

Journal of The Heat Transfer Society of Japan
Vol.35, No.139, October, 1996

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HEAT TRANSFER RESEARCH ACTIVITIES IN TAIWAN

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Abstract

This paper presents the status on the heat transfer research activities in Taiwan. The main research funds of university research comes from projects of the National Science Council (NSC). The industrial and application oriented researches are through the Ministry of Economic Affairs and Ministry of Transportation. There are 21 graduate schools offering Master degree in ME, and 10 of them offering Ph.D. The personnel and research areas will be described. NSC has set up 18 measures for promotion of research. Taiwan has held annually five conferences that accept papers of thermal-fluids engineering. This paper also lists and discusses the publications of papers from Taiwan in some typical international journals. To carry out meaningful researches and improve the quality of papers, one has to promote the communication in international heat transfer societies, and with the related industries.

BRIEF HISTORY OF TAIWAN

Taiwan with a total area of 36,000 km² has a total population of 21 million concentrated on the west coast of the island. Recently, the people of Taiwan have elected their president under the military threat of China. Although some aborigines have been living in this island for thousand years, little is known of Taiwan's earliest history. When the Ming dynasty in the Chinese mainland came to an end, Portuguese sailors landed on the island in 1517, and called it *Ihla Formosa*, what means 'Beautiful Island.' The Dutch invaded the island in 1624 and settled in the South. Spaniards settled in the North, and were driven away by the Dutch in 1641. Soon after that Cheng Chengkung (also known as Koxinga) expelled the Dutch from the island in 1661.

Immigration to the island began in the 17th century when people from the Fujian Province fled from Famine

and persecution on the mainland. The Manchus invaded Taiwan in 1683 and Taiwan became a part of Fujian Province. In the 19th century, the population had risen to approximately 2.5 million. Taiwan became a separate province of China in 1887, and Taipei was the capital. In 1895, Manchus handed over Taiwan to Japan because the lost of Korea war. In 1945, China regains Taiwan after World War II. The civil war between the communists and the KMT separates the PRC on the mainland and ROC on Taiwan.

GOVERNMENTAL FUNDING AGENCIES

National Science Council found in 1959 is the major governmental funding agency that supports the basic researches in science, engineering, agriculture, biology and the medical science, and humanity and social science. The Engineering Division consists of subdivisions of mechanical, civil, electrical, and chemical engineering and the other related disciplines. The thermal fluids engineering group including heat transfer, fluid mechanics, and combustion is under the mechanical engineering subdivision. The majority of research projects of NSC are proposed by university professors.

The science and technology advisory boards in Ministry of Economic Affairs and Ministry of Transportation finance industrial or application oriented researches. Energy committee in MOEA also supports the energy related researches. The major portion of funding of MOEA and MOT goes to the ITRI, an independent nonprofit research and development organization, only a small portion goes to Universities.

UNIVERSITY AND RESEARCH INSTITUTES IN TAIWAN

As shown in Fig. 1, there are 21 graduate schools that offers Master degree in mechanical engineering. These schools are scattering around the west coast of Taiwan

island. Ten of them offer Ph.D. As shown in Table 1, the names of these schools are listed from northern part of Taiwan to the South. The total numbers of professors, Master students, and Ph.D. students in mechanical engineering are 529, 1973, and 552, respectively. Roughly speaking, about 1/4-1/3 of professors and students are major in the thermal-fluids engineering. National Taiwan University has the largest ME graduate program in Taiwan. National Cheng Kung University is the second one. National Tsing Hua University is the number four, slightly greater than the number 5, our neighbor National Chiao Tung University. Two private schools, TTIT and CYCU also offer Ph.D. in ME. Usually, it takes two years to finish the Master degree with thesis that is compulsory in Taiwan. The time required for a Ph.D. is about 4-6 years. Some part time Ph.D. students may take longer than six years to finish their course work, preliminary examination, and the thesis.

MEASURES FOR PROMOTION OF RESEARCH

One cannot say that there was absolute no scientific activity in Taiwan during the period of Japanese occupation from 1895 to 1945. As I know, some research activities in medical science and agriculture have been reported, but no research in basic science and engineering has been found in that time. The National Science Council of Taiwan established in 1959 has set up the research policy covers all fields of scientific researches. To strengthen the research power, 18 measures are taken for the promotion of research activities of Universities, Research Institutes, and National Laboratory [1].

- Measure 1: Subsidizes the recruit of research chair, and fellows.
- Measure 2: Subsidizes domestic researchers for study abroad.
- Measure 3: Subsidizes the recruit of researchers from China.
- Measure 4: Subsidizes the researchers for short term study in China.
- Measure 5: Subsidizes the bilateral symposia with China.
- Measure 6: Subsidizes undergraduate students for project research.
- Measure 7: Finances the NSC research projects.
- Measure 8: Subsidizes researchers for excellent

performance.

