My Reminiscences

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1. THE EARLY LIFE

I was the youngest child of my parents, and was born in the city of Howrah, West Bengal in 1937. My father retired when I was only few years old. From 1942 to 1948, we witnessed large-scale turmoil. Japanese invasion and air raid over Calcutta, food shortage and inflation causing the Bengal famine and millions of starvation deaths. Within a few years, large-scale communal riots, massive refugee influx from East Bengal before and after independence took place. The social and economic fabric of Bengal received serious setback as a consequence.

It is during that period, my father lost all his savings kept in a private bank due to its liquidation. Since my elder brothers and sisters had not yet completed their studies and were not earning members, somehow the family was sustained through sale of mother's ornaments and some help from relatives.

I was not a good student at primary school level. It was at the secondary school that my performance started gradual improvements. I developed special interest in mathematics. I also started to take interest in extracurricular books in a variety of subjects. My father was not directly teaching me, but used to tell lots of stories, especially on history. Thus he was instrumental in creating academic interest in me. I was a rank holder at the district level in School Final Examination, making me entitled for scholarship for 2 years.

I was a student of the 2-year program of Intermediate Science (I.Sc.) at the college. Then I became very much interested in physics and chemistry, besides mathematics. Even before the classes started, I had covered the textbooks substantially through self-study without any help. I even studied some advanced topics in physics which were not part of curriculum. My performance was so good that I was a rank holder in the I.Sc. examination of the Calcutta University, which entitled me for freeship and scholarship for further studies.

I was also a rank holder in the entrance examination of the then Bengal Engineering College (now Bengal Engineering and Science University). This entitled me to receive the merit-cum- means stipend, which was sufficient to cover all my expenses including boarding and lodging in hostel. As it is now, then also metallurgy was almost the last choice of students. I could have joined any branch, but voluntarily opted for metallurgy. I received B.E.degree of Calcutta University in 1958 with 1st rank amongst the Metallurgical Engineering graduates. After a few months, I joined the then Hindustan Steels Ltd., which is now known as Steel Authority of India, as a trainee.

At that stage I never thought of higher studies abroad, but had decided to be an earning member of the family. But my B.E.College professors suggested that I should go abroad for higher studies. Since my preference was to specialize in extractive metallurgy and the MIT had the strongest group, I decided to join MIT and landed in Cambridge in 1959 with offer of admission and financial assistanceship. I received the Sc.D.degree in 1963 and was at the Ohio State University as post-doctoral fellow for a year.

During that period, the Indian Institute of Technology Kanpur was being set up with collaboration of 9 U.S. universities. For faculty position in an Indian University, according to the then prevailing norm, a candidate had to apply against advertisement and appear in interview in India. This was a deterrent for qualified professionals abroad to return to India for a career.

IIT Kanpur was the first institute in India, which decided to advertise abroad inviting application in plain paper and selection directly. So many professionals, including myself, joined IIT Kanpur. Also the institute opted for science based engineering education like the U.S. Universities. We also were given freedom in research efforts and liberal dollar grants under the Kanpur Indo-US program for import of sophisticated equipments and materials, not available in India.

2. MY PROFESSIONAL MISSION

From technological point of view, my broad area of specialization is extractive metallurgy, which is concerned with extraction and refining of metals. Extractive metallurgy, again, has 2 subdivisions – ferrous and non-ferrous metallurgy. I have specialized in ferrous metallurgy, and am concerned with ironmaking, steelmaking and casting of liquid steel. These processes are carried out at high temperatures in liquid or solid state.

The relevant scientific fundamentals are:

(i) chemical metallurgy, dealing with thermodynamics, chemical kinetics , physicochemical properties of high temperature materials including non-aqueous melts

(ii) process engineering, dealing with momentum, heat and mass transfer ; mathematical and computer techniques.

I joined IIT Kanpur end of 1964. From then upto about 1990 / 1995 was a dark period for the country's economy as well as steel and metals industry. Growth rates as well as infrastructure developments were marginal. Sickness in manufacturing sector was rampant. It is a tribute to the Indian steelmakers that, even then, they made reasonably good progress in modernization of plant practices.

Undergraduate teaching in extractive metallurgy was primarily descriptions of processes. Emphasis on quantitative metallurgical and engineering sciences was almost absent. Post-graduate programs almost did not exist.

