

**DEFORMATION AND DETACHMENT OF AN OIL DROPLET
FROM THE SOLID SUBSTRATE BY SIMPLE SHEAR FLOW**

by

AMIT KUMAR GUPTA

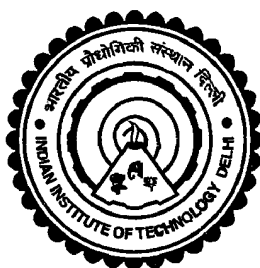
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Dedicated to my parents

CERTIFICATE

This is to certify that the thesis entitled **Deformation and detachment of an oil droplet from solid substrate by simple shear flow**, being submitted by **Mr. Amit Kumar Gupta** to Indian Institute of Technology Delhi is a record of bonafide research work carried out by him. He has worked under my guidance and supervision and has fulfilled the requirements, which to my knowledge, has reached the requisite standard for the submission of this thesis. The results contained in this thesis have not been submitted in part or full to any University or Institute for the award of any degree or diploma.

(Dr. Suddhasatwa Basu)

Professor

Department of Chemical Engineering

Indian Institute of Technology Delhi

New Delhi-110016, India

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(Amit Kumar Gupta)

ABSTRACT

Displacement and detachment of immiscible fluids is important in sub-surface processes such as enhanced oil recovery, oil sand processing and detergency. In this study, simulation of an oil droplet deformation and detachment on a solid substrate in simple shear flow has been carried out using computational fluid dynamics tool (Fluent 6.3) and the shape of the oil droplet and shear rate required for detachment are compared with that of the experimental observation. The dynamic behavior of an oil droplet subject to shear flow in a closed channel is considered under the condition of negligible inertial and gravitational forces. The volume of fluid method is used in Fluent to determine the dynamics of free surface of the oil droplet during the fluid flow. The oil droplet deformation increases with the increase in capillary number, Reynolds number and size of the oil droplet. The deformation and detachment of an oil droplet attached to channel surface in simple shear flow is studied experimentally in laminar flow through visual observation using microscope (Zeiss, SV11 APO) with high speed camera (PCO). Aniline and isoquinoline was used to form oil droplet and distilled water with and without surfactants was used as shearing fluid. The deformation and detachment of aniline and isoquinoline droplets were recorded using a high speed camera connected to a PC. The recorded image was replayed and the deformation and detachment of aniline and isoquinoline droplets was analyzed using Axio Vision software and compared with the results obtained from CFD simulation. The deformation of different sizes of aniline and isoquinoline droplets at different flow rates of shearing fluid and with time are well predicted by the CFD simulation. The detachment of an oil droplet having equilibrium contact angle close to 180°

occurs when drag acting on the adhered oil droplet is equal to the retentive force at the three phase contact line e.g., oil-water-solid. The oil droplet detaches as the droplet is about to slide. In the case of oil droplet with intermediate range of equilibrium contact angle, detachment occurs when lift force acting on a sliding droplet overcomes the buoyancy and gravity. In many cases, partial detachment of an oil droplet is seen during experimental observation. Following experimental observation, the partial detachment phenomena is modeled based on above premises and assuming that it occurs when the elongation of oil droplet in the downstream side is stable. The partial detachment occurs as the drag acting on the elongated oil droplet equals to the interfacial resistance in the neck region of the droplet. Finally based on the above premises the deformation and detachment of crude oil from solid substrate by shear flow is presented.

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