TECHNOLOGY MANAGEMENT IN THE STEEL INDUSTRY: CURRENT CHALLENGES

41ST HATFIELD MEMORIAL LECTURE
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BY
DR. JAMSHED J. IRANI
MANAGING DIRECTOR
TATA STEEL

RECYCLING OF STEEL
(in Millions of Tonnes)

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THE NEW FRONTIERS

TECHNOLOGIES:
1. Direct steel making
2. Advanced ladle refining
3. Near net shape casting
4. Coil box
5. Advanced gauge and profile controls
6. Thermo-mechanical controlled processing (TMCP)
7. Surface modification techniques

PROCESSES:
1. Corex process
2. Energy Optimising Furnace
3. Low Height, large dia Blast Furnaces
4. Jumbo reactor Coke Ovens

PRODUCTS:
1. Ultra pure, Gradeless steel
2. Surface engineered Steel (Coated, plastic covered)
3. Tolerances of 5-10 micron in flats
4. Metal Matrix composites of steel

EXHIBIT 6
INTRODUCTION

DR. HATFIELD, THE MAN AND HIS IDEAS

It is indeed a privilege for me, and an honour, to address an audience as distinguished as the one before me. When I attended Sheffield University about 35 years ago, I used to listen to the Hatfield Memorial Lectures regularly, and so, I am particularly delighted to have been invited to deliver one today.

Dr. William Herbert Hatfield was born in this city of Sheffield in 1882, and so it was but natural that he became interested in the intricacies of making steel and remained devoted to this cause all his life. In his early years, his activities were in the area of acid open hearth steel making and foundry technology. It has been hinted that he distrusted basic open hearth steel on the grounds that the final product would not be as sound and as clean as well made acid steel. We will never know what his judgement would have been on the BOF variety, which dominates the steelmaking world today.

Dr. Hatfield rose to the position of Director of the Brown Firth Research Laboratory at the young age of 35, a position he held for many years. Few persons have contributed to the Science of Metallurgy as did Dr. Hatfield. (In later years, his main interests were in the development of high grade alloy steels. He developed these to a high degree of perfection, correlating their properties with specific applications). His reputation went beyond the shores of his home country. He served on many Research Committees,
and chaired select committees on Steel Ingots, Corrosion, Alloys and Castings Research. To this day, Dr. Hatfield and his ideas remain a source of inspiration to his successors in the Iron and Steel Industry. Dr. Hatfield was one of the most successful proponents of Technology Management, and his significant contributions in that field have influenced me to talk on this subject today. I personally feel that we need men of the intellect of Dr. Hatfield in our industry today, when Technology Management could well decide its future, and is the need of the hour.

**TECHNOLOGY MANAGEMENT**

The Steel Industry is Technology driven. For other industries, particularly the service industries, technology could be looked upon as an "enabling" mechanism, but in our industry it is at the very core. Technology is a key resource for ensuring the relevance of steel in human society, and, therefore, its proper management is essential for the success of the Steel Industry. At a business level, technology translates into growth, profitability and competitiveness for Steel Companies, and is indeed, the *very basis* for their survival.

*Management* of technology is thus crucial for all of us in the Steel Industry. It involves dealing with technical issues across a broad spectrum of functional areas. It is a tool for the integration of technology strategy with the business strategy of a Company. On a different plane, it consists of generation and acquisition of technical knowledge, monitoring it for analysis and control, and ultimately utilising it for increasing the effectiveness of an industrial operation in the interests of the community at large.

Finally, technology management demands extreme dynamism
TECHNOLOGY SHOULD AIM AT:

★ Increase in Productivity
★ Saving in Energy Consumption
★ Implement in Quality
★ Flexibility in the use of Raw Materials
★ Shortening Process Routes; leading to plant Integration
★ Protection of the Environment
★ Lower Investment Costs

EXHIBIT-3

to keep pace with the rapid expansion of human knowledge. An extremely rapid rate of change is perhaps the only factor which is common to many spheres of our lives in present day society, and this is even more true as far as technological changes are concerned. Hence, technology must be managed effectively, if we are not to be swept away by the tide of economic forces.

The future competitiveness of the Steel Industry would be ensured if relevant technology is developed in the temples of learning, and surely my alma mater, and yours, figures high among this list.

