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SYNCHRONIZER LIFE ENHANCEMENT USING CARBON FIBRE COMPOSITES

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ABSTRACT

The synchronizer in a domestic tractor is observed to be having a lifetime of 2-3 efficient years with the current material used for synchronizer being Brass. In this work with discuss about how to enhance the existence time of synchronizer by replacing Brass with Carbon – Carbon composite (C-C) material. The pattern of the carbon fiber chosen is Woven Roving Mat (WRM) which is blended with Epoxy resin with two layers of 0.5 mm thickness as a laminate. The WRM cloth is rolled over by the Epoxy resin with the help of a roller and then both are kept inside the bottom portion of the die arrangement. As design has the central guiding, the die can be inserted easily and straight into the bottom portion and the top portion is pressed inside the bottom portion. The composite friction material die is designed with AISI H13 steel and manufactured. A pressure of 400 kg/cm^2 is applied to an area of 7.02 cm^2; therefore, a force of 2800 kg is required, hence a 5 Ton hydraulic press is used. The result is observed that the carbon – carbon composite shows enhanced strength and endurance properties than the brass. By the results obtained we infer that brass can be replaced by carbon –carbon composite to increase the lifetime of synchronizer.

Key words: Woven Roving Mat (WRM), Epoxy resin, Composite, Synchronizer

INTRODUCTION

Synchronizers are widely used in all manual transmission trucks and commercial vehicles. Richard et al., (1968) briefed manual transmission synchronizer, only little information is available in the public domain since majority of the work is patented and copyrighted. Gu Yuming et al., (2011), the synchronizer plays a vital role in bringing the next gear ratio up to speed that gears, and output shaft are at the same speed. This enhances the smooth change of gears. It forms a mechanical part of the gear box. The aim is to ensure speed of the next gear to be the same as that of the synchronizing hub. The synchronization of the hub and gears are facilitated by the friction cones. Lovas et al., (2006) says that the toothed cone clutches are shifted to change the speed manually in a gear box. This method is followed instead of shifting individual gears since the gears are always in meshed condition. Tongli Lu et al (2016) investigated on supervisory control of synchronizer for wet DCT based helped in understanding the concept Abdel-Halim et al (1997) studied the improvement of manual transmission multi cone synchronizer which showed a great result.

METHODOLOGY

Zongyang Gong et al (2008) briefed on analysis of transmission of manual synchronizers. The friction cones are manufactured by using compression molding. William et al., (2003) done survey on different materials used for manual transmission. It involves hard pressing of C – C composite between two halves of a high temperature dies. This transforms into a solid product due to the effect of high pressure and temperature.

Vynatheya, et al., (2006) used carbon fibre for synchronizer. The WRM cloth is rolled over by the Epoxy resin with the help of roller. Then both are kept inside the bottom portion of the die arrangement. The top portion is pressed inside the bottom portion. As design has the central guiding, the die can be inserted easily and straight into the bottom portion. A pressure of 400 kg/cm2 is applied to the area of 7.02 cm^2. Therefore, a force of 2800 kg is required. Hence, a 5 Ton Hydraulic press is used. The resin used is Epoxy, so heating is not recommended. This is because the epoxy has an exothermic reaction. If heated will produce voids in the material. If it is heated and cooled, then it will affect the curing of the epoxy. Hence it is recommended to allow it to cool naturally by metal conduction process. Cured for 3 hours and pasted to the synchronizer ring with cyno-acrylite based bonding solution.

WEAR TESTING: Pin on disc test is carried out to predict the wear rate and co-efficient of friction of the material. In this project brass alloy and WRM carbon fiber epoxy composite is compared and the better one is recommended as the suitable for customer. Samples of brass alloy are prepared with the help of brazing process. Samples of carbon fibers are prepared using bonding process. Both are made to a diameter of 12 mm.

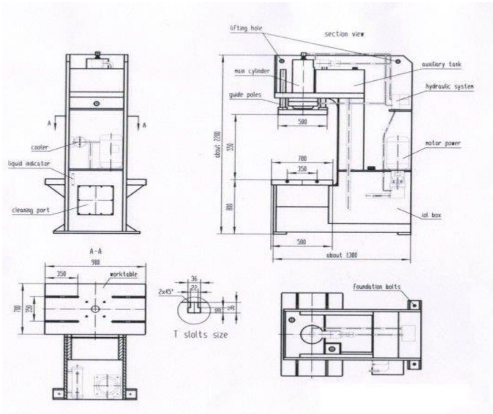

Figure 1. Wear testing

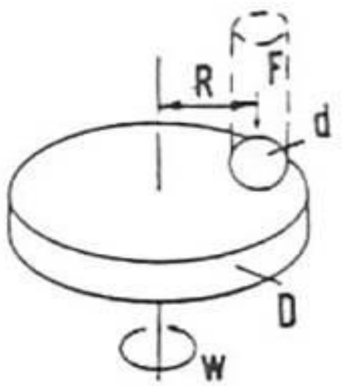

Figure 2. Pin on disc

As Kennedy et al., (1998) investigated by ASTM G99-05, pin-on-disc testing consists of a fixed pin with a spherical top which is in contact with a rotational disc. Fig 4.1 gives a schematic representation. F: Applied normal load. R: Radius of the wear track that is produced. d: Diameter of the spherical top of the pin. D: Diameter of the disc. w: Rotational speed. Lorenz et al., (2007) discussed on the components of synchronizer systems.

