WEATHERING EXPERIMENT ON SPILLED CRUDE OIL USING A CIRCULATING WATER CHANNEL

Mr. Tsutomu Tsukihara
Koa Oil Co., Ltd. Japan

[Introduction]

In order to determin the best suited recovery materials to be used during recovery of spilled oil , it is important to understand properties of the spilth. For that reason, We have constructed a small circulating water channel, and carried out weathering experiment on spilt crude oils.

Further we studied the forming state of emulsified oil using electron microscope.

[Outline of water channel]

The water channel that we constructed for this experiment is an elliptic race track type. (figure 1) This water channel can duplicate various types of waves by an attached wind tunnel, waves generator and sea water circulator.

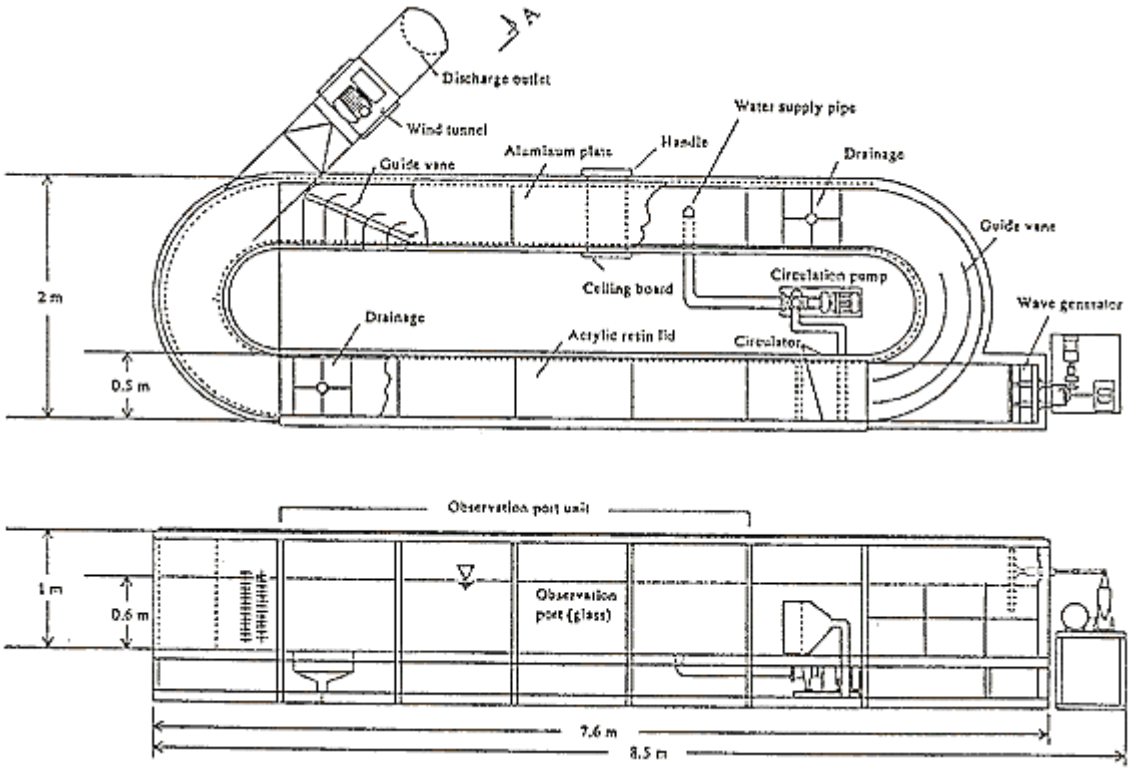


Figure 1. Outline of circulating water channel

[Selection of type of crude oils]

The experiment is part of a three-year plan which started in 1993, and about 30 types of crude oil were selected from the mainstream crude oil imported in Japan. In the first year, four types of crude oil (Oman Crude, Arabian Light Crude, Murban Crude, Umm Shaif Crude) were used.

Table 1 shows the properties of these crude oils.

Table 1 properties of crude oils

property \ crude		Arabian Lt crude	Oman crude	Murban crude	Umm Shaif crude
Dens.	g/cm^3	0.8609	0.8499	0.8271	0.8388
API		32.8	34.9	39.5	37.1
Vis.@15℃	cP	9.11	26.7	6.14	6.40
Pour Pt	℃	< -30.0	< -20.0	-24.0	< -30.0
T.S	wt%	2.0	0.98	0.78	1.30
Asphalten	wt%	1.7	0.9	0.3	0.1
Resin	wt%	2.5	3.8	2.4	2.5

[Conditions of experiment]

The experiment was carried out both during the summer and the winter, where the effects of the different sea water temperatures and waves were studied. Therefore, we experimented using four
different factors and their effects on a specific type of crude oil.

Figures 2 and 3 show weak wave and strong wave, that is two type of waves were used in this experiment. The weak wave is sine wave with smooth surface. The other strong wave is breaking wave with rough surface.

