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Ultrasound Technique for Quality Checking of Diesel Adulteration in Lubricating Oil

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Abstract

All the petroleum products like gasoline, kerosene, diesel, lubricating oils etc. are evaluated on the basis of various properties as given by Institute of Petroleum or ASTM. These includes specific gravity, viscosity, aniline point, carbon residue, ASTM distillation, cetane number, octane number, volatility, flash point, smoke point, diesel index etc. But a petroleum product cannot be identified with a single test and all the related properties prescribed for the product has to be carried out, to identify that product.

A work is carried out for identification of petroleum adulteration in case of diesel adulteration in lubricating oil. For this various properties of these adulterated samples along with ultrasonic velocity were carried out. It is observed that as the molecule weight or specific gravity of sample increases, the ultrasonic velocity is also found to be increases.

Thus, this characteristic can be used to evaluate petroleum samples and its blends.

Key words : Petroleum adulteration, Ultrasound technique for petroleum adulteration, Evolution of petroleum product.

Introduction

In[1,2,3,4] petroleum refinery crude or fraction of petroleum is process through various reactor or processor to obtain the finished product. The efficiency of a process is completely based upon the accuracy of designing of reactors or processors. For designing of reactors or processor, different data is required. More data available more will be the chance to get high accuracy in designing.

The ultrasound velocities determine for the petroleum sample can be correlated with other properties like density and viscosity to obtain different physical properties for the

given petroleum sample. These data then can be usefully utilized to improve the accuracy of designing of reactors or processors.

The propagational properties of an ultrasonic wave in a medium depend on its physical properties. It has been noted that the ultrasonic velocity in a liquid shows a marked change when other liquid samples or impurities are added. It was, therefore proposed to undertake a detailed study of the variation of the ultrasonic velocity in a lubricating oil when it is adulterated by diesel sample, and to correlate these results with the petroleum testing prescribed for lubricating oil. This may leads to developed a reliable method to check the purity of petroleum lubricating oil.

Experimental technique

To[1,5,6,7] extend the ultrasonic study to petroleum products, it is proposed to carry out research work for evaluation of diesel – lubricating oil (4T oil) blends by using ultrasonic velocity. The lube oil has high cost, 4T lube oil having cost minimum Rs. 300/- per litre whereas diesel have minimum Rs. 40/- per litre. Hence to earn money, many times diesels added in lube oil, where it is freely sold in the market. Although blending of diesel to lube oil is limited to certain level, but it is carried out as we observe sometimes. Thus to check the ultrasonic effect on blend of diesel in lube oil, various blends of diesel and lube oil were prepared. For example, 5% diesel, 10% diesel, 15% diesel and 20% diesel in lube oil. As blending of diesel in oil is done, with less quantity of diesel, to avoid the visual inspection and identification of adulteration. Hence in this work the blend composition is limited up to 20% diesel only. To check the purity of diesel and oil these samples are also analyzed for their specification as per IS norm.

The blends so prepared was then analyzed for ultrasonic velocity similarly they were also analyzed for following petroleum properties.

1. Aniline point determination.
2. Specific gravity, API gravity and Diesel Index determination
3. Viscosity determination.
4. Conradson carbon residue determination.
5. Acid value determination.
6. Sap value determination.
7. Flash point by Cleveland open cup method.

The evaluation of samples for petroleum properties were carried out as per IP/ASTM norms.

Ultrasonic Velocity Measurements:

An[1,8,9,10,11,12] ultrasonic interferometer, "Mittal make" has been used to determine the ultrasonic velocity in the various mixture samples adulterated by diesel in lube oil at different percentage by volume at a constant temperature of 30^0C.

The principle used in the measurement of ultrasonic velocity is based on the accurate determination of wavelength, 'λ' in the medium. Ultrasonic waves of known frequency (f) (2 MHz in the present case) are produced by the crystal quartz which is fixed at the bottom of the specimen container. These waves are reflected back by a metallic reflector kept always parallel to the face of the quartz crystal. If the separation between upper face of the crystal and the reflector is exactly a whole multiple of sound wavelength, standing waves are formed in the

liquid. Such acoustic resonance gives rise to an electrical reaction on the generator driving the quartz crystal and the anode current in the generator becomes maximum which is displayed on a meter provided for this purpose. If the distance is now increased or decreased and the variation is exactly one half wave length ($\lambda/2$) or multiple of heat, anode current becomes maximum. From the knowledge of wave length 'λ' the velocity 'v' can be obtain by the relation,

Velocity = Wavelength X Frequency

i,e,. $V = \lambda X f$

Now using this well known relation $V = n\lambda$, ultrasonic velocity in the mixture can be computed.

