Study of Wear Properties on Polyester and Natural Fibers (Jute and Hemp) Reinforced Polymer Matrix Composites

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Abstract— **This paper includes the wear study of polymer composites prepared for polyester as matrix and natural fibers (Jute long fiber, Jute mat fiber, Hemp long fiber and hemp mat fiber) as reinforced materials with different compositions of 10% and 20% reinforcement used for knee implant Material, over the past centuries there is lot research in the medical field ad materials science in development of biomaterials for knee implant application. so a lot of materials are used as implants for replacing of damaged parts. Over the years SS316L and UHMWPE has established as the best available knee implant materials. With the recent advances in the field of material science, metallurgy and designing, still there is scope for development for more advanced bio materials having better properties. It has been observed that the tribological properties like wear resistance play important properties governing the suitability of the knee material. In materials science wear is the erosion of material from a solid surface by the action of another surface. The wear specimens have been developed and tests were conducted using pin on disk apparatus to study wear properties. There are appreciable improvements in results have been observed.**

Keywords— PMC, Jute, Hemp, wear resistance

I. INTRODUCTION

Over the past centuries there is a considerable development in the medical field. There is a lot of development in surgery and prosthetic fields. For this purpose a lot of alternative materials are used for implants while replacing them in place of damaged parts. These materials are called bio materials.

All these years SS-316L has established itself as the best available bio implant material. With the research and development in the field of material science, metallurgy and design, Bio materials which have better properties than SS-316L are observed.

Definition: A Biomaterial is defined as any systemically, pharmacologically inert substance or combination of substances utilized for implantation within or incorporation with a living system to supplement or replace functions of living tissues or organs.

Requirements of biomaterials

Following are the requirements of Biomaterials:

1) It must be inert or specifically interactive.

2) It must be biocompatible: The most commonly used term to describe appropriate biological requirements of a biomaterial used in medical device is biocompatibility. A simple definition of biocompatibility is the ability of a material to perform with an appropriate host response in a specific application.

3) Mechanically and chemically stable.

4) Biodegradable: The biodegradation of biomaterials may occur through a wide variety of mechanisms,

5) Processable (for manufacturability).It must be machinable, moldable, and extrudable

6) Nonthrombogenic (if blood contracting)

7) Sterilizable: Not destroyed or severely altered by sterilizing techniques such as autoclaving, dry heat, radiation, ethylene oxide.

8) Non-carinogenic, non-pyrogenic, non-toxic, non-allergenic, blood compatible, non-inflammatory.

9) Physical Characteristics Requirements:

Strength, Toughness, Elasticity, Corrosion-resistance, Wear resistance & ,Long term stability

The strength characteristics of any continuous fiber reinforced composite can be simulated, as long as the fiber orientation in the composite can be identified. Prediction of the mechanical properties of fibrous composites.

Through the media and conferences it has been observed that there is wide scope of the bio-materials which encourages the researchers in medical field in invention of materials with appreciable mechanical properties.

In this paper the wear study of polymer composites prepared from polyester as matrix and natural fibers (Jute long fiber, Jute mat fiber, Hemp long fiber and hemp mat fiber) as reinforced materials with different compositions of 10% and 20% reinforcement used for knee implant Material, over the past centuries there is lot research in the medical field ad materials science in development of biomaterials for knee implant application.

II. SELECTION OF MATERIALS

A. The Raw materials used in this experimental work are:

Polymer:Polyester resin & Hardener
Natural fiber :Jute (long fiber) , Jute (mat), Hemp (long fiber) & Hemp (mat)

