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# FUEL RESEARCH INSTITUTE

OF SOUTH AFRICA

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TEGNIESE MEMORANDUM
TECHNICAL

NO. 4 OF 1976

## A PRELIMINARY INVESTIGATION INTO THE SULPHUR BALANCE OF A SINGLE-STAGE ANTHRACITE PRODUCER GAS PLANT

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- DR K O R GEBHARDT

DIVISION : ENGINEERING

SECTION : COMBUSTION

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# A PRELIMINARY INVESTIGATION INTO THE SULPHUR BALANCE OF A SINGLE-STAGE ANTHRACITE PRODUCER GAS PLANT

## 1. SYNOPSIS

A two day test has been carried out and it has been shown that approximately 90% of the sulphur in the anthracite was transferred to the product gas.

## 2. INTRODUCTION

The Institute was asked by Dr K O R Gebhardt, (Consultant to APA), to investigate the sulphur balance of a single-stage gas producer, fuelled with anthracite.

Reserves of low-sulphur anthracite (<1%S) in South Africa, are rapidly becoming depleted. APA feel that it is desirable to extend the sale of higher-sulphur anthracite in South Africa and overseas. Many potential customers are in the metallurgical industries, and/or use anthracite-fired producer gas plant, and have processes which are susceptible to a high concentration of sulphur compounds in the gas. Little data are currently available on this subject.

## 3. BACKGROUND TO TEST

### 3.1 LOCATION AND DESCRIPTION OF PLANT

Test facilities were granted to APA by Messrs Cullinan Refractories (Pty) Ltd, Olifantsfontein. The plant is a single-stage Wellman Galusha producer. In common with many such plants which are used as a source of process heat, no analytical or quantity monitoring is carried out.

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3.2 ESTIMATION OF SULPHUR DISTRIBUTION

As this work was to be of a preliminary nature, it was agreed with Dr Gebhardt that no direct estimation of sulphur in the gas should be carried out, but that this should be obtained by difference. Later, if the results merited it, a full coverage test would be carried out.

The sulphur in the gas has been calculated from weights and analyses of fuel, reject fuel (undersize), ashes and dust. i.e.

$$S_{FUEL} - S_{REJECT} = S_{TO\ PLANT} = S_{GAS} + S_{ASHES} + S_{DUST}$$

It was not possible to sample and weigh the fuel to the plant directly.

3.3 FUEL AND ASHES

The anthracite to be used in the test (1 railway wagon) was originally sampled on a falling stream basis at the mine. Unfortunately, however, due to an oversight at Cullinan Refractories, the test fuel was added to the stockpile. A further sample was segregated, weighed and sampled.

The delay between fuel changing and ash discharge was estimated prior to the test by a tracer technique, and the ash sampling was adjusted accordingly.

4. THE TEST

During the test, the plant was run normally by Cullinan Refractories staff, and all readings were taken by FRI personnel.

The fuel was loaded into the empty top hopper of the plant, before the start and the test ended when the hopper was empty

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with approximately the same level of fuel bed in the generator.

The following data were collected by FRI personnel.

| | |
|---|---|
| Temperature of product gas<br>Pressure of product gas<br>Barometric pressure<br>Pitot tube differential pressure<br>Speed of grate<br>Height of firebed | Every 30 minutes |
| Blast saturation temperature | Every 2 hours |

As appropriate at the beginning or end of the test, fuel, ashes, dust etc were sampled and weighed.

