# IoT Based Dipstick Type Engine Oil Level and Impurities Monitoring System: A Portable Online Spectrophotometer


Sidharth Sharma
Precision Mechanical System
CSIR-Central Scientific Instruments Organisation
Chandigarh, India
sharmasidharth055@gmail.com

Supankar Das
Precision Mechanical System
CSIR-Central Scientific Instruments Organisation
Chandigarh, India
supankardas@csio.res.in

Jitendra Virmani
Department of Mechatronics and Industrial Automation
Indo Swiss Training Centre, CSIR-Central Scientific Instruments Organisation
Chandigarh, India
jitendravirmani@csio.res.in

Mamta Sharma
Computational Instrumentation
CSIR-Central Scientific Instruments Organisation
Chandigarh, India
mamta.sharma@csio.res.in

Satbir Singh
Precision Mechanical System
CSIR-Central Scientific Instruments Organisation
Chandigarh, India
satbir2008@ymail.com

Amitava Das
Precision Mechanical System,
Computational Instrumentation
CSIR-Central Scientific Instruments Organisation
Chandigarh, India
adas@csio.res.in



***Abstract*—The paper describes the design and developmentof an IoT based oil impurities, level monitoring instrument and its operational methodology. The research work uses a unique approach with customized white LED spectrophotometry. The developed instrument has done Qualitative and Quantitative assessment of lubricant oil in IC engine's sump. This in turn is helpful in carrying out decisive task towards maintaining Engine life cycle and carbon footprint. Light-dependent sensor with sensitivity <90% and range 500-600nm is used as a detector for experimentation on four stroke IC Engine. The system has advantages of affordability and portable design.**



***Keywords— IoT, Spectrophotometer, Dipstick, LED, Photometry, Light-dependent resistor, Engine oil.***


## I. Introduction

Automotive engine characteristics such as efficiency in terms of quantitative and qualitative parameters such as Engine performance parameters are power, torque and specific fuel consumption is directly related to the designed mechanisms of the engine and its smooth functioning within the limit of carbon footprint. Lubricating oil plays a major role to keep the engine running with desired performance [1]. 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 minimise the friction within the Engine [2]. 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 [3]. Oil degradation is the process by which the lubricating, cooling, cleaning, protection or sealing performance of the fluid decreases [4]. Chemical reactions such as Oxidation, nitration, temperature rise, external contamination, shearing, corrosive ambient, additive depletion, etc are the most important factors for accelerating the oil degradation process [5] [6]. Therefore, 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.

Several experimentation is being conducted worldwide to overcome the limitations by incorporating FT-IR spectroscope, Reflectometer, Oil Density meter, Chemical analysis for Total Acid Number Conventional measurement, Sediment detector, Oil Oxidation measuring device, on-line visual ferrograph (OLVF), wear debris concentration etc.[7] [8] [9] [10] The above methods and instruments have measurable limitations to monitor the quality due to lack of advancement in instrumentation, high cost, lack of portability and ease to use by operator on the go [11]. One of the preferred solution is online oil condition monitoring using IoT interface over smart phone and its smart analytical capability.

Therefore, our research focused on the design and development of an IoT based cost effective oil impurity, level monitoring instrument and its operational methodology.

## II. Proposed Methodology

The research work uses a unique approach with customized white LED spectrophotometry. A light-dependent sensor (LDR) with sensitivity <90% and range 500-600nm is used as a detector for experimentation on four stroke IC Engine [12] . The operational methodology adopted for development of the IoT based dipstick type spectrophotometer as shown in Figure 1.


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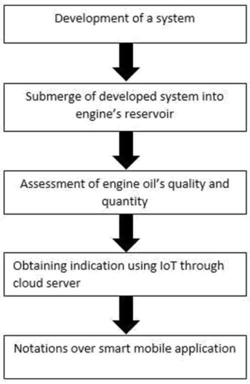


Fig. 1. Flow diagram to demonstrate operations for obtaining notations over mobile application.

Design of instrument is done over CAD software, which involves mechanical, logical and operational difficulties. Position and attributes of the embedded components are precisely designed. After that submerge of designed system into engine oil's sump. After few seconds computation of data processed over microcontroller and stored over cloud server. At cloud server all the calculations are done for qualitive and quantitive assessment. Developed GUI represents graphical information for user.