Fig 1: Polyester resin general purpose resin

Generally polyester resins can be made by a dibasic organic acid and a dihydric alcohol. They can be classified as saturated polyester, such as polyethylene terephthalate, and unsaturated polyester. To form the network of the composite matrix, the unsaturated group or double bond needs to exist in a portion of 8 the dibasic acid. By varying the acid and alcohol, a range of polyester resins can be made. Orthophthalic polyesters are made by phthalic anhydride with either maleic anhydride or fumaric acid. Isophthalic polyesters, however, are made from isophthalic acid or terephthalic acid. The polyester resin is usually dissolved in monomer (styrene is the most widely used), which will copolymerize with it and contribute to the final properties of the cured resin. The addition of catalyst will cause the resin to cure. The most frequently used catalyst is methyl ethyl ketone peroxide (MEKP) or benzoyl peroxide (BPO) and the amount varies from 1-2%. The catalyst will decompose in the presence of the polyester resin to form free radicals, which will attack the unsaturated groups (like C=C) to initiate the polymerization. The processing temperature and the amount of the catalyst can control the rate of polymerization, the higher temperature or the more the catalyst, the faster the reaction. After the resin turned from liquid to brittle solid, post cure at higher temperature may need to be done. The purpose of the post cure is to increase Tg of the resin by complete cross-linking. The properties of the polyester resin areaffected by the type and amount of reactant, catalyst and monomers as well as the curing temperature. The higher the molecular weight of polyester and the more points of unsaturation in molecules, the higher is the strength of the cured resins. Orthophthalic polyesters are environmentally sensitive and have limited mechanical properties. They have been replaced in some applications by isophthalic polyesters due to the excellent environment resistance and improved mechanical properties of the latter. The properties of polyester are shown in table 1 and polyester gel sample taken along with hardener is shown in fig.1.

TABLE I. PROPERTIES OF POLYESTER

Property	Density (g/cc)	Elastic Modulus (Gpa)	Tensile Strength (Mpa)	Compressive Strength (Mpa)	Elongation (%)
Polyester	1.2- 1.5	2 - 4.5	40 - 90	90 – 250	2

B. Hardener

In the present work HY 951(araldite) Hardener is used. This has a viscosity of 10-20 poise at 250oC.

C. Natural Fiber

Fig 2: Jute long fiber & mat fiber

Fig 3: Hemp long fiber & mat fiber

Jute, shown in fig 2. is a long, soft, shiny plant fiber that can be spun into coarse, strong threads. It is produced from plants in the genus Corchorus. Jute is one of the cheapest natural fibers, and is second only to cotton in amount produced and variety of uses. Jute fibers are composed primarily of the plant materials cellulose and lignin. Jute is a rainy season crop, growing best in warm, humid climates.

Hemp, shown in fig 3, is the name of the soft, durable fiber that is cultivated from plants of cannabis genus for industrial and commercial use. The common application of the hemp fiber is to be blend with polypropylene in a nonwoven mat which through compression molding technique turns to a three dimensional part. The properties of natural fibres are shown in table 2

TABLE II. PROPERTIES OF JUTE FIBER & HEMP FIBER

Property	Density (g/cc)	Elastic Modulus (Mpa)	Tensile strength (Mpa)	Stiffness KN/mm^3	Elongation (%)
Jute	1.46	20-50	400-800	10-30	1.5-1.8
Hemp	1.48	30-60	550-900	70	1.6

III. WEAR TEST

In a material science, wear is the erosion of material from a solid surface by the action of another surface. It is related to surface interactions and more specially the removal of material from a surface as a result of mechanical action. The need for mechanical action, in the form of contact use to relative motion, is an important distinction between mechanical The definition of wear does not include loss of dimension from a plastic deformation, all though wear as occurred despite no material removal. This definition also fails to include impact wear, where there is a no sliding motion, cavitations', where the counter body is a fluid and corrosion, where the damage is due to chemical ether than mechanical action. wear another process with similar outcomes. The diameter of the specimen used is 10mm, According to ASTM standard are shown in fig. 5.

a.

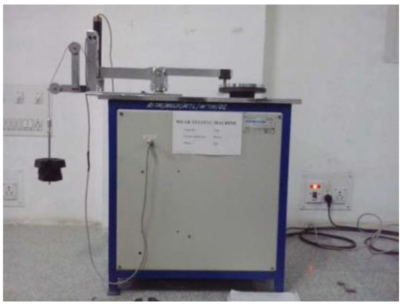

Fig 4: Wear testing machine

Wear testing machine specification:
Capacity: 5kg
Track radius max: 80mm
Motor: 2hp

Fig 5: Wear Test Specimens of different compositions

IV. EXPERIMENTAL VALUES OF WEAR TEST CARRIED OUT IN WEAR TESTING MACHINE

Specimen: 90% Polyester+10%Jute (Long Fiber) For Different Loading Conditions, the results of variation of wear rate and coefficient of friction are shown in fig 4 & fig 5.

