VOL. 14, NO. 5, MARCH 2019 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

PETROL QUALITY ANALYSIS FOR DIFFERENT LEVEL OF ADULTERATION USING THERMAL IMAGNING AND GLCM FEATURES

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ABSTRACT

The most common adulterants in petrol is kerosene. The combination of kerosene and petrol affects the engine working and pollutes the environment as a whole. In this paper, a novel thermal image processing based approach applies to detect the presence of adulteration in fuel. The GLCM (Gray level co-ocurrence matrix) algorithm applies to detect fuel adulterants in a given sample. Test results shows, GLCM algorithm detects adulterants in fuel with 98% accuracy.

Keywords: petrol adulteration, global warming, chloro fluro carbon (CFC), ozone layer depletion, GLCM method, local binary pattern.

INTRODUCTION

Petroleum is a raw form of material, which is found in the earth's surface as geological establishment and is also called as 'crude oil' that contains mostly hydrocarbons and organic compounds. Its primary mixture by weight is normally distributed among sulphur (0.05-6%), oxygen (0.05-1.5%), nitrogen (0.1-2%), hydrogen (10-14%), carbon (83-85%) and organometallic compounds (arsenic, lead, nickel, vanadium, and other trace metals. The significant hydrocarbons groups being in the crude oil are paraffin (alkanes), naphthene's (cycloalkanes), and aromatics, where olefins (alkenes) are establishment, happens during the functioning of crude. Petroleum processing industry classified into three different sectors namely as downstream, midstream and upstream. Examination of the crude oil are carried out by midstream and upstream sector which needs transportation of crude oil from the study site to the refinery site. The petroleum comprises of solid hydrocarbons, gases and liquids. They include propane, methane, butane and ethane, which occur as gases. The pentane is heavier hydrocarbons existing as solid and liquid state. The average hydrocarbon ratings are of 30% alkanes, 15% Aromatics, 49% Naphthenes and 6% Asphaltics.

The term fuel adulteration, means adding combustible foreign substance to petrol which is not defined by specification and requirement of product. The adulterants degrade the quality of petrol and cause pollution. The petrol are adulterated with cheap fuels to save on fuel money. In trailer trucks, the diesel is adulterated with kerosene. In some cased, recycled lubricants and solvents are added to fuel to increase fuel quantity. The adulterated fuel impacts both the environment and engine badly. The harmful effects of fuel adulteration on engines include increased sediment deposition in engine, high combustible sound from engine, and increased smoke emissions. The smoke emission from vehicles includes carbon monoxide and Chloro fluro carbons (CFC). The pollutants such as carbon, chlorine and fluorine increase the effects of global warming and ozone layer depletion. The ozone layer exposes humans to ultraviolet solar radiations. The CFC remains in earth atmosphere for nearly 20 to 100 years. The time enables the CFC to reach stratosphere where they separate into chlorine due to sunlight. The chlorine interacts with ozone to form molecular oxygen. The reaction results in ozone layer thinning. Furthermore, the ozone layer depletion increases greenhouse effect increasing earth surface temperature. The humans exposed to UV rays affect with cataracts and skin cancer. The global warming can further induce climatic changes such as tornadoes, storms and drought. Furthermore, in closed environment high concentration of CFC increases damage to vital organs such as lungs, heart, liver and kidney.

RELATED WORKS

For continuous detection of adulteration in petrol with kerosene, an intrinsic intensity modulated no core fiber sensor (NCFS) is presented here. Based on evanescent waves phenomenon sensing is done. By stubbing a small section of no core fiber (NCF) between two multi-mode fibers (MMF), the sensing head of NCFS is fabricated. Using the proposed sensor, a high sensitivity 390 nW/% and 110 nW/% are obtained for low and high level of adulteration. The change in intensity and confinement loss with various concentrations of the kerosene in petrol are analyzed theoretically by using finite element method. It is known that the theoretical results are similar to experimental results. The advanced sensor has fast response time and good repeatability and high sensitivity. The sensor can be applicable in industries and automotive companies because of its small size, simple to fabricate, secure with inflammable fuels and needs minimum amount for identification [1]. Here the design and fabrication of an Evanescent Optical Waveguide Sensor (EOWS) using silicon oxynitride (SiON) as the core layer on silica-silicon wafer is presented and its implementation for continuous identification of adulterant traces in original petrol by implementing composite planar waveguide geometry. The objective is to bind a sudden option to the time-consuming existing adulteration identification methods which

