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Sea water absorption on corrosion and hardness properties of lining brake with hybrid particulates composites

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Abstract. This work is focused on study water absorption behavior on hybrid particle reinforcement for phenolic resin composites. This experiment works subjected to investigates corrosion and hardness properties effect of seawater absorption. Hybrid composites were constructed by three types of particles such as basalt, seashell, and alumina were mixed for reinforcement, and the phenolic resin was employed as a matrix. Specimens were manufactured by using the hot-press process on temperatures and pressure of 150°C and 2000N. Water absorption test was carried out by immersing specimens in seawater at room temperature for different time durations (3, 14, 24, 30, and 60 days) according to ASTM D 570 standard. The morphology of hybrid particles composites was investigated by SEM. The result showed that the increasing weight fraction of basalt powder has increased the hardness of specimens. Water absorption was shown monotonous trend on all hybrid composites configuration. In addition, hybrid composite immersion in seawater made hybrid particle composites corrosive.

1. Introduction

Particulate composites are the type of composite materials that consisted of a particulate phase as filler in single polymers. Particulate reinforced polymer composites have widely implemented as engineering product in especially on brake shoes of the automobile. Generally, particulate reinforcement has extensively used to expand the properties of matrix material such as to modify the thermal and electrical conductivities. Also, it can improve work temperature, wear, and abrasion resistant, improve machinability, surface hardness, and reduce shrinkage and friction. However, particulate reinforce polymer composite was not effective in improving fracture toughness [1]. All properties of composite particulate reinforced caused by particle size, contour, shapes, and porosity [2].

Particulate reinforced polymer composites (PRPC) have widely involved in engineering product according to the characteristics and the required mechanical properties. Brake shoes on the brake system are one type of PRPC application, which become a major part of active safety for each vehicle [3, 4]. In general, a combination between the asbestos and metallic particulates have been applied as reinforcement and thermosetting polymers have used for matrix such as phenolic resin. The characteristics of asbestos are low in water absorption, excellent mechanical properties, stable at a temperature elevated, and high friction properties. But, Asbestos material has a very negative impact on human health. The asbestosis, mesothelioma, and other cancers are kinds of diseases that infected by asbestos [5-7].

Since a few last decades, environmental issues have become the main reason to develop brake shoes using natural material. The selection of natural material is very important for reflected the fundamental relationships among material properties and be used to find out a range of materials suitable for an engineering application [8-10]. In the present, natural material such as jute, goony, banana fibers, pineapple, coconut fiber [11], and other materials due to their positive properties is possible used as fillers of brake shoes. Several experimental works were performed to investigate the possible uses of natural material as brake shoes. In recent years, the eco-friendly brake friction material has been carried out sporadically [12]. Brake pads using the banana peel for produces eco-friendly brake pads was investigated by Idris, et.al [13]. Ikpambese et.al [14] study for automotive



brakes pad free-asbestos by using palm kernel fibers. Ameh et.al [15] study for the effect of date palm seed particle on the mechanical properties of reinforced polyester.

Water absorption and hardness properties is a major problem for natural material in the brake shoe materials. There are not many studies carried out for corrosion behavior currently for seawater absorption impact on the brake shoes using natural reinforcement. In this work, we would like to investigate particulate composites phenolic resin using hybrid reinforcement of basalt, seashell and alumina particles with immersion on sea water. The purpose is to study the hardness, corrosion, and absorption rate of the hybrid particulate polymer composites. In experimental work, sintering molding at 200°C temperatures for produces specimen was carried out. The test was in accordance with ASTM D 570 standard, and hybrid particulate composites morphology investigated using SEM.

2. Material And Method

2.1. Material

In experiment work, hybrid composites had been applied three particulates for reinforcement and thermosetting polymer as a matrix. Basalt, seashell and alumina particles were used due to their positive mechanical properties and also, it's a part of natural material. Whilst phenolic resin was chosen as polymers. Basalt is filler that produced by the melting process of the volcanic rock on temperatures elevated i.e. 1200°C ~ 1700°C [16]. In addition, seashells powder was conducted by crusher process to found 0.25 mesh grains size. Table 1 shows the properties of the reinforcement and polymer.

