Proc. Vth International Workshop, Advances in Signal Processing for Non Destructive Evaluation of Materials
Québec City (Canada),2-4 Aug. 2005. © X. Maldague ed., É. du CAO (2006), ISBN 2-9809199-0-X

Dynamic characteristics of water surface irradiated by different lamps by using infrared thermography

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Abstract

Human being cannot maintain her life in the earth without air and water. Especially, the nature of water has not been evident even now from scientific viewpoint. It has been reported that it is strongly influenced by the shape of cluster of water molecule, which depends upon water's surroundings such as light, sound, magnet, heat, etc. This study clarifies the behaviors on fluctuating radiation temperatures of water surfaces due to irradiations of infrared and ultraviolet rays. Then, this study considers about relation between cluster of water molecule and characteristics of fluctuating radiation temperature of water surface.

Keywords : infrared thermography, radiation temperature, fluctuation, water surface, power spectral density

1. Introduction

As mentioned in the abstract, some characteristics of water was investigated by using infrared thermography. It can be recognized that behavior of water depends upon its surroundings such as atmospheric temperature, sound, light, vibration and so on. Even now, these effect against water have not been cleared. Therefore, the authors tried to find the effect due to its characteristics caused by behavior of fluctuating radiation temperature of water surface irradiated by different lamps. Speaking of water we have used different kinds of water like having mineral or radioactive component and that which is artificially treated like electrically deposited or irradiated by light , sound , and so on. In these application fields to drink water in order to maintain life, we have not understood how to drink what kind of water is efficiently healthy to us. Therefore, this study is to try to make clear the water characteristics affected by radiation temperature fluctuation by using the technique of frequency analysis.[1], [2]. This research tries to clarify the water reaction due to irradiation of infrared and ultra violet rays by measuring the radiation temperature distribution on the water surface.

2. Experimental Apparatus

2.1 View of Experimental Apparatus

Experimental Apparatus was consisted of the below units as shown in Fig. 1.

1) heater units
2) water basin to be tested
3) shutter and cover: Shutter plate made of Al is installed at the space between lamp and water vessel to give the step irradiation to the water surface
4) infrared thermography
5) oscillographic recorder

The above units are explained in the next 2.2.

Figure 1 experimental set up

2.2 Main Composition of Experimental Apparatus

2.2.1 water Material to be Measured

1) Public Water (civic water)
2) Pyramid Water: it was manufactured by the Great Pyramid Model* to apply the pyramid effect** depending on shape and direction as shown in Fig. 2.
3) Atomic Water: it was manufactured by immersion in the water with radioisotope
*material: acrylic plate of 2mm thickness, size: each base length;920mm, oblique side: 880mm height: 588mm, inclination angle: 51 , each direction of square base length oriented to east, west, south, north, water vessel is set to the location of mass center of pyramid model

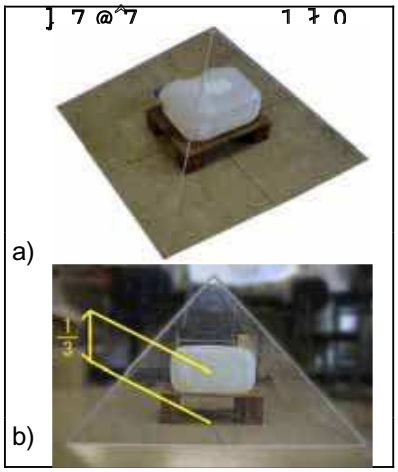


Figure 2 Pyramid model

2.2.2 Irradiators

(1) Infrared Ray Lamp
1) Heater housing was made of SUS (2mm thickness) and heat sink made of Al was installed at the top of heater for effective natural cooling as shown in Fig.3 a).
2) Heater has 6 infrared ray tubes in which power of each tube is 800 [W], and the total power can be adjusted by switching circuit as. shown in Fig.3 b).

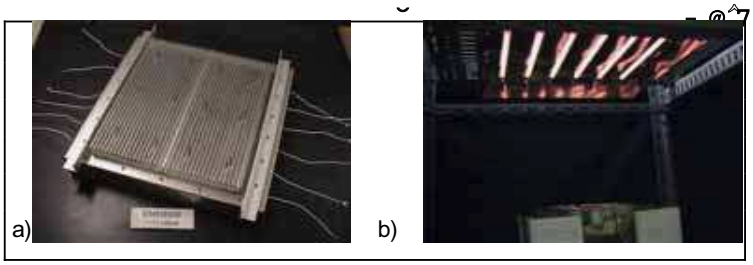


Figure 3 Irradiator for infrared ray: a) outside view b) inside view

(2) Ultra Violet Ray Lamp
1) UV Irradiator was composed of 6 UV lamps with stabilizer and lighting system installed on the Al housing as shown in Fig.4 a).
2) Each lamp has power of 10 [W] and radiates middle type of wavelength. The total power can be adjusted by 2 ways of 40 and 60 [W].The small lamps were installed between heater and switch box to operation as shown in Fig. 4 b).

