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ONLINE MONITORING OF PETROLEUM FUEL PARAMETERS IN STORAGE TANK USING MICROCONTROLLER

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ABSTRACT

This research paper discusses a web based monitoring system that enables effective monitoring of fuel level and percentage of adulteration in underground storage tank in a retail filling station. It enables effective monitoring of fuel filling stations output and sales volume under the domain of a single company/organization. This paper proposed a methodology to determine oil quality in real time with embedded and portable oil assessment device operated by mechanic provides the operational flexibility and rapid means of screening fuel quality that is key to establishing a program to provide real time condition based monitoring products. An improved method based on single chip, which realized the on line signal gathering and data processing to monitor fuel level, temp and viscosity in Underground Storage Tank. The configuration of the sensors chosen are given, which were finalized after many time tests and error analysis.

INTRODUCTION

The oil and gas industry is experiencing a major boom around the world thanks to the seemingly insatiable demand for fossil fuels in both developed and developing countries. Refinery end products including gasoline, petrochemicals, and lubricants all of which are used daily require efficient and adequate supply to meet ever increasing demand. A filling station/ fuel station is a facility which sells fuels and lubricants via fuel dispensers or otherwise called bowsers which themselves are used to pump gasoline, diesel, kerosene etc into vehicles and to calculate the financial cost of the product thus dispensed. India as a country has thousands of petrol stations owned/ operated by government institutions or members of the private sector and it is not uncommon to see a single operator owning one or more fuel stations covering the entire 29 states of the federation. It has to be said that over the years fuel station operators have come in and gone out of business due to bankruptcy issues and mismanagement which can all be attributed to bad management practices resulting from unaccountability issues as lots of approximations are made with the manual system of approach employed. Remote monitoring technology can thus be applied to this process to provide timely information relating to diverse parameters such as pump output volume, cost of delivered volume, and total sales in a particular period, percentage of adulteration etc to enable timely decision making based on accurate data. [1]

There exists a critical need in the mobile and fixed asset market to empower field units to determine oil quality on demand.

In India large public and private sector petroleum companies procure crude oil through Indian Oil Fields or through import from other countries. After refining crude oil, the petrol fuel is stored in large storage tanks. Then it get transported to distant places via rail network or road transport. Petrol is distributed to oil dealers who further sold it to end consumer through retail outlets i.e. petrol pumps.

Purpose

Petroleum companies need to ensure the sale of petrol of pure quality and in correct quantity. Petrol is filled into underground storage tanks (UST) directly from tank-lorry. At that time its quantity, temperature, density & viscosity is measured. The petrol is pumped into vehicle tanks by dispenser nozzle and pumped out quantity is displayed on the display meter.

By real time monitoring of petrol level in storage tank, and keeping its history stored, the company personnel can keep an eye on stealing of petrol by pump operators and dealers. Density and viscosity monitoring will detect percentage of adulteration (like kerosene & bio diesel) in fuel at any stage. Temperature is also monitored because volume and viscosity of petrol both depend upon it. With increase in temperature the fuel level in tank increases

and fuel viscosity decreases.[2] Using volume - temperature chart, the microcontroller can calculate the actual volume at a standard temperature. Thus real time monitoring of petrol parameters will curb malpractices in sale of petrol.

Fuel Adulteration and Its Ill Effect

In the Indian context, the gasoline is adulterated by mixing diesel and diesel is adulterated by mixing kerosene. Government also allows some percentage adulteration of Ethanol (bio fuel) through Petrol Pumps. This is because these types of adulterations when limited to small volume percent are difficult to detect by the automobile user. The expected adulteration percentage is 10% to 30% by volume in both the cases. Less than 10% adulteration is financially unattractive, while more than 30% adulteration is likely to be easily detected by the user from the degradation of the engine performance caused by the adulterated fuel. The Government keeps kerosene rates down and also provide it to poor on subsidized rate through PDS. The diversion of kerosene for adulteration drastically brings down its availability to the poor households, who turn to bio-mass for the purpose of cooking. This leads to an increase in the indoor air pollution and consequent ill effects on health. For the prevention of adulteration, monitoring of fuel quality at the distribution point, therefore, is highly essential.

To check the adulteration effectively, it is necessary to monitor the fuel quality at the distribution point itself. The equipment for this purpose should be portable and the measurement method should be quick, capable of providing test result within a very short time. The measuring equipment should also be preferably inexpensive (as a large number of such units would need be simultaneously deployed) and easy to use.

Fuel Quality Parameters

Real Time fuel parameters measurements is a necessity for oil companies as well as government pollution control departments to ensure that fuel adulteration is under prescribed norms. Essential fuel parameters are.

Volume/Level

Fuel level is monitored in underground storage tank for following reasons

1. Timely information of Top up and drain.
2. Daily fuel consumption / sale analysis
3. Fuel theft can be ceased.
4. Fuel drained out of tank and fuel sold by dispenser operator can be compared.
5. Avoid untimely drain of tank to empty level.

