About Construction of Simulation Tank for Oil Recovery in Marine Situations

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Abstract **- Since "NAKHODKA" oil spill incident in 1997, several new equipments or systems for oil recovery have been researched and developed in Japan. New oil skimmig vessels were launched and expected to work well. It is hard to judge how effectively the each equipments or products performs at the site of coasts without experience. Canada and U.S. test the equipments in a large tank of Ohmsett with towing bridge, Norway does in big circulating tank and on the sea. They can improve their outcomes with many data from the experiments in such real situations. However, we did not have such a test tank in Japan, and we could not have any opportunities to test in real situations.**

The government appropriated funds for constructing new tank at PARI for research and development of oil spill response in supplementary budget for 2002. The tank's specifications were planned to test equipments for oil recovery as if we test them at the site of coasts. This paper collects requirements that the tank should satisfy and themes that we should do with this tank.

Objective of the tank is to advance researches and developments about recovery of emulsified heavy oil that causes hard damages in marine environments. We should simulate waves, velocities of vessels (or currents), water temperatures, viscosities of the oil, and winds at the site of coasts, and test several skimmers, oil booms, oil recovery systems in order to judge their performances and behaviors under being influenced by several factors.

Therefore, the tank dimensions are that the width for 6m, length for 20m, and water depth for 2.5m. Salty water is filled in and controlled its temperature by chiller and heater, and leftovers of the oil are cleaned through oil filter. We can generate waves for the max 0.5m, current for the max 1m/s. Physics and chemistry analyzing room and a cylindrical tank (depth for 10m) are placed as supplementary facilities and the plant is appreciated synthetic.

I. INTRODUCTION

Japanese industries import enormous crude oil and chemicals. Many oil tankers, large and small, are operated internationally and domestically on the coast of Japan. It is as same as Japan that oil and chemicals are shipping many tankers in other countries surrounding Japan and industries of Far East Asia keep on their activities.

Since the Prestige oil spill incident off the northern Spanish coast in 2002, we are impressed that the politics of the double hull tanker regulation is not enough to defend from oil pollutions. In Japan of 2002 year, oil spill incidents of cargo ships grounding occurred one after another. Many Japanese people know that oil spill incidents are not so rare case around their ordinary life. Making progress of oil spill response research and development is appreciated that we should continue it as important theme.

However, it is said that many of oil spill response products can perform only at low level of their specification written on their catalogues in real marine situation. In order to satisfy reality of the specification data, it is necessary that the equipments and the products should to be tested in marine situations. In Norway, they have spread oil and tested products in the ocean once in some years. The biggest test tank of Ohmsett has been used by USCG, EPA CANADA, or so many engineers, for testing real size products and models. It must be also prepared such advanced test field in Japan.

Ministry of Land, Infrastructure and transport of Japan appropriated supplementary budget of 2002 for constructing the new tank for oil spill response research in PARI (Port and Airport Research Institute). The test tank was designed its specification level high ranking with international test facilities. This year (2004), we have begun to research and develop oil skimmer systems with the tank.

This paper introduce you specifications of the test tank named STORMS (Simulation Tank for Oil Recovery in Marine Situations) and realms of the research and development with this facility.

II. PROBLEMS OF R & D FOR OIL SPILL RESPONSE

A. Importance of Test Data with Real Oil

It is necessary to study about behavior of oil for oil spill response technology. The oil is non-Newtonian fluid and its range of viscosity is wide, for example, from 100 to 1,000,000 mPa · s. The oil has good wettability to every surface, and its adhesion to several materials is strong. These properties of the oil directly affect the difficulty of oil recovery. But it is not easy to deal those variables without any real information and actual data. Though there are many trial of test with plastic pellets, they can show indirectly fluid performance of water surface but not oil behavior floating on the water. We can not appreciate data without real oil.

To get an official sanction, it is necessary to submit data of real oil examination. For other example, the World Catalog Of Oil Spill Response Products on which most of the products in the world may be listed has a table in which targeted oil types data should be written, for each skimmer, boom, separator, and so on [1]. It uses the ASTM grades of the oil for the classification of targeted oil. Makers of the oil response products submit often their original test data, or no data. However, they make a point of showing performance to real oil.

