A Portable IoT Based Dipstick Type Engine Oil Level and Impurities Monitoring System Using RF Signals

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ABSTRACT:

Engine oil and lubricating oil in internal combustion engines are exposed to varying strains depending on the operating conditions and the fuel quality therefore it is essential to maintain the quality of engine oil and Lubricating oil so as to minimize the friction within the Engine. On one hand the oil must be changed in time to avoid possible engine failures, on the other hand an unnecessary oil change should be avoided for environmental and economic reasons. Degradation of lubricant and engine oil impacts the performance of the machines such as gears, transmissions or automatisms where they are being used, and often the degradation of the lubricant properties is the cause of downtimes, dramatic failures and increases carbon footprint. Periodic change of these oils is a basic part of the maintenance program of Engine servicing operation which is not an optimum method economically and qualitatively.

Dielectric constant is important indicator of motor oil quality. The conductivity characteristics are relative to influence of impurities concentration, which have various origins. A Portable IoT based Dipstick Type Engine Oil Level and Impurities Monitoring System contains a circularly polarized antenna which is made up of a series of proposed PCM elements which is used to transmit and receive RF signals which detects the impurities present in the Engine oil. Quantity grading done by using two sets of LDR and light source in the developed dip stick. One set is situated at the bottom of the dip stick and other set is mounted 20 mm above the first detector set. Missing signal from bottom detector depicts the low level of oil present in reservoir. Therefore the quality and quantity of engine oil reports can be generated and transmit through a Wi-Fi module to any mobile application from which the users can make quick decisions.

INTRODUCTION:

Knowing the fact that low engine oil levels can be fatal for the engine, the engine oil pressure sensor comes very handy, But the bitter truth is not all two wheelers come featured with this piece of technology, therefore we still have to rely on our instincts and have to be vigilant as far as monitoring the engine oil levels in our rides are concerned. When we talk about our instincts every biker knows how to communicate with his/her ride. Often when the engine starves for the fluids the roughness starts augment and one can feel the heaviness in the engine, the transmission also becomes clunky and chattering sound becomes audible. IoT based Dipstick Type Engine Oil Level and Impurities Monitoring System will be able to detect the quantity of Engine oil present and also detect the impurities present in the Engine oil. Therefore the quality and quantity of engine oil reports can be generated and transmit through a Wi-Fi module to any mobile application from which the users can make quick decisions.

DETAILED DESCRIPTION OF THE INVENTION:

Knowing the fact that low engine oil levels can be fatal for the engine, the engine oil pressure sensor comes very handy, But the bitter truth is not all two wheelers come featured with this piece of technology, therefore we still have to rely on our instincts and have to be vigilant as far as monitoring the engine oil levels in our rides are concerned. When we talk about our instincts every biker knows how to communicate with his/her ride. Often when the engine starves for the fluids the roughness starts augment and one can feel the heaviness in the engine, the transmission also becomes clunky and chattering sound becomes audible.

The best way to keep an eye on the engine oil level is by regularly checking the oil level through the oil gauge. The gauge is a dip stick that dips into the oil pan present at the bottom of the engine where the engine oil lies. Automobile producers endeavor to quantify the motor oil quality by direct measurement of parameters in real time by utilization of on-board sensing system based mainly on: evaluation of parameters using on-board sensing of temperature, viscosity, density, and dielectric properties, determination of correlation between level of contamination and oil properties change, quantification of oil properties change with motor operation cycle and identification of possible reasons of changes in motor oil properties.