Table 2. Conditions of experiment

Conditions	Case 1 (summer)	Case 2 (summer)	Case 3 (winter)	Case 4 (winter)
Waves				
Wave condition	Weak	Strong	Weak	Strong
Wave height (cm)	5-9	10-15	5-9	10-15
Frequency (s)	1	0.5	1	0.5
Wind velocity (m/s)	2.6	6.4	2.6	6.4
Amount of sea water (t)	4	4	4	4
Depth of sea water (cm)	60	60	60	60
Sea water temperature (℃ target)	25	25	10	10
Amount of crude oil charged (l)	10	10	10	10
Slick thickness (mm)	1.4	1.4	1.4	1.4

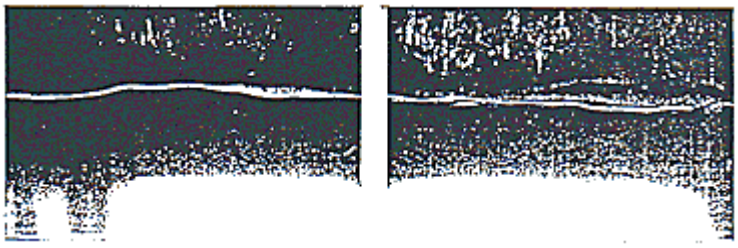


Figure.2 WEAK WAVE

Figure.3 STRONG WAVE

[Experiment method]

In the experiment, the water channel was set up to maintain the condition of waves shown in Table 2. When the condition of the wave was consistent, the crude oil was poured gently on the surface of the sea water. The crude oil on the surface of sea water was collected on an increasing time interval up to 96 hours, and its properties were analyzed.

[Experimental results]

1) Experiment in summer

The experimental results are shown in Figure 4-7.

① weak wave

Oman crude oil and Arabian Light crude oil formed stable emulsions, while the Murban crude oil and Umm Shaif crude oil, the formed emulsions were found to be unstable. Particularly for the Murban crude oil where it gradually dispersed in the surrounding sea water.

② strong wave

Arabian Light crude oil formed a stable emulsion. Oman crude oil once formed emulsion, but the emulsion showed indication of degradation after it had formed. For Murban crude oil and Umm Shaif crude oil, almost all of it dispersed into the sea water after several hours from the time of the spillage.

2) Experiment in winter

The experimental results are shown in Figure 8-11.

① weak wave

Oman crude oil and Arabian Light crude oil formed emulsions. Murban crude oil formed a fragile and coarse emulsion with bubbles. For the Umm Shaif crude oil, it indicated a similar behavior to that of Murban crude oil.

② strong wave

Oman crude oil and Arabian Light crude oil formed stable emulsion. Murban crude oil and Umm Shaif crude oil formed fragil and coarse emulsion with bubbles, while a part of the crude oil dispersed in sea water.

