143/12.

WU/C/114

FUEL RESEARCH INSTITUTE OF SOUTH AFRICA.

TECHNICAL MEMORANDUM NO. 19 OF 1964.

NOTES ON THE EFFECT OF VARIATION IN HUMIDITY CONDITIONS ON THE STRENGTH CHARACTERISTICS OF COAL.

BY:

P. G. SEVENSTER.

&

C. J. GELDENHUIS.

FUEL RESEARCH INSTITUTE OF SOUTH AFRICA.

TECHNICAL MEMORANDUM NO. 19 OF 1964.

NOTES ON THE EFFECT OF VARIABLES IN HUMIDITY CONDITIONS ON THE STRENGTH CHARACTERISTICS OF COAL.

The purpose of this investigation was to assess the suitability of a simple strength test in the study of the effects of climatic conditions on the breaking characteristics of South African coals.

It is well known that coal undergoes dimensional changes when it loses or gains water and gases.

The tendency of some South African coals to disintegrate rapidly when exposed to the atmosphere may be related to the evolution or adsorption of gases and vapours which occur with changes in the environment to which the coal is exposed.

It would therefore be of considerable interest to obtain information in connection with the effect of environmental conditions on the breaking characteristics of coal.

In the case of coal, strength is a complex characteristic. The breakage of the material is influenced by a number of factors, such as, inherent fissures and cracks, and the orientation of these flaws to the bedding plane as well as to the direction of the applied pressure in the testing device.

The determination of compressive, shear and tensile strengths of regularly shaped specimens of an inhomogeneous material such as coal has to be based on a large number of tests to allow for the inherent variability of the material.

In tests designed to establish the influence of an additional variable, viz., the effect of adsorbed gases and vapours, the number of specimens to be tested would have to be even larger. Furthermore, the complication of penetration effects of the gases being adsorbed

has .../

has to be taken into consideration. Due to the impervious nature of coal it is to be expected that the establishment of adsorption equilibrium will be strongly influenced by the size of the specimen used for testing.

It was therefore necessary to consider methods of strength assessment which would require fewer tests and which would allow one to use small particles.

Several empirical methods of measuring coal strength have been introduced. These tests have been considered for adoption to the present investigation and it appeared that the Impact Method suggested by Pomeroy[1] was the most suitable.

DESCRIPTION OF THE METHOD:

The apparatus consists of a vertical steel cylinder of $1\frac{3}{4}$ inch internal diameter. The lower end of the cylinder is closed with a removable screw cap.

A cylindrical steel plunger, 4 lb. in weight and $1\frac{11}{16}$" in diameter can be raised by means of a steel rod attached to its upper end and can be dropped on the coal sample contained in the vessel.

It was found by Pomeroy that the 4 lb. weight dropped twenty times from a height of 12 inches gave consistent results.

The test was made on 100 gm. coal, carefully broken down and screened to the size range, $\frac{3}{8}$" to $\frac{1}{8}$".

The percentage of coal remaining in this sieve range was defined as the Impact Strength Index.

The sampling was conducted according to the procedure prescribed by B.S. 1017, 1960, and the sieving technique of B.S. 1796, 1952, was followed.

COALS .../

---

1) Pomeroy, C.D. J. Inst. Fuel, 30, 1957, 50.

COALS INVESTIGATED:

A fairly wide range of South African coal types has been used in these tests. In Table I, the analyses of these coals are given.

TABLE I.

Proximate Analyses of the Coals Tested.

Colliery	% Ash	% Moisture	% Volatile Matter (Air-Dry Basis)
Elandsberg	9.9	1.9	6.2
Platberg	15.5	1.5	16.7
Natal Steam	19.9	1.2	16.8
Indumeni	11.7	1.3	18.5
Ingagane	17.5	1.5	20.7
Vierfontein	23.0	7.0	21.0
Graspan	16.0	3.4	21.0
Tshoba	14.4	1.2	22.9
Cornelia, Betty shaft	26.5	6.5	23.5
Grootvlei	18.5	5.2	24.0
Utrecht	17.0	2.0	24.0
Belfast	9.3	4.7	25.8
South Witbank	18.5	3.5	26.5
Cornelia, Bertha shaft	22.0	6.6	25.7
Eikeboom	18.7	3.0	27.6
Brakfontein	14.6	4.3	28.6
New Wakefield	13.0	4.0	33.0
Kriel	13.9	4.2	33.2

The experimental results were analysed by standard statistical methods. It was assumed that the results would follow a normal distribution curve.

This .../

This assumption is not justified in the case of coal. Since it is an anisotropic material, one may expect e.g. a distribution curve with two peaks corresponding to the strength indices obtained for measurements made normal to and parallel to the bedding plane. This will be the case in the type of test where the chances are equal for a particle to orientate its bedding plane either normal to or parallel to the direction in which the impact takes place.

However, to observe this behaviour, a very large number of tests would be required. Furthermore, since the results of the present investigation were not intended for calculation of absolute strengths the method was considered satisfactory if it was capable of indicating trends with a fair degree of reliability.

The results tabulated in Table II, illustrate that a reasonable number of tests gave consistant readings and could characterise the coals relative to each other.

THE EFFECT OF VARIATION IN HUMIDITY:

The purpose of this work was to investigate the effect on the strength characteristics of humidity changes in the atmosphere to which the coal samples are exposed.

For this purpose Impact Strength Index tests were made on samples that were exposed to atmospheres of relative humidities of about 20, 45, and 80%, respectively.

The tests were conducted in an air-tight chamber (6'x2½'x2') fitted with perspex windows. All the necessary test equipment was placed in the chamber. Two sets of long rubber gloves, fitted through the windows, enabled the operator to do all the manipulations required during the whole testing procedure, i.e. weighing, crushing and sieving, without exposing the samples to the outside atmosphere.

