The potential of coal wastes in South Africa

by P.J. Lloyd*

Synopsis

There are few data on the composition of discard coal in South Africa, and no overall view of the discards for the entire industry. As a result of work on coal qualities in South Africa, a database was established which enabled a good estimate to be made of the composition of the discard from every mine. The data are presented in the form of histograms of ash, volatile matter and fixed carbon content of the 43 million tons of material which were discarded in 1990. The results are discussed in terms of the closeness of the composition of much of the discard material to presently used power station coal. It is concluded that it is mainly developments in equipment, particularly fluidized bed boilers, which inhibit the wider use of discard coal. However, other factors must be noted, including the relatively high sulphur content of the discards, and the fact that even with the most careful storage the material ages and may become unusable after about 15 years.

Introduction

South Africa started to export coal in the early 1970s. The export contracts required low ash (<9% ash) material, and for the first time, the South African industry started to wash its products in large quantities. The discard was dumped, and many dumps started burning due to spontaneous combustion. By the mid-1980s, the sulphur content of the air in what is now Mpumalanga had reached noxious levels in some regions. Studies soon showed that the primary source was the burning dumps, not, as had been supposed, the power stations which dot the landscape in the area. As a result, methods for constructing dumps were evolved which markedly reduced the chance of spontaneous combustion. From that time, reasonable reserves of potentially useful discards have built up.

However, data on discard composition are not generally available. The Department of Minerals and Energy produces a regular report on coal composition (Pinheiro *et al.*[1], Prevost and Phetha[2]) but these barely touch on discard composition. In December 1998 the Government published its White Paper on Minerals Policy that largely stressed the environmental aspects of coal wastes while recognizing that they represented a significant energy resource. Unlike other aspects of the minerals policy, this particular aspect was not discussed quantitatively—data are lacking.

During 1997 we undertook studies of the contribution of the coal mining industry to the release of greenhouse gases, particularly methane, in South Africa (Lloyd *et al.*[3]). The base date for this study was 1990. The coal mining industry was of great assistance, and made available detailed operational data for that year. Once the data had been used for the purpose for which it had been released, we realized that it could be further employed to provide an overall view of coal discards in South Africa. It is the purpose of this contribution to summarize these findings.

The nature of the database

The database contains:

- A listing of the 80 bituminous and 17 anthracitic mines operating in 1990
- A short description of the geology and the mining method(s) employed on each mine
- The total tonnage of coal mined on each mine, and the total tonnage of waste other than overburden produced, during 1990
- A proximate analysis of at least one product, and where available, of the run-of-mine (RoM) coal. The proximate analysis covered calorific value, air-dry moisture, ash, volatile matter and fixed carbon also on an air-dry basis. Sulphur data were generally lacking.

In 1990, 214 million tons (Mt) were mined to yield 171 Mt of saleable product. Of the mined tons, 207 Mt had data regarding the

* *Department of Chemical Engineering, University of Cape Town, Rondebosch, 7700.*

© *The South African Institute of Mining and Metallurgy, 1999.* *SA ISSN 0038–223X/3.00 + 0.00. Paper received Nov. 1999; revised paper received Dec. 1999.*

wastes produced. The wastes amounted to 42 Mt for which we had data and another 1 Mt of wastes was inferred. The saleable tons comprised 79 Mt of raw coal and 91 Mt of washed coal (note that reporting results to the nearest 1 Mt gives rise to rounding errors; 79 + 91 = 170, not 171). Figure 1 summarizes the flow of material through the Industry in 1990.

Data on coal qualities was available for a total of 210 Mt of either RoM or washed coal, of which

- 126 Mt was for RoM coal, which made up 59% of the total RoM coal, and
- 84 Mt was for washed coal, which made up 91% of the total washed product.

There was no data on discard compositions. However, as discussed below, Grootegeluk kindly provided composition data for their discard in 1990, which permitted the Grootegeluk RoM to be estimated. The RoM for which composition data was available therefore increased to well over 70% of the total RoM.

Analysis of the data

It was necessary to estimate some of the missing composition data. To do this, the existing data for a particular seam was averaged on a tonnage-weighted basis, and the averaged data used in place of the missing data. For multi-seam mining as in some opencast operations, regional data rather than seam data were averaged. An exception was Iscor's Grootegeluk colliery, which has a complex geology.

