

The Legends of Purdue Heat Transfer

compiled by

Brent W. Webb (PhD 1986)

Professor of Mechanical Engineering

Brigham Young University

In 1935 a young graduate student by the name of George A. Hawkins completed his PhD under the supervision of Professor Harry L. Solberg in the School of Mechanical Engineering at Purdue. Hawkins joined the faculty of Mechanical Engineering that year, and a year later (1936) he was appointed Director of the newly established Heat Transfer Research Laboratory. He was promoted to Full Professor in 1942, and in 1943 was named Westinghouse Research Professor. Hawkins was a visionary academic who nurtured engineering education from art and empiricism to science and analysis. Committed to continual learning, he sought collaboration with the heat transfer “greats” of the day, including McAdams, Boelter, Jakob, and Eckert. George Hawkins gathered around him faculty who shared his vision and drive, and together they established Purdue as a pre-eminent university in heat transfer education and research. As the 70th anniversary of the establishment of “Purdue Heat Transfer” approaches, we pause to look back on that first generation of faculty who formed the Purdue Heat Transfer Group. While their impact on the discipline will largely be characterized here in “the numbers,” let it be said that these early Purdue pioneers of heat transfer have been caring mentors to the students with whom they worked, establishing lasting friendships and providing counsel outside the engineering science for which they became internationally known. Those students who were the beneficiaries of the legacy of Purdue Heat Transfer join in honoring these legendary faculty, and celebrating their influence.

The “founding faculty” of the Purdue Heat Transfer Group are shown in Figure 1 with their years of residence at the university. As may be seen, after a developmental start in the first two and a half decades, a significant body of heat transfer engineers joined the group in the late 50’s and early 60’s. Heat transfer graduate education was in its infancy in those early years, and the pool of qualified faculty in the area was modest. Professor Hawkins and his early colleagues who followed were forced to build a heat transfer corps by training many of the early faculty themselves, building the faculty

expertise with those who studied outside Purdue only as exceptional people surfaced. Among Professor Hawkins’ early graduate students, Y.S. Touloukian and R. Grosh joined the Purdue faculty in the Heat Transfer Group. Professor Touloukian was appointed to an academic position in 1944, and he continued to do research in heat transfer and thermodynamics until, recognizing the critical need for characterization of thermophysical properties in the heat transfer science which was emerging, he started the Thermophysical Properties Research Center in 1957. Professor Richard Grosh joined the faculty in 1953 following his doctoral studies. He shared Hawkins’ vision for strong heat transfer education and research. Three of Professor Grosh’s former PhD students (William Cottingham, Peter McFadden, and Raymond Viskanta) subsequently joined the faculty group. Professor David DeWitt did his doctoral studies under Professor Touloukian, and after two years at the National Bureau of Standards, he returned to join the Purdue group in 1965, affiliated with both the Heat Transfer Group and the Thermophysical Properties Research Center. One of Professor McFadden’s PhD students, Calvin Oliver, was appointed to the faculty in 1963, remaining at Purdue for only three years. These Purdue alumni were joined by colleagues in the early 60’s who had completed their PhD work elsewhere: R.J. Schoenhals, E.R.F. Winter, F.P. Incropera, W. Leidenfrost, and J.T. Pearson. Digital computing began to make inroads in heat transfer research in the late 1970’s, and the Group recognized the need for expertise in this area. Professor Satish Ramadhyani joined the faculty in 1983 to provide strength in computer modeling.

As Figure 1 illustrates, the face of the Purdue Heat Transfer Group has evolved since its establishment in 1936. Many of the first generation of Purdue Heat Transfer faculty left the university, accepting positions of influence and leadership in industry and academia elsewhere. After serving as Chair of the Heat Transfer Group, Head of the School of Mechanical Engineering (1962-66), and Associate Dean and Dean of Engineering at Purdue (1966-71), Richard Grosh was named

