

Evaluation of Physical Characteristics and Phosphorus Contents to Assess the Quality of Commercial Gear Oils

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Abstract: In the present work, quality of twelve commercial gear oil brands has been assessed by evaluating the physical characteristics and phosphorus contents. Physical parameters (Flash point, Pour Point, Viscosity index and Kinematic viscosity) and phosphorus contents were determined by standard test methods recommended by the American Society for Testing and Material (ASTM). Evaluated parameters have been compared with PSI standard specifications and the manufacturers specifications. Results indicate that none of the gear oil samples satisfy fully PSI standard test limits specified for Extreme Pressure Grade gear oils. Only a few samples have fulfilled the specifications given by the manufacturers. Marketing of sub-standard gear oil products in Pakistan is an alarming situation. Government of Pakistan should take strict measures to improve the quality of gear oils widely used in sophisticated machines.

Key words: Physical characteristics, phosphorus, quality, gear oils

Introduction

The range of uses for gear oils is very wide and includes industrial, automotive, marine and aviation applications. Gears are used to increase or decrease the speed of shafts and to change the direction of the drive. A variety of gears are employed in industrial applications such as spur gear, spiral gear, helical gear and double helical gear. Gear teeth have natural wiping action on lubricants during their movement and thus remove most of the lubricant so that there is virtual metal to metal contact. Thus gear teeth create almost a pure boundary situation. This wiping action is a problem in spur gears but with helical gears the situation becomes more complicated as the gears not only wipe off the lubricant, they also tend to force it out from the teeth towards the sides of the gears. Hypoid gears are refinement of spiral bevel gears in which the gears are offset. They were originally developed for automotive differential (back axles). Hypoid gear is a combination of spiral bevel and worm gear. The motion of the teeth is a combination of rolling and sliding, causing high loading pressure on the tooth faces together with rubbing velocity. Because a hypoid gear develops an enormous sliding action between the teeth, it is possible exception of the worm gear, the most difficult gearing arrangement to lubricate, demanding exceptional qualities of the lubricant. Extreme pressure (EP) agents are used to meet these demands (Elliott, 1963; Hitchcock and Edwards, 1960 and Pinkus and Sternlicht, 1975).

The important chemical additives used in lubricating oils to improve the properties of the base oil for a particular use are: oxidation inhibitors and antioxidants, corrosion and rust inhibitors, antiwear and extreme pressure agents, detergents and dispersants, pour point dispersants, viscosity index improvers, foam inhibitors, emulsifiers. Some other additives are also added to increase the aesthetic appeal of the lubricants. These additives include tackiness additives, oiliness additives, wettability agents, water repellents, dyes and color stabilizers, antibacterial additives and odor masking additives. Phosphorus containing compounds such as selenophosphates, tributyl-selenophosphates, tributyl thiophosphates, tributyl phosphate, triphenylphosphite, tri-P-tertiary amyl phenol phosphite and their derivatives used as antioxidant additives are superior to corresponding sulphur compounds (Wood, 1969). Selection of additives is made depending upon the interaction of additives with each other or with the oil or metal in contact.

Tests have been developed for lubricants to assess physical and chemical properties which have important bearing on the functioning of lubricants in practice. The physical and chemical methods of testing lubricants can be broadly divided into three groups: tests for the determination of physical constants, tests related to application and tests related to composition. Physical parameters play an important role in the application of lubricants. The physical characteristics which are usually specified in specifications of lubricants are viscosity index, kinematic viscosity, density and specific gravity, flash point, penetration value, pour point, dielectric constant, evaporation loss, interfacial tension and color. Objective of this study was to assess the quality of Extreme Pressure (EP Grade) commercial gear oils marketed by various companies in Pakistan.

Materials and Methods

Twelve commercial gear oil samples of different grades were collected from the local market. A list of commercial gear oils and their manufacturers is given in Table 1. Physical parameters such as Flash point, Pour point, Viscosity index and Kinematic viscosity were determined following the American Society for Testing and Material (ASTM) methods D-92, D-97,

Table 1: List of commercial gear oils and their manufacturers

Sample no.	Oil/grade description	Manufacturer
1	Gear oil EP-140 (GL-4)	A
2	Gear oil EP-140 (GL-4)	B
3	Gear oil EP-90 (GL-5)	C
4	Gear oil EP-90 (GL-4)	C
5	Gear oil EP-90 (GL-4)	D
6	Gear oil EP-90 (GL-4)	E
7	Gear oil EP-140 (GL-4)	E
8	Gear oil EP-140 (GL-5)	E
9	Gear oil EP-140 (GL-4)	F
10	Gear oil EP-140 (GL-4)	G
11	Gear oil EP-140 (GL-4)	H
12	Gear oil EP-140 (GL-4)	I

D-2270, D-445, respectively. Phosphorus contents were measured following ASTM-D 4047 method (ASTM, 1999).

