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Erosion Wear Behaviour of Coir Dust Reinforced Polymer Composites

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Abstract. Erosion wear behavior of bio-waste reinforced polymer composite is undertaken to study the erosion rate for with different reinforcements. The composites are fabricated using Epoxy and Polyester resin as matrix material and coir dust as reinforcement. Composites without reinforcement and composites with 20% weight fraction of reinforcements were made. They were then experimented in the erosion testing machine. The angle of impact was varied keeping other variables constant. Graphs were drawn showing the variation with the mass loss and the erosion rate. The addition of these reinforcements caused a decrease in the density which increases the strength to weight ratio. The erosion test results showed that the mass loss and erosion rate increases with increasing the impact angle. It is found that, the erosion rate and mass loss also increased with time. Polyester matrix composites showed lesser erosion rate than epoxy matrix composites. Scanning electron microscopy analysis showed high degree of cavitations and formation of cracks in the composite at high angle of impact.

Keywords: Epoxy, Polyester, Coir dust,

1. Introduction

Now a day, polymer composite materials are in massive demand for applications in the field of aerospace vehicles, automobile parts, satellites, sports goods, robots, and thermal insulation structures viz. cryostats for low temperature technology, hydrogen technology tanks, in superconductivity and also in biomedicine for body compatible implants. These materials exhibit exceptionally good characteristics viz. low density, high specific strength, good anticorrosion properties, fatigue resistance and low manufacturing costs. Bio-composites are emerging as a viable alternative to glass-fiber reinforced composites especially in automotive and building product applications. Using bio fibers with polymers based on renewable resources will allow many environmental issues to be solved.

Coir dust is the spongy, peat like residue from the processing of coconut husks (mesocarp) for coir fiber also known as coco peat, it consists of short fibers (<2cm) around 2% - 13% of the total and cork like particles ranging in size from granules to fine dust. Coir dust strongly absorbs liquids and gases. This property is due in part to the honeycomb like structure of the mesocarp tissue which gives it a high surface area per unit volume. Coir dust is also hydrophilic (attracts water) which means that moisture spreads readily over these surfaces.

Erosion is an abrasive wear process in which the repeated impact of small particles entrained in a moving fluid against a surface results in the removal of material from the surface. Solid particle erosion is a serious problem in gas turbines, rocket nozzles, cyclone separators, valves, pumps and boiler tubes. Polymer composite materials are finding increased application under conditions in which they may be subjected to solid particle erosion.

The present investigation is undertaken which explores the possible utilization of coir dust reinforced polymer composites. The objective is to study the effect of coir dust reinforcement on the erosive wear behavior of epoxy and polyester under multiple impact conditions. An attempt is made to find the process parameters for minimum erosion.

2. Composite fabrication.

Epoxy resins and polyester resins are used as matrix in different type of composites. High resistance to chemicals and outstanding adhesion, durability, and toughness has made them valuable as coatings. Because of their high electrical resistance, durability at high and low temperatures, and the ease with which they can be poured or cast without forming bubbles, epoxy resin plastics are especially useful for encapsulating electrical and electronic components.

The coir dusts collected from coconut husks are dried. The coir dust particles obtained were used to prepare composites. To prepare the composite slabs, these particles in pre-determined weight proportion (20%) are reinforced with random orientation into the epoxy resin and polyester resin. A block of size (300mm X 150mm X 6 mm) is thus cast. The casting is put under load for about 24 hours for proper curing at room temperature. Specimens of suitable dimension are cut using a diamond cutter for physical characterization.

The composites thus fabricated are designated as follows:

Epoxy:	100% Epoxy
Polyester:	100% Polyester
Epoxy + Coir Dust:	Epoxy + 20% Coir Dust
Polyester + Coir Dust:	Polyester + 20% Coir Dust

Parameters used for Erosion Test

Erodent	Silica Sand
Erodent Size	200 micron
Erodent Shape	Irregular, slightly rounded
Impact Angles	30°, 45°, 60°, 75°, 90°.
Stand off distance(cms)	12
Pressure(bar)	5-6
Test Temperature	Room Temperature

The surfaces of the composite specimens are examined directly by scanning electron microscope JEOL JSM-6480LV after they are eroded to view the fractured and eroded surface. The eroded area is cleaned thoroughly, air-dried and is coated with 100 Å thick platinum in JEOL sputter ion coater and observed SEM at 20 kV. Similarly the composite samples are mounted on stubs with silver paste. To enhance the conductivity of the samples, a thin film of platinum is vacuum-evaporated onto them before the photomicrographs are taken.

