note that the pressure of manufacturing defects plays a significant role in the formation of areas of concentrated stress, which accelerates the failure process. On the other hand, it demonstrated that a manufactured sample exhibited brittle and far from ductile behavior.

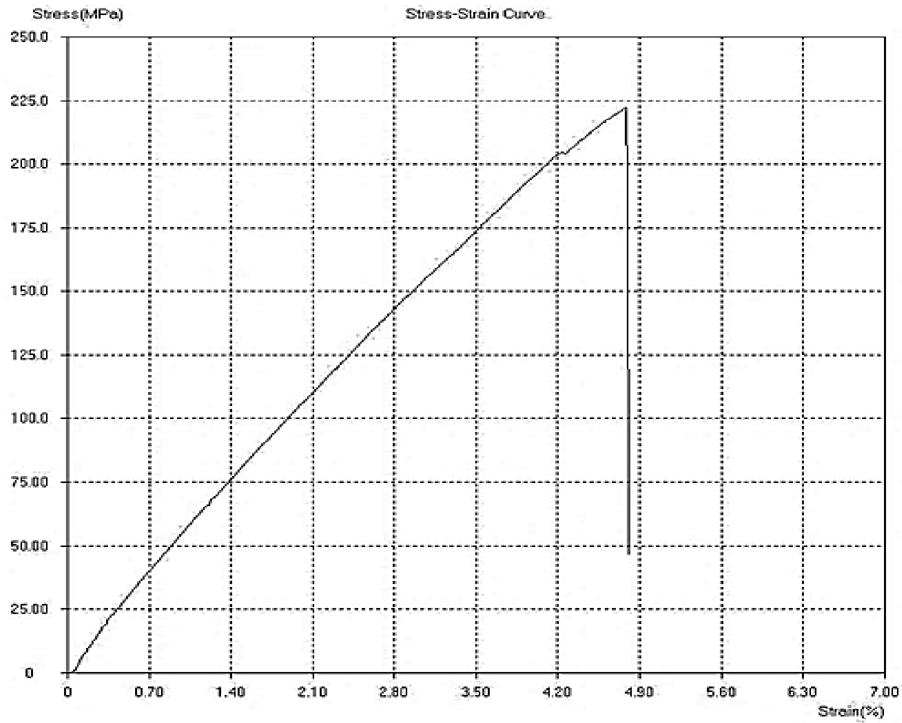
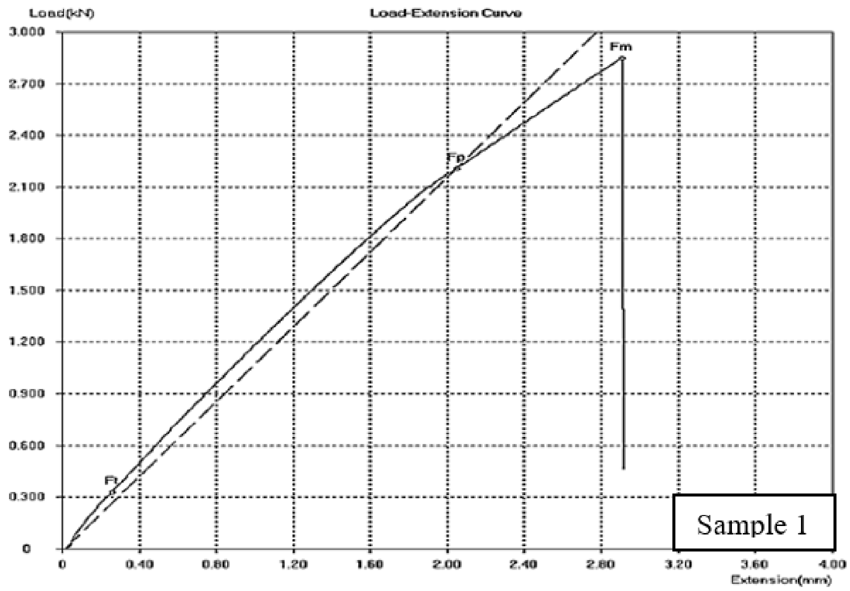
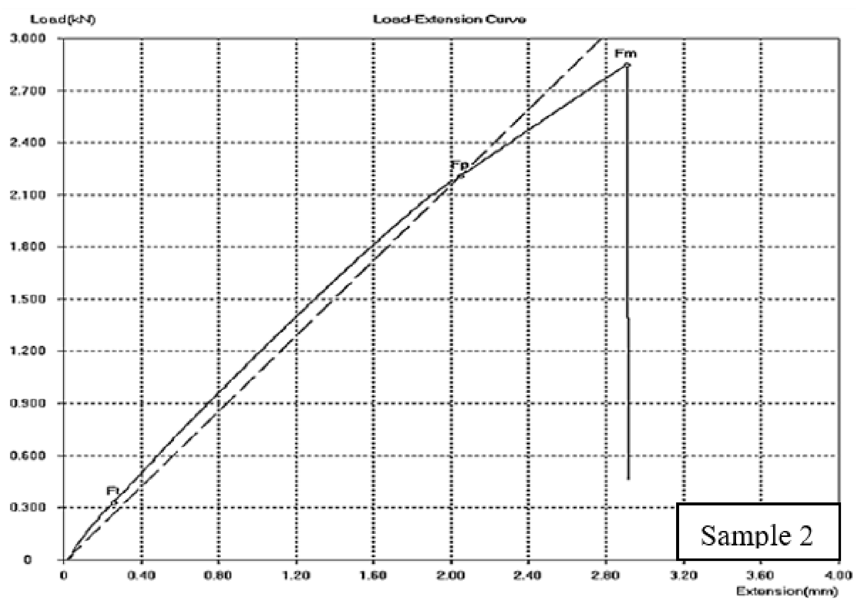