Table 1. Particulate compound.[17, 18]

Particles Item	Compounds content (%)									
	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	CaO	MgO	Na ₂ O	TiO ₂	K ₂ O	P ₂ O ₅	MnO
Basalt	55.50	19.50	8.25	11.20	8.50	3.32	1.00	1.50	1.20	0.11
Seashell	7.88	1.25	0.03	66.70	22.28	-	-	-	-	-
Metallic (Alumina)	0.03	98.4	0.03	0.06	-	0.60	0.005	-	-	-

Table 2. Hybrid Particulate phenolic resin composites

Hybrid Composites	Code	Particulate Filler % (wt)			Polymers % (wt)
		Basalt	Seashell	Alumina	Phenolic resin
B ₃₀ C ₄₀ A ₁₀ P ₂₀	A	30	40	10	20
B ₄₀ C ₃₀ A ₁₀ P ₂₀	B	40	30	10	20
B ₅₀ C ₂₀ A ₁₀ P ₂₀	C	50	20	10	20

2.2. Methods

2.2.1. Hybrid Composite Fabrications

In the present work, the composite was fabricated by compression processes in four steps such as preparation polymers and fillers, mold preparation, molding process and testing of the specimen. Filler preparation by mixing three particulates such basalt, calm seashell and alumina. The weight percentage of fillers and polymers was used in the present investigation is according to ratios 80wt% and 20wt% for all variations. The particulate mixtures illustrated in Table 2. In the present study, three hybrid composite variety were produced, and one specimen made from real brake shoe material was used as a control. Mixing particulate was stirred manually until a homogeneous mixture was obtained.

Then, the mixture is kept in the desiccator for removing pollutants content and made homogeneous compound bound between the particles.

Figure 1 shows the molding process, mold temperature curve, and specimen dimension of composites. In this work, the composite was manufactured with hydraulic molding press (hot press). The compression process was set to 60 minutes with a pressure of 2000kgf/cm² on constant temperature of 150°C. After the mold time has achieved, the hybrid composites cured before removed from the mold.

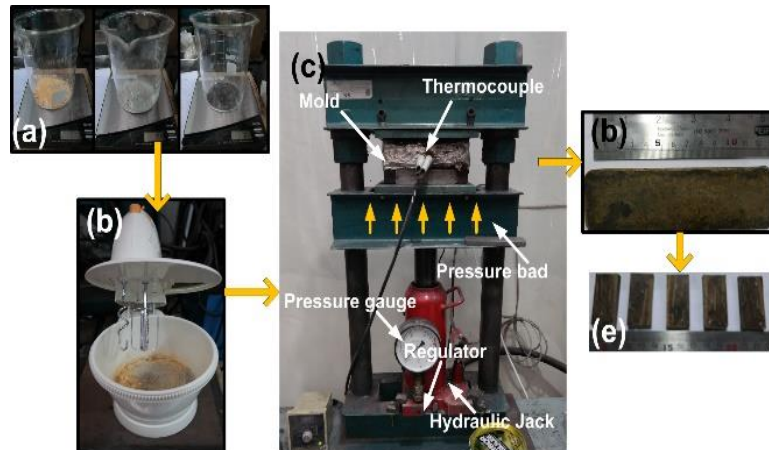


Figure 1. a). Filler particle weighed; b). Particulate mixtures; c). Hot-press machine and molding process; d). Hybrid particulate filler polypropylene polymer composite; e). Specimens test.

2.2.2. Hardness test

Vickers hardness test Zwick was conducted using a square-base diamond pyramid indentation with the angle of the pyramid of 136°. The Vickers microhardness (VHN) was defined as the load divided by the surface area of the indentation. In this experiment, the load indentation uses at 2 kg, and it applied for 15 seconds. Hardness test was done according to ASTM E-92 standard.

