The future of the metallurgical industry in South Africa

Address*

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It seems to me to be particularly appropriate that this topic should be discussed at the first prize-giving function of this kind. As you know, this presentation of awards to young mining engineers and metallurgists is to be an annual event, and never before in the dynamic and rapidly changing climate of the South African metallurgical industry has it been more necessary for young, and perhaps older, practitioners to consider the future of their profession and their role in the industry. I look forward with interest to the time, five to ten years from now, when I shall recall my crystal-gazing of tonight to see how far wrong I have been.

Very rapidly I should like to look backwards and, without going into detail, to suggest three periods into which I believe our development so far has fallen. The first might be called the *bush metallurgical period*, but was none the worse for that. It occupied the period from the colonization of Southern Africa until perhaps the First World War. It depended very largely indeed for its progress on imports of technology, knowledge, processes, and the machinery and equipment that made the processes not only possible but also profitable. Even more important, there was an almost total dependence on operators from overseas, sometimes professionally qualified but more often hard-working adventurers of wide experience that had been accumulated over the years in all parts of the world. Their ability to improvise with the limited resources available locally was often outstanding, and the number of 'characters' was very large, not least among them the 'cousin Jacks'.

The next period — from the early twenties — could be called the *settled, perhaps staid but certainly not smug, period*. There were upsets such as the general strike, the lengthy depression, and even the Second World War, and some quite spectacular developments came about, some of them partly influenced by these stimuli — uranium recovery, Highveld and ferro-alloys, Iscor and Sasol among them. Mining, with the lead very much taken by gold, although expanding, was on an even keel. Things were predictable. Inflation rates of less than 3 per cent could be assumed almost for the life of an operation. Technology was developing rapidly overseas and was easily available. Local effort was often directed to adaptation of that know-how to conditions prevailing here, but development skills were more apparent. Academic and technical training was becoming more readily available, and increasingly the quality improved, although to a large extent the most able proto-metallurgists tended to go overseas for post-graduate work as, for instance, the first batch of Iscor whizzkids. Efforts to improve working conditions and safety standards, and to some extent to slow down the adverse effects of mining on the environment, gradually bore fruit, particularly after the Second World War. There may be argument about the time when this happy period ended, but I place its end rather recently, perhaps in the early seventies.

The third and most recent historical period is not easy to put a tag to. *Technical anarchy* is a strong phrase and probably not altogether appropriate, but extremely rapid, variable, and only partly controllable change has been the basic problem with which we have had to cope in the last few years, and perhaps we have not been very successful so far; certainly, my experience shows that the initiating, developing, and commissioning of a major new plant logically, on time, without over-expenditure and with little fuss, was not the norm in the immediate past. There are a number of reasons for this; the extraordinary inflationary conditions that have developed have affected not only the cost of capital equipment and its installlation, but also the standards of quality and workmanship. The influence of the oil battle, which started in 1973, has changed the rules of the game of metallurgy more than any other factor in this century. Rapid and ill-understood changes in personal relationships between Blacks and Whites and between elements of the same colour group have also brought about relatively unstable conditions, in which long-term planning and training have not kept pace.

It is perhaps easiest to consider important individual aspects that will impinge on the development of metallurgy in South Africa before attempting to formulate any overall view. There are innumerable interacting forces that influence this, but only the main areas, each of which by drastic change could alter the entire future direction, can be considered. Among these are

Energy
Water
Ore Reserves
People and productivity
Socio-political influences
Environmental restraints.

In the discussion that follows, normal considerations of efficient operation and competitive marketing are assumed to apply as at present.

Energy

It is in the availability of energy that the greatest uncertainty exists, partly as a result of the overwhelming

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victory in 1973 of the oil-producing countries, with their strong-arm tactics coupled with clear indications of their resolution to continue to get their own way in the future, and partly also as a result of the chameleon-like attitudes being adopted by the Western World in relation to nuclear energy.

