

Two Decades of Dedicated Contributions of Professor Mujumdar to the Development of Drying R&D in China

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Abstract

This short article will briefly review the continuous contributions as well as the impact Professor Arun S. Mujumdar has made to the development of drying R&D in China over the last 20 years. This summary is prepared as a record of his dedicated service for archival purposes.

Introduction

Professor Mujumdar has paid a total of six visits to China since his first visit to Tianjin University of Science and Technology (previously known as Tianjin Institute of Light Industry), Tianjin, China in 1984. He has traveled widely in China from the north to the south, from the east to the west and gave lectures and seminars at many universities and industries in China. He has constantly been keeping close contact with several universities on different research areas of drying and heat transfer following his second visit to China in 1986. Several major events in the drying R&D have taken place over the last 20 years in China including the publication of the first Handbook of Modern Industrial Drying, the 13th International Drying Symposium held in August 2002 in Beijing, the publication of a special issue of Drying Technology—An International Journal (No.9, Vol. 17, 1999) dedicated to China's National Drying Conference, etc. All these major events would not have been possible without his dedicated effort to actively support the development of drying R&D in China.

This article will go briefly and chronologically through the major activities Professor Mujumdar has devoted himself to for encouraging and assisting in drying R&D in China starting from his first visit in 1984. It also summarizes a successful model for academic cooperation and networking that could be applied by others in other fields as well.

The Starting Point

During his first visit, Professor Mujumdar met with President Yanquan Long of Tianjin University of Science and Technology, a top pulp and paper expert in China. They had met earlier very briefly at an international conference. He was invited by President Long to give lectures at his university due to the institute's research interests in paper drying. This invitation has gone much beyond the initial purpose and led to some unexpected but highly significant impact on drying R&D activities in China, which probably involve more people than anywhere else in the world. Only Brazil has recently come up to a similar level of activity in the past decade based on their contributions to IDS conferences. Interestingly, Professor Mujumdar has also been pro-active in supporting drying effort in many universities in Brazil over the past two decades.

Professor Mujumdar paid his first visit to China in 1984 responding to President Long's invitation. He spent four days giving lectures on paper drying as well as other aspects of drying in various industries and on various types of dryers. He also presented the latest R&D of drying and many other drying topics including vibrated fluidized bed drying. Many industrial engineers and university professors from around China attended his lectures. His lectures led to the initiation of vibrated fluid bed drying research of Professor Yongkang Pan's group in Mechanical Engineering Department of the university and later resulted in three master theses projects and many publications in national and international journals and conferences on the effects on quality, effects of intermittent heating, etc. of vibrated fluidized bed drying. The drying research is still one of the major research areas in the Mechanical Engineering Department of the university. Also influenced by his lectures, a number of dryer manufacturers specializing in such equipment emerged in China after 1984. Such dryers are of special interest to China owing to the size and shape of many food products that need to be dried in China. Professor Mujumdar's own research in this field allowed him to give detailed information for design purposes which hastened the commercialization of such technologies in China. His lecture notes in English were translated into Chinese and made available to all participants.

In early 1980's Professor Mujumdar was also the first to receive a Chinese Visiting Scholar, Mr. W. Cui at McGill in Faculty of Engineering. Mr. Cui worked on Professor Mujumdar's novel idea of using superheated steam for drying paper. This work was not only published in English but also in Chinese. Mr. Cui later returned to China after 3 years in his group and obtained a patent on that drying concept.

Impact of the Second Trip

Two years later Professor Mujumdar was once again invited to visit Tianjin University of Science and Technology in 1986. On this trip he brought with him a big baggage of the drying books and journal issues he edited including Handbook of Industrial Drying, Drying of Solids, Drying'82, Drying'84, Advances of Drying series and many more and donated these books to the university. Due to his donation of his books this time and some later times Tianjin University of Science and Technology has probably the most complete collection of all his drying books-only McGill has the other one also donated by him.

During this visit he met with President Guoxiong Yao. He again gave a series of lectures on drying. The lecture series lasted 7 days (including Saturday and Sunday) with 3 hours each morning. The lectures were interpreted into Chinese mainly by Professor Yi-Fei Zhang--not a simple task! About 100 people (engineers, professors, lecturers, postgraduate students) from academia and industry around China attended the lecture series (including Ph.D. and master candidates from Dalian Institute of Technology, engineers and scientists from Tianjin Paper Making Research Institute, engineers from Tianjin Paper Making Factory and Tianjin Fourth Paper Making Factory, etc.). At that time I was in my first year of my master's program. I attended all the lectures. Topics of the lecture series covered almost all aspects of drying technology from the fundamental drying theories to the latest research developments, from spray drying to fluid bed to rotary drying, from fluidized bed dryers to Yankee dryers, from superheated steam drying, to through drying and of high porous sheets.