3. Results and Discussions

Wear Studies:

The erosion wear of coir dust reinforced in epoxy and polyester matrixes are carried out with different sand size by varying speed and distance. It is found that the erosion rate of different composites varies as a function of impingement angle (α).

Figure 1 : Cumulative mass loss for Epoxy composites at different angles

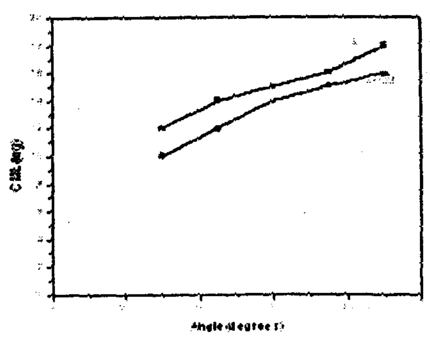

Figure 1 illustrates the characteristic curve of Cumulative Mass Loss (CML) with respect to Impact angle for Epoxy composites. It is observed that erosion rate increases with increase in impact angle. Maximum mass loss (Max.value-18 mg) is observed in Epoxy at all impact angies. With addition of Coir Dust as reinforcement, the mass loss decreases. Mass loss is least for Coir dust reinforced Epoxy composite (Max.value-14 mg).

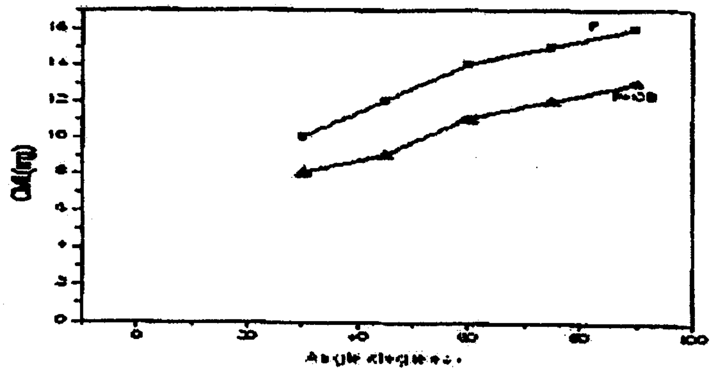

Figure 2 : Cumulative mass loss for Polyester composites at different angles

Figure 2 illustrates the characteristic curve of Cumulative Mass Loss (CML) with respect to Impact angle for Polyester composites. It is observed that erosion rate increases with increase in impact angle. Maximum mass loss (Max.value-16 mg) is observed in Polyester at all impact angles. With addition of Coir Dust as reinforcement, the mass loss decreases.

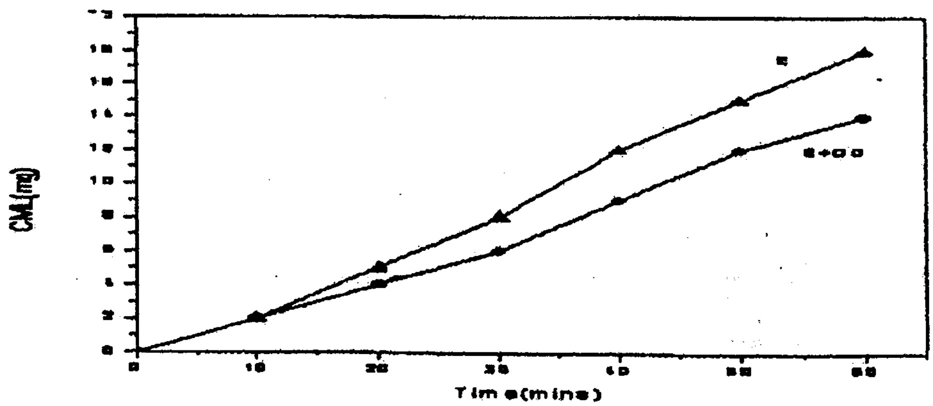

Figure 3 Cumulative mass loss for Epoxy composites with time (at 30°)

Figure 3 illustrates the characteristic curve of Cumulative Mass Loss (CML) with respect to Time for Epoxy composites at an impact angle of 30°.