A. Dielectric Property estimation of Oil

The dielectric properties of the oil are represented mainly by viscosity – measure of resistance or inner friction against deformation or flow of liquid media, which is deformed by shear or tensile stress. The Newton law was formulated for laminar flow, by which the tangential stress is proportional to dynamic viscosity and to velocity gradient of liquid. In motor aggregate environment, the temperature dependence of viscosity is the key property and close corresponds to Arrhenius-type equation

$$\mu = \mu_0 e^{E_\mu/RT} \ [Pa.s]$$

Where μ_0 is viscosity at reference temperature and Eμ is temperature coefficient for viscosity. Viscosity of the liquid decreases with temperature and at lubrication media has a strong hyperbolic dependency. The density is given by mass of substance which belongs to a volume unit, i.e. ρ = m/V [kg/m3] and it is related to atomic mass and molecular bonds. It is influenced by temperature, pressure and surface tension. Additive components sustain the pH in equilibrium and no acidic molecules should be present in oil. The pH is the measure of hydrogen ions concentration in logarithmic representation. pH = -log [H+] its value in unused motor oil is in range of 7-8 and it is still decreasing. TBN/TAN parameters were introduced specially for motor oil quality determination and they are defined through neutralization of acidity or basicity.

Specific conductivity is the ability to conduct the electric current by

$$\gamma = \frac{lG}{S} = \frac{mS}{m^2}$$

Where G is electric conductivity of conductor with length of l and cross-section of S. Electric conductivity of motor oil is strongly related to presence of water and microscopic metallic parts. Increasing temperature supports dissociation of ions, growing its mobility and resulting increasing conductivity of the media. They represent dissociated positive and negative ions. Electric conductivity varies also by measure of additives declination. Dielectric properties reflect the measure of interaction of oscillating electric field in molecules. Dielectric constant can be derived from Debye's equation for molar polarization:

$$\frac{\varepsilon_r - 1}{\varepsilon_r + 2} = \frac{\alpha + \mu^2/3kT}{L\rho 3M_h}$$

where ε_r is dielectric constant of the media, α its polarizability, μ is dipole moment, k is the Boltzmann constant (1.33 × 10-23 J/K), T is thermodynamic temperature, L is the Avogadro's constant (6.02214129 × 1023 mol-1), ρ is oil density and MH is molecular weight of the oil. During normal operation cycle the motor oil temperature is close to 100°C. Dielectric constant of motor oils is in the range from 2.1 to 2.8 and increases approximately 0.0013-0.05 %/°C.

B. Circularly Polarized antenna for transmitting RF signals

Circularly polarized antennas are prominent due to the flexibility in the arrangement of antennas which is very effective in combating multi-path interferences, that gives a higher probability of a successful link as it is transmitting on all planes and also reduce the losses occurring due to the Faraday rotation effects. The antenna is simply composed of a monopole antenna which is protruded into round to achieve efficient excitation and a modified PCM coating. The coating which is made up of a series of proposed PCM elements are etched on the back of the substrate partly. The PCM array is formed by 5×7 elements uniformly distributed along the x and y directions; with a gap width Wm. RT/duroid 5870-filled PTFE (polytetrafluoroethylene) composite substrate material was chosen for the proposed antenna design to achieve operation in the desired band. The antenna is printed on a single-layer polytetrafluoroethylene substrate with Dielectric constant 4.6, loss tangent of 0.02, Volume resistivity 8 × 107 and Surface resistivity 2 × 105.

L	W	H	L1	L2	L3
42	43	2.2	22.6	4.8	2.9
L4	L5	L6	L7	L8	Ld
3	3.4	10.9	4	1.7	10.9
Ld1	Lf	Lm	W1	W2	W3
6.2	4.3	11.3	2.3	1.9	1

W4	Wd	Wf	Wm	R1	R2
0.2	19.2	0.6	0.6	12.1	8.8

TABLE 1 DIMENSIONS OF THE DESIGNED ANTENNA (UNIT: mm)

C. Analysis of Signals and estimating the impurities present in the oil.

Dielectric constant is important indicator of motor oil quality. Its indirect measurement is based on capacity measurement using sensed media as the dielectrics. Changes in motor oil dielectric constant can induce the presence of contamination, e.g. water, fuel, impurities, etc. as well as changes in motor oil composition due to oxidation and deficiency of additives. For measurement purposes the cylindrical capacitor was constructed and utilized. Using RLC200 (Programmable Automatic RLC Meter), through temperature range of 0-100˚C, the capacity C_x of measurement capacitor was related to its value C_0 in room conditions atmosphere by $\varepsilon_r = C_x/C_0$.

