Summary of Dialogue with Prof. Arun S. Mujumdar

(IV Edition)

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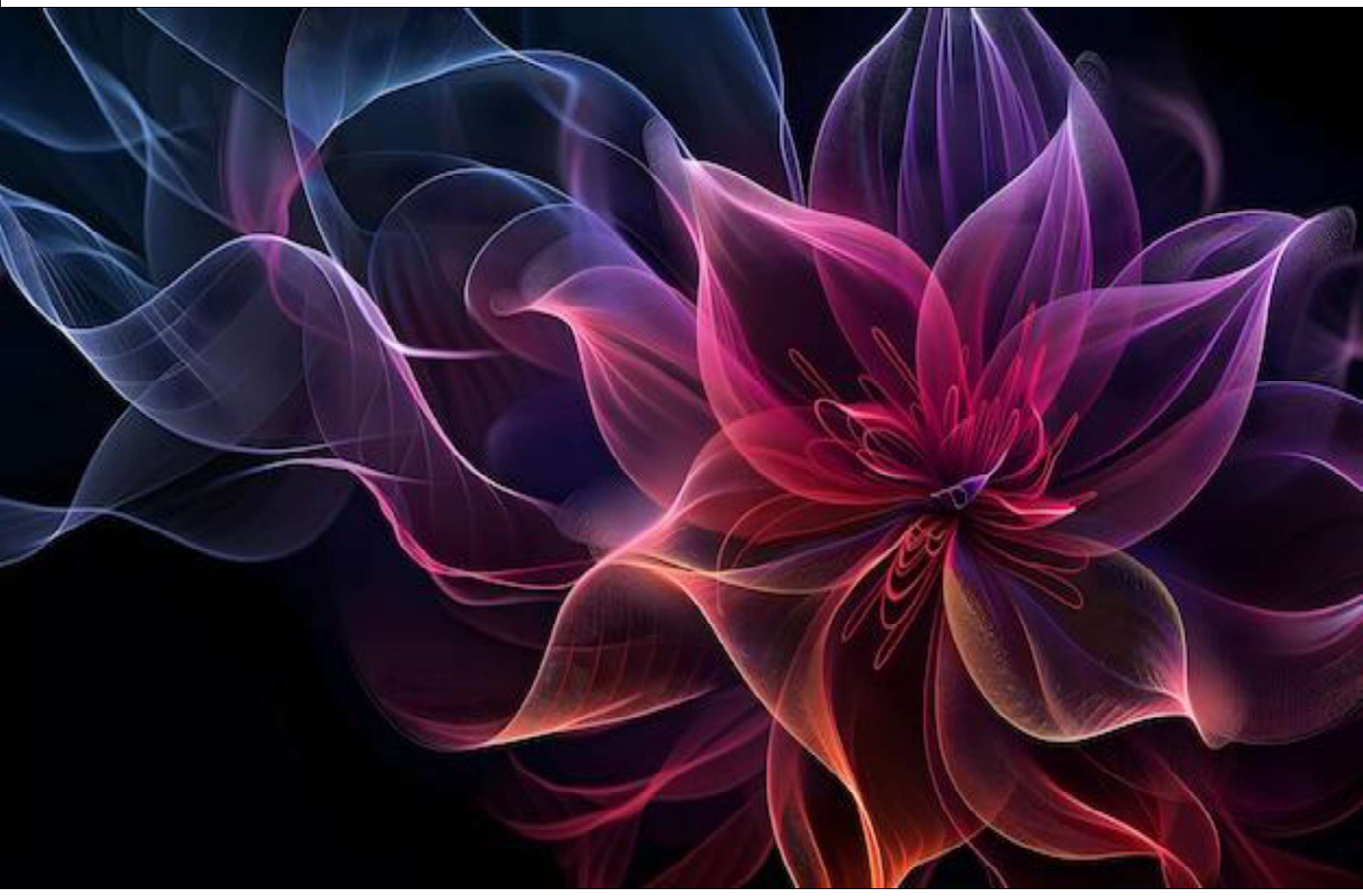

Preface

This IV edition of eBook “Summary of Dialogue with Prof. Arun S. Mujumdar” consists of frank, informal dialogs with Prof. Mujumdar covering a very broad range of topics from education and research to the publication of archival research. It includes his thoughts on research culture, innovation, academia-industry interaction, and international networking for the exchange of the latest knowledge, along with a multitude of topics relevant to both young students and researchers and seasoned veterans of academia and industry.

Professor Mujumdar’s five-plus decades of experience in interdisciplinary international networking and innovation give this compilation a unique value for the reader. Ideas expressed here will help enhance productivity while maintaining ethical and even spiritual considerations.

We fervently hope that this free eBook will be widely distributed and read by students, faculty, as well as policymakers in government and businesses. As always, we welcome feedback to enhance the utility of future eBooks.

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August 2025

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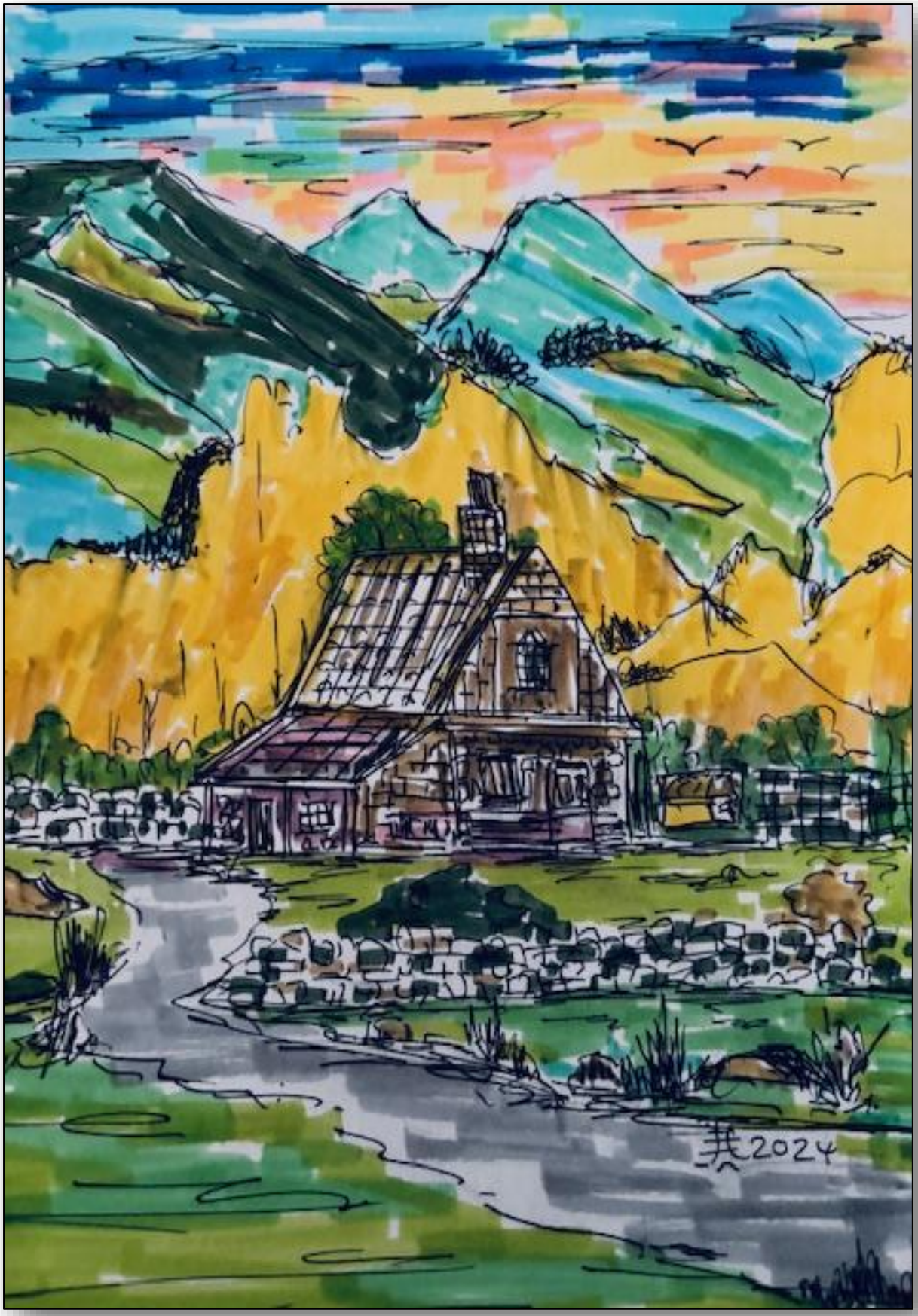
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Section-I

Research Cooperation and Publication Ethics

The following is a summary of a dialogue sessions held by Dr. Shivanand S. Shirkole, Dr. Sachin V. Jangam, and Dr. Aparupa Pani with Prof. Arun S. Mujumdar, with the express purpose of compiling as concisely as possible, without losing the essential detail of his responses that may be helpful to the younger readers of this eBook. Some of the points made are explained in greater detail elsewhere in this eBook.

We hope that this innovative format will trigger introspection among readers and possibly give some new ideas and new avenues for critical thinking for planning their professional careers.

- Dr. Shivanand S. Shirkole
- Dr. Sachin V. Jangam
- Dr. Aparupa Pani

Q. How can we enhance research culture?

Ans: With great effort and perseverance! You will readily notice that the well-known research-intensive universities perform at a superior level in research, teaching as well as service. Typically, they are mature institutions with a strong record of faculty members who, in turn mentor talented young students/ researchers to enhance both depth and breadth in areas of their research or discipline. It is important to aim high and benchmark their performance against similar institutions nationally and internationally. It is not easy to give a to-do list for this. One must strive to excel over long periods of time to achieve recognition.

Q. Any comments on publication policies in academia?

Ans: In the old days, we worried about the "publish or perish" policy of academia. In recent decades, the focus has been on many numerical assessments of the quality of publications. Measuring a subjective judgment quantitatively has its limitations. The focus on various metrics has led to a proliferation of for-profit journals with a rather simplified review process affecting quality. Indeed, more recently, we have seen an increase in the number of retracted papers and even the closing down of numerous open-access journals. I term this as a "publish and perish" situation for such journals.

I think academia needs to give clear statements concerning their vision and mission, and implement policies that match them. No hard and fast advice can be given on this theme.

Q. What can India do to enhance R and D quality and extent?

Ans: China spends an order of magnitude more on higher education and R&D, which is reflected in the five-fold GDP per capita they now have. When I first visited China, the GDP

levels were about the same for both countries. It is important for governments and academia to enhance support several-fold to make a real impact on the national economic performance. Focusing on excellence is necessary. There is no shortage of talent in India.

Q. Is it important to disseminate the research outcomes promptly?

Ans: Research outcomes are valuable if original and have a strategic impact. They also decay in value with time, as their value is transient. If not published after peer review, it is likely that it will be repeated elsewhere and may even be published. If published promptly, it can stimulate further advances by others as well.

Typically, granting agencies want to see if the researchers they fund succeed in their proposed projects. This gives added impetus to prompt publication of useful new outcomes.

Q. What are the big long-term problems that engineers and scientists need to tackle now?

Ans: Food insecurity and climate change are perhaps the most critical issues faced by the globe. One could write a book just listing the R&D problems in need of solution. It is impossible to list them here. Suffice it to say that effort in all fields of research, from the humanities to science and technology, is required to tackle the formidable challenges involved. Furthermore, the research needs to be innovative, interdisciplinary, and international in scope.

Q. What do you think? Will AI impact the most in the next decade or two?

Ans: Certainly, AI will play a critical role in all areas of human activities. It can be extremely valuable if employed ethically by all parties. There is danger in its unethical and indiscriminate use. In the short run, AI-based applications are likely to result in more unemployment in many fields. It will be difficult to control its proliferation and use for undesirable motives. It can also threaten global peace if used unchecked. Certainly, it can be useful in teaching, learning, research, and even processing routine work cost-effectively. There is already a massive amount of serious literature on the pros and cons of AI applications.

Q. Is open-access publication a better way to disseminate research results?

Ans: Open access is becoming popular, and granting agencies are supporting this idea these days. Ease of access to readers will enhance research outcomes from around the world. Publishing is an expensive operation. The voluntary contribution of time and expertise by editors and reviewers is key to the current success of all journals.

Q. Why do technoeconomics and not technology alone drive industrial innovation?

Ans: Industries and businesses are for-profit institutions. Naturally, techno-economics overrides innovations in technology. Superheated steam drying of paper using impinging jets is a highly efficient process, but after a huge R and D effort, it is found to be not competitive with traditional paper drying technology. So, no one is using this novel idea in practice.

Q. Can you identify some research areas that are still in need of further exploration?

Ans: There are literally infinite areas of research that need to be pursued strategically for the benefit of humanity. An effort is needed to cost-effectively enhance food security and safety, in all areas of health care, lowering carbon and water footprints of all processes, and attempting to alleviate climate change, which may turn out to be the most critical issue affecting the survival of the human species.

