

Text of the acceptance presentation of Prof. H. S. Mukunda

Dear Dr. Saraswat, Others on the dias and the combustion fraternity,

Let me begin by expressing my grateful thanks to the Combustion Institute, Indian Section, headed by Dr. Saraswat for this honor. It would perhaps be appropriate to use this occasion to briefly talk of my past and the future of combustion science in India, as I see it.

Combustion science, when I did my graduate work in the late sixties, meant working with single step chemistry. Understanding the nature of solutions through asymptotic analysis was considered prestigious. Comparisons with experiments were generally very qualitative. It would only be fair and truthful if I state that I was quite dissatisfied with my thesis considering the nature of comparisons with experiments. Soon after I joined the band of faculty, I undertook to do myself a number of experiments to get a precise hang of limits of combustion processes in both premixed and diffusion flames. While I also dabbled with asymptotic analysis and I still cherish this part of a special knowledge that I used as course material for mathematical methods in reacting flows that I taught in later years, I intended to switch looking into full chemistry issues. Through the seventies, the chemical mechanisms and the key parameters were getting evaluated and refined in the literature. This led to the development of a one-dimensional flame propagation code with full chemistry that has been one area of research for over two decades and it continues to be useful even now. Subsequently, my interest was both in experimental work as well as computational studies aimed at understanding physics rather than algorithmic development.

At that time, I decided on something that I consider very important. Any work that is done must reference itself to the best in the field that I **could judge**. This necessitated that I publish in journals where one could hope to get critical

reviews of the work even if some may deflate me considerably. I must say that the number of active front line combustion science workers in India was small then and expecting useful critical inputs from within India was not feasible. Hence most of my work with the students has got published in international journals and more importantly international combustion symposia and much less within India.

Participating in the biannual International symposia on combustion with its rigorous paper acceptance procedure for oral presentation - reviews by at least three referees and acceptance only if they are favorable beyond a minimum level without any rebuttal that was the norm at earlier times provided a grand challenge in the selection of problems and the nature of effort required to generate a class work. This is how the twenty and odd years beyond 1982 were spent with several results of significance being presented in symposia, interacting with the best minds in combustion for a week every two years - very rejuvenating, I must say. It may be appropriate to touch upon something interesting in publishing matter not addressed earlier as far as I know. Not all papers that receive excellent reviews by referees are great - they don't get cited as much. Not all those papers that have difficulty in appearing in print because one referee thought that the work was average or some such event, so poor. In fact the influence of a few of such papers could be far more significant than those with excellent reviews. This personal experience has been corroborated by those of a few colleagues of mine.

The work in the seventies was significantly on hybrid rocket engine, research and development. This work provided several new results and an approach to the design of less expensive rocket engine systems more appropriate for space developments, In fact the most recent X - prize competition has a hybrid rocket, perhaps of an inferior performance could in fact be bettered by other approaches. But in the eighties, the Department of Space was offered this knowledge base, but it considered working in this area infructuous; the result

was that this activity was closed. At this juncture, I made another decision. When it came to technology, if we at IISc had to call the shots, we better work in a civilian sector with wider applicability; we don't need to bother about "one" boss's whims and fancies. This and certain providential intervention started us off on the work on biomass combustion and gasification. Gasification became an approach to make the biomass usable in prime movers - reciprocating engines and gas turbines as well perform combustion in a two or three stage mode to make it environmentally benign. A larger number of new results were obtained as a consequence of two decades of research development, design, testing, dissemination, and redesign with field data on systems from 1 kWe to 1000 kWe (2 kg per hour to 1000 kg/hr biomass throughput). One extraordinary counterintuitive result of these studies is that if one designed a combustion device to control the power and limit the emissions, the way biomass is used in stoves and small furnaces for the last 2000 years is perhaps exactly wrong - doing by adding fuel and allowing combustion to occur from bottom to the top. If one desires near constant power and control, one should burn the biomass from top to bottom - this in effect is what gasifier does!

Consequent upon all these was the thinking: "Give me any biomass (including urban solid waste), I will give you electricity". It is now of course well known that there is a strong group at IISc that does work in this area that provides leadership in this country as well as the world itself - through UN agencies by educational and commercial opportunities. Commercial exploitation through six licensees in India and three overseas has permitted an outreach that will grow exponentially in times to come, A part of one of our patents on gasifier stoves has been bought up by British Petroleum - India recently for world wide commercial exploitation. What could not be achieved in the field of Aerospace, it was possible to achieve in the field of solid fuel conversion, a green field that has many wide green pastures to exploit even now. Front ranking issues of engine performance, optimization through engine modeling via reactive flow

CFD continue to remain as problems that will attract younger students in times to come.

Finally, I must state that technical and professional life has had other challenges related to human engineering at several levels - individual, institutional and national - and it would only be fit to say, I have enjoyed it all, sometimes braving the cold and other times basking in the sun. World must move on and like many others, distinguished or otherwise, we all create traces that become dim with time, some after a long time and some in a short while. This act of yours in bestowing me this honor will let me cherish a feeling that may be, I will not be forgotten in a short while! Thank you all then.