## 5. RESULTS

### 5.1 FUEL

| Size analysis | Fuel elevated | Undersize reject (-6,25 mm) |
|---|---|---|
| + 50 mm | 0,57% | |
| - 50 + 25 mm | 58,51% | |
| - 25 + 12,5 mm | 22,71% | |
| - 12,5 mm | 17,79% | |
| Total weight | 28 480 kg | 1 588 kg |

| Proximate analysis | | |
|---|---|---|
| Calorific value | 29,5 MJ/kg | 18,8 MJ/kg |
| Moisture | 1,7% | 1,3% |
| Ash | 15,0% | 45,3% |
| Volatile matter | 10,5% | 7,1% |
| Fixed carbon | 72,8% | 46,3% |

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| | | | | |
|---|---|---|---|---|
| **Sulphur** | | | | |
| Organic | | 0,43% | | 0,35% |
| Pyritic | 0,15% | | 0,12% | |
| Sulphate | 0,02% | | 0,02% | |
| Mineral | 0,17% | 0,17% | 0,14% | 0,14% |
| Total | | 0,60% | | 0,49% |

5.2 ASHES AND DUST

| | Ashes | Dust |
|---|---|---|
| Moisture | 0,6% | 1,2% |
| Ash | 77,7% | 22,7% |
| Combustibles | 21,7% | 76,1% |

| | | | |
|---|---|---|---|
| **Sulphur** | | | |
| Organic | | | 0,76% |
| Pyritic | | 0,10% | |
| Sulphate | | 0,02% | |
| Mineral | | 0,12% | 0,12% |
| Total | 0,17% | | 0,88% |
| Total weight | 4 511 kg | | 162 kg |

5.3 GAS

Due to the non-availability of a producer gas Orsat, gas analysis could not be carried out. For gas volume calculations, typical figures for a single-stage anthracite producer were used.

Mean blast saturation temperature = 61,0°C.

5.4 TAR

Tar in gas was not measured during the test, but at the request of APA, a single estimation was carried out later. In the method used, a metered volume of gas was passed through a benzene trap and the tar was estimated

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gravimetrically.

| | | |
|---|---|---|
| Volume of gas | | 100 litres |
| Barometric pressure | | 643 mm Hg |
| Metering conditions: | pressure | 14,0 mm w.g. |
| | temperature | 32°C |
| Tar yield | | 1,18 grams |

## 6. DERIVED RESULTS

### 6.1 ASH BALANCE

Ash to plant = Ash in fuel elevated-ash in rejects
= (0,150 x 28480) - (0,453 x 1588) kg
= 3552,6 kg.

Ash ex plant = Ash in ashes + ash in dust
= (0,77 x 4511) + (0,227 x 162)
= 3541,8 kg.

Percentage accounted for = 99,70%

### 6.2 SULPHUR BALANCE

Sulphur to plant = Sulphur in fuel elevated - sulphur in rejects
= (0,0060 x 28480) - (0,0049 x 1588)
= 163,1 kg.

Sulphur in gas = Sulphur to plant - (Sulphur in ashes + sulphur in dust)
= 163,1 - ((0,0017 x 4511) +(0,0088 x 162))
= 163,1 - 9,1
= 154 kg.

Percentage of sulphur in coal to gas = $\frac{154}{163,1} \times 100 = \underline{94,4\%}$

Note: Sulphur as sulphate in coal = 0,0002 x 28480
= 5,7 kg.
This is roughly the same order as that calculated for the ashes.

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6.3 TAR IN GAS

Tar in gas (from data in 5.4) = 15,56 milligrams/litre at NTP
(15,56 grams/$NM^3$).

6.4 GAS VOLUMES (Calculated from pitot readings and ancillary data)

Total gas produced during test (62,25 hrs) = 141 330,5 $NM^3$

Mean gas production rate = 2270,37 $NM^3$/HR.

Thus calculated sulphur content of gas = $\frac{154,0 \times 10^3}{141\ 330,5}$

= 1,090 grams/$NM^3$

7. CONCLUSIONS

Neither the relatively short period of the test, nor the difference in method used for sulphur estimation is ideal, but the result of 94,4% of sulphur in the coal appearing in the gas is confirmed by the very good ash balance (99,70%).

D CLARK - CHIEF RESEARCH OFFICER

M DARAZS - SENIOR RESEARCH OFFICER

DC/MD/ug
1976 March 4th

PRETORIA