2.2.3. Water absorption test

In order to obtain the effect of water absorption to each hybrid particulate filler, polymer composites property, the immersion test was carried out. The water absorption test was conducted is immersing specimens in seawater in a beaker at room temperatures as long as 60 days duration. The water absorption on specimens was weighed regularly in each time duration. The moistures absorption was calculated by the weight difference and percentages weight gain. In this test sea water absorption of samples were determined at different day's interval. The measuring of the specimen was started at the 3 days immersion. It process would be repeated at 14, 24, 30 and 60 days according to the ASTM D 570 standard. The water absorption test procedure of the hybrid composites has shown in Figure 2.

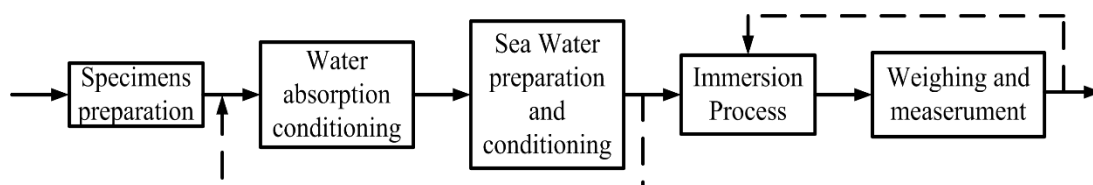


Figure 2. Schematic of the water absorption test

2.2.4. Microstructures test

The microstructure of the hybrid composite was characterized by scanning electron microscopy using JEOL-JSM 6510LA.

3. Result And Discussion

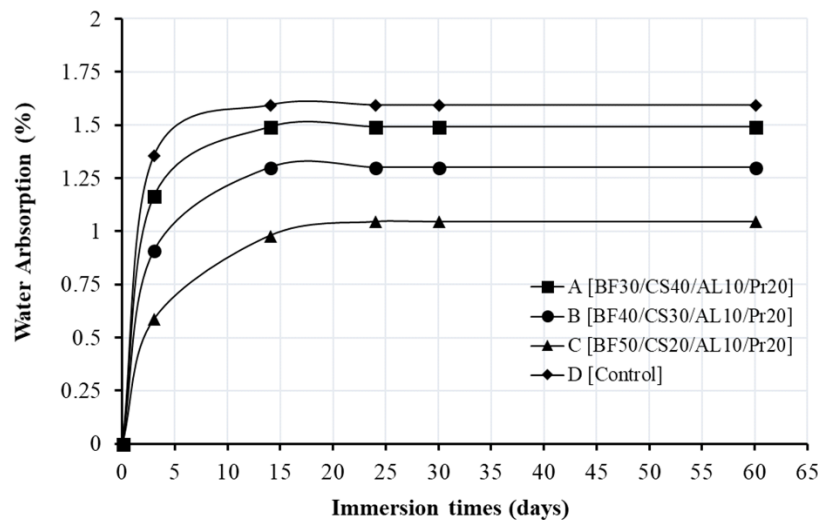


Figure 3. Water absorption of Hybrid particulate reinforced Phenolic resin composites

3.1. Water Absorption properties of hybrid particulate polymer composites

The seawater uptake of hybrid composite phenolic resin with basalt/seashells/aluminum particles reinforced presented in the figure. The water absorption behavior of hybrid composite mainly depends on the voids present in the composites, interfacial adhesion between the reinforcement and matrix, and type of fillers. Figure 3 shows the relationship between immersion time and water absorption of each hybrid particulate reinforced polymer composites which compared with control. It can be seen from the graph that the trend of sea water absorption property shows monotonous. In the first water absorption time, the specimen weight was significantly rising until immersion at fourteen days. Furthermore, immersion duration at 24, 30 and 60 days water absorption were not occurred. It means that there is no add weight on hybrid composites.

