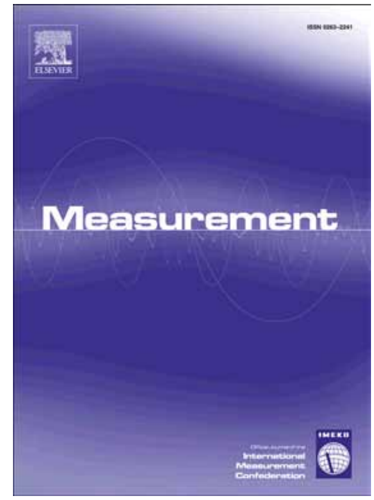

An Exact Model Based Dynamic Contact Angle Algorithm

Zhiniu Xu

PII: S0263-2241(18)30719-X
DOI: https://doi.org/10.1016/j.measurement.2018.07.082
Reference: MEASUR 5766

To appear in: *Measurement*

Received Date: 8 November 2016
Revised Date: 9 May 2018
Accepted Date: 25 July 2018

An Exact Model Based Dynamic Contact Angle Algorithm

Zhiniu Xu*

State Key Laboratory of Alternate Electrical Power System with Renewable Energy Sources, North China Electric Power University, Baoding 071003, China

Abstract: It is hard to accurately evaluate advancing and receding contact angles for drop on inclined surface. Different from existing simplified model-based algorithms, an exact model-based dynamic contact angle algorithm is proposed. A large number of drop profiles on inclined surface with contact angle, inclination angle and Bond number within the nearly whole application range are numerically generated. After systematic investigations, the parameter closely related to Bond number is determined and the Bond number can be predicted relatively accurately and rapid. Thereafter, the Bond number is adjusted according to the dichotomy and the influence of Bond number on drop shape. The methods for determination of drop apex and scale factor of image are presented. By combining the aforementioned methods the exact model-based dynamic contact angle algorithm for drop on inclined surface is proposed. The extensively used dynamic contact angle algorithms and the proposed algorithm are used to hydrophobicity measurement for real drop image and numerical drop profile on inclined surface. The results reveal that: only the proposed algorithm can accurately evaluate dynamic contact angle without any limitation on contact angle, drop volume and inclination angle, and at the same time the exact fitted edge can be presented.

Key words: hydrophobicity; dynamic contact angle; inclined surface; Bond number; dichotomy; prediction

1 Introduction

Hydrophobicity is the important property of material, especially for superhydrophobic surfaces [1], self-cleaning surfaces[1], extern insulating material [2-3] etc. We can use static contact angle [4-6] or dynamic contact angle [7-10] to characterize hydrophobicity of material. The former used more widely. It is easier to measure and evaluate contact angle. Therefore, the corresponding contact angle algorithms have now reached a certain maturity. However, hydrophobicity measurement is influenced by hysteresis caused by roughness and inhomogeneity [11] on surface of material which cannot be completely avoided on the material surface. Some methods can be used to measure dynamic contact angle, such as the Wilhelmy plate method [12], the capillary rise technique [13], the adding/subtracting drop method [14], the ADSA-CSD (Axisymmetric Drop Shape Analysis-Constrained Sessile Drop) method [15], and the inclined plane method [16]. In comparison with other methods, the inclined plane method has a low requirement on instrument and the drop shape is highly resistant to other factors. The inclined plane method can suppress the influence of hysteresis on hydrophobicity measurement. Although its measurement is more complicated than the static contact angle measurement, it is relatively widely used in various fields of engineering, science and technology etc. The core part of the inclined plane method based dynamic contact angle measurement is its algorithms.

The protractor method can be used to evaluate the dynamic contact angle for drop on inclined surface [17]. The method is easy to realize and operate. However, the results will fluctuate significantly by different operators and operations. The error in the method may larger than ±3°. More important, the method is not an automated procedure and the human involvement is required. The other dynamic contact angle algorithms are the fitting-based ones. After analysis of drop profile on inclined surface, the profile can be separated into two parts according to apex and the two parts can be approximated by two circles sharing a common tangent at the maximum height [18].This method improve the accuracy in the evaluated dynamic contact angle. However, it remains high accuracy only within a certain range and its error is significant at large contact angle and drop volume. After investigations, the authors find that a polynomial of a single order in Cartesian coordinates cannot accurately estimate a wide range of contact angles. To overcome this limitation, the authors implement a new polynomial fitting scheme by transforming drop profiles into polar coordinate system [19]. This method is an elegant and exciting approach. The accuracy in the evaluated dynamic contact angle is significantly improved and application range is widened. However, similar to the double circle method, the polar coordinate-based polynomial fitting method cannot evaluate dynamic contact angle within the whole application range. In some cases, the drop profile on the inclined surface is quite similar to a part of an ellipse [20]. Therefore, the ellipse fitting algorithm [21] can be used to fit the drop edge and evaluate the dynamic contact angle. The authors find that the

*Corresponding Author. Tel.:+8603127522486; Fax:+8603127522252
E-mail address: wzcnjxx@sohu.com.(Zhiniu Xu)