So far as research is concerned, steel plants were doing some tinkering. You cannot call them serious research. NML was fairly active in process research. But it was mostly on pilot plant process development. So far as academic institutes are concerned, BHU was active, but mostly on pilot plant studies. Prof. K. P. Abraham of IISc Bangalore was doing some fundamental studies on thermodynamics and kinetics. Prof. V.A. Altekar of chemical technology of Bombay University and Mr.C.V.Sundaram of BARC were also doing something.

Surveying the situation, I recognized that my principal efforts should be to promote nurturing of metallurgical sciences as well as application of the same in teaching, research and industrial practices. Also, perhaps it has to be a life-long mission. I am still pursuing this mission. However, the natures of activities have been different in different phases. For example, one of my major activities for the last 20 to 25 years have been publication of text books either exclusively on quantitative metallurgical sciences, or on technological topics with considerable coverage of theory. 5 books have been published. The last one on kinetics is expected to be published next year. They are low-cost paperback books, which can be acquired both by teachers and students. There have been almost no such equivalent books in the Indian market. An example is the book on "Ironmaking and Steelmaking- Theory and Practice" by Ghosh and Chatterjee [1]. (Figure 1)

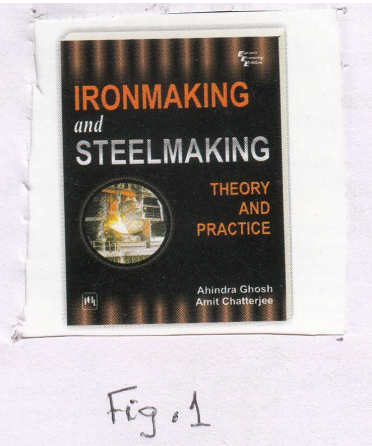

Fig. 1

So far as research is concerned, a major activity was laboratory research. Process research, by and large, is not possible with standard equipments. It required design and fabrication of apparatus for object-oriented investigations. Several such apparatus were set up from 1965 to about 1990 for high temperature thermodynamic, kinetic and some other miscellaneous studies, as well as experiments in room temperature transparent water models for fluid flow, mixing and kinetic studies.

As example, Figure 2 shows the photograph of an apparatus for continuous measurement of weight loss / gain of sample kept in a vertical resistance furnace under flow of chosen gases. Only the Cahn Electro-Balance unit was imported. Rest of the set up consisting of furnace, the framework assembly, gas train etc. were indigenously designed and fabricated.

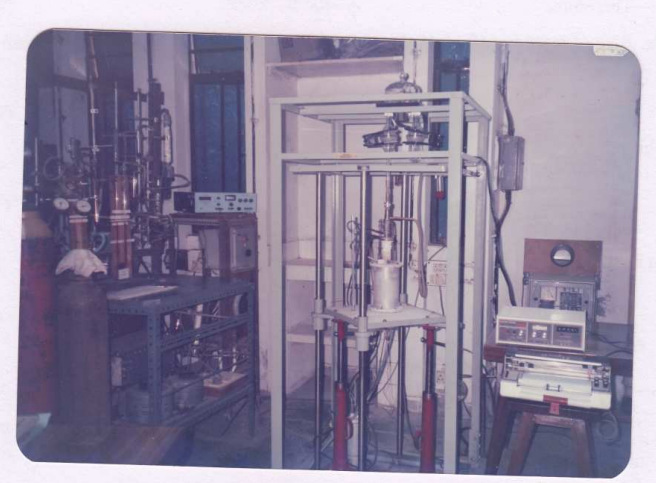

Fig. 2

Figure 3 shows another apparatus for study of solidification of alloys in metal mould [2]. Again, it was indigenously designed and fabricated. Solidification was vertically upwards from the bottom and the rates were controlled. The solidified ingots were vertically sectioned into 2 halves, which were subjected to a variety of physical, chemical and metallographic examinations.

