Note on a Proposed Arbitrary Quality Classification of Coke for use in Interpreting Experimental Coke Oven Results†

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INTRODUCTION

Some years ago the authors proposed a modified procedure[1] for carrying out micum index determinations[2]. The modifications consisted of using a drum of 50 cm internal length, i.e. half the length of the standard micum drum (a modification also adopted by the B.S.I.[3]), and the use of a +25 mm coke instead of +60 mm coke for the test. The proposed modified test and formulae for converting results obtained from it to standard micum test results and vice versa were based on the results obtained during the investigation of about 200 test cokes made in ovens of the South African Steel Industrial Corporation Limited (Iscor), the Fuel Research Institute co-operating with the experiments.

Extensive testing of cokes has since been done at the Fuel Research Institute using both the standard and the modified procedures. The numerous test results obtained during this trial period fully support and strengthen the confidence originally expressed by the authors in the modified testing procedure.

The scope of the modified micum index determination has in the meantime been extended by applying the testing procedure also to test cokes made in the Institute's experimental coke ovens, and also in this case the modified procedure has proved its usefulness.

A difficulty is that when comparing the characteristics of cokes made in the Institute's two experimental coke ovens with each other and with those of cokes made from similar blends in commercial coke ovens, for example those of Iscor, the index values obtained invariably do not check exactly due mainly to inherent differences between the different types of oven[4]. For instance, resistance to abrasion of a coke made in Iscor's ovens is always appreciably higher than that of a coke made from the same blend (and having a similar moisture content) in the experimental ovens. This makes direct comparisons and the prediction of quality to be expected from commercial products, based on experimental coke oven results, difficult. It may also be added that workers in Great Britain some years ago reported a similar experience[5]. In the authors' opinion the main reason for the discrepancy is the relatively low height of the experimental ovens resulting in a much lower static pressure on the charge during coking than that obtaining in a commercial oven.

The difficulty was pointed out and briefly discussed in a publication[4] which appeared at a time when the micum test for coke evaluation had only just been introduced at the Institute, so that only B.S. shatter and abrasion test results were available for discussion in the publication. Needless to say, the introduction of the micum test by no means solved nor even alleviated the problem.

On numerous occasions during the past few years the Institute has had to conduct contract investigations in its experimental coke ovens on behalf of companies which invariably desired an indication of the quality of coke likely to be obtained from certain coals or blends when coked commercially, more particularly in Iscor's type of coke ovens. It was, therefore, essential to accumulate statistical data which would enabe the prediction to be readily made.

Fortunately the compilation of comparative coke-quality index values for the three types of oven under consideration has become possible as a result of coking investigations conducted in co-operation with Iscor over a number of years. During this period Iscor, on numerous occasions, kindly made available to the Institute portions of coals and blends coked in the Corporation's coke ovens, thus enabling parallel coking tests to be carried out in the Institute's experimental ovens. In this way enough statistical data became available to establish relationships between coking results obtained in Iscor's ovens and results obtained on similar coal charges in the Institute's ovens.

The most practical and acceptable method of overcoming the problems of finding a suitable and simple basis enabling direct comparison between the cokes of the different origins mentioned to be made, is the assignment of descriptive arbitrary quality ratings, as indicated below, to the cokes obtained, it being argued that the quality rating assigned to coke made from a given coal or blend in the different coke ovens under standardized conditions should be the same, irrespective of differences in the index values obtained when subjecting the cokes to the usual coke evaluation tests. The system, which should enable the sponsors of coking investigations in the Institute's experimental ovens to make their own interpretations of the results obtained, is explained below.

ARBITRARY QUALITY CLASSIFICATION OF COKES

The M_{10m} index[1] (percentage material smaller than 10 mm after the test) of a blast furnace coke is a measure of its tendency towards breeze formation during handling —a low value indicating a low tendency. This is generally of greater importance under ruling South African conditions, than the M'_{40} index[1] (percentage material larger than 40 mm after the test), which can be regarded as a measure of resistance to shatter. In fact, if the M_{10m} value of a coke as made in Iscor's ovens is higher than about 11, the tendency of the coke to form breeze during handling and in the blast furnace is relatively so high that hardly any notice need be taken of its M'_{40} value, even if this is comparatively high. For this reason, therefore, much more weight should normally be assigned to M_{10m} indices in the quality evaluation of cokes made from South African coking coals and blends, as the coals

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are generally deficient in coking power, thus yielding relatively abradable cokes.

