Characterization of Polymethyl Methacrylate (PMMA) Composites with Graphite

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Abstract. PMMA Composites have become the most popular materials due to its excellent strength-to-weight ratio, graphite reinforced for engineering applications. Researchers have used a variety of reinforcements to enhance the mechanical and tribological characteristics of various polymer matrixes, including carbon fiber, glass fiber, and carbon-based nanoparticles, graphite, alumina, silica, silicon carbide, titanium oxide, bacterial cellulose, Nano-cellulose, and zirconium oxide.This project focuses on the characteristics of composites made with graphite reinforcements that are based on polymethyl methacrylate. Die casting was used to manufacture this reinforced composite. To enhance the mechanical qualities (impact strength and hardness), tribological parameters (slide distance, normal load, and sliding velocity are employed for wear rate). Therefore, in this study, greater focus has been placed on on PMMA-based composites with graphite reinforcement.

Keywords: Polymethyl Methacrylate, Graphite, reinforcement, impact strength, hardness and pin on disc test.

1. INTRODUCTION

1.1 INTRODUCTION TO COMPOSITES

The various component elements retain some of their original identities, but they combine and provide their greatest qualities to the finished material's properties. These composite materials are stronger and more durable. In relation to this work, composites contain polymer matrices reinforced with natural fibers that are of the particulate variety. Because the reinforcements are continuous with the matrix, the matrix is stiff [1]. To enhance performance, these composites also include fillers or additives. The matrix component only carries a minor percentage of the load, with the fiber reinforcements carrying the majority of it. Typically, composites are either natural or manufactured in nature. Composites made

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of natural fibers include cotton, flax, jute, sisal, and hemp [2], whereas those made of synthetic fibers include carbon, glass, etc. Natural fibers are utilized

as an alternative to synthetic fibers for reinforcement in polymer composites due to their affordability, biodegradability, lower weight, and superior strength. Physical characteristics [3] The utilization of particulate matter as reinforcement was investigated further, and it was discovered that a study on composites based on epoxy resin and filled with iron, ferrite, graphite, and coal powders was characterized [4]. The aluminum matrix composites (AMCs) are a class of MMC with characteristics including low density, high stiffness and strength, greater wear resistance, regulated thermal expansion coefficient, higher fatigue resistance, and better stability at high temperatures. The usage of AMCs in engine applications lowers vehicle weight, fuel use, and emissions [5]. Researchers are presently concentrating on the creation of metal matrix composites based on aluminum, copper, magnesium, and titanium and have been investigating their potential uses in several fields. The ceramic minerals alumina, boron, tungsten, graphite, fly ash, silicon carbide, titanium carbide, Zr, SiO_2, and TiO_2 are most frequently utilized as reinforcement in metal matrix composites. SiC particles have been discovered to have increased wear resistance and great compatibility with aluminum matrix among these reinforcements [6-7]. According to researchers' references [8–9], the current work focuses on the preparation of binary composite utilizing the stir casting process and adding 5% SiC by volume to aluminum 2014 alloy.

2. MATERIAL AND METHODS

2.1 ACRYLIC REPAIR MATERIAL & GRAPHITE POWDER

Repair of Plastic methyl methacrylate is an all-purpose, self-curing acrylic material that can be used for any emergency situation, including replacing missing teeth, fixing entire dentures, half dentures, cold-cure full dentures, orthodontic retainers, adding clasps, repairing fractures, and rebasing and modifying full or partial dentures, and adding accessories. Useful for a denture duplicator. The paints and other coatings that resemble them use graphite in powdered form [10-11]. Additionally, this powder is used to raise the carbon content of some metals, such as steel. It also works well as a lubricant to shield surfaces from friction and other.

Fig. 1. Acrylic repair material and Graphite material.

Table 1. POLY (METHYL METHACRYLATE) Properties.

