Coal-mining productivity in South Africa compared with Australia and the USA

by D.R. Hardman*

Synopsis

South Africa is the third-largest supplier of coal on the world's export markets after Australia and the USA, and the second-largest supplier of bituminous steam coal following Australia.

There are many similarities between the coal industries of South Africa and those of Australia and the USA, in contrast to the coal industries in Europe. For South Africa to maintain a competitive position on the export markets, it must continue to compete against these two countries. It is therefore important that the performance of the local coal industry should be assessed against that of the Australian and US coal industries. Although financial performance is the major criterion, financial information is not easily obtained, and the paper therefore uses employee productivity in the form of tonnes per man year as a means of comparison. The paper reviews recent trends in the level of production and numbers of employees prior to reviewing the productivity. The influence on productivity of some mining methods is highlighted.

It is realized that published information (information available within the public domain) can contain anomalies, but every effort is made to compare data of a similar type. Notwithstanding possible inaccuracies, it is shown that South African coal-mine productivity lags far behind that of Australia and the USA. The significance of the difference is that the South African coal industry is able to apply overseas practices and procedures that have been shown to give improved performance, and that the increased use of more productive extraction techniques has limited application.

Introduction

In 1995, coal exports from South Africa reached a record level[1] of 60 Mt, which represents almost 29% of the country's total saleable production of 206 Mt. The remaining 146 Mt of saleable production was used internally, mainly for the generation of electricity, (79 Mt), and in the coal-conversion industry, where 43 Mt of low-quality coal was consumed. The rest of the saleable production was divided equally between metallurgical-industry requirements and general-industry and household use. The total value of the export sales tonnage was slightly higher than that of the much higher tonnage of internally consumed coal, amounting to 6479 million rands for export sales and 6339 million rands for local sales.

For South Africa to remain in the export markets, it has to compete against established producers such as Australia and the USA, as well as more recent market suppliers such as Indonesia, China, and Colombia.

Many factors impact on the competitiveness of export products, but the bottom line from the customers' point of view is obtaining the right quality of coal at an acceptable price and at the right time. By the time the coal has been loaded into ships for export to customers, irrespective of the country in which this occurs, the mined cost of the coal is smaller as a percentage of the total cost, and yet it is only that portion of the cost which coal producers can generally influence to achieve a competitive free-on-board (FOB) price.

As a supplier of coal on the export market, South Africa has an excellent track record of reliability with regard to fulfilling the contract requirements of customers. This has been achieved through close collaboration and understanding between the employers and employees of the companies involved in the export chain, namely the producers, and the rail-transport, coal-terminal, and port-handling authorities. This has been a facet of the South African coal export business that has been difficult to achieve by its main competitors, Australia and the USA, where interruptions to coal supplies due to industrial disputes have been regular occurrences in the past. However, over the past five years there has been a steady decline in the number of industrial disputes, particularly in the coal mines of New South Wales[2]. Thus, what used to be an advantageous situation to South African coal suppliers on the export market will decline in the future if the present trend in overseas industrial action continues.

Australia is by far the major supplier of coal on the export market, with the USA and South Africa close together in second and third positions; however, the combined tonnage of these two countries is still less than that of Australia.

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The fluctuating supply-and-demand situation on the world's export markets inevitably leads to considerable competition among the major supplying countries. Although the final selling price is the major factor in a customer's selection of a particular type or quality of coal, cost information is not readily available, and this paper reviews labour productivities in an effort to assess South Africa's future ability to remain competitive in the export markets.

Existing mining methods

The mining methods used in the three major coal-exporting countries (Australia, the USA, and South Africa) are similar. Each country makes use of bord-and-pillar and longwall mining in underground workings, as well as surface-mining techniques, such as opencast strip mines and truck-and-shovel operations. Although similar methods are in use, the percentage share each method contributes to the total production in each country differs considerably. As will be seen later, the mining method influences the overall productivity; therefore, the tonnage contributed by each method to the total tonnage in each country is of interest. A lack of easily accessible data limits the comparison to surface and underground methods, with the tonnage and share of longwall production also indicated. Unfortunately, the only data available for the USA relate to 1991 and 1992, three years earlier than for the other two countries.