Figure 9. Compressive Strength results are illustrated in the stress-strain curve

6.2. Tensile Results

Tensile can have an effect on a number of different functional aspects of a part, including friction, wear, and heat transport, to name just a few. In order to determine the level of quality possessed by a component, it is necessary to conduct a tensile test on a sample. It is clear from the results that samples with a high tensile (sample 3) sustain considerable damage, whereas samples with a low tensile sustain only very slight damage (sample 1). Tests of tensile strength were conducted on all three samples at the University of Technology (S1, S2, and S3). The results of the tests are displayed in Fig. 10 and Fig. 11.


Load(kN)
Load-Extension Curve
3.000
2.700
2.400
2.100
1.800
1.500
1.200
0.900
0.600
0.300
0
Fm
Fp
Ft
Sample 1
0
0.40
0.80
1.20
1.60
2.00
2.40
2.80
3.20
3.60
4.00
Extension(mm)


Load(kN)
Load-Extension Curve
3.000
2.700
2.400
2.100
1.800
1.500
1.200
0.900
0.600
0.300
0
Fm
Fp
Ft
Sample 2
0
0.40
0.80
1.20
1.60
2.00
2.40
2.80
3.20
3.60
4.00
Extension(mm)

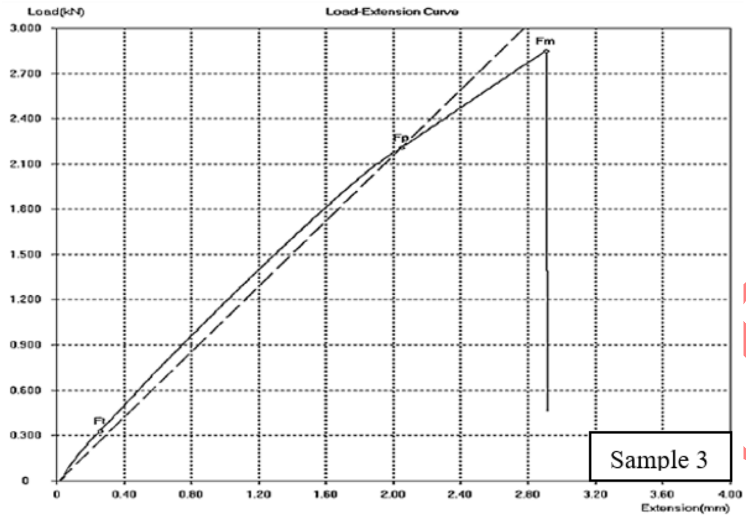
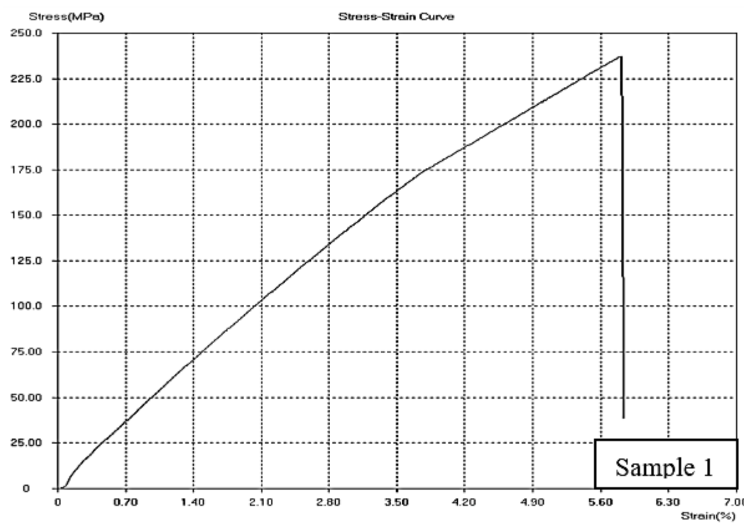


Figure 10. Tensile test result at 90 degrees.



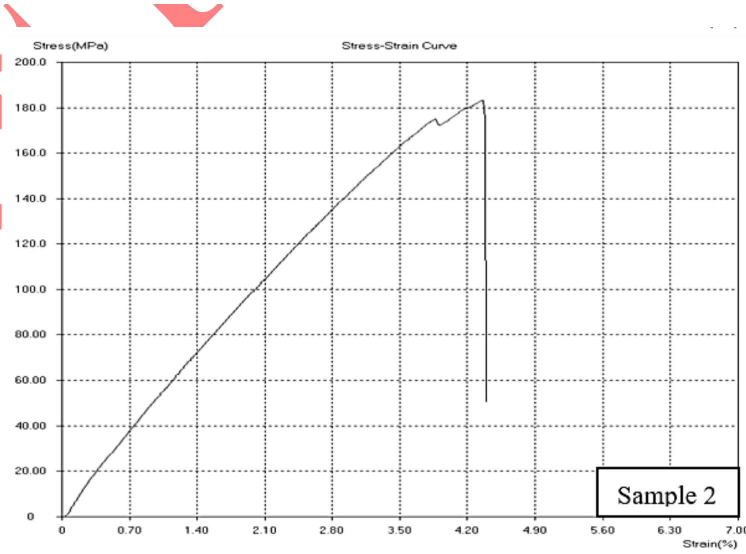


Figure 11. Tensile test result at 45 degrees

6.3. Wear results

The results of the wear test are listed according to the effect of the applied load on the composite reinforced was displayed in Fig. 12.

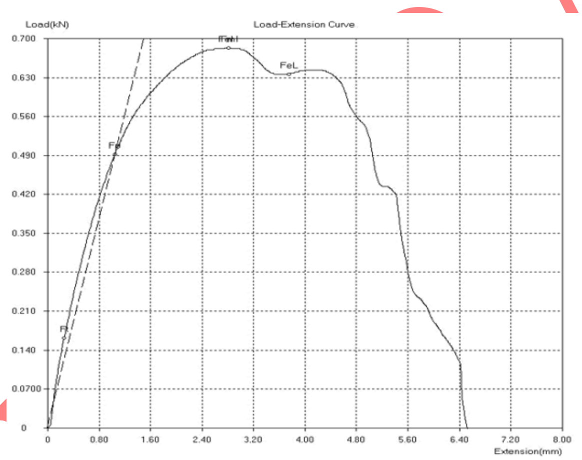


Figure 12. Effect of applied load on the composite mixtures

The load values were (10, 20, 25, 30) N, correspondingly. The test period was (8) minutes, with a sliding radius of (5 cm). It was found that raising the extra materials and decreasing the fiber ratio resulted in an increase in wear rate as the load increase within the limitations of the sliding speed used [20]. The difference in the density of the Kink bands explains why the rates of wear vary in their range or intensity with the change in load. The results of each sample are shown in Table 4.