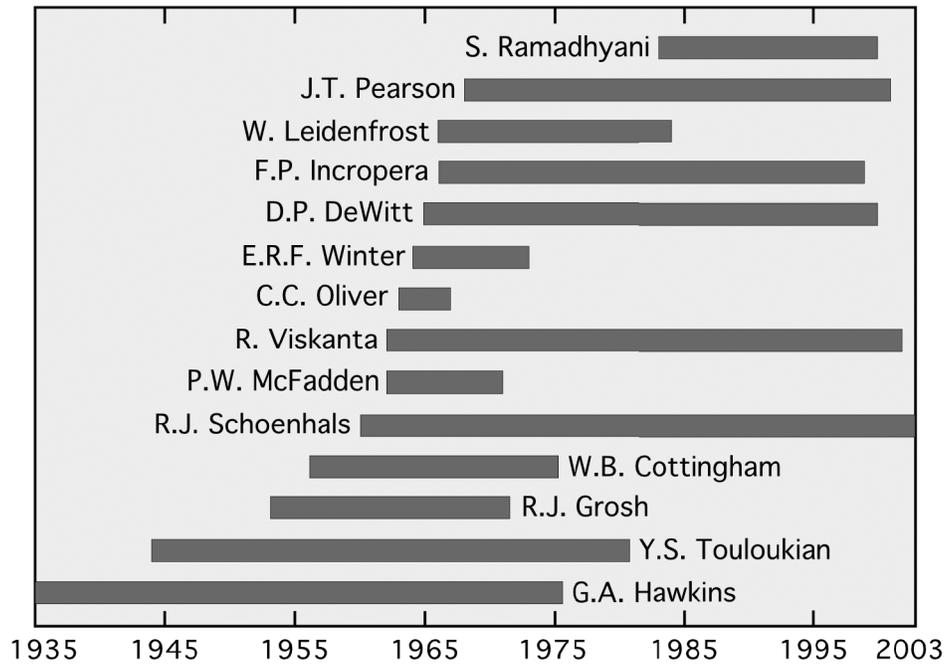


Figure 1. The founding faculty members of the Heat Transfer Group and their years of residence at Purdue.



W.B. Cottingham



D.P. DeWitt



R.J. Grosh



G.A. Hawkins



F.P. Incropera



W. Leidenfrost



P.W. McFadden



J.T. Pearson



S. Ramadhyani



R.J. Schoenhals



Y.S. Touloukian



R. Viskanta



E.R.F. Winter

President of Rensselaer Polytechnic Institute in 1971 at the age of 43. William Cottingham, who led the School of Mechanical Engineering as its Head for four years, became Dean of Academic Affairs at General Motors Institute in 1975, and at age 42, was appointed President of the Institute. Peter McFadden accepted the position as Dean of Engineering at his alma mater, the University of Connecticut. Professor E.R.F. Winter was named Chair of Thermodynamics, Faculty of Mechanical Engineering at the Technical University of Munich in 1973. Professor Frank Incropera served as Chair of the Heat Transfer Group (1976-86), Head of the School of Mechanical Engineering (1989-98), and Assistant Dean of Engineering for Research and Graduate Programs at Purdue before accepting the position of Dean of Engineering at the University of Notre Dame in 1998. A number of others in

that first group also served ably in administrative positions at Purdue. Professor Peter McFadden served as Chair of the Heat Transfer Group from 1962 to 1966, when he took the position as Head of Mechanical Engineering, where he served for five years. David DeWitt was appointed Chair of Heat Transfer in 1986, serving until 2000. He held the position of Deputy Director of the Thermophysical Properties Research Center for a time. The father of Purdue Heat Transfer, George Hawkins' administrative abilities were recognized early at Purdue University. He was the first Chair of the Heat Transfer Group, serving from 1936 to 1953. He was Assistant Dean of the Graduate School where he served as Acting Dean for 15 months (1947-50). Hawkins assumed the position of Dean of Engineering in 1953, serving until 1966, and was also Director of the Engineering Experiment Sta-

tion (1953-61). For the period 1961-63, in addition to his responsibilities as Dean of Engineering, he was Dean of the School of Sciences. In 1967, Professor Hawkins was appointed Vice President for Academic Affairs, a position he held until administrative re-organization when he was designated Vice President Emeritus. He served the engineering education community from 1970-71 as President of the American Society for Engineering Education.

Four of the pioneer faculty in the Heat Transfer Group have been recognized for their influential service in engineering research and education by induction into the National Academy of Engineering. George Hawkins was inducted in 1967, Richard Grosh in 1969 (at the age of 41), Ray Viskanta in 1987, and Frank Incropera in 1996. Arguably the most prestigious recognition accorded engineers, this distinction has been granted to only 174 members of the mechanical engineering community (Source: National Academy of Engineering Web site: www.nae.edu, 2003). They are part of an elite few (only some two dozen) heat transfer engineers in the Academy.