On the longer saturated time, the sea water absorption of the hybrid particulate polymer composite is increased for all variation of basalt and seashells particles, respectively. It can be seen that in the 3 and 14 days, the water absorption has increased sharply compared with the next duration days. In other words, the water absorption value increases drastically on the first immersion, due to the specimen in dry condition and the next time the absorption increase slowly, and then become constant. In the research, the high content of seashells particle (specimen A) increases seawater uptake of the specimen and exhibit a high value of weight gain. The hybrid composite (BF₃₀/CS₄₀/AL₁₀/PR₂₀) has a value maximum of water absorption is 1.35% (wt) highest than (BF₄₀/CS₃₀/AL₁₀/PR₂₀) and (BF₅₀/CS₂₀/AL₁₀/PR₂₀). Normally, density and salinity of seawater have influenced the immersion value of hybrid composites, so it can produce less amount of water absorption.

One of the most dominant compositions that increases water absorption on the hybrid composite has caused by CaO and MgO content [19]. Basalt and seashell particles have a relative high content of CaO and MgO can be seen in Table 2, respectively. This characteristic had been phenomena on the natural fillers [20]. However, thermoplastic (phenolic resin) hydrophobic behavior has small value water. According to the result can be concluded that all particles of the filler are bound well by the matrix. Similar observations were conducted by other researchers. [21-25]

3.2. Hardness property of hybrid particulate polymer composites

Figure 4 shows the hardness properties chart of hybrid particulate polymers composite effect of immersion on sea water. Capital letters such A, B, C, and D on the horizontal axis of the graph shows type of specimens in immersion test. Then, the number such as 3, 14, 24, 30, and 60 indicates duration days of immersion test. According to the test result of hardness, it can be seen that the water absorption decreases hardness Vickers number of each hybrid composites. The high value of hybrid composites hardness was exhibited on sample C, which contains basalt particles weight percent highest, and it occurred on each of immersion duration. Vickers microhardness has the highest value on average is 25.5HVN on three days immersion for each hybrid composites configuration. Additionally, the HVN of hybrid composites after immersion twenty days shows decreases for all hybrid composites about 12.5HVN, and it has constant values in the next immersion day's duration, respectively. In contrast, the hybrid composites effect of water absorption shows harder compared to control specimen due to increases weight percent of basalt particles. In present, it can be concluded that the weight percent of basalt particle increases had improved the hardness of hybrid composites.

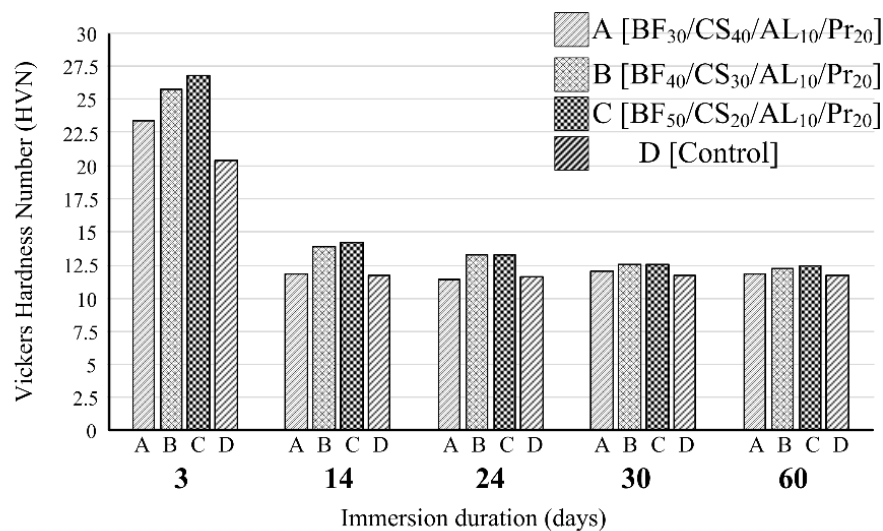


Figure 4. Bar chart of Vickers microhardness hybrid composite after the immersion in seawater

3.3. Corrosion properties of hybrid particulate polymer composites

Figure 5 shows the corrosive damages of a hybrid particulate polymer composite that effect of seawater. It was observed that corrosion occurred after seawater immersion on each hybrid composites variety. Figure 5a, corrosion of hybrid composite with [BF₄₀/CL₃₀/Al₁₀/Pr₂₀] as pointed by yellow color arrows. Then on Figure 5b and 5c were exhibited corrosion on hybrid composite with [BF₅₀/CL₂₀/Al₁₀/Pr₂₀] and [BF₅₀/CL₂₀/Al₁₀/Pr₂₀], respectively. As can be seen in figure delamination, crack, and particles removing of bound are corrosion behavior effect of hybrid composites immersion in seawater.