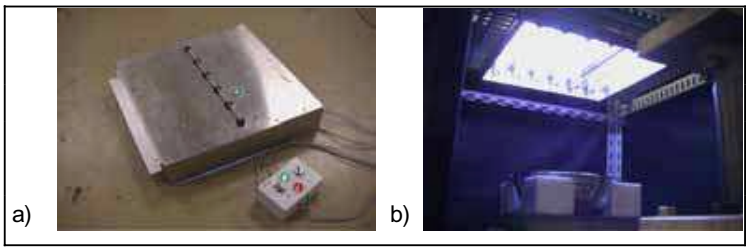


Figure 4 Irradiator for ultra violet ray: a) outside view b) inside view

2.2.3 Infrared Thermography

1) type: TH3102 made by NEC Sanei as shown in Fig. 5.
2) infrared sensor: made of HgCdTe, far infrared of 8~13 [m]
3) thermograms are saved in the inner HDD of control unit of infrared camera
4) radiation temperature related to the thermograms is to be sent to the worksheet of Excel and then treated analytically.

Figure 5 Infrared camera

3. Experimental Procedure

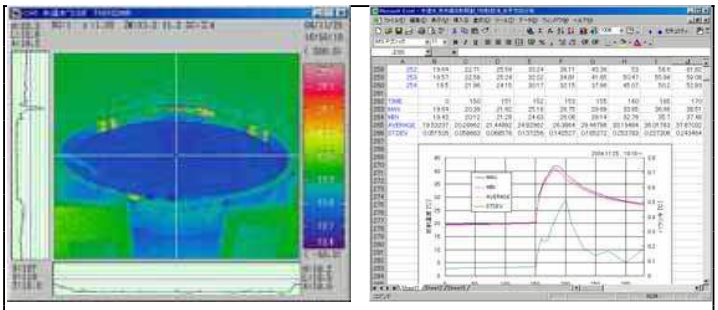
3.1 Acquisition of Thermograms and Its Condition

1) Water of 3000 cc to be tested is supplied in the vessel made of stainless-steel
2) It is irradiated by IR (infrared ray) and UV (ultra violet ray)

3) The former case is 30s irradiation and 150s natural cooling
4) The latter case is 60s irradiation and 120s natural cooling
5) Thermograms of above two cases were measured by Infrared Thermography

3.2 Analysis of Thermograms

1) The cross cursor line in the thermograms is tranformed into radiation temperature distribution after transmitting to Excel by using the software in the off-line of measurement as shown in Fig. 6 a).
2) This fluctuating radiation temperature distribution is analyzed as mean, max., min. and root mean square (that is standard deviation) values in Excel.
3) Then, the mean radiation temperature and its fluctuation distributions on the longitudinal direction of cross cursor line are determined like Fig. 6 b).



a) thermograms and its analysis b) transportation of radiation temperature to Excel sheet

Figure 6 Procedure of getting the radiation temperature and its fluctuation profiles

3.3 Analysis of Power Spectral Density (PSD)

1) The slope of PSD ("n" defined by the equation of PSD = Kf^{-n}) becoms "n=1" in case of naturally moderate phenomena such as wind velocity, streaming sound, twinkling star light, etc.. This case is so called by 1/f theory that was discovered by Dr. Musha [3].
2) Recently It has become recognized that fluctuation level becomes larger if n>1 by the authors [2], [4].
3) The center of water surface measured by time trace mode (during 3s per 3ms) is analyzed as power spectral density (PSD) by use of the data analysis software called DADiSP. Then, the slope of PSD is determined by the below equation (1)~(3).