Q. Can you summarize your personal experience with international research cooperation? Was it more fruitful with certain countries? If so, why?

Ans: More than half of my research output has resulted from international collaboration with over 15 countries over the last five decades. My research lifetime has been nearly six decades! I was able to carry out truly interdisciplinary research thanks to talented researchers from over ten different disciplines. Useful research in drying can be carried out only in an interdisciplinary fashion. Such collaboration leads to greater innovation synergistically. I recommend it very highly, especially to faculty members and researchers, as it is also more cost-effective.

Q. How can one develop fruitful international interdisciplinary cooperation?

Ans: It is quite easy these days to develop international linkages. I had my long-term collaborations thanks to the numerous international conferences I organized and the multitude of books I edited. Personal contact and discussions are important, of course. Conferences are a good way to develop a network of collaborators.

Q. How can junior researchers achieve international visibility, which is necessary for professional advancement?

Ans: It is necessary to publish impactful research and develop an effective network to become visible to the research community. Keeping up weekly, if not daily, with research publications

in your own area as well as allied areas is very important but often neglected. The rapid pace of knowledge generated these days makes it a huge but crucial task.

Q. As R and D funding is scarce, particularly for junior researchers and faculty members, can you suggest possible avenues to carry on publishable research and establish oneself?

Ans: Junior researchers may need to form small teams and also seek industry support for projects of mutual interest. Issues in IP rights are making joint public-private research collaboration difficult these days.

Q. What are the key criteria for selecting international partner institutions or research groups for long-term collaboration?

Ans: The criteria to be used are obvious. Both parties need to be on the same wavelength in terms of mission, objectives, and scope. The level of contribution to the project should be comparable but not be a duplication. It is more fruitful if it is interdisciplinary too. Both parties must agree on the publication strategy and IP rights policies as well.

Q. What regulatory and compliance considerations should be taken into account when planning international exchange activities?

Ans: The preceding response also applies here.

Q. What is your opinion on successful academia-industry collaborations and the commercialization of mutual innovations?

Ans: Once again preceding points are relevant. Although I consulted for over 70 companies and did work on publishable research, it was considered proprietary and hence never published. This can be a major roadblock for young researchers.

Q. Your suggestions on India's research publication "How can the transition from solely publishing research articles to implementing the ideas presented in those publications be enhanced?"

Ans: This is a difficult question as the solution depends on too many policy issues of industry and academic institutions involved. Personally, I found this to be a formidable problem. I do not have a good general prescription for handling this issue.

Q. Is there an effective mantra for highly productive research and development in any field?

Ans: I think the most effective R&D depends on teamwork coupled with selfless leadership and relentless pursuit of common goals for the betterment of society. One needs to think globally but act locally. There is no substitute for perseverance and inclusive innovation. If one examines clearly how countries like Japan and China developed in a matter of a few decades, it is clear that highly focused leadership and effective participation by all stakeholders have been the key to success. Other nations can and should learn from these models for national-level development. Prioritizing infrastructure and education from the primary level to the postgraduate level, along with intensive R&D, has, in my opinion have been the foundation of the progress made by these countries. One cannot build a superstructure on a weak foundation.

Q. As you have just completed eight decades with over five decades dedicated to higher education and research, any thoughts on what more do you wish to accomplish in the coming years?

Ans: It has been a long journey in academia, coupled with close industrial interactions in diverse fields. Although most people associate me with drying R&D, at least forty percent of my publications are in other areas of transport phenomena. As an engineer, I like research directed at medium to long-range industrial applications based on science. I haven't had the luxury of conducting blue sky research. As a junior academic at McGill, I had the vision that enhanced drying technologies are central to most manufacturing sectors and further that this operation is highly energy intensive, with a definitive effect on product quality. Food security depends on drying, without which seasonal harvests cannot be preserved to last over the year. Still, I was surprised that no one in the developed Western world paid attention to understanding the science behind diverse drying processes and the development of innovative, highly efficient technologies. Early on, I recognized the need for an international effort as no one nation had the needed critical mass to progress at a reasonable pace. I believe we worked on the globalization model before it became a popular buzzword. The rest, as they say, is history. I am particularly happy that with over sixty international conferences and over seventy books on drying topics, we have generated much new knowledge about drying and disseminated it globally. There is growing interest in this area, and I want the younger generation to take over this task. It is happening already, so the future for this field is bright for the next couple of decades at least.

To sum up, I hope I can help and mentor young researchers and academics to accelerate the progress we have to make in the coming years. Adapting new advanced tools like AI, big data, machine learning, and new sensing technologies will catalyse future growth.

Q. What do you think about priorities in research by academia?

Ans: Academia needs to balance basic and applied research; like work-life balance is not easy to do. Sustainability goals are important to address for national development. Basic research will be of global interest, while applied research should be primarily of national interest and maybe even of "global" interest. The goal of academic research must not be to produce a bunch of research papers. Some countries are collaborating with highly cited authors from overseas to enhance their publication records, but without meeting sustainability goals.

I like the new term recently coined, viz. R4D to replace R&D. Without development augmented by research, the time and effort spent on research is wasted. Local manpower development should be one of the goals of academic research.

Q. What are the primary driving forces for further R and D in drying?

Ans: By one estimate, I have come across the global energy consumed in industrial drying of all products in all industrial sectors amounts to the total energy production of India in 2023. This is a massive amount generated mostly using fossil fuels. Renewable energy, like solar or wind, amounts to less than ten percent of it. Its implications on global warming are obvious. Since industrial drying efficiency is still in the range of 30 to 50 percent in most industries, the need for improvement cannot be overemphasized. Other goals are to enhance product quality, increase productivity and cost-effectiveness, and encourage a circular economy in an eco-friendly manner. Drying of sludge, manure, and waste from various industries is a huge problem area that depends on efficient drying. Food security, new biotechnology, and medical products also require high-quality drying. The use of AI, machine learning, and data analytics will be the next growth areas. Modeling of dryers and drying remains a challenging area of big potential applications.

Q. Can you summarize your philosophy in the selection of research projects for theses? Is there a general set of criteria that cuts across geographical industrial boundaries?

Ans: Indeed, I have worked with academics and diverse industrial sectors for nearly five decades. There is never a totally free choice for academics to work in specific areas. Typically, I want to ensure the research students achieve both depth and breadth in the research theme

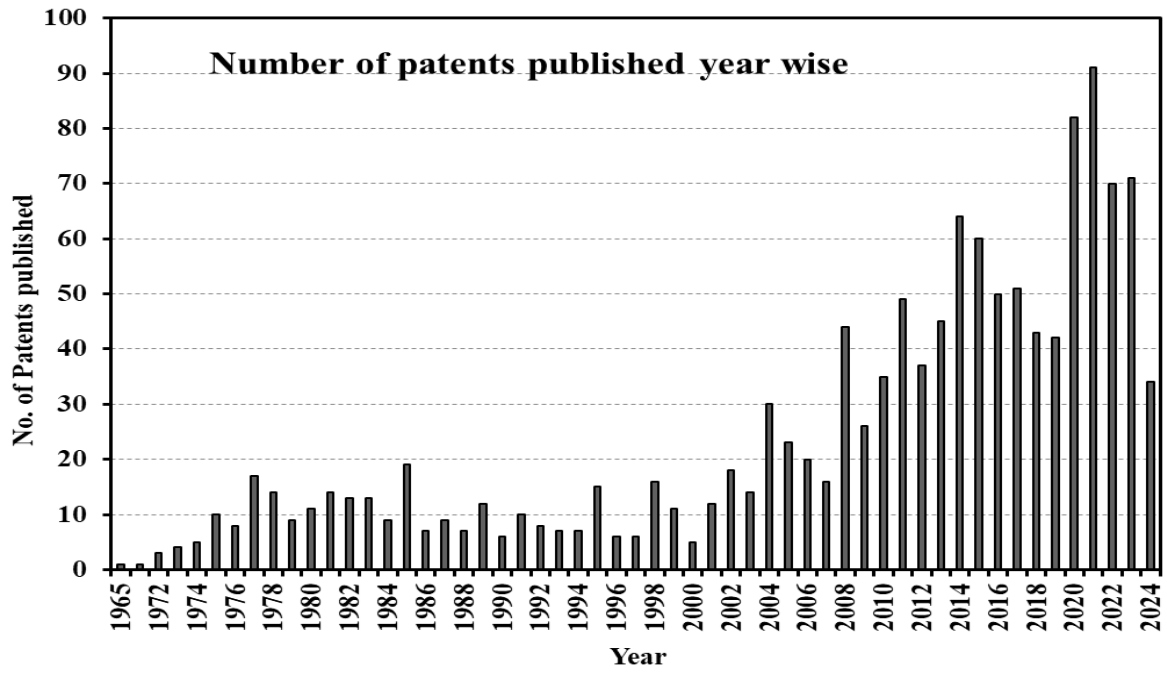
assigned. In addition, try to ensure the seven I's are present in varying degrees so the researcher can be productive in her/his career and also produce creative original contributions to knowledge. The research theme should ensure these four I's are present, albeit to varying degrees: Independent effort, Interdisciplinary nature, Innovative ideas and execution, and industrially relevant. It is a tall order, but it is feasible. Conferences like IDS, ADC, Euro-Drying, etc., permit one to develop networks and global collaborations more readily than was possible two decades ago.

Q. What is your personal experience with research and protection of innovation during your professional journey? Can you please share any examples?

Ans: Recently, I came across the news "Vortex Shedding Flowmeter Market Size, Growth, & Industry Analysis by Market Segmentation & Regional Insights & Forecast to 2031".

I came up with this same idea during my Master's at McGill way back in 1966 to measure velocity in a wind tunnel. Although it could be an excellent device for industrial flow metering but I didn't think about the commercial potential. There was no patenting culture then, and McGill actively pursued a policy against patents as too costly with little return.

I even studied some 39 different shapes of shedders for better accuracy and reduction of noise, almost 5 years later. This was presented at the ASME Petroleum Engg. Conf around 1972 or so. I believe the first patent in vortex shedding metering was issued in the late 60's.



Timely protection of innovation is key to success these days!

Advice to Young Researchers

Q. What do you advise fresh Ph.D. students for their career goals? What are the prospects for an academic career?

Ans: Clearly, my response is more applicable to engineers. Depending on your personal goals, I recommend that they consider both industrial R and D or academic career paths. In my case I followed the former for two years and then switched to academia for the freedom to pursue your preferred areas of research. For-profit research generally is geared towards know how while the later seeks know-why which may not pay off in terms of profit. There are few challenging academic jobs available now, and they don't pay as well too. So, one needs to decide if research and making an inclusive contribution to knowledge and service to society is one's dominant traits.

Q. Why did you choose an academic career yourself? What was the mentors' role?

Ans: My mentor advised me to get industry experience before deciding which stream to follow. I learnt a lot in my first R and D job as an aerodynamicist modeling using custom-coding to simulate multi-stage axial compressors for ethylene plants and diffusers. In fact, less than 10 per cent of what I learnt in undergraduate and graduate studies was relevant to what I had to do with no mentor or expert locally. CFD was an emerging area with no textbooks. I learnt CFD from journal articles in Aeronautical & Aerospace engineering as well as nuclear engineering as well as applied physics. What helped was my ability to self-learn and conduct research independently. Later, I used my knowledge of CFD to teach courses in computational methods and initiate research on modelling complex flows such as impinging jets on moving porous walls with transpiration. This was my first work related to impinging jet drying of paper and tissue. It helped my thinking about academic research. I did complex statically measurements of turbulence in packed beds as well as flow and heat transfer measurements in wakes of complex bluff bodies, both which were very fundamental in nature with no clear applications in sight. However, they were truly great learning experiences for me.

In later years, I was very comfortable wearing an industry hat in my consulting assignments and in teaching industry participants in workshops.

Q. What is your view on interdisciplinary, transdisciplinary, and multidisciplinary R&D? What would you like to suggest for young researchers?

Ans: I think this is increasingly important but not yet fully recognized. Most granting agencies and academic institutions to not yet "walk the talk". Drying for example, simply cannot be tackled by one discipline. As a minimum, you need to couple transport phenomena with material science. Now many industry problems need expertise in food processing, food chemistry, electrical engineering, nanotechnology, electrochemistry, control, artificial intelligence, machine vision, soil mechanics, biology, medicine, botany etc. the list is endless. We need collaborators in various fields depending on the problem. International networking is needed to conduct impactful research these days. It also reduces need for high financial and human resources while avoiding potential duplication of effort.

Q. What would you like to suggest to young researchers for pursuing higher studies in the present deglobalizing world?

Ans: Globalization occurred faster than deglobalization. The latter is something of a geopolitical issue I would rather not get into. Developed countries are concerned the flattening of the world in a knowledge economy could provide great advantages to emerging nations. In a wisdom-based economy, this will not pose a problem but provide a solution to alleviation of poverty and food insecurity, leading to world peace and reduced conflicts. I think international expire is very important. One learns a lot by just being in a different environment. I recommend it strongly.

Q. Why do you recommend that all researchers must publish any new results they have? Should negative results be publicized as well? Why?

