Proceedings of One day Workshop on

"MULTIPHASE FLOW"

September 02, 2017

Organised by
Department of Chemical Engineering
National Institute of Technology Karnataka
Surathkal, Mangalore - 575025

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About the Workshop on "Multiphase Flow"

For a flow to occur there should be a driving force and this force may not be limited to a single phase. There may be many phases driven by a single force of gradient and this may lead to simultaneous flow of two or more phases where these phases may interact at their interfaces which can be termed as multiphase flow. It covers a diverse range of flow phenomena involving various combinations of phases like solid, liquid and gas. The presence of an interface varying over space and time renders the hydrodynamics of two phase flow substantially different from single phase. Thus a multiphase flow is the flow of mixtures of phases (gas - bubbles, liquid - droplets, solid-particles) in a continuous medium which could be a liquid or gas. For example two-phase flow in a fluidized bed can be illustrated as a system of particles distributed in a gaseous/fluidic medium with geometrical arrangement of phase boundaries.

Three phase flows are common in chemical engineering applications especially where gas bubbles in slurry flow systems are considered. For many years the design of these three phase systems were based on empiricism. However innovations in sophisticated measurement techniques have improved the quantification and control of multiphase systems. The introduction of numerical methods and upgardation of computational techniques have lead to the greater achievements in the design of the multiphase systems.

The Department of Chemical Engineering since its inception has been engaged in addressing multiphase flow problems faced in both industries and research areas. The father of Chemical Engineering Department at NITK Surathkal (KREC), Prof. M G Subba Rau had great vision which

helped his faculty/colleagues to experiment and innovate methods/techniques and to fabricate systems in the departmental workshop to handle the multiphase problems. The faculty have diverse interest in addressing the multiphase related problems like handling, controlling, converting and transforming processes of multiphase systems. Some of the problems addressed, consisted of multiphase systems like spouted beds for solids drying and as bioreactors for effluent treatment processes, pulse-plate columns as bioreactors for effluent treatment, rotary disc contactors involving, two-phase aqueous systems for extraction of valuable components, catalytic photo-oxidation systems, drug delivery systems, establishment of multiphase systems for synthesis of nanoscale particles and bio-active molecules. Also, certain theoretical analysis of flows in microchannels and molecular stability using sophisticated computational techniques, have also been carried out.

The domain of multiphase system being expansive few topics of interest viz. Pollution Control, Sensor based Control System, Spouted Bed Contactors, Hydrogen Production and applications of multiphase flow system in oil and gas industries will be explored in this one day workshop.

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Dr. Hari Prasad Dasari, Asst. Professor
Dr. Chinta Sankar Rao, Asst. Professor

Workshop Schedule

Venue: Seminar Hall, Lecture Hall Complex C

9:00 am to 10:00 am	:	Inauguration
10:00 am to 10:30 am	:	**high tea**
Technical session 1 **10:30 am to 11:15 pm**	:	Professor D V R Murthy, Dept. of Chemical Engineering, NITK, Surathkal
11:15 pm to 12:00 pm	:	Professor T K Radhakrishnan, Dept. of Chemical Engineering, NIT, Trichy
12:00 pm to 12:45 pm	:	Professor S. Sundaramoorthy, Dept. of Chemical Engineering, Pondicherry Engineering College, Puducherry
12:45 pm to 1:45 pm	:	Lunch
Technical session 2 **1:45 pm to 2:30 pm**	:	Professor Madhu Gopal, Cochin University of Science and Technology, Kochi
2:30 pm to 3:15 pm	:	Professor Murthy Shekhar, Dept. of Chemical Engineering, Siddaganga Institute of Technology, Tumkur
3:15 pm to 4:00 pm	:	Ms. Deepthi Chaudhry, Manager, Technical Services, OMPL
4:00 pm to 4:30 pm	:	High Tea
4:30 pm onwards	:	**FELICITATION CEREMONY**

Spouted Beds

Professor D V R Murthy
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Spouted beds are fluid-solid contactors used to contact coarse granular solids with a fluid to perform a unit operation or a unit process in chemical process industries. The fluid may be either a gas, vapour, liquid or a combination of two. Mathur and Gishler developed the spouted bed contactor in 1954 at the National Research Council of Canada for drying wheat grains. A systematic recirculation of solids and absence of any bubble formation or slugging in the bed are typical features of a spouted bed. These features, when compared to fluidized beds, enthused many researchers around the world to find the use of spouted beds in a wide variety of processes. In addition, many proposed modifications to conventional single spouted beds helped to consider scale-up of these contactors for large-scale operations. A brief overview on these devices is the focus of this presentation.

