

Lubrication Performance of Multi-Level Gear Oil in a Gasoline Engine

Feng-Tsai Weng, Dong- Syuan Cai, Tsochu-Lin

Abstract—A vehicle gasoline engine converts gasoline into power so that the car can move, and lubricants are important for engines and also gear boxes. Manufacturers have produced numbers of engine oils, and gear oils for engines and gear boxes to SAE International Standards. Some products not only can improve the lubrication of both the engine and gear box but also can raise power of vehicle this can be easily seen in the advertisement declared by the manufacturers. To observe the lubrication performance, a multi-leveled (heavy duty) gear oil was added to a gasoline engine as the oil in the vehicle. The oil was checked at about every 10,000 kilometers. The engine was detailed disassembled, cleaned, and parts were measured. The wear of components of the engine parts were checked and recorded finally. Based on the experiment results, some gear oil seems possible to be used as engine oil in particular vehicles. Vehicle owners should change oil periodically in about every 6,000 miles (or 10,000 kilometers). Used car owners may change engine oil in even longer distance.

Keywords—Multi-level gear oil, engine oil, viscosity, abrasion.

I. INTRODUCTION

THE Society of Automotive Engineers (SAE) has established a numerical code system for grading motor oils [1], and also gear oil according to their viscosity characteristics [2]. Fig. 1 revealed viscosity characteristics comparisons of both motor oils and gear oil [3]. To determine the appropriate oil change interval, an oil condition sensor has developed that measures the electrical properties of engine oil, and correlates these electrical properties to the physical and chemical properties of oil [4].

Automobile engines can be classified in many several different ways such as: (i) Strokes per cycle, modern engines have four strokes per cycle: intake, compression, power, and exhaust. (ii) Types of fuel used, gasoline engine or diesel engine. (iii) Number of cylinders. (iv) Arrangement of cylinders. (v) Firing order. (vi) Arrangement of valves. Gear oils have great thermal stability which is adaptable to various temperatures and they also protect gearboxes and steering gears for heavy duty operation. Engine oil could be mixed into additives to improve the properties or to lower cost. Owing to the use of spent oil or recycled refined oil, environmental pollution can be decreased [5], [6].

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Some motor owners confuse engine oil with gear oil. The goal of this research is to investigate possibility for gear oil be used in a motor engine as oil. There may be some possibility according to the classifications of SAE standards in Fig. 1. The purpose of this paper is to assess the mileage interval of motor oil change and to determine if gear oil can be used as an alternative oil in a motor engine.

Comparative Viscosity Classifications			
ISO 3348 Industrial oils	AGMA 9005-D94 Gear oils	SAE J300 Engine oils	SAE J306 Gear oils
1500			
1000	8A		250
680	8		
460	7		140
320	6	60	
220	5	50	90
150	4	40	85 W
100	3	30	80W
68	2		
46	1	20	
32	0	15W	75W
22		10W	
15		5W, 10W	
10			
7			
3			
2			

ISO and AGMA are specified at 40°C. SAE 75w, 80w, 85, 5w, & 10w are specified at low temperature. SAE 90 to 250 and 20 to 50 are specified at 100 deg C. Viscosities can be related horizontally assuming 96 VI single grade oils.

Rule of Thumb: SUS @ 100°F / 5 = cSt @ 40°C.

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Fig. 1 Viscosity characteristics of engine oils, and gear oil [3]

II. EXPERIMENTS AND RESULTS

In this experiment, gear oil of the brand Taiwan CPC (grade 80W/90) was used as engine oil. The oil was sampled and checked every 10,000 kilometers without replacing it to elicit reduced engine lubrication. The vehicle used in the experiment is a 1997 Honda Accord with 170,000 km of mileage. The experiments were conducted from April 2015 to May 2016, and involved road driving a distance of about 300 km/day.