Many other postgraduate students from Mechanical Engineering and Chemical Engineering departments also attended most of his lectures. I still remember one of the postgraduate students, Yujun Liu (later got his Ph.D. from University of South Carolina and now working in Dow Chemical Company, USA) said to me "Professor Mujumdar is so handsome and looks just like a movie star".

Many of his lecture notes and articles were translated into Chinese and used extensively in subsequent years. Some of his lecture notes in Chinese were even available in Taiwan many years later.

In addition to the lecture series, Professor Yi-Fei Zhang and Professor Yongkang Pan went through quite some intensive discussions about the collaboration on both experimental and numerical work that could be done with minimal resources at the university. Three major research projects were initiated at that time. They were (1) Modeling refractory material drying, (2) Cyclic melting/freezing phase change heat transfer and (3) Vibrated fluidized bed drying. Professor Zhang and I started in early 1988 the refractory drying project which led to one master's thesis and a couple of joint papers published in English and another one in Chinese before I left for McGill University to pursue my Ph.D. in early 1993 under Professor Mujumdar's direction. After I went to McGill Professor Mujumdar and I jointly published another seven papers in several different journals and two conference presentations on this projects from 1993 to 1997. This project attracted considerable interest from Professor Robert Moore from Ceramic Engineering Department, University of Missouri at Rolla as well as from the American Ceramic Society during 1992 to 1997. Professor Zhang and I also started the cyclic melting/freezing simulation project in mid 1988. This project led to one master's thesis and one joint paper in an international conference before I went to McGill. It was extended during my Ph.D. program and became part of my Ph.D. thesis. We jointly published another six papers in several international journals, one conference paper and one conference presentation for this project from 1993 to 1997.

After his 7-day lecture series and research discussions he also visited and gave lectures at Beijing Institute of Chemical Technology in Beijing, Northwestern Institute of Light Industry in Xianyang, Shanxi, East China Institute of Chemical Technology and Huayuan Drying Inc. in Shanghai, as well as Zhejiang Silk Engineering Institute and the famous Longjing Tee Factory and Farm in Hongzhou.

During this long trip he met with many professors and engineers and proposed many new ideas to them. Take one, for example, he suggested a novel two-stage drying process, using superheated steam, of silk cocoons to Prof Chen in Zhejiang Silk Engineering Institute. The idea was later proved to work very well. The silk was brighter and stronger with less loss. Conventional method leads to major loss and damage to silk quality. This work was published in *Drying Technology—An International Journal* in 1989. We hope this idea was pursued further as it certainly had great potential for China as well as many silk producing countries. He also proposed evaluation of the idea of using low pressure superheated steam to dry other agro-products like vegetables, fruits, sea

foods, tea, tobacco leaves etc. using different types of dryers such as conveyor, flash or fluid bed types. Indeed, many of these ideas have since been tested by many researchers around the world, and applications are being found widely. In fact, the concept was proposed almost two decades ago in his lectures in China.

Before 1986 drying research in China was spotty and scattered. Due to the influence of his lectures, a group of university professors and industrial engineers in China started thinking about initiating their first National Drying Conference. One year after his second visit, China had its first National Drying Conference in 1987. This biennial series of conferences have been going on successfully even now. The next meeting is scheduled in October 2005 at Nanjing. Professor Mujumdar was invited to give keynote lectures at many of them but the distance to Canada and the time required did not permit him to attend them. However, his message did reach the audience through translated papers that were presented by Chinese colleagues on his behalf.

Since his second visit he has been keeping close contact with several research groups in China, such as in Tianjin University of Science and Technology and in Zhejiang Silk Engineering Institute. He was first invited as an adjunct professor of Mechanical Engineering Department of Tianjin University of Science and Technology in 1987. At a later time he was bestowed an honorary professorship of the university in 1988, which was the highest honor the University could present on an overseas professor.

A Long Delayed Third Trip

His third visit to China came after a long time. Since his second visit was so fruitful to several organizations and universities, Tianjin University of Science and Technology and Tieling Precision Engineering Co., strongly hoped to further extend the collaboration with him and further benefit from his lectures, expertise and ideas. He was invited several times to revisit Tianjin University of Science and Technology in 1988, 1990 and 1992 after IDS'92. Due to his busy schedule he could not make these trips. However, he continued to keep close contact with several different research groups in China, which led to numerous fruitful results.

