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Analyzing Contact Angle of Different Fluids Present In Petroleum Reservoirs

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Abstract:- The idea behind the current work is determining the contact angle of few different fluids namely water, oil, detergent water and mixture of oil cum water using imaging method. Imaging method provides wettabillity of rock or formation information. Analysis were carried out using metal plate made up of silver. Since contact angle measurement is an important parameter for petroleum reservoir fluids we used contact angle goniometer for accurate analysis.
Keywords: Contact angle, petroleum reservoir, oil water mixture, wettability

I. INTRODUCTION

The contact angle is the angle, conventionally measured through the liquid, where a liquid–vapour interface meets a solid surface. It quantifies the wettability of a solid surface by a liquid via the Young equation. A given system of solid, liquid, and vapour at a given temperature and pressure has a unique equilibrium contact angle. However, in practice contact angle hysteresis is observed, ranging from the so-called advancing (maximal) contact angle to the receding (minimal) contact angle. The equilibrium contact is within those values, and can be calculated from them. The equilibrium contact angle reflects the relative strength of the liquid, solid and vapours molecular interaction.

The Young–Laplace equation for a three-dimensional drop is highly non-linear. This is due to the mean curvature term which includes products of first- and second-order derivatives of the drop shape function :
Solving this elliptic partial differential equation that governs the shape of a three-dimensional drop, in conjunction with appropriate boundary conditions, is extremely complicated and an alternate energy minimization approach to this is generally adopted. The open-source software, Surface Evolver, which solves for the drop shape by minimizing the sum of potential and surface energies, has been used by many for this purpose. The shapes of three-dimensional sessile and pendant drops have been successfully predicted using this energy minimization method.

Figure.1 Cloth, treated to be hydrophobic, shows a high contact angle

Contact angles are extremely sensitive to contamination; values reproducible to better than a few degrees are generally only obtained under laboratory conditions with purified liquids and very clean solid surfaces. If the liquid molecules are strongly attracted to the solid molecules then the liquid drop will completely spread out on the solid surface, corresponding to a contact angle of 0°. This is often the case for water on bare metallic or ceramic surfaces, although the presence of an oxide layer or contaminants on the solid surface can significantly increase the contact angle [1]. Generally, if the water contact angle is smaller than 90°, the solid surface is considered hydrophilic and if the water contact angle is larger than 90°, the solid surface is considered hydrophobic. Many polymers exhibit hydrophobic surfaces. Highly hydrophobic surfaces made of low surface energy (e.g. fluorinated) materials may have water contact angles as high as ~120°.Some materials with highly rough surfaces may have a water contact angle even greater than 150°, due to the presence of air pockets under the liquid drop. These are called super hydrophobic surfaces. Conversely, the fluid which adheres less readily, the non-wetting phase, occupies the largest areas of the pore-space, principally in the centres of large pores [2].

If the contact angle is measured through the gas instead of through the liquid, then it should be replaced by 180° minus their given value. Contact angles are equally applicable to the interface of two liquids, though they are more commonly measured in solid products such as non-stick pans and waterproof fabrics.

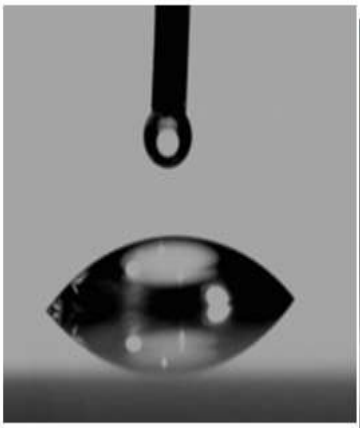

Figure. 2 Water drop on glass, with reflection below

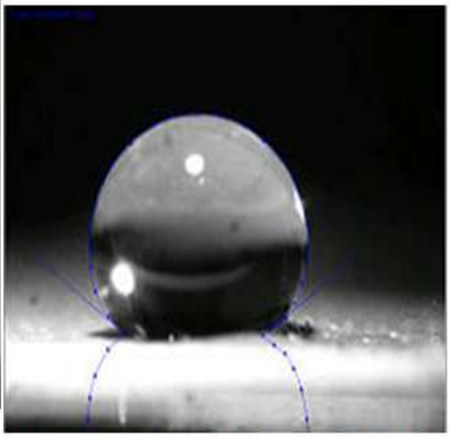

Figure. 3 A water drop on a lotus leaf surface showing contact angles of approximately 147°