In the case of Grootegeluk, the original database had data only on the product compositions. The mine was therefore approached directly, and agreed to make available the average discard composition for the year. This seemed desirable, not only because Grootegeluk has a unique geology, but also because the waste from Grootegeluk makes a significant (>10%) contribution to the total coal wastes in South Africa[4]. These data permitted the otherwise unknown feed composition to be estimated.

Then for virtually every washery we had data on at least two of the mass flows (usually product and waste) during the year, from which the mass flow of the third (usually the RoM) could readily be derived. Those washeries for which we had insufficient data produced in total approximately 300 kt of washed product (or 0,33% of the total washed product), and were excluded from further consideration.

In every case analysed further (representing over 99% of all discard), there was data on the composition of the feed and product streams (although in some cases, representing a little over 20% of the total tonnage fed to washeries, averaged data had to be used for the feed composition, as discussed earlier). The composition of the discard stream was then derived by mass balance.

Results of the analysis

The results of the analysis are shown in Figures 2 to 6. The data are given on a dry basis.

The ash distribution shown in Figure 2 is strongly bimodal, with over 30%, or about 20 Mt of discards having over 70% ash. About half of this arises from the Grootegeluk operations. The remainder of the >70% ash discards arise from double-washing operations producing both a low-ash export coal and a power-station middlings. It is interesting to note that the power station middlings show high abrasiveness, poor burnout and occasionally slagging problems as well, hinting that unwashed discards may show even poorer performance when fed to power stations.

In contrast, the distribution of volatile matter is sharply unimodal, with virtually no material at all above 30%. Very low (less than 10%) volatiles would be expected to be associated with high ash contents, but whereas Figure 2 shows over 30% of the coal has over 70% ash, Figure 3 shows that only about 10% of the coal has <10% volatile matter. This in turn means that some of the moderately volatile-rich material must also be of high ash content.

Figure 4 shows that the distribution of fixed carbon is also bimodal, and is effectively the inverse of the ash distribution. To clarify just what was happening, the data were re-analysed in three dimensions.

Figure 5 makes it clear that there is indeed a strong association between high ash and low volatiles, but in the medium range of ash content there is very little low-volatile material, while in the lowest (<40%) ash content there is similarly very little high (>25%) volatile material.

Similarly in Figure 6 we show the variation of fixed carbon with ash in the discard. This shows that there is a

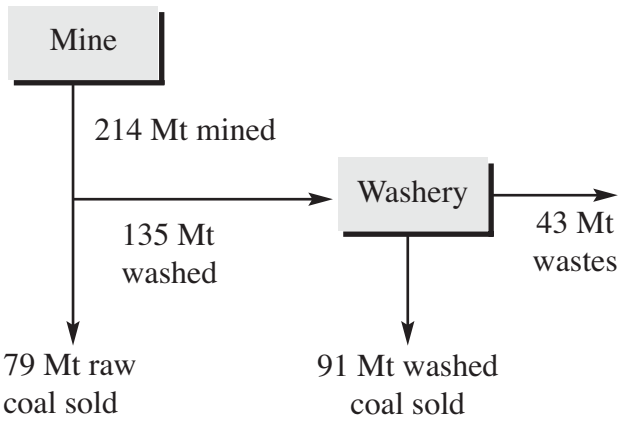

Figure 1—Flows in the industry in 1990

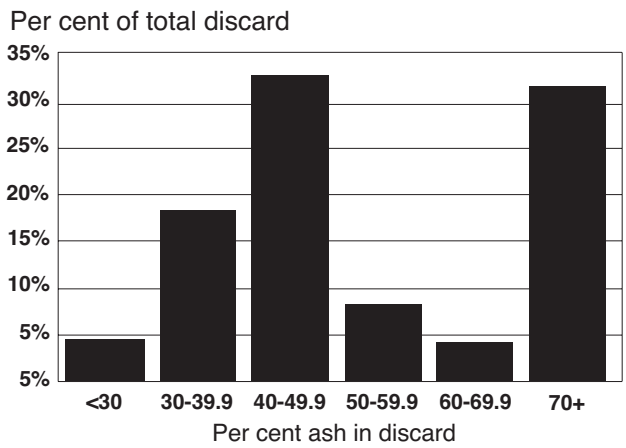

Figure 2—Discard ash distribution (dry basis)

surprisingly large quantity of material which has more that 40% fixed carbon, and less than 40% ash. It is clearly a fairly high rank material approaching anthracite.