In advanced Northern countries, where the energy mix is well balanced with reasonably predictable levels of generation from fossil fuels and fully committed hydroelectric installations, reliance on new nuclear stations is high, and vulnerability to this uncertainty is at a maximum. We in South Africa are better placed because of the pre-eminence of coal (about three-quarters of the total) as a raw material for the supply of power and energy. However, our vulnerability in liquid fuels is very great in spite of intensive efforts to discover local resources, and Sasols I and II bear witness to this. Technically, we lead the world in this area, but the cost in capital expenditure and technical manpower is very high. In the metallurgical field we have all sought sources of clean heat, and the time has certainly come for increased activity in the development of this concept. Fluid-bed combustion of low-grade fine-coal products is perhaps the most promising line. Certainly, the use of expensive and hard-won liquid fuels or natural gas cannot be countenanced, except for very specialized metallurgical activities. These must be materials reserved morally for our colleagues in the chemical industry, and politically for our motor cars. At long last, also, attention is being paid to other forms of energy, particularly solar heat, although the emphasis so far has been placed on its possible application to water heating. We are of the opinion that there is, in addition, a considerable field for development in high-temperature metallurgical processes for the heating of hydrometallurgical leaching solutions and also, by more sophisticated techniques on which research work is now under way, for the production of higher usable temperatures in the pyrometallurgical field. Another use of solar energy, although photosynthetic, that has recently been announced, is that by a hybrid poplar bush, which is capable of being grown in indifferent climates on soils unsuitable for normal agriculture. It is claimed that, weight for weight, this plant can provide energy at almost the same cost as from coal; so it is possible that we might get back to the bush metallurgical stage of using cord wood or its equivalent.

Water

Unlike the outlook for energy, where we have plenty in total and retain a competitive position that should continue, we do not have enough water. One estimate is that, if present trends continue, the total resources available will be committed by about 1992. Considerable strides have been made, particularly by organizations such as Sasol, AECI, and Iscor, in the intensive recirculation and re-use of waters, and this is a trend that will have to be encouraged and insisted upon. Even so, there is another aspect that is seldom realized: there is no way that we can obtain sufficient water if our neighbouring States do not co-operate, since almost all the main perennial rivers of Southern Africa are international boundaries and the State on the other side is obviously entitled to some say in their exploitation. It may be of interest to record that about three-quarters of the surface water in South Africa as at present occurs in rivers that either rise in or flow through Black homelands, which on independence will undoubtedly look to this asset to assist their future development. We shall have to intensify our conservation methods, and the re-use, particularly of industrial waters, will have to be greatly increased. Anyone who has operated a mineral-flotation plant on a Monday will sympathize when I suggest that re-use of water without partial purification at least will not be acceptable. This example is real and urgent because Monday is wash-day, and the detergents that accumulate in inadequately treated water supplies can upset the entire process. I am impressed with the collaboration that exists between State departments, public utilities, and private industry in attempting to solve the water problem, and, as long as the user does not try to cheat and the control authorities have a reasonable understanding of what is the 'best practicable means', I am sure progress will continue to be made. The C S I R has a part to play here; it has been mentioned that, even for partially effective treatment of low-grade industrial liquid wastes, the use of activated carbon might increase from some hundreds of tons per annum as at present to more than 60 000 tons per annum in twenty years' time.

Ore Reserves

South Africa has been a mining country for a long time, and any ore deposit that has been worked for a hundred years or so, as have some of the traditional diamond deposits and the Witwatersrand complex, has not only been around for a long time but must be closely watched to assess its remaining life. Clearly, in the case of gold there is no chance that the extension of known ore reserves can possibly offset the present rate of depletion, and the gold-mining industry will die unless new deposits can be found. The death can, however, be delayed by techniques and devices for the more-effective operation of lower-grade marginal materials, and the metallurgist has a very great part to play in this. It is every bit as important as finding some new deposits elsewhere, and may be economically more rewarding, because infrastructure may loom large in the capital estimates for the new deposit. Adding to the excitement and raising the stakes for which this game is played is the presence of uranium with many of the gold reefs. We may be seeing the beginning of an era in which it will be more common to have a uranium–gold mine than a gold–uranium mine. In the case of most other metals and minerals, it is perhaps unlikely that many spectacular new high-grade deposits will be found. Again, South Africa has been a prospecting country for a long time. What we as metallurgists will therefore have to do is to concentrate on the development of techniques, some related to existing processes and others perhaps completely different, that will enable us to treat mineral deposits of such low grade that they are not even regarded as ores at present. One example of this, which is being successfully done elsewhere, is the

in situ leaching of uranium that occurs in porous strata, where very low-grade materials are profitably extracted. This technique using natural or synthetic leaching solutions will become increasingly applicable to other base metals. The metallurgist of the future will have to know his microbiology as well. An interesting concept is introduced by this type of exploitation, and a grave responsibility is placed on the metallurgist. There is little chance that he will obtain a high percentage recovery by these methods, and the purist will claim that it is not morally right to leave such a large proportion of the reserve unavailable for future recovery. This is of course nonsense, since, if conventional techniques were used, none of the material could be economically recovered anyway, and in any case such critics may be proved wrong: some tin mines in the Far East have been dredged three times, all profitably, as new techniques have been developed and the price of tin has increased. The Ergo development also illustrates this point.