Application of Soft Sensors in Control of a Process Intensification System

Professor T K Radhakrishnan
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The design and implementation of recurrent neural network (RNN) based inferential state estimation scheme for an ideal reactive distillation column is presented. Various control structures are presented. Decentralized PI controllers are designed and implemented. Further, the advantage of using parallel cascade controller is also evaluated. The reactive distillation process is controlled by controlling the composition which has been estimated from the available temperature measurements using a type of RNN called Time Delayed Neural Network (TDNN). The performance of the RNN based state estimation scheme under both open loop and closed loop have been compared with a standard Extended Kalman filter (EKF) and a Feed forward Neural Network (FNN). The online training/correction has been done for both RNN and FNN schemes for every ten minutes whenever new un-trained measurements are available from conventional composition analyzer. The performance of RNN shows better state estimation capability as compared to other state estimation schemes in terms of qualitative and quantitative performance indices.

Catalytic Steam Reforming Process for Production of Hydrogen – A Case Study in Modeling and Simulation of Multiphase Flow Reactor

Professor S. Sundaramoorthy,
Department of Chemical Engineering,
Pondicherry Engineering College – Puducherry - 605014

In future, demand for hydrogen as an environmentally friendly fuel will be on the rise as hydrogen will be used as a feed stock in fuel cells for production of electricity. Catalytic steam reforming of natural gas is a principle process used in industry for large scale production of hydrogen. With large resources of natural gas available in the world, the steam reforming process will become more attractive for hydrogen production. Increasing demand for hydrogen will require more efficient design and operation of steam reforming process.

The presentation will cover the derivation of one dimensional model equations for an industrial scale methane steam reformer and simulation of model equations for obtaining optimal plant operating conditions. As the reactions are reversible and endothermic, the maximum achievable methane conversion was limited to around 50%. In order to achieve a higher methane conversion, the Membrane Steam Reformer (MSR) is taken up in this study as an alternative to the conventional steam reforming process. The use of a permselective Pd membrane shifts the equilibrium toward hydrogen production yielding high methane conversion at relatively lower temperature. A mathematical model for the Membrane Steam Reformer is developed and simulation studies are carried out to compare its performance with the conventional steam

Multiphase Flow in Pollution Control Systems

Prof. G. Madhu
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Cochin University of Science and Technology
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Multiphase flow is encountered in many of the systems used for air pollution control as well as waste water treatment. Several authors have attempted to model and simulate the multiphase flow phenomenon taking place in these systems. This paper discusses the multiphase flow phenomena associated with the following pollution control systems.

1. Bubbly two-phase flow in waste treatment
2. Granular sludge formation and flow dynamics in activated sludge process
3. Fluidized bed reactors for waste water treatment
4. Particle-laden flow in cyclone separators.

Multi-phase Flow Metering In Oil And Gas Industry

Dr. S. Murthy Shekhar
Department of Chemical Engineering,
Siddaganga Institute of Technology, Tumakuru-572 103

Abstract: In oil and gas industry, for many years operators have expressed the industry's need for multiphase flow meters, since measurement is at the core of all surface testing applications. With increase in capital cost and energy cost, in the exploration of crude oil, a need for accurate and reliable methods of measurement in well surveillance and monitoring, production optimization, flow assurance and fiscal or custody transfer have led to application of different types of multi-phase flow metering systems in practice. In the production cycle, with varying flow rate during the life of well leading to changed flow regimes, measurement of delivery of three phases oil, gas and water is being done by measuring phase velocity and phase fractions using different techniques.

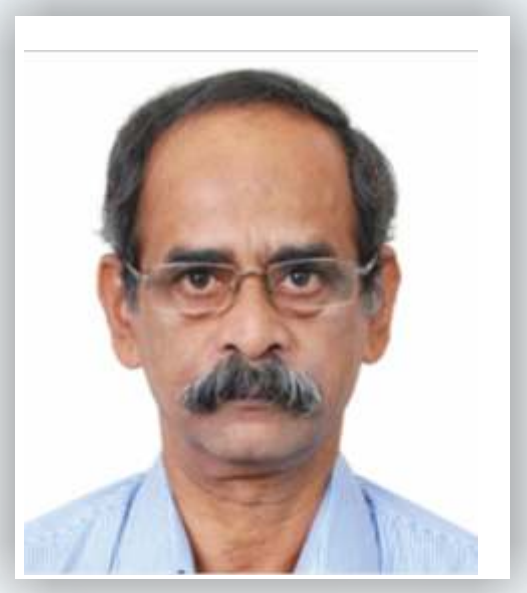
In this regard, a need exists to understand the various multiphase flow metering principles and their suitability in measurement of two and three phases that exist in the oil industry. With change in availability and nature of crude oil, new challenges to be faced in application of multiphase flow metering techniques.