- Measure 9: Offers scholarships for Ph.D. students.
- Measure 10: Subsidizes research assistantship for projects.
- Measure 11: Subsidizes the publication of domestic journals.
- Measure 12: Helps the patent and copy right application [2].
- Measure 13: Helps researchers for technology transfer [2].
- Measure 14: Subsidizes the joint research projects with industrials.
- Measure 15: Supports the participation of international symposia.
- Measure 16: Subsidizes the invitation of well-recognized persons.
- Measure 17: Subsidizes the organization of international symposia.
- Measure 18: Subsidizes the over sea scholars for short term visit.

The NSC can also pays the page charge for the publication of papers written from the results of NSC funded research projects. The travel expense should be applied separately, and you may get it at most once every fiscal year. The Ministry of Education and University may also subsidize the travel expense for international symposia, at most once every fiscal year. The allowance can be part of budget of industrial research project, that can be part of professor's salary with a certain amount of upper bound.

RESEARCH AREAS OF THERMAL FLUIDS ENGINEERING IN TAIWAN

Researches in thermal fluids engineering includes heat transfer, fluid mechanics, and combustion. It combines with the other fields in mechanical engineering is under the Division of Engineering. Currently, the research areas of heat transfer in Taiwan emphasizes the following areas [3]: materials processing related transport phenomena; high power electronic cooling; high performance heat exchangers; thermal environmental control engineering; software development for computer aided design. Fluid mechanics research covers: fluid machinery; transportation related fluid mechanics problem; micro-machinery related fluid mechanics problem; wind engineering related fluid

mechanics problem; software development. Combustion research includes: fuel and combustion characteristics; automotive and motor cycle IC engines; furnace and burner; fire study.

CURRENT RESEARCH PROJECTS IN THERMAL FLUIDS ENGINEERING

Table 2 shows the NSC funded research projects in thermal fluids engineering [3]. The number of projects funded are 107 and 136, in fiscal years of 1995 and 1996, respectively. In 1995, The number of projects in heat transfer is 41, the number in fluid mechanics is 21, and the number in combustion is 45. In 1996, the number of projects in heat transfer is 69, the number in fluid mechanics is 14, and the number in combustion is 45. We have more emphasis in applied research recently. The number of projects increases in the period of 1995 and 1996 in materials processing related heat transfer problem, electronic cooling, thermal environmental control engineering (TECE), and engine studies. Due to the promotion of some over sea scholars and local needs, the projects in TECE related air conditioning, compressor, refrigerants, and energy storage has formed four research groups. Similarly, three research groups in engine studies have been organized. The study on micro-scale heat transfer and fluid mechanics has become popular recently. A separate fund is allocated on this topic.

The heat transfer researches in the Thermofluids Division in Energy & Resources Lab., ITRI are carried out by 10 persons including 2 Ph.D. They emphasize the researches on the following areas [4]:

1. Air side performance for heat exchangers,
2. Tube side performance of alternative refrigerants,
3. Computer aided heat exchanger design software,
4. Expansion device,
5. System performance of small air-conditioning units (window/split-type) using alternative refrigerants (R407C & R410A).

HEAT TRANSFER CONFERENCES AND SYMPOSIA IN TAIWAN

There are five conferences held annually that accept the presentation of heat transfer, fluid mechanics, and combustion papers. The first one is the National Conference of Theoretical and Applied Mechanics

organized by the Society of Theoretical and Applied Mechanics. The second one is the National Conference of Mechanical Engineering organized by the Mechanical Engineering Society. The third one is the National Heat Transfer Conference organized by the Thermal-Fluids Engineering Division of Mechanical Engineering Society. The fourth one is the National Conference of Combustion Science, Technology and Application. The last one is the Conference on Computational Fluid Mechanics held by the Aerospace Engineering Society. The first two have been held regularly in Winter, the third is in Summer, and the fourth and the last ones are in Spring. There are about 70 to 100 papers in thermal-fluids engineering in each conference. The conference venue are rotating around the island. The fund expenses of these conferences is partially supported by government and partially donated by industry. Only a small portion is from the registration fee.