Increase in erosion rate is more or less uniform with increasing time. Maximum mass loss (Max. value-14 mg) is observed in Epoxy at all time intervals. With addition of Coir Dust as reinforcement, the mass loss decreases. There is a trend of decreasing mass loss at higher time values observed in case of reinforced composite.

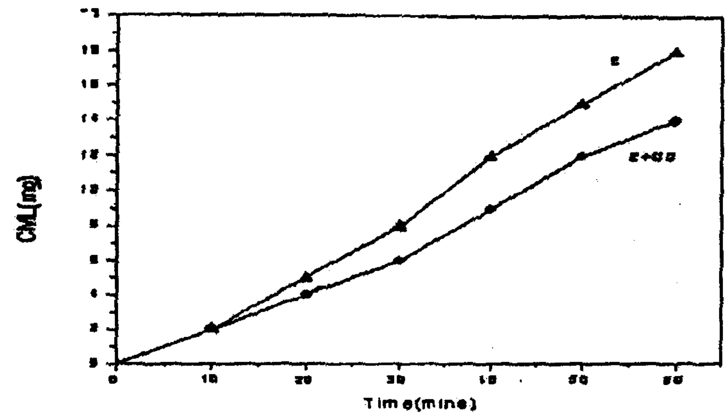

Figure 4 : Cumulative mass loss for Polyester composites with time (at 30°)

Fig 4 illustrates the characteristic curve of Cumulative Mass Loss (CML) with respect to Time for Polyester composites at an impact angle of 30°. Increase in erosion rate is more or less uniform with increasing time at higher time intervals. Maximum mass loss (Max. value-12 mg) is observed in Polyester at all time intervals. With addition of Coir Dust as reinforcement, the mass loss decreases. There is a trend of decreasing mass loss at higher time values observed in case of reinforced composites.

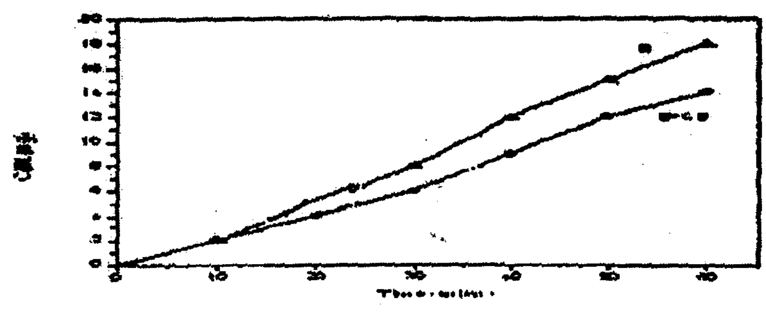

Figure 5 : Cumulative mass loss for Epoxy composites with time (at 90°)

Figure 5 illustrates the characteristic curve of Cumulative Mass Loss (CML) with respect to Time for Epoxy composites at an impact angle of 90°. Increase in erosion rate is more or less uniform with increasing time. Maximum mass loss

(Max. value-18 mg) is observed in Epoxy at all time intervals. With addition of Coir Dust as reinforcement, the mass loss decreases. Mass loss is least for Coir dust reinforced Epoxy composite (Max.value-13 mg).