## III. Experimental System Analysis and Discussion

The trial setup used to lead this investigation is represented in Figure 2. There are two sections of the experiment which are i) Quality Grading and ii) Quantity Grading. This investigation was done on six different types of engine oils are used in these experiments, which belongs from fresh and degraded samples of a SAE 10W30 engine oil category.

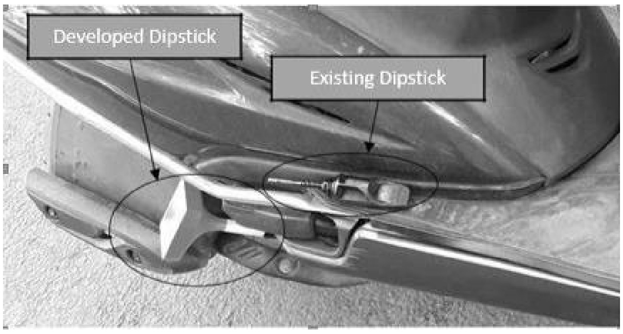


Fig. 2. Experimental setup installed in 4 stroke IC engine's reservoir

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 as shown in Figure 3. So as to guarantee no predisposition on the capacity impact, all the oil tests were kept in the organizer at room temperature.


Fig. 3. Shows the degradation of oil sample after predefined interval of distance run by engine.

For each section, six samples are utilized. Therefore, 12 samples altogether are set up for the two trials which are Quality and Quantity Grading.

### A. *Quality and Quantity Grading Experimental Setup*

The system is based on Lambert-Beer's law, in which material transmittance is considered [13]. A portable version of the device has been developed using Rapid prototyping for reducing the cost of manufacturing. It includes a hollow cylinder dipstick consists of LDR sensor and light source mounting attachments. The light source and LDR are being placed axially face to face on the two side of measuring cylinder. The Cylinder is dipped into oil to be measured and come in contact of source and detector surface. It is considered that the amount of light varies with the varying density or refractivity of oil due to presence of impurities. Therefore, a new sample of oil is tested with the device first and result is used as reference for the measurement of oil quality.

The Controller sends the processed signal to Cloud server, which are accessed by smart phone thereafter [14].IoT setup with microcontroller is shown in Figure 4. An advance mobile application is developed to display the end results in graphical mode. A partial amount of light travels through the oil to the detector which sends the electrical signal to the controller. The signal is processed by Arduino controller. Block diagram of instrument is shown in Figure 4.

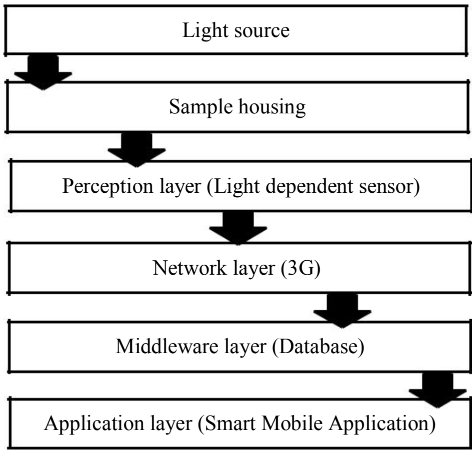


Fig. 4. Block diagram of instrument

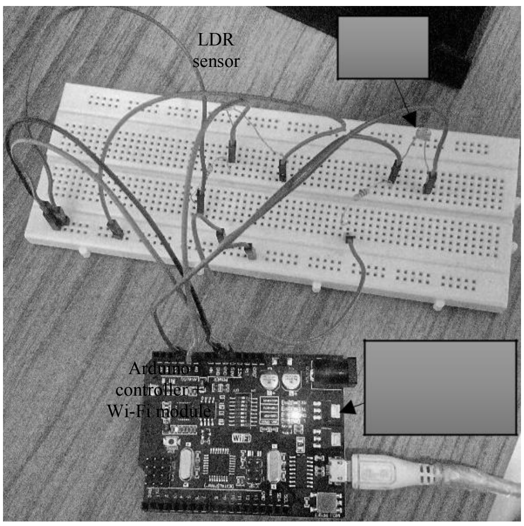


Fig. 5 Electronic Setup shows the wireless module and IoT setup.

