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FUEL RESEARCH INSTITUTE

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TECHNICAL MEMORANDUM

NO. 38 OF 1968

VARIATION OF ASH CONTENT AND SO₃ IN ASH WITH
CONDITIONS OF ASHING

OUTEUR: W.H.D. SAVAGE
AUTHOR: F.H. KUNSTMANN
J.F. HARRIS

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Some of the possible variables in ashing were considered in determining the effects of (A) depth of layer of coal and (B) SO₂ passing over ashes and different rates of heating.

A. For this a sample from Bertha No. 1 Colliery (62/13630) was ashed in normal ashing dishes and otherwise standard conditions.

Wt. of coal in dish gm.	Ash %	SO ₃ % in ash	Ash % (SO ₃ -free)
1	23.73	3.50	22.90
2	24.05	4.41	22.99
3	24.22	5.25	22.95
4	24.50	6.34	22.95
5	24.67	7.06	22.93

Obviously increasing the depth of the coal increases both the ash content and sulphate in ash in a fairly regular way. The sulphate-free ash remains virtually constant, without any trend. Thus for a coal such as Bertha with high alkaline earths and fairly high sulphur (probably just over 1%), it has been demonstrated that significant increases in ash content are easily attained by ashing in too deep a layer, and that these increases are due to fixation of additional SO₃.

B. For this investigation two coals were chosen - Natal Steam (Sample 63/8790) as a source of SO₂, and New Schoongezicht (Sample 62/707B) as a potential absorber of this SO₂. The Natal Steam coal had 2.9% sulphur and in ash only 1.5% CaO, 0.86% MgO and 0.07% P₂O₅ so that the bulk of the SO₂ ^{formed} ~~found~~ on ashing must be in the combustion gases. The New Schoongezicht coal was fairly low in sulphur (0.6%) and high in alkaline earths (in ash 10.1% CaO, 2.05% MgO and 0.73% P₂O₅*).

/Two series

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CaO equivalent to P₂O₅ assuming fluorapatite = 0.96

Two series, (I) at standard heating rates and (II) at maximum heating rate of the furnace, were run in parallel. In both series the plan was the same. Three dishes with Natal Steam coal were inserted across the front of the muffle with three rows of three dishes with New Schoongezicht coal behind, and a parallel test without the first row of Natal Steam coal. These tests were normally done in triplicate. The ash contents in the individual dishes were determined, the ashes from each row across the furnace mixed and sulphate determined on the combined ash.

SERIES (I). The results were as given below; the rows are numbered from 1 to 4 from front to rear:

	Ashes			Mean ash	SO ₃ % in ash	Mean ash % SO ₃ -free	Contents without Natal Steam			Mean ash %	SO ₃ % in ash	Mean ash % SO ₃ -free	
							Ashes						
(a) Row	4	14.41	.33	.36	.37	2.03**	14.08	.33	.27	.30	.30	1.96	14.02
	3	.36	.35	.35	.35	1.95**	14.07	.23	.30	.33	.29	1.83	14.03
	2	.29	.32	.42	.34	1.93**	14.06	.29	.34	.37	.33	1.95	14.05
	1	22.44	.60	.54		(0.68**)							
(b)	4	14.26	.26	.27	.26	2.03**	13.97						
	3	.23	.20	.30	.24	1.95**	13.96						
	2	.29	.30	.27	.29	1.93**	14.01						
	1	22.49	.45	.55		(0.68**)							
(c)	4	14.32	.33	.34	.33	2.32	14.00	.32	.36	.36	.35	2.88	13.94
	3	.24	.32	.27	.28	2.36	13.94	.34	.36	.31	.34	2.68	13.96
	2	.29	.33	.36	.33	2.43	13.98	.38	.43	.34	.38	2.35	14.00
	1	22.50	.51	.51									
Overall means of New Schoongezicht				14.31	2.17	14.00					14.33	2.275	14.00

** Not known if SO₃ refers to (a) or (b) or (a) + (b) - SO₃ probably refers to (a) only J.F.H.

It was not known if the sulphate values marked referred to the (a) or (b) ashes, so they were applied to both. In order to make a valid comparison of the New Schoongezicht coal with and without Natal Steam coal in front, the overall means of New Schoongezicht coal with Natal Steam coal present were calculated from (a) + (b) + (2c).

/A look at the

A look at the overall means shows 0.02% difference in ash and 0.1% difference in sulphate in ash, while the sulphate-free ash shows no difference. As the very minor differences in ash and sulphate were in favour of higher values without the extra SO₂ given off by Natal Steam coal, one can only conclude that, as regards New Schoongezicht coal alone at any rate, no absorption of SO₂ occurs between ashing dishes in the same furnace (or at least in the furnace used) if heating is at the rate laid down in the specification. This is confirmed to some extent by the average ash and sulphate values for rows 2, 3, 4, which are as regards ash 14.32%, 14.29% and 14.32% in the presence of Natal Steam and otherwise 14.36%, 14.31% and 14.32%; corresponding sulphate values are 2.18%, 2.16%, 2.16% and 2.15%, 2.21% and 2.42%.

