Self-checking impurity method in liquids

Shyam Singh*
Physics Department, University of Namibia
340 Mandume Ndemufayo Avenue, Private Bag 13301, Pioneerspark, Windhoek, Namibia

Received: 10th March, 2013. Accepted: 4th April, 2013.

Abstract

We propose a very simple technique for the determination of impurity in liquids based on the refractive index. This technique requires two similar gratings, two similar low power lasers emitting same wavelength and a position detector. The change in refractive index of liquid determines the impurity in a liquid.

Keywords: impurity in liquids, refractive index, gratings.

ISTJN 2013; 1(1):7-10.

1 Introduction

Refraction is one of the most important optical phenomena in optics. The refractive index of liquids exhibits the optical properties of liquids. Refractive index may help in controlling adulteration in liquid products as this parameter changes with impurity in liquids.

Various techniques for the measurements of refractive indices of liquids have been reported [1-4] using a low power laser. The proposed technique gives an alternative of checking impurities in liquids on spot in a liquid plant. This technique does not require any additional parameters for the determination of refractive index of liquids and hence the impurity in liquids can be checked instantaneously.

*Corresponding author - E-mail: ssingh@unam.na; Tel: +264 61 206 3401; Fax: 264-61-206-3791

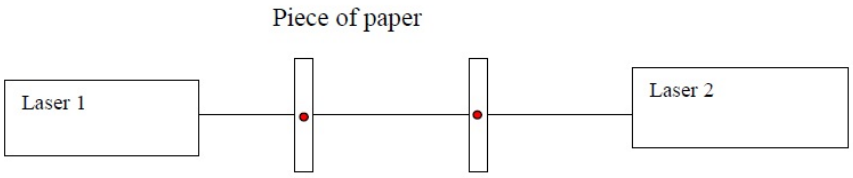

Figure 1: Alignment of lasers

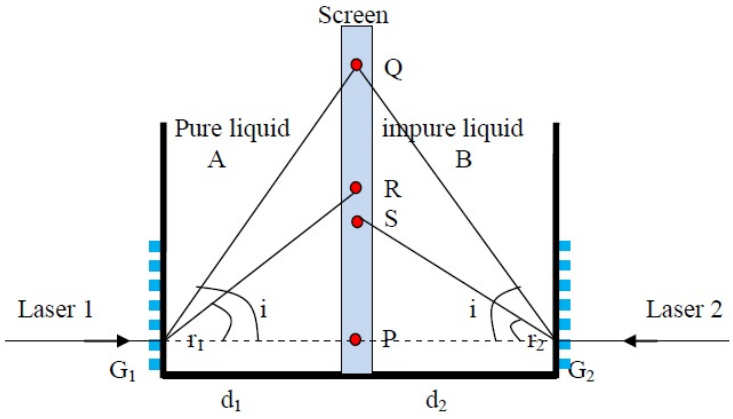

Figure 2: Diffraction from two similar gratings

2 Description of the Apparatus and Methods

Laser light, from two similar lasers having same wavelengths is aligned as shown in Figure 1. A piece of paper is moved along the laser light. If there is only one central spot on the paper along the laser beam, then the lasers are aligned. Now a specially designed glass-cell system having a screen and two identical transmission diffraction gratings, G_1 and G_2 is inserted between the two lasers as shown in Figure 2. Both the gratings have the same grating constants. The normal light from both the gratings meets the screen at point P. The screen is positioned between the two glass cells A and B. The first order diffraction from the two gratings meets at point Q on the screen when there is no liquid in either cell. In glass cell A, the standard liquid (pure liquid) is poured and the refracted light is observed at point R. The liquid under experiment is poured in glass cell B. If the liquid in B is same as liquid in A, then the refracted light from B will meet at the same point R, otherwise if the liquid in B has any impurity, it will meet the screen at point S. With the help of a micrometer, the positions of Q, R, and S are noted down and hence the distance $(QP) = a$, $(RP) = b$, and $(SP) = c$ are calculated. The thickness of the glass cells are d_1 and d_2 but both cells can be taken similar so that $d_1 = d_2$. Now using Figure 2, we have

$$\sin i = \frac{a}{G_1Q} = \frac{a}{G_2Q} \tag{1}$$

$$\sin r_1 = \frac{b}{G_1 R} = \frac{b}{\sqrt{(d_1^2 + b^2)}} \tag{2}$$

$$\sin r_2 = \frac{c}{G_2 S} = \frac{c}{\sqrt{(d_2^2 + c^2)}} \tag{3}$$

But

$$n_1 = \frac{\sin i}{\sin r_1} \tag{4}$$

and

$$n_2 = \frac{\sin i}{\sin r_2}, \tag{5}$$

so that

$$\frac{n_2}{n_1} = \frac{\sin r_1}{\sin r_2} = \frac{b}{c}\sqrt{\frac{(d_2^2 + c^2)}{(d_1^2 + b^2)}} \tag{6}$$

If $d_1 = d_2$, and $n_1 = 1$ for air, then

$$n_2 = \frac{b}{c}\sqrt{\frac{(1 + tan^2 r_2)}{(1 + tan^2 r_1)}} \tag{7}$$

If the liquid B has no impurity and is very identical to liquid A, then $r_1 = r_2$ and $c = b$ and hence $n_2 = n_1$.

If the gratings and the lasers are mounted permanently then the separation between the two light spots of R and S will determines the magnitude of the impurity in liquid B. If the scale is calibrated and a position detector is used, this technique will enhance the accuracy of measurements and the reading of the scale on the screen will give the impurity in the liquid instantly.

3 Conclusions

A simple and inexpensive technique for detecting the impurity in a liquid based on the refractive index has been successfully developed. The experimental results will be reported in the next article.

Acknowlegements

The financial support from the University of Namibia (UNAM) is gratefully acknowledged.

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