Figure 4

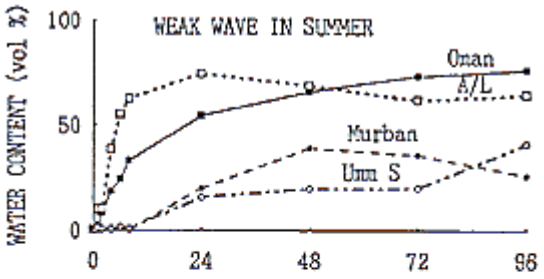


Figure 5

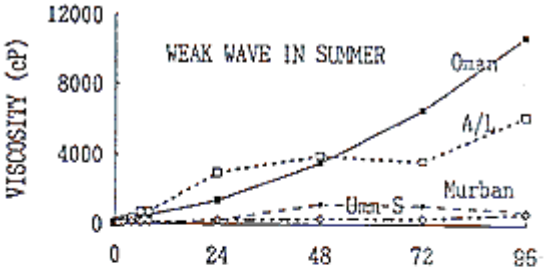


Figure 6

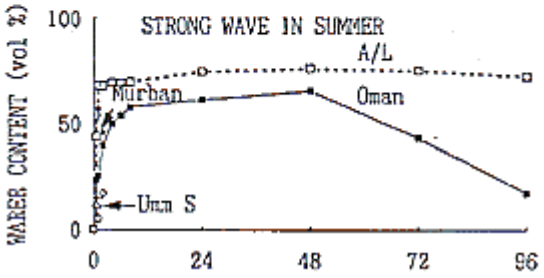


Figure 7

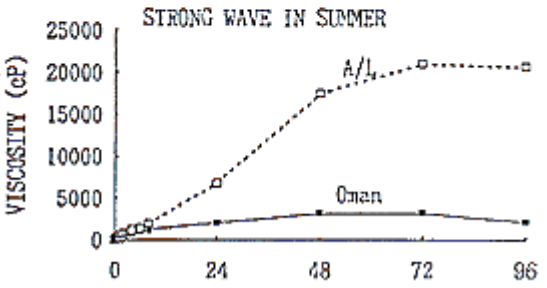


Figure 8

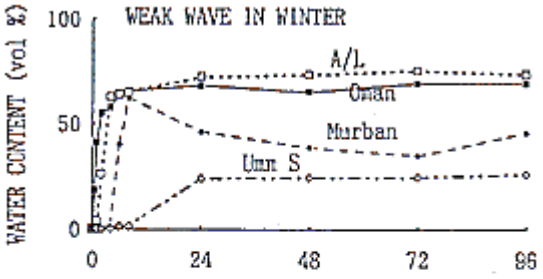


Figure 9

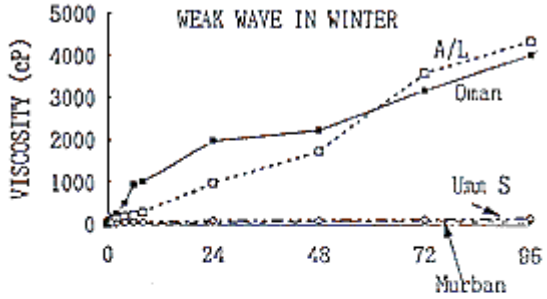


Figure 10

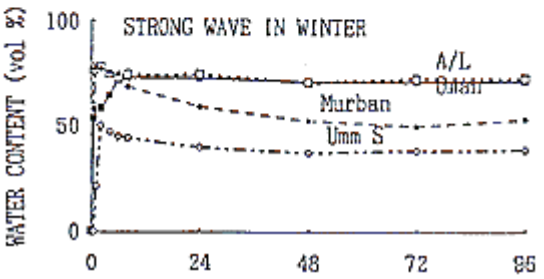
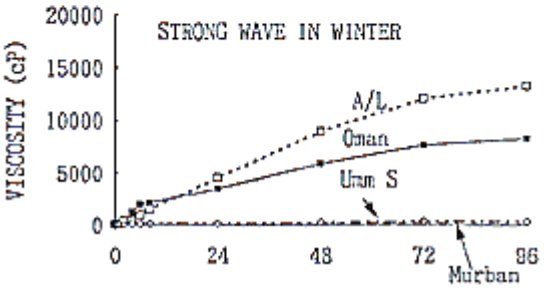


Figure 11



[Results of investigation on emulsion using electron microscope]

When crude oil spills in the sea, it is exposed to the meteorological conditions including the atmospheric temperature in the sea area, sea water temperature, and waves, so that light density components evaporate in a short time. During the gradual evaporation of medium density components, the crude oil takes up the sea water. In this case, the crude oil with a large percentage of heavy density components makes a stable emulsion. In the course of emulsification, the surface of the emulsion particles was observed using an electron microscope in order to investigate the forming state of emulsified oil. Kuwait Crude oil was selected, because it emulsifies easily. The emulsified oil was refrigerated rapidly and was observed with an electron microscope.

Figure 12 shows the initial stage of the emulsification, and Figure 13 shows its enlargement. These Figures reveal that fine particles of sea water are dispersed in the crude oil, and recessions are found on the periphery of the sea water particles. These recessions are formed by the sublimation of the light density components of crude oil during an electron microscope observation. This phenomenon is found in the initial stage of the emulsification. It is also found that the inside of the sea water particles are exposed by the sublimation of water.

Figure. 12

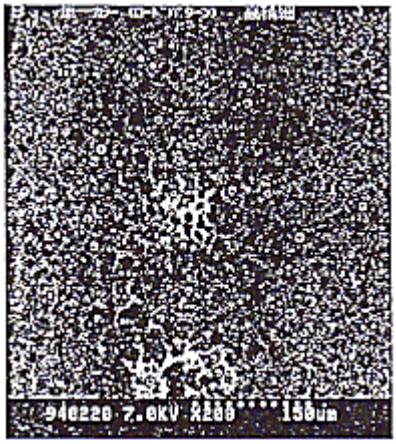


Figure. 13

Figure 14 and 15 show the final stage of the emulsification. In these Figures, the recessions as observed in the initial stage of emulsification reduced and the water particles that are surrounded by the heavy density components were observed.

Figure. 14

Figure. 15

[Summary of experimental results]

① The properties of spilt crude oil depend largely on the mechanical properties of the waves and the sea water temperature.

② Murban and Umm Shaif crude oils which are particularly rich in light density components, will disperse into the sea water as fine particles in the summer, and tended to form a fragile and coarse emulsion with bubbles in the winter.

③ Arabian light and Oman crude oils indicate a tendency of emulsification in each seasons. But, Arabian light crude oil indicates a large tendency of emulsification in the summer as compared with that in the winter. While the Oman crude oil tended to disperse into sea water with increase in wave height in the summer.

④ The heavy density components of the crude oil surrounding the sea water particles form a strong protective membrane to cause the emulsification. At this moment, I anticipate resin and asphalten could be key components to cause the emulsification. Resin and asphalten might function each other.

[CONCLUSION]

On the experimental results, in terms of emulsification tendencies of 4 types of crude oil were compared. The Arabian Light crude oil indicated the highest tendency, while the Umm Shaif crude oil indicated the lowest tendency to emulsify.

[Next plan]

It is evident from the experiment that crude oil spilth at sea is exposed to the meteorological conditions of the sea area to be mixed with sea water in various states. The fact indicates that the recovery of spilt oil should be implemented with the use of best-suited materials, equipment, and processes.

In this sense, the accumulation and utilization of data on weathering experiment of crude oil are important. Plenty of experimental data on various types of crude oil will be collected to contribute to all concerned.