Analytical Grade Reagents supplied by Merck were used throughout this work. Measurements were made using Viscometer Bath (VCH-220-DIOV, VCH-22003P, Gallenkamp), Flash Point Tester (Semi automatic 3531-000-00, Lauda), Pour Point Tester (SETA, England), Muffle Furnace (FSE-621 series, Gallenkamp) etc.

Results and Discussion

Physical parameters such as Flash point, Pour Point, Viscosity index and Kinematic viscosity and phosphorus contents were determined in twelve Extreme Pressure (EP Grade) commercial gear oil brands following ASTM D-92, ASTM D-97, ASTM D-2270, ASTM D-445 and ASTM-D 4047 methods, respectively. Results have been presented in Table 2.

Evaluated parameters have been compared with Pakistan Standard Institution (PSI) standard specifications (PSI, 1990) and the Oil Blending and Marketing Companies recommended specifications for different Extreme Pressure (EP Grade) gear oils.

Table 2: Physical parameters and phosphorus contents of commercial gear oil samples determined by ASTM procedures

Sample no.	Oil/grade description	Manuf-cturer	Kinematic viscosity @ 100° C cSt/sec	Kinematic viscosity @ 40° C cSt/sec	Viscosity Index	Flash point °C	Pour point °C	Phosphorus Wt %
1	Gear oil EP-140 (GL-4)	A	36.199	713.54	82	264	-12	0.047
2	Gear oil EP-140 (GL-4)	B	31.136	551.25	84	246	-17	0.006
3	Gear oil EP-90 (GL-5)	C	28.24	465.6	85	238	-36	0.064
4	Gear oil EP-90 (GL-4)	C	29.28	486.94	86	216	-24	0.057
5	Gear oil EP-90 (GL-4)	D	29.77	450.18	95	240	-16	0.054
6	Gear oil EP-90 (GL-4)	E	26.32	369.84	95	220	-25	0.069
7	Gear oil EP-140 (GL-4)	E	30.18	527.0	83	226	-17	0.047
8	Gear oil EP-140 (GL-5)	E	30.10	534.93	81	234	-33	0.054
9	Gear oil EP-140 (GL-4)	F	27.80	425.33	88	202	-16	0.058
10	Gear oil EP-140 (GL-4)	G	27.80	363.28	100	180	-39	0.039
11	Gear oil EP-140 (GL-4)	H	31.96	448.12	86	236	-13	0.061
12	Gear oil EP-140 (GL-4)	I	27.47	425.47	89	202	-17	0.049

Table 3: Pakistan Standard Institution (PSI) specifications for different parameters of gear oils

Parameter	Grade		Test method
	EP-90	EP-140	
Flash Point (min.)	240° C	248° C	ASTM D-92
Kinematic Viscosity @ 100 °C cSt/sec	13.5 (min.)	24 (min.)	ASTM D-445
Viscosity Index	23.9 (max.)	40.9 (max.)	
Pour point	90	90	ASTM D2270
Copper Strip	NR	NR	ASTM D-97
Corrosion 3 h @100° C	1 (max)	1 (max)	ASTM D-130
Phosphorus wt %	0.045 (min)	0.06 (min)	ASTM D-4047
NR Not Reported			

Table 4: Manufacturer's specifications for different parameters of commercial gear oils

Oil/grade description	Manufacturer	Kinematic viscosity @ 100°C cSt/sec	Viscosity index	Flash point °C	Pour point °C	Phosphorus Wt %
Gear oil EP-140 (GL-4)	A	24.0 to 41.0	70	204	-15	0.045
Gear oil EP-140 (GL-4)	B	19.0 to 20.0	98	245	-15	0.039
Gear oil EP-90 (GL-5)	C	32.0 to 46.0	81	240	-20	0.046
Gear oil EP-90 (GL-4)	E	25.0 to 30.0	90	235	-18	0.048
Gear oil EP-140 (GL-5)	F	24.0 to 41.9	85	210	-15	0.045
Gear oil EP-140 (GL-5)	E	28.0	90	240	-25	0.024
Gear oil EP-140 (GL-4)	I	24.0 to 40.0	89	248	-30	0.029

Results indicate that none of the gear oil samples satisfy fully the PSI standard specifications for Extreme Pressure gear oils regarding physical parameters and phosphorus contents (Table 2). However, it has been observed that some of the gear oil samples show some parameters up to the required standard specification but values for other parameters do not. All EP-90 and one EP-140 Grade gear oil sample met the required phosphorus contents specified by PSI but other EP-140 Grade gear oil samples failed to meet the standard requirement. It is worth mentioning that different gear oil marketing companies in Pakistan do not follow the standard specifications as prescribed by PSI for EP-90 and EP-140 Grade gear oils. In comparison to manufacturer's own standard specifications, gear oil samples tested for physical parameters show variable values. However, phosphorus contents have been found acceptable according to company's standard specifications. Only a few samples have fulfilled all the specifications given by oil marketing companies.

Marketing of sub-standard Extreme Pressure (EP-90 and EP-140 Grade) gear oil products in Pakistan is highly alarming. It is suggested that the Government of Pakistan should take strict measures to improve the quality of gear oils widely used in sophisticated machines.

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