Effect of Texturing Patterns on Friction and Wear Behaviour of Glass Fiber Filled Polyamide (Pa66)

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ABSTRACT

Polyamide (PA66), an engineering thermoplastic polymer is having excellent balance of strength, ductility and heat resistance. However its application has been limited due to poor wear and abrasion resistance. The wear resistance can be significantly improved by texturing and addition of some filler materials. Polyamide (PA66) with 10% glass fiber composite produces very thick, uniform and adherent transfer film of PA66 and glass fiber. Therefore, in this, the effect of three texturing patterns i.e. elliptical, circular and square with 10% dimple density on the friction and wear behavior of Polyamide (PA66) filled with 10% glass fiber particles at varying load and sliding velocities were studied. The test pins of PA66 composites were examined by rubbing it on stainless steel disc AISI SS 304 with surface texturing under dry and wet lubrication conditions using pin-on-disc tribometer (TR-20LE) at NTP. The results and observations of this investigation shows that as load and sliding velocity increases wear loss and friction goes on increasing. Among the three texturing patterns circular texturing pattern shows better result than elliptical and square. The lowest coefficient of friction and wear was examined at wet lubrication condition and using circular textured pattern with dimple density 10%.

Key Words: Surface texturing, Dimples, Friction, wear Tribometer

INTRODUCTION

It is very necessary to lower the friction and wear between the mating parts of tribological components and it results to the saving an energy, improves durability of component, improving an efficiency and also helps in keeping an environment safe for further engine systems. In such situations surface texturing of mating parts plays an important role. It enhances the tribological properties i.e. coefficient of friction, wear loss, lubrication and also improves load carrying capacity. Theory of hydrodynamic lubrication shows that the microstructures distributed on bearing surface affect the load carrying capacity and lubrication state of the component. The “Surface texturing” i.e. surface topography means making the grooves or cavities on plane surfaces so that it helps to improves tribological properties of mating parts. It improves lubricating property by acting as a oil reservoir so that when oil film breaks down it provides or retains oil for lubrication and also helps in entrapping wear particles and works as a abrasion resistance under boundary and dry lubrication. So for the research work, there is a need of understanding the material, lubricant and running conditions before going for surface texturing, tribo testing. In early research textures are limited to grooves and troughs but now a days there are some new techniques which gives complex nature or shapes of textured patterns such as elliptical, triangular, circular, square and some other geometrical shapes which are having different performance on friction and wear behavior of material. The effectiveness of textured patterns also varies with aspect ratio, area, depth, shape of the textured patterns.

EXPERIMENTAL METHODOLOGY

Fig.1 shows the experimental set up of pin-on-disc tribometer (TR-20LE) which was used for readings of wear and frictional force. In experimental work, tests were carried out at the sliding velocities of 0.09 m/s, 0.105 m/s, 0.12 m/s and at the load of 56.81 N, 61.39 N and 65.96 N under dry and wet lubrication condition IPOL 3 Oil was used as lubricant for wet condition.
PREPARATION OF SPECIMEN

Polyamide (PA66) filled with 10% glass fiber material was used to prepare test specimens. The test specimen dimensions were 6 mm diameter and 30 mm length for the experimentation. The disc of material AISI SS 304 stainless steel plate having surface finish 0.20 µm was used as counter surface disc. The three surface texture patterns i.e. elliptical, circular and square were made on disc by the laser surface texturing. The details of three texturing on AISI SS 304 disc are as shown in Table 1 - 3:

Table: 1 Details of elliptical texturing on disc

<table>
<thead>
<tr>
<th>Sr. no.</th>
<th>Dimple major axis (µm)</th>
<th>Dimple minor axis (µm)</th>
<th>Dimple depth (µm)</th>
<th>Dimple density (%)</th>
<th>Dimple orientation</th>
</tr>
</thead>
<tbody>
<tr>
<td>E1</td>
<td>732</td>
<td>366</td>
<td>50</td>
<td>10</td>
<td>Circumferential</td>
</tr>
</tbody>
</table>

Table: 2 Details of Circular texturing on disc

<table>
<thead>
<tr>
<th>Sr. no.</th>
<th>Dimple diameter (µm)</th>
<th>Dimple depth (µm)</th>
<th>Dimple density (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1</td>
<td>100</td>
<td>50</td>
<td>10</td>
</tr>
</tbody>
</table>

Table: 3 Details of Square texturing on disc

<table>
<thead>
<tr>
<th>Sr. no.</th>
<th>Dimple size (µm)</th>
<th>Dimple depth (µm)</th>
<th>Dimple density (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>450 x 450</td>
<td>50</td>
<td>10</td>
</tr>
</tbody>
</table>

The running parameters used for experimentation are as Table 4.