It is apparent from Table I that the more productive methods, namely surface mining and longwall underground mining, are employed more in Australia and the USA than in South Africa. In the case of Australia, surface mining contributes approximately 71% of the total saleable production, while in the USA the surface contribution was 59% in 1992. In South Africa, surface mining contributes 45% of the total saleable output. The figures show a similar trend for longwall operations, with the Australian coal industry deriving about two-thirds of the underground saleable production from longwall extraction. For the USA, the longwall saleable production was almost one-third of the underground production in 1992. In South Africa, the number of operating longwall faces decreased during the latter half of the 1980s, and at present longwall mining contribute about 13% towards the total underground saleable production.

Table I shows that the amount of coal produced in Australia by the more highly productive extraction methods of surface mining and underground longwall extraction is about 90% of the total saleable production. In the USA, the comparable figure was 72% in 1992 while, in South Africa, the figure is at present around 52%.

Labour productivity

Although similar mining methods are applied, and although it has been shown that the percentage contributions of the methods vary, it is of interest to compare the labour productivity of the three countries over a period of time. Since productivity can be increased either through an increase in the output at constant input, or through constant output at reduced input, the input and output trends are compared first.

Figure 1 indicates the trend in saleable output for the three countries with 1985 as the base year. Over the ten-year period to 1995, South Africa (RSA) increased its saleable output by 30 Mt from 176 to 206 Mt, an increase of 17%. For the same period, the USA[6] increased its saleable output by 153 Mt, from 778 Mt to 931 Mt, an increase of 19,7%, and Australia increased its saleable output from 129 Mt to 193 Mt, an increase of 64 Mt or 49,6%. The downturn for the USA in 1993 was abnormal, being due to an extended industrial dispute between union and owners.

Figure 2 shows the average number of employees involved in each of the mining industries of the three countries since 1985, and Figure 3 shows the change in the number of employees with 1985 as the base year.

The employment level in the Australian coal industry fell slightly over the period 1985 to 1995, decreasing from 31 165 to 25 514, a reduction of 5651 employees, or 18,1% of the 1985 labour force. Approximately half of this reduction occurred in the period 1992 to 1995. The USA and South Africa show dramatic reductions in the number of employees

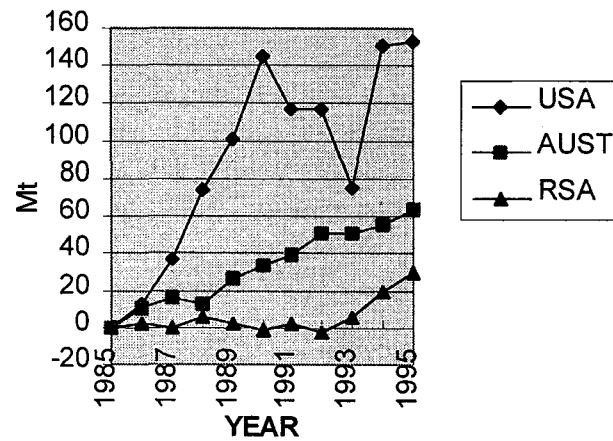

Figure 1—Increase in saleable coal since 1985

Table I

Production by mining method (in saleable megatonnes, Mt)

Country	Year	Total	Surface	Underground	Longwall		
					Output	% of underground	% of total
Australia[3]	1994	184	130	54	35	64.2	18.9
	1995	193	136	57	39	68.6	20.2
South Africa[4]	1994	196	89	107	11	10.6	5.8
	1995	206	93	113	14	12.7	7.0
USA[5]	1991	895	528	367	107	29.3	12.0
	1992	895	529	366	115	31.4	12.8