Ans: Publication in an archival journal improves the quality of research as it is peer reviewed by experts in the field prior to publication. Readers can confidently refer to the results to build up the next step and advance the knowledge frontier. Remember that conducting research is expensive; we cannot afford unnecessary duplication of effort and resources. If every group did similar research concurrently, there would be no real advancement.

Q. You had networked and sought virtual mentors even as a graduate student. Why and how?

Ans: We often can expand our mentorship base by reaching out to experts anywhere in the world who may have experience and/or expertise your research may need. Since most

academics are not motivated by monetary rewards, they are often willing to spare time for serious mentees who may benefit from their guidance. It is useful even to study biographies or biodata of accomplished experts to learn from their professional journey. No university can afford to have permanent faculty that is expert in numerous rapidly evolving fields. Often, some of my senior graduate students have mentored graduate students in developing countries with limited resources.

Q. What is your advice to students doing a Ph.D. in the drying area?

Ans: Drying is multidisciplinary and generally an applied field. So, defining the problem is key to success. Now you can find rather easily enough, resources to get going on almost any problem in drying. You may need to collaborate if you do not have the needed advanced analytical tools or expertise locally to model a complex drying system. It is important to carry our in-depth literature search and study the literature carefully. Often researchers are not keen to read extensively but there is no real easy alternative to it. Doing a PhD research project allows you learn basic engineering science as well as experimental techniques, optimization, control, computational techniques etc. This knowledge can be readily transmitted to other research areas well. Most of my PhDs in drying projects are working very successfully in totally unrelated areas.

In my case, I have worked with material scientists in pulp and paper, foods, grains, wood, ceramics, pharmaceuticals, coal, biomass etc. my engineering collaboration covers all traditional engineering disciplines, including metallurgy and mining engineering. I could move across a disciplinary boundary with no real problem. Of course, I have had to be on steep learning curves all my professional life, which is what I truly enjoy.

Thoughts on Archival Publications

Q. Why the free eBook project?

Ans: Here, the goal was to make high-quality technical books of broad interest freely available globally, especially for the developing world. Technical books cost US$100-200 each; this is beyond the financial resources of individuals as well as libraries.

Q. What do you think of fully digital libraries? Are hard copy journals still a useful and effective mode for learning and innovation? Why?

Ans: I like printed journals which I can thumb through and often read papers in entirely different area. By reading outside my limited research area, I often obtained innovative ideas I could apply to my research. When one depends on digital searches and looks at specific papers only one loses the potential for unexpected innovation.

Q. What prompted the establishment of the Drying Technology journal?

Ans: The journal was an idea of the publisher. When Marcel Dekker approached me, we had held three IDSs successfully. However, I thought there wasn't enough critical mass of drying researchers around the world. In 1989 while attending a Heat and Mass Transfer Conference in Minsk, now in Belarus, I had the pleasure of meeting Academician A. Ginsburg who was a colleague of Academician Luikov- a giant in drying area. Prof. Ginsburg congratulated me for doing something that Prof Luikov tried unsuccessfully for years - that is to establish a journal on Drying Technology. So, I think it was quite an accomplishment.

It has been a hard journey and a couple of times there was a possibility of folding the journal itself although books in my Drying series did well. Authors wanted to publish in my books rather than the journal as it still did not have a firm footing.

Q. Were running IDS and the journal smooth sailing? What specific hurdles did you encounter and how were they tackled?

Ans: Running initial IDSs and the journal was far from smooth sailing with no support from university, industry or granting agencies. It was an unknown field. Vendors were too small to fund research. Users thought they already had state-of-the-art dryers mainly because they didn't know better.

Q. Could the journal or IDS survive without globalization before even the word became a buzzword?

Ans: No. I think I did use the word globalization in my keynote lectures before it became a buzz word. No single country has had the critical mass of drying researchers to hold a major conference. Only China was hosting drying meetings during 70's. Now China continues to be the major contributor to both IDS and the journal. India has just started interest in drying but that seems to be limited to vendors so this may not lead to strong publications quite yet.

Section-II
Higher Education and Ranking of Universities

Q. Any thoughts on the relative importance of teaching versus learning?

Ans: I think learning is more important at higher levels of education. Teaching is key to successful educational outcomes in schools. It is widely recognized that the half-life of an engineering program that is updated regularly is only between 5 and 7 years. Once outside academia, an engineer needs to self-learn and continuously upgrade his/her knowledge base and required tools. Teachers and professors must self-learn even more vigorously to remain relevant.

After my PhD at McGill in chemical engineering, I went to work in the US Research Centre as an Aero-dynamist. The only knowledge I learned that was useful then was the ability to self-learn totally new areas and the ability to think critically and carry out independent research. I have experienced the need to self-learn without a mentor in increasingly critical.

Q. Any thoughts on what subjects need to be added to most engineering curricula?

Ans: The curriculum needs to be updated every 4-5 years. Delete obsolete topics and include new developments. Also, the whole program and faculty capabilities must be evaluated regularly every five years or so. Fortunately, most countries have some kind of accreditation bodies that define and check if their criteria are met. Not all countries follow or enforce them, and so the quality of engineering programs varies widely.

Q. How can developing countries improve higher education and research culture?

Ans: Enforcing accreditation requirements without interference or bias is necessary to assure quality. Research culture is something that takes years of hard work and good policy to support it.

Q. How will higher education enhance R and D outcomes, leading to higher GDP?

Ans: There is a denoted nonlinear correlation between R&D effort and GDP. There are studies that confirm it. You can Google and find interesting reports on how China developed so rapidly and now beats even the USA and EU in basic high-impact publications as well as patent issues. Other countries can do this but have no funds and or will to do this as it is hard.

Q. Why do you think China advances so much faster than the rest of the world?

Ans: Razor's sharp focus on higher education and R&D coupled with public-private partnerships in all areas. The vision and mission are clearly defined and rigorously followed.

Due resources are allocated by the government to meet the targets. I think this is their key to success. Of course, talent and perseverance must go hand-in-hand concurrently.

Q. Who should go for a PhD in engineering? Criteria to be considered. Is academic life suitable for most PhDs

Ans: Only those eager to focus on the depth of a specific area and work hard can do good PhD research requiring original contributions to knowledge. It is hard and time-consuming, and the financial award is typically not very attractive.

Q. Your recent thoughts on the ranking of universities by various private agencies? Is it useful? Can this be misinterpreted and maybe misused too?

Ans: There are too many rankings of universities, research, faculty members, etc. If the objectives and scope are well defined, the benchmarking is useful to stimulate high quality. However, often profit-making non-academic organizations now engage in lucrative rankings of global universities. This can introduce errors and bias in the rankings. The same institution is ranked differently by different agencies. Given this limitation, I think it is a good exercise.

Q. How about school education which provides a foundation for higher education? What subjects should be included to make life of future citizens more productive?

Ans: I have some strong ideas on what is missing in early school education. I think students in all grades should be exposed to ethics, the environment, civics, and economics. These need not be new subjects to be added to the curriculum. The traditional curriculum should include exercises that allow for these important topics everyone must face in daily life. This is a huge topic. One can introduce all these themes in a series of math courses, for example.

Section-III

Drying Science and Technology

Q. How will carbon tax levied by many countries alter future drying technologies?

Ans: This tax is aimed at lowering greenhouse gas emissions. It is a useful idea but the jury is out on its efficacy in practice. It has an adverse effect on the economics of individual taxpayers. Certainly, it will promote more efficient drying systems in the coming years.

Q. Why do drying innovations take a long time to reach the market? Indeed, some never made it to market, is it?

Ans: Drying is a highly nonlinear operation. Tests at lab or even pilot scale cannot be reliably scaled up to full scale. As most innovations are reported at smaller scales, the industry is not always prepared to take the risk.

Q. Why is pharma drying different from other sectors? Value of product drives the technology?

Ans: Drugs are very expensive. The cost of drying is very low compared to the value of dried products. The scale of production is also small relative to that of commodities.

Q. Why is there no new drying technology for paper despite millions of dollars spent on R and D in the 70s and 80s?

Ans: At least four innovative drying concepts have been proposed and tested over the last five decades. Only incremental evolutionary innovations to traditional technology have been found to be cost-effective. This is true of many other industrial sectors as well.

Q. Why is China advancing too fast in drying technologies compared to the West where the effort has declined for two decades?

Ans: From my knowledge as early as 1990, drying technology was recognized as a strategic area for R and D as it is needed in practically all industries. Other nations did not pay attention to this. The result is that China has a massive industrial base and a very large number of dryer vendors that supply the global needs.

Q. Your comments on the rate of patenting and publications in China?

Ans: This is a direct result of advances in manufacturing industries in China.

Q. For drying do you think renewable fuels will make a big dent in coming decades?

Ans: Certainly, a small but finite effect. In the future, there will be more attention paid to renewables.

Q. Is there less innovation in drying as well as allied fields? Why?

Ans: Hard to tell. I feel we already have more innovations published and patented, but few in use.

Q. Is there a plan for an Academy for Drying Science and Technology?

Ans: This is now established as an NGO in China. In the next 2-3 years, you will begin to see the impact on the promotion of drying science and technology around the globe. China, understandably, is taking the leadership role.

Q. What are your thoughts on the future of IDS and ADC?

Ans: With the Academy formally formed, I feel IDS and ADC will continue to provide a forum for direct interactions, networking, and potential collaboration as well, which should enhance innovation.

Q. How can countries like India strengthen R and D culture and increase funding for it? China spends an order of magnitude more than India does at this time.

Ans: This is hard to predict. We need more academic research. More interaction with industries and a higher level of research support from granting agencies.

Q. You announced the first IDS in 1977 while you were a junior faculty member at McGill University and managed to host the first IDS in 1978 without the benefit of modern telecommunication technology. You had to use mechanical typewriters and individual snail mail to publicize the event, seek manuscripts, review them, and even retype them if needed, and also have a publisher in the USA formally publish them as well at the first IDS. All this was done without external help and with minimal resources. There was no assurance of success as drying was not accepted as an area worthy of serious research. Any comments on this on the eve of possibly the biggest assembly of drying researchers in Wuxi, China in November 2024?

Ans: Indeed, I am deeply satisfied with the massive amount of time and effort I put into initiating IDS and then being actively engaged as the Founding Chair of IDS to ensure continuity and provide valuable links to the organizers of the events in different countries,

which has been successful for well over four decades. Most such series have a limited lifetime of one to two decades. The awareness of the significance of R&D in thermal drying required in most industrial sectors that this series and associated publications brought to academia and industry, has been highly impactful knowledge on a global scale.

The new initiative spearheaded by Prof. Min Zhang of Jiangnan University, Wuxi, China, will inject new enthusiasm for enhanced research in drying science and technology. So, a second phase with a broader vision has emerged, and I hope the younger community of researchers will make great advances in innovative technologies and generate cost-effective, sustainable solutions for the industry. The amount of fossil fuel-based energy consumed around the world for the drying of tens of thousands of products is truly staggering. It must contribute to global warming. We need to reduce the carbon imprint of current technologies and use renewable resources to the full extent. Much has been achieved, but more needs to be accomplished.

As I complete eight decades of my life and over decades devoted to research in drying, I think the time has come for the next generations to carry the torch further. I feel quite confident this will happen.

Q. You have contributed very significantly to the scientific and technical literature over the past four decades. Your coauthored monograph on Superheated Drying Technologies in fact, is the 75th book with your name on the cover. Your Handbook of Industrial Drying is considered the Bible of Industrial Drying and the Drying Consultant on Desktop. It has gone through four editions. Any chance of a fifth edition, as it has been a decade since the fourth edition appeared?

Ans: Each edition has taken five years for me to edit. I was also the main author of the content. Now I hope to enlist the support of two or three co-editors and bring out the fifth edition before I hang my hat. I need to do this task as I have had both industry and academic contacts globally in all sectors where drying is a key operation. This experience is important in editing such a handbook that is authoritative and useful for at least the next decade.

The Advances in Drying Science and Technology, published by CRC Press, is also a valuable contribution to knowledge in drying science. It is recognized formally by the Chairman's Book Prize at IDS2024.

I am especially proud of the Modern Drying Technology series published by Wiley with Prof E. Tsotsas of Germany as principal editor and me as co-editor. It is a set of highly impactful books that every library that deals with drying must have.

Q. IDS2024 in Wuxi, China, has been a grand success in terms of the quality of organization, number of participants, quality of research presented, etc. What is your general impression about this and the future of the IDS series?

Ans: As the founder of the series way back in 1978, I could not be more happier. With some 410 registered participants from 29 countries and some 300 keynote and research contributions, it was a great success. The number of industry sponsors and their contributions to IDS2024 have been unparalleled. In my opinion, the Program chair Prof Min Zhang, and his team along with a big team of graduate student volunteers, presented the grandest IDS to date, even after 46 years after its start. Jiangnan University gave major support too for which we are grateful.

Q. What is the role of the newly registered NGO in Macao International Research Association for Drying Science and Technology (IRADST)?