After completing 100,000 km of road testing, the engine was disassembled and all parts were cleaned and checked. The oil analysis was trusted to a professional lab, SIGNUM. Results of the gear oil analysis was in Fig. 2. According to the oil analysis, the quantity of iron was alert, which reveals the wear of engine components. The level of iron is extremely high, and the quantity of other elements, such as Si, Pb, Al, as well as the oil viscosity is high, too. This shows parts were subjected to severe wear for long distance driving with no oil change. Some engine

parts showed serious evidence of oil engine sludge such as the lead ring of oil filter, oil pan and oil filter, piston rod, rocker chamber, and so on. Oil sludge is caused by reduced oil lubricating ability and affects the efficient operation of an engine. Fig. 3 shows the disassembled engine parts after completion of the experiments. All parts were reassembled after undergoing a thorough cleaning and the engine was then checked in accordance with the Honda Accord Service Manual [7]. Cylinder block warpage was checked using a feeler gauge, and results are shown in Table I [7]. Cylinder block warpage was within the normal range when compared with the standard value range. Cylinder block bore taper was checked using a cylinder bore gauge, the results of the measurement were recorded in Table II [7]. The results show that the cylinder block bore taper value for A and B was higher than the standard value indicating wear. Piston diameter was examined, and the piston rings end gap was checked using a feeler gauge, the results were recorded in Table III [7]. The third ring was not measured because it had already seized. Piston diameters were slightly smaller than new ones, while the piston rings end gap were smaller, too. The second ring end gap was much smaller, and this may be owing to the deformation of the piston rings which operated in extremely high engine temperatures for an extended period of time. The crankshaft main journal diameter

was checked and the data recorded in Table IV [7]. The crankshaft main journal diameter value was normal. The connecting rod journal bore taper was recorded in Table V [7], and was also in the normal range. The camshaft lobe height was recorded in Table VI [7]. Fig. 4 illustrates the contaminants and sludge accumulated in the oil pump. Fig. 5 shows the contaminants and sludge accumulated on the oil screen. Fig. 6 reveals the contaminants and sludge accumulated around the oil sump. Fig. 7 shows the contaminants and sludge accumulated around the cylinder and engine chamber and the inner oil guide. Fig. 8 illustrates the disassembled pistons and connecting rods. Fig. 9 reveals damage to the bush bearing on the right hand side. Most engine parts were considered worn or damaged beyond repair such as the oil filter, third piston ring, and bush bearing. The sludge produced in the engine hindered the flow of the oil feed lubrication system. Sludge clogged the sump oil strainer, which resulted in insufficient lubrication leading to a build-up of sludge and carbon in the pistons. High oil temperature also caused the piston rings to lose elasticity and seize. Carbon accumulation and oxidation deposition could happen in the engine combustion chamber. Long-term accumulation of sludge brought out oil deterioration, which resulted in vicious oil, lower liquidity, and insufficient cooling.