The overall range for 18 determinations of Natal Steam ash is 22.44% to 22.60% ^(mean 22.57%), and for New Schoongezicht ash 14.20% to 14.42% and 14.23% to 14.43% for the two series of results. The rather wider range for New Schoongezicht is due to a combination of more results and a "more difficult" coal, due to the high alkaline earths.

SERIES (II). Results as for Series (I) are given below:

		Ashes			Mean ash %	SO ₃ % in ash	Mean ash % SO ₃ -free	Ashes			Mean ash %	SO ₃ % in ash	Mean ash % SO ₃ -free
(a) Row	4	14.53	.41	.56	.50	3.54	13.99	.50	.43	.49	.47	3.59	13.95
	3	.44	.46	.48	.46	3.43	13.96	.48	.40	.40	.43	3.39	13.94
	2	.40	.44	.41	.42	3.06	13.98	.44	.46	.43	.44	2.96	14.01
	1	22.44	.54	.47									
(b)	4	14.50	.50	.55	.52	3.72	13.98	.45	.40	.46	.44	3.51	13.93
	3	.48	.47	.46	.47	3.43	13.97	.42	.35	.42	.40	3.19	13.94
	2	.45	.41	.45	.44	3.13	13.99	.43	.42	.40	.42	2.91	14.00
	1	22.50	.52	.56									
(c)	4	14.54	.47	.48	.50	3.76	13.95	.42	.54	.52	.49	3.91	13.92
	3	.46	.45	.48	.46	3.52	13.95	.40	.39	.43	.41	3.49	13.91
	2	.42	.42	.44	.43	3.21	13.97	.49	.43	.43	.45	3.16	13.99
	1	22.44	.52	.46									
Overall means of New Schoongezicht					14.47	3.42	13.97				14.44	3.34	13.95

/The overall

The overall mean values of New Schoongezicht in the presence or absence of Natal Steam are very much the same, all three values being slightly higher when Natal Steam is present. The ash values however, are definitely higher than were obtained at the standard rate of heating, the ranges being 14.40 to 14.56 and 14.35 to 14.54 with hardly any values overlapping. The Natal Steam range and mean (22.49) are very much the same as for the standard rate of heating. Sulphate in ash is also higher by about one per cent, but the sulphate-free ash values are lower.

Considering the different rows, in the presence of Natal Steam both ash and sulphate increase towards the back of the furnace, whereas in the absence of Natal Steam there is a similar increase in sulphate but the ash tends to be variable with lower values mainly in row 3. Sulphate-free ash here also is a bit odd with row 2 always higher than rows 3 and 4.

It would appear that SO₂ passing over the dishes was absorbed to some extent as shown by the increase in sulphate and to some extent in ash content towards the back of the muffle. However, two further tests were done which negate such a conclusion. A row of three dishes of New Schoongezicht coal was ashed approximately at row 2, and later a row of three dishes was ashed approximately at row 4. The results are as follows:

Position in Furnace	Ash Contents			Mean Ash %	SO ₃ % in ash	Ash % (SO ₃ -free)
Row 2	14.43	14.38	14.43	14.41	2.77	14.01
Row 4	14.48	14.46	14.42	14.45	3.74	13.91

Although only one row of dishes was present on each occasion, there was a considerable difference in sulphate in ash, and the values are similar to those obtained with three or four rows of samples in the furnace.

CONCLUSIONS

Under standard ashing conditions there is no evidence of interaction, i.e. of SO₂ formed by the combustion of one sample being absorbed by another sample. With rapid heating there was an increase overall in ash content and sulphate in ash, and this

/increase

increase became progressively greater towards the back of the oven, which seems to imply interaction. However, single rows of New Schoongezicht coal near the front and back of the oven showed similar differences in sulphate and to some extent in ash content, so that interaction is by no means proved, and is probably absent. The effects noted may be purely a characteristic of the particular muffle used, but may also apply to other muffles not very different in general construction. The first tests with varying coal thickness showed increases in ash and sulphate with increasing coal thickness.

Summing up, in the Heraeus oven there was no evidence of interaction between SO_2 (in the atmosphere passing over the dishes due to oxidation of sulphur in the samples) and ash (alkaline earth oxides, or possibly carbonates) in the series of tests conducted. However, both increased heating rates (maximum rate obtainable) and increased thickness of coal layer caused increased sulphate in ash and thus higher ash contents.

NOTE: This investigation was carried out by Mr. Harris and Dr. Kunstmann under the control of the latter, and was only compiled for record purposes by the undersigned.

Probably due to "more rapid" conversion of CaCO_3 to CaO at higher heating rates so that SO_2 passing through is more easily fixed; at deeper layers due to slower oxidation of CaCO_3 so that SO_2 still given off in reasonable quantity after CaO formed in upper layers.

W.H.D. SAVAGE

PRETORIA
August 15, 1968