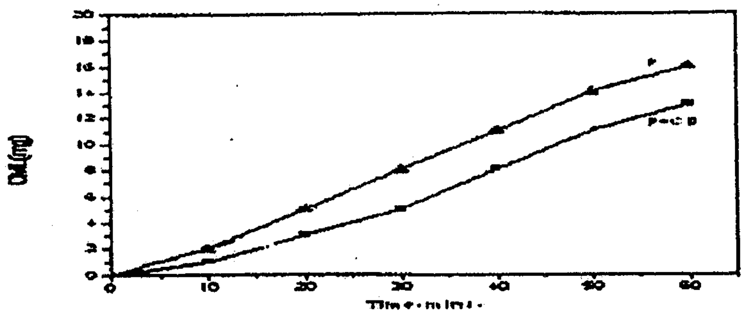

Figure 6 : Cumulative mass loss for Polyester composites with time (at 90°)

Figure 6 illustrates the characteristic curve of Cumulative Mass Loss (CML) with respect to Time for Polyester composites at an impact angle of 90°. Increase in erosion rate is more or less uniform with increasing time. Maximum mass loss (Max. value-12 mg) is observed in Polyester at all time intervals. With addition of Coir Dust as reinforcement, the mass loss decreases. Mass loss is least for Coir dust reinforced Epoxy composite (Max.value-7 mg).

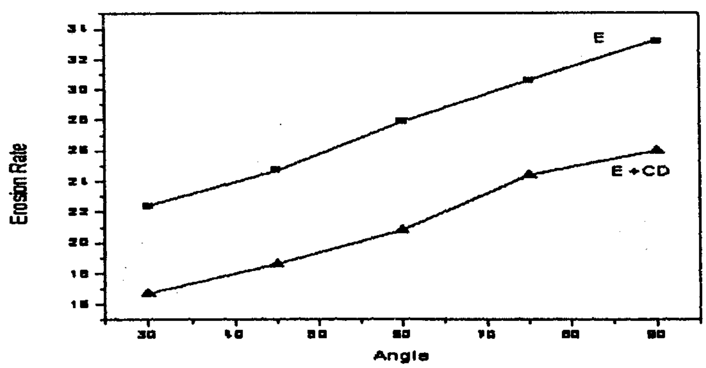

Figure 7 : Erosion rates for Epoxy composites at different angles

Figure 7 illustrates the characteristic curve of Erosion rate with respect to Impact angle for Epoxy composites. Increase in erosion rate is more or less uniform with increase in impact angle. Maximum erosion rate (Max.value-33 g/g) is observed in Epoxy at all impact angles. With addition of Coir Dust as reinforcement, the erosion rate decreases.

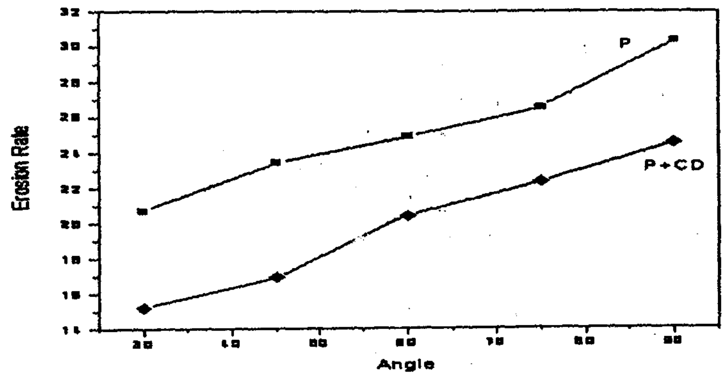

Figure 8 : Erosion rates for Polyester composites at different angles

Figure 8 illustrates the characteristic curve of Erosion rate with respect to Impact angle for Polyester composites. Increase in erosion rate is more or less uniform with increase in impact angle. Maximum erosion rate (Max. value-30 g/g) is observed in Polyester at all impact angles. With addition of Coir Dust as reinforcement, the erosion rate decreases. Erosion rate is least for Coir dust reinforced Polyester composite (Max.value-24 g/g). There is a trend of decreasing erosion rate at higher angles observed in case of reinforced composites.