The range of the oil in ASTM is from 150 to 170,000 cSt, so that it is a problem whether we can judge performance of the products on these data to emulsified heavy oil which is

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high viscous like the NAKHODKA, Erica, and Prestige oil spill incidents. It is said that the oil viscosity of the incidents were over 200,000 mPa · s.

However, it is difficult to get the data of test used real oil, because most of the test tanks are forbidden to float oil on their water. The causes of them are that cleaning after experiments is painful and most of the sensors ought to be coated in oil, and water of the tank contains scattered oil particles which are broken into colloid. They can not use the tank without exchanging the sensors and the water after the examination.

In that background, it is necessary to build the special test tanks which are allowed to fill in oil for research and development of oil spill response technology.

B. Problem of the Model Scale in Examination

Oil skimming systems perform well only when those mechanical links and combinations are rational. It is not able to appreciate the system's capacity of oil recovery from basic data of each element. Objective of the oil spill response products should to be different from that like stability in hydrodynamics examination of airplanes, submarines, and boats. Consequently the model scale should be nearer to real size so that the system can be made to move natural. We should not use small model.

Another problem is how to do about similarity law because of members of viscosity. It is easy to solve this problem with big size model examination.

C. Problem of Specific Gravity of Water in the Test Tank

Specific gravity of the oil concerns its behaviors in water. The specific gravity of the oil is varies by its weathering and for example, heavy oil shows about 0.9 readings. It is heavy oil that inflicts enormous damage on coasts [2]. The heavy oil is sure to be emulsified by waves and its specific gravity become higher such as 0.98 readings. In this case, behavior of the oil is definitely different whether it is floating on water or salty water. Of course, we must prepare the specific gravity of water filled in the test tank at the coast. Therefore, the test tank should be filled in with seawater or salty water prepared its gravity for each examination case at each targeted local ocean's readings.

Ⅲ. USCG and Ohmsett

A. Opinion from USCG Expert

We have made interview to USCG expert of oil spill response and have gotten some good opinion before building of our facility. USCG has a close connection with Ohmsett which was managed by Navy only in 1989.

They make a point of simulation of the oil recovery site in oceans because of their practical viewpoint. They substantially trust data scored from such simulated test. It is said that capabilities of oil skimmers in real situation at the site may be lower than 20-30% than those of products catalogue. But if the data were taken from the test of Ohmsett, they say that it will be able to trust as 60-70% in the site. However, it is said that the efficiency of oil recovery at the site of sea may be 20-30%, and the rest may be recovered on beach [3].

The performance and capability of oil spill response systems are influenced by situations of waters, so they say that it should be better not to adopt the data for US to Japanese coasts.

B. Facilities of Ohmsett [4]

Ohmsett is the National Oil Spill Response Test Facility. It was established in 1973 by the EPA. The EPA administered the facility up to 1988. In 1989, the facility was closed and transferred to the Navy. Then the supertanker EXXON VALDEZ oil spill incident was occurred that year. Title Ⅶ of the Oil Pollution Act of 1990 (OPA-90) stipulated that "agencies represented on the Interagency Coordinating Committee for Oil Pollution Research shall ensure the long-term use and operation of the Ohmsett Research Center in New Jersey or oil pollution technology testing and evaluations". Since 1990, MMS (Mineral Management Service) had been delegated the management of the Ohmsett. The Ohmsett facility has been used by USCG, EPA, U.S. Navy, Environment Canada, and MMS.

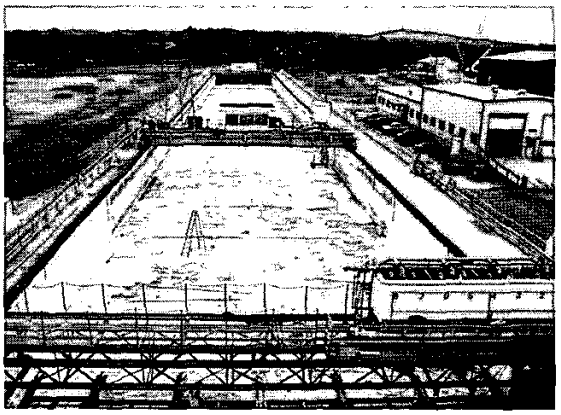
Between 1990 and 1992, Ohmsett was refurbished by MMS at a cost of 1.5 million dollars. The financial support was from the USCG and Environment Canada. Since 1992, MAR Inc., of Rockville, MD has been awarded the contract to operate and maintain Ohmsett under MMS management.

