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## Heat in History

# The Heat Transfer Family of Kyushu University

YASUYUKI TAKATA

Department of Mechanical Engineering Science, Kyushu University, Fukuoka, Japan

*Kyushu University has been one of the most active universities in heat transfer research, especially in the field of boiling and condensation. The heat transfer research in Kyushu University was initiated by Prof. K. Yamagata about 75 years ago. He brought up a number of heat transfer professors including Prof. K. Nishikawa and his successors, and his group has been called the "Heat Transfer Family." The present article introduces its history and the current status of heat transfer research in Kyushu University.*

Kyushu University, established in 1911 as one of the imperial universities, is located in Fukuoka City in the southwest of Japan. As seen from the map in Figure 1, Fukuoka City is geographically close to major Asian cities and has the position as the gateway to Asia in Japan. Because of this accessibility, many heat transfer researchers frequently visit Kyushu University from overseas.

The heat transfer research at Kyushu University began by one distinguished professor, Kiyoshi Yamagata, in 1932; since then, Kyushu University has become a major heat transfer research core with a number of heat transfer researchers. Many years ago, Professor J. P. Hartnett at the University of Illinois referred to the research group of Kyushu University as "the Heat Transfer Family" because he observed that the researchers were getting along well so happily and friendly. The present article introduces the history and the current status of the "heat transfer family" in Kyushu University.

The founder of the family is Professor Kiyoshi Yamagata, as seen in Figure 2. The pedigree of the family is shown in Figure 3, and the professors are summarized in Table 1. Readers can roughly understand the relationship between professors. Professor Yamagata graduated from the Department of Mechanical Engineering, Kyushu University, and was appointed as a lecturer in 1927. He was promoted to an associate professor in 1929 and then to a professor in 1940. In 1937, when he was an associate professor, he started a lecture entitled "Applied Thermal Sci-

ence," which was the first lecture on heat transfer in Japan. His first article on heat transfer, though it was in Japanese, was "On the Heat Flow under the Furnace Hearth," which appeared in the *Journal of the Japan Society of Mechanical Engineers* in 1932 [1]. The first English paper was "A Contribution to the Theory of Non-isothermal Laminar Flow of Fluids inside a Straight Tube of Circular Cross Section," which appeared in *Memoirs of Faculty of Engineering, Kyushu University*, in 1940 [2]. It should be worthy of attention that the paper was cited in the famous textbook, *Introduction to the Transfer of Heat and Mass*, written by Professor Eckert in 1950 [3].

Afterward, Professor Yamagata made outstanding achievements in the boiling and natural and forced convection of supercritical fluids. His ability lay not only in heat transfer research but also in education. He brought up a number of heat transfer researchers and engineers with his motto of "Friendly and Strictly." He left the university in the able hands of three distinguished professors, Kaneyasu Nishikawa, Shu Hasegawa, and Tetsu Fujii. They and their staffs together with professors who joined later from other institutions have become a big family and have been in all their glory.

There remains an amusing story [4] about the chance of research on boiling heat transfer. During World War II, Professor Yamagata and his family were evacuated from Fukuoka City to his hometown to avoid the air raid. After the war, he alone returned to the university and was living in his laboratory, bringing his bed in it. He used an Erlenmeyer flask instead of a kettle to make a cup of tea. He often observed the boiling bubbles in the flask and was interested in their behavior. One night, Associate Professor Nishikawa and a colleague came to see him at his

Address correspondence to Professor Y. Takata, Department of Mechanical Engineering Science, Faculty of Engineering, Kyushu University, 744 Motoooka, Nishi-ku, Fukuoka 819-0395, Japan. E-mail: takata@mech.kyushu-u.ac.jp



Figure 1 Distance from Fukuoka City to other major cities in East Asia.

office. Professor Yamagata pointed at the flask and said to them, "The boiling bubbles seem to have a regularity, but they also seem chaotic. Though the water is heated uniformly from the bottom, why do bubbles generate from the fixed points and not from everywhere?" Then he added, "So, Mr. Nishikawa, shall we go at boiling research?" This was the initiation of boiling research at Kyushu University. After his retirement from Kyushu University, Professor Yamagata served as the president of the



Figure 2 Professor Kiyoshi Yamagata.

Heat Transfer Society of Japan and as the president of Ube National College of Technology, and passed away in 1971.

