

STUDY ON COMPONENTS RATING OF GASOLINE ENGINE AS A PERFORMANCE QUALITY INDICATOR OF LEMIGAS FORMULATED API SL LUBRICANT

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ABSTRACT

Poor lubrication may cause wear on the surface moving parts of engine components such as bearings due to the metal-to-metal contact. Engine components utilized on the road-test of gasoline engine's lubricating oil API SL showed wear and tear on some parts of them. The sum of wear occurred during the road test were varied. Therefore, an analysis of wear quantity of engine's components was a necessity in order to get information about lubrication condition on engine. Analysis of wear was conducted by components' rating based on the standard specifications set out for performance level of lubricant oil API SL and ILSAC GF-3 (SNI 06-7069-2005). Analysis based on Seq. IIIF showed that average value of the piston skirt varnish is 10, low temperature viscosity is 4673 cP, and cam wear lifter is 0.002 mm. It was also showed that the minimum kinematics viscosity increase was managed to be stay-in-grade. Analysis based on Seq. IVA showed that the average value of cam wear is 0.0015 mm. Analysis based on Seq. VII showed that the value of bearing weight loss was 0.010 g and there was no deposit at high temperatures. Shear stability analysis based on Seq. VIII showed that the viscosity of lubricant oil is still in the range of allowed values.

Key words: *rating; gasoline engine components; API SL lubricating oil*

I. INTRODUCTION

Lubricating oil is an important matter in the operation of motor vehicle engines. The rapid development of engine technology requires the use of lubricating oil with better quality so that lubricant can still provide good performance in a variety of extreme conditions, such as very high operating temperatures, higher operating pressure, the possibility of impurities entry and many other disorders arising from the environment. Lubricating oil quality is indicated by the physical-chemical characteristics while the actual quality of performance is demonstrated by the actual work on machinery/equipment used. Some international standards are used to indicate the quality of lubricating oil, such as API Service, SAE, JASO and ILSAC. However the most actual quality can be detected by analyzing the ratings of the vehicle engine parts through road test.

Lubricating oil formula used in this studi was gasoline engine lubricating oil API SL recommended for gasoline engine technology of 2001. This type of lubricating oil can also be used for earlier automotive engine technologies. This paper present the result of lubricating oil performance studies conducted through road test, with the use of the new Lemigas formulated gasoline engine lubricating oil SAE 15W40/API SL. Performance test was conducted with a 2006 Toyota Innova which recommends the use of lubricating oil to the level of quality performance API SJ or SL. The test vehicle was run to reach 15,000 km mileage.

The research was aimed at determining the performance of lubricating oil Lemigas formulated formula SAE 15W40/API SL on the vehicle. Rating analysis of the engine components that was made

before and after the road test is an essential step to achieve that goal.

II. MATERIALS AND METHODS

To obtain the study results as expected, this study is conducted by following three main stages; namely preparation of lubricating oil samples (SAE 15W40/API SL), implementation of the road test, and component ratings before and after implementation of the road test. Analysis and evaluation rating are based on engine components by referring to the specification of performance parameters of lubricating oil and the level of API SL ILSAC GF-3 (SNI 06-7069-2005).

III. RESULT AND DISCUSSION

Analysis of vehicle engine's components through component rating is the proper way to determine the actual performance of the lubricating oil. Engine components assessed (by rating) were: pistons, camshaft, cam follower, connecting rod bearings, oil screen/oil filter, and others. Rating of engine's components before and after implementation of the road test can indicate changes in the condition of engine components with the use of lubricating oil.

Rating Piston Set Components

Piston set consists of a piston, piston pin and piston ring pairs (Figure 1). Rating of pistons was made

on the new set and the end of the road test (15,000 km), i.e. the diameter of the piston and the wear marks, particularly on his side thrust. Piston pin diameter was measured to determine wear of the piston pin. Cracks on the piston and piston ring liner (ring gap) were measured to determine the wear after 15,000 km usage. Piston rings, particularly compression (ring no.1 and no. 2), were weighed to determine the wear ring after 15,000 km.

Occurrence of wear of the piston sets can lead to reduced ability of machines to produce maximum energy. Results of analysis of the four piston ratings show the same dimension values before and after the road test. Good lubrication performance can reduce friction thereby reducing wear of metals.

Analysis of the piston pin was carried out to know weight loss after implementation of the road test. Piston pin weight losses are very small namely is an average of 0.0015 grams, so the value of the wear on the piston pin is considered normal. Visually on the piston pin there are no visible hot spots (bluish color) that indicate the occurrence of inter-metal touches.