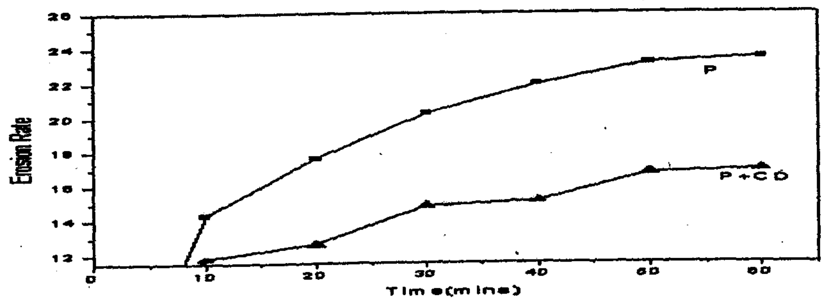

Figure 9 : Erosion rates for Polyester composites at different time (at 30°)

Figure 9 illustrates the characteristic curve of Erosion rate with respect to Time for Polyester composites at impact angle of 30°. Increase in erosion rate is more or less uniform with increase in time. Maximum erosion rate (Max.value-24 g/g) is observed in Polyester at all time intervals. With addition of Coir Dust as reinforcement, the erosion rate decreases. Erosion rate is least for Coir dust reinforced Polyester composite (Max.value-17 g/g).

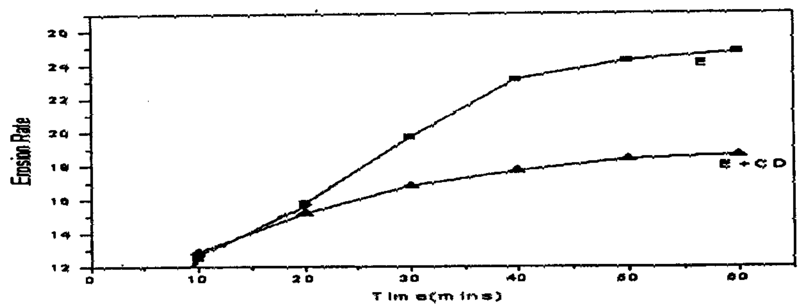

Figure 10 : Erosion rates for epoxy composites at different time (at 30°)

Figure 10 illustrates the characteristic curve of Erosion rate with respect to Time for Epoxy composites at impact angle of 30°. Increase in erosion rate is more or less uniform with increase in time. Maximum erosion rate (Max.value-25 g/g) is observed in Epoxy at all time intervals. With addition of Coir Dust as reinforcement, the erosion rate decreases. Erosion rate is less for Coir dust reinforced Epoxy composite (Max.value-18 g/g).

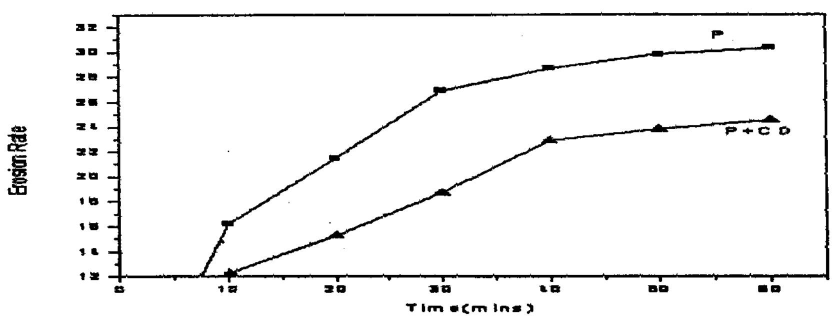

Figure 11 : Erosion rates for Polyester composites at different time (90°)

Figure 11 illustrates the characteristic curve of Erosion rate with respect to Time for Polyester composites at impact angle of 90°. Increase in erosion rate is more or less uniform with increase in time. Maximum erosion rate (Max.value-30 g/g) is observed in Polyester at all time intervals. With addition of Coir Dust as reinforcement, the erosion rate decreases. Erosion rate is less for Coir dust reinforced Polyester composite (Max.value-24 g/g).