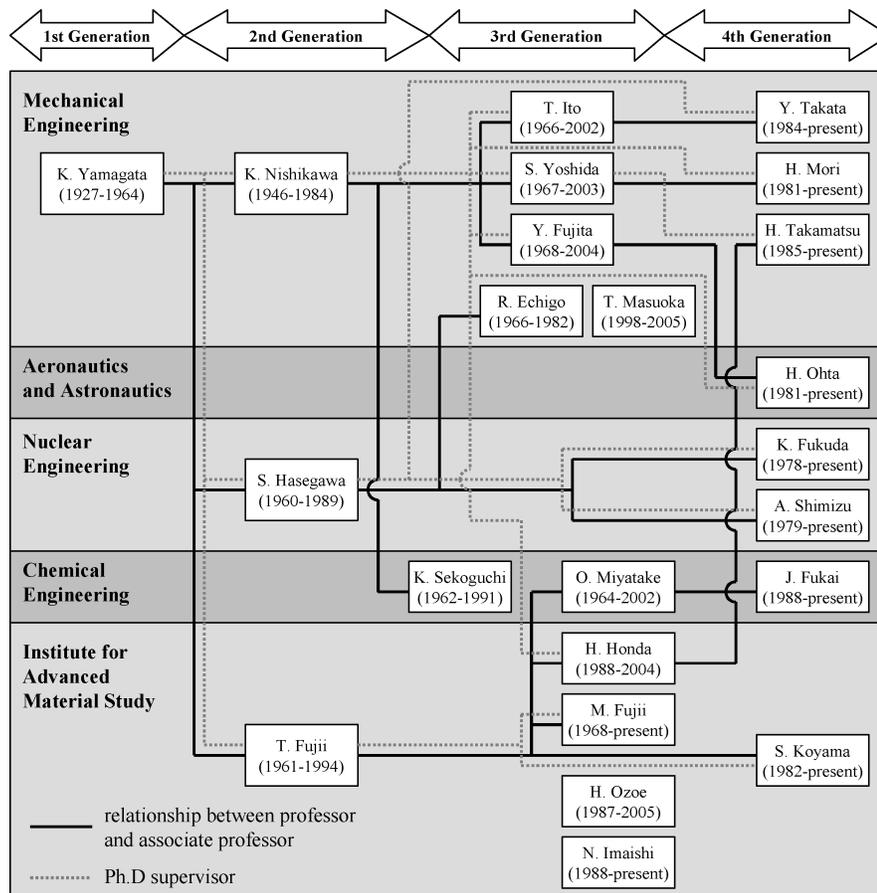
The history now moves on to the second generation. As mentioned earlier, Professor Yamagata left three successors. Professor Kaneyasu Nishikawa (see Figure 4) graduated from Kyushu University in 1943. After two years of military service, he was appointed as an associate professor in the Department of Mechanical Engineering. Professor Nishikawa made outstanding contributions to boiling heat transfer by his monumental work of two correlation equations of nucleate boiling, which are known as Nishikawa-Yamagata's equation [5] and the improved version of Nishikawa-Fujita's equation [6]. In addition to this achievement, he expanded his research field to film boiling, natural and forced convection of supercritical fluids, boiling of liquid helium, forced flow boiling of refrigerants, transition boiling, and boiling of mixtures. These studies were performed together with young professors of third generation. Professor Nishikawa served as the president of the Heat Transfer Society of Japan (HTSJ) and the vice-president of JSME. After his retirement from Kyushu University, he served as the President of Kurume National College of Technology and consecutively as a professor at Kurume Institute of Technology and a technical advisor at Kyushu Electric Power Co., Inc.

Professor Shu Hasegawa rejoined the family in 1960 after several of years research experience at the Japan Atomic Energy Research Institute, and he was appointed as a professor at the Department of Nuclear Engineering. His research interest was nuclear thermal-hydraulics. In particular, he proposed a new type of cooling system for a fusion reactor that involves the utilization of gas-solid multiphase flow, asserting that fine carbon particles suspended in helium gas absorb and emit radiation; consequently, heat transfer is much enhanced. This study was performed with Professor Ryoze Echigo, now Professor Emeritus at Tokyo Institute of Technology, and Professor Akihiko Shimizu. Professor Hasegawa and his successor, Professor Kenji Fukuda, have studied experimentally and theoretically the instability of multi-channel two-phase flow of a nuclear reactor. Professor Hasegawa brought up numerous professors and doctors, including the present author. Like Professor Nishikawa, Professor Hasegawa served as the presidents of HTSJ, Kurume National College of Technology, and, after his retirement from Kyushu University, Kurume Institute of Technology, and died in 2001.