$$\log_{10}PSD = \log_{10}K - n\log_{10}f \quad (1)$$

$$\log_{10}(PSD_1/PSD_2) = \log_{10}(f_2/f_1)^n \quad (2)$$

$$n = \log_{10}(PSD_1/PSD_2) / \log_{10}(f_2/f_1) \quad (3)$$

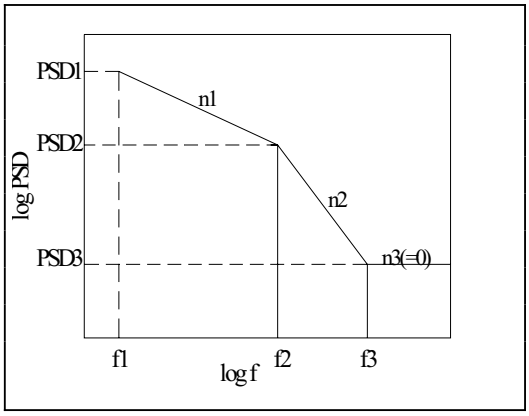
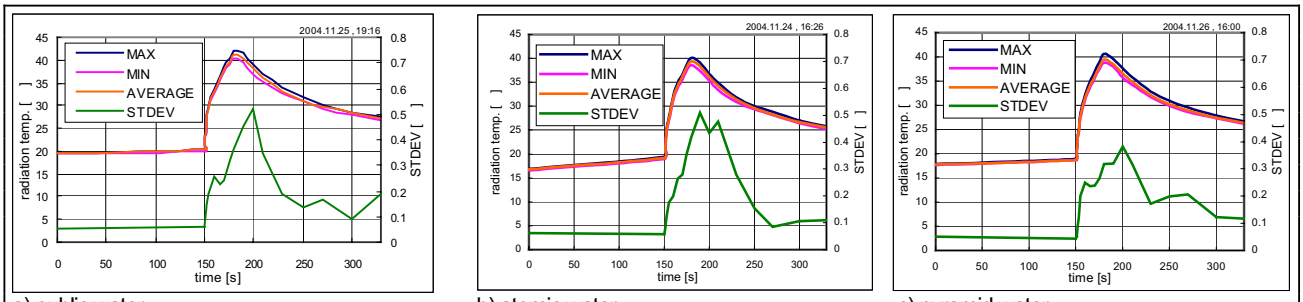


Figure 7 Determination of slope n_1, n_2, n_3 (=0)

4. Experimental Results and Consideration

4.1 IR Radiation Temperature and Its Fluctuation

The results of radiation temperature distribution and its fluctuation profiles are shown in Fig. 8 a) ~ c).
1) The profile of radiation temperature distribution is almost same in three kinds of waters.
2) But that of each fluctuation distribution shows quite different pattern. The cases of a), c) have max. value after 20s from stopping irradiation and the case b) has two peaks around stopping irradiation.
3) In the cooling process after stopping irradiation, fluctuation pattern shows different behavior.

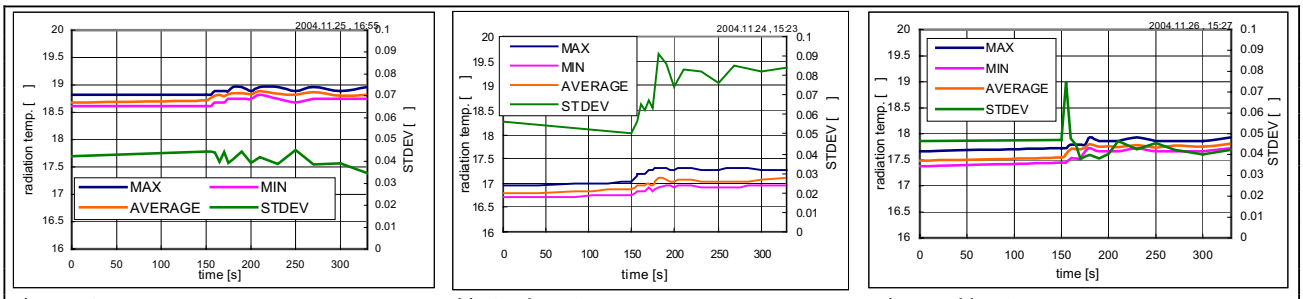


a) public water b) atomic water c) pyramid water

Figure 8 Radiation temperature distribution and its fluctuation

4.2 UV Radiation Temperature and its fluctuation

The results of radiation temperature distribution and its fluctuation profiles are shown in Fig. 9 a) ~ c).
1) The profile of radiation temperature is also almost same in three kinds of waters and temperature change is small compared to the case of IR irradiation.
2) Its fluctuation profile shows quite different profile in three kinds of waters.
3) The case a) shows only up and down after UV irradiation, but the cases b) and c) shows peculiar pattern (it is considered due to shape of the cluster of water molecular).