normally needs some time to provide the consequence. Using Simple Effective Index Method (SEIM), the theoretical assumptions and experimental results at 632.8 nm wavelength are analyzed and presented, which shows that the sensitivity of the proposed EOWS is 40 times larger than that of the existing planar waveguide sensors and 20 times larger than that of asymmetric waveguide structure thereby enabling continuous identification of adulterant traces in original petrol without adding any new chemicals. The sensor structure is not dependant on polarisation and advantages are high sensitivity, easy fabrication and, requirement of very low amount of sample volume for identifying adulteration [2].

Because of the adulterants which use compounds that are already present in fuels, detection of adulteration in petroleum fuels is a challenging one. Measurements of various physico-chemical properties are used in addition to chromatography and spectroscopy for identifying the compositional variations of these fuels. The incorporation of statistical design and data treatments simultaneously provide minimum sensitivity to distinguish adulterated and unadulterated samples in gasoline. Through this review, an attempt to organize the literature information on this area with an emphasis to detect and formulate methods suitable for monitoring adulteration. More Information's on the role of physico-chemical, chromatographic and spectroscopic methods in gasoline and diesel characterization have been presented [3].

Synchronous fluorescence spectroscopy (SFS) is a continuous, responsive method without causing damage is suitable for the analysis of multifluorophoric mixtures. The present study describes SFS and multivariate methods to analyse petroleum products which is a complex mixture of multiple fluorophores. Two multivariate techniques such as principal component regression (PCR) and partial least square regression (PLSR) have been efficiently utilized for the classification of petrol–kerosene mixtures. Calibration models were made using 35 samples and their verification was done with different composition of petrol and kerosene in the calibration range. The results demonstrated that the method can be applied for the estimation of kerosene in kerosene-mixed petrol. The model was found to be effective, identifying even 1% contamination of kerosene in petrol [4]. A procedure for the prediction of quality parameters of motor gasoline and to distinguish between the different adulterated motor gasoline samples using density values, distillation temperatures and Fourier transform infrared (FTIR) analysis along with multivariate calibrations. Ten blend mixtures of regular and super motor gasoline were taken in order to analyze density, distillation temperatures and FTIR spectra characteristics for each blend. Distillation temperatures were obtained for the pure and blend mixtures of regular and super motor gasoline at initial boiling point (IBP) to final boiling point (FBP) at 5%Vol. Exact distillation data on the fuel not contaminated would be effective for comparison. The results obtained were found to be useful in deduction and differentiation purposes, providing information on whether the density values, distillation temperatures and FTIR analysis along with multivariate method could be an essential feature for distinguishing a particular pure motor gasoline sample from the others. The variations found in the specific spectral bands are analyzed and discussed. They have proven to be an effective combination in the event of management's differentiation goals [5].

Based on fiber-optic surface plasmon resonance (FO-SPR) a method used to identify mixed petrol is proposed to realize real-time, rapid monitoring of the mixed petrol interface in transportation pipelines. The mixed petrol could be identified by measuring the refractive index of the petrol, which corresponds to the resonance wavelength in the SPR curve by immersing the sensing region of the FO-SPR sensor. Mathematical simulation done with optical fiber theory and the SPR principle to improve the efficiency of structural parameters of the sensor. Small changes in the refractive index is reflected by the optimized sensor for the mixed petrol detection. Further the end-reflection FO-SPR sensor was designed and fabricated. In addition to the revolution of the coating disc, the fibre was rotated to form a uniform coating of the circumferential surface of the fiber core during vacuum coating. A wavelength modulation optical measurement system with the FO-SPR sensor was formed. Petrol 90#, Petrol 93#, Petrol 97#, and their mixtures were measured. The experimental results shown that this method could identify various mixing ratios of petrol with good repeatability, which provides the technical foundation for fast and accurate online detection of the mixed petrol interface in transportation pipelines [6].