Industrial Applications Of Multi-phase Reactors

Ms. Deepthi Chaudhry,
Manager, Technical Services,
ONGC Mangalore Petrochemicals Limited, Mangalore – 574509
Email: deepthichowdary@omplindia.com

In a refinery/Petrochemical complex multi-phase reactors play a major role in converting the crude oil to high value added products ranging widely from aromatics to different Petrochemical products like paraxylene, benzene etc in the downstream units. Technological development in this area is resulting in increasing yield and quality of the products. Major industries are upgrading their assets periodically to reap the benefits of various new technologies available world-wide. Innovations in the reactor design and catalyst formulation will be discussed during the talk.

Felicitation



Prof. Duvvuri Venkata Ramana Murthy

About Prof. D. V.R. Murthy

Prof. Duvvuri Venkata Ramana Murthy, known amongst his colleagues as DVR Murthy, was born on 14th August, 1952. He obtained his Bachelors in Chemical Engineering from Andhra University, Vishakapatnam in 1974. He did Masters in Chemical Engineering from Birla institute of Technology and Science, Pilani, Rajasthan, in 1976. Prof. Murthy started his career as a project associate in a DST sponsored project at Indian Institute of Technology, Madras and worked there for one and a half years. Later he moved to Manipal Institute of Technology, Manipal as a lecturer and worked there for a little over three years. He joined Karnataka Regional Engineering College, Surathkal(presently known as NITK, Surathkal) as lecturer in the year 1982, and has been working in this institute ever since. He became an Assistant professor in the year 1991. He obtained his PhD in 1992 from Mangalore University working under the supervision of Prof. P N Singh. Prof. Murthy became a professor in 1997. He served the institute in various capacities, which are:

- *Chairman Center for Continuing Education, 1998-2002.*
- *Head of the Department, Chemical Engineering, 2000-2003.*
- *Chief Vigilance Officer, 2006-2008.*
- *Dean(Planning & Development), 2008-2011.*
- *Coordinator Mentoring NIT, Goa during 2011.*
- *Chairman, Library Advisory Committee, 2011-2016.*

In addition to the above mentioned official roles, Prof. Murthy was also actively involved in very many activities like: the development and updating various laboratories in the department under M H R D funded schemes like I I T- R E C Network Scheme and Modernization of laboratories; Staff Adviser to the Association of Chemical Engineering Students, K R E C, Surathkal for three years; Assistant Warden (Maintenance), K R E C Student Hostels for two years looking after the maintenance of all Hostel Blocks; Honorary Regional Secretary to the Mangalore Regional Centre of Indian Institute of Chemical Engineers for two years during 1994-96; Chairman, Board of Examiners for B.E. (Chemical Engineering), M.Tech. (Chemical Plant Design) and M.Tech.(Industrial Pollution Control) of Mangalore University; Member of Board of Studies in Chemical Engineering of Mangalore University; Member of Board of Examiners and Board of Studies in Chemical Engineering of other Universities and Autonomous Institutes; Member of two committees for organizing the I S T E National Convention in K R E C, Surathkal

during December 1991; Member of various committees for organizing the Annual Convention of Indian Institute of Chemical Engineers held in Manipal during December 1992; Delivered several invited lectures in various institutions, short-term courses and continuing education programmes.

Prof. Murthy was also active in the sphere of professional consultancy related to the "Simulation of Ammonia Synthesis Loop for Modifications", at Zuari Agro Chemicals Ltd., Goa. He was involved in the collection of data and report preparation on the "Calibration of Waste Water Pumps" of various pumping stations in Mangalore City Corporation under the DANIDA-DEE EMPS Project. He also contributed in the product analysis and testing work for various industries in the region.

Prof. Murthy's professional activities entailed him to visit various countries. He attended a Professional Development Course on "System Management and Capacity Improvement of Technical Education ", October 13 – 18, 2008, Asian Institute of Technology, Bangkok, Thailand. He visited Loker Hydrocarbon Research Institute in University of Southern California, Los Angles, USA, May 20 – June 28, 2013 to interact with a research group working on Methanol Economy. He also attended 8th Asia – Pacific Drying Conference to present the research paper entitled "Grain Drying in a Multiple Draft Tube Spouted Bed – A Preliminary Study", August 10 – 12, 2015, Kuala Lumpur, Malaysia. He has visited Japan from March 01, 2016 to March 05, 2016 to attend 5th International Engineering Symposium (IES 2016) in Kumamoto University, Kumamoto and delivered a Key Note Lecture.