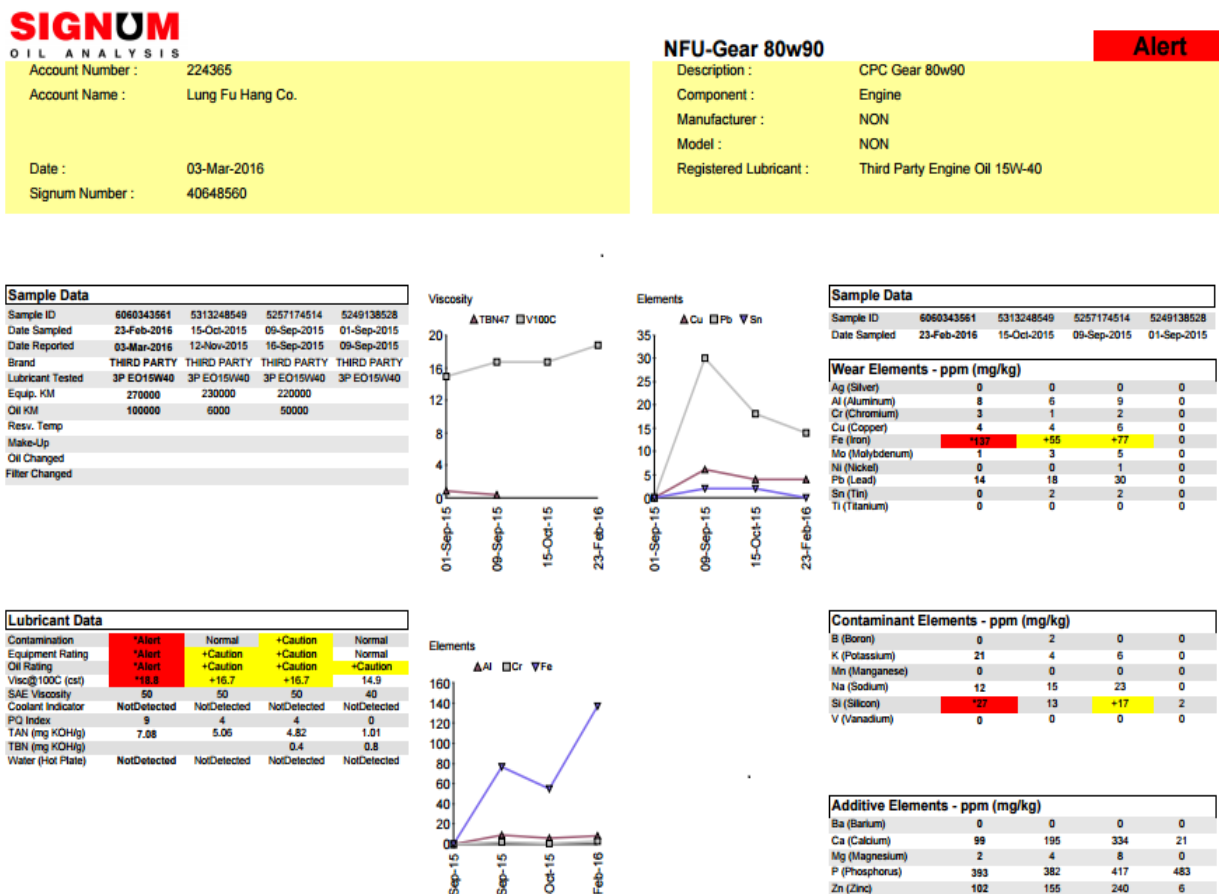


Fig. 2 Results of gear oil analysis

Fig. 10 revealed measurement of cylinder block warpage. Measurement of cylinder block bore taper was illustrated in Fig. 11. Measurement method of piston diameter and piston rings end gap was illustrated in Fig. 12. While the measurement of crankshaft main journal diameter and clearance was described in fig. 13. Fig. 14 shows measurement of connecting rod journal and clearance. Measurement of Camshaft height clearance was illustrated in Fig. 15.

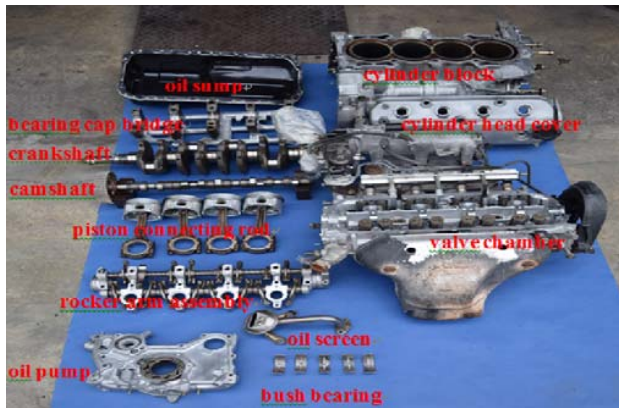


Fig. 3 Disassembled engine parts



Fig. 4 Contaminates and sludge accumulated in the oil pump



Fig. 5 Contaminates and sludge accumulated on the oil filter

III. DISCUSSION AND RECOMMENDATIONS

Piston diameters and piston rings end gaps were smaller compared to new ones. Deformation of the piston rings did occur, which may be the result of the engine operating over a long period at an extremely high temperature without an oil change.



Fig. 6 Contaminates and sludge accumulated in the oil pump



Fig. 7 Contaminates and sludge accumulated around the cylinder and engine chamber and inner oil guide



Fig. 8 Disassembled pistons and connecting rods

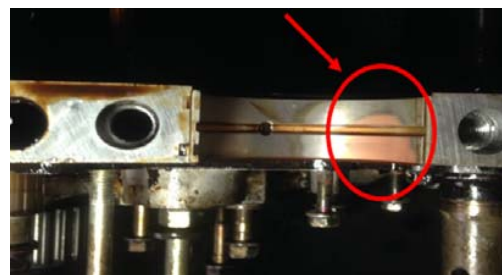


Fig. 9 Bush bearing shows damage on the right hand side after 100,000 km

Some manufacturers recommend an oil change about every 10,000 miles. Vehicle manufacturers suggest that oil should be changed every 3,000 to 5,000 miles (approximately 5,000 km to 8,000 km). Vehicle owners should change the oil regularly, or when it looks black and sticky.

A used car can run 100,000 kilometers without an oil change, because engine technology reliability is in progress. The new car and high performance vehicle owner would not change oil over time, although gear oil is cheaper and can be used in a motor engine as engine oil.