The quality of petroleum-based products is the most important aspect of social and environmental standard in a developed society. High-quality petroleum-based fuels would have many advantages (e.g., reduction in rate of consumption, less environmental pollution and durability of hardware). Recent advances in the application of infrared spectroscopy in the petroleum industry are analysed. Here the focus is on the methods suggested for the analysis of a wide range of characteristics in petroleum-based products. The methods based on the applications of vibrational spectrometry and chemometrics to achieve pattern recognition are discussed. In the petroleum industry, chemometrics and infrared spectroscopy solve many problems. IR spectrometry is used in the detection adulteration in petroleum products [7]. The foremost proposal for containing the air pollution is the appointment Committee by Indian government is the foremost proposal for containing the air pollution. It is hard to identify the adulterated fuel with visual examination because the basic fuel is mixed with other minimum boiling point range hydrocarbons having more or less same composition leading to change and affect the quality of the base fuel. The committee proposals regarding the Auto Fuel Policy and to formulate a road map for its implementation along with the other fuels for transport, identifications for the fuel quality along with others are the main objective for reduction of environmental pollution [8]. Here standard samples of Premium 91 and Super premium 95 octane gasoline were taken from Oman Oil Refineries and Petroleum Industries

Company SAOC (ORPIC) and were investigated. Different adulterated samples were measured by applying NIR spectroscopy in the absorption mode in the range of wavelength from 700 to 2500 nm. The multivariate methods like PCA, PLSDA and PLS regressions are used for statistical analysis of the acquired NIR spectral data. Partial least-squares discriminant analysis (PLSDA) was used to identify the difference between the pure and adulterated gasoline samples. For PLSDA model the R-square value result was 0.99 with 0.012 RMSE. Furthermore, PLS regression model was also formed to quantify the levels of Premium 91 adulterant in Super Premium 95 gasoline samples. The PLS regression model result was the R-square 0.99 and with 1.33 RMSECV value having better identification with RMSEP value 1.35 and correlation of 0.99 [9].

The petrol quality determine by parameters such as smell, density, colour, composition of petrol and distillation range. The parameters of petrol analyse to estimate the adulteration in petrol. The density of petrol analyse by Anton paar density meter The distillation range estimate with Auto Dist Distillation analyzer and dye presence in petrol analyse by thin layer chromatography [10]. Synchronous fluorimetric analysis applies to obtain fingerprints of fuel. The analysis is based on the principle of polycyclic aromatic hydrocarbon content. Two wavelength namely excitation and emission differ in value with respect to level of adulteration in fuel [11]. A complementary split ring resonator (CSRR) detects the kerosene adulteration in petrol. The CSRR works at 2.7 Ghz, on the basis of Babinets principle. The rings present on the outer surface of CSRR works as a electric dipole when exited with electric field. The CSRR electric field vary when a particular sample introduce in CSRR cavity. The variation in electric field helps analyze adulterant in petrol [12]. An optical sensor and PIC microcontroller apply to detect the level of adulteration in petrol. The optical sensor detects the level of adulteration up to 5%. The optical sensor comprises of LED transmitter and optical detector circuit. Depending on the level of adulteration in fuel the level of light illuminated on the receiver side vary. The variation in light signal analyzes the level of adulteration in fuel [13].

METHODOLOGY

The change in petrol quality and adulterant presence in petrol analyze for texture and change and Gray Level Co-occurrence Matrix (GLCM) features. Initially, a thermal image of petrol acquire under room temperature. Thermal camera comprises of optical lens and infrared emitter. The emitted infrared light focus with a lens on a object in its vicinity. The infrared light on object scan by infrared detectors. The detector elements produce image of object with temperature details called thermo gram. The thermo gram converts into electrical pulses. The pulses process by signal processing element, which translates the pulses to image data. The different in colour on thermal camera vary with respect to electrical pulses. The generalised block diagram of Thermal camera is shown in Figure-1.

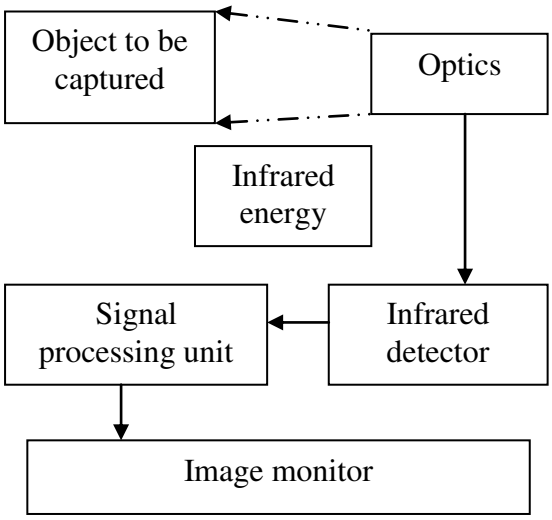

Figure-1. Thermal camera block diagram.