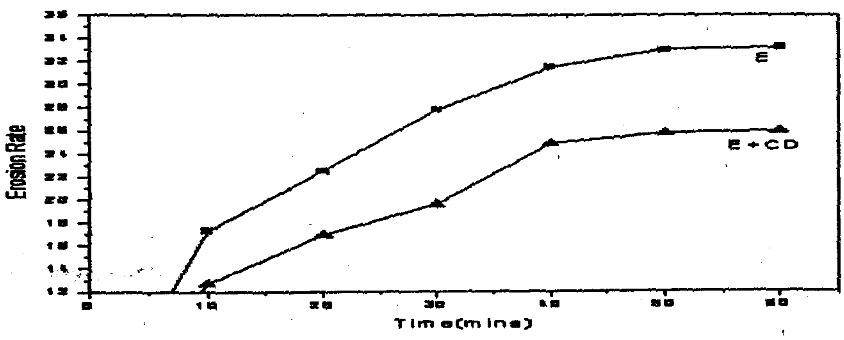

Figure 12: Erosion rates for epoxy composites at different time (90°)

Figure 12 illustrates the characteristic curve of Erosion rate with respect to Time for Epoxy composites at impact angle of 90°. Increase in erosion rate is more or less uniform with increase in time. Maximum erosion rate (Max. value-33 g/g) is observed in Epoxy at all time intervals. With addition of Coir Dust as reinforcement, the erosion rate decreases. Erosion rate is less for Coir dust reinforced Epoxy composite (Max.value-25 g/g).

SEM Analysis

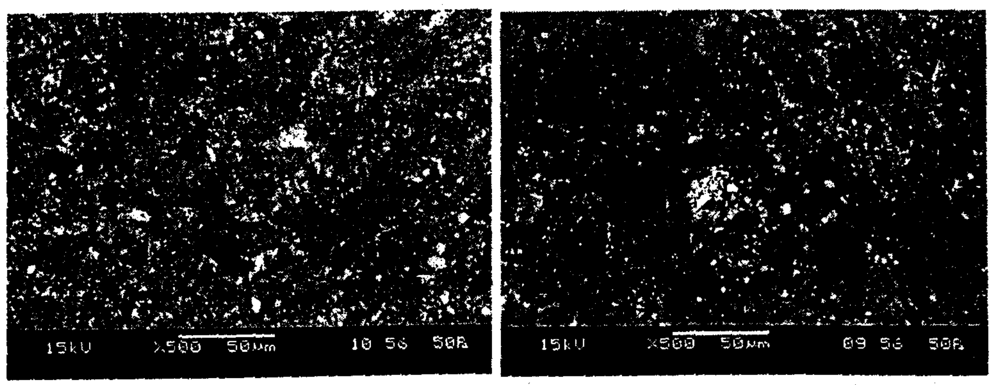

Figure 13 : SEM of pure Epoxy at impact angle (i) 30^0 (ii) 90^0

Figure 13 shows the eroded surface of epoxy when impacted at 30^0 and 90^0. For 30^0 impacts, the figure shows a number of pits whereas when impacted at 90^0, less number of pits is observed.

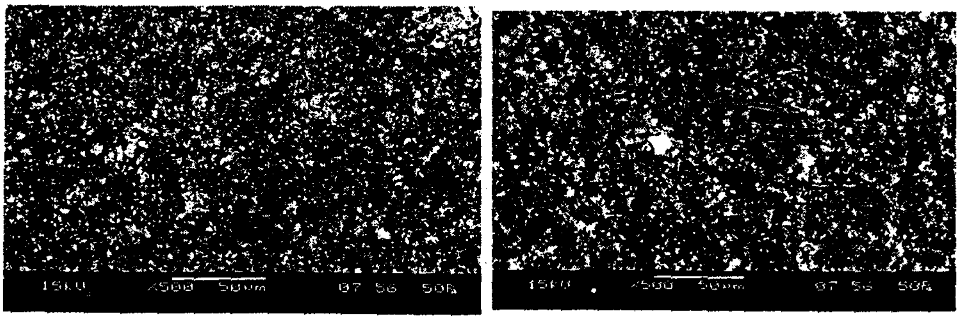

Figure 14 : SEM of Epoxy + 20 wt% Coir dust at impact angle (i) 30^0 (ii) 90^0

Figure 14 shows eroded surfaces of epoxy with coir dust as reinforcement. At 30°, there is layer removal and fragmented things are found whereas at 90°, pore structure is observed.