Result and Discussion

The comparative statement for various testing is as shown in following table:

Sample	Ultrasonic velocity m/sec	Specific gravity	API Gravity	Aniline Point, ^0C	Diesel Index	Kinematic Viscosity (centistokes)	%CCR	Flash point ^0C (COC)	Sap value (mg of KOH/gm of sample)	Acid value (mg of KOH/ gm of sample)
100% oil	1482.22	0.8638	32.31	40	33.60	258.31	0.5	236	2.21	0.85
95% oil + 5% diesel	1442.16	0.8610	32.84	41	34.74	173.66	0.3	221	2.07	0.61
90% oil + 10% diesel	1402.10	0.8545	34.09	42	36.68	120.48	0.3	165	1.93	0.58
85% oil + 15% diesel	1379.66	0.8530	34.38	44	38.23	88.29	0.29	130	1.86	0.55
80% oil + 20% diesel	1370.85	0.8518	34.61	48	40.98	50.33	0.25	120	0.7627	0.47
100% diesel	1281.92	0.8290	39.18	60	54.85	5.2	0.1	60	0.3665	0.04

1. The test done for diesel sample indicate that it has specific gravity 0.8290 and Diesel Index 54.85, indicating that the diesel fallows the IS specification.
2. The ultrasonic velocity through diesel sample is 1281.22 m/s and through oil it is 1482.22 m/s. The ultrasonic velocity through lighter sample is less whereas ultrasonic velocity through heavier sample is high. Similarly as the quantity of diesel in oil increases, the ultrasonic velocity get decreases. This give a clue for checking the quality or type of

sample associated with given hydrocarbon fraction.

3. Aniline point determination gives aniline point for diesel 6^0C and for oil 40^0C. As aniline point is an indication of aromatics types of hydrocarbon. This indicates that diesel sample consist of less aromatic type of hydrocarbon than the oil sample. Hence oil having less value and diesel having high value of aniline point.
   As the quantity of diesel in oil sample get increases, the aniline point also found to be increases. This increase is observed for all blended sample.
4. As oil is heavier than diesel, hence kinematic viscosity value for oil should be more than the diesel sample. Same trend is observed in diesel-oil blend sample. Here oil has kinematic viscosity 258.31 centistokes at 20^0C and diesel has kinematic viscosity 5.2 centistokes at 20^0C. This variation in blend is also observed.
5. Carbon residue value depends upon the type of sample and type of hydrocarbon associate in that sample. Commonly high molecular weight or high boiling range hydrocarbons sample gives more carbon residue. Here carbon residue is determined by using Conradson carbon residue test.
   The value of CCR for oil is found to be 0.5% and for diesel it is 0.1%. Similarly in a blended sample as the quantity of diesel increases, the value of CCR is found to be decrease; this is due to increase in lighter hydrocarbon in blended sample. But all samples have CCR value less than 1% that is required one.
6. Total acid value gives an idea about the acetic nature or component (organic and inorganic) associated with given sample. The acid value of oil sample is found to be 0.85 and for diesel it is 0.04 mg of KOH per gram of sample. This indicates that the oil consist of more amount of acidic nature components than diesel. Here as the quantity of diesel in blend increases, the acidic value is found to be decreases, some additives is also contributed to the total acid value of sample.
7. Saponification value, *i.e.* sap value is an indication of total saponifing material present in the given sample. Heavier sample commonly consist of more saponifing material. The sap value for oil is 2.21 and for diesel it is 0.3665 mg of KOH per gm of sample. This is indicate that oil consist of oil consist of more saponifing components than diesel. Again some non-hydrocarbon and additives also contributes to the sap value. The order of decreases of sap value is continue as the percentage of diesel in blend get increases.
8. Flash point is totally depending upon the lighter hydrocarbon associate with the sample. As diesel is lighter than the oil sample. Hence diesel shows low flash point than the oil.

Conclusion

Above work shows that the sap value, acid value, flash point, CCR, kinematic viscosity and specific gravity of oil sample having more value than diesel sample. Again as the quantity of diesel in oil sample get increases, the value of above properties get decreases.

This is an attempt to evaluate the petroleum sample and adulteration in petroleum by using ultrasonic velocity. It is observed that

as the molecular weight of sample increases, the ultrasonic velocity also found to be increases. This may be justified from the equation 'v = λ x f'. That is through the heavier sample the wavelength, *i.e.* λ is found to be increases. This characteristic can be used to evaluate the petroleum sample and its blend. Thus, this may be a single step tool to check the adulteration in given sample, particularly when kerosene is adulterated in diesel or diesel is adulterated in oil sample.

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