The difference in infrared reflection from different objects, fluid has distinctive properties. The generalised block diagram of thermal camera based fuel adulteration detection is shown in Figure-2. These properties are invisible when acquired and view on thermal camera. Hence, the acquired image process with clustering algorithm to group similar pixels in petrol image. The composition of fluid in acquired image group in to form image with similar pixel colours.

The similar pixels are grouped based on Euclidean distance as described in equation 1.

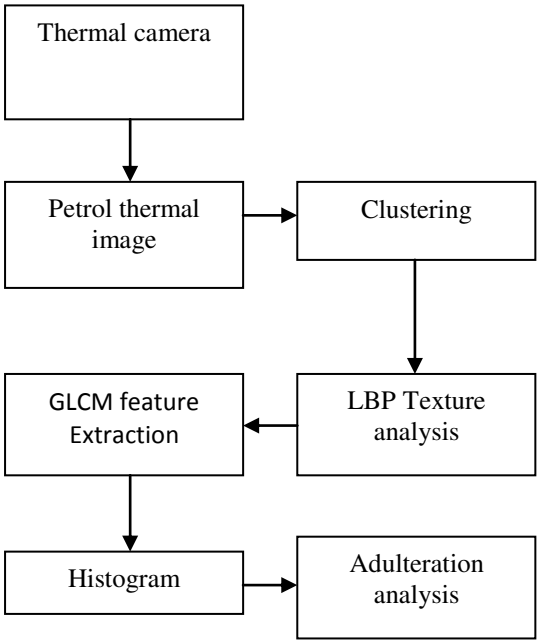

Figure-2. Petrol adulteration detection generalised block diagram.

$$\mathrm{dist}(\vec{x}, \vec{y}) = ||\vec{x} - \vec{y}||_2^2 \quad (1)$$

The clustering values vary with respect to distance between points in a cluster. The acquired thermal image, process with local binary pattern (LBP) to view different textures of adulterants in petrol image. LBP s are fast and apply in applications such as facial recognition, motion analysis and texture analysis. The LBP determines distance between S&H (sample & hold) histograms for texture classification and recognition. The histogram intersection LBP apply to analyse textures. The Histogram intersection give by equation 2.

$$D(S,M) = \sum_{b=1}^{B} \min(S_b\ M_b) \tag{2}$$

The adulterated fluid comprises of more than one compound. Each compound have different textures, the texture analysis help determine the composition of fluid. In addition, a GLCM (Gray level co-ocurrence matrix) help calculate differ gray level scales and textures in image. The gray scales express in terms of energy generalised by equation 3.
GLCM Energy level

$$Energy = \sum_{i,j=0}^{N-1} \left(P_{ij}\right)^2 \tag{3}$$

The adulterated petrol image and normal petrol image compare for pixel intensity changes. The pixel intensity changes with adulteration in petrol.

RESULTS AND DISCUSSIONS

The proposed system effectiveness validate by analysis different level of adulteration in petrol. Initially, a normal unadulterated petrol image acquire as shown in Figure-3. Similarly 5% and 10% adulterants (kerosene) add in petrol and acquired image are shown in Figures 4 & 5 respectively.

Figure-3. Unadulterated petrol.

Figure-4. 5% Adulterated petrol.

Figure-5. 10% Adulterated petrol.

In the above Figure 3 & 4 the level of adulteration is low such that there is minimal change in optical colour petrol. However, when the adulteration increase to 10% there is change in optical colour. The change in colour perceive by consumers as normal due to the smell and temperature of petrol. The acquired thermal image of petrol cluster to group pixels with similar intensity. The petrol has uniform intensity, hence the clustering results in similar clusture without color discontinuity as shown in Figure-6.