It is generally conceded that, with the possible exception of the U.S.S.R., South Africa is the most self-sufficient country in the world in relation to mineral resources, and it is certain that we are very well endowed. However, like all generalizations, this one should be probed to reveal the real strengths and weaknesses. Of the strengths, gold remains of the utmost importance, and there is no doubt that our place in the production of the platinum-group metals is well entrenched. Diamonds also remain extremely important, although much of the African production comes from surrounding areas. Chromium is another very great asset, and production is increasing all the time. This is one of the local reserves that the fussy might classify as 'less than ideal' for metallurgical processing. However, imaginative work on the low-ratio Transvaal chromites has come up with two important discoveries: first, that it is possible to use these ores for the production of alloys, and that it is possible at reasonable cost to improve the chrome:iron ratio. This ratio can be altered from the 1,6:1 occurring naturally to as high as 6 or 7:1. This illustrates a fact to which the future metallurgist will have to be constantly sensitive at all times, and he will of necessity lay stress on the importance of thinking broadly and collaborating more fully with other disciplines. There are many cases in the past of how, particularly in large organizations, insufficient attention was paid to the merits of a potential ore deposit because its quality or grade was assumed to be sub-standard in relation to current technology. More and more there is a tendency for formal communication to be insisted upon to avoid, or at least minimize, these misunderstandings, and it is becoming regular and important routine for even preliminary borehole cores and other samples to be scanned and tested at an early stage in exploration. Many of the specialized techniques developed for doing this with speed, accuracy, and low cost are instrumental and mineralogical in nature, and here again the ingenuity and breadth of knowledge of the metallurgist are being extended into fields that he may previously have found unrewarding or felt to be unrelated to his task. There is no longer much place for the metallurgist with no other skills and interests.

Iron ores occur in abundance, although not all are of good quality. The export of ores and semis is expanding, and will no doubt continue to do so to the advantage of the economy.

The same is true of our very considerable strength and potential in coal resources. Here a responsible position has been taken, and surveys have been made to assess what proportion of production and reserves of the various types should be made available for the lucrative export market without detriment to South African industry and the unnatural depletion of overall reserves. Again, imaginative thinking has meant that it has been possible to improve the value and acceptability of coal products by mineral-dressing techniques, but there is much further work to be done before the full potential of our coals is realized.

Vanadium, produced by the treatment of titaniferous iron ores, has become a major export, and South Africa is now the leading producer in the world, and with care should remain so.

Manganese is another very large reserve, and an excellent export business has been built up. Further processing in this case, even as far as high-purity electrolytic manganese, is being undertaken in South Africa. In this industry, the need to assess the competitive aspects of manganese recovery from so-called deep-sea nodules will be ever-present, and defensive research and development work will be essential if we are to remain competitive.

In non-metallic minerals, the importance of limestone should not be underestimated. Its use, not only in cement, as a flux in pyrometallurgy, as a neutralizer and coagulant in hydrometallurgy and water treatment, but also as a raw material for calcium carbide cannot be over-emphasized. In a way, calcium carbide represents a return to the bush period, but, owing to the present feedstock problems in the chemical industry, carbide as a precursor to the production of acetylene using local anthracite immeasurably strengthens the base of our organic chemical industry, including plastics. This illustrates the need for our future metallurgists not to lose sight of and discard the special skills of earlier times. It is not easy to re-assemble lost know-how.

Asbestos is another material whose future potential in terms of variety, quality, and reserves is high. However, for better or for worse, various question marks have been raised about environmental problems caused by the fibres and, even discounting the hysteria, a responsibility rests upon the metallurgist to promote a sensible approach to the evaluation of its hazards and to ensuring that its production and manufacture take place under conditions in which any real dangers are minimized.