During this period he accepted and supported Professor Pan as a Visiting Scholar in his research group in McGill University in 1988-89, working on drying of impinging sprays by impingement of heated surfaces. This work was later continued at Tianjin University of Science and Technology and obtained the support of China's National Science Foundation after Professor Pan went

back to China. This project also produced a couple of master theses and several papers on studies of the effects of vacuum, etc.

Interestingly, Professor Mujumdar's group at McGill had always been very international with researchers and students from all corners of the globe. Professor Pan got the unique opportunity to interact with many international researchers, which led to further cooperation projects for his university. For example, Dr. T. Kudra shared the office with Professor Pan and they mutually developed additional cooperative projects with Lodz Technical University in Poland as well. Also, many Chinese students whom Professor Mujumdar could not accommodate in his group at McGill were re-directed to his international contacts, especially in Japan's Nagoya University.

In 1991 he also accepted another Chinese visiting scholar, Professor M. Zhang, who later became the vice president of East China Institute of Chemical Technology (now known as East China University of Chemical Technology), working on finite element analysis of the stress field generated by drying of grains subjected to microwave and convection, drying of coated papers, etc. Their work on finite element analysis of intermittent volumetric heating is still widely cited after nearly 12 years of publication. It clearly showed that intermittent heating can reduce drying-induced stress-cracking. This is verified by others in later years.

In 1995 he finally managed to find the time for his third trip to China, hosted by Tieling Precision Engineering Co., to chair a special drying symposium where he gave a plenary report on the latest research development and trend on drying in the world. Most of the Chinese drying experts from universities as well as industry attended this symposium. Very good response was received on his report, as Professor Cao of Beijing Agricultural Engineering University recalls. It may be noted that Professor Mujumdar now has a Ph.D. student at NUS who comes from Professor Cao's laboratory now headed by his student.

During his short stay he helped to initiate the formulation and editing of the first Handbook of Modern Industrial Drying Technology with Professor Pan (Tianjin University of Science and Technology) and Professor Wang (Dalian University of Technology).

He also met and discussed in Beijing with Professor Chengji Xiao, the chairman of Chinese Chemical Engineering Association, and Professor Cao, about planning an International Drying Symposium (IDS) in China. That is where the seeds of IDS'02 were first sown.

On this trip he also gave lectures to East China Institute of Chemical Technology, where he accepted the honorary professorship, and to also Wuxi Spray Drying Co. in Wuxi. Indeed, the main office of the Wuxi Spay Drying Co. has a number of photos from his visits to their facility, which Professor Mujumdar always remembers with great fondness. This trip concluded with a sightseeing trip to beautiful Guilin, famous for its wonderful mountains and cruise in Li River. He always mentions the kind hospitality and great food he and his wife always enjoyed on their China visits. No wonder, it is now a favorite destination for him and Mrs. Purnima Mujumdar!

IDS' 2002

The 13th International Drying Symposium (IDS'02) was held in Beijing in August 2002 with some 250 participants from about 50 countries. It was the first time the IDS was held in China and it was a big success.

As is recalled by Professor Cao, the chairman of IDS'2002, Professor Mujumdar gave the committee much valuable guidance in organizing this IDS, including selecting keynote papers, organizing papers into sessions and posters, suggesting awards, distributing announcements worldwide and many others. Without his devotion IDS'2002 could not have been held in China with the high level of success actually achieved.

At this IDS he was bestowed an Award for Outstanding Contribution to Drying Technology in China from the Organizing Committee of the 13th International Drying Symposium. It is noteworthy that Professor Mujumdar's Practical Guide to Industrial Drying was translated into Chinese and this edition was inaugurated at the time of IDS'2002 in Beijing.

A number of his papers have been translated and published in Chinese journals. It is very common to find citations to his Chinese language papers in numerous papers. His keynote overviews dealing with new and emerging areas such as vibrated beds, spouted beds, superheated steam drying, impinging steam drying, pulse combustion drying etc. have attracted many researchers at several Chinese universities to work in these areas. Professor Mujumdar recounts his collaborations in China as true success stories and likes to credit this success to his hosts in China for their unique level of enthusiasm, hard work and willingness to learn new things at all time.

Professor Mujumdar's effort has led to true globalization of Chinese effort in drying R&D just as it has perhaps in 50 different countries and hundreds of institutions around the world. His book, Practical Guide to Industrial Drying, itself is a distillate of the latest information and knowledge about various drying processes, equipment as well as new developments and emerging technologies. It is always hard to assess the real impact of his effort but it is easy to see that it must be considerable as drying occurs in all industries and consumes anywhere from 10-20 percent of national industrial energy consumption aside from affecting product quality and value. As the standard of living rises in China it will certainly consume more fossil fuel resources so every attempt to reduce energy consumption goes a long way on the environmental front as well. With cost of oil at nearly US\$55 a barrel at the time of writing this article, there is no doubt that drying will continue to be an area in need of research in most countries around the world. Burning fossil fuels has adverse effect on climate change. Hence it is necessary to reduce energy consumption in drying operations by effective R&D to develop appropriate technologies.