Discussion

The typical raw coal from most South African collieries has

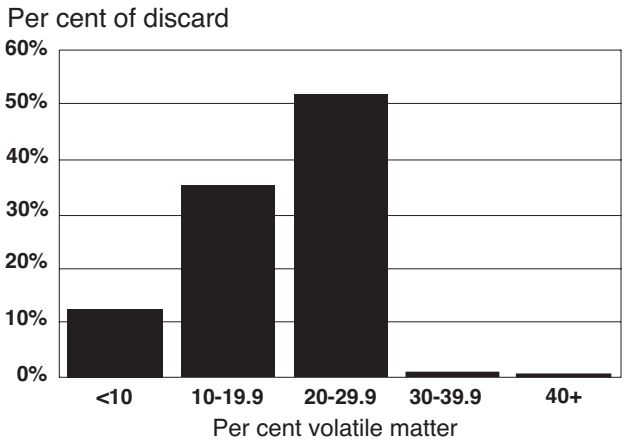

Figure 3—Discard volatile matter distribution (dry basis)

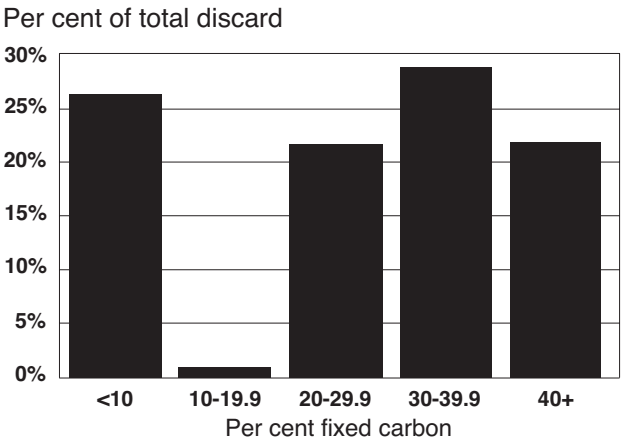

Figure 4—Discard fixed carbon distribution

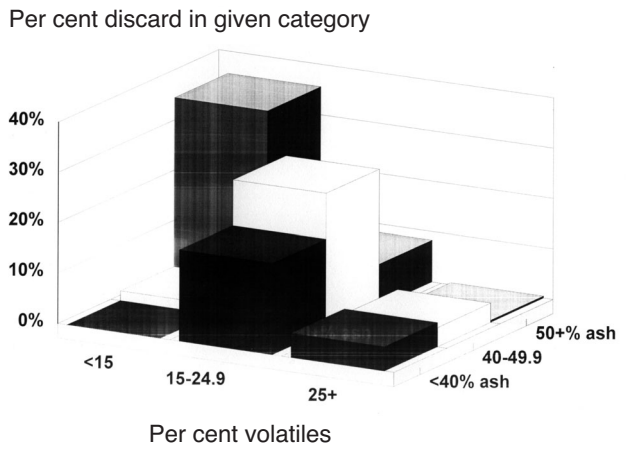

Figure 5—Discard composition as a function of ash and volatiles

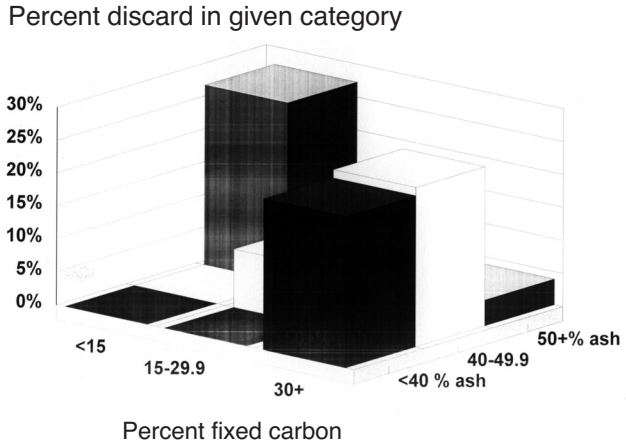

Figure 6—Discard composition as a function of ash and fixed carbon

about 25–35% ash, 22–24% volatile matter, and 44–50% fixed carbon. In contrast, the discard coal typically has well over 40% ash, 15–25% volatile matter and <35% fixed carbon. It must, therefore, be recognised that discard coal is a *poor material.*

That being said, it is not surprising that the Government is very interested in a possible source of energy, readily available on surface and growing at more than 40 Mt per annum. The question is, how can we use it?