Figure. 4 Goniometer for contact angle analysis

Dynamic sessile drop method

1) The static sessile drop method

The sessile drop contact angle is measured by a contact angle goniometer using an optical subsystem to capture the profile of a pure liquid on a solid substrate. The angle formed between the liquid–solid interface and the liquid–vapour interface is the contact angle. Older systems used a microscope optical system with a back light. Current-generation systems employ high resolution cameras and software to capture and analyse the contact angle. Angles measured in such a way are often quite close to advancing contact angles. Equilibrium contact angles can be obtained through the application of well-defined vibrations

2) The pendant drop method

Measuring contact angles for pendant drops is much more complicated than for sessile drops due to the inherent unstable nature of inverted drops. This complexity is further amplified when one attempts to incline the surface. Experimental apparatus to measure pendant drop contact angles on inclined substrates has been developed recently. This method allows for the deposition of multiple micro drops on the underside of a textured substrate, which can be imaged using a high resolution CCD camera. An automated system allows for tilting the substrate and analysing the images for the calculation of advancing and receding contact angles.

3) The dynamic sessile drop method

The dynamic sessile drop is similar to the static sessile drop but requires the drop to be modified. A common type of dynamic sessile drop study determines the largest contact angle possible without increasing its solid–liquid interfacial area by adding volume dynamically. This maximum angle is the advancing angle. Volume is removed to produce the smallest possible angle, the receding angle. The difference between the advancing and receding angle is the contact angle hysteresis.

4) Dynamic Wilhelmy method

A method for calculating average advancing and receding contact angles on solids of uniform geometry. Both sides of the solid must have the same properties. Wetting force on the solid is measured as the solid is immersed in or withdrawn from a liquid of known surface tension. Also in that case it is possible to measure the equilibrium contact angle by applying a very controlled vibration. That methodology, called VIECA, can be implemented in a quite simple way on every Wilhelmy balance.

5) Single-fiber Wilhelmy method

Dynamic Wilhelmy method applied to single fibers to measure advancing and receding contact angles.

6) Washburn's equation capillary rise method

In case of a porous materials many issues have been raised both about the physical meaning of the calculated pore diameter and the real possibility to use this equation for the calculation of the contact angle of the solid, even if this method is often offered by much software as consolidated .clarification needed change of weight as a function of time is measured.

II. SAMPLING

To prepare sample about 40 mL of water is taken and 10 mL of gear oil to mix oil with water about 1-2 gm of detergent surf is added

Figure. 5 Preparation of oil water mixture samples

III. EXPERIMENTAL PROCEDURE

Fill the syringe with water and fix it to the stand. Carefully inject droplet of the water on the glass cell or metal cell. Adjust the imaging system until a drop is in focus that is a clean outline of the image appears on the screen

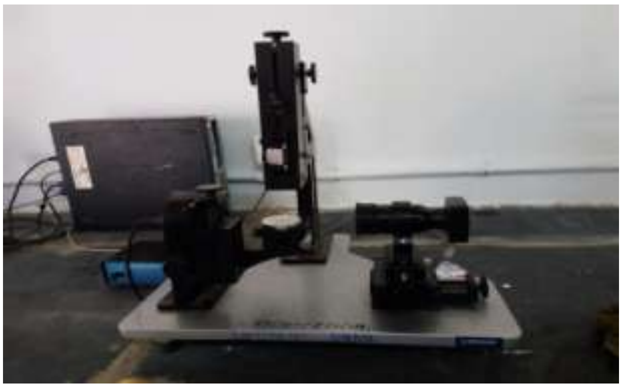

Figure. 6 Setup to determine drop image

Take image picture and measure the dimension of the drop image. Repeat the same procedure for different samples. Output is determined prescribed software.