Prof. Murthy has guided 5 research scholars towards Ph.D and 66 M.Tech students in their project work, in addition to providing guidance to innumerable B Tech students. The results of these research endeavors culminated in a large number of peer reviewed publications and two applications for patents.

Prof. Murthy has been a role model for all his colleagues in his punctuality, dedication and earnestness in all activities related to his professional life. His simplicity and friendliness are qualities that many of his colleagues would like to emulate.

Prof. Murthy is blessed with two children. His son D. Subramaniam, has done his PhD from CALTECH, USA, in Aerospace Engineering and is at present a Post-Doctoral Fellow at Princeton University, USA. His daughter, D. Neelima is a Bar council registered legal practitioner.

On the occasion of his retirement from service on attaining superannuation, we wish him a very happy, healthy and contended retired life.

A note of thanks…

DVR – my friend!!

In 1980 I had just joined the prestigious KREC (now the NITK) Chemical Engineering Dept as Lecturer after doing a 3-year Doctoral Programme at I.I.T. Madras, when I was sent as an External Examiner for a Practical paper at Manipal Institute of Technology. This is where I first met the irresistible DVR Murthy!! He was the Internal In-charge of the Lab and my co-examiner. With his curly hair and thick moustache, Murthy straight away made an imprint in the mind. However what struck me most were, his mercurial movements inside a chemical engineering Lab full of water pipes and fixtures and so many equipments .!!! I recall a few more similar interactions with Murthy... till one fine day in 1982 he joined the faculty of KREC Chemical Engineering Dept.

In my time, I must say KREC Chemical Engineering Dept was under the respected stewardship of highly renowned Prof. M. G. Subba Rau, who was revered by all of us as "Father of Chemical Engineering". The Department also boasted of eminent Professors namely Dr. P. N. Singh, Dr. NCLN Charyulu, Dr. M. S. Kamath (fondly named the big three), Prof. Ranganathayya and Prof. DiwakarRao. In fact I also had the privilege of studying under the tutelage of these great intellectuals for my B.E. and M.E. Degree courses. So, when I joined this great institution as a staff member, it was a dream-come-true moment for me. It was their selfless guidance, support and mentoring, that not only helped me to evolve as a teacher but also ingrained in me a spirit of leadership, friendship and societal well-being.

So, when DVR joined us in 1982, we two were relatively green horns. Both being in the same age group, we gelled well and became good friends. I recall Mr. Murthy was very strong in subjects like mass transfer and reaction engineering (Chemical Kinetics), He also took thermodynamics, I think. He used to take very

active role in practical too, always involving himself and guiding the students. Subsequently Dr. Sriniketan joined the Department in 1983/84. I knew Sriniketan earlier too at I.I.T. Madras. We three formed a nice 'second' team, I recall. Later on Mr. Gopal Mugeraya also a proud KRECean joined us.

I must say, KREC days were the golden years of my life not only because of the academic excellence and team spirit but also because of the love and affection of our mentors and colleagues like Murthy. Even though I left KREC in 1986, our affectionate association & friendship continued all through. There were many forums and social functions where we continued to meet and enjoy the days.... well, even today....

I whole heartedly complement DVR Murthy for his dedicated services at KREC and I am really thrilled to see that the Institution and the Department have grown manifold over these years. This has been possible only due to people like Murthy who have given their entire career to strengthen the academic ambience of this great institution.

I sincerely wish Murthy & his family the best of health, goodwill and prosperity in his post-KRECean life!!

Sri. Hatwar

Sr. VP- Corporate Environment & Sustainability, GVK,
Mumbai International Airport Private Limited, Mumbai

My Good Friend

I am extremely happy and delighted to comment on my acquaintance with Dr.D.V.Ramana Murthy on the occasion of his retirement from service at N.I.T.K, Surathkal. My association with Dr.Murthy dates back to late1960s during our college days at Andhra University College ofEngineering, Visakhapatnam. My close interaction with Dr.DVRM had started since 1982 when I joined M.I.T, Manipal. Dr.Murthy has been my senior as teacher though I am senior to him at the college.

