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A technology review for lubricating oil sensors in reference to lubricating properties of engine oil

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***Abstract* – Lubricating Oil in any machine is like vital fluid as blood in human body, unlike humans this vital fluid cannot be purified and hence it is to be replaced for proper functionality of any machine. So detection of quality of oil becomes more important. Many methods are proposed and for detection some of them are on-board sensors while some requires samples to be collected and sent to laboratory for finding quality. Many methods and sensors are presented in this paper. Mainly quality of oil is measured by detecting any of the following property:-**
Refractive index, dielectric coefficient and viscosity of oil etc
These methods and sensors are still not very popular that is why most of detection work is done manually by an operator. The method used by operator is usually visual method (by color of oil).

Keywords – Lubricating oil, oil quality, optical sensor, incuctive sensor, contact sensor.

I. INTRODUCTION

Many methods are developed for finding quality and quantity of lubricating oil. Goal of this review paper is to explore most of the methods for detecting quality of lubricating oil and find out advantage and disadvantages of each.

A. Dipstick with automatic warning device[1]

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The object Fig. 1 of the method is to provide automatic dipstick with automatic warning Lamp for visual indication by a light denoting the of a low level of oil in any type of combustion engine. if excess of oil is present I the oil chamber of oil is also indicated by a presence of a high level of oil. It includes circuitry and mechanical actable members that are mainly cooper. Device can give information about conditions of oil level(s) inside oil chamber. consisting of an insulating hollow pipe constructed so that it can be inserted into and arranged to be inserted within an inner side of a dipstick housing for an oil chamber of an any engine and having an upper end and a lower end thereof, indicator disposed externally on the insulating tube used for indicating ADD and FULL and the like conditions of a oil there are contacts preset electrical contact means FULL of the insulating tube (14), a plastic cover (20,22) which is located at lower side and below disposed at opening of the pipe inside oil chamber extending there through for passage of oil from the oil chamber so as to support contact of the ball if level of oil in the chamber changes insulating tube, a conductive floatable ball (40)the diameter is sufficient to bridge respective sets of electrical contacts an upper cap closing off the upper end of the insulating tube, a 4-wire connector (44) disposed in the upper cap for coupling for communications member for coupling.
Method is not for Quality of oil but quantity of its

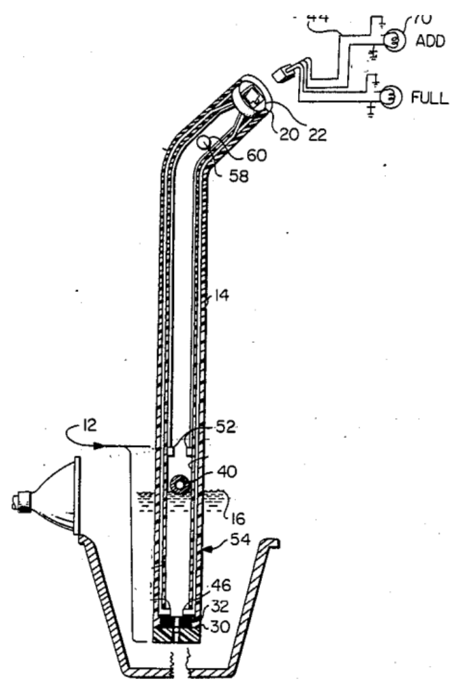

Fig. 1 Construction Dipstick with automatic warning device [1]

B. An acoustic automotive engine oil quality sensor [2]

In this sensor arrangement make use of acoustic shear waves to monitor condition of oil. Acoustic waves are generated with the help of a piezoelectric resonator present in oil. Contamination of oil changes visco-elastic properties of the oil, which produce change in phase ,frequency of the shear

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waves, and hence piezoelectric resonator (resonance frequency). Equivalent electric circuit for a piezoelectric resonator when it is loaded (viscous) is represented as inductor and capacitors shown in Fig. 2. The circuit parameters inductance ***L*,** and resistance ***R*,** both change as a function of viscosity and density of oil, which also affects the resonant characteristics of the resonator circuit represented.