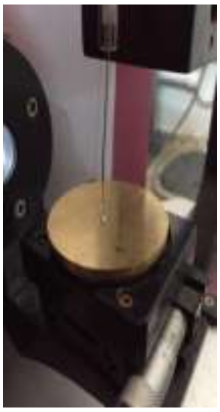

Figure.7 Water Figure. 8 Oil Figure. 9 Detergent water with oil

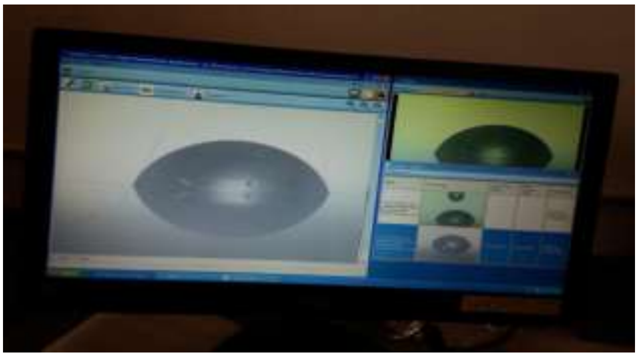

Figure.10 Image of water bubble

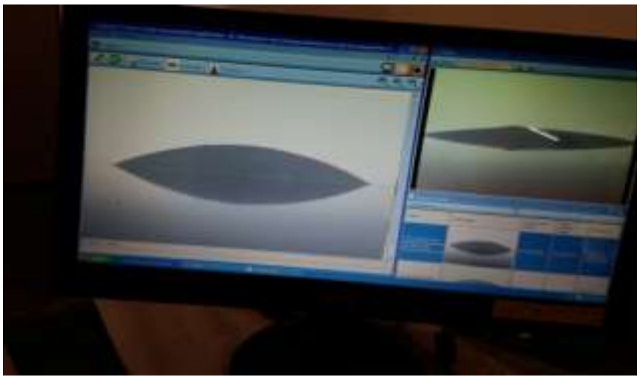

Figure.11 Image of oil bubble

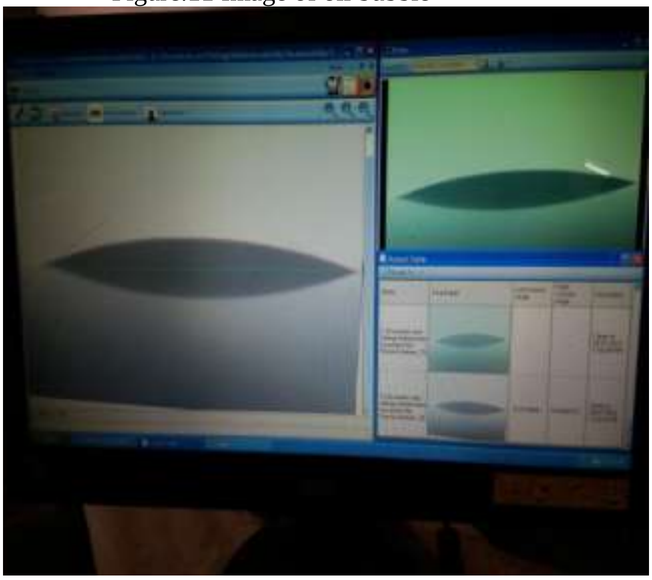

Figure.12 Image of detergent water and oil bubble

IV. RESULTS

The left contact angle of water is 71.323deg and right contact angle is 80.34deg. The left contact angle of oil 1 is 29.31deg and right contact angle is 30.6deg. The left contact angle of oil 2 is 31.029deg and right contact angle is 14.314deg. The left contact angle of detergent water and oil is 30.669deg and right contact angle is 25.016deg.

V. CONCLUSIONS

The contact angle of water is more when compared to other fluid samples and it is more wettability than other fluids. The water present in the reservoirs is much solid wet than other fluids. This can be also due to change in there density.

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