

Research on Fuel-Dilution Monitoring of Engine Lubricant by FT-IR Spectroscopy

Gong Xiaolong^{1, a}, Tian Hongxiang^{2, b}, Sun Yunling^{3, c}, Li Jing^{4, d}

¹College of Power Engineering, Naval University of Engineering, Wuhan 430033, P. R. China

²College of Power Engineering, Naval University of Engineering, Wuhan 430033, P. R. China

³College of Power Engineering, Naval University of Engineering, Wuhan 430033, P. R. China

⁴College of Power Engineering, Naval University of Engineering, Wuhan 430033, P. R. China

^axlgong20140707@163.com, ^bhxtianwuhan@aliyun.com,

^cSunyunling315@163.com, ^dLeejing0820@163.com

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Abstract. FT-IR spectroscopy provides a measurement for fuel dilution in engine lubricating oil. Quantitative analysis techniques such as peak height and peak area could be employed in the analysis program of FT-IR spectroscopy. The accuracy of peak height method and peak area method is compared.

Introduction

With the development of computer technology, the application of oil analysis by FT-IR spectroscopy became relatively commonplace for production oil analysis laboratories ^[1]. Now FT-IR spectroscopy technology is widely used in the detection of lubrication oil, analyze the important parameters of lubricating oil in water, fuel dilution, ethylene glycol, carbon deposition, oxidation, nitration and antioxidant concentration ^[2, 3].

Experimental device and materials

The apparatus used Agilent Cary 630 FT-IR spectrometer which works at 600 cm⁻¹ to 5100 cm⁻¹. Figure 1 shows the Agilent Cary 630 FT-IR spectrometer.



Fig. 1 Agilent Cary 630 FTIR spectrometer

The Shell CD15W-40 lubricating oil is diluted with 0# diesel fuel. Table1 show the oil samples.

Table1 Dilution of oil samples

No.	Diesel fuel quality (g)	Lubricating oil quality (g)	Percentage of diesel fuel (wt%)
1	10.176	40.001	20.3
2	5.005	45.003	10.0
3	2.502	47.507	5.0
4	1.246	48.750	2.5
5	0.735	49.274	1.5
6	0.355	49.685	0.7
7	0.000	50.231	0.0

Results and discussion

Obtained the spectra of seven oil samples with the Agilent Cary 630 FT-IR spectrometer, and showed in a coordinate system. Figure 2 show the infrared spectra of the oil samples have no significant change on most of the wave number. But in the range of 800cm^{-1} to 825cm^{-1} , there is a significant change.

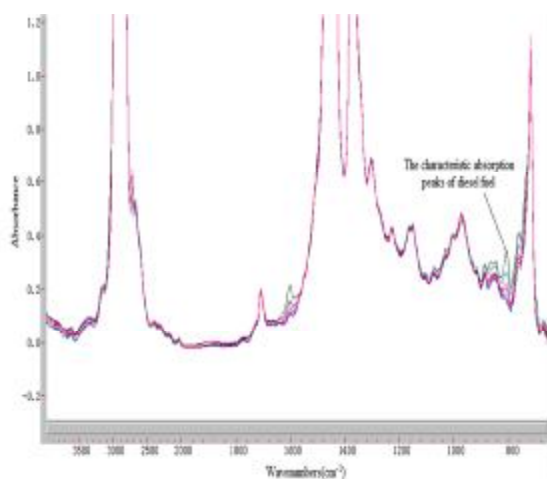


Fig. 2 The FTIR spectra of all oil samples

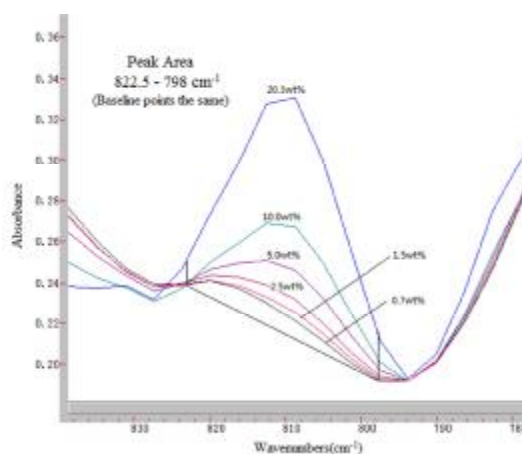


Fig. 3 Spectra of oil samples

A marker band typical in diesel-contaminated samples is found at 809.98cm^{-1} . Baselines points are taken as the minima between 835cm^{-1} to 820cm^{-1} (left) and between 805cm^{-1} to 795cm^{-1} (right) [4]. The area is measured over the range of 822.5cm^{-1} to 798.0cm^{-1} .