Engine piston ring is a component that serves as seal between the combustion chamber with the lubricants crankcase (Figure 1). A load charge received by the piston ring is usually very high so that dimensional changes occur and the wear is an important parameter that must be observed. The results show that there is wear of the piston ring, indicated by the occurrence of weight loss. Average weight loss of each piston ring amounted



Figure 1
Piston thrust side, pin piston and ring piston

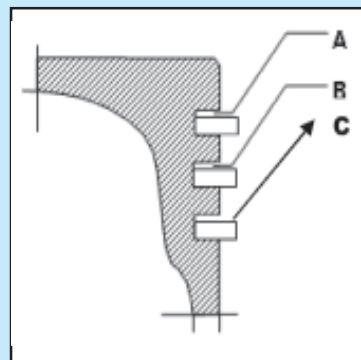


Figure 2
Piston ring side clearance

to 0.001 grams (R.1), 0.00125 grams (R.2) and 0 grams (R.3), or not more than 0.032%-wt.

Friction between the piston cylinders can cause wear and tear that resulted in a loss of engine compression. The results show that there is no wear on the cylinder liner. This was also detected from the compression constant value until the end of the road test.

Piston Ring-Side Clearance

This parameter is a measure of the spatial dimension of piston ring placement (Figure 2). This value is analyzed to determine deposit formation tendency of the ring-land which resulted in ring-sticking. The results show that the ring-side clearance is still in good condition and remain until the end of the road test, which is 0.03 mm for ring A, 0.03 mm for ring B and 0.05 mm for ring C. Ring condition of the piston ring has a value rating of 10, indicating there is no ring sticking.

Ring Gap

The occurrence of wear and tear can cause the ring-gap increases (Figure 3) so that engine compression will decrease. Results showed that the ratings gap on all four-ring pistons remained on average the same until the end of the road test (Table 1).

Piston ring conditions that remain good shows that the lubricating oil performance provide lubrication so well that the wear can be minimized. This was also detected from the engine compression pressure test

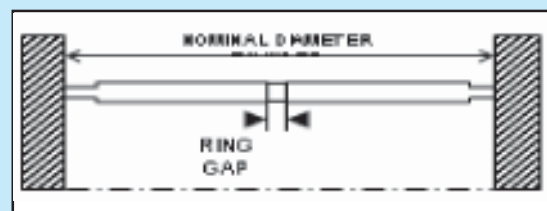


Figure 3
 Ring gap measurement



Figure 4
 Piston condition (Skirt Varnish)

Table 1
 Ring gap analysis

Ring Ref.	1a	1b	2a	2b	3a	3b	4a	4b
A	0.30	0.30	0.30	0.30	0.25	0.25	0.20	0.20
B	0.60	0.60	0.40	0.40	0.50	0.50	0.50	0.50
C	0.15	0.15	0.15	0.15	0.15	0.15	0.10	0.10

Remark : a = new part (0 km) ; b = used part (15.000 km)

Table 2
Skirt varnish and deposit analysis

Rating	Piston 1		Piston 2		Piston 3		Piston 4	
Ring Sticking	10		10		10		10	
Skirt Condition	9.5		9.5		9.5		9.5	
Crown Cutting	10		10		10		10	
Groove Filling	1	8.6	1	8.6	1	8.6	1	8.6
	2	8.6	2	8.6	2	8.6	2	8.6
	3	10	3	10	3	8.6	3	10
Land deposit	1	8.2	1	8.2	1	8.2	1	8.1
	2	8.6	2	8.6	2	8.9	2	8.7
	3	10	3	10	3	10	3	10

Table 3
Conrod bearing rating

Position	Connecting rod Bearing (gram)							
	1a	1b	2a	2b	3a	3b	4a	4b
Top	13.287	13.287	13.192	13.191	13.298	13.298	13.214	13.213
Bottom	13.282	13.281	13.152	13.151	13.305	13.305	13.314	13.314

Remark :

a = new part (0 km)

b = used part (15.000 km)

showed no change, i.e. 5.11 bar. Compression pressure that remains good will indicate the condition of the combustion chamber is still in accordance with standard conditions, so that the engine is able to provide optimum performance.

Piston Skirt Varnish and Deposit

The results on the skirt varnish and deposits that formed on the piston shows characteristics of some parameters of the condition of the piston component after the execution of road tests (Table 2).