The tank of Ohmsett must be largest test tank for oil pollution research and development in the world (Fig.1). The tank is built in Naval Weapons Station in New Jersey without a roof. This open-air tank has 3 bridges and they can tow real size oil response systems. The dimension of the tank is 20m in width, 203m in length, and 2.4m in depth of water. The scale of the facility is so large that it can be supposed as real site of the water in the sea. Around the tank, there are a control tower, oil storage tanks, filtering plant, chemical analyzing container, workshop, and office. Salinity concentration of the water filled in the tank is prepared between 32-35 psu as same as the open sea water's one.

Mechanism of wave generator is very simple and it can generate waves for maximum 0.7m height. There is no current generator and towing bridge is used for the test in current or velocity of ships. They also use bridges for dispersing oil and acquiring the test data.

Water filled in the tank is recycled after being purified by gravity separator, cyclone separator, and diatomeceos earth filter. Oil remains only less than 15ppm in the water after filtering and it can be disposed to Sandy Hook Bay when they must work for big maintenance once in 2-3 years.

Fig.1 Panoramic View of Ohmsett Facility



IV. Condition in Japan

A. Previous Facilities in Japan

After NAKHODKA oil spill incident, many examinations of research and development for oil spill response systems were carried out at a test tank which is managed by a private enterprise. The tank is not designed for oil recovery research and flesh water is filled in. Water depth of the tank is 1.2m in length that allow only small size skimmer to be tested. Of course most of oil booms are not able to be tested in real size in such shallow basin. Though waves can be generated for maximum 0.3m height, current generator is not built-in. We could not examine and research the oil response without several limits like an accuracy of each data, resignation of using sufficient scale models, and cost to be paid for the private sector's tank.

As a reference, Maritime Disaster Prevention Center has tanks for oil spill response training. They have unique pools that enable to train cleaning of beach. The beach models are 3 types, a rocky beach, a beach with dissipating concrete blocks, and a sandy beach. They also have a tank for training of operation of the machinery and materials for oil recovery [5].

Formerly, Tsukuba Institute of Ship and Ocean Foundation (SOF) had run large scale facilities for research preventing from oil pollution with real oil. They have practically closed the facilities before the NAKHODKA incident and not been restored today. However the facilities were full-dress test site for research and development of oil recovery systems, booms, and so on. Though they used flesh water in tanks, they could use from crude oil to heavy oil. Once the examinations for official recognition of oil booms were done in this facility and also other several accomplishments came out. The facility in Tsukuba Institute is to be referred to, so next paragraphs introduce it [6].

B. Large Circulating Water Channel of Tsukuba Institute

Tsukuba Institute of SOF had managed 2 different types of large test tanks and the circulating type can simulate situations constituted currents, waves and winds. Especially, capacity of wave height and current speed are in the highest class. Depth of water is also the deepest class, in 4.3m, so that they could test big booms and deep-draft skimmers. Because the tank is indoor basin, big fans can blow to simulate winds.

Significant specifications

>current speed:		0.1-1.5m/s
>wave height:	max	0.6m
>wavelength:	max	10m
>wind velocity:		5-20m/s
>oil dispersion capacity:		1.5m^3/min
>usable water channel:	Length;	60m
	Width;	3.8m
	Depth of water:	4.3m

C. Rectangular Tank of Tsukuba Institute

Another large test tank is rectangular type. It has a very large space of water surface. Objective of the tank were researches for seaworthiness and controllability of boats, about marine structures in waves, and oil spill responses. There is a long span bridge and it can do towing test. This tank is also an indoor facility so that wind waves don't affect the examination quality.

Significant specifications

>wave height:	max	0.3m
>wavelength:	max	10m
>towing speed:	max	2m/s
>water surface:	Length;	80m
	Width;	45m
	Depth of water	2.3m

D. Oily Water Purifying Facilities of Tsukuba Institute

The facilities are for purifying oily water and recycle as clean water for examinations. The separator of oil / water is coalescer type and it makes oil concentration less than 10ppm, and combined system of flocculator, sand filter and activated carbon filter purify oily water until it contains oil less than 5ppm.

