Quantitative investigation of oil-layer resistance to entrainment

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C-IMAGE

This poster presents the preliminary results of a plunging jet method combined with a high speed camera to obtain quantitative data of the entrainment of oil under different circumstances.

Plunging jet description

Our plunging jet measurement system (Fig. 1) consists of a holding tank containing 9 liters of seawater. A specific amount of oil is placed within a confinement on the surface so the height is known. The plunge container is a 250 ml glass container and its height can be varied with a rig. A high speed camera that is fixed to the rig, perpendicular to the holding tank, records the underwater events after the plunge hits the oil slick. A backlight behind the tank enhances oil droplet contrast.

The volume and droplet sizes of oil in the water column are registered over time and quantified using image processing software. The resulting (projected) surface of each individual particle is converted to droplet size assuming the droplets are spherical.

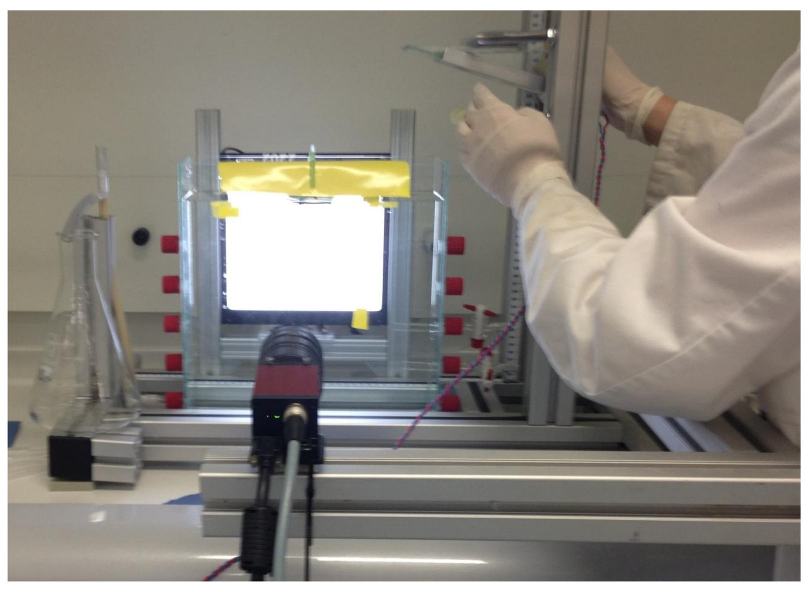

Figure 1. The plunging jet rig, with background lighting and camera system

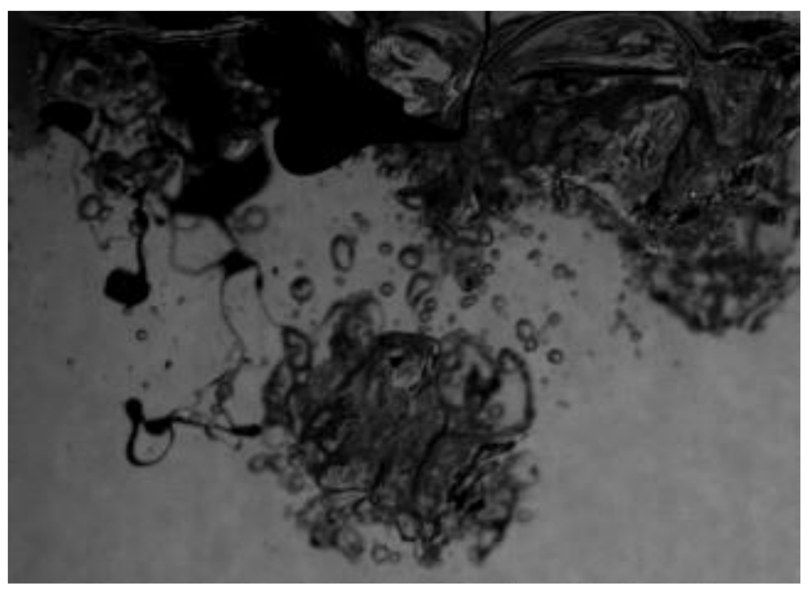

Figure 2. Test 1.1; T = 0,2 sec, An example of visually observable oil 'filament' formation, prior to droplet break up

Preliminary results

Figure 3a shows the general sequence of events occurring after the impact of the plunging jet hits the oil layer. The events occurring in the first 0-2 sec cannot be quantified due to disturbing air bubbles and turbulence, however do yield qualitative information about breakup mechanisms (as an example, see Figure 2). Images in the more quiescent period (2-3 sec after initial impact) are more suitable for quantification of initial entrainment.

Effect of oil layer thickness

A 2 way ANOVA with 3 replicates for each test, reveals a statistically significant influence of the layer thickness on the volume of oil entrained ($V_{entrained}$) over time: It is clear that there is a positive trend in volume entrained with layer thickness (Figure 4). However, when compared to 'amount of oil present' (oil layer thickness, h_{oil}), relative entrainment of thinner layers is much higher.