Check the top of the block for warpage.
Measure along the edges and across the center as shown.

Engine Block Warpage:
Standard (New): below 0.07 mm (0.003 in) max.
Service Limit: 0.10 mm (0.004 in)

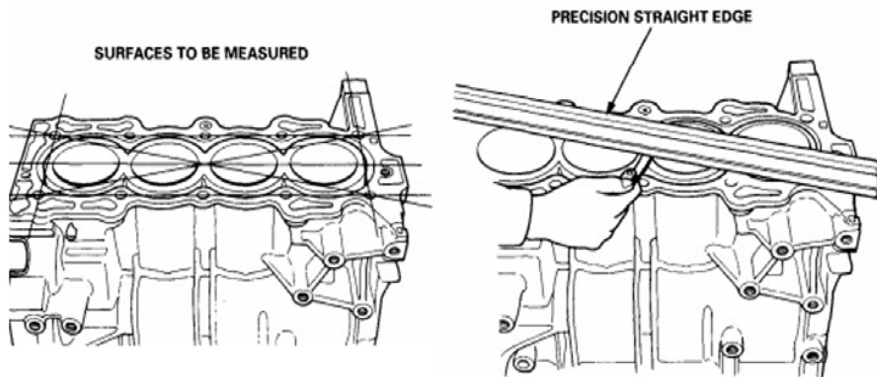
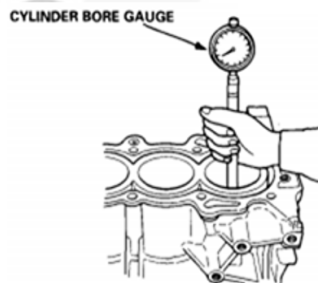


Fig. 10 Measurement of cylinder block warpage [7]

Measure wear and taper in direction X and Y at three levels in each cylinder as shown.



Cylinder Bore Size:
Standard (New):
A or I: 85.010 – 85.020 mm (3.3468 – 3.3472 in)
B or II: 85.000 – 85.010 mm (3.3465 – 3.3468 in)
Service Limit: 85.070 mm (3.3492 in)

Fig. 11 Measurement of cylinder block bore taper [7]

Piston Diameter:
Standard (New):
No Letter (A): 84.980 – 84.990 mm (3.3457 – 3.3461 in)
B: 84.970 – 84.980 mm (3.3453 – 3.3457 in)
Service Limit:
No Letter (A): 84.970 mm (3.3453 in)
B: 84.960 mm (3.3449 in)

Piston Ring End-Gap:
Top Ring
Standard (New): 0.20 – 0.35 mm (0.008 – 0.014 in)
Service Limit: 0.60 mm (0.024 in)
Second Ring
Standard (New): 0.40 – 0.55 mm (0.016 – 0.022 in)
Service Limit: 0.70 mm (0.028 in)

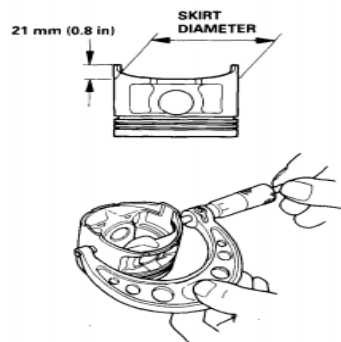


Fig. 12 Measurement method of piston diameter and piston rings end gap [7]

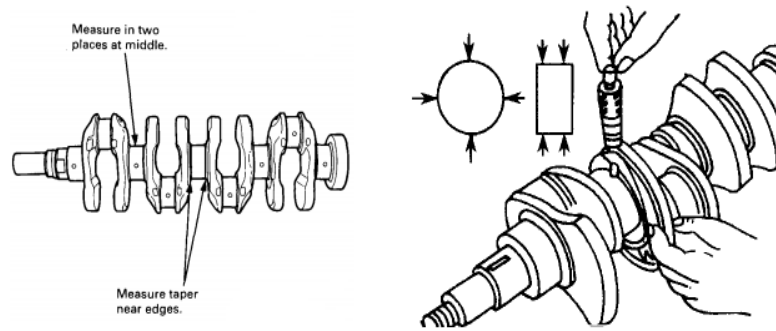


Fig. 13 Measurement of crankshaft main journal diameter and clearance [7]