*B. Quality Grading Analysis*

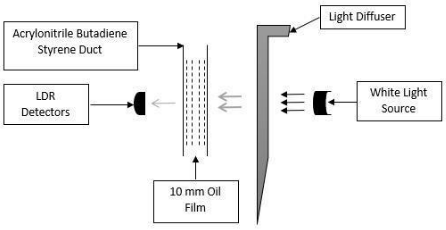


Fig. 6 Shows block diagram of the light source and detector

Oil was tested first at 0 Km travel by developed instrument and the measured value was considered as reference value i.e. 973 Lux. After running engine for 96 Km again test was conducted and value was sent to cloud server and compared with reference value. The test schedule may be automised according to user's requirement. In present experimentation, one reference value and three test value has been taken for generating a table as shown in Table I, which are then classified into three category i.e. GOOD, MEDIUM and BAD quality as shown in Figure 8. At the time of experimentation qualitative grading uses the two set of detectors for more reliable result.

*C. Quantity Grading Analysis*

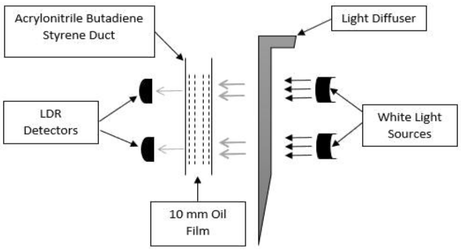


Fig. 7 Shows the block diagram of the light transmission and detection through oil

Quantity grading are 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 as shown in Figure-7 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. During experimentation, top detector gets a value of 1230lux, then instruments shows there is no addition of unwanted solutions in engine oil, because the value of source light is 1230lux without any transmissive medium. At second condition top detector got a value of 973, then the instrument indicates for high level that means addition of unwanted solution begins. At third condition bottom detector obtains a value of near about 973lux, then it is a detection of fresh engine oil and instrument shows oil sump is full of fresh oil and there is no need of lube oil to be added. If bottom detector gets a value of 1230lux it means level of engine oil in sump is very low & need to refile with fresh engine oil. As shown in Figure 9 at this time instrument declare low level at value of 1230lux got over bottom detector.

## IV. Result and Discussion

In the following, we present sample results as shown in Table I and II and comparisons to results obtained with developed dipstick instrument. To evaluate the sensor principle, we used oil samples taken every predefined interval of distance run by engine.

A rigorous experimentation has been conducted for the qualitative measurement of engine oil. At initial stage total empty engine sump with filled with new engine oil. Therefore, the sample oil is considered as reference oil. In every experimentation reference value was measured by dipping the developed dip-stick instrument and after specific kilometre run the test was repeated. The following Table-1 represents the amount of light transmitted through the used oil. Figure-8 and 9 shows the App screen or user interface.

TABLE I. Represents the amount of light transmitted through unused and used oil

| **Distance Travelled [Km]** | **Electrical signal of the sensor [Lux]** | | **Difference signal (ref. – obt.)** | **Status of oil quality/ quantity** |
|---|---|---|---|---|
| | *Reference Band [Lux]* | *Obtained Band [Lux]* | | |
| 0 | 973 | 973 | 0 | Good quality |
| 84 | 973 | 946 | 27 | Good quality |
| 196 | 973 | 934 | 39 | Good quality |
| 832 | 973 | 254 | 719 | Medium quality |
| 3117 | 973 | 0 | 973 | Degraded |
| 4000 | 973 | 0 | 973 | Degraded |


Fig. 8 Shows the mobile app screen or user interface for indication of oil quality.

Quantitative analysis was performed using the difference of Lux values obtained by two detectors In order to evaluate the quantitative assessment of engine oil. Based on the result obtained as shown in Table II, it can be observed that Quantity of engine oil in engine sump are successfully classified. Figure 9 shows the final result of quantitative analysis at different stages. For better result of quantification two sensor systems were used. Precision level of this instrument can also be increased by using alteration of sensors.