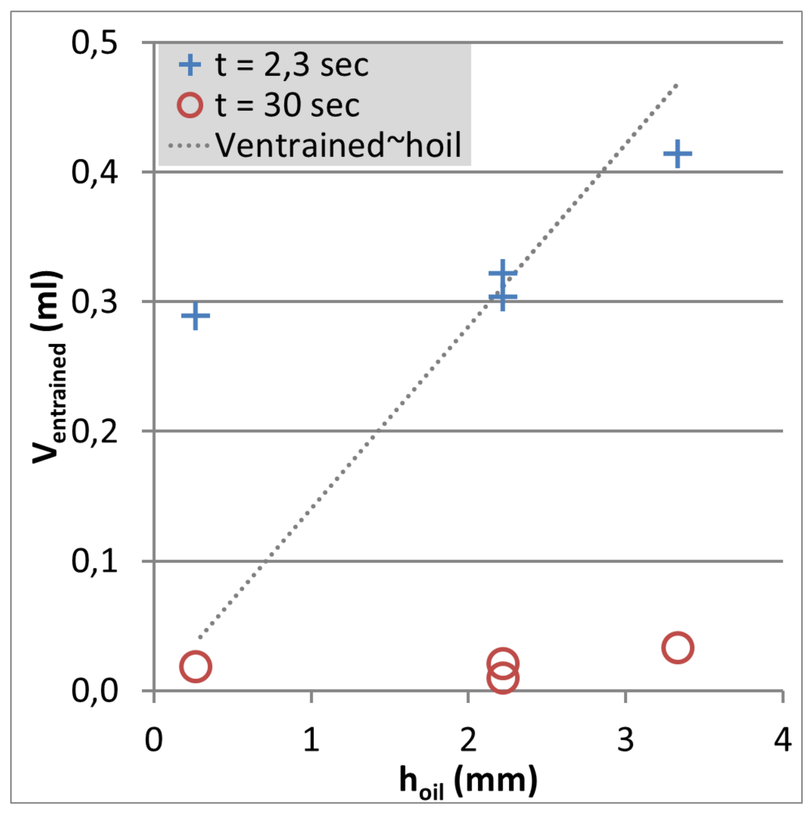

Figure 4. Volume of oil entrained(ml), at time=T

Influence of dispersants

Dispersants clearly make the oil break up into smaller droplets with longer residence time in the water column (Figure 3b) than without dispersants (Figure 3a). This could not yet be quantified due to the extreme small size of these droplets.

Conclusions

The preliminary results show that, with some slight modifications, the plunging-jet method is suitable for quantitative investigation of the entrainment of oil under different circumstances.

We will use the system to provide the lacking parameters for improved oil dispersion modeling including the effects of: oil type (viscosity), layer thickness, dispersants and interaction with various types of particles.

Current challenges to overcome are:

- Making thinner oil layers
- Quantifying small droplets
- Automated image processing

Acknowledgements

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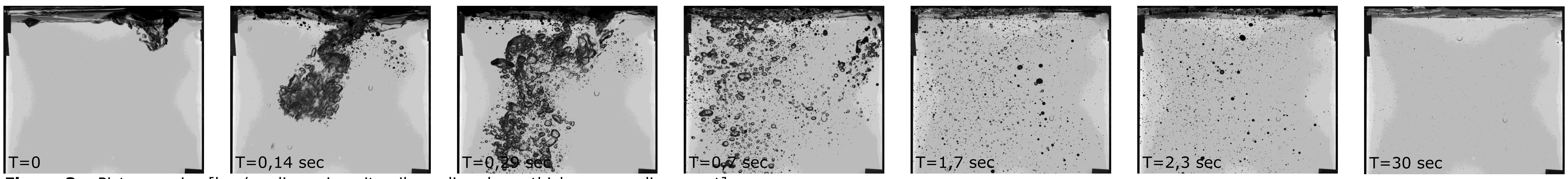

Figure 3a. Picture series [low/medium viscosity oil, medium layer thickness, no dispersant]

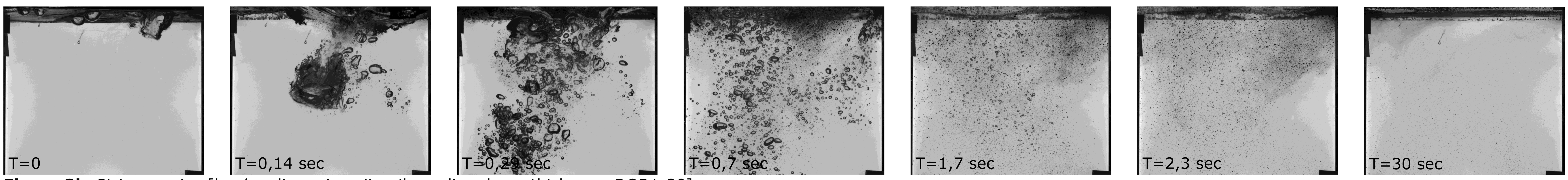

Figure 3b. Picture series [low/medium viscosity oil, medium layer thickness, DOR1:20]

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