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Engine's lubrication oil degradation reasons and detection methods: A review

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ABSTRACT

The main requirement of engine lubrication oil is to lessen the wear on the engine parts, reduces corrosion, clean, improves sealing and also to reduce the heat from the engine. If this oil is not frequently changed, dirt and sludge can develop on the engine and this old and impure oil won't properly lubricate the engine moving parts such like new lubrication oil does. Dirty oil can cause the serious damage, and if it continues as bad enough, it can be even an engine replacement happens in the near forthcoming period. The scope of this review article is to discuss various methods of detecting the degradation of engine oil by various methods in detail.

KEY WORDS: Lubrication oil contamination, detection methods, sensors.

1. INTRODUCTION

Lubrication oil in Engine Lubrication system: When the vehicle isn't in motion and the oil isn't being used, it pools in the oil pan, also known as a sump as shown in figure 2, which is located under the engine. The oil pan holds engine lubrication oil. When the vehicle starts, the oil pump sucks the oil to the top using pickup tube. The oil transfers through the oil filter to remove any dirt or debris that the oil picked up on circulation around the engine. The oil then goes through spurt holes in places like the crankshaft and the bearings to keep these parts lubricated. When the car turns off, gravity takes over and the oil returns to the oil pan. Lubricating oil produces an intense film between the surfaces of closely moving parts to reduce the direct contact between these parts, lessening heat produced by abrasion and reducing wear, thus provides the shielding to the engine. During usage, engine oil handovers heat through convection while it runs through the engine in the form of air around the oil pan, oil cooler and through the accumulation of oil gases getting out through the Positive Crankcase Ventilation (PCV) system. The predictive maintenance environment model is shown in figure 1. The service provider will keep monitor the vehicle systems through the network provider and receive data to their service location. Based on it the vehicle user will get information about service need of the vehicle.

In petrol type engines, the piston ringon the top which exposes the engine oil to the temperature of 160 degrees Centigrade. In diesel engines, the top piston ring can expose the oil to temperatures over 315 degrees Centigrade. Coating metal parts with oil also keeps them from exposing to oxygen, stopping oxidation at projected operating temperatures which prevents rust or corrosion. Many engine lubrication oils also have detergents and dispersants mixed to maintain the engine to minimize oil sludge created and clean.

Because of heavier operating load, temperature effect, speed and the formation of foreign substances into the lubrication oil system, there will be a chances that the system slowly loses the properties and it becomes harmful for the engine operation. Further, it is always good to recognize the oil contamination and report earlier to the user using warning light in dashboard, Jun (2006), quantify the Viscosity, Fuel soot, Water contamination, Fuel dilution, Antifreeze, Permittivity, Oxidation and Oil consumption of the oil and oil quality indicators which specify when to replace the oil. Jan Kraljr (2014), quantify the Kinematic viscosity, Soot Carbone, Oxidation products, Nitrating products, Sulphating products, Aromatic products, Water presence, Glycol presence and High antioxidant. Charlotte Besser (2013), investigated the influence of bio-fuels on the engine oil steadiness. The author used two fully framed engine oils were artificially changed in a novel laboratory modification device as well as evaluated in a chassis dynamometer test bench. The author found that the amount of anti-wear additive (ZDDP) during artificial alteration dropped down to a low level of 20–30%.

Adnan Mujahid and Franz Dickert (2012), presented a decision about performing an oil change depends on driving behavior and the automotive operational conditions which cannot be generalized. The exact valuations of engine oil condition online monitoring systems areinflexible Gebarin, (2004). Current articlesconcerning oil degradation monitoring add very little when considering the regular oil changes recommended by a large number of vehicle manufacturers. Oil changes based on dielectric measurements were once performed by Mercedes but this is no longer the case. Various marketable sensors have been tossed including the GM oil life system GM, (2012) Delphi Intellek oil condition sensor Basu, (2000) Daimler Chrysler system Bodensohn (2005), Symyx oil condition monitoring, Bennett, (2005) and other different companies bring together oil degradation sensors.