PUBLICATIONS IN INTERNATIONAL AND DOMESTIC JOURNALS

One of index to see the performance of researchers is to examine the publications in Journals. Several international journals from 1991 to 1995 in heat transfer, fluid mechanics and combustion have been selected in the present study. Publications by the researchers from USA, Canada, Japan, Korea, and China are also included in the list. USA is selected because it has the largest amount of publications in the world. The reasons for the selections are givens as follows. Canada has about the same population as that in Taiwan. Japan is the most developed oriental country. Korea is the most energetic country in Asia. China is the most populated country and on the opposite side of Taiwan Strait. It is known that quality of the paper is always more important than the numbers. The number of paper merely indicates how hard you work to carry out the research.

Table 3(a) shows the number of papers for ASME Journal of Heat Transfer. The total number of paper in 1991-1995 is 712. Canada, Japan, and Taiwan have about the same amount of quantity. Table 3(b) lists the publication of International Journal of Heat and Mass Transfer. Taiwan has published a large amount of papers in this Journal particular in 1993. A similar performance has been observed in Numerical Heat Transfer as shown in Tables 3(c) and (d).

Table 3(e) depicts the publication in Journal of Fluid Mechanics. Canada and Japan publish more than 13 papers from Taiwan in these years. Table 3(f) shows the publications in the Journal of Fluid Engineering. Taiwan publishes 17 paper in this Journal. Concerning the publications in Combustion, Taiwan has 16 papers in Combustion and Flame as shown in Table 3(g). Japan has 33 papers in this Journal. Table 3(h) shows the paper presented in the International Symposium on Combustion in 1992 and 1994. Japan contributes 33 papers. Only a small amount of papers contributed by Canada, Korea, China and Taiwan.

There are three journals published that accept the papers in thermal fluids engineering. The Journals are Proceedings of National Science Council, Journal of Society of Mechanical Engineering, Journal of Mechanics. The first and the third ones are published quarterly. The second one is published bimonthly.

CONCLUDING REMARKS

The heat transfer researches in Taiwan started in early 1970, only a small number of paper published annually. After 25 year efforts of individuals with the encouragement of NSC, the fruitful results of heat transfer research have been observed. What is left to be done in the future. One has to carry out more meaningful research and improve the quality of publication. To achieve this ends, one has to promote the communication in the international heat transfer societies and the communication with the related industries.

ACKNOWLEDGMENTS

The author would like thank the Heat Transfer Society of Japan for providing the chance for presentation of the paper at the 33rd National Heat Transfer Symposium of Japan. The author also like to thank the Ph.D. student Mr. S.C. Tzeng and the other students in my laboratory for their patience in preparing some of materials for the paper.

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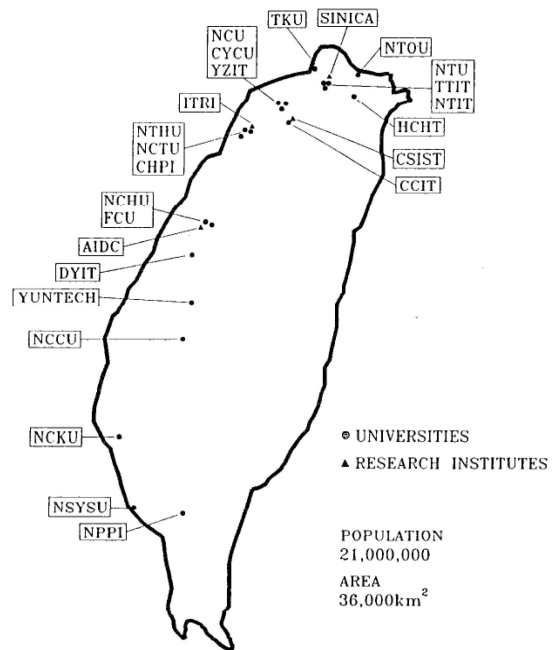


FIG.1 UNIVERSITIES AND RESEARCH INSTITUTES IN TAIWAN

Table 1 GRADUATE PROGRAMMES IN MECHANICAL ENGINEERING

April, 1996

中文校名	英文校名	專任師資	M.Sc.	Ph.D.
國立海洋大學	NTOU	21	38	0
國立臺灣大學	NTU	54	281	104
國立臺灣工業技術學院	NTIT	46	63	46
大同工學院	TTIT	14	57	10
淡江大學	TKU	18	48	0
華梵人文科技學院	HICHT	14	14	0
元智工學院	YZIT	17	76	0
中原大學	CYCU	15	90	18
中正理工學院	CCIT	39	66	22
國立中央大學	NCU	37	209	58
國立清華大學	NTHU	32	169	79
國立交通大學	NCTU	30	166	77
中華工學院	CHPI	15	40	0
國立中興大學	NCHU	24	101	0
逢甲大學	FCU	17	54	0
大葉工學院	DYIT	12	26	0
國立雲林技術學院	YUNTECH	18	40	0
國立中正大學	NCCU	8	61	0
國立成功大學	NCKU	47	206	91
國立中山大學	NSYSU	28	145	47
國立屏東技術學院	NPTI	23	23	0
Total		529	1973	552