E. Comparison of Specifications of the Tanks

Table 1-3 show the specifications of the test tanks in Japan and abroad. In Japan, only flesh water filled in, but both of Ohmsett and KYSTVERKET uses salty water. KYSTVERKET is the heir of Norwegian Pollution Control Authority (SFT). These years, they look at the problems of oil spill in low temperature, so they put chillers in both KYSTVERKET and Ohmsett.

It was very important that what specification for us should be given priority to, because of limit of the funds and cost of operation. We decided the specifications of our test tank from what we are to do.

Table 1 Comparison of Test Tank (scales)

	Type	Scale
		m
Ohmsett	towing	L203×W20×D2.4
KYSTVERKET	circulating	30×7×2
Tsukuba Institute 1	circulating	60×3.8×4.3
Tsukuba Institute 2	towing	80×45×2.3
A Private Enterprise	rectangular	23×13.6×1.2
MDPC	rectangular	12×8×4

Table 2 Comparison of Test Tank (performance)

	Wave Height	Current	Wind
	m (Max)	m/s (Max)	m/s
Ohmsett	0.7	3.34	-
KYSTVERKET	1	0.77	-
Tsukuba Institute 1	0.6	1.5	5-20
Tsukuba Institute 2	0.3	0.2-2	-
A Private Enterprise	0.3	-	-
MDPC	possible	-	-

Table 3 Comparison of Test Tank (water)

	Water	Oil	Temperature Control
Ohmsett	salty water	crude oil	chiller
KYSTVERKET	salty water	crude oil	chiller
Tsukuba Institute 1	flesh water	crude oil	-
Tsukuba Institute 2	flesh water	crude oil	-
A Private Enterprise	flesh water	possible	-
MDPC	flesh water	-	-

V. Subjects of Oil Spill Response Research

A. Background

Drifting heavy oil affects serious damage to activities and environment of coast, because heavy oil is weathered slowly. Heavy oil is generally used for banker of ship and large cargo ship uses classification of "C" heavy oil. We must take care of the large cargo incidents for their large amounts of banker spill.

However, the research and development for heavy oil and its emulsion are not so progressed. Conversely floating crane has been a highly capable oil skimmer for high viscous oil practically at the site of the incidents ever. There can be better method and mechanical system in such situation.

B. Evaluation of Oil Recovery Systems

It is important for research and development to evaluate products and systems for oil recovery by an official organization in the same criteria. Objective evaluation promotes research and development of this field. Oil recovery system performs differently in each different situation constituted wave height, wavelength, sweeping velocity, oil viscosity, and so on. We must chose suitable system for each situation, but we have no data of the performance and capacity at the same situation. If there were data for each system in equally situation, we were not bothered what and how to chose the best one.

Therefore, new test tank should be used for making up criterions of testing standards in order to evaluate performances of the products and the systems. It is necessary that new facility can control and simulate waves, current, wind, temperature of water, specific gravity of the water, and property of the oil.

C. Collecting and Containment System

Generally, the oil recovery system has to collect and contain drifting oil in order to increase the oil thickness and encounter efficiency of its skimmer. The oil collecting and containing system contributes obviously to skimming capacity of whole system. It is significantly affected by current or vessel velocity if the collecting and containment system can perform enough. Factors of wave period, height, and length complicate the problem because oil is floating on water and sometimes performs as solid.

It is necessary to prepare windows for observing surface and under water in order to research behavior of the system and of course enough current speed, water width, depth and salty water are needed.

D. Test of the System with Vessel Body Model

Performance and capacity of the oil recovery system is not sum of its parts ability. Generally, the oil recovery system is installed on a boat, and when it works it is unfolded near the body of the boat. So the boat body affects performances of the oil recovery system. Especially, in case of the system that put on board or between the catamaran hulls, reflection of waves and current affect severely. We should consider the vessel body as a part of the whole oil recovery system. If we use small test tank, we have no choice but exam each part like skimmer, pump, separator, and so on. One of the important problems of oil recovery system is consistency in the whole system. It is necessary that dimension of the new test tank is enough to test the whole system including vessel body model.

