

Heat and Fluid Flow in Accident of Fukushima Daiichi Nuclear Power Plant  
Accident Scenario based on Fluid Dynamics and Thermodynamic Models

Shigenao Maruyama  
Institute of Fluid Science, Tohoku University  
Sendai, Japan

Abstract

The Great East Japan Earthquake and ensuing tsunami occurred on March 11th, 2011 caused the accident of the Fukushima Daiichi Nuclear Power Plant (hereinafter referred to as “Fukushima Daiichi NPP”). Consequently, the Units-1 to 4 experienced severe accidents, although they were successfully shut down by scram but lost functions related to cooling their decay heat. The objective of this lecture is to investigate the facts and causes of the accident at the Fukushima Daiichi NPP based on the data known to date and the results of several analyses.

At first, the outline of the East Japan Great Earthquake and the accident of the Fukushima NPP will be presented. Then, an official report and that of Tokyo Electric Company (TEPCO) of the accident scenario and analysis will be introduced. In which, they assumed that the isolation condensers (ICs) of the Unit-1 were not functional after the arrival of the tsunami followed by the station blackout because so called “fail safe” system closed the valves in ICs.

Then, an accident scenario of Fukushima Daiichi NPP will be analyzed independently from the data open to the public, in order to investigate the process of accident. Thermodynamic and fluid dynamics models were applied for the analysis. Phase equilibrium process model and adiabatic expansion model were introduced in the thermodynamic model. We proposed a scenario that the IC was operational for a certain period after the arrival of the tsunami. The present analysis model and the scenario describe the data measured at the accident and many evidences and witnesses reported at the early stage of the accident.

Finally, we will estimate the ruptured position and time in the Unit-1 using a heat transfer model in the fuel clusters according to the estimated accident scenario.

## Curriculum Vitae

Shigenao MARUYAMA

Name: Shigenao Maruyama  
Affiliation: Professor,  
Heat Transfer Control Laboratory  
Institute of Fluid Science, Tohoku University  
Sendai 980-8577, Japan

### 1 Academic Qualifications

B.Eng. 1977, Department of Mechanical Engineering II, Tohoku University, Japan  
M.Sc. 1979, Department of Aeronautics, Imperial College, London University, UK  
M.Eng. 1980, Department of Mechanical Engineering, Tohoku University, Japan  
Dr. Eng. or PhD, 1983, Department of Mechanical Engineering, Tohoku University, Japan

### 2 Professional Carriers

1983 Research Associate( faculty member), Institute of High Speed Mechanics, Tohoku University  
1988 Visiting Scholar, School of Mechanical Engineering, Purdue University, USA  
1989 Associate Professor, Institute of Fluid Science, Tohoku University  
1997 Professor, Institute of Fluid Science, Tohoku University.  
2005-2006 Specially Appointed Assistant to the President, Tohoku University  
2006-2009 Councilor, Tohoku University  
2006-2008 Special Advisor to President, Tohoku University  
2006-2013 Special Advisor for Centenary Events and Alumni, Tohoku University  
2008-2011 Distinguished Professor

### 3 Activity of Academic Societies

AIAA Associate Fellow 1995-  
JSME Fellow 2004-  
The Engineering Academy of Japan, Member, 2005-  
Assembly of the World Conference on Experimental Heat Transfer, Fluid Mechanics and Thermodynamics, member, 2005-  
International Centre for Heat and Mass Transfer, Scientific Council, Member, 2006-2014  
The Science Council of Japan, cooperation member, 2012-

Editor, Experimental Heat Transfer, an International Journal, 2005-  
Editor, Journal of Quantitative Spectroscopic and Radiative Transfer, 2004-  
Editor, International Journal of Rotating Machinery, 2008-2013  
Vice President of Heat Transfer Society of Japan, 2014-2015.  
Chair of International Scientific Committee, the 15<sup>th</sup> International Conference of Heat Transfer, IHTC-15, Kyoto, Japan, 2010-2014.

#### 4 Awards

JSME Award for Young Engineers, 1989  
Award for Fluid Science, 1995  
Heat Transfer Society of Japan, Award for Scientific Contribution, 1998  
JSME Medal for Outstanding Paper, 1999  
Award for Scientific Measurement, 1999  
JSME Tohoku Division, Award for Technical Contribution, 2001  
Japan Society of Applied Electromagnetic and Mechanics, Best Technical Contribution Award, 2001  
JSME Thermal Engineering Division, Award for Academic Achievements, 2001  
Heat Transfer Society of Japan, Award for Technical Contribution, 2002  
Societe Francaise de Themique, 2002 International SFT Award, 2002  
JSME Thermal Engineering Division, Award for Contribution, 2003  
JSME Fellow, 2004  
Medal of Honour (Medal with Purple Ribbon) (紫綬褒章), 2012  
JSME Thermal Engineering Division, Award for Achievements (Research), 2012  
JSME Medal for Outstanding Paper, 2013

#### 5 Research Areas

Radiative Heat Transfer in Complicated Systems  
Heat-transfer Control under Extreme Conditions  
Heat-transfer Control of Biological Organs  
Power Generation System utilizing Oceanic Methane Hydrate

He has published more than 200 academic papers and contributed more than 10 books. The textbook, "Thermodynamics" is the best seller in Japanese engineering text books. He is listed in Who's Who in the World since 1995, and Who's Who in Science and Engineering. He is chairmen of more than six international conferences i.e. : International Forum on Heat Transfer(IFHT2004), The First, Second, Third and Fourth International Conference on Flow Dynamics, 2004, 2005, 2006, 2012, The 6<sup>th</sup> World Conference on Experimental Heat Transfer, Thermodynamics and Fluid Mechanics, 2005 and NanoRad2012. He is also editors of international academic journals and international committee members.