Measurement of Viscosity in a Vertical Falling Ball Viscometer

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In this study, the authors considered that there are two factors affecting the experimental results—the resolution of the camera and the curve-fitting equation in Figure 2. When the pin for fixing the falling ball is released, it represents the ball beginning to fall. In this study, the authors checked the images recorded per 1/30 sec one by one, and tried to find one that recorded the initial movement and one that recorded the ball passing the end line.

Nevertheless, it is difficult to distinguish which picture recorded the pin moving away from the falling ball when the camera's resolution is not high enough to zoom in on the pin. Therefore, an effective camera can promote the accuracy and stability of the measurement of dynamic viscosity in the vertical falling ball viscometer. On the other hand, the study selected C_d = 30/Re instead of the Stokes' law of C_d = 24/Re, because the curve-fitting line of C_d = 30/ Re is much better in Figure 2. If one uses the curve-fitting line of C_d= 24/Re, the relative error will increase to be over 10%.

The restriction in this measuring method is that the Reynolds number must be less than 5. Therefore, the sphere falling ball must be changed when the falling Reynolds number is larger than 5, because it violates the derivation of Eq. (7) in this study. Nevertheless, the method in this study extends the suitable range from Re<1 to Re<5, i.e., it extends the available range of the falling ball. This means that the method can decrease the chances of changing the falling ball in the experiment. In addition, according to the theory of Stokes' law, the figure of drag coefficient versus Reynolds number depicts the properties of a perfect sphere ball moving in a liquid. In this research, although the authors measured the out-of-roundness of the sphere ball, they did not analyze the error due to the effect of the out-of-roundness. The authors hope to further investigate the effect of out-of-roundness on the measurement results in future work, and validate the accuracy of the method by measuring more reference liquids.

Conclusion

A new method for measuring dynamic viscosity based on the falling ball viscometer has been developed. The characteristics of the method are that Newton's law of motion includes the acceleration term, and the dynamic viscosity must be calculated by a numerical code with an iteration scheme. Because the falling tube is vertical to the ground, which is different from the devices claimed in international standards, the study refers to it as the vertical falling ball viscometer.

The study used SAE 30 oil as the sample liquid, and the results indicated that the confidence interval of measurement is ±0.0034 with a confidence level of 99.73%, and the measuring error of viscosity is close to 6%. It is hoped that future work will increase the measurement accuracy and stability by utilizing a camera with higher resolution, and consider the effect of the out-of-roundness of the falling ball on the measurement.

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