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SUBJECT: THE REDUCTION IN ASH CONTENT OF SOME SOUTH AFRICAN COALS

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FUEL RESEARCH INSTITUTE OF SOUTH AFRICA

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THE REDUCTION IN ASH CONTENT OF SOME SOUTH AFRICAN COALS

The high capital cost of a coal hydrogenation plant makes it essential that the oil output be maintained at as high a level as possible and this factor must primarily govern the choice of the coal to be used or the decision as to whether a coal is suitable for hydrogenation.

There are two major factors to be considered in evaluating a coal for hydrogenation purposes. The one is the ease with which its organic constituents can be liquified, the other is its mineral matter content. In so far as South African coals are concerned, the former factor has been studied by Petrick, Gaigher and Groenewoud (The Hydrogenation of South African Coals C.M. and M.S. Vol. 38. No. 3. p.p. 122 - 144. 1937). Their tests show that, apart from narrow bands of coal in some few seams, our coals can not be as readily hydrogenated as the best of the British coals but that the following coals are sufficiently amenable to hydrogenation to be worthy of consideration.

The Bottom Seam of the Vereeniging Field.

The C Seam of the Breyten Field.

The lower bright portion of the No. 2 Seam of the Witbank Field.

The No. 5 Seam of the Witbank Field.

The No. 3 Seam of the Witbank Field.

The No. 4 Seam of the Paulpietersburg Field. (when unaffected by dolerite)

The Coal of the Molteno Field. (when unaffected by dolerite).

Of these, adequate quantities of the Vereeniging, Breyten and Witbank No. 2 Seam coals are known to exist, the Witbank No. 5 Seam has been traced over large areas but little is known of possible variations in its quality as this seam is not being worked, the known high volatile deposits of the Paulpietersburg No. 4 Seam are nearly worked out but there is a possibility of further deposits existing in the area to the west of Paulpietersburg, the thin Witbank No. 3 Seam is only of theoretical interest and the Molteno Seam, besides being thin and very dirty, is not known to occur in any considerable quantity. It is possible that, as a result of further investigation, some of the high volatile coal of the Klip River Field may also prove to be easily hydrogenated.

The mineral constituents of coal as fed to a hydrogenation plant decrease its capacity by the volume they occupy in the plant and further reduce the yield owing to the difficulty of separating completely the oily product from the mineral matter. In addition, owing to their abrasive properties, they considerably increase maintenance costs and decrease average throughput. It is therefore essential that the ash content of the coal feed be reduced to a minimum. The coal used by the Billingham hydrogenation plant is washed to 2½% ash and the estimates in the Rivett Report are based on a coal of 4% ash.

This paper deals with some preliminary observations on the ash contents of the Vereeniging, Breyten, Witbank No. 2 Seam and Paulpietersburg coals based on an investigation of the following samples.

I. Nut Coal (-1¼" + ¾") from a colliery working the bottom seam in the Vereeniging Field.

II. Washed Cobble Coal (-3½" + 1¼") from a colliery working the bottom seam in the Vereeniging Field.

III. Nut Coal (-1¼" + ¾") from a colliery working the C seam in the Breyten Field.

IV. Sample III washed by gravity separation at Sp.Gr. 1.45 without previous crushing, yield of clean coal, 67%

V. Run-of-mine Coal crushed to -1" + 0" from a colliery working the lower portion of No. 2 seam Witbank Field.

VI. Sample V washed by gravity separation at Sp.Gr. 1.45 without further crushing, yield of clean coal, 71%.

VII. Run-of-mine Coal crused to -½" + 0" from a colliery working the high volatile No. 4 seam, Paulpietersburg Field.

Cumulative specific gravity analyses of these samples made after crushing to pass a 1 m.m. square mesh sieve are given in Table I.

TABLE I

SPECIFIC GRAVITY ANALYSES ON -1 m.m. COALS

SAMPLE	I Vereeniging	II Washed Vereeniging	III Breyten	IV Washed Breyten	V Witbank	VI Washed Witbank	VII Paulpietersburg.
Float at S.G. 1.30 %	0	0	2	3	13	19	37
Ash on float at 1.30 %	-	-	-	3.1	3.0	2.9	3.3
Float at S.G. 1.35 %	10	15	22	33	34	49	65
Ash on float at 1.35 %	3.0	3.6	4.6	4.7	5.0	4.5	4.7
Float at S.G. 1.40 %	29	30	41	57	47	67	86
Ash on float at 1.40 %	4.3	5.0	6.6	6.5	5.7	5.9	6.3
Float at S.G.1.45 %	44	55	59	77	61	82	91
Ash on float at 1.45 %	5.8	6.7	8.1	7.8	7.0	6.8	7.0
Float at S.G. 1.60 %	67	89	78	93	81	95	96
Ash on float at 1.60 %	9.1	10.3	10.7	9.7	10.0	8.5	7.5
Ash on whole coal %	27.4	12.7	17.8	11.8	15.1	9.6	8.7

These analyses show that the samples contain relatively small amounts of coal of 4% or even 6% ash even when finely crushed to separate the low from the high ash constituents as far as possible. This data represents the ultimate possibilities of gravity separation which may not, however, be realizable in practice with less finely crushed coal.

For example, samples IV and VI show about 20% sinks at S.G. 1.45 although these samples were floated at this specific gravity in their original sizing. Their ash contents are also considerably higher than these of the floats at S.G. 1.45 on the finely crushed coal. This gives some indication of the effect of increasing particle size on the efficiency of gravity separation as a means of recovering low ash coal from these coal types.