The atmospheric conditions in the test chamber were obtained by placing standard solutions of sulphuric acid in glass pans to maintain the required humidity conditions and circulating the air in the chamber by means

of a .../

TABLE II.

Values of Impact Strength Index of some South African Coals according to the method of Pomeroy.

Origin of Sample	No. of Tests	Mean I.S.I.	Stand. Deviation	Stand. Error of Mean	Confidence Interval at 95% level.
Elandsberg	5	80.0	1.49	0.67	80.0 ±1.8
Platberg	5	63.3	1.55	0.70	63.3 ±1.9
Natal Steam	5	54.0	4.46	2.0	54.0 ±5.5
Indumeni	5	56.1	1.83	0.82	56.1 ±2.5
Ingagane	5	65.7	1.81	0.80	65.7 ±2.2
Vierfontein	5	70.0	1.22	0.55	70.0 ±1.5
Graspan	5	69.0	1.75	0.78	69.0 ±2.2
Tshoba	5	72.4	8.02	0.72	72.4 ±2.0
Cornelia, Betty shaft	5	75.0	1.14	0.51	75.0 ±1.4
Grootvlei	5	68.0	1.31	0.59	68.0 ±1.6
Utrecht	5	62.5	3.85	1.72	62.5 ±4.8
Belfast	5	71.0	2.34	1.04	71.0 ±2.9
South Witbank	10	71.0	1.38	0.44	71.0 ±1.0
Cornelia, Bertha shaft	5	70.4	1.57	0.70	70.4 ±2.0
Eikeboom	5	76.0	1.17	0.53	76.0 ±1.4
Brakfontein	5	70.0	1.21	0.54	70.0 ±1.5
Wakefield	10	75.1	3.04	0.96	75.1 ±2.2
Kriel	5	78.0	0.81	0.36	78.0 ±1.0

of a fan. A recording hygrometer was used to measure the humidity. The samples were exposed for at least 24 hours to constant humidity conditions before the tests were started.

It was not possible to maintain the conditions absolutely constant for long periods, but it was found that the variation in humidity was never greater than about 5%.

RESULTS:

In Table III, the results of these tests are given. These figures clearly indicate that the adsorption of water vapour by the coal particles reduces the Impact Strength Index.

TABLE III.

Variation of Impact Strength Index of Coal Samples Exposed to Atmospheres of Different Humidities.

Sample.	Impact Strength Index of Coal Samples after "conditioning" in an Atmosphere of relative humidity:		
	15-20%	45-50%	80-85%
South Witbank Colliery	75	71	68
N. Wakefield "	81	75	72
Belfast "	75	71	63
Kriel "	85	78	71
Grootvlei "	77	68	66
Vierfontein "	73	70	59
Brakfontein "	74	70	67
Eikeboom "	78	76	73
Cornelia Colly. Betty shaft	80	75	63
Graspan Colliery	75	69	62

It is ..../

It is, of course, difficult to translate this effect to the load-bearing capacity of relatively large specimens, since in this case, the slow penetration of water vapour must be taken into account.

Penetration into flawless material can be expected to be rather slow, but in practice such specimens are seldom encountered. It is, therefore, not unreasonable to conclude that the adsorption of water may have a considerable influence on strength measurements done, say, on one inch cubes.

COMPARISON OF IMPACT STRENGTH INDEX WITH COMPRESSIVE STRENGTH.

In order to establish whether the empirical Impact Strength Index bears any relationship to a more fundamental strength characteristic of South African coal, a number of compressive tests were made on cubes of coal under controlled humidity conditions.

Samples about one inch cube were prepared from large blocks of coal by means of a high speed diamond wheel. The cubes were cut so that the bedding plane was parallel to a pair of sides. The tests were made with load applied normal to the bedding plane.

The samples were conditioned at 15-20% relative humidity before testing.

The results of these tests are given in Table IV. It is seen that the variability of the compressive strength is much more than that of the Impact Strength Indices.

Comparison of the compressive strength and Impact Strength Index does not reveal any relationship for South African coals which is contrary to the finding of Pomeroy. He has found for British coals an almost linear relationship between these indices for loadings both perpendicular and parallel to the bedding plane.

The statistical analysis indicates that many more tests per sample would be necessary to reduce the confidence interval to a more reasonable value.

TABLE 4. .../

TABLE IV.

Compressive Strength of some Typical South African Coals Measured on One Inch Cubes. (In the last Column the Figures for the Impact Strength Index of the Coals are Given.)

Origin of Sample	No. of Tests	Mean Compressive Strength*	Stand. Dev.	Stand. Error of Mean	Confidence Interval at 95% level	Mean I.S.I.
N.Wakefield	45	3878	2045	305	3878±597	75
Natal Steam	20	3895	1560	352	3895±733	54
Belfast	21	3982	1679	366	3982±764	71
Indumeni	20	4315	1651	374	4315±778	56
Brakfontein	20	4525	1026	229	4525±480	70
Utrecht	20	4516	1331	296	4516±615	62
South Witbank	20	4558	953	213	4558±446	70
Graspan	20	4963	1394	312	4963±652	69
Jackson's	20	5657	2826	632	5657±1323	-
Kriel	20	8419	1415	317	8419±663	78
Elandsberg	20	8336	2652	600	8336±1250	80
Eikeboom	20	9229	3019	675	9228±1413	76

*Pounds per square inch.

(SIGNED) P. G. SEVENSTER.
PRINCIPAL RESEARCH OFFICER.

C. J. GELDENHUIS.
ASSISTANT TECHNICAL OFFICER.

PRETORIA.
1/9/64