STEEL INDUSTRY AT THE CROSS ROADS

I expect that almost everyone in this hall is interested in the steel industry. In this gathering of the faithful, I need not dwell on our glorious history, except to highlight the creeping complacency which had lately enveloped the entire Industry. Men of steel of yesteryears could not imagine that their mighty industry could be faced with competition from other materials and may, one day, have to fight for its survival—and indeed it is in that situation in many of the industrialised countries today.

The oil shock of the seventies which led to smaller and lighter, if not fewer cars, made the first of the several significant dents to our bottom line. That event focused on the global concern for dwindling natural resources. Against this back drop we have to contend with the emergence of cheaper alternative materials which continue to make inroads into a market shrinking with recession, and fragmented by trade and tariff barriers.
But, if we have been shaken out of the complacency of the past, we must shake off the despondency of the present too. Steel has been and shall remain fundamental for the well being of an industrial economy. It is time to identify the challenges before us, devise effective strategies and carve out a bold new trail, which the steelmakers of tomorrow could follow with confidence. We have several advantages and strengths working for us, and if we wisely manage technological changes, it will be a long time before new materials can inherit our domain, and displace steel as a primary requisite of the society as it exists today. And technological change can help us to reverse the trends seen in the developed world in recent years.

**CURRENT CHALLENGES**

To enable the steel industry to move out of its present troubles, certain technological challenges have to be recognised, faced and overcome.

First of all, steel must become more affordable. Steel consumption is an index of economic development, and the per-capita consumption in industrialised countries is substantially higher than that in the largely agricultural economies of Asia, Africa and South America. [EXHIBIT 1]. As the economic focus of these regions shifts inexorably towards industry, this vast under privileged population would consume more steel than the entire currently idle steel making capacity could ever hope to produce. But economic compulsions, manifest in the poverty endemic to these regions, make it impossible to translate this latent need into tangible demand. The first challenge before the steel

**THE CHALLENGES BEFORE US**

★ Make steel affordable, worldwide

★ Steel production not at variance with sustainable development

★ Steel Industry Must cope with Change

★ Create conditions to attract the best talent

EXHIBIT-2
technologists is to ensure that steel is affordable to each and everyone, even in the developing world.

**The second challenge**: Like any other mineral processing industry, production of steel results in a net depletion of non-renewable resources of ore and energy and leads to an irreversible degradation of the global environment. Obviously this cannot go on for ever. The steel industry must harmonize itself to the needs of both the current generation as well as those of the future, and devise ways to transcend the ecological limits on growth.

**The third challenge** is the ability to change. Change is a time-tested mechanism for growth, and the ability to change is the hallmark of successful organizations. The steel industry with its huge capital investments and long product development life-cycles, finds itself very often out of sync with global trends. The industry in general and individual plants in particular, must re-engineer their technological operations, and become flexible enough to manage change, cope with uncertainty and thrive in a dynamic environment.

Ever since the birth of Material Science as a separate discipline for research, the focus of academic and research institutions has shifted away from the metallurgical operations of the steel industry. This shift in emphasis is evident in Sheffield University itself. As a result, these core disciplines of steel are getting very little share of R & D funding and efforts. A consequence of such unfortunate developments is that the image of steel has become one of a sunset industry, which in turn deters the best and brightest brains in the land from making a career in iron and steel. If not today, then very shortly, we are heading for an acute scarcity of new ideas with which to overcome our current problems.
This is the final and perhaps the most difficult challenge. We must improve our image. We must motivate and rally the best talents to our cause, if only to have the wherewithal to meet all the other challenges which we are facing.

Thus the challenges before us are:— (EXHIBIT 2):

- Make steel affordable, worldwide,
- Steel production not at variance with Sustainable Development,
- Steel industry must cope with CHANGE,
- Create conditions to attract the best talent.

These can be met by effective management of existing and emerging technologies in the field of iron and steel.

All these challenges have to be met through the Management of Technology, and I would now like to expound on this theme.

TECHNOLOGY STRATEGY: THE SPRING BOARD

The first stage of technology management is the development of clear and well "thought through" strategies which would define the boundary conditions for all subsequent activities. This strategy falls into place with an answer to this simple question:—

What do we expect from technology?

would always be the management of technology as far as steel is concerned.

As we go back to our work places, I hope we would dwell further on the fundamental question of our responsibility and allegiance to the steel industry. The need of the hour is to cut across various boundaries to the benefit of the steel community at large, because it is cooperation which would finally ensure that steel continues to occupy the nodal position in our society as we know it today. The challenges for steel technologists is to make items which the society, our customer, needs. And make these affordable and available where and when they are required.