Professor Tetsu Fujii was appointed as an associate professor in 1961 and then was promoted to a professor in 1967 at the Research Institute of Industrial Science after five years as a researcher at the Central Research Institute of Electric Power Industry. He has made a number of outstanding achievements in the field of free convection and condensation. In 1991, he published a book entitled *Theory of Laminar Film Condensation* [7]. Later, the institute was reorganized and changed its name to the Research Institute of Advanced Material Study. Professor Fujii invited Professors Hiroshi Honda and Hiroyuki Ozoe from Okayama University and Professor Noriyuki Imaishi from Tohoku University to his research institute. He served as the president of HTSJ and the president of the Japan Society of

**Table 1** Heat Transfer Professors of Kyushu University in Chronological Order

Name of professor	Department	Term	Research area
Kiyoshi Yamagata	Mechanical engineering	1927–1964	Supercritical fluid, nucleate boiling, forced and natural convection
Kaneyasu Nishikawa	Mechanical engineering	1946–1984	Boiling heat transfer, steam engineering, Nishikawa-Yamagata correlation, Nishikawa-Fujita correlation
Shu Hasegawa	Nuclear engineering	1960–1989	Thermosyphon, enhancement of radiation heat transfer with solid particle suspension
Tetsu Fujii	IAMS	1961–1994	Film condensation, natural convection
Kotohiko Sekoguchi	Chemical engineering	1962–1991	Two-phase flow
Ryozo Echigo	Mechanical engineering	1966–1982	Combustion, enhancement of radiation heat transfer by porous media
Takehiro Ito	Mechanical engineering	1966–2002	Film boiling, cryogenics, thermodynamic cycle
Osamu Miyatake	Chemical engineering	1964–2002	Flush evaporation
Suguru Yoshida	Mechanical engineering	1967–2003	Flow boiling
Yasunobu Fujita	Mechanical engineering	1968–2004	Nucleate boiling, Nishikawa-Fujita correlation
Hiroshi Honda	IAMS	1988–2004	Film condensation, transition boiling
Takashi Masuoka	Mechanical engineering	1998–2005	Convection in porous media
Hiroyuki Ozoe	IAMS	1987–2005	Natural convection in enclosures
Noriyuki Imaishi	IAMS	1988–present	Heat and mass transfer in crystal growth
Motoo Fujii	IAMS	1968–present	Cooling of electronic devices, thermophysical property measurement
Kenji Fukuda	Nuclear engineering	1978–present	Two-phase flow instability
Akihiko Shimizu	Nuclear engineering	1979–present	Cooling system for nuclear fusion reactor
Shigeru Koyama	IAMS	1983–present	Refrigeration and air-conditioning systems
Haruhiko Ohta	Aeronautics and Astronautics	1981–present	Boiling under microgravity
Hideo Mori	Mechanical engineering	1981–present	Flow boiling
Yasuyuki Takata	Mechanical engineering	1984–present	Phase change, wettability effects
Hiroshi Takamatsu	Mechanical engineering	1985–present	Bioengineering
Jun Fukai	Chemical engineering	1988–present	Thermal energy storage



**Figure 3** Pedigree of heat transfer professors in Kyushu University.



**Figure 4** Professor Kaneyasu Nishikawa.

Thermophysical Properties. After his retirement from Kyushu University, he served as a professor at East Asia University. He is still enthusiastic about film condensation and has published a book on it in 2005 [8].

Next came the third generation. At the Department of Mechanical Engineering, Professor Nishikawa left three professors: Professors Takehiro Ito, Suguru Yoshida, and Yasunobu Fujita. During their era, a variety of boiling research applications were developed, such as a numerical analysis of convective film boiling and helium cryogenics by Professor Ito, forced flow boiling by Professor Yoshida, and a correlation of nucleate boiling (Nishikawa-Fujita's equation [6]) and boiling of mixtures by Professor Fujita. Professor Fujita served as the president of HTSJ and is called the "Boiling Master" by his overseas friends. Later, in 1998, Professor Takashi Masuoka joined the family from Kyushu Institute of Technology and made outstanding achievements in the field of heat transfer in porous media.

At the Research Institute of Advanced Material Study, professors invited or brought up by Professor Tetsu Fujii have been working in a variety of fields in heat and mass transfer. Among them, Professor Hiroshi Honda's theoretical analysis on film condensation [9] is well known. He built up a set of complicated basic equations and obtained the solution that predicts the film thickness of condensate on a finned surface.

As these professors have already retired from Kyushu University, the current professors are the fourth generation. As of the year 2007, there are ten or more heat transfer laboratories, and the total number of heat transfer researchers in Kyushu University is definitely the largest in Japan. In the Department of Mechanical Engineering, there are three laboratories, including the author's. Professor Hideo Mori, a successor of Professor



**Figure 5** Experimental apparatus for developing heat pump systems using multi-component refrigerants (courtesy of Professor Koyama).

Yoshida, has been studying and expanding his research field in flow boiling. Professor Hiroshi Takamatsu, who used to be associated with Professor Honda at the Research Institute of Advanced Material Study, moved to the Department of Mechanical Engineering and is now devoted to bio heat and mass transfer.