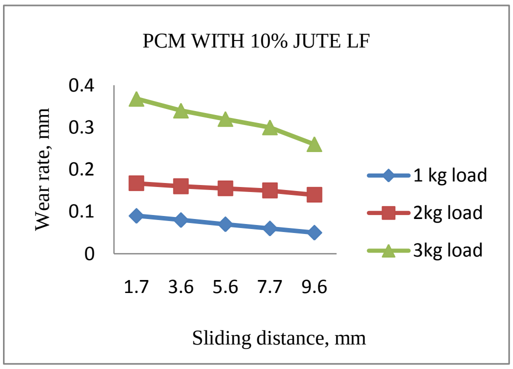

Fig. 4

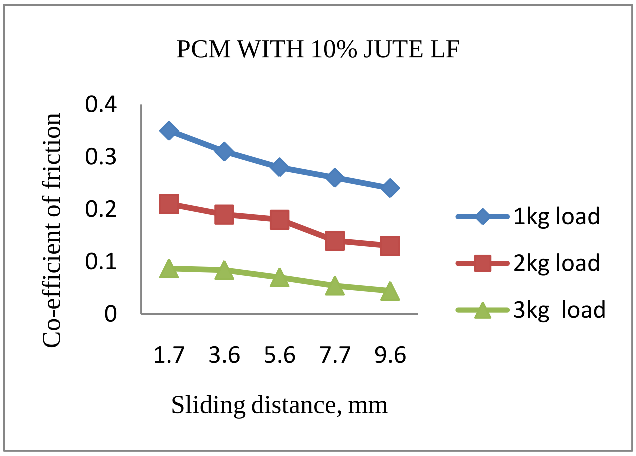

Fig. 5

Specimen: 80% Polyester+20%Jute (Long Fiber) For Different Loading Conditions, the results of variation of wear rate and coefficient of friction are shown in fig 6 & fig 7.

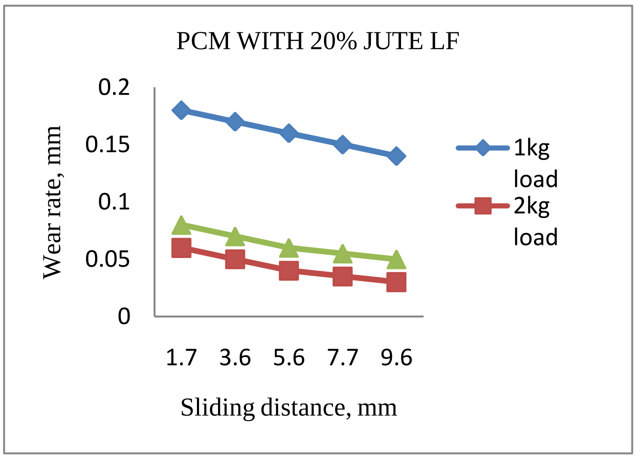

Fig. 6

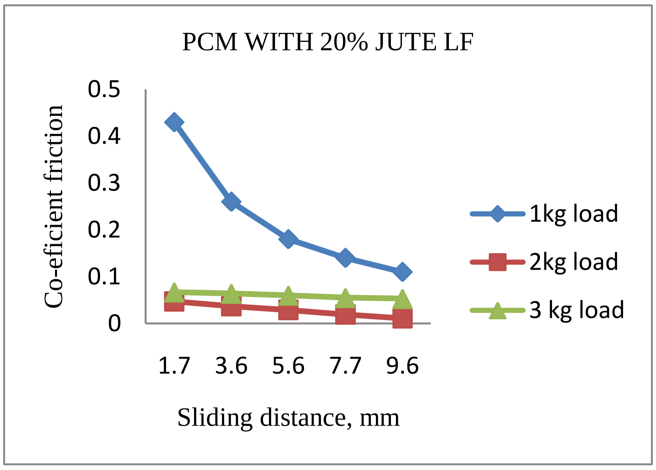

Fig. 7

Specimen: 90% Polyester+10%Jute (Mat) For Different Loading Conditions, the results of variation of wear rate and coefficient of friction are shown in fig 8 & fig 9.