Table: 4 Running parameters

<table>
<thead>
<tr>
<th>Sr. no.</th>
<th>Load (N)</th>
<th>Sliding velocity (m/s)</th>
<th>Test duration (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>56.81</td>
<td>0.09</td>
<td>60</td>
</tr>
<tr>
<td>2</td>
<td>61.39</td>
<td>0.105</td>
<td>60</td>
</tr>
<tr>
<td>3</td>
<td>65.96</td>
<td>0.12</td>
<td>60</td>
</tr>
</tbody>
</table>

RESULTS AND DISCUSSION

1. Variation of wear and coefficient of friction with test duration under dry and wet lubrication condition:

a. Variation of wear with test duration at dry condition:
Fig. 2 shows the variation of wear with time. It shows that wear increases with increasing load and sliding velocity. By observing graph run 6 i.e. at load of 65.96 N and sliding velocity of 0.09 m/s of elliptical dimple shape gives minimum wear for dry lubrication condition.

b. Variation of c.o.f with test duration at dry condition:
Fig. 3 shows the variation of C.O.F. with test duration at dry lubrication condition. At the load of 65.96 N and sliding velocity 0.105 m/s of square dimple shape value of C.O.F is minimum i.e. run 9.
c. Variation of wear with test duration at wet lubrication condition:

Fig. 4: Wear vs Time at wet lubrication condition

Fig. 4 gives the wear variation of various runs. Wear increases with increasing load and after some time the value of wear keeps constant. Run 1 gives better result for this investigation i.e. Circular dimple shape with 10% dimple density and load of 56.81 N and sliding velocity of 0.09 m/s.

d. Variation of C.O.F. with test duration at wet lubrication condition:

Fig. 5: C.O.F vs Time at wet lubrication condition

At run 1 C.O.F is minimum compared to other runs. At first C.O.F increases with time after that it remains almost constant.

2. Effect of Load

a. Effect of load on C.O.F under wet lubrication condition

Fig. 6: Effect of load on C.O.F under wet lubrication condition

b. Effect of load on wear under wet lubrication condition

Fig. 7: Effect of load on wear under wet lubrication condition

c. Effect of load on C.O.F under dry lubrication condition

Fig. 8: Effect of load on C.O.F under dry lubrication condition

d. Effect of load on wear under dry lubrication condition

Fig. 9: Effect of load on wear under dry lubrication condition
3. Effect of Sliding Velocity
   a. Effect of sliding velocity on C.O.F under wet lubrication condition

Fig. 10: Effect of sliding velocity on C.O.F at wet lubrication condition

b. Effect of sliding velocity on wear under wet lubrication condition

Fig. 11: Effect of sliding velocity on wear at wet lubrication condition

c. Effect of sliding velocity on C.O.F under dry lubrication condition

Fig. 12: Effect of sliding velocity on C.O.F at dry lubrication condition

d. Effect of sliding velocity on wear under dry lubrication condition

Fig. 13: Effect of sliding velocity on wear at dry lubrication condition

DISCUSSION

It is seen from the results obtained, as the load and sliding velocity increases the coefficient of friction and wear increases for both dry and wet lubrication condition. From Fig. 2 to 5 at first C.O.F. and wear increase after some time it goes on decreasing and become constant. It is observed from the graphs that coefficient of friction increases with increasing load and sliding velocity. But load is more affective than sliding velocity on coefficient of friction.

It is observed from Fig. 2 to 5 that circular dimple shape shows better performance than elliptical and square. At minimum load i.e. 56.81 N and at minimum velocity i.e. 0.09 m/s and circular textured pattern the total value of wear (9 microns) which is minimum as compared to the other textured patterns and value of coefficient of friction is (0.004) minimum at wet lubrication condition. In wet lubrication with minimum load and sliding velocity, there is a formation of constant thick film of lubricant between mating surfaces which causes minimum wear.

CONCLUSIONS

From the results and discussion, following conclusions were made about the friction and sliding wear of PA66 filled with 10% glass fiber rubbing against the textured AISI SS 304 stainless steel disc:
Circular textured pattern showed better performance i.e. has given minimum wear (9 microns) and C.O.F (0.004) than elliptical and square textured patterns.

For the selected range of load and sliding velocity, friction and wear value were minimum at low load and low sliding velocity.

Friction gets more affected by load than sliding velocity i.e. values of coefficient of friction were increased with increasing load and remained constant after some interval.

Wet lubrication has given better performance on wear and friction than dry lubrication condition for selected range of load and sliding velocity.

REFERENCES