We have many advantages, such as wide-spread availability, a versatile product and a demand from a society, which may have yet not been fully exploited. We must look for new areas of application, with new types of steel.

And above all, we must be looked upon as and be environment friendly. Then we can ensure a sound future. May be that the large integrated steel plants of this century have, like dinosaurs, moved into history. But steel the product has a sound future. It is for us technologists, like Dr. Hatfield in his era, to ensure the place for steel in the society of the next century, and beyond.
overcomes limitations faced by an industry. In India of the 19th century, Jamsetji Tata founded THE TATA IRON AND STEEL COMPANY, the first integrated steel plant in India. He not only conceived a steel plant, but also a green township for the city named after him, Jamshedpur. His own words to his son, Dorab were "Be sure to lay wide streets planted with shady trees, every other of a quick growing variety. Be sure that there is plenty of space for lawns and gardens. Reserve large areas for football, hockey and parks." In short he had the foresight to anticipate and envisage the concepts which the world community has since recognized as issues of sustainable development and eco-friendly industrial systems.

When others thought exclusively of political freedom in India, Jamsetji realised that political freedom, without the economic strength to support and defend it, would be a cruel delusion and such strength could only come from a humane approach to industrial development. Even as we remember Dr. Hatfield with respect today, we would like to pay homage to entrepreneurs like Jamsetji Tata without whom steel would not have come to occupy the commanding heights of the industrial world.

**CONCLL**

Technology management is a closed loop control mechanism that seeks to transform technology into profitable enterprise through proper management of knowledge, talent and change. And it is this mechanism which ultimately controls the destiny of any industry. Today, there are a set of challenges confronting us, tomorrow there might be other, but the underlying common strategy for overcoming these

In a nutshell, technology should aim at (EXHIBIT 3):

- Increase in Productivity.
- Saving in Energy Consumption.
- Improvement in Quality.
- Flexibility in the use of Raw Materials.
- Shortening Process Routes; leading to Plant Integration.
- Protection of the Environment.
- Lower Investment Costs.

These objectives would result in low cost, high quality steel to serve specific user markets. Such a strategic approach has, for example, resulted in the setting up mini-mills in many parts of the world. We in the iron and steel industry must have clear visions, goals and strategies in order to meet the challenges before us and only through such a focus can we hope to succeed. So, to address these aims and these challenges, we must turn to R & D.

**RESEARCH & DEVELOPMENT: THE CUTTING EDGE**

Research and development efforts generate new technologies or adapt existing ones to local requirements, and so are the major steps in technology management. How can R & D help meet the challenges before us?

We have to learn from some earlier experiences. Bessemer gave us a process for the mass production of steel by
blowing air through the bottom of a converter vessel. It was the oxygen in the air which was the important element in the conversion. But it took us almost one century before we had the LD process which made use of pure oxygen, to be followed by the bottom blown and combined blowing operations.

Another example of technological change, and R & D improving upon a given phenomenon, is the one concerning continuous casting. It was well appreciated that segregation in the solidified steel is something we could do without. I remember hearing during my lectures at Sheffield University that "god gave us segregation, and we have to live with it", because the study of phase diagrams clearly show that it will be there. But rather than chopping off the segregated top portion of the ingot, the entire length of continuously cast steel can be used now, without experiencing the harmful effect of segregation. Submerged entry nozzles, electromagnetic stirring and multitapered moulds have improved the quality of continuously cast steel.

Now, consider the challenge of making steel available to every life style-the need would be to lower capital and operation costs; so that steel applications can break though the floor levels of purchasing power. Even a casual calculation would show that it would be impossible to find the funds for putting up a large number of new plants if there were to be a surge in the demand for steel. Further, even if the funds are made available, the detrimental impact of integrated steel plants on the environment would be a major deterrent.

Superior and reliable product quality, resulting in lowering of the safety factor, and incorporation of high tensile environmentally friendly, affordable and acceptable, and such an atmosphere in turn will attract the best brains needed. We should set up iron and steel plants which have a worker friendly environment, so that creativity is nurtured and the industry can flourish.