Table 4. Specimen No. (1) time= 5 min, radius of wear =6.5 cm, =950

Sample	Weight	Specimen after wear	Applied weight (N)	Δ w(N)	wear
S1	0.0562	0.0563	10	0.000033	$3.093 * 10^{-8}$
S2	0.0669	0.0678	10	0.000053	$2.7836 * 10^{-7}$
S3	0.1138	0.1146	10	0.000082	$2.4743 * 10^{-7}$

When an axial load is applied to the hybrid composite material samples, which controls their hardness and brittleness, longitudinal splitting forms gradually. It was noticed that when stresses are applied to the test sample's surface and towards the weak areas, these splitters grow in size, converging and forming grooves [20]. The thin layers are removed when these grooves come into contact with each other or with the wear lines. because particles and wear debris are easily removed in the direction of the sliding motion, that which is created as a result of surface fatigue in the surface layers of the composite material during the sliding process of the matrix polymer, which without a doubt reduces wear resistance with continuous load application. Because of the ploughing process,10 N protrusions were removed from the sample blend e's surface. When the load is increased to (20) N, the ploughing process slows down, which is due to simple fiber protrusions caused by ploughing due to their good mechanical properties. This is illustrated in S3. With continued sliding motion and increased load (25)N wear ratio will increase due to the convergence of these grooves (formed at low loading) with each other to form large continuous cracks that lead to particle flake separation.

6.4. Coefficient of Friction Test

The coefficients of friction for the samples are shown in Table 5.

Table 5. Values of coefficient of friction for the samples

sample	coefficient of friction (μ)
*S*1	0.341
*S*2	0.374
*S*3	0.292

The coefficient of friction in S3 decreases as the (graphite and antimony trisulfide) ratio increases due to the lubrication effect, and thus the coefficient of friction between the contact surfaces decreases. S2 showed an increase in coefficient of friction due to an increase in the proportion of alumina oxide (Al2O3), which causes friction.

6.5. Hardness Test Result

The three samples (S1, S2, and S3) were subjected to hardness tests in the labs of the University of Technology as displayed in Table 6. So, the hardest properties of these disc clutches were tested, which showed an increase in damping, which lowers the size of the vibrations. The yield strength of samples that have been modified by adding Al203 reinforcement has been found to be the best pressure/face. The force applied was 0.981 N. To achieve excellent accuracy, hardness measurements were averaged over three readings in the table. The difference in hardness was very small, as the average hardness of the first model was 82.56HI, while the second model was 82.5HI, and the third was 82.56HI. The reason is the difference in the components of the three models, which are fiber filler, epoxy, iron powder, and graphite powder.

Table 6. The results of three samples' hardness tests

Specimen	First Reading	Second Reading	Third Reading	Average
S1	81.2	82.0	83.8	82HL
S2	81.4	82.1	84.0	82.5HL
S3	81.1	82.6	84.0	82.566HL

7. Conclusions

The findings of the study have led to the following conclusions:

1- Controlling the weight ratios of the reinforcing materials and the preparation process is one of the ways in which the requirements of the clutch lining can be achieved.

2- Reinforcing materials also contribute to the wear resistance of the composite material.

3- When Kevlar fiber aramid was utilized in the hybrid composite at a weight ratio of 49% in three samples, the best performance of the hybrid composite (sample3) has the highest values in comparison to the other two samples of composites (sample2 and sample1) (modulus of elasticity and higher wear resistance).

4- When compared to the composite sample 1, the hybrid composites Sample2 and Sample3 have the highest values in terms of hardness test.

Conflict of interest

The authors declare that there are no conflicts of interest regarding the publication of this manuscript.

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