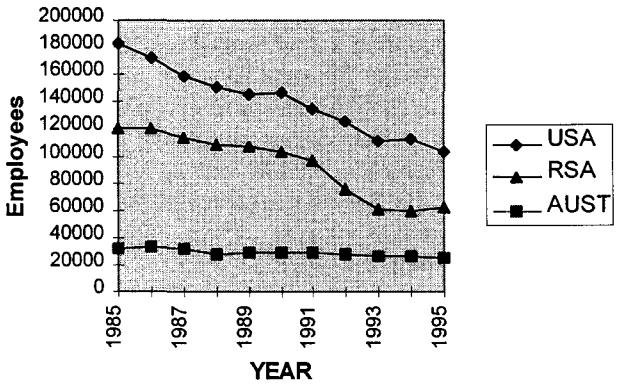

Figure 2—Average employment levels

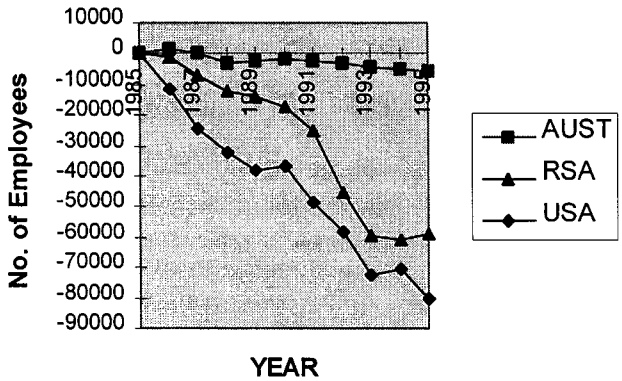

Figure 3—Change in employment levels

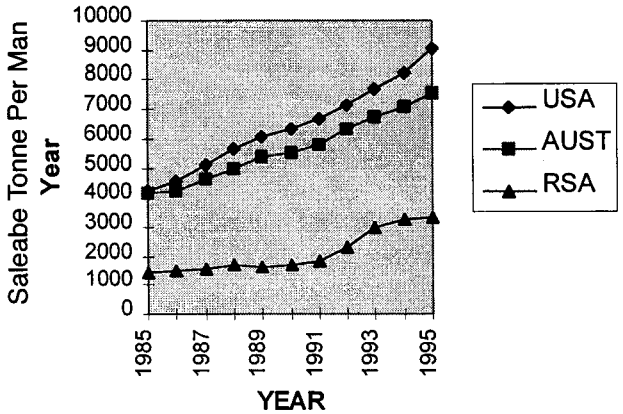

Figure 4—Employee productivity

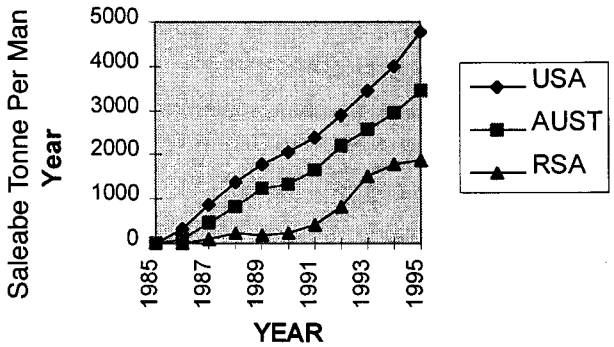

Figure 5—Change in employee productivity

in comparison with Australia. Over the ten-year period, the employment level in the USA coal industry decreased from 183 373 to 103 162, a reduction of almost 44%, while the South African employment levels fell from 120 959 to 62 125, a reduction of almost 50%. In the USA and South Africa, the reduction in the number of employees was most dramatic between 1990 and 1993. Of the three, South Africa is the only country at present showing an increase in employment levels.

It is apparent from the generally increasing trends in saleable output, as well as the reductions in input (decreasing number of employees), that all three countries will reflect an increase in employee productivity. Figure 4 shows the trend in absolute value of employee productivity since 1985, and Figure 5 shows the change in productivity with 1985 as the base year.

Both the USA and Australia showed a steady increase in productivity throughout the period, whereas South Africa had only a marginal increase up to 1991, with the main increase occurring between 1991 and 1993. The average output per employee in the USA increased from 4243 saleable tonnes per man per year (tpmy) in 1985 to 9025 tpmy in 1995, an increase of 113%.