The founding faculty of the Purdue Heat Transfer group have significantly influenced the science of heat transfer. Early work in Professor Hawkins' group was directed at understanding the limits of heat transfer in water at high pressure related to cooling in nuclear reactors. Later, one of Professor Hawkins' hobbies—rifles and pistols—led to his selection to direct another unusual project, U.S. Army Ordnance-supported research on cooling of automatic weapons. His team found ways to improve cooling efficiency and increase firing rate. Stories still circulate on campus about experimental testing of machine guns behind the Mechanical Engineering Building. Over the years, research in the Heat Transfer Group migrated with societal needs to address thermal challenges of timely interest. Looking back, one sees the tremendous contribution to fundamental heat transfer science and application. Their work has been disseminated widely. Figure 2 illustrates the history of publication and presentation for the members of the founding Heat Transfer Group through the year 1995. This year marks loosely the beginning of the “changing of the guard” in the Heat Transfer faculty—retirements of the founding faculty and the hire of a new generation. Figure 2 shows that the rate of publication has grown

steadily from the mid-1950's as the Group grew, their stature in the technical community matured, and research funding blossomed. Graduate students were attracted to Purdue where it was known that high quality research in thermal sciences was performed. The publication activity of the early Purdue pioneers has been phenomenal, totaling well over 1100 peer-reviewed publications of scientific research¹. The vast majority of these publications have been with student co-authors—generally with the students as lead author, reporting results of their thesis research. The publications reported in the figure are only a small part of the story of the dissemination of Purdue scholarly activity. Dozens, perhaps hundreds of presentations—invited lectures, short courses, industrial presentations and consulting—also reflect the Group's reach in the discipline both here and abroad.

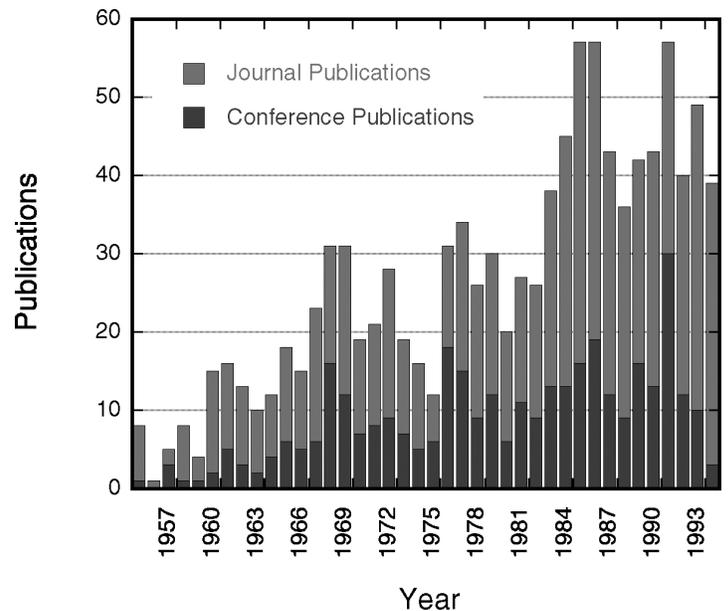


Figure 2. Publication history of the Heat Transfer Group for the years 1955 to 1995.

The Celebration of Purdue Heat Transfer focuses on the founding members of the Group. The data in Figure 2 therefore includes only publications of the original Purdue Heat Transfer faculty identified here. It should be clearly stated that the current generation of faculty is building on the foundation laid by their predecessors.

¹ It should be stated that an accurate accounting of publication from the Heat Transfer Group is rather difficult. The results reported here represent perhaps the minimum, collected from faculty vitae where available. Further, it is noted that while Professors Touloukian and Winter were part of the original Heat Transfer Group and contributed significantly, their works are not included in Fig. 2. As was stated, Professor Touloukian's principal responsibility was the Thermophysical Properties Research Center since 1957, and Professor Winter joined the faculty at the Technical University of Munich in 1973.

² The data reported in Figure 3 were taken from the printed version of Science Citations Index (Institute for Scientific Information, Philadelphia, PA) for the years 1961 through 1979. The printed edition lists citations only of lead-author publications. From 1980 through 2000, the online edition (Science Citations Index Expanded, Institute of Scientific Information Web of Science) was used, which reports citations of publications with both lead and secondary authorship. 1980 is the first year for which the online database was available to the author.

The Heat Transfer Group now includes Professors T.S. Fisher, S.V. Garimella, J.P. Gore, I. Mudawar, J.Y. Murthy, R.J. Schoenhals, L. Xu, and X. Xu, and their work continues to significantly impact the discipline.