Ans: This idea and the huge effort that went into spearheading this initiative goes to Professor Min Zhang and Jiangnan University, along with a number of companies in China who recognized the need to have a formal structure to stimulate global-scale R and D in drying. Both scientific and technological aspects need to be studied in cooperation with industry in different sectors. At IDS2024, we held an inaugural conference where a number of recognized experts from different countries were inducted as Fellows and Associate Fellows. They presented summaries of their contributions and future needs. Such meetings will be held annually at IDS and the Asia-Pacific Drying Conferences in the future. The goal is to allow networking and collaborative interdisciplinary research in drying and to enhance current drying technologies.

Q. At IDS2024 your CRC book series was awarded the Best Drying Books Award. Editors and authors of 26 books published over a decade were recognized for their contribution to dissemination of the latest knowledge in drying science and technology. What is your plan for the future?

Ans: Indeed, it was exceptional and a surprise. We have covered numerous themes and now I wish to focus on AI, machine learning, advanced sensors for control, etc. I have some interest but no time in putting together the fifth edition of my Handbook of Industrial Drying. Who knows it may still materialize if I can find one or two young enthusiastic co-editors with experience. Let us see.

Q. What are the future plans for the Drying Technology journal?

Ans: I have been involved with it since 1982. The first decade was especially challenging for numerous reasons. I had to be innovative to meet the publisher's requirements. Then it got relatively easier with help from several of my own mentees. Dr Devahastin helped me while he was a senior PhD student of mine. His contribution to the successful running of the journal is truly admirable. The fact I organized the IDS series successfully and my own research covered drying in many industries like pulp and paper, wood, grains, foods, polymers, ceramics, pharmaceuticals, etc, and several dryer types made it possible to seek papers in several areas. Now, much of drying research focuses on spray drying and foods. I am in search of authors in diverse areas. In the future, I foresee more papers on AI, drying science, and biomedical and environmental applications, but foods will continue to dominate.

As you know, we try to cover both sciences and technologies. Our readers are not all academics who publish papers and cite the papers as their work. So unlike science journals, we cannot aim to attain similar impact factors. I believe in value and real impact, and not virtual impact through an arbitrary measure. Our papers have a long half-life and thus remain useful over a long period of time.

Thoughts on Drying R&D

Q. Is there a correlation between innovative research and citations?

Ans: In my personal experience, no. My most innovative research papers had minimal citations in two to three years. Some started receiving citations 6-8 years later. In the other hand, a few of my papers were cited 50 years later as they provided some fundamental measurements which were used to compare with modelling, which was impossible until recently. Higher citations are associated with buzzword themes with large funding and large population of researchers. In medicine and science, the citation numbers are astronomical compared to engineering, mathematics, economics etc. Most research scientists publish papers; most engineers do not, although they follow up on literature to hone their knowledge. For example, I have had papers with thousands of reads or downloads but very few citations. Many with a large number of citations have not attracted many downloads or reads.

Q. What is the role of IDS proceedings and edited books in promoting drying R&D?

Ans: I have written about it. The influence has been immense using any criteria. The symposium and availability of published proceedings made drying research and the needs for

further research widely available. We published special reviews and articles by experts identifying research areas worth pursuing.

Q. How DRT and IDS have brought about a sea-change in industrially developing countries such as West Asia, South East, Asia, South America, and Africa?

Ans: In 1990, China recognized drying as a strategic manufacturing area for r and d. This allowed extensive training and research at a number of universities and industrial laboratories. The interaction between industry and academia was enhanced exponentially. Within a decade or so the largest vendors of drying equipment were from China. I know a dryer company that makes over twenty dryer types for many industries and exports to over 140 countries. This transformation is only possible with extensive collaboration supported by government funds and industry participation.

I think free availability of technical literature around the world has inspired many in the developing world to look seriously into cost-effective dryers for grains and foods as an immediate need. As the industry develops there they can leap-frog into modern drying technologies quite readily.

Q. Role DRT will play in re-globalizing intellectually?

Ans: For IDS or Drying Technology there is as yet no deglobalization. Our publications are available worldwide. I believe we have published papers from over 80 countries, although the bulk of the papers come from about ten countries.

Q. How do you think China went from very little to maximal contribution to drying R&D?

Ans: As noted above it is the government policy and early identification of drying as a key enabling technology deserving extra support that catapulted Chinese dryer vendors to the top in just about a decade. Hard work and intellectual ability to learn new technologies and apply them in practice are, in my opinion, the key drivers. As you know, China has a massive number of researchers in all fields and also now publishes the most papers in the STEM area along with a strong patent base as well.

Q. Industrial contribution to drying? Is it at a reasonable level?

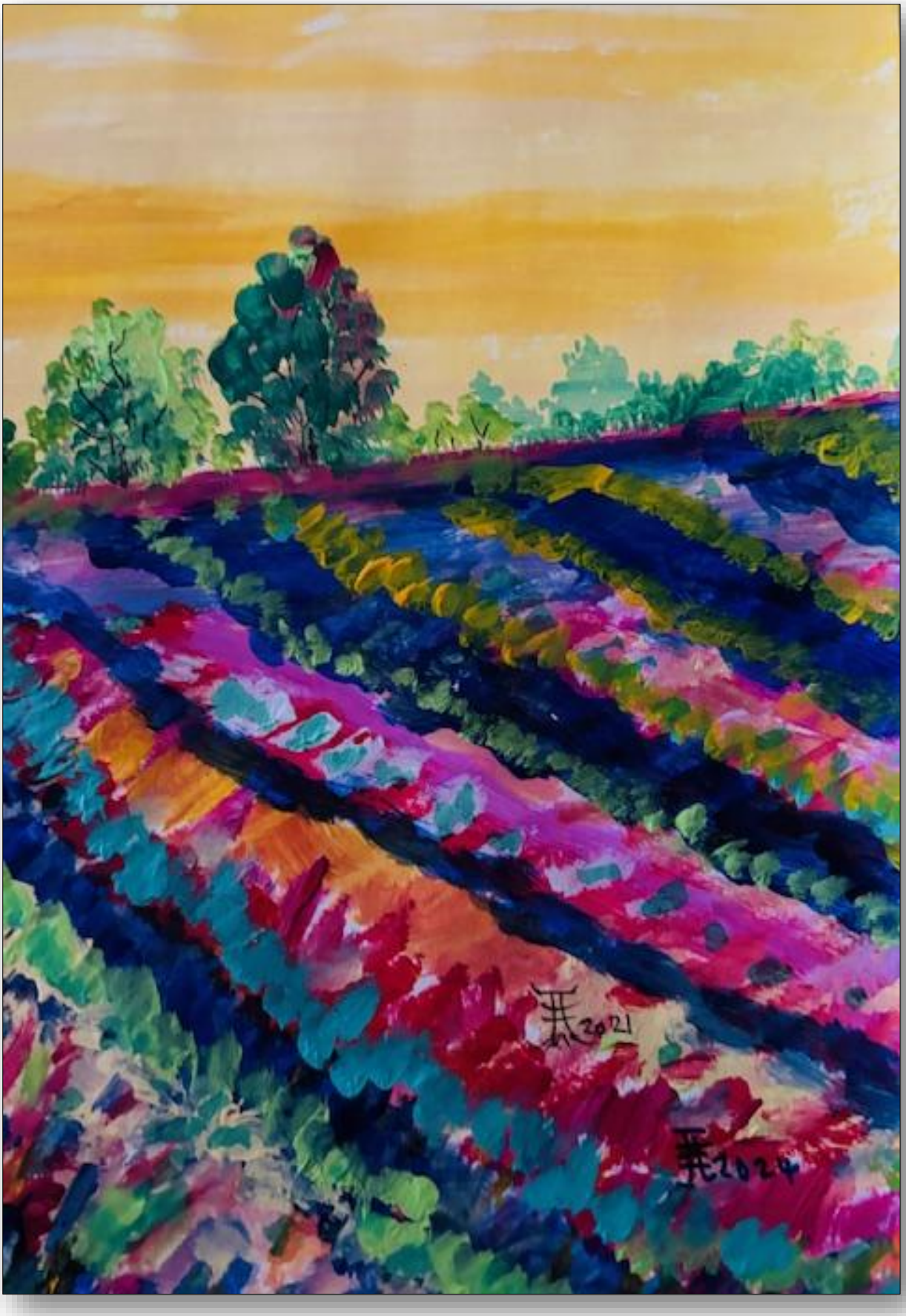
Ans: I have lectured in over 40 countries in four continents, most on drying to academic and industry audiences. Except in China, I find industry contribution is little and sporadic- certainly not enough to make a measurable impact on a national scale.

Q. Future of drying R&D?

Ans: Despite 40 years of Drying Technology journal and 44 years of IDS and many sister symposia on drying, we have yet to develop enough knowledge base to scale-up, design, optimize and control most dryer types with much empirical as l experimentation. Quality of products remains tough problem to predict. There still are many unresolved issues. The need to minimize use of energy and resources to reduce carbon footprint is a new challenge. We foresee greater use of renewables in dryer operation along with implementing AI. So, a lot remains to be done but the progress made since 1978 is simply remarkable.

Q. How we can move from a linear economy to a circular economy considering the circularity of drying processes?

Ans: This is very complex. Drying technologies have a long life- 20-40 years. This reduces waste of materials. It is possible to retrofit dryers and make them more efficient. Switch from fossil fuels to renewables will approach circularity but not quite. I think vendors of drying equipment need to keep principles of circularity in mind at the design stage itself.



Section-IV

Advice on Post Retirement Activities

Q. What are your thoughts about retirement? Is it for every academic to stop all types of work that was done for decades?

Ans: This is not for everyone. If one must work hard often at own cost and without financial or other benefit, most academics refuse to carry on their research post-retirement.

Q. What did you do and do you recommend it for all academic retirees? If not, why not?

Ans: I didn't recommend it to most retired academics I know. Many slowed down well before actual retirement. A special type and degree of passion and commitment is needed to devote almost full-time effort to mentoring and research.

Q. I know you spend considerable time in spiritual reading, listening, and attending lectures on spirituality by well-recognized individuals. Can you comment on the role of such activities in retirement even pre-retirement years?

Ans: My spiritual activity developed mainly through the Purnima and the dedicated work she puts into spiritual activities. I find it has a calming effect on me and enhances my productivity appreciably, although I devote a large amount of time and resources to it.

Q. How can one retain a passion for work without remuneration? What is the objective of such efforts? Does it have health implications?

Ans: If one has a passion to serve and make a contribution to society through the generation of knowledge and its dissemination, then it is possible. For most, this may not be possible.

Q. You have mentioned that retired academics as a minimum, can mentor students and young faculty. Their experience and expertise can have a major impact on young people. How have you accomplished this?

Ans: Yes, I continue to mentor students, researchers, and young faculty around the world. It is a satisfying effort so keep enjoying doing it. Often, I am up at 4 am just to complete some reports or papers or reference letters for my mentees when there is a deadline.

Q. Would your responses be quite or somewhat different from the early ones now that you have been nominally retired for over ten years? Specifically in what areas?

Ans: Not really. My work schedule is what it was. I spend ages least a few hours working each day of the year without a break. Such continuity is important. If I take a long break, maybe I will stop this activity altogether.

Q. What do you think about your recent election to the Canadian Academy of Engineering as a Fellow?

Ans: It is a form of recognition of one's contribution to the engineering field in Canada. At my age, there is no personal or professional benefit for me but it is satisfying to be recognized. Special thanks go to the nomination must do all the work.

Personal/Professional Experience

Q. Can you briefly summarize your own innovative achievements? Why did you not commercialize them via patents?

Ans: Even as Master's student I used a new idea to measure air velocity. Basically, I measured vortex-shedding frequency in the wake of cylindrical rod. From fluid mechanics it is well known that the von Karman frequency is related to the Strouhal number which has a fixed value of 0, 205 over a wide Reynold number range. This is the principle of the now-common vortex shedding flow mater used extensively in most industries. This meter wax patented several years after I was already using it without ever thinking of its huge commercial implications. Later I developed a rotating spouted bed dryer for grains and also a two-dimensional spray dryer as well as a two-dimensional spouted bed dryer for granular products. Another example is the conceptual design of a novel superheated steam dryer for paper.

Q. How did you initiate/ promote drying research at various academic institutions?

Ans: Mostly, it was initiated by someone at the institution who recognized the need to initiate research. I provided some ideas within the resources available. I also supplied copies of my books and some journal issues to help with definition of suitable research project.

Q. Can you say something about Exergex Corporation that you established to provide industrial consulting and find some academic research as well?

Ans: I had to incorporate my consulting activity mainly for legal reasons to limit liability. Most of my earning from consulting was used to purchase PCs for students, supplement their stipends as needed and to cover some publication expenses as the grant funds were inadequate to cover all expenses.

Q. Would you recommend a tenured academic from a well-recognized university in N. A. to accept limited tenure or contractual term positions with set retirement age?