Zolkapli, (2012) developed a sensor unit which has LED and LDR placed in a vertical alignment and fixed inside a Perspex material block. The author performed the test to predict the mileage of the vehicle with respect to contamination of the engine oil while using with across the different kilometres. Idros, (2011) use UV/VIS Spectrometer to examinethe optical behavior of lubricant and the correlation with real factor of lubricant such as Total Acid Number, oxidation and contamination.

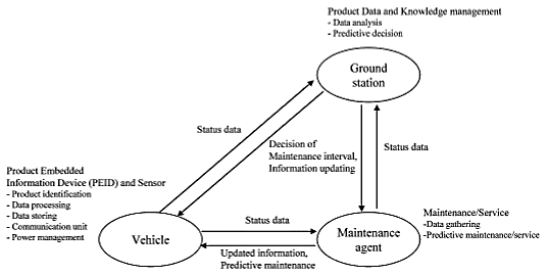

Figure.1. Predictive maintenance environment model

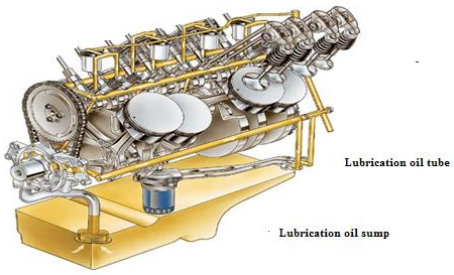

Figure.2. Engine Lubrication system

How Lubrication oil in engine is contaminated or degraded?

There are several majors factors contribute to the lubrication oil's degradation, but it is essentially the growth of contaminants in the oil and chemical variation in the oil itself which makes the lubrication oil unhealthy for further usage. With time, it is unavoidable that the oil will be contaminated by dirt or sludge and need to get identify in advance to safeguard the engine which is costlier part any vehicle.

Extreme Heat: Engine is hotter part of automotive. More powerful engine assembly, turbo chargers and aerodynamic design have formed highly hot situations that get less cooling from surrounding air. This high heat can leads to oil oxidation, bonds and thickening in conventional oils. The small, less weight molecules in conventional oil tend to disappear as the oil is heated, leaving large, heavy molecules behind and produce to oil consumption and increase in the oil's thickness. These large and heavy molecules are chemically unbalanced and they may also collapsed and form deposits on component surfaces, further constraining the release of heat into the oil stream. Even comparatively in medium temperatures, oxygen works to broken some of the substances into conventional lubricants. The extreme heat in engines truly promotes oxidation. When the conventional oil impurities break down, it coat the components with varnish, deposits and sludge and leave the lubricant thick, unable to pump and with very poor heat transfer capability.

Extreme Cold: Generally cold temperature is the reason for oil to become thicker. Conventional lubricants contain paraffins which makes the oil to thicken in fewer temperatures as the paraffin gels. Initially, this can leave working parts unguarded for as long as five minutes while the oil warms to a temperature that allows it to flow.

Common Contaminants: The dust and dirt from the air will enter into the engine through defective air cleaners, and crankcase ventilation systems. Normal engine wear creates small metal particles that are picked up and distributed by the oil. The rough particles of lane dust raise the rate of wear and generate bigger metal particles. Those particles are similarly rude and the degree of wear quickens with a snowball effect. While purification removes most of these impurities, some remain and are left to circulate with the engine oil.

Methods of oil contamination detection: There are only 4 major methods of oil contamination detection which has been adapted by various automotive companies' products as given below.