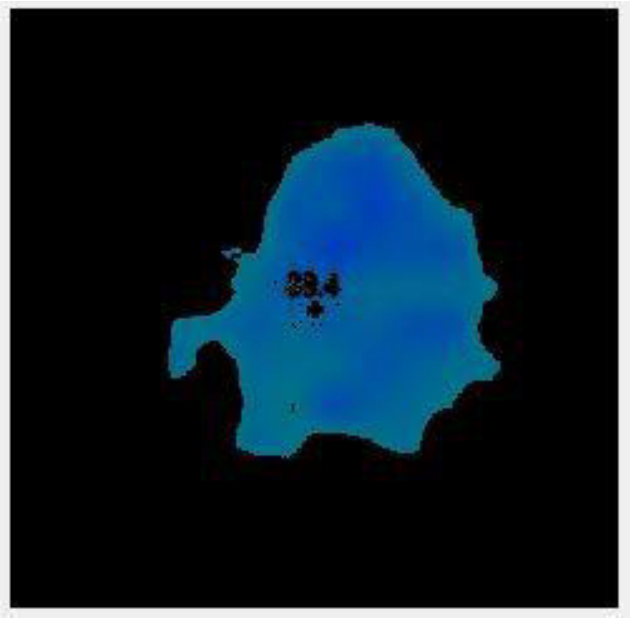

Figure-6. Unadulterated petrol cluster image.

The thermal image and corresponding binary pattern of image construct to view different textures in acquired thermal image. The change in texture occurs due to petrol interaction with air resulting in evaporation. The petrol evaporates resulting in different textures and corresponding LBP histogram is shown in Figure 7a and 7b respectively.

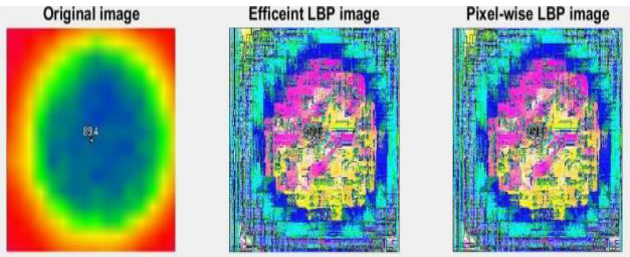

Figure-7a. LBP of Petrol thermal image.

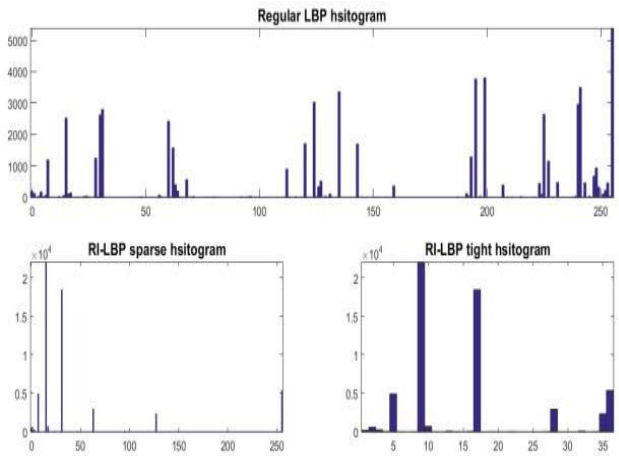

Figure-7b. LBP histogram for unadulterated petrol image.

The GLCM features of image extract to determine the effective region over which the adulteration is spread. The GLCM feature compute from thermal image as shown in Figure-8.

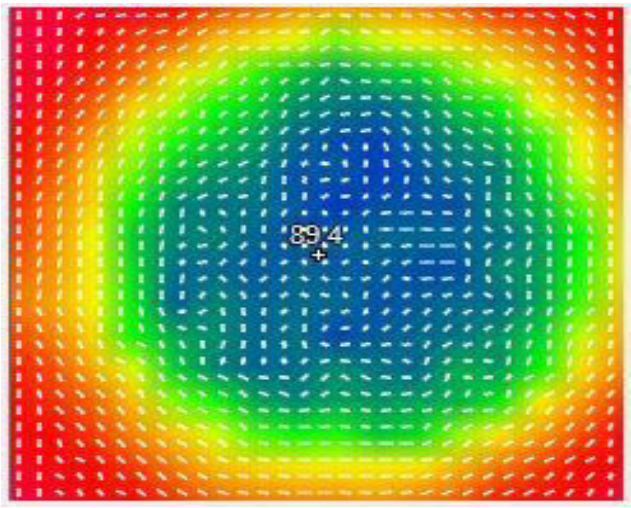

Figure-8. Thermal image of unadulterated petrol.