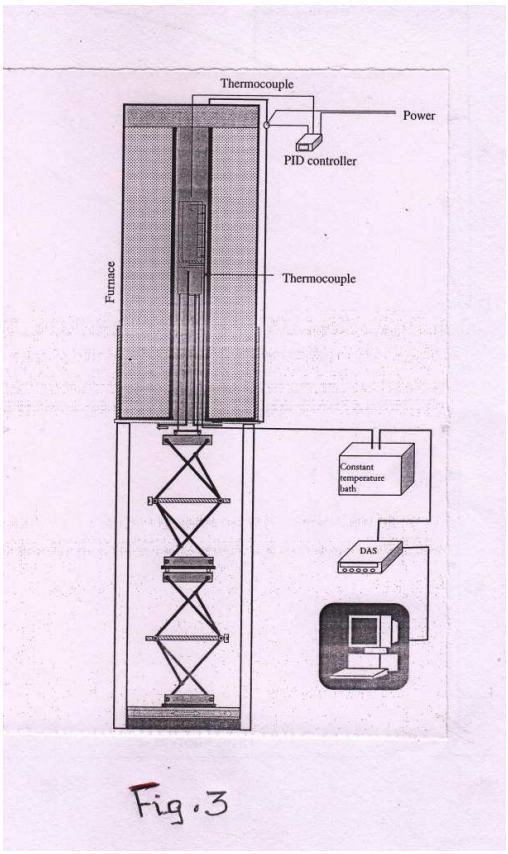

Fig. 3

Figure 4 schematically shows the main steps for the individual experiments. Elaborate mathematical modeling was carried out for quantitative interpretations of data [3].

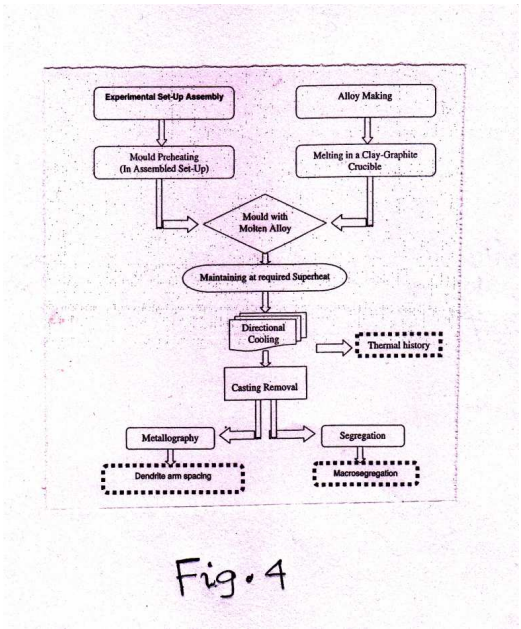

Fig. 4

Interaction with steel plants and R&D organizations was an important parallel activity, on and off, from 1970 to 2007. Programs consisted of visits, delivery of lectures, and collaborative R&D. For example, a significant part of collaborative R&D was fundamental studies on fluid flow, mixing, chemistry, and heat transfer in ladle furnace refining of molten steel. Data collection and experiments were carried out in the LD-2 shop of Tata Steel, Jamshedpur. Scientists of the Tata Research,

Development and Design Centre, Pune actively participated in this program, and also carried out the mathematical modelling exercises. I acted as the adviser for the entire program.

Finally, based on these studies and further work, an on-line reckoner for prediction and control of steel temperature and composition was developed and installed in the LD-shop of Tata Steel [5].

Figure 5 shows the sketch of a ladle furnace.