E. Study about Property of Heavy Oil Emulsified

Property of heavy oil emulsified is quite different from that of water. The emulsion of oil is non-Newtonian fluid, and its viscosity varies in condition of share rate. The properties of oil are different each other by their source. Basically, heavy oil is mixture of several carbon compositions, and they are expediently divided into groups of aroma, resin, asphaltene, and saturated hydrocarbon. Therefore it is difficult to understand the property of the heavy oil from both chemical and physical method.

It is necessary that basic equipments for analyzing heavy oil are supplied. We must study and solve the problem of relations between properties and performances of oil in recovering works.

F. Simulations of Several Water Situations of Coasts

In Norway, they test in the ocean with real oil once in 2-3 years. There hard to be good data acquired in the site of incidents, and it is not so rare case that only rumor is information from the site. So it is important to acquire data from the test in the ocean. However it is too difficult to get a permission to test with real oil.

Property of the water and waves are different at each region of coast. If we are to simulate water in test tank, we should prepare parameters of the water in the tank. Waves and current or velocity of the vessel collecting oil must be adjusted as real situations. If we can simulate the water in each region, we will be able to develop and tune the oil recovery systems adapted to each region waters.

G. Suction Oil from Foundered Boat

The oil tanker NAKHODKA sunk in 1997 has a lot of heavy oil in its tank under water. Now, a little spill from her on bottom of the Sea of Japan keeps on. If such a big oil tanker, cargo vessel, container ship, or so will sink with a lot of oil in their oil tank, we should care about oil spill pollution. When the ship sinks in water way, anchorage and other interrupting area in harbor, we had to prevent from oil spill before salvaging her.

Though most of the works of suction oil from foundered boat are implemented by divers, it is not so safety works that we should develop new methods. If the foundered boat is located at deep sea like NAKHODKA, diver's works may be impossible. And there are many cargos, tankers, passenger ships, and warships sunk under water, we had to prevent from oil pollution by them.

In this background, it is an important problem how to suck or seal the oil from the foundered boat under water in low cost and short time. In order to simulate the works, we need a deep tank in which is allowed infusing oil.

VI. STORMS (Simulation Tank for Oil Recovery in Marine Situations)

A. Specifications to Satisfy

What we considered for our research and development of oil spill response is international standard level of examination and really needs of this realm. For example, there were many persons mention to take care of precision waves generated, but practically it is not so important but scale and irregular wave like harbor-chop are more important. Current is an essential function for simulate the performance of the oil recovery systems because oil collecting and containment booms and skimmers are usually advanced with vessel operation and the current of

water affects significantly behavior of floating oil.

Water filled in the tank had to be salty water because remainder of specific gravity between oil and water affect the velocity of oil movements.

Viscosity of the emulsified oil is an essential factor in all of the oil recovery systems. The viscosity varies widely affected by its temperature. Because the viscosity becomes high in low temperature, the many of recovery systems are influenced their works. Ohmsett and KYTVERKET has introduced chiller for icing their water in tanks. Because of sensitivity of the viscosity to temperature, a controller of water temperature should be put in the tank.

It is crucial equipment that purifies water filled in the tank for managing the facility. In Yokosuka, the wastewater quality standards for draining into the sea from a business facility force us to contain oil in the wastewater less than 5ppm. If we dispose all water as industry waste, the cost will stall all activities of research.

In these requirements, we designed the new facility to have reasonable specifications in limited funds. We named the facility "STORMS", Simulation Tank for Oil Recovery in Marine Situations, and it has constructed in March, 2004.

B. Scale of Tank

Main facility of STORMS is a water tunnel tank with wave generators. The tank wall and floor slab is reinforced concrete. Surface of the concrete is coated in waterproof daub. It makes tank to be long life. Water basin scale is 32m in length, 9m in width, and 3.5m in wall height (2.5m in water depth). Water amount of the tank is about 720 m^3. Water area is divided into 2 channels, and the channel of 3m in width is for tunnel of current generator, and another of 6m in width is for measurement of examinations (Fig.2).