Copper, lead, zinc, antimony, phosphate, tin, and sulphur certainly all rank as adequate — far more than adequate as far as self-sufficiency goes — and the same is undoubtedly true of uranium, which perhaps poses one of the greatest challenges to South African metallurgy in the next twenty to thirty years. We have the material, in most cases a by-product of gold mining and therefore competitively priced in spite of the very low grades. After many years, the necessary work for the refining of the yellow-cake concentrate to nuclear

standards has been completed, and a successful South African UKOR enrichment process is at present being operated on pilot-plant scale. Technically, we are well placed, and Escom is going ahead with its Koeberg plant. However, environmentalists and fellow travellers of many persuasions have been making life extremely difficult for uranium-based activities throughout the Western World, be they the activities of producers or potential users of the material for peaceful uses, and it is very difficult indeed to assess the degree of deferment or delay that these protests will cause in various nuclear-energy programmes. What is quite certain is that they will not stop the use of nuclear energy, since its advantages, both economic and (oddly enough) also environmental, are clear. Perhaps I should elaborate on the environmental aspects. The harbingers of gloom presuppose a nuclear explosion, accident, or event and, in spite of learned and completely honest attempts by professionals to evaluate the chances of such an incident, these prophets have so succeeded in obscuring the issue that people are almost beginning to accept that such an occurrence is inevitable instead of only an extremely remote possibility. They overlook the problems of other sources of energy, including the considerable amounts of sulphur and particulate matter that are steadily being added to the air we breathe.

However, South Africa has very real deficiencies: oil, gas, bauxite, and potash as well as natural supplies of soda ash among others. Consequently, the use of possible South African or Southern African raw materials, or precursors for the production of these materials, will remain a serious preoccupation, particularly in research and development programmes with long-term objectives.

Non-metallurgical Factors

So far I have concentrated on the technical aspects but the picture becomes distorted, or at least significantly changed, when other factors not related to metallurgy are considered; put another way, the real world is not such a comfortable place.

Of major importance is infrastructure or the lack of it in relation to possible competition elsewhere. South Africa is well behind the highly developed Western nations, but much of their infrastructure was paid for by the depletion of their mineral reserves, and they are not usually serious competitors in the exploitation of primary reserves. At the other end of the scale are the Third World countries, where the provision of infrastructure can be frighteningly expensive since it is almost entirely absent. To compensate at least to some extent is the fact that their ore reserves are relatively untouched and the grades are high.

The topic of the people directly concerned in the industry is of vital importance and merits separate discussion, but the social and political attitudes of outsiders can also play a very substantial part in the success or failure of a projected metallurgical operation. Recently there has been an increasingly strident clamour for State intervention in the exploitation of minerals in developing countries. This is perhaps inevitable but is certainly not helpful if the aim is rapid and efficient production. This situation is compounded by short-sighted policies that at times reject the idea of production limitation. This was successfully used in the past to correct an overall inbalance between supply and demand, and helped stabilize the price of a commodity. Now, in some basic commodities, production continues at maximum rates, even if the realization price is close to or perhaps below the real production cost. The dilemma is that there is an urgent need for foreign exchange in order to keep going, and this becomes a prime target, irrespective of whether the ore reserve is being depleted without any real gain. This may be necessary for very short periods but must lead to disaster if it is continued for any length of time. Of equal interest are the surprising developments taking place in thinking in countries that, by most definitions, are considered to be highly developed. There is a tendency to plead that all natural resources are the property of the people, and not of individual organizations that are prepared to face the high risks of mining for profit. Foremost in this school are Canada and Australia; particularly in Canada has this kind of thinking become very fashionable. In addition to this doctrinaire approach, cunning use is being made of emotive environmental topics to delay production; the saga of the Alaska oil pipeline has recently been succeeded by another concerned with a gas supply line — also in the West of Canada.

Our problem, though, is where to place South Africa in its relative competitive position. It is my opinion that it is necessary to make one fundamental assumption, without which it is difficult to see that there is a position. It is that socio-political attitudes, both here and among our overseas competitors, will have to become more reconciled. Without this, considerable non-economic pressures, if applied recklessly, could continue to diminish or destroy our competitive position. Our metallurgical future depends on exports, and the Rhodesian chrome example readily comes to mind. However, I believe that substantial change and development will have to occur before concensus is obtained, and our competitive position can have any hope of survival only if this is controlled change rather than 'the too little, too late, nationalize and dilapidate the industry' syndrome. Provided this is possible, our competitive metallurgical potential is considerable — perhaps even outstanding. Until it happens, South Africa is literally in the middle.