This experiment provides the user the facility to control and measure the speed, oscillation frequency, temperature, pressure, the applied normal load, environmental parameters and type of gas, lubricant and refrigerant etc. The transducers are used to measure the normal and friction forces. The pin holder can deflect slightly as it is attached to a fixture. The transducer measures the deflection and converts it to force. The coefficient of friction and wear rates characterize the performance. It is determined by the mass or the volume with the help of a profilometer. Xu WanLi et al (2015) investigated on failure characteristics of synchronizer and used tribometers. Though ASTM G99-04 outlines to use a spherical pin, to simulate the best result from the actual system different geometry of specimen is engaged. Tribometers machines are used to conduct the testing.

MEASUREMENT METHODS OF WEAR:

Hani Aziz Ameen et al (2011) stated the effect of load and time in wear. weighing method is used in the current research work, which is derived from the easiest methods that are followed to fix and measure the wear. The sample must be weighed before and after the test and then the rate of wear will be calculated from the difference in the weight. The brass alloy and the carbon fiber composite are considered for the wear test. Samples are made for the purpose of testing. Pin on disc test is carried out for the measurement of wear.

ASTM-PROCEDURE: The following procedure is taken from the ASTM standard. Sare et al., (1997) and Joe H. Tylczak et al (1999) investigated about various methods for testing wear from that we followed this procedure.

1. The sample is cut into a disc and a hole is drilled in the center to insert the pin.
2. The weight of the disc is measured before taking the test.
3. The disc is placed on the testing machine with a hanging mass of 3 kg and the pin is made to revolve over it after the required specifications are set. The results are plotted in the computer
4. After the test is done, the tested part is weighed again to analyze the effect in weight
5. The test is repeated with different specimens to obtain significant results based on the sufficient data.

TEST RESULT FOR WEAR

Figure 3: Test Sample

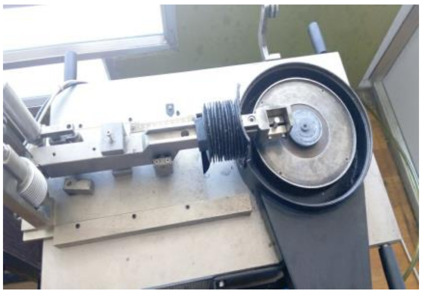

Figure 4: Pin on disc testing

Test condition: Constant load = 3.00 kg,
Constant Speed =1500 RPM

Table 1: Sliding distance at 250 m

S.No	Sliding distance, m	weight loss brass alloy, gm	weight loss Composite, gm
1	250	0.036	0.0097
2	250	0.041	0.0086
3	250	0.04	0.0080

Table 2: Sliding distance at 500 m

S.No	Sliding distance, m	Weight loss brass alloy, gm	Weight loss composite, gm
1	500	0.0504	0.0111
2	500	0.0498	0.0110
3	500	0.0502	0.0110

Table 3: Sliding distance at 1000 m

S.No	sliding distance, m	weight loss brass alloy, gm	weight loss Composite, gm
1	1000	0.157	0.0338
2	1000	0.146	0.0339
3	1000	0.15	0.0321

Table 4: Average of three readings

S.No	sliding distance, m	weight loss brass alloy, gm	weight loss Composite, gm
1	250	0.0397	0.0087
2	500	0.0501	0.0110
3	1000	0.151	0.0194

Table 5: Co-efficient of friction at 250m

S.No	sliding distance, m	Co-efficient of Friction brass	Co-efficient of Friction Composites
1	250	0.088	0.13
2	250	0.086	0.13
3	250	0.081	0.13

Table 6: Co-efficient of friction at 500m

S.No	sliding distance, m	Co-efficient of Friction brass	Co-efficient of Friction Composites
1	500	0.086	0.11
2	500	0.086	0.11
3	500	0.080	0.11

Table 7: Readings for sliding distance 1000m: Co-efficient of friction at 1000m

S.No	sliding distance, m	Co-efficient of Friction brass	Co-efficient of Friction Composites
1	1000	0.080	0.11
2	1000	0.081	0.11
3	1000	0.076	0.11

Table 8: Average of three readings: Comparison of coefficient of friction

S.No	Sliding distance, m	Co-efficient of Friction brass	Co-efficient of Friction Composites
1	250	0.085	0.13
2	500	0.084	0.11
3	1000	0.079	0.11

RESULTS AND DISCUSSION

The results are plotted in the graph with different sliding distance in the X – Axis against its weight loss in the Y – axis. It is inferred from the graph that Brass weight loss is much higher compared to C – C composite when the sliding distance increases.