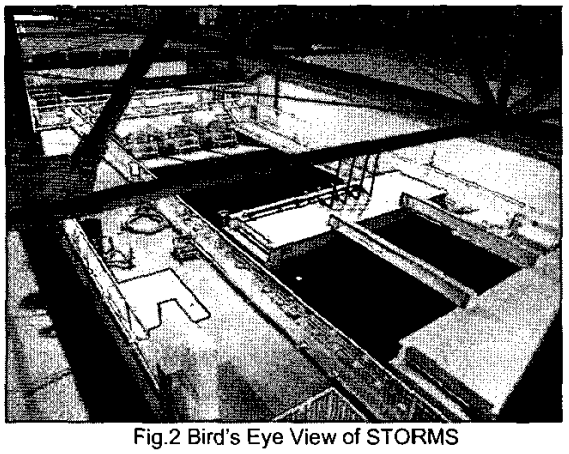


Fig.2 Bird's Eye View of STORMS

Therefore dimension of the water for the measurement channel is 20m in length, 6m in width and 2.5m in water depth. These scales are supposed to test, in real size, the large-size weir skimmer on "Hakusan", the drug and oil skimming work vessel. When the bigger circulating skimmer set on board of Hakusan is to be tested, the skimmer model scale is 1/2. Hakusan is one of the largest vessels for oil recovery. Vessels of catamaran type which operated by regional bureaus for cleaning up and skimming oil from water take their width between hulls in about 3m, and the tank has sufficient size to simulate phenomenon between the hulls.

There are 4 windows at the one side of the tank wall for observing underwater. Size of the window is 1m in width and 2m in height. Especially for observing the oil behavior creeping out under skirt of containing boom, the windows will be used efficiently.

C. Wave Generators and Current Generator

Type of the wave generators is 3 series of salter duck. The generators are put on the water surface and a beach for wave absorber is put on another side. The maximum wave height generated is 0.5m (regular waves). Waves are generated from 1 to 5 seconds for period, and other wave type like irregular waves can be generated. The highest wave height can be generated only their period for 2s.

The current generator has two propellers in tunnel for circulating water (Fig.3). The current speed is able to 1m/s, about 2 knot for maximum. One propeller output is 132kw and two propellers are controlled its output continuously by inverter system. Current speed 2 knot is one of critical speed for oil collecting works, if the current speed is over 2 knot, floating oil will sink and dive out under the skirt of boom. Practically oil recovery at the site is carried out on this speed. When real size model is examined, we can simulate the case of the system advancing by vessel in 2knot.

These two systems are operated from control room standing on the end of the tank.

The tank has two bridges, one is for measurement, controlling a model, and another is for dispersing oil and blow with optional fans. Two bridges are connected together and can run at speed of 0.25m/s.

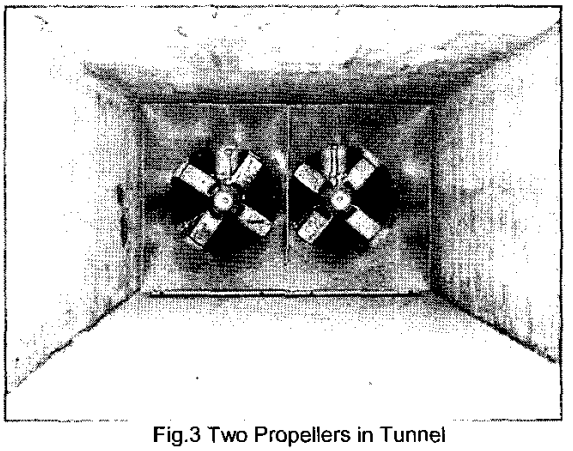


Fig.3 Two Propellers in Tunnel

D. Temperature Controller and Salty Water

Temperature of the water in the tank is able to be controlled from 5 to 30 ℃ by a temperature controller. The controller heats water by two steam boilers, each of the boiler output for 1253kw and 1000kg/h. the controller cools water by an absorption refrigerating system which outputs for 210USRT (735kw).

In most of Japanese coast, the water temperature is from 5 to 30℃, except the winter icy water in the Sea of Okhotsk. So the facility covers most of Japanese sea water temperature. Consequently the tank solves the problem of varying viscosity during examinations caused by the water temperature. Viscosity of target oil is the most essential factor for recovering result. Of course, the specific gravity of the water is able to be fitted to the coast. Generally, the open sea's specific gravity (salinity) is higher than that of the

bay. These factors are varied by location, seasons, rains, and tide. It is difficult to fit these situations if the facility does not allow salty water.