As a first step, it is worth remarking that, while discard coal is not a very good source of energy, it is quite similar to the poorest coal presently being supplied to existing Eskom power stations. It will burn, and so it can be used to generate energy. Indeed, some washing plants that originally produced a large discard stream found it more economic to change their operations slightly, and produce a power station middlings product, so reducing the volume of discards.

The primary reason for not burning discard coal already, is that it is only recently that boilers have been developed which are able to use material nearly as abrasive as the average discard. In a nutshell, we have lacked the equipment for burning it. However, fluidized bed combustors are rapidly reaching the stage of technical development essential for their use in commercial power generation. So the problem of the lack of suitable equipment might soon disappear.

A subsidiary problem is that the discards are generally situated in remote locations (because high-ash materials produced close to a power station are being burned in the station). There is the added problem that, in Mpumalanga where most of the discards are stored, there is a definite shortage of the water that would be needed if they were to be used for power generation. To make matters worse, the discards contain over 2% sulphur, which is relatively high by South African standards (but below the 3% levels common in some North American and European coals.) The Chief Air Pollution Control Officer has prohibited the emission of further sulphur dioxide in large areas of Mpumalanga where most of the better quality discard is stored. Thus either clean coal technologies, which are expensive, would have to be adopted for using the discards, or they would have to be transported away from their present location to be used in an area where there are less restrictions on sulphur dioxide releases.

There is also the possibility of re-treating the material to extract the more valuable constituents. A number of collieries practise 'double washing' to reduce the value of their discard as far as possible. It works, and the middlings fraction is indeed saleable—provided you can find someone to buy it. It transpires that, effectively, the power station market is the only one that will take such low grade material, and the nature of the supply contracts is such that it is barely worthwhile entering into a contract with material with such potentially variable qualities. The National Power Regulator is looking into policy changes which would ease the contractual conditions under which coal is sold to Eskom, but it has to take into account the fact that you can't monkey around too much with the feed to a plant worth R10 billion.

Then, whatever use to which it is put, the material must be used soon, or it will be lost. Recent studies[5] have shown that, in spite of all the attempts to exclude air from the dumps, the coal definitely ages on standing. This results primarily from the loss of the more reactive macerals, with the result that, in testing for use as a pulverized fuel, burnout times become unacceptably long. At the proximate level, volatile matter disappears. The rate at which ageing occurs is directly related to the volatile matter concentration in the discard. Material with a high content of volatile matter loses most of it within fifteen years, even under the most stringent storage conditions.

We would conclude that, while it is true that discard coal has some potential to make a contribution to South Africa's energy supply, there is no cause for optimism about its long-term prospects. Coal miners are no different from other people —they don't knowingly throw stuff away if someone is prepared to buy it from them. It isn't called 'discard coal' for nothing.

Acknowledgements

It is a pleasure to acknowledge the assistance of Dawie van Wyk, then of Ingwe and now a private consultant, Xavier Prevost of the Minerals Bureau, and the mines themselves for much of the data on which this paper is based; and the National Climate Change Committee via the FRD for financial assistance towards the original study which in turn gave rise to the possibility of exploring this extension of the original work.

References

1. Pinheiro, H.J., Pretorius, C.C., Boshoff, H.B., and Du Cann, V. *Analyses of coal product samples of producing South African Collieries*. Bulletin No. 112, CSIR, Pretoria. 1998.
2. Prevost, X.M. and Phetha, T.N. *Operating and developing coal mines in the Republic of South Africa* 1988, Directory D2/99, Minerals Bureau, Pretoria. 1999.
3. Lloyd, P.J., Cook, A., Van Wyk, D., Prevost, X., and Falcon, R. *Emission of methane from coal mining and post-mining activities*, Appendix 1g, Report to Foundation for Research Development for SA Climate Change Committee. 1997.
4. Dreyer, J.C. Personal communication. 1999.
5. Wagner, N. The petrography of material recovered from waste coal dumps. PhD thesis, University of the Witwatersrand, 1999. ◆