ITEM	UNIT	PQ60 120-150 MESH	PQ61 150-200 MESH	PQ62 0-200 MESH
The melt flow rate g/10min	g/10min	1.0-2.0	0.5-1.0	1.0-2.0
Density g/cm3	g/cm³	1.16-1.17	1.18-1.19	1.18-1.19
all indentation hardness N/mm2≥	N/mm²≥	120	130	130
Mold shrinkage % ≤	%≤	0.5	0.5	0.5
Refractive index 25°C	25°C	1.50-1.51	1.49-1.50	1.49-1.50

2.3. PREPARATION OF DIE (ALUMINIUM SPLIT DIE)

By using this arrangement, samples were prepared fast and readily by using an aluminum split die to prepare samples manually. Given that it is effectively a one-part mold with a deliberate split cut across it, this technique is almost equivalent to the one part open mould making technique and specifications are 100 mm in length, 10 mm in width, and 10 mm in thickness. A digital electronic weighing scale is a device used to calculate weight or mass. It functions as a load cell with a strain gauge. While digital scales convert an object's weight force into an electronic signal, analog scales use springs to indicate an object's weight. The General Chemistry labs feature highly accurate computerized mass scales that can weigh items down to the milligram (0.001 g) level. Please be gentle with them. When weighing chemicals, use containers, and always weigh items at room temperature. In my project, PMMA powder and graphite powder are measured using a digital weighing scale while creating samples with the right composition.

Fig. 2. Aluminium split die.

3. METHODOLOGY

3.1 PROCEDURE FOR PREPARATION OF PMMA

PMMA and graphite were used as reinforcement and the proper amounts of both the polymer and the reinforcement were used to create the composites. Determine the PMMA and graphite powder weights at various compositions (5, 10,15wt %).In a bowl, combine the two mixtures for 10 minutes. Split the Brass Die with the Allen keys after properly mixing. Apply the oil to the die after it has been opened to stop the material from sticking. By incorporating the required amount of the monomer, the mixture was polymerized. After thoroughly combining the ingredients in the bowl, the mixture immediately forms fibers.
The mixture was permitted to reach the stage of dough. After that, the dough was evenly stuffed into the split die's two sides.The die was then shut, and extra After 10–12 minutes have passed, the die is opened, and the composites are ejected. Material is scraped out of the die's exteriors. Finally, the necessary Composite samples are acquired, packaged, and ready for further analysis (Izod and charpy impact, Hardness test).
Features and descriptions: A self-polymerizing acrylic compound with a cold cure that can be used for all kinds of denture repairs. 4 minutes of working time. 14-minute bench cure time is quick.

Fig. 3. Weight Measurement and missing the PMMA Composite with graphite

Fig. 4. Polymethyl Methacrylate-Graphite Sample.

3.2 PLANNING FOR CUTTING CONDITIONS AND AN EXPERIMENT

Pilot tests were carried out in accordance with manufacturer instructions, and workable parameter ranges for a system were chosen. Nine trials in all were planned, according to L9 orthogonal array. Process parameters for the corresponding tests are 1.Impact test (load, degree of notch and % of reinforcement), 2. Hardness test (%PMMA, % reinforcement and % graphite) and 3. Wear test (load, RPM and % reinforcement).

4. EXPERIMENTAL SETUP

4.1 IMAPCT TEST

A known-weight pendulum is hoisted to a known height, then allowed to descend and strike a specimen that is secured at the bottom of the swing. The impact resistance is measured using the same principle by Izod and Charpy. The test results were obtained from the izod and charpy impact from strength of materials laboratory in the KG Reddy College of engineering and technology.

4.2 HARDNESS TEST

Indentation hardness tests are used by mechanical engineers to evaluate a material's resistance to deformation. To try and estimate these qualities, methods for measuring material "hardness" by making a very small impression on a material have been devised. The test results were obtained from the izod and charpy impact from strength of materials laboratory in the KG Reddy College of engineering and technology.

4.3 WEAR RATE

4.3.1 PIN ON DISC TEST

One of the most used tribometers for determining friction and wear (often wear rates and wear resistance) in materials is pin on disk testing. The success of the method can be ascribed to its ease of use and the wide variety of tribological contacts that can be accurately described by a simple pin-on-disk motion, from the dry contacts of bolt screws to the lubricated contacts of biological implants and train wheels. The test frequently examines a number of motion modes, such as unidirectional, fretting, and more recently, any other complicated motion patterns. The tests are typically carried out in accordance

with ASTM G99, G133, and F732 testing standards based on the requirements. The wear rate test was carried out at Hyderabad's GRIET COLLEGE.