Piston skirt varnish rating results show that the value of the component ratings are satisfactory to meet the ILSAC GF-3 Sequence IIIF, the 9.0 minimum. It is also apparent in the physical condition of the pistons that are clear of deposits and varnish (Figure 4). Piston skirt are in good condition with a value rating of 9.5 that indicates the condition of the wear



Figure 5
Connecting rod Bearing Kijang Innova 2006

on piston skirts, especially the thrust side only at trace levels.

Connecting Rod Bearing

This is the component of the engine that of gets a high workload, so the likelihood of wear and tear is

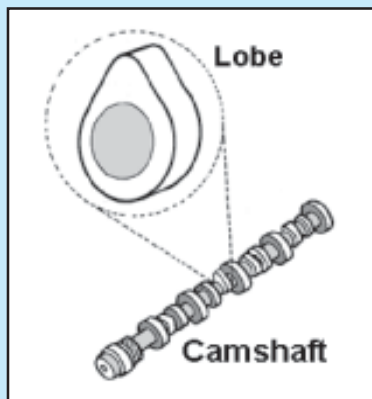


Figure 6
 Camshaft



Figure 7
 Camshaft follower condition after road-test

also high. The results on the connecting rod bearing components showed that almost no wear has occurred during the test road mileage to 15,000 km. Some little loss of material was detected from the top of connecting rod bearing and below-average <0.01 grams (Figure 5). The value of weight loss is still within safe and passes the test based on performance test ILSAC GF-3 Seq. VII for API SL, at a maximum of 0.0246 grams (Table 3).

Camshaft

This is an important engine component part which is used as one of the objects of observation and study (Figure 6). The results on the camshaft components showed that during road tests little wear has occurred despite the limitation value which is still very safe. The result of the camshaft lobe rating average is 0.001 mm on the inlet and the outlet of 0.002 mm (Table 4). Wearable of the maximum allowable under the standard test of ILSAC GF-3 Seq. IVA amounted to 0.12 mm so that the wear of the camshaft after 15,000 km mileage is still far below the specified maximum wear limit.

Camshaft Follower

Camshaft follower is a component that was analyzed in the ratings (Figure 7). Measurements taken on the dimensions of the camshaft follower shows that there is no wear and tear on these components (Table 5). ILSAC GF-3 tests Sequence IIIF provide maximum limit wear of the camshaft follower of 0.002 mm.

Table 4
 Camshaft component rating

No.	Inlet a (mm)	Inlet b (mm)	Outlet a (mm)	Outlet b (mm)
A	42.925	42.925	42.925	42.925
B	42.915	42.915	42.935	42.930
C	42.925	42.923	42.935	42.932
D	42.915	42.915	42.935	42.932
E	42.915	42.915	42.935	42.933
F	42.915	42.913	42.935	42.935
G	42.925	42.920	42.935	42.932
H	42.915	42.915	42.935	42.933

Remark:

a = new part (0 km)

b = used part (15.000 km)

Table 5
 Analysis of wear of the camshaft follower

No.	Inlet (mm)	Outlet (mm)
A	16.995	16.995
B	16.995	16.995
C	16.995	16.995
D	16.995	16.995
E	16.995	16.995
F	16.995	16.995
G	16.995	16.995
H	16.995	16.995

Oil Screen

Oil screen is very important component to ensure the cleanliness of lubricating oil that circulates in the engine is in clean condition (Figure 8). Analyses of these components are conducted to determine whether there is a blockage or are still in good condition. This parameter can be found by doing an oil screen weighing. The results show that the condition of oil and the screen still does not show blockages. This is detected from the result of oil weighing a fixed screen, which is 279.84 grams. This is in accordance with the restrictions in the standard test sequence VG ILSAC GF-3, which should not happen in the oil screen clogging.

Oil Filter

Oil filter function is to filter out the impurities brought by the lubricating oil (Figure 9). Oil filters, does its function to filter sludge, dust and metal wear. Blockage on the lubricating oil filter may cause the lubricant not to circulate properly so as not to be capable of providing excellent lubrication performance. The results show the existence of impurities retained on the filter, amounting to 2.62 grams. This amount is classified as very small and not to cause filter clogging, so it is still safe to use.

Sludge Formation and Varnish

Sludge and varnish formation is a condition that may interfere with the performance of vehicle engine lubrication. Analysis of sludge and varnish formation on the crankcase oil pan, a living dead zone camshaft, valve cover, oil pump strainer and oil filter (Figure 10). The results show that there is no formation of sludge and varnish formed so that in general these components are in clean condition (Table 6).