FT-IR spectroscopy determines fuel contamination by measuring the absorbance bands of specific components in the fuel. Quantitative analysis measurement techniques such as peak height and peak area could be easily employed in the analysis program of FT-IR spectroscopy.

The peak height of the oil sample in the wave number is 809.980cm^{-1} as the arguments and the fuel concentration is the dependent variable. The fitting equation of peak height (h) with fuel concentration (c) is acquired.

$$c=173.h-0.614$$

(1)

This fitting equation displayed good correlation ($R^2=0.9962$) between peak height and fuel concentration. Figure 4 show the fitting line of peak height.

The peak area of the oil sample over the range of 822.5 cm^{-1} to 798.0 cm^{-1} as the arguments, and the fuel concentration is the dependent variable. The fitting equation of peak area (a) with fuel concentration(c) is acquired.

$$c=10.9a-1.479 \quad (2)$$

This fitting equation displayed good correlation ($R^2=0.9968$) between peak area and fuel concentration. Figure 5 show the fitting line of peak area.

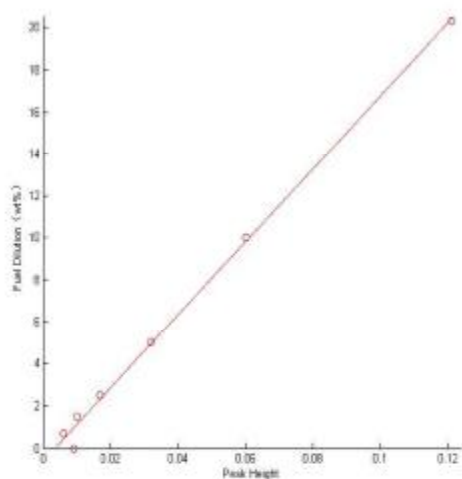


Fig. 4 The fitting line of peak height

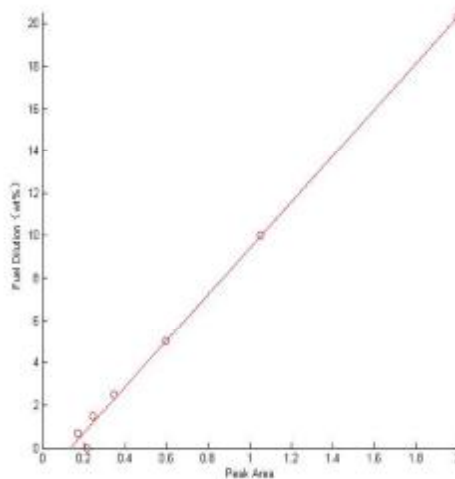


Fig.5 The fitting line of peak area

The relative error of the oil samples is calculated by comparing the peak area method and the peak height method. Table 2 show the relative error of the oil samples.

Table 2 The relative error of the peak height and area of oil samples

No.	Actual fuel content (wt%)	Peak height method		Peak area method	
		Fuel content (wt%)	Relative error (%)	Fuel content (wt%)	Relative error (%)
1	20.3	20.40	0.5	20.33	0.2
2	10.0	9.81	1.9	9.97	0.3
3	5.0	4.94	1.2	5.03	0.6

The relative error of the peak area method is smaller than the peak area method. So peak area method for the detection of fuel dilution with high accuracy.

Conclusion

FT-IR spectroscopy for detection of fuel dilution with the peak height method and the peak area method, and the fitting equations are obtained. By comparing the relative error of the peak area method and the peak height method, the accuracy of the peak area method is higher.

Acknowledgements

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