Ans: This is a highly personal decision. I probably did not consider all the cons- just the pros. Leaving a life-long tenured faculty position with a world class university like McGill to a relatively less known university when I moved and that too with limited term contractual appointment is not recommended for the faint of heart. It was a huge challenge to give up established research and teaching in chemical engineering to join a mechanical engineering department with different research culture and teaching environment was a big challenge. I missed three sabbatical leave options at McGill while at NUS. The retirement benefits at McGill and in Canada were lost too. This is important to evaluate pros and cons of such big moves for established academics. On the positive side I stayed on a steep learning curve all the time and the opportunity to develop long term collaborative connections with major institutions in Asia. These are continuing even after my return almost eight years ago. Fortunately, I continued my research career despite lack of human and financial resources.

Q. Can you provide guidance to young tenured faculty who may wish to find employment overseas?

Ans: This is a difficult question since the advice has to be highly personalized. An experienced mentor or colleague with no conflict of interest would prove very valuable for such advice. Note that the mentor should be the one to ask the right questions; he/she must, of course, be provided with sufficient details of the potential overseas institution. A decision should not be made amid busy schedules (e.g., overwhelming academic requirements and/or professional commitments). It is strongly advised to seek solid information regarding research, teaching, service and support environment at the new location prior to making the decision. It is still quite possible to receive wrong or misleading advice due to potential conflict of interest or simply lack of detailed knowledge about the overseas institution, so care must be exercised when seeking advice.

In a nutshell, my advice to those thinking of overseas moves is: (1) get all the relevant information on service requirements, employment policies, research funding, promotion and tenure criteria, retirement age, sabbatical leave policy, pension funds, frequency and seriousness of evaluation methodology and support staff (if any); (2) armed with all this information, talk with those who have had first-hand experience and then decide. Short term benefit may not justify a move. Of course, family circumstances may sometimes override all of the academic criteria. Most importantly, avoid making decisions based on only the initial

financial package alone but make a life cycle analysis based on benefit during and after formal retirement.

Q. What are your thoughts on global ranking of global universities which are based on one size fits all basis? Also, this is done by profit-making no academic organizations, right?

Ans: A complete answer will need pages to list all aspects of rankings by different agencies which are all no academic with very few exceptions. The criteria are determined by non-academics often placing high weight on quality criteria that are arbitrarily quantified so they can readily obtain numerical values so it is easy to rank the institutions. Depending on selected criteria and weight given to each the ranking order can change. The focus is on research output, international interactions, where the students and faculty come from etc. Universities from English speaking countries tend to benefit from the assessment criteria. Benefits to countries the institutions serve are not considered. Overall, it is useful exercise for some but not do beneficial for others. The pros and cons is such rankings have been discussed extensively in the literature. Unfortunately, rankings affect the quality of students and faculty the university can attract; it also influences government support, research grants as well as philanthropic donations. This there are significant financial implications which worries me.

Q. And, how about criteria used to rank journals again with same criteria regardless of discipline?

Ans: Once again, ranking of journals has some benefits but there is a risk that one-size-fits all type ranking can give wrong results. There is much literature on the criteria we commonly use such as impact factor, citations, h index and numerous other criteria that basically convert a quality parameter into a number that is subjected to algebraic manipulations to arrive at a number of conclusions. Different disciplines tend to have very high or very low citations which affects the numerical values of most indexes. I don't have space to discuss this in detail. My short answer is that the rankings are useful but the numbers must be interpreted with extreme care.

Q. What are your thoughts about social media? How do you use them?

Ans: I don't use social media except to view and read about Nature, historical articles by recognized experts as well as quotations. I share whatever I find useful with my students and

mentees. More recently the media is overtaken by those who publicize fake or highly biased news and thoughts. I am therefore cutting back on my time devoted to media. Surely J use Google a lot to seek and read technical articles of my interest. This keeps on the learning curve all the time.

Q. Often you share many meaningful quotes including many by Swami Vivekananda, late president Abdul Kalam, well known scientists etc. Can you briefly state the reasons you are so keen about sharing them with your mentees, collaborators etc.

Ans: As a graduate student, I used to buy books of quotations which are basically capsules of wisdom. I never get tired of reading them again and again. Many have lasting ageless messages that everyone can benefit from such quotations.

Swami Vivekananda's quotes about education, spirituality, diligence, moral values etc are part impertinent. I am also keen about creativity, innovation, entrepreneurship, research and development, food security, water footprint etc. I find many quotes on these topics and selectively share with my mentees.

Q. How did you get interested in artwork? Does your activity in watercolors, acrylics etc. affect your scientific output as that must consume some time over a couple decades? You had suggested in an editorial that all research students should take a required subject in any art-oriented e.g., painting, writing, languages, sculpting, music, dance etc to ensure both the left and right parts of the brains are engaged to enhance creativity. Even team and individual sports are in this category. Please elaborate.

Ans: I started to draw, sketch, paint using crayons, water colours, acrylics etc. mainly as a means of relaxation. I overburdened myself by taking on many projects that I was keen about but for which there was not enough funding of Human Resources. This resulted in massive increase in stress. I took on this hobby without talent or training but certainly he'll a lot.

Q. You have devoted an incredible time and effort on establishing drying as a viable interdisciplinary R and D area. After almost 5 decades of such monumental effort with missionary zeal - and single-handled all by yourself in the initial decade - do you think it was worthwhile as you had to give up on family time and some benefits is academic life?

Ans: Short answer, yes! Had I not worked on some 50 international conferences and scores of books, could have published many more research paper with much more limited and local impact as well as readership. The global effect on a massive number of researchers in academia and industry has had important effect that is difficult to quantify but is easy to discern qualitatively. There has been tremendous innovation in drying technologies they provide high quality products with lower net energy consumption and lower emissions. This has implications on climate change and food security. So, in a nutshell it was well worth the effort.

Q. How did sister conferences like ADC, IADC, WFCFD, NDC, MEDC etc. come about?

Ans: IDSs as you know are held in even years and the site is purposely moved from continent to continent to allow different participants to attend these global gatherings; these are more like family reunions. The friendly atmosphere makes exchange of ideas, knowledge, technology etc much easier to take place. Much networking has occurred over past decades resulting in effective collaboration and innovation. Several sister conferences that cover single continents or nations are modelled after IDS. I have been proactively involved in several these meetings. This has helped enhance drying effort globally.

Q. Why did you produce and distribute hundreds of copies of the book Mujumdar's Practical Guide of Industrial Drying? It was compiled elegantly by Dr Sakamon Devahastin when he was your last but one PhD student at McGill University. I note it has been reprinted freely in many countries and translated in five or more languages. You paid for it using personal funds. This is rare and highly unusual. Please elaborate.

Ans: This is definitely a unique and pioneering effort before the widespread availability of the Internet. I wrote the chapters such that the content was concise and really useful to academics and industry personnel. I paid for and freely distributed over 500 hardcover books. Many conferences in different countries were given free rights to reprint and distribute any number of hard copies. The book also was translated into Chinese, Farsi, Bhasa Indonesia, French etc. and widely sold/ distributed in numerous countries. This promoted drying technical knowledge very widely and very quickly at no cost to the users. I think this effort along with IDS, ADC and the journal have been prime movers for promotion of drying science and technology around the world. Dr Sakamon Devahastin must be congratulated for putting the book together elegantly and getting it printed in Thailand so I could afford to distribute over 500 copies free.

Q. You have experienced teaching and research in several highly ranked universities like McGill University, NUS, HKUST, Nagoya University, Keio University, University of São Paulo, KMUTT, UKM, NTNU, etc., and have given lectures in over 40 countries. How can Indian universities excel and get listed in the top globally ranked universities? Any thoughts on this?

Ans: A thorough answer will need a book to list what needs to be done. Governments have to prioritize higher education and research and provide adequate funding, and high-quality faculty without internal or external political influence. In-breeding of faculty is a major issue that works against innovation, creativity, and quality of research and teaching/learning. India has fewer researchers leading to low output in peer-reviewed journals. Research culture needs to be cultivated and rote learning discouraged. Multidisciplinary and interdisciplinary research requires loose walls between different departments in engineering and science faculties, for example. Networking at national and international levels needs to be supported. Hiring, promotion, and tenure processes need streamlining with rigour. Having reservations for faculty positions or student seats can lower quality unless there is an incentive to work harder for entry and employment. Qualifications should be the sole of at least the main criterion.

Excellence must be encouraged without inculcating a personality cult. Furthermore, curricula need updating every four or five years as what we teach gets dated very fast in a knowledge-based economy. I don't know if this is done routinely or on an ad-hoc basis in India.

Recognition of excellence and contribution to education and research in India- by residents as well as nonresidents is essential to motivate continuing support. Often there is a tendency to scratch each other's back and reward themselves even when there is no justification. Focus on self-service needs to be replaced by a focus on public service. This is true of politics but this tendency seems to have crept into academia as well. Faculty must refrain from professional jealousy and try to keep outstanding potential faculty from being hired lest their own performance should appear poor by comparison. This happens everywhere but the degree is probably lower elsewhere.

To sum, much remains to be done by outstanding leaders who themselves are true role models. Just correcting one weakness will not show a really significant effect. Sorry, I cannot list all the actions that can be taken to enhance the overall quality of education and research in engineering.


2021

Section-V

General Topic

Q. After ten years of returning to Canada as a retired academic, what is your opinion about the move you made from McGill to NUS which change in discipline from chemical to mechanical engineering and life-long tenure to short renewable contracts and a retirement year? How did it affect your own situation personally and in terms of research achievements?

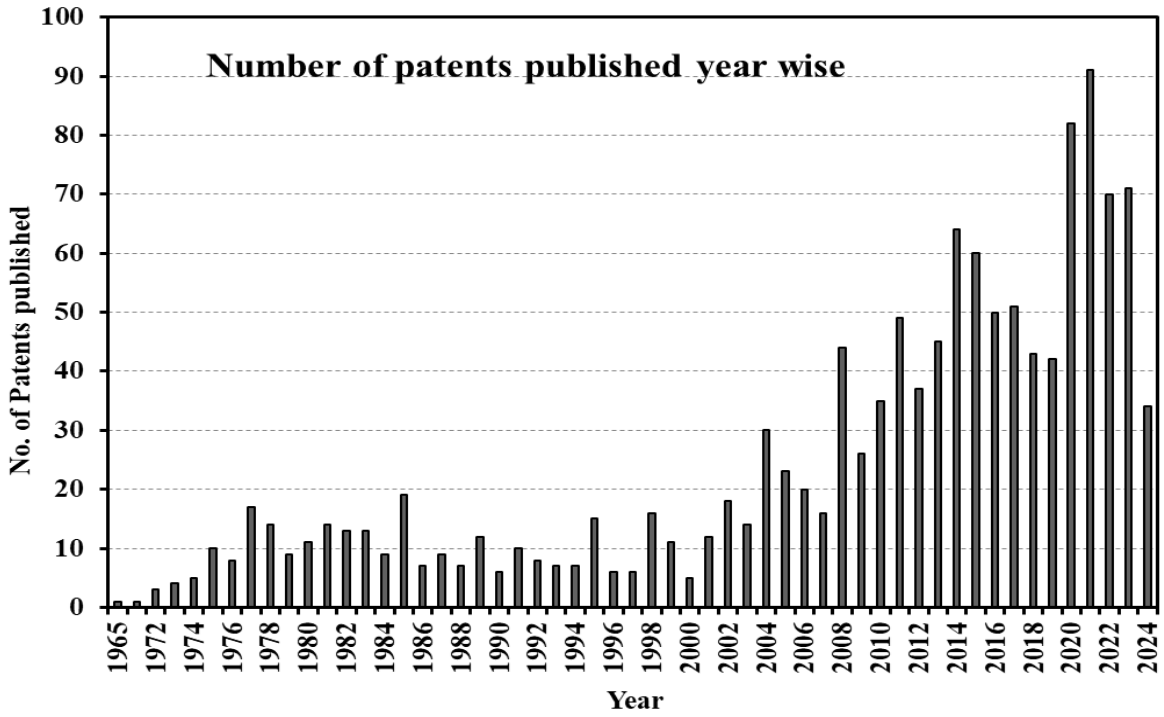
Ans: This requires a long answer that does fit the dialog which needs to be brief. There are pros and cons. Personally, this move to NUS meant living away from our daughter and son and their growing families in the USA. Major extra effort went into teaching mechanical engineering. I had to switch to research themes to meet local needs. As you know this is not easy to do. As I had to continue my research in drying, I developed a number of external collaborations. Lifestyle changed significantly which was enjoyable but harder as well. Overall, a mixed bag but very valuable express well. Not recommended for all! There are numerous complexities involved in moving overseas and equally difficult and expensive one return to the homeland.

Q. What in your opinion was your first the lost significant truly original innovation from the start of your research career? I believe your M. Eng. thesis research at McGill in 1965-1966 dealt with measuring statistical turbulence parameters in the pores of model packed beds.