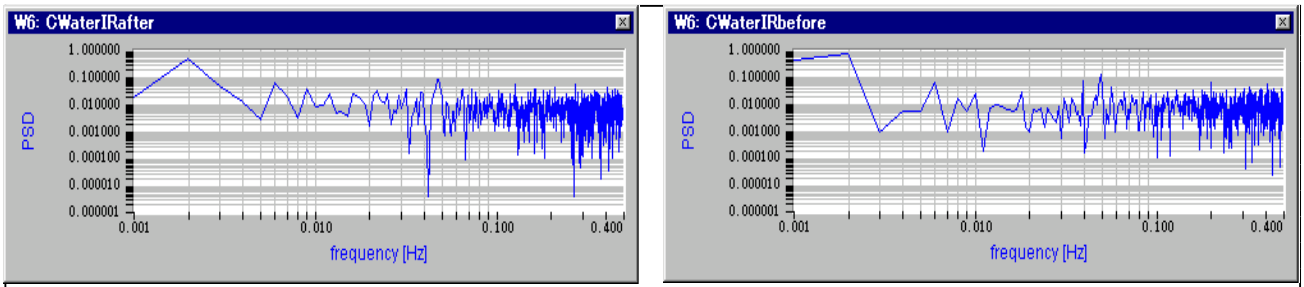


a) pu water b) atomic water c) pyramid water

Figure 9 Radiation temperature distribution and its fluctuation

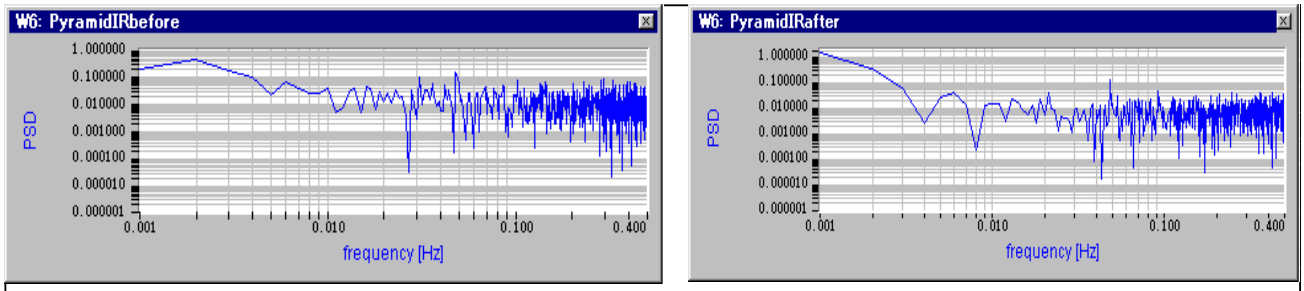
4.3 PSD Graph of IR Irradiation

The PSD graph of IR irradiation are shown as Power Spectral Density (PSD) versus frequency (f) in the case of public water and also in the case of pyramid water in Fig. 10 and Fig. 11, respectively. The slope of PSD was approximately calculated in a low frequency region of f < 0.02 [Hz]. It becomes to be flat like white noise in the region of f 0.05 [Hz].



a) before IR irradiation b) after IR irradiation

Figure 10 PSD graph of IR irradiation (public water)

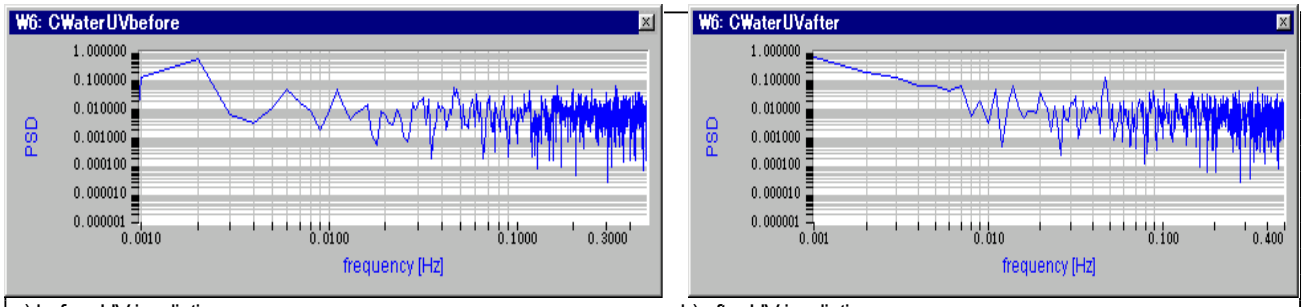


a) before IR irradiation b) after IR irradiation

Figure 11 PSD graph of IR irradiation (pyramid water)