During my journey as teacher, I have the good fortune and privilege ofworking with stalwarts Dr.M.G.Subba Rau, Dr.P.N.Singh, Dr.Charyulu, Dr.Kamath, Dr.Ranganathaiah and also very good friends and wellwishers Dr.DVRMurthy, Dr.Srinikethan, Dr.Saidutta, Dr.Gopal, Dr.Vidyashetty and other colleagues. Dr.DVRMurthy has been my good friend, philosopher and guide throughout my journey as teacher at M.I.T, Manipal. Dr.Murthy has occupied all academic positions at the department level and also key coveted positions at the Institute level. All through his service, Dr.Murthy has displayed his sincerity, dedication, impartiality and above all his unquestionable integrity. Dr.Murthy has been an asset to the Institute and played key role in the development of the Chemical Engineering Department and also N.I.T.K, Surathkal. He is very much liked and respected by all colleagues at the Institute and his efforts are well appreciated by the higher authorities.

Dr.DVRMurthy is a role model for teachers. He is an outstanding teacher, academic researcher, Guide and philosopher for many colleagues and students. He

used to devote time even after working hours to educate and guide youngsters. Dr.Murthy played several roles as teacher, mentor, counsellor, adviser, friend and confidant.

Dr.Murthy has taken active role in nurturing Mangalore regional Center of IIChE and has been popular among leading Industry professionals in and around Mangalore and many other places. He has been nominated to various prestigious committees of Karnataka Government and Central Organizations. I always recollect and cherish the memories of best part of my life inthe company of my good friends Dr.DVRMurthy, Dr.Srinikethan, Dr.Saidutta, Dr.Gopal and feel elated in my spirits. Dr.Ramana Murthy has been very lucky to have an understanding Life Partner and two loving children.

On the occasion of his retirement, I take this opportunity to thank Dr.DVRMurthy for being my good friend and well wisher and wish him a happy, cheerful and healthy retired life.

With warm regards and best wishes,

Dr. B.N.Reddy
Retired Professor, MIT, Manipal.

Prof DVR Murthy:
Reflections and Recollections from Roaring Eighties

I have great pleasure to write this narrative to felicitate Prof DVR Murthy upon his retirement from active service at the Chemical Engineering Department, NITK Surathkal. My reflections and recollections take me to mid-eighties, when my batchmates and I joined KREC as seventeen- year olds; fresh from a secure home life to a campus, miles away from home, that remained our home for the next four years. It was also the era, when breathtaking changes were happening at national and global level, and we were the testimony of the timeline that eventually changed India for good. Anyways, the topic for discussion is about Prof DVR Murthy, and I will stay focused on that!

The reason why I alluded to our sojourn as late teens is because the mind is very impressionable and our idealism hits the roof at that age. We believed we can become anything and do everything. Well, those are tall orders and we all know how the landing is when reality strikes in! However, we owe a ton of gratitude to all the faculty, staff and fellow students @KREC for laying a solid foundation in our personal and professional lives, so that we stayed on track to realize our destiny and became good fellow citizens. Prof DVR was unanimously one such faculty who chiselled and shaped our lives; passionate about teaching; strict when required; sincere, committed, articulate and dedicated to the cause; and always positive in life. I join my fellow graduates of several generations from our illustrious ChE Department to honour and express our sincere gratitude to Prof DVR for everything he did for the department and later at the college level.

The recollections are many; I want to highlight a few to make my statement. Those days, the course curriculum was so designed that we had the senior most faculty to teach Process Calculations in third semester (in our case, it was the legend Prof MG SubbaRao). What an amazing approach to settle us down and kindle the love for Chemical Engineering very early in the program! Sometimes, when Prof MGS had other engagements, Prof DVR came over and just continued where Prof MGS left! It was seamless and the knowledge just got transferred without any glitch! I heard later, after Prof MGS retired, Prof DVR took over teaching this important course - a testimony to demonstrate his passion for teaching.

Now, let's talk about Perry. For generations of students, this was a mantra that got drilled into us during the six-hour-long labs. The editors of this handbook in the US wouldn't have found a better champion than Prof DVR to properly utilize this treasure trove of knowledge. Of course, I am stating this in lighter vein! The importance of using theoretical framework to validate the experimental results is definitely a substantial contribution of the department, particularly at the undergraduate level. I appreciate the efforts of Prof DVR and other faculty to have had us trained in this mindset, which personally helped me immensely as I worked on my Masters and Doctoral studies after my

graduation from KREC. Further, this continued as I embarked on an academic career at Kansas State University, USA. Doing laboratory experiments is part of any ChE curriculum; however, to inculcate a genuine interest in the rationale behind the experiments has definitely been the forte of the department and Prof DVR with his persistence and commitment worked hard on the students to develop these skills set.