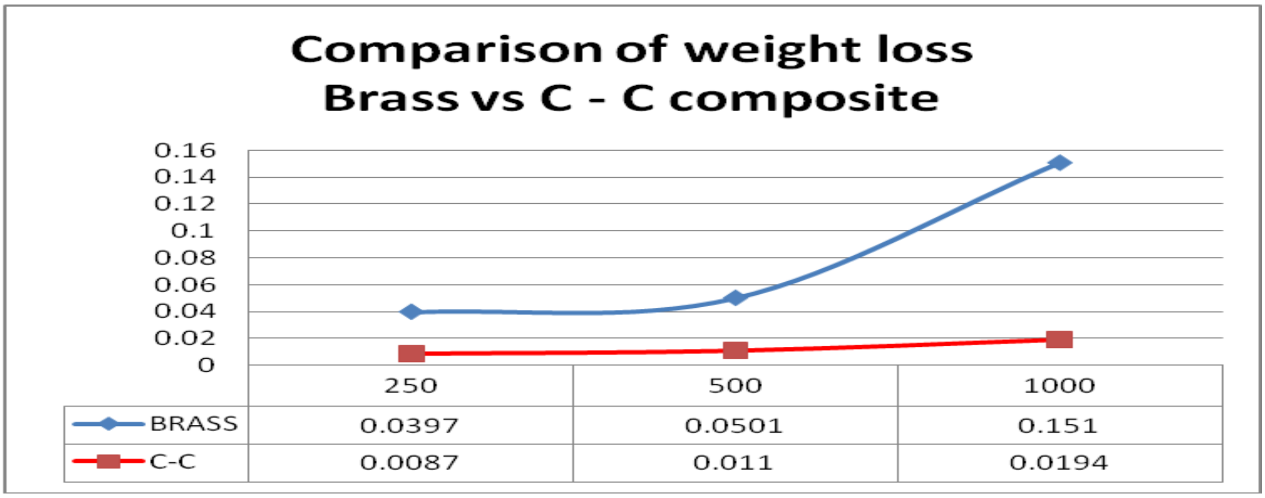

Figure 5: Average of three readings

The results plotted in the graph with different sliding distance in X – Axis and the co – efficient of friction in Y – axis. It is evident that the C –C composite exhibits more co – efficient of friction comparing with the currently used material Brass.

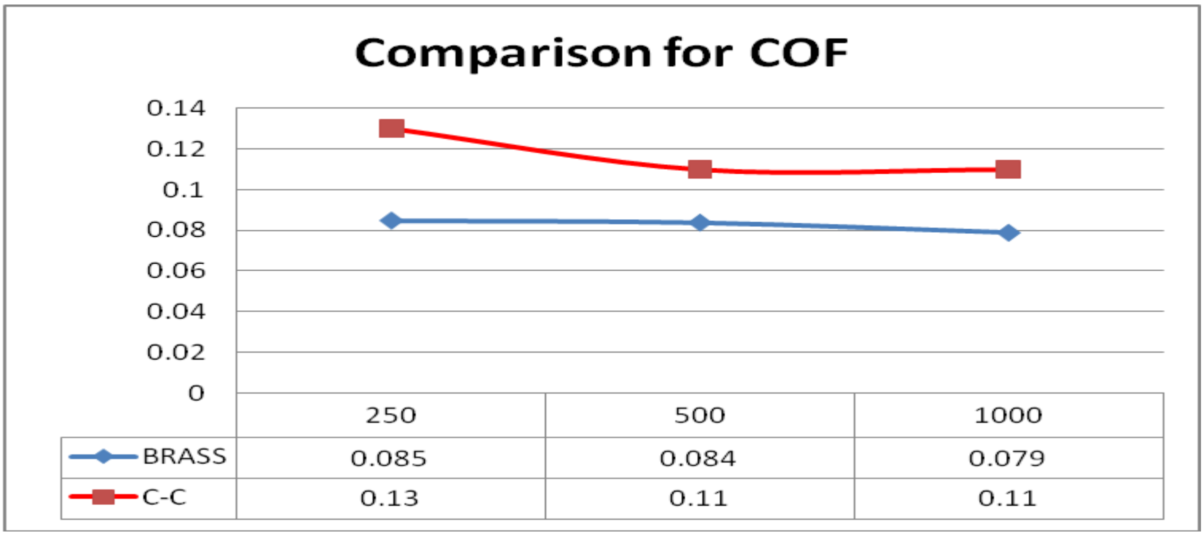

Figure 6: Average of three readings

CONCLUSION

The average lifetime of synchronizer in a tractor is determined as 2 years against 10 years of tractor life for the brass alloy. And the customer has to replace the synchronizer 4 times in a tractor's lifetime. With the synchronizer with friction material, the lifetime is increased by 50% such that number of services and the cost incurred in replacing the synchronizer is reduced. Hence synchronizer with friction material becomes low cost to the customer over a period of time. From the results it is evident that the carbon – carbon composite can effectively replace brass.

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