Wear testing of polypropylene termina chebula fibres

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Abstract. In this polypropylene termina chebula composites were developed and studied for wear behaviour at two different applied loads and termina chebula concentrations. Wear tests were conducted using taber abraser or taber abrader apparatus. The composite discs were tested against E100-125 steel disc. The wear test is experimentally investigated for speeds of 500 and 1000 rpm. The specific wear rate of polypropylene reduced on addition of termina chebula powder.

1. Introduction
In manufacturing industries the use of composites and fiber reinforced polymers are growing continuously because of their good amalgamation of properties, fiber-reinforced-polymer, composites are used in manufacturing of automobiles, aircraft components like floor beams, wing, rudder, landing gear door and ships [1–3]. The industries opt for FRP rather than their metallic counterparts due to the relatively low density and high strength and stiffness in the direction of high loading when stacked in sequence [4]. Natural-fiber reinforced polymer composites posses properties such as bio-degradability, low density, a range of mechanical properties, less abrasiveness, etc. [5–12]. Which makes it as an environmental friendly polymer and thus are highly preferred over synthetic fiber reinforced polymers. The physical properties of plastics are enhanced by integrating nano particles with polymers [12].

Termina chebula is one of the most prominent fibers used in several applications, ranging from fabrics to composites, among natural fibers. Thermoplastic polypropylene is used in this testing is having wide range of applications in manufacturing industries, and it is a semi-crystalline polymer with large number of industrial applications [13], since it is economical by costing and having low level of mechanical resistance and high processing facility [14]. This polymer is chemically stable with these chemical substances such as material which is alkaline by nature, having acidic properties, agents which de-greases, etc. On the other hand its resistance towards aromatic or aliphatic hydrocarbons, chemical compounds that contain chlorine (chlorinated solvents) is low and ability to withstand ultraviolet radiation is also less. It has high tensile strength. It exhibits strong resistance towards stress and cracking. Regular geometrical appearance is possessed by polypropylene and which is crystalline by nature. Polypropylene does not get affected by exposing it to water because its ability to absorb moisture is very low.

There have been numerous studies of the wear mechanism of termina chebula-polypropylene composites [15–19]. In earlier days only statically loaded parts are manufactured by this material but in recent trends, by making improvement material suitable for the manufacturing of dynamic components [20]. The wear resistance of this material must be known before using it for production [15]. In industry, particularly materials working in places under wear effects are desired to resist wear. The materials wear resistance was determined through laboratory experiments. In this study, under
various loads and speeds the wear behaviours of a termina chebula polypropylene composite and plain polypropylene were investigated experimentally.

2. Experimental

2.1. Materials and specimen
Test materials antermina chebula powder and polypropylene (110 MA PP) were chosen for this study. The specimens having size of 100mm diameter, 3mm thickness and 6.5mm hole on center of the plate which is going to process for the wear tests.

2.2. Powder treatment
The moisture content present in the termina chebula powder will affect the strength of the final composite material. So that the powder was placed inside the oven for more than 4 hours at 80°C to remove the moisture content present in it.

2.3. Preparation of composites

2.3.1. Twin screw extruder. The figure 2 picturizes twin screw extruder which consists of hopper, screw conveyor, and die set for extrusion. Initially the machine has to run nearly 4 hr without any load in it, to warm-up the machine. Once the machine is ready, a predefined mixture of 3% termina chebula powder, 97% of polypropylene, and 10ml of silicon oil is well mixed and filled in the hopper. The screw conveyor pushes the mixture from the hopper into 9 heating zones, which is placed along the length of the screw.

The temperature at zone 1 is 90°C and finally the temperature rises to 190°C. That heated material is then passed through a tube and the tube passes through a coolant where the heated material gets...
cooled. Then the tube is connected to palletizers where the cooled material passed through the tube is then cut into a small round piece.

2.3.2. Injection moulding. In this stage the cooled material is placed in an oven where the moisture in the material gets sovereign from pores. Since the material passed through the water gets moisture which can create pores in the material. To eradicate this cooled material must be placed in an oven and the oven must be in 80°C for one day. After this process, turn on the injection moulding machine till the temperature reaches to 190°C.

![Injection moulding](image)

Figure 3. Injection moulding.

Then the material in the oven is then take out and then placed in Hopper. The material gets melted and this heated material is then injected into a Die to shape the material. After five seconds the die is automatically opens and then places the material for five seconds in room temperature where the material gets cooled. Finally the random sample gets completed.

2.4. Wear test details

Taber abrader test method was used to perform wear test, which is picturized in figure 4. Wear tests were carried out in a Taber 503 Abraser (figure 4) fitted with abrasive wheels (CS-10) and a load of 0.25 kilogram is added to it, by following ASTM D4060 (2007) standards determination of specific wear rates of neat PP, and termina chebula powder composites is performed. 100 x 3 mm is the dimension of the specimen in which test was performed. The weight loss of the test specimen was used to find the specific wear rate.

The instrument platform, driven by motor driven at a constant speed to which the test piece is placed. Two abrasive wheels are placed in a position that it just contacts the specimen surface, and as the platform rotates, two wheels turns while the platform is rotated. Debris are removed during testing by a vacuum system.