Moving on, all of us are indebted to him for his fine exposition of CRE fundamentals and its applications in various process configurations, when he taught us CRE I and II in our final year. Personally, I benefited immensely when we worked on our project and design thesis. Though he was not our direct supervisor; however, he took more than random interest in our work. I still recollect the late-night adventures when we were working on RTD studies in the rotary drum dryer; how he and Prof Sundaramurthy diligently pursued us to make us realize the importance of doing high quality experiments with proper theoretical understanding.

Let's fast forward to December 2015. The department celebrated its 50 glorious years of functioning and I was fortunate to have participated in the celebrations. It was indeed a rare treat to witness all the stalwarts (both from the past and the present) that were instrumental in making the department a top-notch place to pursue ChE in the nation. Prof DVR along with other faculty was very actively involved in attending to every detail and I was moved when they elected to have alum like me to felicitate the esteemed faculty and staff. Primarily, we were pleased to realize that the Future of the Department is perfect – the baton has been successfully handed over to the new and energetic faculty that are at the helm of affairs. The past traditions and innovative futuristic idea shave been judiciously blended as a way forward. For this, we should be thankful to the faculty, including Prof DVR, that took up the responsibility to steer the ship through all challenges and ensured that the department evolve as an outstanding teaching and research program.

Sir, it is a pleasure knowing you. We rarely come across individuals that make the best use of the available resources to excel in their output, so that the future generations will walk on the footsteps left behind by you. Your passion for teaching and research is exemplary and I join all the fellow graduates from our department in applauding all your achievements. Your physical presence in the department will be missed, but your legacy will continue forever.

Venkata Praveen Vadlani
Class of 1988
President, Saivera Bio
(Formerly Lortscher Endowed Associate Professor
in Renewable Energy
Kansas State University, USA)

My Good Friend- Prof. DVR Murthy

Every week day, for the past seven years after moving into my present quarters, I have seen a neatly dressed, bespectacled man with a bag slung across his shoulderand halfhidden under a massive black umbrella brave torrential rain or the merciless sun and walk briskly to the Instituteat exactly 1.30 pm. This image of my good friend, Prof. DVR Murthy perfectly symbolizes hisunique characteristics - simplicity, punctuality and commitment to duty. For me, he is one of the last 'old school', KREC teachers who lived by a set of values that is best described by William Burroughs's saying – "The aim of education is the knowledge, not of facts, but of values." For them, moulding the character of the student was just as important as the subject taught.

Prof. Murthy has earned the reputation of being an excellent teacher who made sure knowledge was transferred in the class room through the simple, yet effective 'chalk and talk' approach. I am given to understand that even during the last semester of his tenure, he prepared for each of his lectures the way did at the beginning of his career. A few months ago, he borrowed a text book from me and I was quite amazed to know that he wanted to learn some concept in fluid mechanics from a different perspective so that he could help his doctoral student! Prof. Murthy truly cares for his students. He knows the names of each of his students, mentors them and stays in touch with them even after they graduate. He is also fiercely proud and possessive of his profession, Department, Institute and country and will get greatly agitated when their reputations are sullied because of faulty policies, inefficiency or unethical practices. Senators have been witness to his often emotional and passionate pleas aimed at improving the quality of education at NITK. During his successful stints as Head of Department and as Dean (P&D), Prof. Murthy embodied the much desired traits of an efficient 'administrator-with-a-heart'; taking everybody along, being unbiased, honest and ethical, and offering a good word to even the subordinate at the bottom of the administrative ladder.

On a personal note, I have greatly benefited from the friendship and interactions with Prof. Murthy gaaru, as he is fondly known. In particular, I am grateful to him for the hand-holding when he passed the baton of Dean (P&D) to me. For over 3 decades we have exchanged notes on a variety of issues ranging from teaching to philosophy which have provided me an insight into the personality of this sensitive and spiritual man. Generations of students in the Department of Chemical Engineering at KREC/NITK Surathkal were fortunate enough to have been tutored and mentored by this greaty in a new role. teacher and human being.

On the occasion of his superannuation from service at NITK, I am reminded of Richard Bach's famous quote – "What the caterpillar calls the end of the world, the master calls a butterfly". I am sure Prof. Murthy will continue to actively contribute to society. May you and your family remain blessed Prof. Murthy gaaru.