TABLE II. REPRESENTS THE AMOUNT OF LIGHT TRANSMITTED THROUGH ABSENCE OF OIL, UNUSED AND USED OIL

| **Distance Travelled [Km]** | **Electrical signal of the sensor [Lux]** | | **Difference signal (ref. – obt.)** | **Status of oil quantity** |
|---|---|---|---|---|
| | *Signal at Top Detector [Lux]* | *Signal at Bottom detector [Lux]* | **Ref value = 1230** | |
| NIL | 1230 | 1230 | 0 | Low |
| 0 | 973 | 973 | 0 | Good quality, but level is High |
| 84 | 1230 | 946 | 284 | Full |
| 196 | 1230 | 934 | 296 | Full |
| 832 | 254 | 254 | 0 | High |
| 3117 | 0 | 0 | 0 | High |
| 4000 | 0 | 0 | 0 | High |


Figure-9 Shows the mobile app screen or user interface for Indication of oil level.

## V. CONCLUSION AND FUTURE SCOPE

Results show the device used a very much cost effective and reliable method of detecting the impurities and level of oil. It is also able to successfully send the measured value using cloud network and displayed on smart mobile app. Instrument is working properly. Output resolution of this instrument is up to satisfactory level also data can be remotely accessed. It is very useful for statically analysis.

This instrument can be used for different grades of oil like vegetable, edible oil, reagent solution, organic solvent for their adulteration analysis.

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## REFERENCES

[1] T. Muthamilselvan et al., “We are IntechOpen , the world ’ s leading publisher of Open Access books Built by scientists , for scientists TOP 1 % Control of a Proportional Hydraulic System,” Intech open, vol. 54, no. June, pp. 713–727, 2016.

[2] D. Perakovi and M. Peri, Advances in Design, Simulation and Manufacturing, vol. 1. Springer International Publishing, 2019.

[3] B. Okonokhua, B. Ikhajiagbe, G. Anoliefo, and T. Emede, “The Effects of Spent Engine Oil on Soil Properties and Growth of Maize (Zea mays L.),” J. Appl. Sci. Environ. Manag., vol. 11, no. 3, 2010.

[4] J. A. Heredia-Cancino, M. Ramezani, and M. E. Álvarez-Ramos, “Effect of degradation on tribological performance of engine lubricants at elevated temperatures,” Tribol. Int., vol. 124, pp. 230–237, 2018.

[5] J. Ma, Z. Zong, F. Guo, Y. Fei, and N. Wu, “Thermal Degradation of Aviation Synthetic Lubricating Base Oil,” Pet. Chem., vol. 58, no. 3, pp. 250–257, 2018.

[6] S. Zzeyani, M. Mikou, and J. Naja, “Physicochemical characterization of the synthetic lubricating oils degradation under the effect of vehicle engine operation,” Eurasian J. Anal. Chem., vol. 13, no. 4, 2018.

[7] S. Feng, B. Fan, J. Mao, Y. Xie, and Y. Che, “An oil monitoring method of wear evaluation for engine hot tests,” Int. J. Adv. Manuf. Technol., vol. 94, no. 9–12, pp. 3199–3207, 2016.

[8] K. Azevedo and D. B. Olsen, “Engine oil degradation analysis of construction equipment in Latin America,” J. Qual. Maint. Eng., 2019.

[9] T. Holland, A. Abdul-Munaim, D. Watson, and P. Sivakumar, “Influence of Sample Mixing Techniques on Engine Oil Contamination Analysis by Infrared Spectroscopy,” Lubricants, vol. 7, no. 1, p. 4, 2019.

[10] S. M. Azzam et al., “Characterization of essential oils from Myrtaceae species using ATR-IR vibrational spectroscopy coupled to chemometrics,” Ind. Crops Prod., vol. 124, no. February, pp. 870–877, 2018.

[11] L. Hong and K. Sengupta, “Fully integrated optical spectrometer with 500-to-830nm range in 65nm CMOS,” Dig. Tech. Pap. - IEEE Int. Solid-State Circuits Conf., vol. 60, pp. 462–463, 2017.

[12] Sunrom, “Light Dependent Resistor -LDR,” p. 4pages, 2008.

[13] P. Onorato, L. M. Gratton, M. Polesello, A. Salmoiraghi, and S. Oss, “The Beer Lambert law measurement made easy,” Phys. Educ., vol. 53, no. 3, 2018.

[14] R. Khan, S. U. Khan, R. Zaheer, and S. Khan, “Future internet: The internet of things architecture, possible applications and key challenges,” Proc. - 10th Int. Conf. Front. Inf. Technol. FIT 2012, pp. 257–260, 2012.