THE MINI-MILL:
A NEW TECHNOLOGICAL PARADIGM

What type of steel plants would dominate the iron and steel industry as it heads into the next century? Those which are compact and integrated production units aimed towards well defined niche markets. The answer may therefore seem to be in the Mini-Mill model. What is remarkable about these plants is the selection of highly efficient technologies, such as blast furnace, BOF steelmaking, advanced ladle refining techniques, near net shape casting, and hot connections with rolling mills, cascaded to achieve the best production flexibility. Such a technology would contain very few processing steps, all controlled and linked together by extensive use of computers and a small number of workers, each with flexible job classifications, resulting in low capital and operating costs. Such innovative use of men and machines will ensure that steel production will continue to be an economically viable industry, even in rapidly changing situations such as the one we are currently facing.

THE TATA PHILOSOPHY:
WE DARE TO DREAM

In the final analysis it is not technology alone which counts, but the symbiosis between man and machine which
TECHNOLOGY MANAGERS: TAPPING TALENTS

Now let us turn to the final challenge of getting the right people who can help meet all the other challenges discussed so far. None of these were light weight issues and they can be addressed adequately if, and only if, we can attract the best and brightest minds to our industry.

It is unfortunate, but true, that technically inclined young men and women today are drawn towards 'spectacular' technologies like informatics and bio-engineering. There is a widespread perception that these technologies would be the foundation on which future human societies would be based, and with the passage of the iron age, the steel industry is destined to ride into the sunset. This is a myth which needs to be exploded decisively, and quickly. Steel has remained at the core of industrial activities and national economies for the last two centuries, not because technologists did not know of the effective replacements for steel, but because of the fundamental capabilities of this versatile and innovative material. Abolishing steel from the planet is a dream of its critics which is unlikely to become a reality.

As a means or re-asserting our confidence in its future, and to husband the seed from which we will harvest our new generation of ideas, steel metallurgy must receive national recognition. Funding in the form of sponsorships and fellowships must be made available from industry so that creative people are motivated to work for the progress of steel. Towards this end, the image of the industry with respect to environment and working conditions must improve. We must attract the best brains to make it possible.
owe it to future generations to make steel through methods which conserve on energy usage.

Research must also be directed towards design and development of new materials. Focussed collaborative research should replace the current xenophobia about aluminium, ceramics and plastics, so as to result in innovative uses of steel in specialized applications. While it may not be commonly said, the fact remains that steel is in any case a composite, and specialised techniques must be adopted to realise its full potential in the domain of composites. The trend for the future is to make materials uniquely tailored, either singly or in combination with other materials.

Making Steel must no longer be an art or even a science, but a sound technology. For example, continuous casting should be made as precise and flexible as a computer aided manufacturing station, though creative use of robotics, electronics, and computers. All these areas are a challenge to our technology, the type of challenges men like Dr. Hatfield would have revelled in.

Research and development in iron and steel covers a very wide area and EXHIBIT-6 shows a sprinkling of the new frontiers; there are undoubtedly many more. Thus we have to seriously consider affordable research on an industrywide platform. Given the nature and magnitude of technical breakthroughs sought to be achieved, we can safely assume that not one company, may be not even a group of companies in a country, can afford the cost of this effort. It has to be a global, industry wide approach, industrial houses, national laboratories and academic institutions across political frontiers would have to come together. The days of one organisation seeking such breakthroughs are probably over.

These figures show that only about half of all the steel produced today has its origins in virgin ore, and the rest is recycled scrap. As steel consumption reaches saturation levels, as has happened in the industrialised countries, there will be the theoretical possibility that much, if not all, of the fresh steel production will be of the recycled variety. If this concept reaches maturity on a global scale, we can look forward to a vibrant steel industry which does not mine ore or pollute the environment while making its product. Let us plan to exploit this advantage of steel to the farthest extent. This propensity to recycling is the natural foundation on which steel can lay claim to continue as a metal of the future, as much as it is of the present.

ENERGY CONSIDERATIONS

On the energy front, the challenge is at two levels. Not only are fossil-fuels limited, coal being available at best for the next 200 years and petroleum for a mere 35, but their use pumps carbon-dioxide into the atmosphere. This leads to global warming and other catastrophic climatic effects. Steel is an energy intensive industry and the quality of the response to environmental issues has a decisive impact on its future.

Efficient integrated steel plants today consume nearly 5.25 Gcals of energy per ton of liquid steel. Though these figures are a far cry from levels which were double these only a couple of decades ago, innovative technological effort must be directed to prune this even further. Adoption of smelting reduction, for example, could save another 25% from the total figure and near net shaped casting a further 5%.
SUSTAINABLE DEVELOPMENT

CHALLENGE OF RECYCLING

Economic development can no more be divorced from the issue of environmental degradation because of the accelerating impact of industries on ecology. I must hasten to add here that the steel industry is perhaps one of the smaller players in this tragic drama, but that should not absolve us of our responsibilities. How can we prevent depletion of our finite resources and permanent degradation of the environment?

