The residual oil film adhering to rough inner wall of bell prover

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Bell prover is used as a primary standard for testing gas flow rate in calibration laboratories worldwide, and much effort has been devoted to measuring its volume and evaluating its uncertainty. Oil film adherence is one of sources of uncertainty since it occupies the part of calibrated volume after bell is withdrawn from the bath at a constant velocity. Drainage of oil film results in the decreasing thickness until the thickness reaches practically stable during the bell’s dwell period. Previous investigation showed that the variation of film thickness with the time, based on a balance between viscous resistance and gravity, ends up with negligible thickness in view of the smooth wall assumption. An optical measurement of film thickness shows a different thickness profile as falling film covers a practically rough surface attributed to machining residual or the texture of stainless steel. The falling film is separated into two layers in order to characterize the drainage behavior. One is trapped layer with the thickness less than or equal to the height of residual or texture, within which velocity profile becomes gentle because of increased friction. The other is free layer located above rough surface，within which the film moves faster than it does on solid surface. Further investigation shows that the decreasing rate of film layer is slowed down by rough surface, and final film thickness remains almost same height as that of residual or texture because oil film is unable to escape from texture by gravity under such a surface tension dominant condition. Therefore, it is unnecessary to evaluate a constant oil film thickness remaining on the surface of the bell withdrawn from an oil reservoir because gravity drainage results in thinner oil film. Concern should be given to the deposited oil film by rough texture as it reduces the collection volume inside bell.