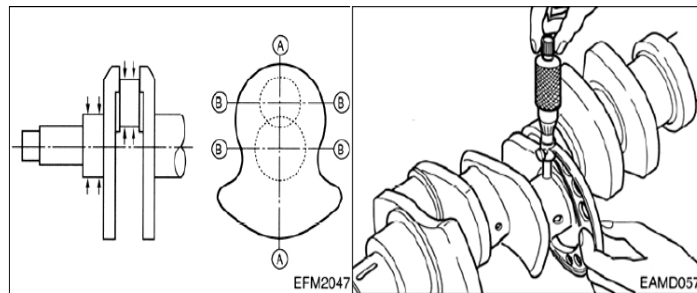


Fig. 14 Measurement of connecting rod journal and clearance [7]

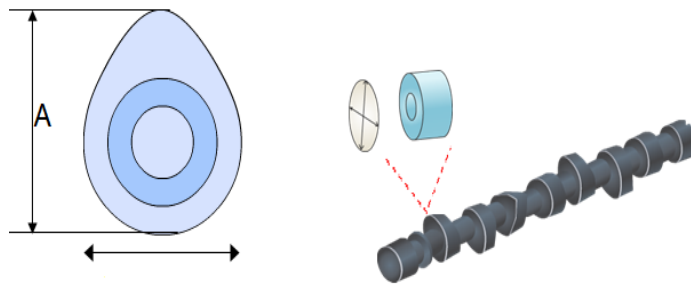


Fig. 15 Measurement of Camshaft height clearance [7]

TABLE I
CYLINDER BLOCK WARPAGE

Cylinder Block Warpage (mm)	1	2	3	4	5	6	Service limit
	0.03	0.015	0.03	0.03	0.05	0.05	0.10

TABLE II
CYLINDER BLOCK BORE TAPER

Cylinder block bore taper (mm)	1	2	3	4	Standard	
Bore A	85.26	85.22	85.24	85.22	85.010	85.020
Bore B	85.25	85.25	85.23	85.24	85.000	85.010
Taper AB	0.01	0.03	0.01	0.02	0.005	

TABLE III
PISTON DIAMETER AND PISTON RINGS END GAP

piston diameter (mm)	1	2	3	4	Standard
	84.960	84.965	84.960	84.970	84.980~84.990
piston rings end gap	Standard				
top ring	0.19	0.19	0.19	0.19	0.2~0.35
Second ring	0.24	0.24	0.24	0.24	0.4~0.55

TABLE IV
CRANKSHAFT MAIN JOURNAL DIAMETER AND CLEARANCE

Main journal diameter (mm)	1	2	3	4	5	Standard
A	49.99	49.98	49.97	49.99	50.00	Journal 1.4 49.984 50.008
B	49.995	49.985	49.975	49.99	49.99	Journal 2 49.976 50.000
Taper AB	0.005	0.005	0.005	0	0.01	Journal 3 49.972 49.996
						Journal 5 49.988 50.012

TABLE V
CONNECTING ROD JOURNAL CLEARANCE

connecting rod journal (mm)	1	2	3	4	standard
A	44.985	44.99	44.985	44.99	44.976~45.000
B	44.985	44.985	44.985	44.985	
Taper AB	0	0.005	0	0.005	

TABLE VI
CAMSHAFT HEIGHT CLEARANCE

Camshaft height (mm)	1	2	3	4	5	6	7	8	Standard
Intake A	38.70	38.71	38.72	38.72	38.72	38.71	38.72	38.73	38.741
B	33.42	33.40	33.41	33.40	33.40	33.41	33.41	33.42	
Exhaust A	38.96	38.96	38.95	38.95	38.96	38.96	38.96	38.96	38.972
B	34.04	34.05	34.04	34.035	34.035	34.035	34.035	34.04	

IV. CONCLUSIONS

To investigate whether multi-level (heavy duty) gear oil has the same lubricating effect as engine oil, gear oil was added to the gasoline engine of a Honda Accord. The engine oil performance was checked every 10,000 kilometers in driving test.

The results show that: 1) Multi-level gear oil seems possible to be used as oil in a gasoline engine. 2) Impurities in the engine caused wear on the parts. 3) The viscosity of the oil increased when the driving test was completed, which indicates that car owners must conduct periodical oil changes. 4) Engine oil can be changed approximately every 10,000 km in older vehicles. 5) Average fuel consumption is 11.5km/l per 100,000 km.

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