Lakshman Nandagiri
Professor,
Department of Applied Mechanics & Hydraulics
NITK,Surathkal.

Fond Memories

A teacher plays a significant and indelible role in life of human being. When it was suggested to share the memories of moments spent with beloved teacher Prof DVR Murthy, I felt privileged and honored, being one of his old students. Though it is three decades back, on time scale, still it is fresh listening to Chemical Reaction Engineering (CRE) lectures of him. CRE develops general principles useful in approaching a variety of systems (chemical; bio chemical; environmental etc) where engineering of reactions is needed. Young DVR Murthy was trying, penetrating minds of budding chemical engineers with the concepts of batch reactor; stirred tank reactor; plug flow reactors and their combinations for achieving highest conversions. Perhaps we felt immediately no visible change, but for chemical engineering student absolutely sure that, sooner or later there will be discernible influence in life. We are fortunate enough to meet such a young DVR Murthy, in his thirties and observed his nature at close quarters. With matching kinetic orders; he was approachable and amenable for all our needs and deeds. We may forget many things learnt during class, but concepts taught will remain etched in memory of students, always. He taught us basics of reaction engineering, which makes chemical engineer distinct and specialized from engineers of other branch. My family and batch-85 fellows join me in wishing him happy and contended post retired life.

Dr. TL Prasad, *F.I.E, F.I.I.Ch.E*
Chemical Engg (1985)
Chemical Engg Group BARC Trombay-400085

Memories of Interaction with Prof. DVR Murthy

I am happy to share my association with Prof. D. V. R. Murthy during my Ph.D. Work.Prof. Murthy was my Guide and Mentor. I am very fortunate for having him as my guru. Although I was his student, he treated me as a friend. He always inspired me. He is always trying to help the student, encourage the students and discuss with the students formally and more informally. He always tried to inculcate good habits. His experience sharing, out of box thinking and discussions related with research work over a cup of tea and also on holidays in his cabin cannot be forgotten.Such discussions provided me a positive energy. Every one during their research work goes to the depression stage. At this time, proper guidance, strong and positive support is required. Prof Murthy tried to bring me out from this stage and due to which I could complete my Ph. D work.

I am lucky that I was his first full time Ph. D. research scholar under QIP scheme. He took utmost care of mine and at every stage, paid more attention and guided me in right direction. He always helped me to solve my research related as well as my personnel problem. Someone in research conference has said that, research is journey of thought in dense forest and researcher has to start his journey from one end of forest and come out from other end. Hence, proper direction is very necessary so as to come out in stipulated time. Prof. D. V. R. Murthy guided me in right direction. I wish every researcher should get guide like Prof. D. V. R. Murthy. I learnt many things from him not in the classroom but outside the classroom, at the time of discussion and by his behavior with the students. His sincerity, discipline and time management is truly admirable. He is of opinion that one should keep high goal and try to achieve it through his hard work and sincere efforts. If sky is kept as a goal, then one can at least reach to stars.

When we were working on research topic "Spouted Bed Bioreactor",we had many times a long discussion on the experimental results obtained, even on holidays. Because of his expertise in process equipment design we fabricated a spouted bed reactor in the chemical engineering workshop of NITK. Perhaps, he is the only person in India who worked on various types of spouted bed and used them effectively for drying and also as a bioreactor. I have every hope that Indian patent filed by him will be approved. Guru like this are rare.

Prof. D V R Murthy is retiring on superannuation on August 31, 2017. Throughout his service period he has made the deposit of knowledge in the minds of students and created a space in the heart of thousands of students. I pray God for his happy and healthy retiring life.

Dr. Madhukar A. Dabhade
Principal
Institute of Petrochemical Engineering
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Thank You Prof. D V R Murthy

It makes me sad to know that my teacher, research guide, and mentor Prof D V R Murthy is retiring in August after more than three decades of service to our alma mater NITK. I have known Prof D V R Murthy since 1986-87, when I was an undergraduate student in KREC, and during the period he had taught our batch CRE (Chemical Reaction Engineering). He had also guided my B E. project in 1989.

Many of the concepts that he had taught in the class and during the project work, I can still remember even today, for he taught in such a way that complicated concepts appeared simpler to deal with. Needless to say, he had shown utmost seriousness for teaching and guiding. Truly, he is a sincere and a dedicated teacher. Prof D V R Murthy is also known for simplicity and benevolent nature.

Prof D V R Murthy along with Prof M B Saidutta guided me for the doctoral research. Both the Professors were constant source of inspiration right from the initial stages of research proposal till the final presentation. This has helped me in timely completion of the study and hones my research skills.