The standard CS-10 Calibrase® or H-18 Calibre® wheels are utilised in many wear test procedure, but there are other wheels that can provide more or less abrasive action. For typical applications special type of wheels are available. The load applied during testing can be varied. Generally the loads applied are 0.5 kilogram and 1 kilogram, by adding additional counter weight it can also be varied. After marking the center in that test specimen a hole can be made by drilling process by placing it in a table of 6.35mm dimensions. The table used in abraser is made from the material (EN32 Hardened steel) which is rigid and flexible materials. The test specimen is held firmly in the testing apparatus whereas it can fit with either the clamp plate or clamp ring for additional support. There are some other tables to conduct wear test which do not have center hole instead test specimen is secured by stretching it or by testing in a wet condition.

Testing was carried out in room temperature and they are tried to be kept at same conditions from the temperature point. The testing of termina chebula composites and the polypropylene specimens were conducted at the different experimental conditions such as speeds of 500 and 1000 rpm and at two different loads of 0.5 kilogram and 1 kilogram. After rotation weight loss were measured. Wear was as weight loss calculated in the experiments. The wear rate was assessed by using a balance scale (10³).
3. Experiment results
Thus from the experiments we found out the following results

| Percentage of materials     | Before wear test(g) | After wear test(g) | Loss of weight(g) |
|-----------------------------|---------------------|--------------------|-------------------|
| VIRGIN                      | 25.5865             | 25.4632            | 0.0633            |
| POLYPROPYLENE(PP)           |                     |                    |                   |
| PP+ 2% TERMINA CHEBULA      | 26.1952             | 26.1874            | 0.0078            |
| PP+ 4% TERMINA CHEBULA      | 26.4838             | 26.4592            | 0.0046            |
| PP+ 6% TERMINA CHEBULA      | 26.5856             | 26.5789            | 0.0067            |

Figure 4. Taber abrader machine.  
Figure 5. Taber abrader wheel rotations.

Figure 6. Sample before Wear Test.  
Figure 7. Sample after Wear Test.
Figure 8. Loss of wear test for 500 gms per 500 cycles.

Table 2. Results of 500 gms/1000 cycles.

| Percentage of materials | Before wear test (g) | After wear test (g) | Loss of weight (g) |
|-------------------------|----------------------|---------------------|--------------------|
| VIRGIN POLYPROPYLENE(PP) | 25.5665              | 25.439              | 0.1266             |
| PP+ 2% TERMINA CHEBULA   | 26.2758              | 26.2602             | 0.0156             |
| PP+ 4% TERMINA CHEBULA   | 25.3996              | 25.3899             | 0.0097             |
| PP+ 6% TERMINA CHEBULA   | 26.2167              | 26.2027             | 0.0140             |

Figure 9. Loss of wear test for 500 gms per 1000 cycles.
Table 3. Result of 1000 gms/500 cycles.

| Percentage of materials | Before wear test (g) | After wear test (g) | Loss of weight (g) |
|-------------------------|----------------------|---------------------|--------------------|
| VIRGIN POLYPROPYLENE(PP) | 26.8590              | 26.6446             | 0.2144             |
| PP+ 2% TERMINA CHEBULA  | 26.7313              | 26.6587             | 0.0726             |
| PP+ 4% TERMINA CHEBULA  | 26.5198              | 26.4887             | 0.0311             |
| PP+ 6% TERMINA CHEBULA  | 26.5559              | 26.5322             | 0.0237             |

Figure 10. Loss of wear test for 1000 gms per 500 cycles.

Table 4. Result of 1000 gms/1000 cycles.

| Percentage of materials | Before wear test (g) | After wear test (g) | Loss of weight (g) |
|-------------------------|----------------------|---------------------|--------------------|
| VIRGIN POLYPROPYLENE(PP) | 27.1590              | 26.8634             | 0.2956             |
| PP+ 2% TERMINA CHEBULA  | 26.9832              | 26.9107             | 0.0725             |
| PP+ 4% TERMINA CHEBULA  | 27.8829              | 27.8447             | 0.0382             |
| PP+ 6% TERMINA CHEBULA  | 27.2946              | 27.2707             | 0.0239             |
Figure 11. Loss of wear test for 1000 gms per 1000 cycles.

Figure 12. Percentage of PP composition vs loss of weight.

3.1. Sem images

The graph inside the sem images shows the roughness of the image. Figure 12 picturize the sem image and roughness graph of polypropylene after wear test and figure 14 shows the sem image and roughness graph of polypropylene with termina chebula after wear test. Both the graph clearly shows that roughness is more in polypropylene than polypropylene with termina chebula. This one clearly states that loss of weight is more during wear in polypropylene than polypropylene with termina chebula.

Figure 13. SEM image of Virgin pp before wear.

Figure 14. SEM image of Virgin pp after wear.
4. Conclusion
From this work we have found that the wear resistance for polypropylene with termina chebula 2%, 4%, and 6% plate is higher than that of virgin polypropylene plate. This work is still continued with varying percentage of termina chebula with polypropylene material.

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