One quantifiable measure of the impact of Purdue's founding Heat Transfer Group research is the number of citations of their work by colleagues in the technical community. The history of such citations for the founding members of the Purdue Heat Transfer, in five-year blocks, is illustrated in Figure 3, from 1960 to 2000². The work of Purdue faculty has been cited even from the early days of heat transfer research. The number of citations has risen steadily, and to date (February, 2003), a total over 7000 references of published work of the founding Heat Transfer Group have been identified. In just over two years since January 2001, the Group's work has been referenced nearly 1300 times.

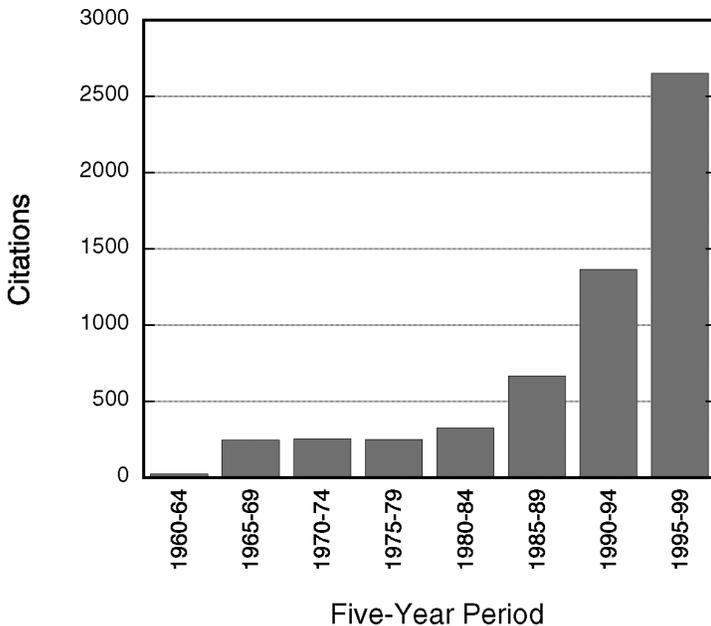


Figure 3. Citations of Purdue Heat Transfer faculty publications by five-year period, 1960-2000.

Some of technical publications of the founding Purdue Heat Transfer faculty might be considered "classical" works, having been referenced many times. Fifty-one publications of eight different faculty members in the Group have been cited thirty or more times since 1979. Twelve faculty publications have been cited sixty or more times; four have been cited more than 100 times (Source: ISI Web of Science, Science Citations Index Expanded, 2003). Professors Incropera and Viskanta were recognized by the Institute for Scientific Information for being among the one hundred most-cited researchers in engineering worldwide (source: ISI HighlyCited.com). The premier heat transfer textbook in the field, *Fundamentals of Heat and Mass Transfer*, co-authored by two Purdue Heat Transfer faculty, Professors Frank Incropera and David DeWitt, is yet another illus-

tration of the Group's influence on heat transfer education. The text has been adopted at over 200 universities in the United States and has been translated into five languages for use abroad. Since its first publication in 1981, it has appeared in five editions (1981, 85, 90, 96, and 2002), and has been read by more than 300,000 students. In addition to its pre-eminence in undergraduate heat transfer education, the text has become something of a reference for heat transfer research. Its five editions have been cited over 1900 times in technical publications worldwide (Source: ISI Web of Science, Science Citations Index Expanded, 2003).

In addition to the impressive quantity of citations of Purdue Heat Transfer technical publications, several of the early works from the faculty stand even today as foundation additions to the literature. Two of Professor Hawkins' publications on steam properties were cited twice since 2000, nearly seventy years after their publication. Two of Professor Groh's early published works from the 1950's on heat transfer in welding processes have been cited regularly since their publication, most recently in 2001. Professor McFadden's early research on boiling heat transfer in 1961-62 was cited ten times between 1995 and 2000. These are just three such examples illustrating the enduring impact of quality research from the Heat Transfer Laboratory on the discipline.

The measurable influence of Purdue's legendary Heat Transfer Group has been documented in the foregoing paragraphs. However, it might be argued that the primary product of the faculty has not been the papers, but the people—graduate students, post-doctoral fellows, and visiting scholars with whom they have worked. Figure 4 shows the history of heat transfer student supervision since 1941, mentored by first-generation Purdue Heat Transfer faculty. The numbers are impres-