People and Productivity

It is of interest to consider the direct effect of people on the future of the metallurgical industry, and I should like to begin with a quotation from a recent document. 'It is highly likely that, unless drastic measures are taken to increase the output of graduates and technicians from South African universities and technical colleges, the expansion of the industry will be limited by the availability of competent people to do research and design and manage our operations.' Let us try to assess what this means. One way of estimating the number of technical people required is to equate manpower with capital expenditure, and a basis of one to two engineer years per million rands of capital is proposed. Others

put the figure as high as five engineer years. If the requisite capital can be made available for major metallurgical and related chemical projects and the necessary infrastructure, it is likely that more than ten billion rands will be needed over the next ten years. If this is even reasonably accurate, it means that at least one thousand additional metallurgical engineers will have to be found to cater for new capital projects, let alone the staff needed to operate these projects and to replace wastage in existing plants. However the build-up is planned, this means that an 'average' of at least 200 new metallurgists per year must be found. At present, only about one-tenth of this number is graduating.

The quotation seems to refer to traditional ideas of technical graduates and technicians, no real note being taken of groups that, at least in Southern Africa, can be regarded as untraditional. Perhaps thought was given to the take-over by Blacks of junior technician jobs left vacant by the elevation of the White occupants to so-called graduate jobs. To me, however, there is no implication of massive training, both academic and practical, for Black graduates to come in to take their rightful place as leaders in industry. The definition of places where they might be considered to be rightfully in charge is subjective and could vary between White South Africa, the Homelands, peripheral countries such as South West Africa, Rhodesia, etc., and those slightly further afield in Southern Africa with substantial mineral resources.

If we are to have any chance of achieving objectives in South Africa, let alone the rest of Southern Africa, where we could be helping so much and in fact taking the lead, it is absolutely essential that the potentially available resources of the Black population be exploited fully.

It is possible at the moment to provide academic training leading to engineering degrees for these people, and it is being done, but it is extraordinarily difficult for a man so qualified to be given anything resembling worth-while exposure to practical, on-the-job training and management experience. As a consequence, it is easy to become discouraged and to wait for the opportunities to arrive before attempting to have people available to fill them. This cannot be correct, and courage and forethought are necessary to ensure that none of these vacancies goes by default when they do occur. Returning to the academic training, I do not believe that the universities are yet fully aware of the problems in training people of different backgrounds and cultures in technical subjects. Where it is possible for Blacks to do an engineering curriculum, it would be very interesting to find out whether there is a lack of appreciation of some aspects of the course, which was designed by Whites for teaching Whites. As a specific example, do Blacks easily manage to absorb the basic principles of engineering drawing, or do they have difficulties with perspective and three-dimensional visualization on a flat sheet of paper? If so, what are we going to do to minimize or eradicate these difficulties, or is it enough to say that the student will probably need extra time and that, in our planning, we should allow for one extra year at university? This approach is not only intellectually lazy, but it is also very expensive.

Even if some of these strong words were taken very seriously and real efforts were made to develop all potential engineers and technical specialists as fully as possible, without restrictions or frustrations, there would still not be enough metallurgists or engineers to handle the hoped-for expansion. The only way therefore in which our metallurgical industry can begin to reach its potential is to accept that we shall have to operate with fewer than the traditional number of people. This implies the development of new labour-saving processes, but also a most concerted effort to overthrow traditional thinking in relation to the utilization of labour in existing mines and metal-recovery processes. In spite of considerable discussion and real efforts in some directions, there is still little indication that a substantial rate of increase in labour effectiveness with increased productivity will be achieved. We are not talking about a historical increase of a few per cent per year but perhaps ten times that, and it is not easy to see where this will come from.

The future of South Africa and its metallurgical industry cannot be considered in isolation, and brave words are spoken about inter-dependence. There is no alternative to inter-dependence, but the terms on which this can be achieved makes prediction — not of the direction, but of the rate of development of the metallurgical industry — an uncertain task. What is certain is that Southern Africa's mineral resources will continue to be exploited and that, in the absence of complete change throughout the area, there will be a place (and an important place) for South Africans who are properly trained and prepared to give all they can to this continued development. The message is one of hope and certain fulfilment, but equally certain are the deep hurts and frustrations that will be encountered along the way. To paraphrase an old mining proverb, there is no substitute in mining for 'grade', and there is no substitute in metallurgy for 'ore reserves', and these we have here in abundance.