Temperature

Sensing of liquid and viscosity is useful only if the actual temperature of the liquid is known as the volume of fuel is highly dependent on its temperature. To get correct results, it is advantageous to measure temperature as near as possible to the position where viscosity is measured. [3]

Density

Liquid density is an important characteristic used to provide information concerning composition, concentration, mass flow in fuels, and caloric content. Density is expressed as mass per unit volume but is often expressed in terms of specific gravity (SG liq), which is the ratio of the liquid density to the density of water both taken at the same temperature and pressure.

The density of liquids and gases is very temperature dependent. [4]

Density of Petrol	0.74 - 0.75 g/ml
Density of Kerosene	0.79 - 0.80 g/ml.
Density of Diesel	0.83 - 0.85 g/ml.

Viscosity

Viscosity is the measure of the internal friction of a fluid. This friction becomes apparent when a layer of fluid is made to move in relation to another layer. Highly viscous fluids, therefore, require more force to move than less viscous materials.[5]

Viscosity is defined mathematically by this formula:

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$$\eta = \frac{S}{F} = \frac{shearstress(dyne/cm^2)}{shearrate(\sec^{-1})}$$

The fundamental unit of viscosity measurement is the poise.
Kinematic Viscosity of the Fluid is

$$\upsilon = \frac{\eta}{\rho} = \frac{viscosity}{density}$$

FUEL QUALITY SENSOR

The temperature sensor, humidity sensor and optical sensor is not inserted directly to the fuels, it results in short-circuit, corrosion, and gumming.
So the sensors are chemically passivity and electrically insulated hermetic seal for its electronics. This approach has been found to be necessary in any real measurement environment intended for long-term operation.

Level Sensor
The level (volume) based measurement systems are basically - manual (dipstick), float and tape, servo (displacer based) etc.
We will prefer non-contact level measurement ie., ultrasonic level sensor.

Temperature Sensor
Temperature is also monitored because volume and viscosity of petrol both depend upon it. With increase in temperature the fuel level in tank increases and fuel viscosity decreases. Using volume - temperature chart, the micro controller can calculate the actual volume at a standard temperature. The LM35 series are precision integrated-circuit temperature sensors.

Density Sensor
Density Sensors employed with liquid fuel are generally.

1. Ultrasonic Liquid Density Meter
2. Magnetostriction Sensor
3. Differential Pressure Density Meter
4. Capacitive Type Density Meter

Viscosity Sensor
There is a continuous demand for real time monitoring of petroleum. The various sensor principles are available for the viscosity measurement as SHAPM (Shear Horizontal Acoustic Plate Mode) sensor, TSM-MPS (Thickness Shear Mode – Monolithic Piezoelectric Sensor) sensor, Micro-acoustic sensors, piezoelectric BAW sensors, BICONVEX Quartz Crystal, Solid State Sensors, Optical sensors etc.[6]
Sensing of viscosity is useful only if the actual temperature of the liquid is known.

Arduino Microcontroller
Arduino is a single board microcontroller intended to make the application of interactive objects or environments more accessible. The hardware consists of an open-source hardware board designed around an 8-bit Atmel AVR microcontroller or a 32-bit Atmel ARM. Current models feature a USB interface, 6 analog input pins as well as 14 digital I/O pins which allow the user to attach various extension boards.

Technical Specification

- Microcontroller ATmega 328
- Operative Voltage 5V
- Input Voltage (recommended) 7-12V
- Input Voltage (limits) 6-20V
- Digital I/O Pins 14 (of which 6 provide PWM output)
- Analog Input Pins 6
- DC Current per I/O Pin 40 Ma