Ans: Without recognizing it as an original idea that I came upon during my Hotwire anemometer measurements, I had the need to measure men's velocity profiles concurrently. As I studied fluid mechanics with great interest, I was very interested in the massive literature on flow past cylinders and in particular the unsteady wake. It intrigued me immensely that the dimensionless frequency of eddy or vortex shedding was constant at 0.21 in the lower Reynolds number range. I could measure the wake frequency by autocorrelation or spectrum analysis of the fluctuating velocity signal from the anemometer. This gave me the idea of measuring the mean velocity by measuring the correct shedding frequency by choosing a right diameter circular cylinder. I used rather expensive instruments to do this in a jiffy but I did come up with a number of ideas about how it could be done in different ways and even tested in later years some 40 different cylinder designs including composite shapes to enhance the shedding frequency signal. Some of the shapes I studied were later used in many commercial vortex shedding flowmeters- nor a multi-billion-dollar business globally.

Q. Seems there was no patenting culture those days some six decades ago.

Ans: Indeed. In fact, I did not even think of it as a major innovation either massive commercial possibility. No one at McGill that I knew had expertise in this area and could advise or mentor me. I did not even think it was worth mentioning my advisor. Here are stats about the patents on vortex shedding flowmeters supplied by Dr. Mukund Bade of Surat, India.



It is noteworthy the first patent was issued in 1966. I learned about patents in this area some ten years later as it was extremely hard and very expensive to access patents those days. The university did not encourage patenting due to cost and no return as only 1-2 percent of patents made any money.

Thus, my most interesting innovative idea with enormous business potential led to just a curiosity on my part. I published just one paper at an ASME Petroleum Engineering conference in the early seventies giving away about 40 different shedder geometries for potential application in vortex shedding flowmeters.

Q. I understand you predicted right after your first 4-week visit to China in August 1984 that China would be a technological superpower within three years. As a young academic what was the basis for such a profound prediction which did come true? You were invited by the Ministry of Light Industry and accorded VIP hospitality to give a 7-day workshop on Industrial Drying. Can you give some details for general information of students and faculty?

Ans: I was amazed at the efficiency and effectiveness of the entire organization of the visit. Most memorable visit for me of all the hundreds of local and overseas trips I have made over the past 5 decades. My lecture notes arrived in Tianjin just a week before I arrived. All 100+ attendees had copies of the notes translated manually. We needed an interpreter those days so lecturing was a challenge for me as well as the interpreter. It was hot and humid without AC. Huge fans blew air in the auditorium. The attendees came from the industry from around China. Drying was not a major academic discipline then but the industry and government recognized its importance in manufacturing in most industries. What amazed me was the deep interest and diligence of all participants who were trying hard to absorb whatever knowledge I could impart those days, despite the hardship. I travelled to several cities and visited many companies and universities. I noted a tremendous thirst for knowledge and a willingness to work very hard. In particular, every adult male and female worked according to their qualifications. I extrapolated this observation to what I knew about India and the West as well. It was really no rocket science to predict the economic miracle that transformed the country within three decades. Every time I visit even after four decades I see massive progress in every aspect of life for the population. Truly a model and case study for most countries to emulate.

Q. We know that you keep regular and fewest contact with your mentees which include graduate students, researchers, young faculty members, etc. Your messages include not only responses and suggestions on respective research projects but also caricatures, paintings, powerful quotes, the latest innovations, selected newsworthy items, useful statistical data as well as spiritual writings to some. Can you summarize the objective in trying to enhance depth of knowledge but also enhance breadth in research as well as humanities and arts?

Ans: It is well known that exposure to any art along with sciences compliments human brain activity as both sides of the brain are stimulated resulting in greater potential for innovation. In my opinion, it is not enough to become a talented researcher; it is arguably even more important for the world to become an ethical human being with empathy for all. I feel spiritual engineering in a broad sense, is a valuable asset for all professionals regardless of specific disciplines. So, the diverse feedback I send selectively is geared towards giving this added dimension to my mentees around the globe. I do feel confident that it has had a positive and lasting effect on most of my mentees. I am very proud of their accomplishments and contributions to society. I have successfully tried to connect many mentees over three decades

in different institutions, disciplines, and countries to collaborate productively via my communications. A complete response will need a booklet to explain with examples.

Q. Can you define success and the key elements that one needs to follow rigorously to ensure success?

Ans: This is a loaded question for there are as many definitions of success as there are individuals interested in achieving it. I cannot comment on the definition itself except to say that the goal should be to be happy one achieves success according to one's own definition without compromising ethical standards or adversely affecting others.

Recently I came across a post on Facebook that summarizes what I always had a similar list to accomplish one's goals. These are the seven Cs that are needed to ensure success in achieving goals. They are:

Character
Confidence
Concentration
Consistency
Commitment
Creativity
Courage

I would like to add the following three Ds to this list:

Diligence
Discipline
Dedication.

Indeed, a tall list but then achieving success is a dynamic lifelong process that requires continuous renewal of objectives depending upon the circumstances.

Advice to Young Researchers

Q. What do you advise fresh Ph.D. students for their career goals? What are the prospects for an academic career?

Ans: Clearly, my response is more applicable for engineers. Depending on your personal goals, I recommend that they consider both industrial R and D or academic career paths. In my case, I followed the former for two years and then switched to academia for the freedom to pursue your preferred areas of research. For-profit research generally is geared towards know how

while the later seeks know why which may not pay off in terms of profit. There are a few challenging academic jobs available now, and they don't pay as well too. So, one needs to decide if research and making an inclusive contribution to knowledge and service to society is one's dominant trait.

Q. Why did you choose an academic career yourself? What was the mentors' role?

Ans: My mentor advised me to get industry experience before deciding which stream to follow. I learnt a lot in my first R and D job as an aerodynamicist modeling using custom-coding to simulate multi-stage axial compressors for ethylene plants and diffusers. In fact, less than 10 per cent of what I learnt in undergraduate and graduate studies was relevant to what I had to do with no mentor or expert locally. CFD was an emerging area with no textbooks. I learnt CFD from journal articles in Aeronautical & Aerospace engineering as well as nuclear engineering as well as applied physics. What helped was my ability to self-learn and conduct research independently. Later, I used my knowledge of CFD to teach courses in computational methods and initiate research on modelling complex flows such as impinging jets on moving porous walls with transpiration. This was my first work related to impinging jet drying of paper and tissue. It helped my thinking about academic research. I did complex statically measurements of turbulence in packed beds as well as flow and heat transfer measurements in wakes of complex bluff bodies- both which were very fundamental in nature with no clear applications in sight. However, they were truly great learning experiences for me.

In later years, I was very comfortable wearing an industry hat in my consulting assignments and in teaching industry participants in workshops.

Q. What is your view on interdisciplinary, transdisciplinary, and multidisciplinary R&D? What would you like to suggest for young researchers?

Ans: I think this is increasingly important but not yet fully recognized. Most granting agencies and academic institutions to not yet "walk the talk". Drying for example, simply cannot be tackled by one discipline. As a minimum, you need to couple transport phenomena with material science. Now many industry problems need expertise in food processing, food chemistry, electrical engineering, nanotechnology, electrochemistry, control, artificial intelligence, machine vision, soil mechanics, biology, medicine, botany etc. the list is endless. This we need collaborators in various fields depending on the problem. International networking is needed to conduct impactful research these days. It also reduces the need for high financial and human resources while avoiding potential duplication of effort.

Q. What would you like to suggest to young researchers for pursuing higher studies in the present deglobalizing world?

Ans: Globalization occurred faster than deglobalization. The latter is something of a geopolitical issue I would rather not get into. Developed countries are concerned the flattening of the world in a knowledge economy could provide great advantages to emerging nations. In a wisdom-based economy, this will not pose a problem but provide a solution to alleviation of poverty and food insecurity leading to world peace and reduced conflicts. I think international expire is very important. One learns a lot by just being in a different environment. I recommend it strongly.

Q. Why do you recommend that all researchers must publish any new results they have? Should negative results be publicized as well? Why?

Ans: Publication in an archival journal improves the quality of research as it is peer reviewed by experts in the field prior to publication. Readers can confidently refer to the results to build up the next step and advance the knowledge frontier. Remember that conducting research is expensive; we cannot afford unnecessary duplication of effort and resources. If every group did similar research concurrently, there would be no real advancement.

Q. You had networked and sought virtual mentors even as a graduate student. Why and how?

Ans: We often can expand our mentorship base by reaching out to experts anywhere in the world who may have experience and/or expertise your research may need. Since most academics are not motivated by monetary rewards, they are often willing to spare time for serious mentees who may benefit from their guidance. It is useful even to study biographies or biodata of accomplished experts to learn from their professional journey. No university can afford to have permanent faculty that is expert in numerous rapidly evolving fields. Often, some of my senior graduate students have mentored graduate students in developing countries with limited resources.

Q. What is your advice to students doing a Ph.D. in the drying area?

Ans: Drying is multidisciplinary and generally an applied field. So, defining the problem is key to success. Now you can find, rather easily enough, resources to get going on almost any problem in drying. You may need to collaborate if you do not have the needed advanced

analytical tools or expertise locally to model a complex drying system. It is important to carry our an in-depth literature search and study the literature carefully. Often, researchers are not keen to read extensively, but there is no real easy alternative to it. Doing a PhD research project allows you learn basic engineering science as well as experimental techniques, optimization, control, computational techniques, etc. This knowledge can be readily transmitted to other research areas well. Most of my PhDs in drying projects are working very successfully in totally unrelated areas.

In my case I have worked with material scientists in pulp and paper, foods, grains, wood, ceramics, pharmaceuticals, coal, biomass etc. my engineering collaboration covers all traditional engineering disciplines including metallurgy and mining engineering. I could move across disciplinary boundary with no real problem. Of course, I have had to be on steep learning curves all my professional life which is what truly enjoy.

Q. Your thoughts on your mentorship and your own mentors?

Ans: I could write a book on this topic. I think this is very important for one's career. It is harder and takes much longer to achieve one's goals by trial and error. A true mentor can guide one on the right path-professionally and personally- in a shorter time so you can accomplish more in your career which has a limited period. As I have stated elsewhere in this e-book, one can have real and also several virtual mentors. In this internet age, it is easy to have virtual mentors whose career accomplishments you can know in advance and then try to develop links with him/her in cyberspace if necessary. I did that myself even while I was a Master's student at McGill. I shall not mention names as they were numerous and covered different periods in my four decades of professional life. I used snail mail to contact those who I thought had made key contributions in areas of my interest and sought their advice and critical comments. Surprisingly, I have had a high rate of success and this is why I have been able to work comfortably in multi-disciplinary areas covering many diverse themes. It is important to find mentors who are genuinely keen to see you excel and have no self-interest in doing so.

Q. What do you like and not like about academia?

Ans: I started my professional work in industrial R&D in aerodynamics- a far cry from my PhD work and experience. I was "forced" to self-learn CFD, aerodynamics of multi-stage axial compressors, design and build wind tunnel, and also start two-phase heat transfer modeling

work all in a span of little over 18 months. This is a huge change from academic life. The time scale of the projects was short and switches were made very swiftly with no input from those who carried out the research. Just as I began to develop the necessary background- all on my own- the project was changed depending on what the market needed. The attachment to a particular project which is essential in academic life can be a deterrent in industrial R&D since the attachment needs to be temporary and easy to break when one is assigned a different project at short notice. Doing research in a non-profit mode is very different from R&D that needs to be done for-profit in a much shorter timeframe. I like the freedom to choose (within limits since granting agencies now decide what you can do!) your research areas that one finds in academia. This mode does not work for all, however. I like the fact that your R&D effort is often put into practice in the industry while in academia it is rarely so. However, the good thing is that one can contribute to enhancing the pool of knowledge that someone can build up on in the future.

Q. Why did you leave lifelong tenured job at a renowned university like McGill to take on a smaller term contractual NUS position at a time when NUS was not a ranked university?

Ans: When I decided on the move over ninety percent of my contacts had this question. Only a few said it was consistent with my nature to take risks and go into the unknown as a challenge. The metrics of what I could do in the new position despite a massive disruption in my teaching and research areas and widely different academic cultures, show that the move was successful for the most part. I do not recommend such drastic action for all-in facts few can and should try this in view of the high-level risk involved. Aside from the fact I had to switch my research directions to suit mechanical engineering, I also was forced to limit myself to shorter-term research projects, which has serious ramifications for most. I did start totally new areas but thankfully managed to do enough contributions to these that I get invited for delivering keynotes and contributing to books or even writing/editing books in the new areas I worked in for just 3-5 years. This is a very short period for anyone to get into a new unrelated area and be recognized for the effort in a globally competitive research arena.

On the other hand, the challenge gave me extra drive to excel in a short time. I had to continue Drying R&D simply because I was committed to it and many around the world depended on me continuing strongly with IDS and Drying Technology journal. The fact that I could devote 12-14 hours a day to work and even vacations/weekends meant 5-6 hours of solid work, compensated for the fact that I had to continue earlier research line and add new ones

concurrently. In fact, as you know, 2011 was "bumper year" for my group with 30 journal papers, 2 books, 5 book chapters, 20+ conference papers and over 1000 citations to boot although my research is not in bio-nano-info area where lots of funding is available and there is a preponderance of researchers as well.