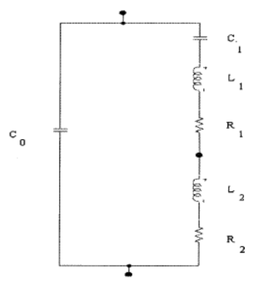

Fig. 2 Equivalent circuit for piezoelectric resonator

C. A remote acoustic engine oil quality sensor[3]

An equivalent circuit representation for a piezoelectric resonator, in visco-elastic liquid is shown in Fig. 3. The parameters C_0 ,C_1, L_1, and R_1, are for non immersed resonator which is non immersed. The parameters L_2, and R_2 equivalent to loading of the resonator due to viscosity change. There exist relations between the characteristics of the piezoelectric resonator and the oil, an resonator's equivalent electric circuit can be represented with the help of a expressions. The oil quality depends on changes in the visco-elastic properties of the oil, mainly effect the electrical properties such as resonance frequency of the piezoelectric resonator represented here, due to the changes in L_2andR_2.

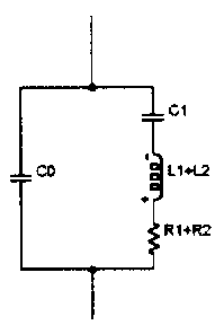

Fig. 3 Resonator's equivalent electric circuit

System of measurement make the use of Voltage Controlled Oscillator (VCO) . This system at the same time effect added to produce phase and amplitude changes of the signal which is being sensed.

V_{DC} voltage = $K |s_{12}| \cos\Phi_Q$ …..(1)

K the V_{CO} system detection constant.

$|S_{12}|$ is scattering parameter magnitude

Φ_Q difference in phase the sensing and reference level.

D. A Novel Approach to On Line Oil Quality Sensing Through Side- Polished Optical Fiber[4]

System proposed is consists of an optical fibre sensor in which the transmitted optical power output is at fixed wavelength. The optical fibre silica (9/125 m) in order to perform polishing lapping machine along with fibre held with mask to avoid breakage .polishing process was monitored by microscope until the desired depth was obtained. Thermocouple used to find oil temperature. Whole setup kept inside a thermal bath to obtain temperature change .Data acquisition was performed with same value of a monochromatic light source having wave length 568 nm. the silicon detector was operating at wavelength 350 to 1100 nm. This resulted into degrading of the optical power due to coupling power by medium in contact this solely depends on the optical property external medium such as oil used in this case.

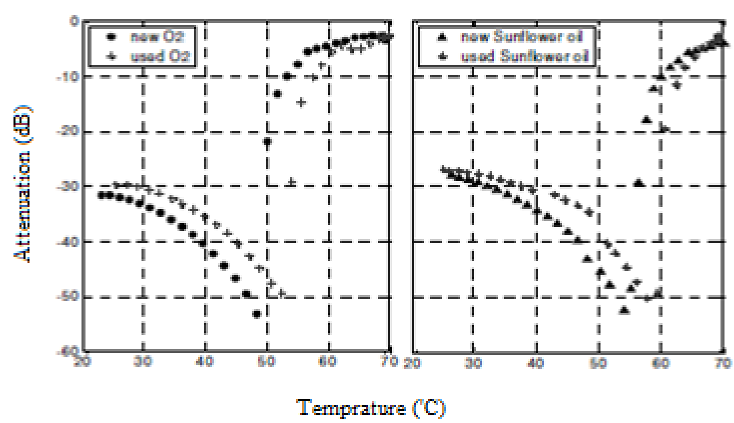

Fig.4 Curves of used and unused oil optical attenuation with temperature

E. A novel method for online monitoring engine oil quality based on tapered optical fiber sensor[5]

In this paper, the change of refractive index of oil related to measure changes optic properties and predict age of engine oil. Large difference in oil parameters observed with respect to a minute variation of refractive index. Proposed sensor can be used to precise detection of oil quality over a period of time. proposed setup is shown in Fig.5

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$$dp = \frac{\lambda}{\sqrt{2\pi\sqrt{n\, l_{cl}^{2}\, \sin 2\theta - n_{ex}^{2}}}} \qquad \ldots\ldots(2)$$

Where, λ is the wavelength of laser light used (808nm), θ represent the incidence angle of the light at the cladding(optical fiber) external medium interface., l, taper length, d_p, penetration depth, n_{co}, n_{cl} and n_{ex} are the indexes for core, cladding and external medium, respectively.