Table 2 NSC Funded Research Projects in Thermal Fluids Engineering

Heat Transfer	1995	1996
Materials Processing	15	19
Electronic Cooling	3	11
Heat Exchanger	3	1
Thermal Control	13	32
Computer Software	1	3
Others	6	3
Subtotal	41	69
Fluid Mechanics	1995	1996
Fluid Machinery	4	2
Transportation	1	2
Micro Machinery	—	3
Wind Engineering	1	—
Computer Software	6	4
Others	9	3
Subtotal	21	14
Combustion	1995	1996
Fuel and Combustion	13	14
Engines	20	31
Furnace	9	7
Fire Study	2	1
Others	1	—
Subtotal	45	53
Total	107	136

Table 3 Journal paper publications

1991-1995 美加及東亞四國熱流論文在相關期刊發表情形

(a) ASME Journal of Heat Transfer

YEAR	篇數	USA	Canada	Japan	Korea	China	Taiwan
1991	160	113	5	7	3	2	8
1992	160	120	3	11	0	2	7
1993	162	104	13	6	4	1	6
1994	106	75	6	2	1	2	4
1995	124	83	6	9	2	1	13
總篇數	712	495	33	35	10	8	38
百分比(%)		69.52	4.63	4.92	1.40	1.12	5.34

(b) International Journal of Heat and Mass Transfer

YEAR	篇數	USA	Canada	Japan	Korea	China	Taiwan
1991	256	97	16	15	10	10	18
1992	297	122	11	18	4	5	21
1993	405	149	20	18	15	9	43
1994	314	122	10	20	11	8	32
1995	262	92	7	17	6	6	25
總篇數	1534	582	64	88	46	38	139
百分比(%)		37.94	4.17	5.74	3.00	2.48	9.06

(c) Numerical Heat Transfer Part A: Applications

YEAR	篇數	USA	Canada	Japan	Korea	China	Taiwan
1991	58	29	4	1	0	4	3
1992	52	31	2	2	1	1	5
1993	25	11	2	3	0	0	4
1994	108	66	14	5	3	2	11
1995	76	26	16	5	1	0	12
總篇數	319	163	38	16	5	7	35
百分比(%)		51.09	11.92	5.01	1.56	2.19	10.97

(d) Numerical Heat Transfer Part B: Fundamentals

YEAR	篇數	USA	Canada	Japan	Korea	China	Taiwan
1991	31	17	1	1	0	0	2
1992	34	19	3	1	0	0	1
1993	52	30	4	0	2	1	2
1994	26	17	0	0	3	0	4
1995	53	16	9	1	4	1	8
總篇數	196	99	17	3	9	2	17
百分比(%)		50.51	8.67	1.53	4.59	1.02	8.67

(e) Journal of Fluid Mechanics

YEAR	篇數	USA	Canada	Japan	Korea	China	Taiwan
1991	338	177	9	8	1	3	5
1992	350	188	7	9	1	1	6
1993	347	161	9	7	2	0	0
1994	359	166	11	8	0	3	1
1995	389	174	12	9	1	0	2
總篇數	1783	866	48	41	5	10	14
百分比(%)		48.57	2.68	2.30	0.28	0.56	0.79

(f) Journal of Fluid Engineering

YEAR	篇數	USA	Canada	Japan	Korea	China	Taiwan
1991	98	65	5	6	3	1	1
1992	97	58	5	11	3	0	2
1993	99	64	4	9	2	1	5
1994	97	61	5	10	3	1	4
1995	85	59	4	5	2	0	5
總篇數	476	307	23	41	13	3	17
百分比(%)		64.50	4.83	8.61	2.73	0.63	3.57

(g) Combustion & Flame

YEAR	篇數	USA	Canada	Japan	Korea	China	Taiwan
1991	159	108	3	12	1	0	4
1992	98	62	4	4	0	2	2
1993	127	75	3	8	0	0	2
1994	90	43	1	7	3	0	5
1995	143	87	3	6	0	1	3
總篇數	617	375	14	37	4	3	16
百分比(%)		60.97	2.26	5.99	0.65	0.49	2.59

(h) The International Symposium on Combustion

YEAR	篇數	USA	Canada	Japan	Korea	China	Taiwan
1992	225	119	0	15	0	0	1
1994	328	78	3	18	3	1	2
總篇數	553	197	3	33	3	1	3
百分比(%)		35.62	0.54	5.97	0.54	0.18	0.54