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Tribological impact of CI engine piston rings under different blend ratio biodiesel

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ABSTRACT – The eagerness of commercializing higher blend ratio biodiesel around the globe was an initiative to support renewable energy and protecting the environment. However, other negative impact including to the engine components was crucial for application in automobiles. In this study, the wear impact due to changing biodiesel blend from B5 to B70 was investigated. Results show that as we utilized higher blend ratio biodiesel, the wear also increased approximately 9%, which give negative impact to the engine life and overall performance. As the engine speed increases, the wear also increased until reaching its peak and reduces to a minimum. This result conflict with lab based using four-ball tester and need to be further investigated and correlated.

1. INTRODUCTION

Biodiesel is a renewable fuel actually known as a mono alkyl ester that produced using renewable resources such as animal fats and vegetable oils [1-5]. Compared to petroleum-based diesel, biodiesel has more favorable combustion emission profile, such as low emission of carbon monoxide, particulate matter and unburned hydrocarbons. In automotive fuel deliveries system, many metallic materials are exposed to the biodiesel, which have different characteristics than diesel. This would cause damaging effect such as corrosive and tribological attack on the engine parts [6]. The use of biodiesel, especially at high blend ratio (HBR) could have some tribological side effect on internal engine parts especially piston rings.

2. METHODOLOGY

A single cylinder CI engine was used for this investigation. The specification of the Yanmah 2500CX CI engine is shown in Table 1.

Table 1 Yanmah single cylinder specifications.

2500CX-A YANMAH ENGINE BASIC SPECIFICATIONS			
BORE	70 mm	MAX HP	4.7
STROKE	55 mm	CONT HP	4.2
DISPLACEMENT	211 cc	START SYSTEM	RECOIL
ENGINE SPEED	3600 r/min	WEIGHT	56 kg

A biodiesel blend of B5 (5% biodiesel and 95% petroleum diesel) and B70 is investigated on this engine. The B5 is currently available from the petrol station while B70 biodiesel was blended in laboratory according to the standard [1].

Experimental test matrix was design to investigate the effect of running different blend of biodiesel including B5 and B70 biodiesel. In this study, the engine was dissembled and the piston rings were weighted accordingly before running with Biodiesel fuel.

Generally, this investigation involved with running different Biodiesel grade in a single cylinder diesel engine. Later, the engine was disassemble to weight the piston rings. Then the experiment was repeated with a fresh set of piston rings. The CI engine was investigated with B5 biodiesel first at a steady state speeds from 1500 to 3500 rpm. At each engine speed, the engine was dismantled and the piston rings were weighted. The experiment was repeated at increasing engine speed. For further verification, each experiment was repeated fives time to observe for repeatability and variation. The full experimental matrix is shown in Table 2.

Table 2 Experimental test matrix at various engine speed (rpm).

Biodiesel	B5	B70
Experimental mode	X 1500 rpm	X 1500 rpm
1. X-dissembles engine and weighing piston rings.	X 2000 rpm	X 2000 rpm
	X 2500 rpm	X 2500 rpm
2. Engine test on dyno from 1500-3000 rpm	X 3000 rpm	X 3000 rpm
	X 3500 rpm	X 3500 rpm

3. RESULTS AND DISCUSSION

The results obtained were a result from using digital analytical Balance to measure the wear mass before and after the engine test. Table 3 shows the result for wear mass after running the engine using B5 biodiesel.

Table 3 Piston rings wear mass with B5 biodiesel.

Piston rings (B5)	Weight before, g	Weight after, g	Wear mass, g
1st Compression	6.2468	6.2439	0.0029
2nd Compression	6.5099	6.5074	0.0025
Oil Control	6.7813	6.7773	0.0040
Total wear volume			0.0094

Repeating the same procedures with B70 biodiesel give another set of result as shown in Table 4.

Table 4 Piston rings wear mass with B70 biodiesel.

Piston rings (B70)	Weight before, g	Weight after, g	Wear mass, g
1st Compression	6.2647	6.2614	0.0033
2nd Compression	6.4571	6.4543	0.0028
Oil Control	6.7770	6.7728	0.0042
Total wear mass			0.0103

From these two initial results, it was observed that B5 biodiesel resulted in 0.0094 gram of wear mass as compared to 0.0103 gram for B70 biodiesel. Repeatability study was also conducted to ensure the result obtained was moderated and reflect more significant findings. It also ensures that error from measurement was minimized.

By plotting them together for all engines operating speed (rpm), for all five repeated tests, a unique pattern was observed. These results was plotted in the graph shown in Figure 1.

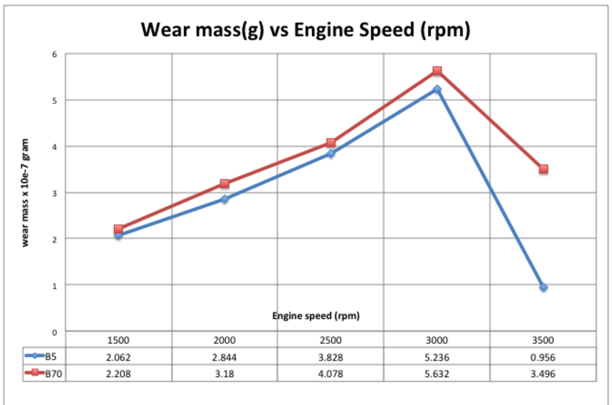

Figure 1 Comparison of wear mass for B5 versus B70 biodiesel.

Figure 1 shows an average values of fives repetitive test for each biodiesel fuel (B5 and B70). It was observed that, the wear pattern increased over increasing engine speed. From the B5 results against B70 biodiesel, it was observed that the wear rate also increased, as the Biodiesel blend ratio increased from B5 to B70.

4. CONCLUSION

Based on the two-biodiesel blend ratio investigated, it could be concluded that, as the biodiesel blend ratio increased, the wear characteristic also increased by 9%. This has negative impact on the engine life and performance. This finding may have conflicting results with lab based testing using four ball tester and need to be further evaluated and verified. Furthermore, it is recommended to have a suitable additive develop to compensate this loss to the engine parts if this is verified.

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