The GLCM features extract which shows the accumulation of blue region representing the petrol. Since the petrol is pure, there is minimal discontinuities in blue region in image. The GLCM feature and corresponding histogram show in Figure-9. Furthermore, GLCM histogram help analyze the level of petrol and level of adulterants in acquired thermal image.

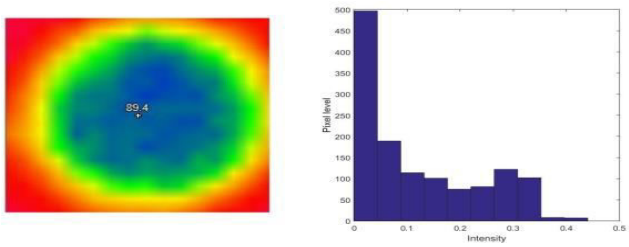

Figure-9. GLCM feature and Histogram.

5% Adulterated petrol

A 5% of kerosene adds to total petrol quantity. The clustering shows the region where the petrol are spread. During the initial phase petrol does not entirely combine with kerosene. The petrol and kerosene present as separate fluid, not visible to naked eye. The thermal clustering shows the region where petrol is spread in blue. The discontinuities in blue region shows the petrol separated by adulterants as shown in Figure-10.

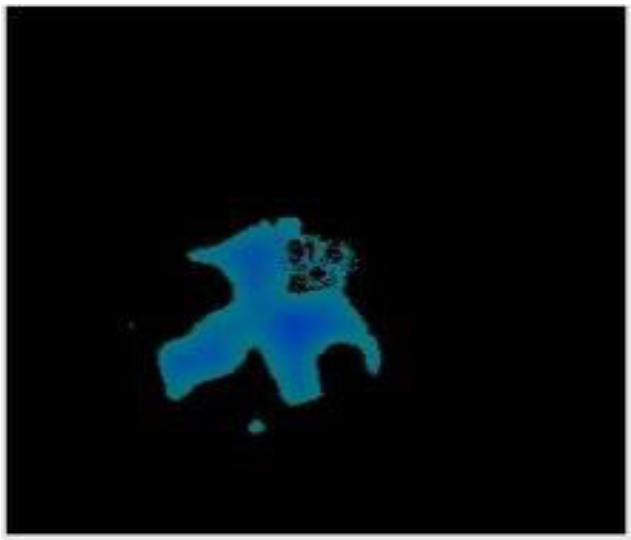

Figure-10. 5% Adulterated petrol.

The kerosene when added changes the petrol reaction when in contact with air. Under room temperature conditions, the petrol starts to evaporate as observed in Figure-7a. However the reaction slows due to the addition of adulterant in petrol. The change in thermal activity is shown in Figure-11a and LBP histogram 11b.

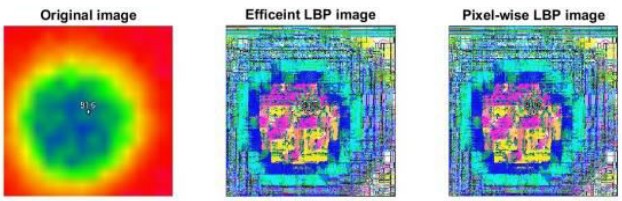

Figure-11a. LBP of 5% adulterated petrol.

The change in thermal activity views clearly in LBP histogram highlighted in Figure-11b. Compared to LBP histogram in Figure-7b the pixel intensity reduces considerably exposing the effect of adulteration in petrol.

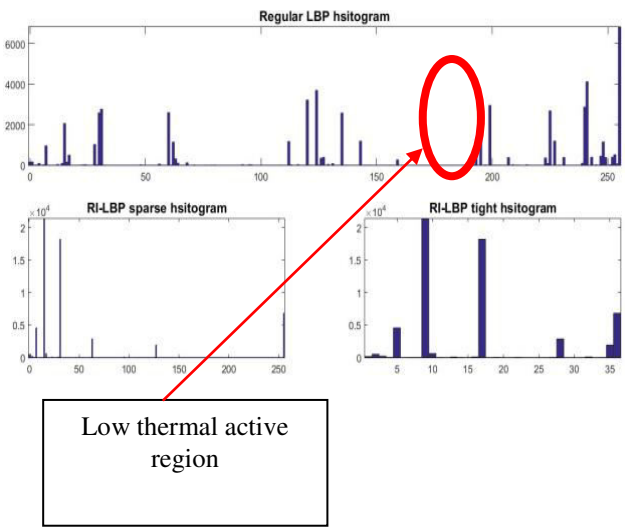

Figure-11b. LBP histogram for 5% adulterated petrol.