So, you can see it has been a good move made possible by the changes I made to my lifestyle, possible at a personal cost which is hard to estimate, of course. In the decade since I joined NUS the University and the Faculty of engineering made remarkable strides in research and is currently recognized as a research-intensive university with global reach. It is heartening to see this happen during one's relatively short association.

Q. Why did you not continue Exergex Corporation where you could do valuable industrial consulting even with Fortune 50 companies? Part of risk-taking nature and focus on change?

Ans: Exergex Corporation (1989-1999) was an outstanding experiment for me. As I stated elsewhere earlier, I call myself "An Accidental Academic"- a catchy title for a book! I never planned my career to become an academic. Four decades ago, the prospects (and salaries) were much better in industry and business. I had even considered an MBA at McGill rather than a PhD. The option quickly disappeared due to family commitments in India. I feel that, bar exceptions, an academic career gives one the opportunity to excel and make an impact beyond what is doable in the industry with its focus on profits and short-term gains. My industry friends may differ from my view. Of course, few academics actually make a true and lasting impact on the profession, but most do assist their mentees and to that extent, they have a significant impact. Academics can make a valuable contribution to the generation and dissemination of knowledge. As a consulting firm, Exergex helped many firms- some very large ones- improve their operations and possibly make huge profits as a result. I was happy to see I could use my fundamentals to solve interesting industry problems that never make into a journal or a textbook. This makes one's academic effort satisfying.

I must state that my own outlook toward engineering research in academia changed as I got exposed to numerous industrial problems. I find that in our coursework, we do not inject the ability to think critically and communicate well. This is a major theme worth discussing on its own. We need more faculty members with strong industry exposure to change the system adequately. The reason I decided not to do both industrial R&D consulting and academic pursuits was that I found it hard to do both at a level that I was happy with. Thus, I had to make

a clear choice. Post academic career I hope that I can revert to a smaller level of consulting activity.

Q. Who should take up industrial R&D vs academic job and why?

Ans: I have prepared a PowerPoint presentation on Traits of an Academic. They are clearly unachievable for the most part as several who saw that PPT wrote me. They are the ideals I look for. Passion to mentor students and researchers without a proportional return on one's effort and time doing this is a key requirement. One must strive for your mentees to exceed your own level of accomplishment and be happy when that happens. Dedication to the generation of new knowledge and disseminating it widely without commensurate material return is also a desirable trait in an academic. Industrial R&D must be profit-driven for survival. This is a big difference. Not all academics are able to work with industry for this reason. A few can do both by switching hats quickly and effectively. This is necessary for engineering research which must have some relevance to the real-world to deserve funding from taxpayers.

Q. How is the health of academic Research health globally?

Ans: It is generally good as most governments recognize R&D as being central to a nation's economy. However, generating many PhDs, and research papers that attract lots of citations cannot directly impact the economy. Basic research turns into economic return only when applied R&D brings it into practice which takes time happens rather rarely as well. In poor economic times R&D suffers disproportionately since its effect is felt years after the funds are spent. It is also hard to do proper accounting for the return on investment in R&D. many even consider it as an expense. It is well known that China is marching ahead with strong funding of research and select institutions of higher learning. Many Asian nations are following suit. In the coming decade, I feel that Asian universities will rise even higher in number among world's top universities. They have both the human talent and the financial resources to achieve this goal.

Q. What is your opinion is the effect of globalization on R&D? Is it positive or is it denting R&D activities?

Ans: The proverbial flattening of the world has generated the possibility to transfer financial resources where the talent pools are and vice versa. Both funds and talent are incredibly mobile now. Geopolitical boundaries now are very porous and flexible, allowing freer (not free yet!)

movement of finances and talent. This is a big boost for R&D, which needs highly qualified scientific and engineering manpower. Developing countries can now do high-end research and not just low-end manufacturing, which was the old paradigm. Of course, this has raised the bar on quality and effectiveness of R&D to die to increased competition.

Q. What about diverse ranking exercises around the world; which one should one follow?

Ans: This is both good and bad. Good because it provides an approximate benchmarking exercise. Bad because diverse criteria lead to major differences that make the interpretation of the ranking outcome confusing.

Institutions and even journal editors can see where they are in the pecking order and try to move up the ladder. This is a tough call since everyone is trying to do the same. Typically, climbing the ladder needs financial resources aside from human resources. Another undesirable part is that the rankings can be misinterpreted by those who do not understand the criteria well enough. Different criteria and different weights given to the same criteria lead to big changes in relative rankings. Some institutions can move a large number of places up or down without having done anything the whole year. The time scale of changes at a comprehensive university should be in the range of a decade at least. So a change in ranking in one year must be taken with a big dose of salt! As long as academia do not follow the needs of ranking agencies- typically profit-making organizations- to decide their academic policies, the ranking exercises are good. The motivation of the ranking agencies in conducting such exercises must be considered carefully as well.

Q. What are your post-NUS plans and how would you continue the path of impactful professional and personal development?

Ans: Had I continued at McGill I would not probably have considered the next move at all! So, it is a good thing as it allows me to consider many different options. The next one will include some time for myself as well. I need time to do some general reading that is not teaching or research-related, including books on the spiritual life. Also, I hope I can carry out more charitable work that can have a different type of impact- maybe even bigger and more important to society than what I have tried to do with mixed success so far. On the other hand, over four decades of academic and industrial experience in many countries has given me some unique perspectives that I feel should be shared not only with my mentees but maybe to a wider audience. I also feel we need to innovate more and use right part of our brain more routinely

than we actually do. When I started to do watercolors as a way to de-stress some six years ago, I began to appreciate the role of art in innovation. Do you know that Nobel Laureates in science are five times as likely as the common scientist or engineer to excel also in some art-form like music, painting etc., which use the right brain? Pity that universities tend to separate arts from sciences/engineering and perhaps do a major disservice to the future generation of students.
I hope to assist institutions and even individuals in many universities to enhance their academic activities in teaching, research, and/or service.

Q. How do you manage so many things at one time? Does only experience bring this or does it require some intellectual abilities?

Ans: With great difficulty, of course. One tends to become much more efficient at multi-tasking if you need to do fifty different things in a day. I feel one needs excellent memory to be able to process numerous tasks like reviewing manuscripts, writing papers, decision-making on manuscripts for journals etc. If I had to look up my hard drive for over 50% of what I do, my output will hardly be 50% of what it is. I am not sure if the Indian educational system I went through which required memorization to a much greater extent, helped me achieve this. I must say I am against rot eLearning myself. If there is an advantage as a by-product, perhaps the method improves one's memory skills (if one wants to).
The main driver for what I does is passion, dedication, and a feeling of responsibility to deliver on whatever I commit myself to. Maybe I have not yet mastered the "art of saying NO sufficiently politely"!

Q. What are your other interests?

Ans: I am hoping I can improve my dexterity with the paintbrush. I never did any sketching or painting before, I just jumped-started it without any guidance. I hope I can take some lessons and do better. I also wish to take up tennis once my wife, Purnima, and I settle into one location. We both like travel, photography, and of course watercolors. I hope Purnima's love with things spiritual will rub on me at some stage in the near future. It will require a lot of time to do the essential reading and listening. I also want to know more about world history- so far it has been geography only.

Q. What are your thoughts about your mentees? Are you satisfied with their work and contribution after they started their career?

Ans: For lack of a better word, I can call my students/ associates "mentees". Being older has at least one advantage here. I can dispense unsolicited advice but typically I avoid it. I provide a wider view and perhaps a "prediction" of the outcome of certain actions based on my long-may not be wise- experience. I try to provide career guidance by just providing my take on the pros and cons. Here is no free lunch. If something looks too good to be true, it almost always is. I encourage and help my students publish their work if it is of archival quality. This is a very time-consuming part of my job. At my stage having one or two or even ten extra papers have no real professional value to me personally. However, for a student for whom this could be the only paper he/she ever wrote, this is very important. So, as a mentor, I must help. I expect my mentees who went into academia to contribute to knowledge and also carry out effective professional service. I am delighted that the majority of my mentees have done so, and most who are at early stages in their career will soon do likewise. By and large, I am very pleased with the outcome. I know many will exceed what I have achieved in my own career. I believe in leadership by "role modeling". I do not ask others to do what I have not done myself and shown that it can be done. I believe in "leading by first doing".

Q. Besides being a successful academician, you are a great human being and a great family person. How do you manage this?

Ans: I am influenced by the value systems I picked up subconsciously from my grandparents and parents as a child and later as an adult from my teachers, mentors, and associates. My students and associates have mentored me very significantly; I am fascinated by what I learn from them while they think they are learning from me. Everyone has some outstanding personal trait that is worth emulating. I believe very strongly in being charitable in the true sense of the word without expecting anything in return. I believe in this "Gita" philosophy. I do not think I do anything to "manage" my personal philosophy which pervades seamlessly into my professional actions as well. The starting of the free e-book project is a case in point. I thought it would be a great idea to share one's knowledge with a wide readership that has access to the internet but not to the expensive books on technology that can help them in their livelihood. I am pleased I have so many like-minded colleagues and students who concurred. Thus, we now have a good collection of freely downloadable ebooks. One is even being used as a text at a major US university! Your own contribution to this effort at a very young age is truly remarkable ad something you ought to be proud of.

Q. What would you like to do professionally after completing your NUS term? I think it is too early to retire fully. In fact, your highest research productivity came about in 2011-2012 at a stage and age when most academics truly retire from research and ramp down their activity and output.

Ans: Indeed, surprisingly my research output measured by conventional metrics seems to have peaked when it should be ramping down. The tapering down started two years ago when I stopped taking on new students although there was also a rise in excellent students from very elite institutions wanted to do their PhD under my mentorship. On the other hand, numerous institutions have inquired about my plans and want them to include shorter or longer-term regular visits. I have not decided yet what I will do as I do want to allocate time for our grandsons in the USA! I think I can better serve institutions serious about enhancing their global reach and achieve higher quality in graduate studies and research. It is important for such institutions to be able to attract strong faculty and then mentor them to excel. I find most young faculty in most places simply do not know of suitable role models and advisors they can rely on. Publication in journals is another area where researchers need guidance. I have contacts in over 40 countries-many are decades-long. The TPR Group is an excellent network and new members can benefit from the linkages. I would like to help senior administrators of academic institutions develop networks of excellence and effectively "get more from less". Everything is globalized these days so having good networks is important and yet not easy to build. It is necessary to have visibility and credibility which I hope I can bring to such institutions.

Aside from the above I hope to continue to guide PhD students at many institutions and publish articles. I will continue to edit the journal for some more time at least and also help with the Drying conference series in many parts of the world.

So, my plate remains full- if anything overflowing...!!

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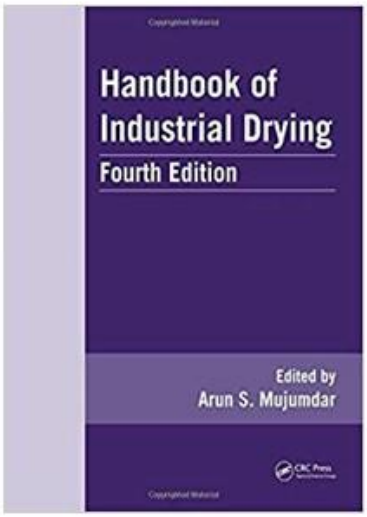