The conductivity characteristics are relative to influence of impurities concentration, which have various origins. Their concentration grows with detrition of metallic surfaces and absorption of water, fuel and combustion products. These components compose the electrolyte with motor oil. Conductivity temperature dependence of this substance is related with dissociation of such impurities and with mobility of ions variation. Character of conductivity change is also associated with loss of additives concentration and with continuing oxidation. Depletion of additives introduces increased potential of acidic components formation, which affects all key characteristics. Moreover, variation of electric conductivity is liable to variation of water concentration, mainly in cold season operation.

As a result, a systematic analysis is very complex problematics and therefore requires complex view to continuing degradation processes. Typical lowering of dielectric constant with temperature is about 0.0013 (0.05 %) at 1˚C, what is mainly related to slight specific density variation of motor oil. Dielectric constant of motor oil varies in 2.1-2.4 range, what corresponds with presumptions. Expected growth of values through continuous degradation is relative to contaminants concentration growth, mainly water, microscopic metallic parts and various contaminants from combustion zone. Contamination by water introduce noticeable factor of dielectric constant variation due to strong polarity of water molecule. Values of dielectric constant at underrated motor oil samples are connected with the highest concentration of additives.

Analysis of motor oil samples provides a view to relevant characteristics in the scope of continuing degradation processes. Mainly, the viscosity is the most important parameter in evaluation of motor oil condition, but it cannot provide the information about degradation factors. Evaluation of dielectric properties together with electric conductivity focus on character of continuing processes, what support reliable motor oil diagnostics.

Quantity grading is done by using two sets of LDR and light source in the developed dip stick. One set is situated at the bottom of the dip stick and other set is mounted 20 mm above the first detector set. At the time of experimentation both the qualitative grading and quantitative grading uses the both the set of detectors are used. Quantitative measurement is done by checking the signal from both detectors simultaneously. Missing signal from bottom detector depicts the low level of oil present in reservoir. The values are also displayed as symbol LOW, HIGH, FULL. It can detect the undesirable change in level generally occurs during the addition of impurities such as water, coolants etc. The condition and level of the engine oil and can be transmitted to a mobile application through a Wi-Fi module and the same can be monitored by the service agents, which helps them to intimate about the change in oil.

Detailed description of the drawing

The main objective of this invention is to propose a method for design and development of an IoT based oil impurities and level monitoring device. Engine oil and lubricating oil in internal combustion engines are exposed to varying strains depending on the operating conditions and the fuel quality therefore it is essential to maintain the quality of engine oil and Lubricating oil so as to minimize the friction within the Engine.

Figure 1 depicts the Degradation of oil sample after predefined interval of distance run by engine. This oil was deteriorated by running 4 stroke motor bike engine for 0 Km, 84Km, 196 Km, 832 Km, 3117 Km, and 4000 Km travel. So as to guarantee no predisposition on the capacity impact, all the oil tests were kept in the organizer at room temperature.

Figure 2 depicts the Block diagram of the light transmission and detection through oil - Quantity Grading Analysis. Quantity grading is done by using two sets of LDR and light source in the developed dip stick. One set is situated at the bottom of the dip stick and other set is mounted 20 mm above the first detector set.

Figure 3 introduces a new configuration of compact, triangular- and diamond-slotted, micro strip-fed; low-profile antenna for mm wave applications on polytetrafluoroethylene (PTFE) glass microfiber reinforced material substrate. The antenna is composed of a rectangular-shaped patch containing eight triangles and two diamond-shaped slots and an elliptical-slotted ground plane. The proposed antenna offers relatively stable gain, good radiation efficiency, and omnidirectional radiation patterns in the matching band.

Figure 4 depicts the process Flow to demonstrate operations for obtaining notations over mobile application. The operational methodology adopted for development of the IoT based dipstick Type Engine Oil Level and Impurities Monitoring System using RF Signals is shown.

Figure 1: Degradation of oil sample after predefined interval of distance run by engine.

