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Book of Abstracts
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Kellie Ann Beall, Editor

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RADIATION CHARACTERISTICS AND FLAME TEMPERATURE OF LARGE SCALE CRUDE OIL POOL FIRES

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ABSTRACT

Large oil fire experiments were conducted in Japan in 1998, where Arabianlight crude oil was burned in pans which were 5 m, 10 m and 20 m in diameter. The experiments were done in very good condition. Huge data were obtained in terms of radiation, flame temperature, gas concentration inside flame and other burning characteristics. In this report, results relating radiation and flame temperature were discussed.

INTRODUCTION

It is important to investigate protection of fire brigades and surrounding facilities against radiation heat from a fire in advance. However, it is difficult to do large scale fire tests due to budget constraint, environmental problems and limited techniques for measurement. There were a few large pool fire experiments[1,2] in Japan, for example, the experiment[1] which was done in Gotemba, Shizuoka, in 1981, in which kerosene was burned.

Large scale pool fire tests using Arabianlight crude oil were conducted through the collaboration of the National Research Institute of Fire and Disaster, Japan National Oil Corporation and the University of Tokyo in Tomakomai, Japan in January 1998.

It is useful to predict the burning characteristics of large scale fire on basis of result of small scale fire tests. Three different steel pans, 5 m, 10 m and 20 m in diameter were used as burning tank to investigate the scale dependency. The experiments were conducted for the purpose of preparing basic data for making fire fighting system of the petroleum storage facilities.

MEASUREMENTS

Irradiance was measured by twelve radiometers[3] which were set around the burning pan. Distance between pan center and each radiometer was set at L/D = 2 or 3. Here L was the horizontal distance from pan center, and D was the pan diameter. The radiometers faced to the fire center to obtain the maximum irradiance at each place. They were set about 1.2 m height. They had wide angle view, 120 ° and their time constant was 0.3 second. Outputs of radiometers were stored in a personal computer through a data acquisition system every 5 seconds.

Temperature inside flame were measured by four K-type thermocouples at pan center. Diameter of thermocouples was 0.3 mm. All data of temperature inside flame were stored in a personal computer every second.

RESULTS AND DISCUSSION

Tests were run twice in all tanks. Most tests were done in calm weather conditions. There was little wind in the second test of 20 m tank. Average wind speed was about 0.05 m/sec during the test. Relationship between irradiance and dimensionless distance from tank center (L/D) was examined for all tests. The ratio of decrease of irradiance between the point at L/D=2 and the point at L/D=3 was almost the same values in terms of all tests.

Relationship between irradiance at L/D = 2 and 3 and pan diameter was shown in Fig. 1. The data of circle points (○ and ●) were measured in this work. The data of triangle points (△ and ▲) were from the reference[1] of kerosene test and converted into the values at L/D=2 and L/D=3 following to the square law. The data of square points (□ and ■) were from the reference[2] of crude oil test and converted by the same way. Irradiance at the points of L/D = 2 became low with increasing of D. The results at the points of L/D = 3 had the similar tendency with the results at the points of L/D = 2. Angle factor was 0.10 at L/D=2 and 0.05 at L/D=3, which was calculated with assuming that configuration of flame was cylinder. Flame height was about 30 m (Hf /D=1.5, Hf: flame height). The ratio of decrease of angle factor between the point at L/D=2 and the point at L/D=3 was 0.5. Irradiance of 20 m pan tests decreased greater than the result of this calculation.

Radiative fraction, ratio of total radiation loss and total heat release rate was about 29 % in 10 m, 16 % in 20 m pan fires, smaller than that of small scale tests[3]. Here total heat release rate was calculated with assuming complete combustion, and radiation outputs were calculated with averaged irradiance data at L/D = 3. These results mean most flame surface might be covered with huge amount of smoke produced from fire.

Relationship between the maximum temperature of the flame axis and dimensionless height (H/D) from the liquid surface was shown in Fig. 2. At height of H =4.4 m (H/D=0.22) in 20 m pan test, the maximum temperature became about 1350 °C. K-type thermocouple may not give exact value in such high temperature. Flame core, which means the zone in the flame has the maximum temperature along with the flame axis, should be at H/D=0.22 or higher. In 5 m and 10 m pan tests, temperature decreased where height was beyond H/D=0.1.

REFERENCES

1)The Japan Society for Safety Engineering, 1981, Report of Petroleum Burning Tests

2)The Japan Society for Safety Engineering, 1979, Report of Tank Fire Tests

3)H.Koseki and T.Yumoto, 1988, Fire Technology, 24(1) p.33

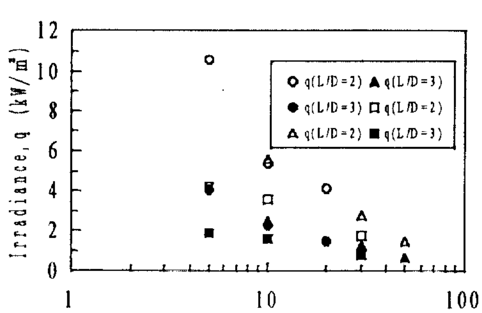

Fig.1 Relationship between irradiance and pan diameter

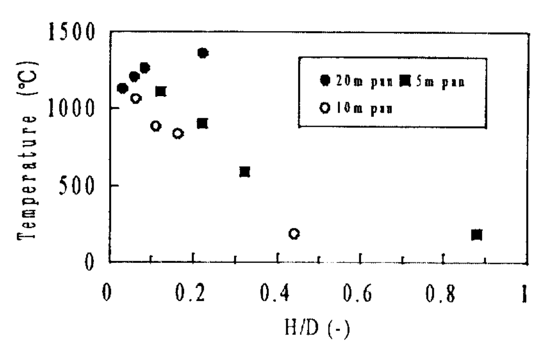

Fig2. Relationship between maximum temperature of flame and dimensionless height from the liquid surface