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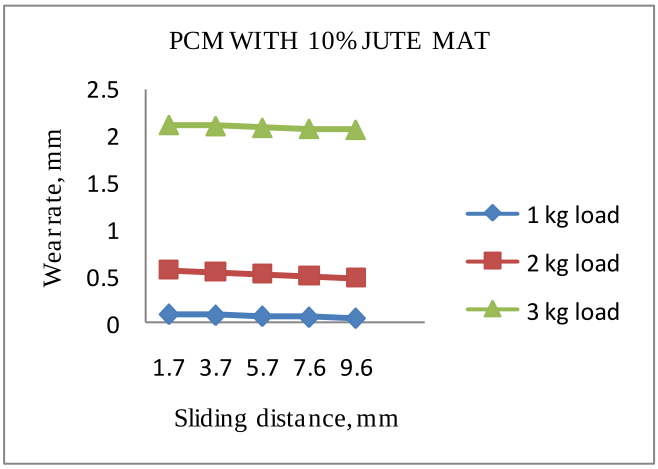

Fig. 8

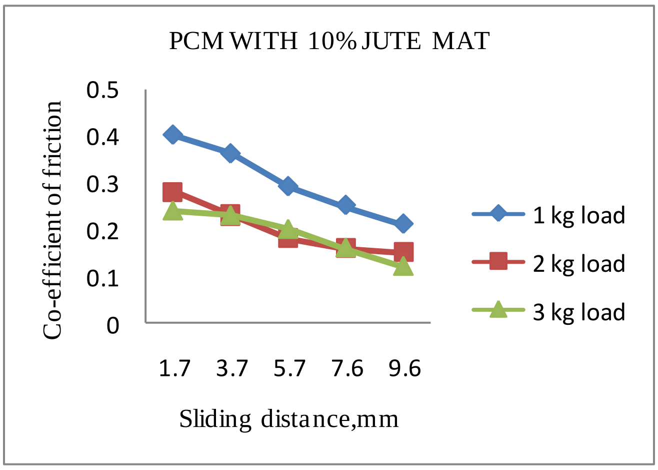

Fig. 9

Specimen: 80% Polyester+20%Jute (Mat) For Different Loading Conditions, the results of variation of wear rate and coefficient of friction are shown in fig 10 & fig 11.