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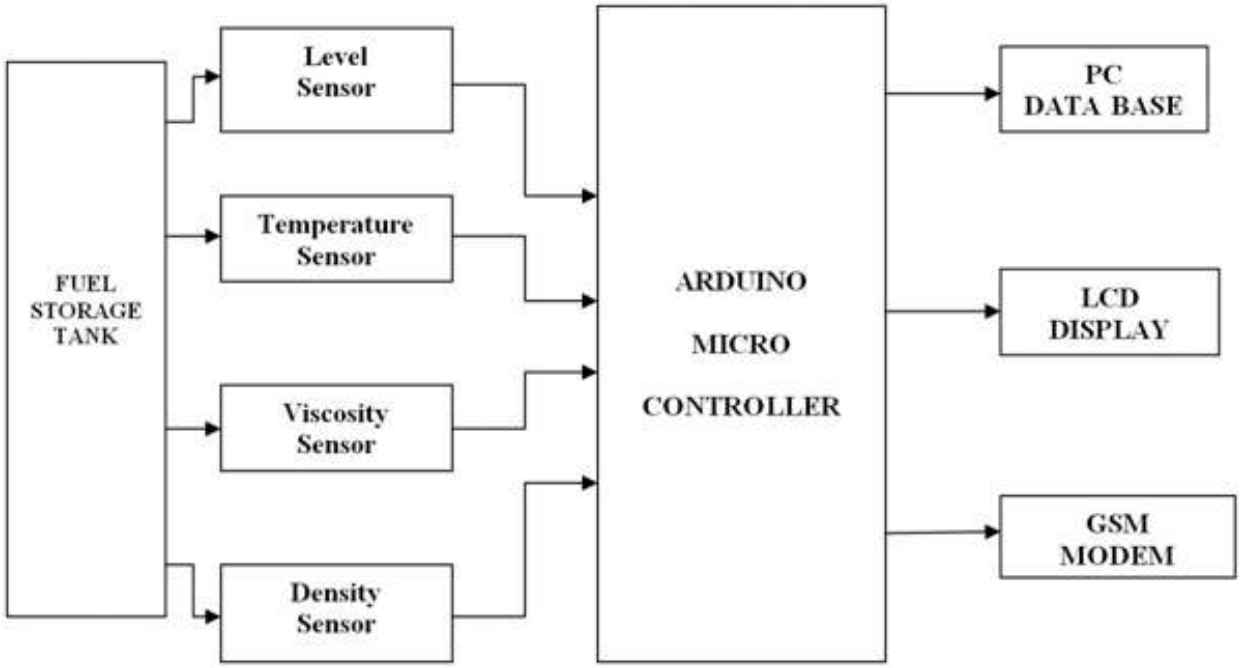
- DC Current for 3.3 V Pin 50 mA
- Flash Memory 32 KB of which 0.5 KB used by boot loader
  - SRAM 2 KB
  - EEPROM 1 KB

MEASUREMENT SETUP

The measurement setup of he adopted techniques and sensor used is shown in Fig. 1



Block Diagram of Measurement System

Display and Sensor Output Part

LM35 will record temperature of petrol inside the tank, ultrasonic sensor will measure the petrol level and BAW viscosity sensor will monitor viscosity. All data will send to microcontroller.

Microcontroller will convert the reading of level and viscosity (at actual temperature) to the values at standard temperature by comparing with standard charts.

- Monitor will display it on LCD
- Data will be logged at fixed time intervals (say 30 minute or 1 hours) in device memory
- Data will be send to control station or company Head Quarter through GSM Module with activated SIM Card.[7]

INTERFACING

Basic requirements for interfacing:

1. Power Supply 12V, 5V
2. GSM module with activated SIM Card.
3. DB9 connector for GSM and PC connection (RS-232C) with our system.
4. Ultrasonic sensor for level monitoring.
5. LM35 temperature sensor
6. Bobber (differential pressure) density meter
7. Resonant piezoelectric BAW Viscosity Sensors.
8. SQL Database and embedded 'C' language.
9. LCD Screen with suitable resolution.

10. Program burning circuitry
11. Arduino Microcontroller

RESULTS

Table 1. : Viscosity dependency on temperature of petrol, diesel and kerosene (in poise)

Temperature in °C	Viscosity of diesel (in poise)	Viscosity of Kerosene	Viscosity of Petrol
28	2.5	1.31	0.72
30	2.46	1.23	0.7
32	2.42	1.26	0.68
34	2.39	1.23	0.67
36	2.37	1.21	0.65
38	2.34	1.19	0.63
40	2.29	1.18	0.63

Table 1 clearly indicates that viscosity of different fuels is highly dependent on temperature. With a variation of 24°C to 40°C in temperature viscosity varies approximately 11% for diesel, 14% for kerosene and 18% for petrol.

Table 2. : Density and Kinematic viscosity of diesel fuel and adulterant kerosene at different proportions

S. No.	Diesel and Kerosene Proportions	Density at 15°C g/ml	Viscosity at 40°C (in poise)
1	Pure Diesel	0.85	2.6
2	95:05	0.846	2.52
3	85:15	0.841	2.39
4	75:25	0.838	2.24
5	65:35	0.834	2.12
6	50:50	0.831	1.98
7	25:75	0.824	1.81

Table 2 Suggest that the overall sensitivity of this method is rather poor if the change in density is used as an indicator of extent of adulteration (only 3%) variation. Whereas the viscosity of fuel show a considerably stronger dependence on the percentage adulteration (about 30% variation)

Therefore viscosity should be a preferred parameter to be calibrated against level of adulteration.[8]

CONCLUSION

This paper argues that properly implemented system offer better reliability, is more rugged in corrosive and abrasive environments, with hazardous fluids.

To date, the method selected in this paper appears to be favored primarily because it provides good correlation to extremely critical kinematic viscosity to detect fuel adulteration by retail fuel station dealer. It will send real time information of top up and drain of underground storage tank. It will keep vigil on fuel theft and short delivery to end consumer. It will put control over air pollution due to bad quality fuel.

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