On this occasion of his retirement, I sincerely thank him for all the guidance and help that he has bestowed on me, and wish him all the best for his retired life. I will continue to associate with him in future for his guidance.

M. Ramananda Bhat
Department of Biotechnology,
Manipal Institute of Technology (MIT)
Manipal

An Exemplary Educator

I would like to express my sincere gratitude to my supervisor Prof. D.V.R.Murthy , Professor, Department of Chemical Engineering , NITK, Surathkal. Dr.DVR Murthy sir has been a great source of inspiration to me. He is an exemplary educator who trained me in research and helped me in shaping my character. I am fortunate to be his student and to have received invaluable guidance. His wide knowledge and logical thinking have been a great source of inspiration for me. The interesting explorations and the extensive discussions we had during my research work have helped me a lot. The time I spent with him has been indeed wonderful and truly a corner stone of my life. He has enriched me with encouragement and ideas, sound advice, remarkable teaching all through my research period.

I am greatly indebted to Prof DVR Murthy for his support and invaluable guidance and I wish to extend my warmest wishes on his retirement. I pray to the almighty to bless him with good health, wealth and peaceful retired life.

Srinivasan, G., Ph.D
Professor,
Dept. of Chemical Engg.,
PEC., Pondicherry.

Thoughts on Prof. DVR Murthy

It is with great pleasure that I congratulate Prof. DVR Murthy on his retirement and mark a successful career as a teacher, researcher, and administrator. I am humbled to be sharing some thoughts about my association with Prof. DVR Murthy on this occasion.

It is impossible for me to capture all of his accomplishments and contributions to the Department of Chemical Engineering, and to NITK. I am aware of his significant contributions related to departmental and institutional governance, but what I know him best is as a teacher and a mentor during my years with the department (1998 - 2001).

My most vivid memories of Prof. DVR as a teacher were from two classes - the first Mass Transfer class and the Process Design class, both in the third year of engineering. The two classes together represent an excellent example of fundamental concepts and application. As a teacher, this was Prof. DVR's strength - in making a seamless connection between theoretical fundamentals and application. He is one of those rare teachers who can both explain a complex concept, and make it come to life with a real-world application. This is very critical, especially in explaining abstract concepts such as boundary layers, which seemingly appeared out of nowhere. Prof. DVR was able to explain this with a physical example like a bubble column or a packed bed, where reaction happens at the interface between two phases, and the "zone" of reaction is the boundary layer. With this approach, Prof. DVR already set a stage during the Mass Transfer class for the upcoming Process Design class! Likewise, during the Process Design class, where there were hundreds of empirical relationships that seemingly appeared out of nowhere (spread across the pages in Perry's Chemical Engineering Handbook), Prof. DVR was able to tie them back to the same fundamentals he had discussed in the Mass Transfer class!

The Mass Transfer course turned out to be very important to me personally, since I went on to pursue a PhD in colloids, interfaces, and fluid mechanics, for which a sound foundation in transport processes is an absolute requirement. I still use those concepts extensively and I am very grateful to Prof. DVR for providing me with a solid technical foundation.

In addition to being an excellent teacher, Prof. DVR was also a strong advocate for students, and genuinely cared about their development, not only academically, but overall. I vividly remember his support for sports and extra-curricular activities. He was passionate about the history and mission of the Institute and the Department, which he emphasized to students both in and out of class. He was also a very progressive teacher - He had a fondness for students with a penchant for what he termed "mischief". He recognized that a certain rebellious and independent character, as long as it was motivated by positive outcomes was an attribute which needed to be fostered and guided, not chided.

I am sure that the announcement of Prof. DVR's retirement was bitter-sweet to the Department and the Institute. That is certainly the case for me - it is hard to digest that faculty and students will not be able to see Prof. DVR teaching a Mass Transfer class, pacing around purposefully, balancing the numerous tasks on his plate, or seeing him in the Mass Transfer lab sipping coffee (I will digress here - but the coffee made in the Mass Transfer lab always held a certain mystique for me. I envisioned that there was an elaborate setup with an experimental column built by Prof. DVR for maximum flavor extraction! I finally got to try a cup a couple of years after I graduated, and it was an exciting moment!).

I would like to take this opportunity to profusely thank Prof. DVR for being an excellent teacher and mentor to me and to many others. I hope that the Department can continue to involve him in some capacity so that future classes can continue to benefit from his vision and approach. I wish Prof. DVR the very best for his upcoming retirement and congratulate him again on all his achievements.

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