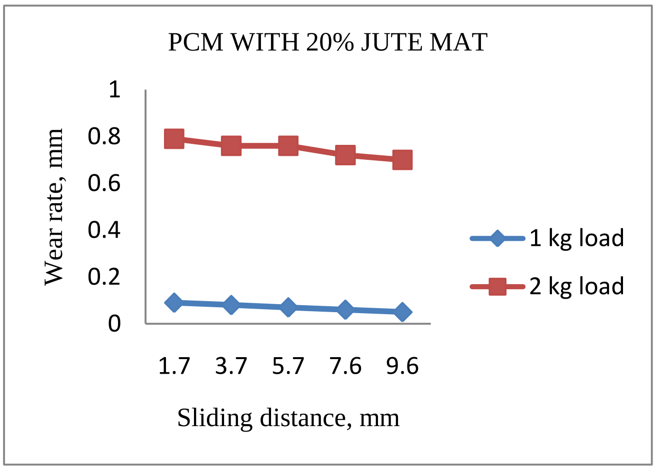

Fig. 10

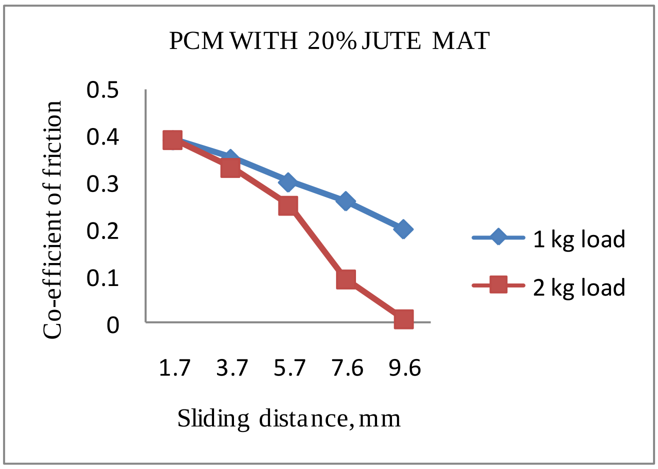

Fig. 11

Specimen: 90% polyester+10% hemp (long fiber) for Different loading conditions, the results of variation of wear rate and coefficient of friction are shown in fig 12 & fig 13.

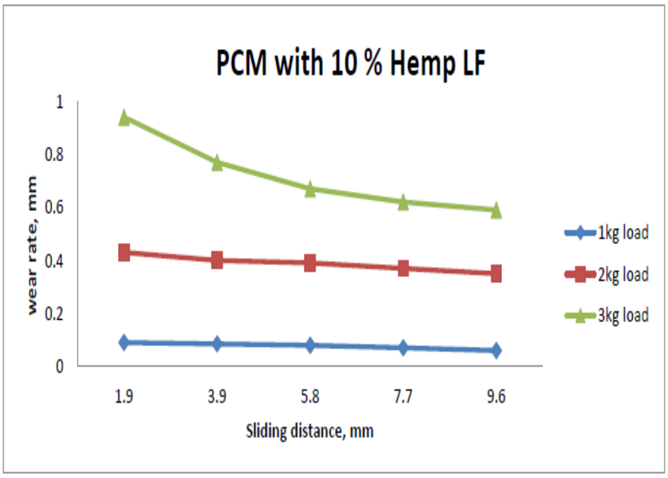

Fig.12

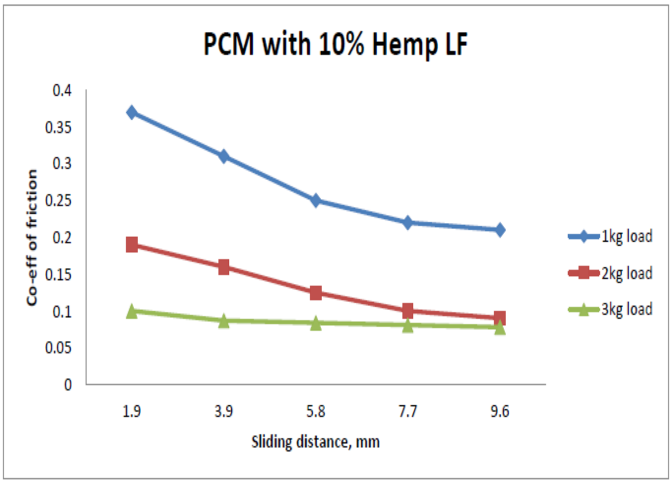

Fig. 13

Specimen: 80% polyester+20% hemp (long fiber) for Different loading conditions, the results of variation of wear rate and coefficient of friction are shown in fig 14 & fig 15.