The change in petrol viscosity also varies due to adulterants in petrol. The region, over which the petrol spread, is in blue colour with green colour surrounding the edges as shown in Figure-12. Comparing Figures 11 & 12 the effect of thermal activity in petrol reduces. Furthermore, the adulterants stay together without completely mixing with petrol. In Figure-12 the blue region represents the petrol. The region with small bubble like pattern represents the adulterants present in the petrol. The histogram representation of Figure-12 shows the level of adulterants compared to level of petrol in acquired thermal image.

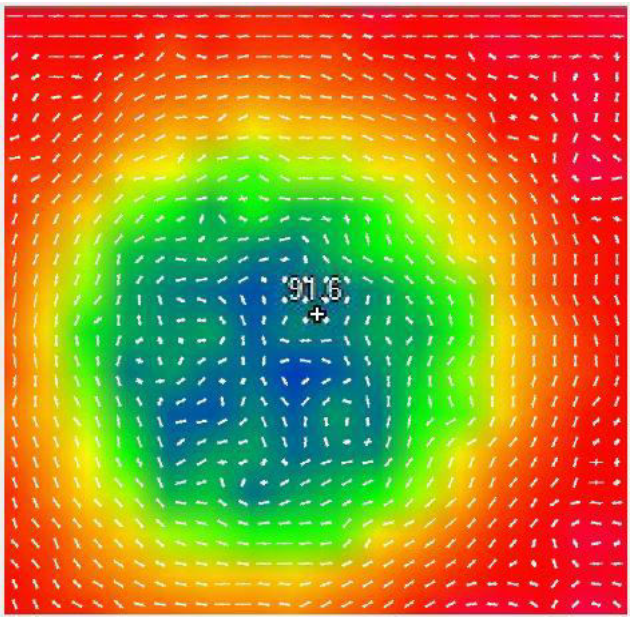

Figure-12. 5% Kerosene adulterated petrol Thermal image.

The GLCM feature extraction and corresponding histogram shows change in GLCM1 feature and texture in Figure-13.

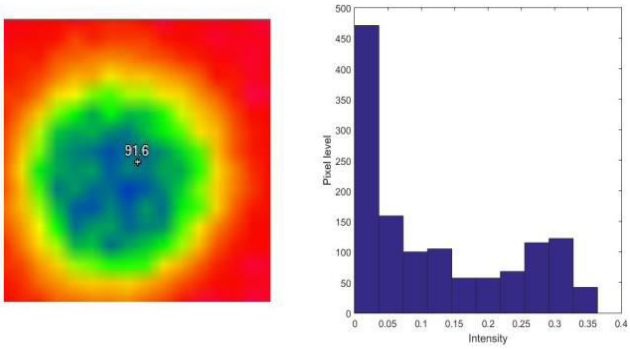

Figure-13. GLCM feature and histogram.

10% Adulterated petrol

The petrol add wtih10% of kerosene to analyse thermal activity. The petrol molecules separate by quantity of kerosene in petrol. The change in petrol molecules and

corresponding adulterants results in chunks of petrol as shown in Figure-14.

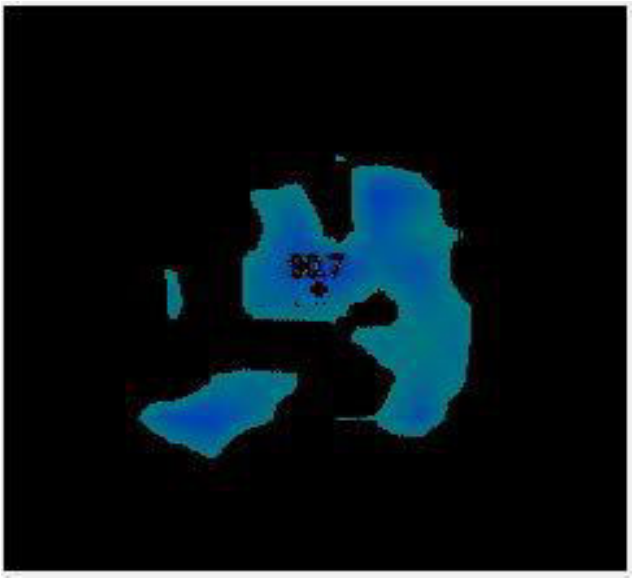

Figure-14. 10% Adulteration in petrol.