Over the same period, the overall productivity in Australia increased from 4139 to 7564 saleable tpmy, an increase of 83%. From Figure 4 it is noticeable that employee productivity in the USA had an advantage of just over 100 tpmy compared with that of the Australian coal industry in 1985. By 1995, this advantage had increased to just less than 1500 saleable tpmy.

Between 1985 and 1995, the South African coal industry had the highest percentage increase in employee productivity, increasing from 1455 to 3316 saleable tpmy, an increase of 128%. However, it is apparent that the average level of productivity in the South African coal industry is well below that prevailing in the USA or in Australia, and it is generally much easier to improve performance from a lower level, with future increases becoming progressively more difficult. Figure 4 also shows that the present level of productivity in the South African coal industry is still only about 80% of the 1985 level attained by the industries of Australia and the USA.

Surface and underground productivity

The average employee productivity is influenced by the particular mining methods employed. As previously shown, the wider use of longwall operations underground results in higher employee productivity. Similarly, a wider application of surface-mining operations also leads to increased employee productivity. This is illustrated in Figures 6 and 7, which compare surface and underground productivity in Australia and the USA.

Over the respective time periods, there was a wide variation in the increase in productivity with the underground increase in Australia (Figure 6), being 105% over the ten-year period to 1995, while the increase in surface productivity for that country was only 49%. In the

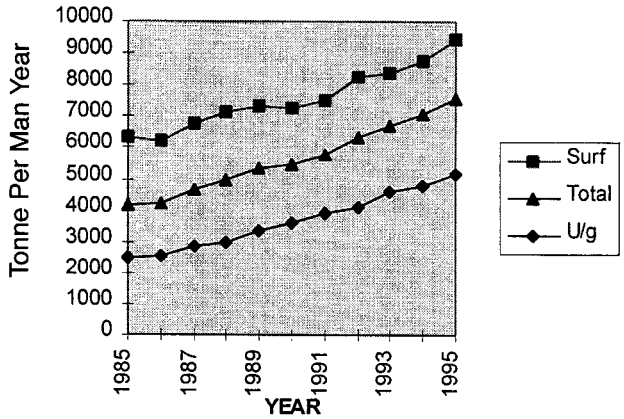

Figure 6—Surface and underground productivity in Australia

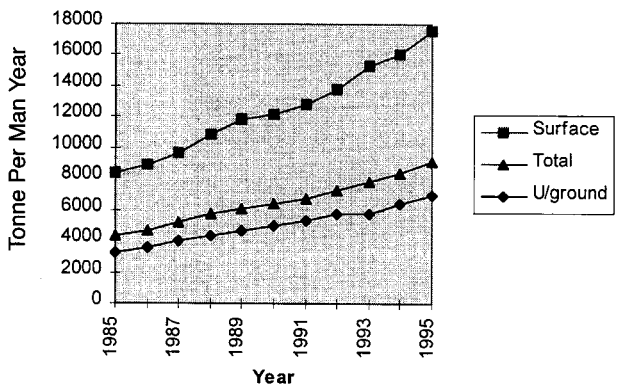

Figure 7—Surface and underground productivity in the USA (bituminous coal mines only)

bituminous-coal industry of the USA (Figure 7), the increase in productivity of the two methods was much closer, being 117% for underground mines and 111% for surface mines.

For Australia, the difference between surface and underground productivity decreased over the time period, and this is further illustrated in Figure 8, which shows the trend in the ratio of surface to underground productivity for Australia and the USA.

In 1985, the productivity of the surface mines in Australia was greater than that of its underground mines by a factor of 2.5, but this decreased to a factor of 1.8 in 1995. For the USA, the ratio has remained reasonably consistent since 1985, being in a narrow range between 2.4 and 2.7.