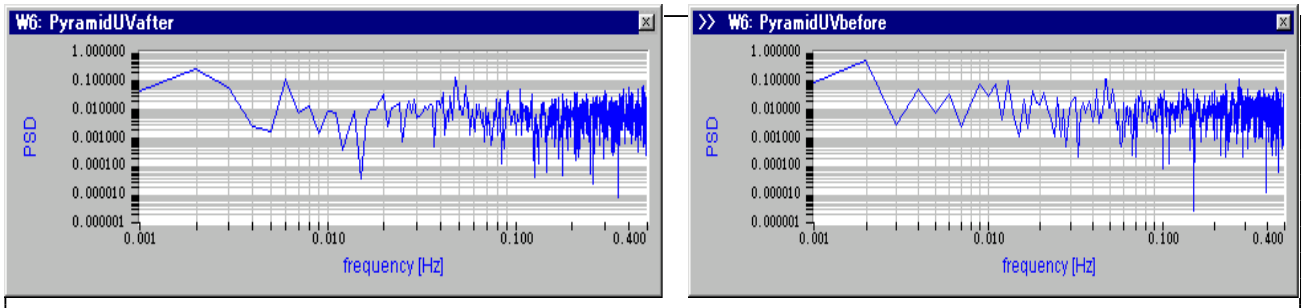
4.4 PSD Graph of UV Irradiation

The PSD graph of UV irradiation are shown as Power Spectral Density (PSD) versus frequency (f) in the case of public water and also in the case of pyramid water in Fig. 12 and Fig. 13, respectively..



a) before UV irradiation b) after UV irradiation

Figure 12 PSD graph of UV Irradiation (public water)



a) before UV irradiation b) after UV irradiation

Figure 13 PSD graph of UV Irradiation (pyramid water)

4.5 Consideration of PSD Slope

1) According to the results by calculating the slope in PSD graphs as shown in Fig.10 to Fig.13, each slope of PSD is shown in Fig. 14 a) and b).
2) It is recognized that each slope of PSD shows different behavior depending upon water type where 1, 2 and 3 is corresponding to public, atomic, and pyramid water, respectively.
3) The slope n in both IR and UV irradiations becomes n>1 and ranged from 1.2 to 2.3. Except the pyramid water, n after irradiation is smaller than n before irradiation.
4) In the case of IR irradiation, pyramid water shows particular behavior that n after irradiation is larger than that

before irradiation.

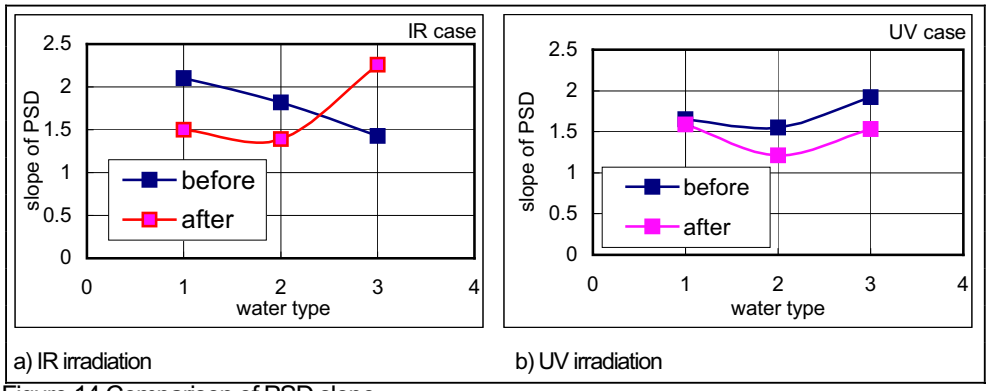


Figure 14 Comparison of PSD slope

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5. Conclusion

1) The radiation temperature of water surface became increased by IR irradiation, and gradually decreased after stopping of irradiation. On the contrary it became gradually and slightly increased in the case of UV irradiation.
2) The STDEV of fluctuating radiation temperature in IR irradiation showed approximately same in each water and had max. value at 20 ~ 30s later after stopping irradiation. But that in UV irradiation showed quite particular shape depending on water type. This behavior is considered to be depending on shape of cluster related to motion of water molecule.
3) According to applying the PSD analysis of fluctuating radiation temperature at the only center of water surface, it was clarified that PSD slope is n >1, and n after irradiation is smaller than that before irradiation except the pyramid water.
4) The PSD slope n of the pyramid water showed max. value of 2.26 among three kinds of water, and now its reason was not cleared. Hereinafter, the systematic approach will be expected in this field.

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