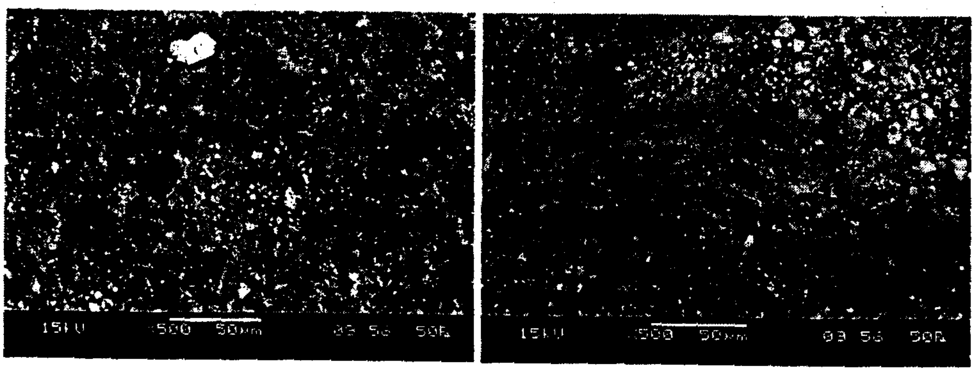

Figure 15 : SEM of pure Polyester at impact angle (i) 30^0 (ii) 90^0

Figure 15 shows the eroded surface of polyester. At 30°, the surface is flat and no cracks are observed. Small pits are observed with less material removal. At 90°, more amount of material is removed. Fragmented things are found.

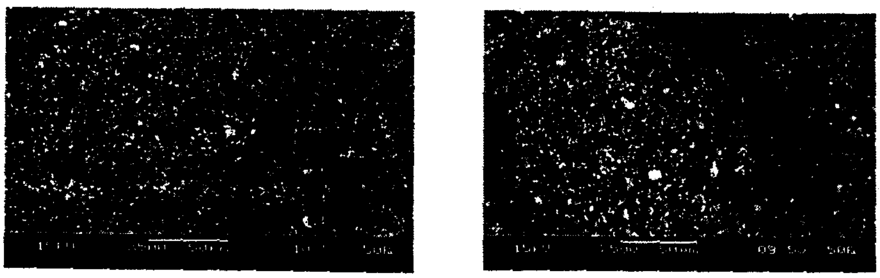

Figure 16 : SEM of Polyester + 20 wt% Coir dust at impact angle (i) 30^0 (ii) 90^0

Figure 16 shows the SEM of Polyester + 20 wt % Coir Dust composite after erosion testing of impact angle 30° & 90° respectively. In Figure 16 (i), the matrix surface is observed to be almost flat which signifies that the erosion of the matrix surface has been more or less uniform. Some cavitations are also observed along with removal of some amount of reinforcement (coir dust). In Figure 16(ii) we see that the cavitations is more and also deeper pits are formed in comparison to the surface of the specimen subjected to erosion at an impact angle of 30°. Multi-directional cracks are seen on the edges of the pit due to higher magnitude of the normal component of the impact velocity, which is not seen in the case specimen subjected to erosion at an impact angle of 30°.

4. Conclusions

[1] Coir dust reinforced PMC could be successfully fabricated.

[2] The results indicate that angle of impact is the most important parameter during erosion. The angle of impact greatly affects the erosion wear behavior of coir dust reinforced epoxy and polyester matrix composites. Maximum erosion rate is observed at 90° impact angle.

[3] Polyester composites showed better resistance to erosion than epoxy composites.

[4] At higher impact angles, high degree of cavitation along with formation of cracks is observed in case of all the PMCs.

[5] Steady state erosion rate is observed in case of reinforced PMCs at higher time length.

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