Resume of Components Analysis and Rating

Summary results of the analysis and rating engine components made with reference to the specification of performance parameters specified for the level of lubricating oil of API SL and ILSAC GF-3 (Table 8).

a. Sequence III F

Study results showed that lubricating oil drain interval SAE 15W40 API SL through the road test can give a good performance and test standards sequence III F (Table 8).

b. Sequence IVA

Testing sequence IVA is conducted to determine the wear characteristics. Wear value is limited by its

Table 6
Measurements oil filter

Weight (gram) (new part - 0 km)	Weight (gram) (used part - 15.000 km)
248.87	251.49

Table 7
Sludge dan varnish formation analysis

No	Sludge / Varnish Analysis	Result
1	Oil pan carter	Clean
2	Dead zone camshaft	Clean
3	Valve cover	Clean
4	Strainer oil pump	Clean
5	Oil filter	Clean



Figure 8
Oil Screen Kijang Innova 2006



Figure 9
Oil filter

maximum value. The results showed that the wear that occurs during the road test still meet the standard specifications (Table 8). Figure 11 shows the difference of the two components that have passed and the one which failed to meet the standard specification test sequence IVA.

c. Sequence VII

Wear of bearings is a common phenomenon that occurs in engine operation. However, the wear should not exceed the maximum limit value. Analysis of the wear pads are made with the lost weight calculation shows that the some bearing weight loss has occurred during the road test. The magnitude of weight loss is only 0.010 grams, less than the maximum limit of 0.0264 grams (Table 8). This means that it still meets the specifications set forth in sequence VII.

d. TEOST Test

This analysis is intended to determine the trend of high temperature deposit formation. The results show that there is no deposit formation as a result of heating at high temperature. This can be known from observation of hard deposits on the walls of the lubricant crankcase, valve covers and other engine parts. TEOST limiting high temperature deposit a maximum of 45 milligrams (Table 8).

e. Shear Stability, Seq. VIII

Lubricating oil resistance characteristic to the shear force is an important parameter to ensure that lubricating oil can still provide good lubrication on vehicle engine parts. Shear can cause damage to polymer additives which decreased the viscosity of lubricating oil. To avoid products with bad quality, viscosity resistance is limited by its minimum value. Test results of shear stability characteristics of lubricating oils showed a trend lubricating oil dilu-



Figure 10
 Sludge and varnish formation

Table 8
 Lubricating oil analysis based on the level and quality of API SL ILSAC GF-3

Test Parameters	Standard Value	Test Value
Seq. III F		
Average piston skirt varnish	9.0	10.0
Minimum cinematic viscosity increase	Stay in grade	Stay in grade
Low temperature viscosity, cP	7000 max	4673
Average cam lifter wear, mm	0.002	No wear
Seq. IVA		
Average cam wear, max, 7 position, mm	0.12	0.0015
Seq. VII		
Bearing weight loss, max, gram	0.0264	0.010
TEOST test, high T-deposit, mg	45	0
Seq. VIII, shear stability	Stay In grade	Stay In grade

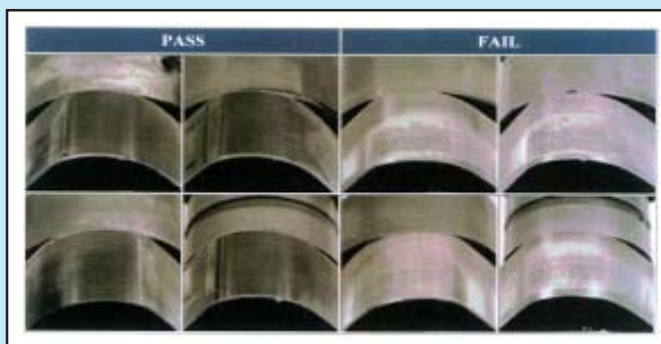


Figure 11
 Cam lobes wear

tion due to shear force. However viscosity values are still within the range of specifications, "stay in grade" (Table 8). This indicates that the lubricating oil has a very good stability against shear forces so that the degradation of polymer additives that occurred did not cause lubricating oil to be off-specification.

IV. CONCLUSION

The rating of engine components before and after the road test can identify the quality and performance of lubricant oil during use. The results showed that the lubricant oil SAE 15W40/API SL formula of Lemigas still performing well enough to use up to 15,000 miles. The discrepancy with the lubricant oil quality standards can cause wear and damage to engine components. The existence of lubricant oil which has not registered and does not meet the specifications set out to show the importance of control of lubricant oil on the market. Also replacement of lubrication system parts and engine service on a regular basis is important enough for the performance of engine components to work at its optimum.

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