Figure. 5. Pin On Disc Testing Machine

4. RESULTS AND DISCUSSION

5.1 IMPACT TEST RESULT

Our composite material underwent a pendulum type impact test (izod & charpy) to determine its impact resistance. The test results are displayed in the table column below.

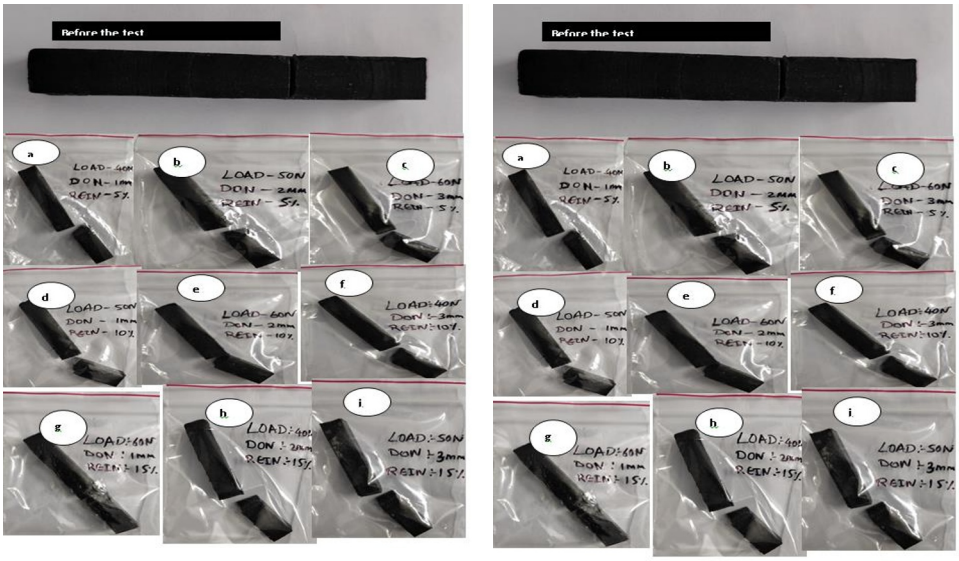

Figure. 6. Impact test samples before and after.

Table 2 : Izod Test Result

S.NO	PMMA (%)	GRAPHITE (%)	DEPTH OF NOTCH (MM)	LOAD (N)	INITIAL VALUE	FINAL VALUE	IMPACT STRENGTH (KJ/M^2)
1	95	5	1	40	168	166	2.66
2	95	5	2	50	168	166	2.66
3	95	5	3	60	168	166	2.66
4	90	10	1	50	168	167	1.33
5	90	10	2	60	168	165	4
6	90	10	3	40	168	165	4
7	85	15	1	60	168	164	5.33
8	85	15	2	40	168	164	5.33
9	85	15	3	50	168	164	5.33

5.1.1 CHARPY TEST RESULT

Table 3: Charpy Test Result

EXP.NO	PMMA (%)	GRAPHITE (%)	DEPTH OF NOTCH (MM)	LOAD (N)	INITIAL VALUE	FINAL VALUE	IMPACT STRENGTH (KJ/M^2)
1	95	5	1	40	300	298	3.63
2	95	5	2	50	300	298	3.63
3	95	5	3	60	300	297	5.45
4	90	10	1	50	300	296	7.27
5	90	10	2	60	300	296	7.27
6	90	10	3	40	300	296	3.63
7	85	15	1	60	300	298	3.63
8	85	15	2	40	300	298	3.63
9	85	15	3	50	300	297	5.45