Consistent and Continuous Dedicated Effort

More recently, Professor Mujumdar was invited by the President of Southern Yangtze University in Wuxi to present lectures in their Food Engineering Department and, therefore, visited China twice in 2002 and in 2003. He co-directed with Professor Min Zhang two Ph.D. theses in vacuum frying and hybrid hot air and freeze drying. He also visited and gave a seminar at Nanjing Normal University in 2003.

Currently he has a joint project with China Agricultural University in Beijing in pulse combustion drying with the simulations done at NUS and some experiments being done in Beijing. Recently he teamed up with a Professor at Dalian University of Technology to write a review on drying of nano-particles. It is noteworthy that 6 of his current 9 Ph.D. students at NUS come from top universities in China. He talks very highly about their academic credentials, abilities, willingness to work hard and eagerness to learn. Many have already published numerous archival papers with him despite the short stay at NUS.

He is also closely involved in the second edition of Handbook of Modern Drying Technology which will be published in 2005 although this book is in Chinese. He recently sent two new chapters for this book.

Honors and Impact

As a result of the significant contributions Professor Mujumdar has made to institutions in China, he has been accorded Honorary Professorships from the following universities in China:

1. Tianjin University of Science and Technology, 1988
2. East China University of Chemical Technology in 1992.
3. Zhejiang Silk Engineering Institute, Hangzhou in 1992.
4. Zhejiang University of Technology in 1994
5. Jiangsu University of Science and Technology in 1996.
6. Southern Yangtze University, Wuxi, 2003

Obviously it is not an easy task to estimate quantitatively the impact and contributions Professor Mujumdar has made to drying R&D not only in China but also around the world. The following two stories might be able to shed some insight about the difficulties involved in making a true assessment.

The President of Tieling Precision Engineering Co, Mr. Zhenhua Chen said during his visit to Montreal in 1993, “The success of his company came from a motivation by Professor Mujumdar’s lecture in 1984 in Tianjin on the topic of vibrated fluidized beds. His lecture on vibrated fluidized bed led to over 2000 vibrated bed dryers being built and sold by his company alone. This is one of the reasons that his company was named the most successful company by Tieling City for several years in the late 1980 and early in 1990”. This is indeed a very major impact of an academic research project of Professor Mujumdar. Indeed, Professor Mujumdar also talks highly about the effectiveness of his collaborations with Chinese institutions, which were always very friendly, hospitable and receptive to new ideas and willing to work hard for their success. He felt that the time and effort he devoted to networking with researchers in China were most productive.

Another story is from the 95th Annual Meeting & Convention of the Canadian Ceramic Society held in Montreal in 1997. After I finished my presentation on “Modelling Drying of Ceramic Refractories: Principles, Applications and Potential Role in Practice”, Dr. Polin from a refractory material company in UK came to and told me that he is very grateful to Professor Mujumdar for his suggestions of using superheated steam to dry prefabricated refractory parts. He told me that Professor Mujumdar’s idea both greatly improves the quality of the dried parts but also significantly decreases the energy consumption compared with conventional drying method. This has made their products successful. When I came back and mentioned this story to Professor Mujumdar he could not even remember where and when giving this idea to whom simply because of the sheer number of people, academics and industry personal he deals with on a regular basis.

Closing Remarks

This is a short story spanning two decades. Obviously many details are lost but the overall picture that emerges is clear: Professor Mujumdar has made every effort to make a positive, sustained and lasting contribution in the field of drying in China and elsewhere. At a time when buzz word research is easy to fund and attract students to, he worked hard and managed to develop a critical mass of serious researchers around the globe that works effectively on drying R&D. He thinks that there is no real need to expand this mass of researchers but only to sustain it with higher quality newcomers who need challenging problems that are worthwhile. He thinks that overpopulation of researchers, like kangaroos in some parts of Australia, in any specific area can lead to self-destruction due to lack of adequate resources and lack of “gene” variety. Every field has its own “sustainable” level of funding and researcher population. He believes that drying has reached a sustainable level with no urgent requirement to expand but certainly a need to maintain its critical mass and quality. For developing countries drying is of strategic importance. We hope that the large base of drying researchers in China will continue the lead and make innovative contributions to drying globally. Professor Mujumdar also is a proponent of active industry-university collaboration. This has occurred in China in the drying field and hence speeded its development.

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