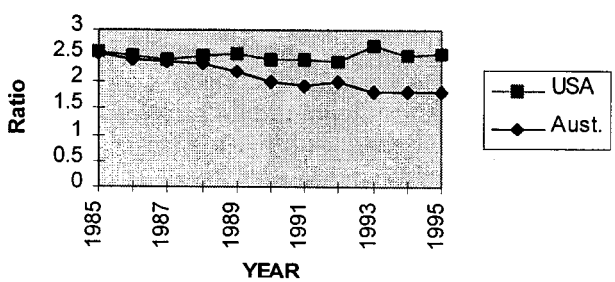

Figure 8—The ratio of surface and underground productivity

Productivity values for surface and underground operations in South Africa are not as easily available as those in Australia and the USA. However, for 1994, the following values were derived: 5794 saleable tpmy by surface mining and 2502 saleable tpmy by underground mining. For 1995, the respective values were 5999 and 2607 saleable tpmy. It is of interest to note that the ratios of surface to underground productivity for South Africa were 2.32 and 2.30 for 1994 and 1995, respectively.

Relevance of employee productivity comparisons

The fact that the average employee productivity in the South African coal industry is less than half that of the Australian and US coal industries is of significance in that it shows the South African industry what is achievable elsewhere with given technology and with particular work practices. Given South Africa's present objectives of job creation, the priority in the local coal industry is to maintain employment at the highest level that will sustain a profitable operation. Within the boundaries of existing labour structures and cost factors, the profitability on average can be sustained at present at an average level of just over 3000 saleable tpmy. However, coal-mine profitability on average can be maintained in Australia and the USA only by mining at employee productivity levels that are far higher than those required locally. Although the labour cost is only one part of the whole cost structure, it is apparent that South Africa does not yet need to match the productivity levels achieved by the coal industries in Australia and the USA.

The rise in employee productivity levels illustrated in Figure 4 equates to average increases per year of 11.3% for the USA, 8.3% for Australia, and 12.8% for South Africa over the ten-year period. Output increased in Australia with a small (18%) reduction in employee levels, which implies improved utilization of the existing employees and equipment, as well as improved extraction technology. In the USA, increased productivity was accompanied by a much greater reduction in the number of employees than in Australia, and this could be possible only by the use of more efficient extraction procedures.

Both countries increased the percentage share of longwall production from underground operations, and this helped to improve the underground productivity. However, whereas surface productivity in the USA over the past ten years increased by about 10% per year, (similar to the increase in underground productivity for both Australia and the USA), surface productivity in Australia increased by an average of only about 4% per year. The higher improvement in surface productivity of the coal industry in the USA is the reason that they have managed to improve more than the Australians over the past few years.

Environmental issues in the USA have, in recent years, resulted in a change in coal production from the high-sulphur coal of the eastern states to the low-sulphur coal of the western regions, where there are highly productive opencast mines. It is only in recent years that restrictive work practices affecting surface mines have been relaxed in Australia, and this may result in improved employee productivity in the near future.

The future for South Africa

When the need arises, the changes that have taken place in Australia and the USA will have to be applied in South Africa as a means of increasing productivity. The average productivity over the whole South African coal industry is less than what was achieved by the Australian and USA industries more than ten years ago, which indicates that much can still be done by the local industry to increase productivity. It can do this in two ways: either by improving the productivity of the existing methods, or by changing to more productive methods of extraction. To achieve the former is an on-going operational process undertaken by mine management and production teams, but the latter invariably requires extensive feasibility studies because of a need for high capital expenditure and the solving of potential environmental issues.

An increase in the percentage of total production from opencast operations is a means of increasing productivity, but this depends on the disposition of the coal deposits with regard to depth and stripping ratios, and most of the shallow deposits are nearing exhaustion for the purpose of sustaining large mining operations. Small-scale surface operations may therefore become a more viable alternative. Much coal still remains in the ground as support pillars, and experience with existing surface mines designed to extract the pillars from surface may lead to a wider application of such techniques.

The wider application of longwall mining is still limited by geological anomalies in many of the existing mining areas, resulting in inefficient operation of a highly capital-intensive system. However, there appears to be scope for the future increased use of mini-walls as a means of attaining improved productivity.

Although the recent fall of the rand against the US dollar will benefit revenue in the short term, it will eventually lead to increases in capital and operating costs. Therefore, operators will be looking more critically at how to better utilize their existing equipment and employees, rather than purchasing new technology from overseas. Continuous miners are still far from being continuous, and alternative methods of utilizing the existing equipment need to be devised to improve the overall productivity. Generally speaking, the present-day continuous miners used in South Africa do not have a cutting problem as they did in the past, but they still cut coal for only 20 to 40% of a shift. The short- and long-term training of employees is an area where benefits are foreseen, and an increase in this aspect of employee upliftment is of paramount importance, from the viewpoint not only of direct productivity improvement but also of health and safety aspects.