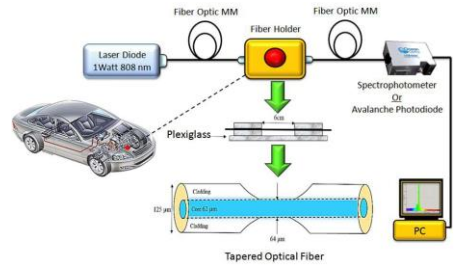

Fig. 5 setup for system

TABLE I

COMPARISON OF VARIOUS KIND OF SENSING TEQUENIQUES

S. no.	Reference	Technique(s)	Advantage	Disadvantage
1	Dipstick with automatic warning light	Quantity of engine oil tested using floatable conducting ball and a tube containing copper electrodes in which contact is made and breaker by floating conductive ball.	The simplest system for detecting level of engine oil. No modifications in engine are required. No requirement microprocessor or complex electronic circuits.	Quality of oil not reported Requires regularly maintained components Only two options to display
2	An acoustic automotive engine oil quality sensor	Acoustic waves are generated with a piezoelectric resonator present in oil. Contamination of oil changes visco-elastic characteristics of the oil, which produce change in characteristics of the shear waves, and hence piezoelectric resonator (resonance frequency).	Accurate method of testing oil quality. Oil quality can be displayed in percentage etc. Circuit is away from machine so less effected by temperature	Shear waves are affected by temperature. Sensor itself requires complex circuit. Not easy to install on board.
3	A remote acoustic engine oil quality sensor	Piezoelectric probe having shear mode and a on-board VCO based electronic measurement system. Capable identifying different grades and relating oil condition resulting from engine operation and contamination due to dilution with water, coolant and gasoline etc	Resonance frequeucy measurement may have noise but inductive property was used in it .hence low noise Can differentiate between new and used oils	Circuit required is complex and requires isolation Dedicated section for oil quality measurement hard to make on board
4	Electrical measurement of oil	Sensor is based on the capacitive measurement relative to permittivity of the oil, Having an oscillator circuit and sensor is one of the component of unit for measurement The oscillator circuit comprises a LC oscillator Which provides an output signal, whose amplitude dependent upon the looseness of the oil.	Direct relation of lessens of oil with permittivity. System does not requires dedicated microprocessor etc.	Based on oscillator circuit so requires stabilization. Temperature drift may produce large variation in signals.
5	A Novel Approach to On Line Oil Quality Sensing Through Side-Polished Optical fiber	A polished and grooved optical fiber was used which was immersed into the oil whose characteristics needs to be determined. Thermocouple was used to find temperature. Viscosity of oil can change optical properties of wavelengths traveling via optical fiber.	Method uses optical property for measurement. Optical property and temperature both are measured simultaneously.	Optical fiber requires complicated coupling and range of sensor may vary. Sensor must have thermocouple in oil bath making it more complicated and large in size.
6	A Novel Method for online monitoring Engine Oil	In this optical fiber was used as a medium for sensing oil quality. A laser diode was used for the purpose of light which would pass through optical fiber and refractive index of fiber was varied as the lubricating properties	Contact less type of sensor requires low maintenance. More accurate due to presence of spectroscope. Do not require temperature sensor	Spectroscope is costly and complex hard to make on board sensor. No temperature compensation provided. Optical fiber construction is guided

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	Quality Based on Tapered Optical Fiber Sensor	of oil changes.	for its working.	under microscope so hard to manufacture such sensor.

CONCLUSION

Comparison of oil quality sensor was made. In this different types of sensors were seen along with very basic such as oil level sensor and advances one with inductive properties related oil viscosity. Optical sensors are included in the comparison having use of optical fibers (specially constructed) having used along with temperature compensation and the without temperature compensation as oil behaves differently on different temperatures. From all the sensors and system studied and identified need for oil quality sensor arises for modern engines may be mobile or immobile engines as per emission standards in today's world. From above study need for a accurate oil sensor arises for the modern engines. Optical sensors are more accurate but are complex to make, while inductive and capacitive sensors are less accurate but easy to make. Both of sensors compared are difficult while making it on board in reference to above comparison following things should be considered along with their priority:-

1. System should be simple and easy to implement on most of the engines.
2. Should use as basic phenomena for sensing and quantitative approach should be followed.
3. System should be reliable and compatible with previous standards and norms.
4. Sensor must have medium level of accuracy.

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