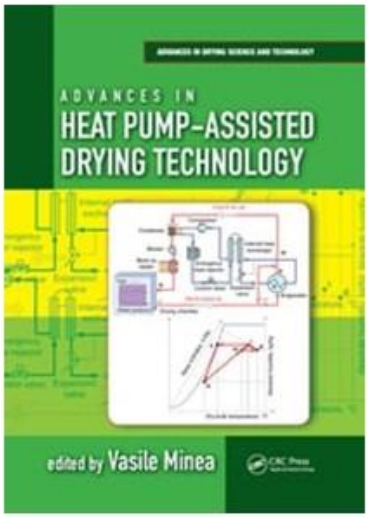

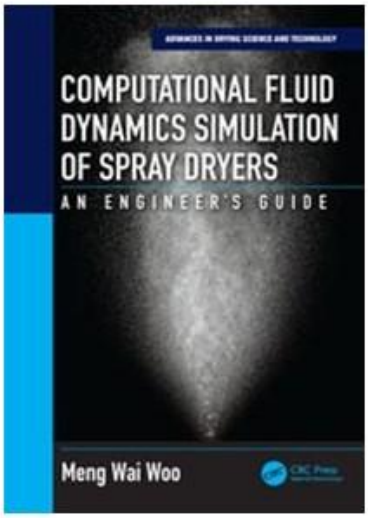

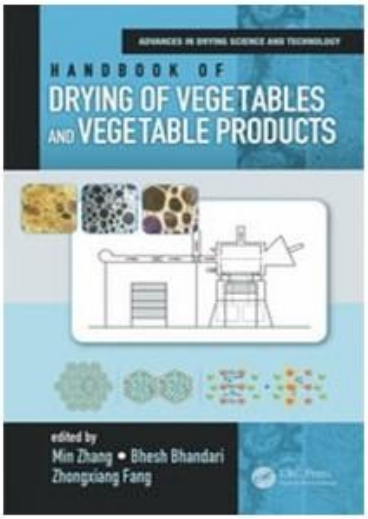

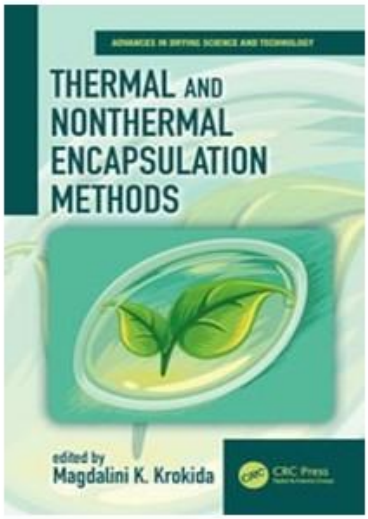

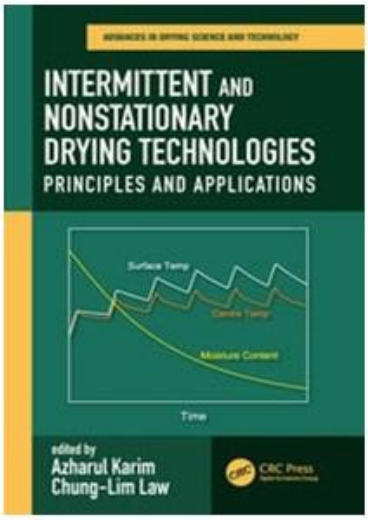


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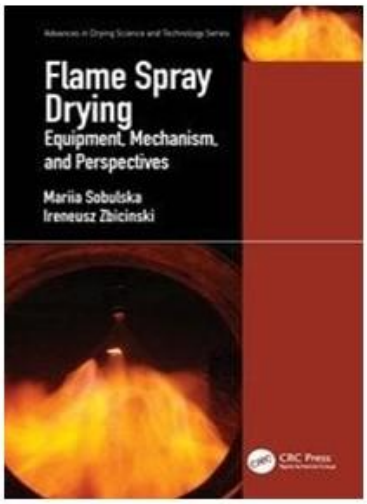

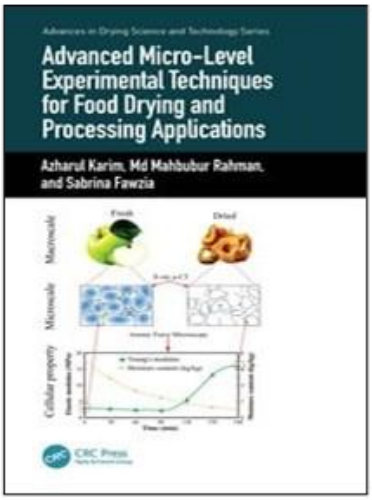

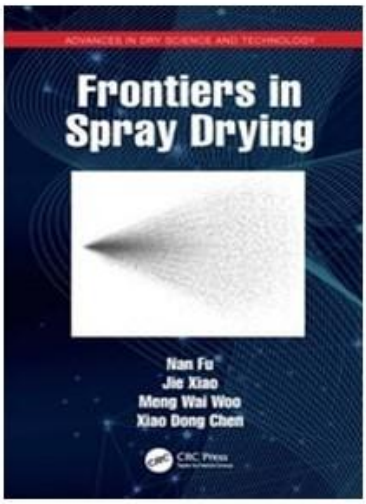

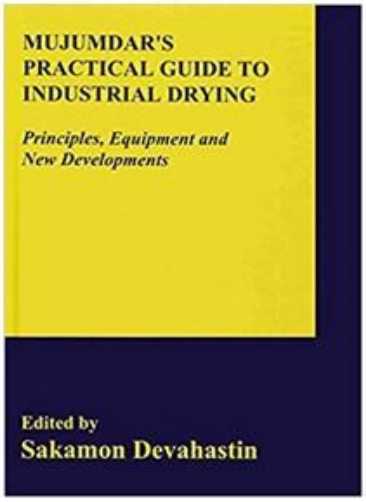

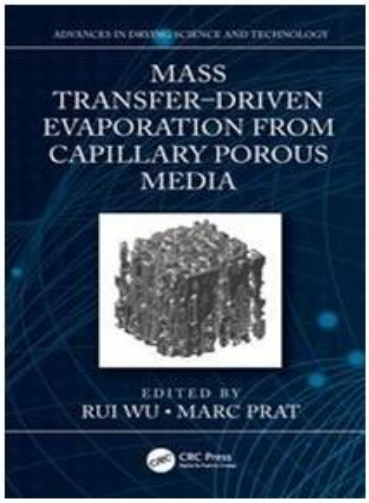

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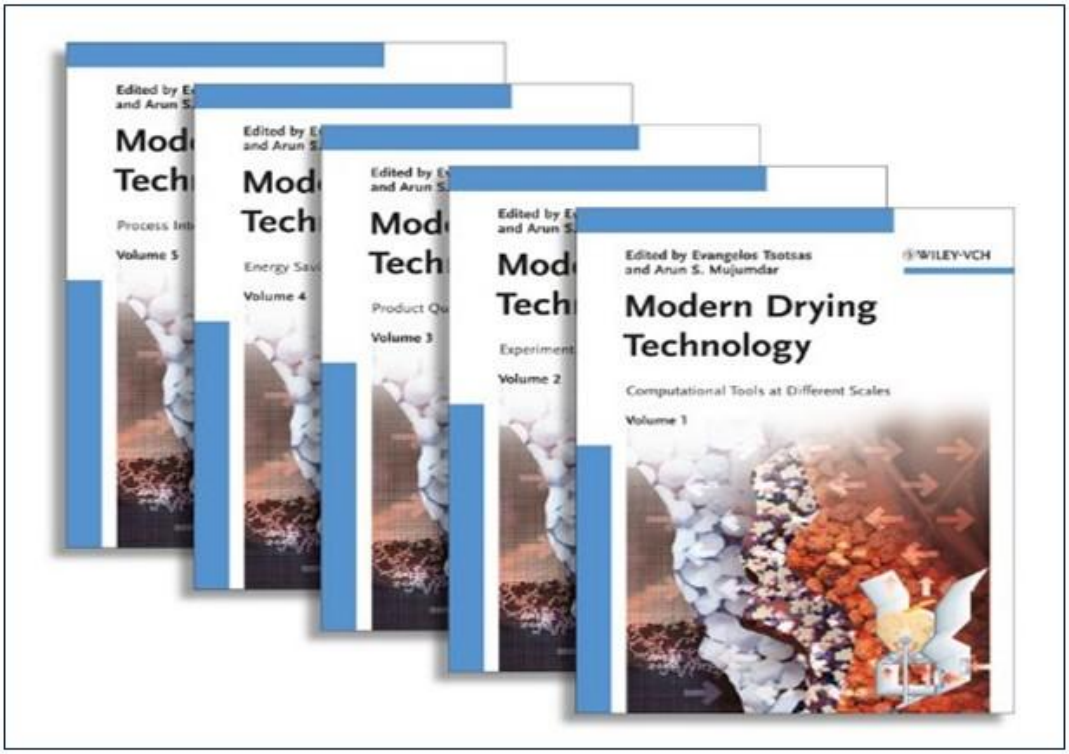

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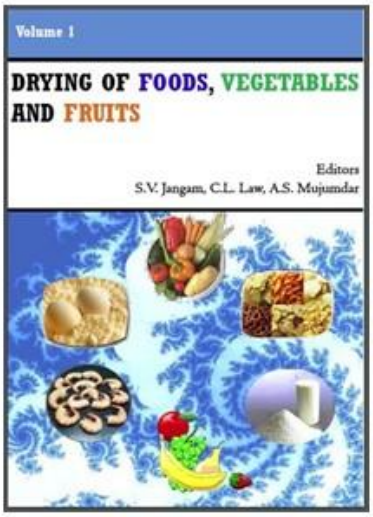

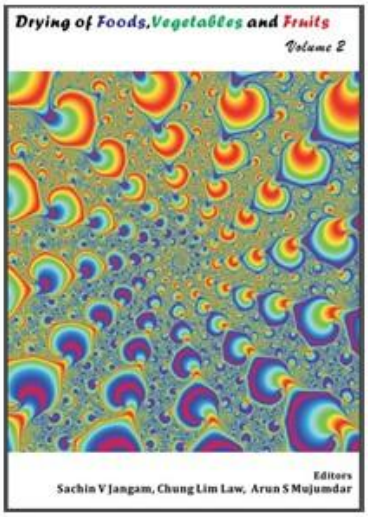

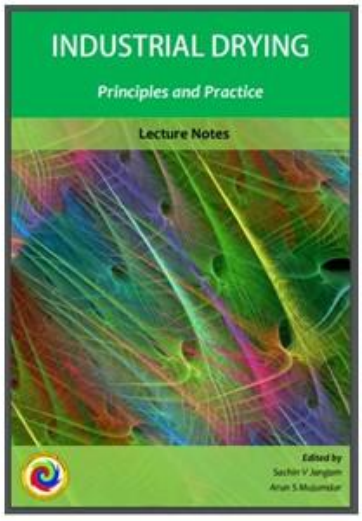

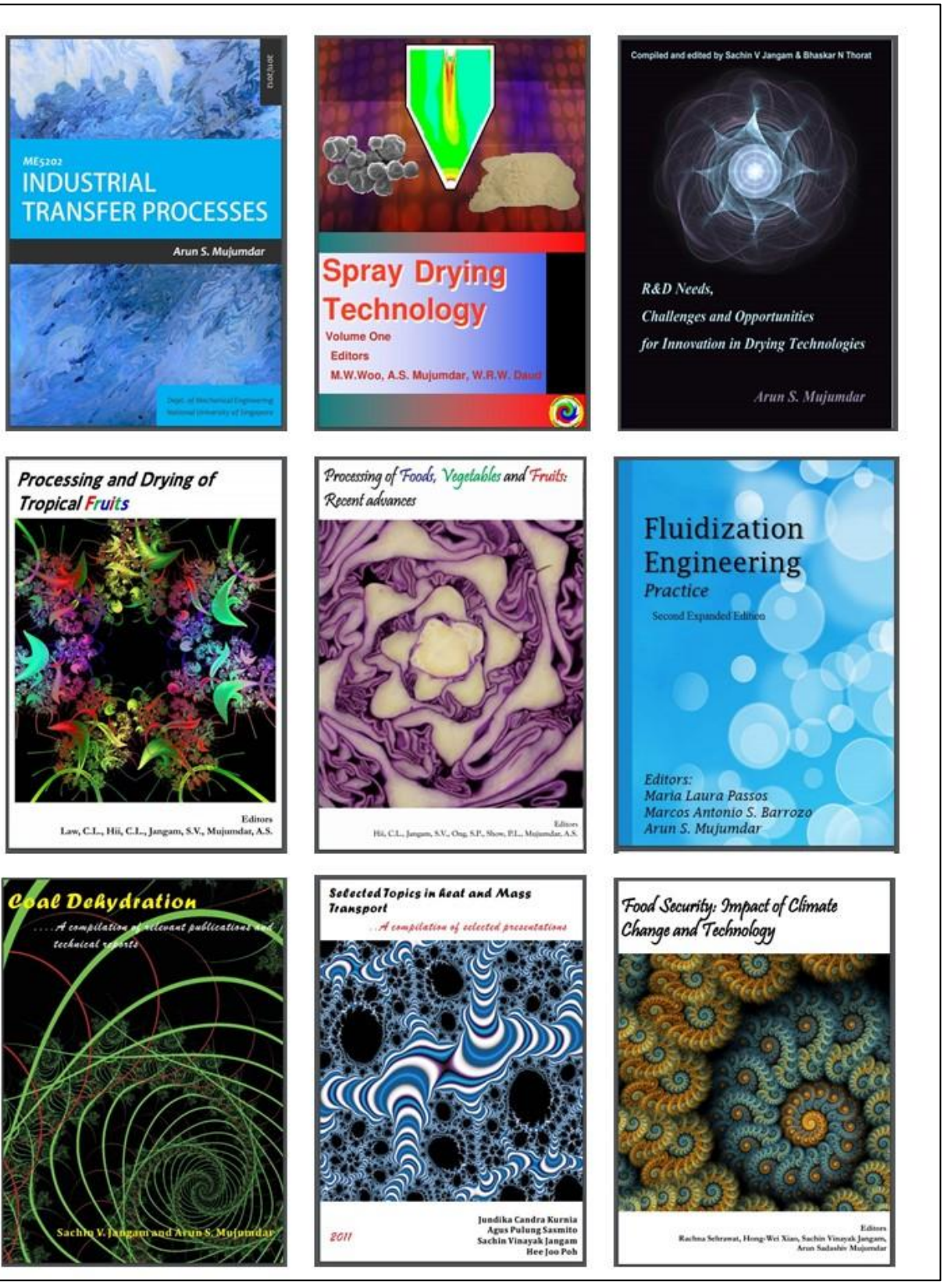
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