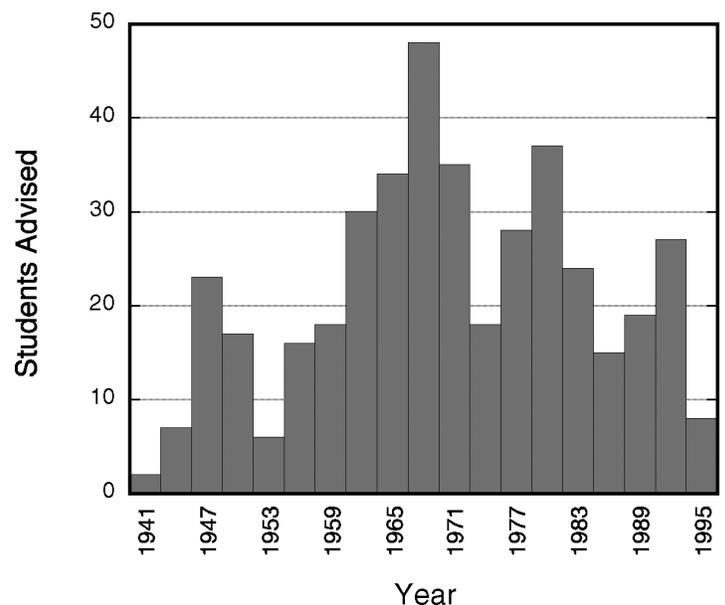


Figure 4. Student advisement in the Heat Transfer Group by year.

sive, with nearly 600 students—some 250 MS students, 200 PhD students, and 70 post-doctoral and visiting scholars—having completed their studies through 1995. These students have carried the Purdue legacy into positions in academia, industry, business, sharing the heritage of training in careful thought, meticulous research, and concise writing wherever they are. It should not be inferred from Figure 4 that graduate advisement in the Heat Transfer area is “winding down.” As the founding faculty in the Group have retired or taken positions elsewhere, they have passed the opportunity and responsibility of student advisement on to the current generation of Heat Transfer faculty. There are currently some fifty students and visiting scholars are pursuing work in the Group.

The worldwide influence of Purdue Heat Transfer alumni is illustrated in Figure 5, where shaded (dark) are the 35 different countries with which alumni have ties (either countries of origin or of current residence). Truly, the influence of Purdue Heat Transfer has been global, spanning North and South America, India, China, Australia, Russia, Western Europe, and Africa. Students have come to Purdue to be educated from Africa, where engineering education is yet immature, to Western Europe, which itself has a rich history of strong engineering training.

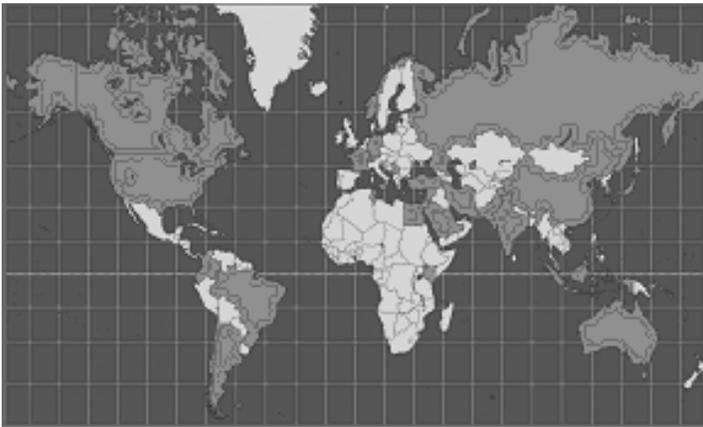


Figure 5. Countries (shaded dark) to which Purdue Heat Transfer alumni have ties (i.e., countries of origin or of current residence).

Finally, it should be said that from its inception the faculty in the Purdue Heat Transfer Group have been deeply concerned with their students. Former Dean of the Schools of Engineering John Hancock wrote of George Hawkins:

George Hawkins' leadership in engineering education at both the national and local levels has been well recognized. He has made many outstanding contributions to engineering education during his tenure at Purdue. While George Hawkins is a talented, innovative individual, I feel that much of his success can be directly attributed to the concern and understanding which he has of people. I feel that it is rare indeed to find a man who is just as concerned about a faculty member's health or his family problems as he is about his professional growth and his contributions to Purdue. From my own experience I know that George Hawkins is a humanitarian and Purdue University is richer to day as a result of his leadership in all phases of its life.

The same can be said of Professor Hawkins' colleagues in that group of founding faculty. Discussions with students went beyond technical issues in their work. Their interest was in the development of total, balanced leaders. They did so with the support of their families, who often entertained students in their homes, and who were supportive of long hours in the office and laboratory. On the eve of the 70th anniversary of Purdue Heat Transfer, the alumni honor their faculty mentors, celebrate their achievements, and appreciate their friendship and influence in their lives.