In the Department of Aeronautics and Astronautics, Professor Haruhiko Ohta, who moved in from the Department of Mechanical Engineering, has been making outstanding achievements in the field of boiling under microgravity. In the Department of Chemical Engineering, Professor Jun Fukai took over the laboratory originated by Professor Osamu Miyatake and is now studying heat transfer related to thermal energy storage and effective energy use.

In recent years, Kyushu University has dramatically changed structurally and geographically. The Research Institute of Advanced Materials Study was reorganized to the Institute for Materials Chemistry and Engineering. Under this new name, Professor Shigeru Koyama, who took over from Professor Tetsu Fujii, moved to the Faculty of Engineering Sciences in April in 2006. He has been successively devoted to heat and mass transfer related to heat pump systems with a large experimental setup (see Figure 5), as well as to refrigeration and air conditioning.

In addition to the reorganization, the Faculty of Engineering has just relocated to the new campus (see Figure 6), which has a larger area and great potential for various research projects such as the Hydrogen Campus Project. Many hydrogen

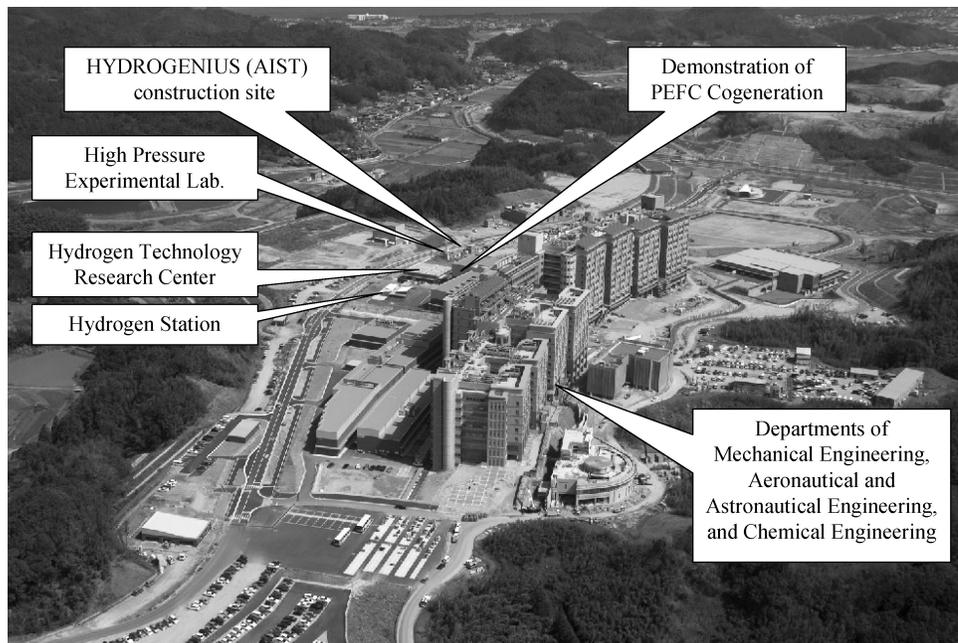


Figure 6 New campus and hydrogen research area of Kyushu University.

research projects are ongoing there. One of these is the establishment of the Research Center of Hydrogen Industrial Use and Storage (HYDROGENIUS) founded by the National Institute of Advanced Industrial Science and Technology (AIST). In HYDROGENIUS, measurement of various hydrogen thermophysical properties at high pressure is planned as one of the research projects. Professor Motoo Fujii, who currently belongs to the Institute for Materials Chemistry and Engineering, also serves concurrently as a group leader of HYDROGENIUS. The author and the other young associate professors are also involved in the project as the members of the research group.

It has been 75 years since Professor Yamagata started heat transfer research in Kyushu University. During these years, a number of professors and doctors have been produced from the family. We hope that the prospect of the family will be permanently brilliant, and moreover, that all family members will get along with each other “friendly and strictly.”

#### ACKNOWLEDGMENTS

The author would like to express his special thanks to Professor Emeritus Kaneyasu Nishikawa for his excellent memory and materials that contain various histories of heat transfer research in Kyushu University, as well as to Professor Emeritus Yasunobu Fujita for his assistance and encouragements and Professor Satish Kandlikar at RIT for giving the author an opportunity to write this history.

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**Yasuyuki Takata** is a professor of thermofluid physics in the Department of Mechanical Engineering Science, Kyushu University, Japan. He received his Dr. Eng. in 1984 from Kyushu University. His research area covers phase change heat transfer, micro JT cooler, micro heat transfer devices, and thermophysical properties of hydrogen, as well as a database of thermophysical properties of fluids. He is a fellow of the Japan Society of Mechanical Engineers (JSME), an editor-in-chief for *Journal of Thermal Science and Technology*, and an associate regional editor for *Applied Therm.*