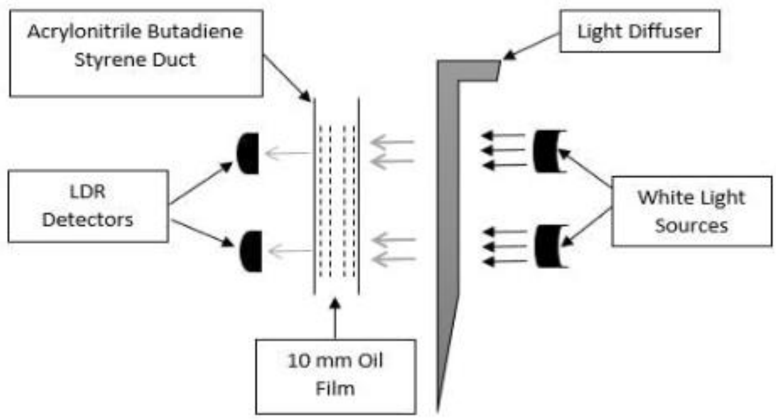

Figure 2 Block diagram of the light transmission and detection through oil - Quantity Grading Analysis.

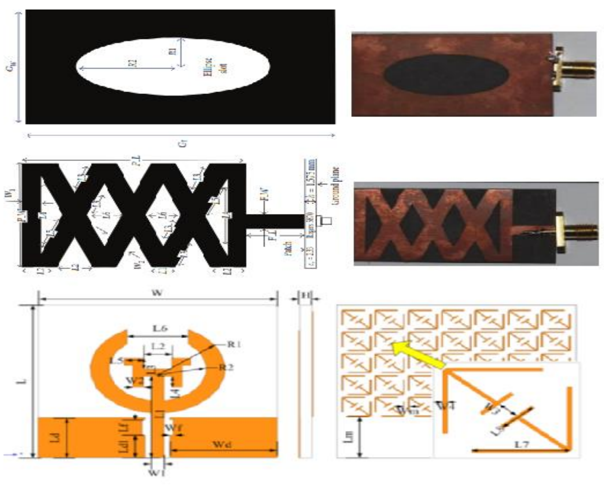

Figure 3 The structure of the Circularly Polarized antenna Top view & Back view

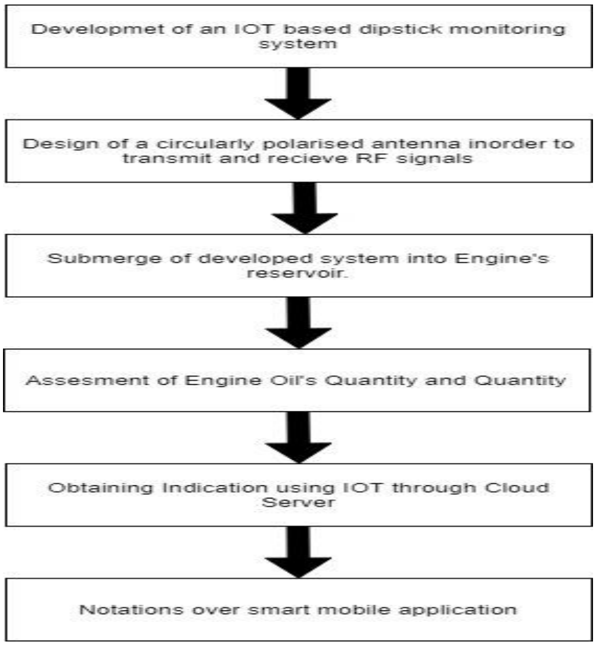

Figure 4 Flow diagram to demonstrate operations for obtaining notations over mobile application

CONCLUSION:

IoT based Dipstick Type Engine Oil Level and Impurities Monitoring System said in the above will be able to detect the quantity of Engine oil present and also detect the impurities present in the Engine oil. Therefore the quality and quantity of engine oil reports can be generated and transmit through a Wi-Fi module to any mobile application from which the users can make quick decisions

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