At current levels of consumption, economically recoverable reserves of iron ore would last 170 years, aluminium-260 and copper, molybdenum and nickel all less than 70 years. Considering the span of human civilization, this is indeed a very tight constraint and, the only way we can harmonize with it, is through intense recycling of available materials.

Steel is particularly fortunate in this regard because of the ease with which steel scrap can be re-cycled into the finished products. We must capitalise on this advantage for our industry, make recycling cheaper, more acceptable to the environment. Consider the following figures which are in millions of tonnes (EXHIBIT 7).

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THE CHALLENGE OF QUALITY: PRODUCT AND TOTAL

We know come to Quality which should not be only an idle passion, it should not be even a mere programme: it needs to be a strategy. The bottom line is that quality is a "win-win" proposition for everybody—customers, producers, suppliers and the economy at large. Over the years, quality consciousness has evolved through Quality Control (QC), Quality Assurance (QA) and now Total Quality Management (TQM). While QC focused on product defect detection through post-production inspection, QA recognized that inspection is not the answer, and that the entire manufacturing process must be committed to meeting the quality needs of the product through design, process compliance and product conformity at all stages of production. TQM represents an even more fundamental shift beyond QA, and comprises of tools and techniques for continuous improvement in order to achieve customer satisfaction and business success. If we are to expand our frontiers in the steel market, or even maintain the existing markets in the face of inroads being made by competing materials, TQM must become a way of life in our industry.

Historically, we in the steel industry have been blamed for slow responses, particularly to concepts which have evolved as support systems for survival and growth of industrial enterprises. The challenge now lies on our shoulders to adopt techniques of TQM, JIT, SPC etc. so that steel becomes more affordable, and thus retains its relevance well into the future. Here, I would like to stress the point that these concepts must be viewed as structured approaches for effective functioning. In the simplest terms, they are basically guidelines for industrial discipline. The choice is ours, adapt or we shall not be able to market or consume more steel.
FORMATION TECHNOLOGY

As technology becomes more complex, the task of managing it becomes even more so because the relationship is clearly exponential. The steel industry has of late become very complex. In the period after World war II, producing steel was like producing gold, and this period continued till the mid and late 1970s. The steel industry thus suffered from unplanned over-production, as companies and countries entered this lucrative area. The result was imbalances of price and production costs in the global markets. Dumping on one hand, and trade barriers coupled with stringent demands on product quality and deliveries on the other, have led to the painful realisation that management of technology as well as of business, cannot be done without accurate and extensive information systems.

Informatics could help to look into the future and this the steel industry did not do, or rather did not want to do during the halcyon days of the 60s-70s. If we are to peep into the future, we can see steel works producing high quality products at high speeds through shortened routes of precise processes. Maximum use would be made of the energy inherent in the raw material, so that minimum extra energy is expended. Clearly, the capability to control such plants will have to be through immediate capture, analysis and utilisation of vast quantities of information for rapid decision making. Market, product and process information must move as fast as the material flows, if not faster, and all key process data must be collected and processed on-line to allow statistical process and quality control to be effective.

Viewed from the perspective of managing steel plants of the future, these facts highlight the necessity of information technology as a tool to help us thrive and prosper.

In the steel plant that I am connected with, we have been making steel for the past 80 years. But at no time in our history has it been more necessary than now to introduce change. Information technology, new processes and new equipments are being introduced, to remain competitive.

BUSINESS RE-I

More than automating or expediting business processes, information technology has a far more important role to play in re-engineering the business altogether. Re-engineering maximizes the organisational performance by fundamentally reshaping and aligning strategy, people, processes, technology and infrastructure with customer needs. Information technology is not a mere support vehicle, but a powerful enabler of doing things differently.

Information technology increases the reach and range of individuals and organisations. While reach is concerned with connectivity- who all can be reached-range is concerned with integration of information. Viewed in this light, some areas become immediately apparent. For example, R & D staff with access to quality and process data in an integrated plant could dramatically cut the lead time required to get new products, and processes, into production. Information Technology will reduce production costs by providing more accurate and faster analysis of data, and thus identify operational bottlenecks making steel production more economical, and therefore, the steel product more affordable.