5.2 HARDNESS TEST SAMPLES AND RESULT

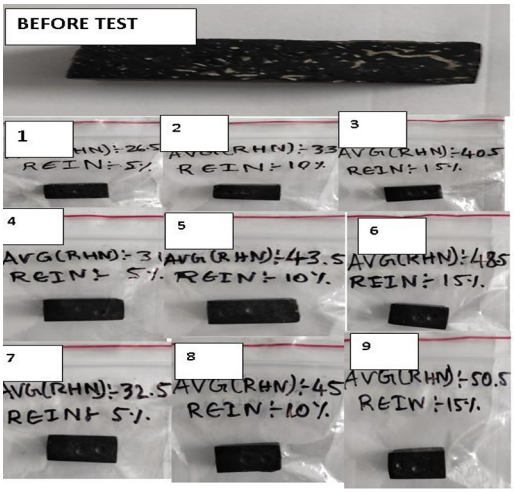

Figure. 7. Hardness test samples before and after

S.NO	PMMA (%)	GRAPHITE (%)	SAMPLE (RHN)	SAMPLE (RHN)	AVG (RHN)
1	95	5	26	27	26.5
2	90	10	32	34	33
3	85	15	40	41	40.5

4	95	5	30	32	31
5	90	10	42	45	43.5
6	85	15	48	49	48.5
7	95	5	32	33	32.5
8	90	10	44	46	45
9	85	15	50	51	50.5

Table 4 : Hardness Test Result

5.3 PIN ON DISC TEST RESULT

Using a pin-on-disk device, this test technique describes a lab procedure for evaluating material wear while sliding. Materials are examined in conditions that are abrasive. These equipment's primary experimental emphasis areas for measuring wear are outlined.The test were performed in the Gokaraju rangaraju college of engineering and technology R & D labaratory. The following are the results were obtained from the pin on disc machine.

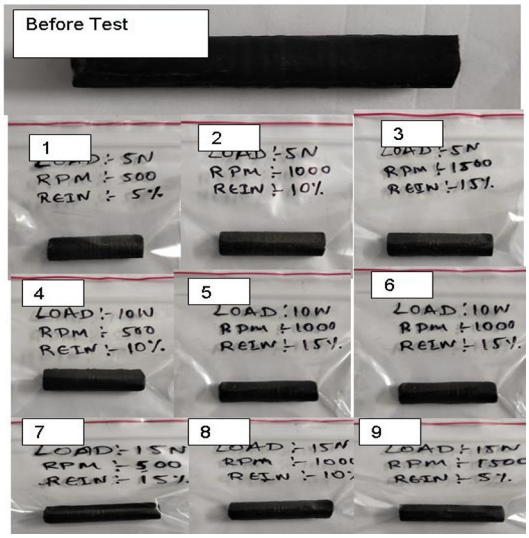

Figure. 8. Wear test samples before and after

Table 5. Pin On Disc Test Result

EXPERIMENT	LOAD (N)	RPM	REINFORCEMENT	SLIDING DISTANCE (MM/REV)
1	5	500	5	47.12
2	5	1000	10	94.24

3	5	1500	15	141.12
4	10	500	10	47.12
5	10	1000	15	94.24
6	10	1500	5	141.12
7	15	500	15	47.12
8	15	1000	10	94.24
9	15	1500	5	47.12

CONCLUSION

The experiments performed and the conclusions drawn from them are presented in this work,

1. Cylindrical and rectangular test samples of polymethyl methacrylate (PMMA) and its composites including graphite were successfully made by die casting method, employing fabricated aluminum split die, according to the experiments conducted and the results obtained in the current work.
2. Impact tests (izod & charpy tests) performed and explained with the proper images. Impact strength for the izod test was improved to 5.33 kj/m^2 (EXP. NOs: 7, 8, 9) at 85% PMMA and 15% graphite. Charpy test with 90% PMMA and 10% graphite produced better impact strength results: 7.27 kj/m^2 (EXP.NO 4,5).
3. The results of the hardness test have been explained with the proper images. Avg hardness number = 50.5 (EXP.NO: 9), a better hardness value was obtained with 85% PMMA and 15% graphite.
4. An improved outcome was attained at 90% PMMA, 10% graphite, load of 5N, and 1000 rpm (EXP 2).

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