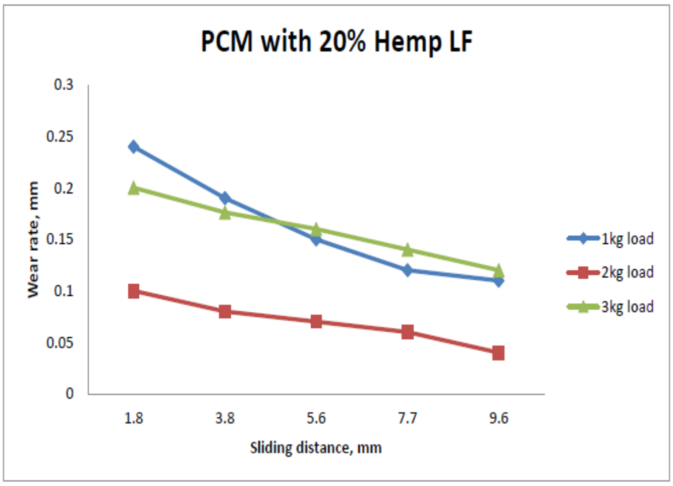

Fig.14

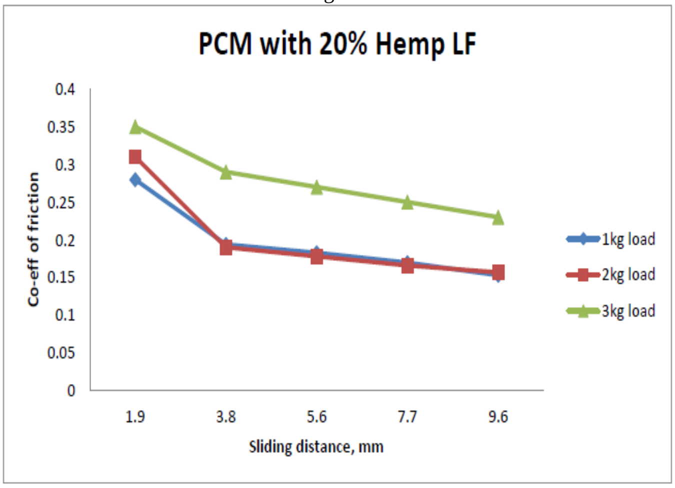

Fig.15

Specimen: 90% polyester+10% hemp (mat) for Different loading conditions, the results of variation of wear rate and coefficient of friction are shown in fig 16& fig 17.

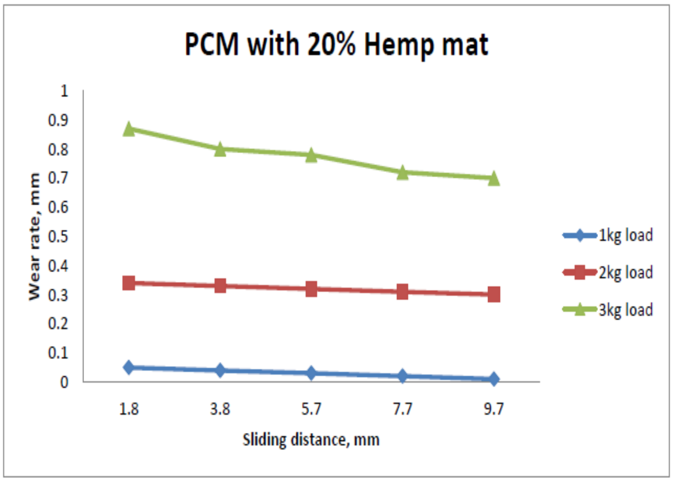

Fig.16

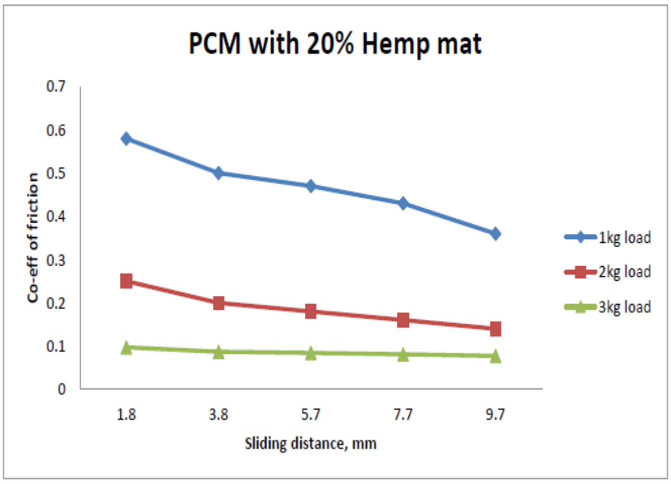

FIG.17

V. CONCLUSION

The conclusions of the above work can be drawn as follows:

- The density of polymer composite materials is approximately 1.37x10-3g/mm3 and it is similar to the density of bone (1to2g/cc).
- As the sliding distance increases, both wear rate and co-efficient of friction decrease.
- With the above observations it can be can conclude that the polymer composite material with long fiber may be used as alternative material for the replacement of implant material in human body.

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