The practical possibilities of gravity separation are indicated in Table 2 in which are recorded the specific gravity analyses of sample I, V and VII in their original sizes and sample III after crushing to pass a ½" square mesh sieve. In order more nearly to approach practical conditions the - 1/16" material was removed from the samples before analysis because this dust cannot easily be washed. The proportion of this material removed is recorded in the table.

TABLE 2

SPECIFIC GRAVITY ANALYSES OF CRUSHED COALS

SAMPLE		Vereeniging -1¼" + ¾" I	Breyten -½" + 1/16" III	Witbank -1" + 1/16" V	Paulpietersburg -½" + 1/16" VII
Float at S.G. 1.30	%	0	½	18	10
Ash on float at 1.30	%	-	4.8	4.7	4.1
Float at S.G. 1.35	%	13	18	40	67
Ash on float at 1.35	%	6.7	6.8	6.0	6.3
Float at S.G. 1.40	%	32	47	55	87
Ash on float at 1.40	%	8.6	8.8	7.2	7.1
Float at S.G. 1.45	%	42	66	71	93
Ash on float at 1.45	%	10.2	10.3	9.5	7.5
Float at S.G. 1.60	%	65	85	91	96
Ash on float at 1.60	%	14.6	12.5	12.3	7.8
Minus 1/16"	%	-	14	8	40

The Breyten coal, without previous crushing, yielded 67% float of 11.8% ash at S.G. 1.45 and 89% float of 14.5% ash at S.G. 1.60. This shows an improvement in ash content though not in yield on crushing to $-\frac{1}{2}$". On crushing to $-\frac{1}{4}$" neither yields nor ash contents were further improved and the proportion of -1/16" material increased to 36%. Similar comparative tests on the Paupietersburg coal also showed no appreciable improvement of the separation on crushing to $-\frac{1}{4}$".

In order to obtain returns on a large scale similar to those recorded in Table 2 it would not be practicable to use an upward current washer owing to the bad washing characteristics disclosed by the specific gravity analyses. A gravity separator such as is typified by the chance washer would be required and such a washer cannot handle coal of less than 1/16" size. The best results which could be expected from such a washer are recorded in Table 3 in which the yields of coal of 5%, 6% and 7% ash from samples I, III, V and VII are given. These yields are calculated on the raw coal before removal of the -1/16" fraction though only the + 1/16" fraction is assumed to be washed.

TABLE 3

COAL	% Yield of Coal of		
	5% Ash	6% Ash	7% Ash
Vereeniging $-1\frac{1}{4}$" + $\frac{3}{4}$"	0	2	16
Breyten $-\frac{1}{2}$" + 1/16"	2	9	18
Witbank -1" + 1/16"	20	34	48
Paulpietersburg $-\frac{1}{2}$" + 1/16"	20	35	51

The yields from the Paulpietersburg coal could possibly be increased by a quarter by crushing to -1" only thereby decreasing the loss of -1/16" material. It is doubtful whether the yield of the Witbank coal could be much increased by further crushing owing to the increased loss of -1/16" material involved.

Owing to the low yields to be expected, the production of low ash coal by washing is not very attractive and another method of ash reduction was investigated. This method is based on the proposals of Lategan and van Eck (S.A. Patent Application

No.1270/28) and the I.H.P. (German Patent Application No. I 52940 IVc/120 - 1935.)

This method consists of grinding the coal to a fine powder in the presence of oil and water. Under suitable conditions coal of low ash content separates as a paste with the oil from the water which retains the majority of the mineral matter originally associated with the coal.

The South African coals tested were found to give satisfactory results when ground to pass a 0.2 m.m. screen with half their weight of oil and twice their weight of water and subsequent thorough kneeding of the coal oil paste with fresh water. The separation of low ash coal from mineral matter is complete, the mineral matter showing no trace of black colour. The yields and ash contents of the coals obtained in these tests are recorded in Table 4, the yields being calculated on the original unwashed coals.

TABLE 4

COAL	SAMPLE NO.	YIELD %	ASH %
Vereeniging	I	80	8.1
Vereeniging	II	-	6.1
Breyten	III	87	5.3
Breyten	IV	63	5.2
Witbank	V	90	5.8
Witbank	VI	67	4.1
Paulpietersburg	VII	96	4.7

The oil used in these separations was a mineral lubricating oil. Sample V, treated with a crude shale oil and with a hydrogenation residual oil, yielded coals of 5.6% and 5.5% ash respectively indicating that the nature of the oil can be varied over wide limits without affecting the results materially.

The ash contents recorded in Table 4 are probably not the minima obtainable since they apparently all contain a certain amount of iron derived from the grinding mortar, and this iron sticks preferentially to the oil.

The pyrites present in the coal tends to remain in the oil paste and this in part accounts for the lower final ash contents of the washed samples II, IV and VI compared with the unwashed coals.

These tests indicate the far reaching degree to which mineral matter and coal can be separated by grinding to sizes smaller than can be washed, and suggest the possibility of obtaining high yields of low ash coal from run-of-mine products, with or without a preliminary washing to remove pyrites and bone coal of high inherent ash content.

An alternative process which might also give good results is the vacuum froth flotation process which is based on similar principles and both these processes appear to be worthy of further investigation in view of their possible applicability for the production of coal-oil pastes of low ash content.

J. Vogel

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