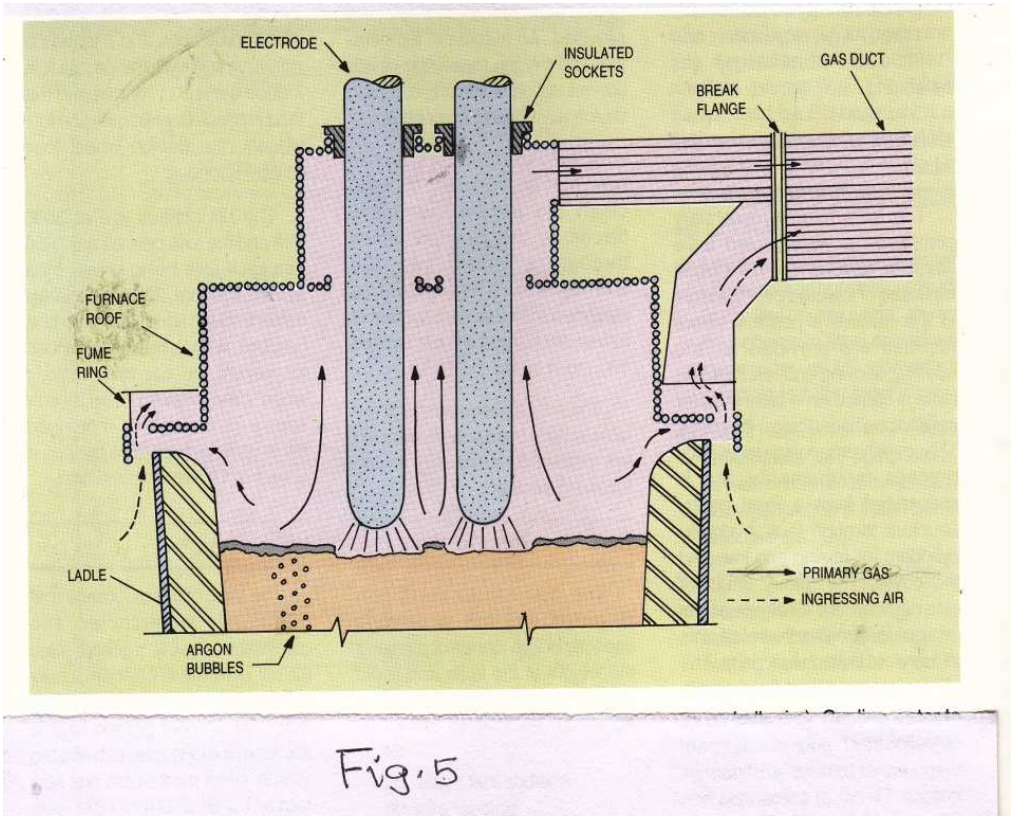

Fig. 5

Figure 6 schematically presents the control strategy.

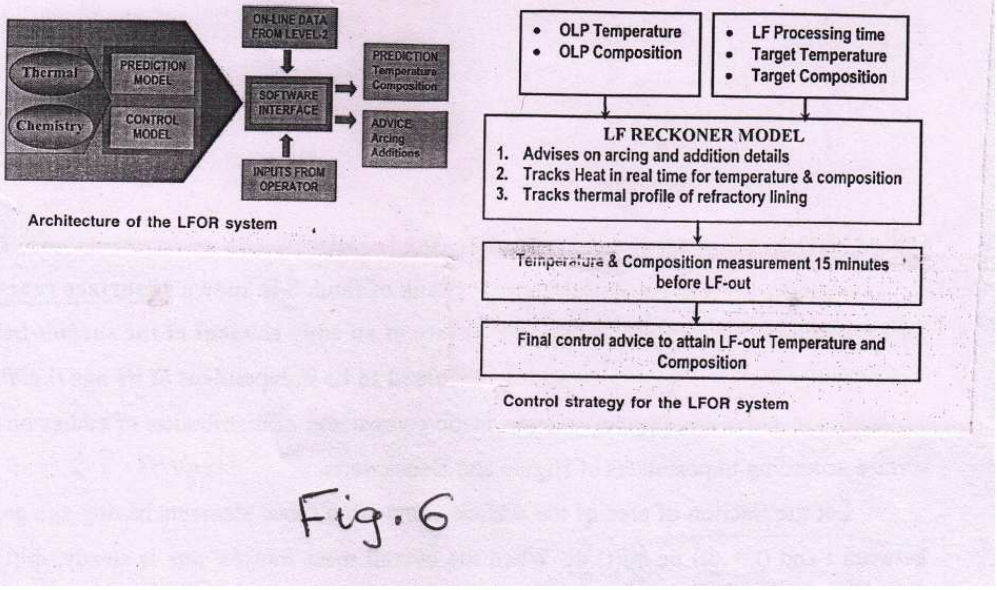

Fig. 6

Mathematical modelling is a powerful tool for R&D. In several research projects, we carried out mathematical modelling of process in addition to experimental work.This combination gave us significant results. I have already cited two examples [4,5]. Ghosh (6) has reviewed some of these, which has list of original publications. It was possible to do this only by collaboration with some others, some faculty colleagues or scientists from other organizations who had expertise in modelling.

At this juncture, I wish to state that, during my interactions with industry, I had opportunities to meet and have discussions with many professionals who were very knowledgeable with plant practices. It was a great education to me.

However, importance of metallurgical and engineering sciences in design, development, innovation and process control has not yet been recognized by the steelmaking community . Some of us in the academic institutes became concerned with this and thought that something had to be done about it for the future viability of the steel sector. Our efforts ultimately resulted into organizing a successful international conference on "Advances in theory of ironmaking and steelmaking" at the Indian Institute of Science, Bangalore in December 2009. I acted as the Chairman.

3. ON SCIENCE, RELIGION AND SOCIETY

For World peace and healthy environment on the Earth, we need awareness of current ethical challenges. The essential role of ethics is to promote social consciousness for our harmonious existence with the society. The term SOCIETY is being increasingly replaced by a more broad-based term ENVIRONMENT, which includes not only human beings, but our surroundings on the Earth as well. An important cultural issue, which is very relevant in general and in this connection, is harmony between science and religion.

I have been concerned with this and have done some reading and writing, such as my paper on "Peace and Universal Religion" [6].

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