In these days the problems of oil spill in ice bound seas are attracted and the tank does not cover such situations. But the water in the tank is salty seawater, so that we can put anytime optional equipments and materials like chiller, mass of ice, or so. From the 4 windows of the tank wall, we will able to observe behavior of oil under ice.

In Japan, STORMS is the first facility that the sea water filled in for oil recovery research. Perhaps, STORMS is the first facility in the world as the large circulating tank with wave generators and the temperature controller for oil recovery research.

E. Oil Separator

Another basin for oil separating pit is mounted on the wall of the main tank. The basin is designed as an oil separator. Oil comes floating into the first pit from the gate between the main tank and the separation basin, and dived oil comes next pit and rises, the third pit absorbs the small particles of the oil and the forth pit absorbs micro particles. Then for the last, oil concentration becomes less than 5ppm, that is clear the regulation of drain.

The purified water is recycled to main tank. The oil separator is also used for separating oil from waste water of cleaning. The facility makes the amount of water disposed down and the cost of disposal will be lower.

F. Physical and Chemical Laboratory

It is an interesting theme between behavior of oil and the oil chemical composition. The chemical composition of oil is varied by source of the oil. There have been several reports and researches about weathering of crude oil in marine conditions, and many of those have been carried out by petroleum industries. In addition concentration of water in oil emulsion varies viscosity, adhesion, and behavior of the oil emulsion. Therefore it is important to analyze physical behaviors composed of viscosity, adhesion and fluidity, because they influence performance of oil recovery. So we must approach the problem from rheology, surface chemistry. We have to analyze several chemicals for oil dispersant, oil separator, emulsion breaker, and so on, from colloid chemistry. Several absorbents and chemicals are strange for us because they don't say why and how they can works well or not. Of course, safety for environment is not indemnified by them.

The physical and chemical laboratory supplies some kind of equipments for analyzing heavy oil, oil emulsion, chemical dispersant, and so on. For example, viscometers, TLC/FID, FT-IR, moisture measuring system, automatic contact angle measuring system are main equipments.

There is a temperature control room in the laboratory. In the room, a small tank for long time examination of oil being emulsified is put on. Basin of the tank separated in 3 channels and each has a flap of wave generator.

G. Cylindrical Tank

There have been a cylindrical tank in our institute and this time it is added a new function that enable to inject oil in. A new oil separator is mounted beside of the tank. However, we should take care that we can not use salty water in this tank, flesh water only.

The basin is 5 meters across and 10m in water depth. The cylindrical wall is made of steel and the basement is concrete floor. Crane is placed over the top of the tank and a hatch and an observation window is opened on the sidewall at the bottom.

This tank will be used for research and development of prevention from oil spill of founded boat and sucking oil from the boat safely and rapidly.

Ⅶ. Conclusion

Condition for oil spill response research has been prepared with the new facility "STORMS". See Table.4, STORMS can simulate several situations in the coast of Pacific Ocean, Japan Sea, East China Sea, Seto Inland Sea, Tokyo Bay, Ise Bay, Osaka Bay, and so on. We are sure that STORMS contributes to progress of research and development of the oil spill response. The scale of the basin and diverse equipments allow STORMS to be used for training of oil spill response. Real oil and seawater makes examinations carried out in STORMS to be examinations in a real site of the coast.

In Japan, the market of oil spill products may be very small. Marine accidents are not rare, but oil spill doesn't occur every day. Because of that, private sector in Japan can not research and develop hard in this realm of their own accord, so public sector had to do and decrease the damage and influence of oil pollution.

Ministry of Land, Infrastructure and Transport Government has 3 large oil skimming vessel "Hakusan", "Kaisyomaru", "Seiryumaru", which is usually a drug suction vessel. They have other vessels for use of oil recovery, for example, sea surface cleaning boats which are kind of catamaran type. We must improve oil skimming systems on these vessels, and henceforth with STORMS, we can suppose the test data as those acquired in the site of coast.

Table 4 Specifications of STORMS

Type	circulating
Scale (test basin)	L20×W6×D2.5m
Wave Height	0.5m
Current	1.0m/s
Wind	option
Water	salty water
Oil	heavy oil
Temperature Control	5~30℃ heat and cool

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