In the long term, owing to changing circumstances and priorities, the need to remain competitive will require new technology, rather than the adaptation of existing technology. It is usually such changing needs in an atmosphere of survival that lead to innovation and new technology. The South African coal industry should be able to remain competitive in the short term by adopting procedures previously applied in the other two countries. Because of their existing high levels of employee productivity, the coal industries of the USA and Australia will require new technology before the South African coal industry does, and their need to survive will generate the required technology.

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Scholarship to South African post-graduate students — ferroalloy research in Norway

The Norwegian Ferroalloy Research Association (Norwegian Abbreviation FFF) is an association founded in 1989 by the Norwegian ferroalloys industry to carry out joint research on ferroalloy processes and products. This research takes place in close co-operation with SINTEF Materials Technology and the Norwegian University of Science and Technology, Dep. of Metallurgy. The research programme is aimed at supporting the education of PhD-students as well as general research of interest to all the Norwegian ferroalloy producers.

One of the projects is, since 1990, SLAG PROCESSES where the objectives are to study phase relations, equilibria, kinetics and mechanisms related to the production of manganese and chromium ferroalloys in submerged arc furnaces. The ultimate goal is to improve the process understanding by providing the basic knowledge necessary for process modelling and for control of slag and metal composition, metal yield, slag/metal weight ratio, energy consumption etc. Important parameters are slag basicity, process temperature, raw material quality, and of course the electrical parameters.

The research group will normally consist of 6-8 researchers, including the PhD-students. International cooperation is considered very important and we are doing joint research with groups in China and Russia. One Chinese has graduated as PhD, and one Russian did more than 3 years of post-doctoral work in the group. At present we are waiting for one or two post-graduates from Jilin Ferroalloy Works in China to stay here for about one year.

FFF would like to promote further contact with Mintek and universities such as the University of the Witwatersrand which they believe would be of mutual benefit. To initiate such research contact/cooperation, FFF will offer a research scholarship to a South African post-graduate or post-doctoral researcher for about one year.

The scholarship will cover travel to and from Trondheim-Norway, and a monthly salary of about 3000–3500 US$, dependent on qualifications.

The FFF wish to study ferromanganese slag properties and melting/reduction relations of manganese ores. An example is determination of liquidus composition-temperature relations for five component slags. Another is to study wetting properties of slags towards different carbon qualities. In the research group we also study equilibria and kinetics related to reduction of MnO from various slags.

A suitable arrival in Norway would be as soon as possible after the end of August this year. Please contact Professor Sverre E. Olsen, Department of Metallurgy, Norwegian Institute of Science and Technology (NTNU), Trondheim, Norway, fax: 094 775592784, phone: 094 775595000 for more details. ◆

Sasol sponsors four new awards for top Wits engineering students

Dr Tim Fenton, manager of the process department at Saftech, presents the Sasol achievement medal for the best final year project in corrosion science in the School of Process and Materials Engineering at Wits University to Warren le Roux

Sasol, a long time supporter of the engineering faculty at Wits University, has added four new awards to several already sponsored by the group for top Wits engineering students.

The new awards are part of an ongoing initiative by Sasol to encourage students countrywide to excel in technical fields, in which graduates are critically needed.

The new Sasol awards take the form of achievement medals for the best undergraduate and postgraduate students in the School of Mechanical Engineering and in the field of corrosion science in the School of Process and Materials Engineering. They were recently presented for the first time at the faculty's annual prize giving.

Awards already presented by Sasol on an annual basis at the Wits engineering faculty prize-giving include the Sasol medal for excellence in mining engineering, and four prizes for deserving students in different final year subjects in the School of Process and Materials Engineering.

MSc student Paulus van Nierop receives the new Sasol achievement medal for the best postgraduate student in mechanical engineering at Wits University from John Bredenkamp, manager of group training and development services at Sasol. ◆

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