The effect of thermal activity reduces largely compared to 5% adulteration in petrol as shown LBP histogram in Figure-15a and 15b.

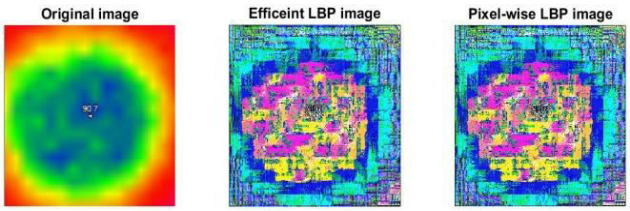

Figure-15a. LBP of 10% petrol thermal image.

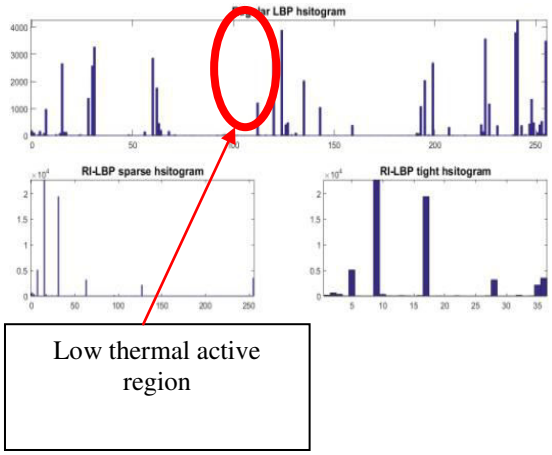

Figure-15b. LBP histogram of 10% petrol thermal image.

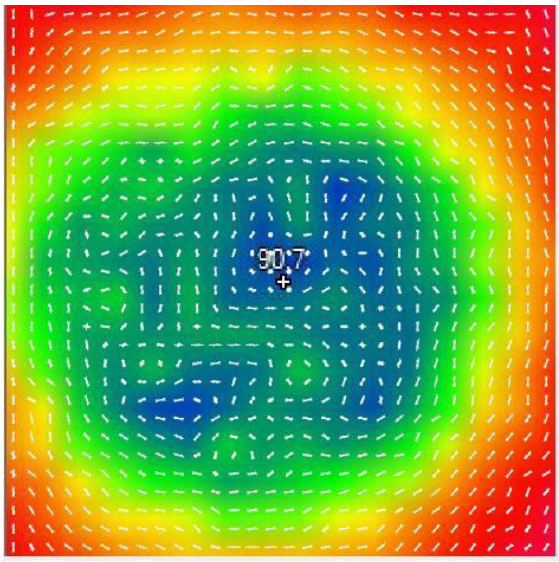

Figure-16. GLCM feature extraction of 10% adulterated petrol thermal image.

The GLCM feature extraction of 10% adulterated petrol image shows the accumulation of petrol region and adulterant region show in Figure-16. The Figure-17 shows GLCM feature histogram.

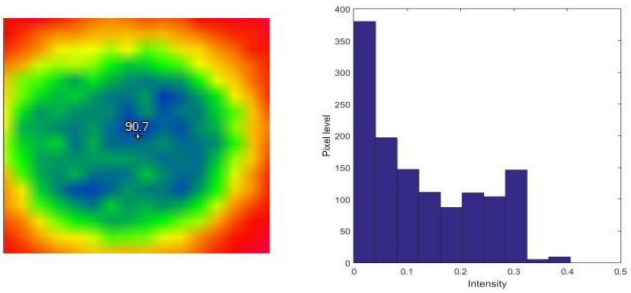

Figure-17. GLCM feature histogram.

CONCLUSIONS

Petrol adulteration occur mainly with distribuitors Oil and Gas industries for monetary gain. In this paper, a petrol adulteration detection scheme is proposed to determine level of adulteration in petrol. The thermal of image of petrol acquire and process with clustering, GLCM texture, feature extraction to determin the level of petrol. Exprerimental analysis shows the proposed scheme detects the level of adulteration for 5% and 10% of adulteration in petrol with 98% accuracy. Furthermore, the region over which the adulterated fuild groups togather is precisly estimated.

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