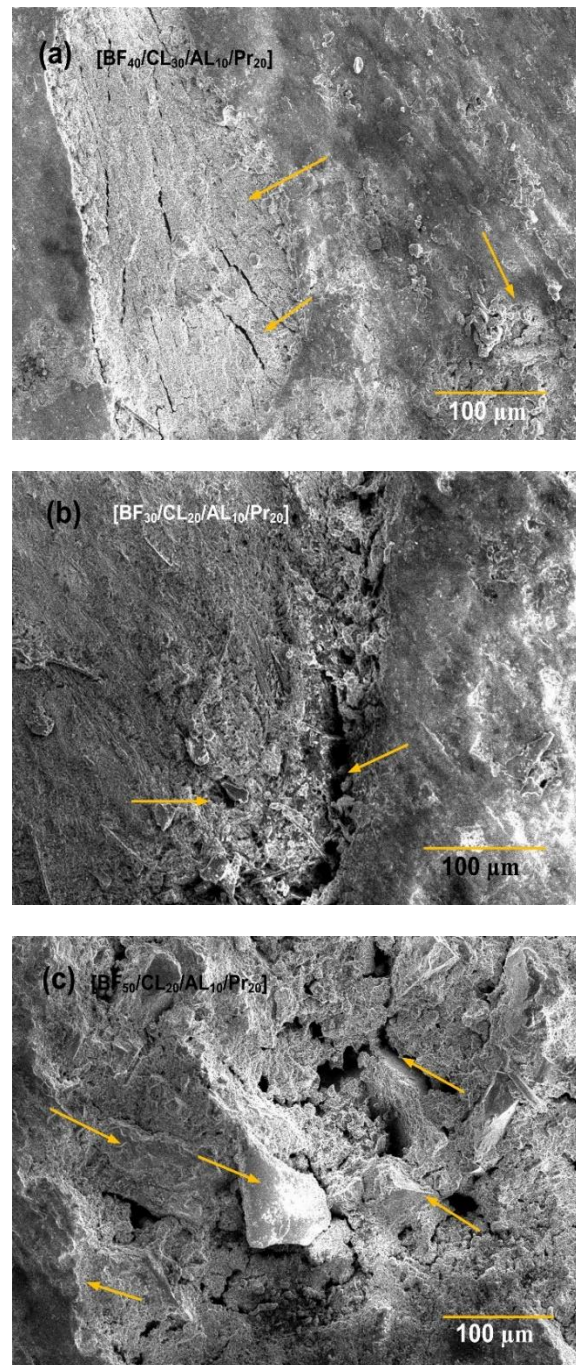


Figure 5. corrosion behavior hybrid composites in seawater at 30 days immersion

4. Conclusion

The corrosion and hardness properties of hybrid composite effect of seawater absorption have been investigated. The hybrid composite with a varied weight ratio of basalt particulates and seashells particulate have used in this test. From the results obtained, the following conclusions are drawn:

1. The amount of water absorbed by hybrid composites are constant after 14 days immersion in seawater at duration days.

2. Increasing basalt particle content has been increased Vickers microhardness for all hybrid composite configuration. However, all composition of the hybrid composite was reduced their hardness after immersion in sea water.
3. The sea water immersion for all configuration hybrid composite was effective made samples corrosion, due to the salination. The corrosion was influenced on immersion at 30 days. The corrosion was shown by many delaminations, crack and particles removed from the bond that occurred on the hybrid composite surface.
4. Hybrid particulate polymer composite property has potential used alternative material of brake shoes of the vehicles.

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