- Capacitance Method
- Electrochemical Bead Matrix Method
- Algorithmic Method
- Acoustic Waves Method

Capacitance method: In the capacitance method Jaedong Cho (2010), a capacitor has two conducting plates separated by an insulating material called as dielectric. In this capacitance based oil condition sensor, the oil is considered as insulating fluid. Capacitance is reliant on the surface part of the plates and the gap between these two plates and the insulating material. As the oil worsens, the capacitance quantified also changes and Capacitors store charge over time. It is similar like storing a bucket with a hole at the foot, and also it delivers pressure on the hole when it is full. The capacitor requires time to charge fully and it also requires time for it to release. After fully charges, the voltage is provided across the capacitor.

The INTELLEK Oil Condition Sensor (Basu, 2000) which is the product of Delphi Automotive uses both an intelligent algorithm and sensing element that straightaway measures numerous oil properties. This algorithm takes into all consideration of all important factors affecting the quality of oil deteriorating like temperature, driving rigorousness, oil level and oil type. It also measures the temperature every 10 seconds to confirm whether it attains the specific normal operating temperature before the engine locks off. It also accounts the number of times the engine turns power on and off.

An exclusive capacitive detecting element is the essential technology. It follows the oil's conductivity, senses glycol contamination and water, oil temperature and defines the oil level. According to Delphi Automotive, the lubricants conductivity is substantial since it describes seasoning depletion and variation in width and acid number. This INTELLEK Oil Condition Sensor system recognizes as many various parameters using on-board software in order to specify when the lubricant is forth coming to the end of its working life.

Electrochemical Bead Matrix Method: In this method a polymeric bead matrix comprising charged groups that help as a conductive path for measuring the solvent properties of lubricant. In this method, it works similar to the battery works. The charged resin beads which are in milligram sized are enclosed between two conductive surfaces parted by a nonconductive medium. Further, the charged groups of beads composed of both anions and cations can alter to form an electrochemical link of changing strength subject on a relative change in the polarity of the oil. Since engine oils are fairly nonpolar and the beads are ionic, the beads do not have arrangement a conductive bridge. As the lubricant starts to worsen, the fluid becomes more polar such as conducive to ionic interactions and a bridge begins forming. This relative modification in conductivity is further measured between these two conducting surfaces.

Algorithmic Method: In the Algorithmic method, it uses mathematical representations based on study to define the optimum oil change intervals. Conditions like fluid speed, time, temperature and other acute factors are observed and merged into the algorithm. Since the method do not actually test the thickness of the oil, it cannot test for engine damage, coolant leaks, etc. So this method does not utilised by major OEM's (Original Equipment manufacturer)

Acoustic wave Method: In the acoustic wave's method (Lec, 1997; Hammond, 1997), micro acoustic device defines the thickness. This device uses the piezoelectric effect to electrically stimulate high-frequency mechanic (or acoustic) vibrations at a sensitive surface. When this sensitive surface approaches into contact with the oil, the electrical device parameters, such as oscillation frequency and damping, are changed according to the oil's mechanical properties, especially thickness. Thus, the viscosity can be electrically detected by calculating these parameters. The microacoustic sensor does not comprise any moving parts. Furthermore, due to its small size, it can be easily combined into the multifunctional oil-level and condition sensor.

Bosch multifunctional oil sensor is more suitable for spark-ignition and diesel engines convert ultrasound waves to electrical signals or vice versa. There are varieties of applications available with ultrasonic sensor. The Ultrasonic sensors are extensively used in vehicles as parking sensors to support the driver in moving back into the parking spaces. Also they are being verified for a number of other automotive uses including ultrasonic people detection and assisting in autonomous Unmanned Ariel vehicle navigation.

2. CONCLUSION

Oil contamination analysis has been done with three parts. They are

- Properties of the lubricant
- Condition of the lubricant
- Fueldirt contamination and dilution

The oil analysis can increase the engine lifetime, decrease failure, and lessen money paid for healing. At present, changing oil is advised at periodical intervals and the number of kilometres of vehicle used. But the engine condition and drivers driving style and operating environment is different for each vehicle. By considering all these situations, the global automotive market is expecting some simple warning system to predict the contamination level of lubrication oil at low cost.

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