For convenience when judging and comparing cokes made in Iscor's ovens and from similar blends in either one or both of the Institute's pilot coke ovens, an arbitrary quality classification system has been adopted at the Institute. The system has been based on modified micum indices obtained for cokes made from blends coked in the three types of oven mentioned. Details of the system, which will probably also be of help to those not so conversant with micum values, appear in Tables I and II.

TABLE I

ARBITRARY QUALITY CLASSIFICATION OF COKES BASED ON MODIFIED MICUM INDICES*

	Limiting values for modified micum indices			Quality rating assigned to coke
	Cokes made in Iscor's ovens	Cokes made in FRI ovens		
		Narrower	Wider	
M'_{40} index	>73	>79	>78	Ex: Excellent
	73–69	79–75	78–74	VG: Very good
	68–64	74–70	73–69	G: Good
	63–59	69–65	68–64	F: Fair
	58–52	64–58	63–57	P: Poor
	<52	<58	<57	VP: Very poor
M_{10m} index	<9·0	<11·2	<12·0	Ex: Excellent
	9·0–11·0	11·2–13·7	12·0–14·7	VG: Very good
	11·1–13·0	13·8–16·2	14·8–17·4	G: Good
	13·1–15·2	16·3–19·0	17·5–20·4	F: Fair
	15·3–18·3	19·1–22·9	20·5–24·6	P: Poor
	>18·3	>22·9	>24·6	VP: Very poor

*Only cokes resulting from moist top charging were considered when selecting the values used for this classification. It is, however, believed that the values assigned will also be reasonably applicable to cokes resulting from dry or stamp charging, provided they are made from coking blends of a standard similar to those coked commercially in South Africa at present.

For the convenience of readers not so conversant with modified micum indices the following approximately equivalent values in terms of standard micum indices (M_{10} and M_{40}) and B.S. shatter and abrasion indices may be quoted[1]).

APPENDIX TO TABLE I

M_{10m}	9·0	11·0	13·0	15·2	17·4	19·0	20·4	24·6
M_{10}	9·4	11·5	13·5	15·7	17·9	19·5	20·9	25·1
B.S.A.I.	78	76	74	72	69	68	66	62
M'_{40}	78	72	68	66	61	59	55	52
M_{40}	78	73	69	67	63	61	57	54
B.S.S.I. on 1½ in	93	90	88	87	85	84	83	81

In effect the system amounts to the use of ranges of M_{10m} and M'_{40} values of cokes for classifying them descriptively on a scale ranging from 'excellent' to 'very poor' quality. As the two characteristics of coke, viz. resistance to abrasion and resistance to shatter, are largely independent they have to be considered (and described) independently.

As will readily be seen from Table I, the quality ratings provide a convenient method of directly comparing the cokes made in the three types of coke oven considered, and predicting the quality of commercially produced coke from the results of experimental coke oven tests.

TABLE II

ARBITRARY QUALITY CLASSIFICATION OF COKES MADE IN FULL SCALE OVENS, BASED ON B.S. SHATTER AND ABRASION, MICUM AND MODIFIED MICUM INDICES†

	Limiting values for mechanical strength and hardness indices						Quality rating assigned to coke
	B.S. shatter and abrasion indices		Micum indices		Modified micum indices		
	Index	Limits	Index	Limits	Index	Limits	
Mechanical strength	B.S. shatter index (on 1½ in.)	> 90	M_{40}	>74	M'_{40}	>73	Ex: Excellent
		90–88		74–70		73–69	VG: Very good
		87–86		69–65		68–64	G: Good
		85–84		64–61		63–59	F: Fair
		83–81		60–54		58–52	P: Poor
		>81		<54		<52	VP: Very poor
Hardness	B.S. shatter index (on ½") (SI) and B.S. abrasion index (AI)	> SI 98·3, AI 78	M_{10}	<9·4	M_{10m}	<9·0	Ex: Excellent
		SI 98·3–97·3, AI 78–76		9·4–11·5		9·0–11·0	VG: Very good
		SI 97·5–96·9, AI 75–74		11·6–13·5		11·1–13·0	G: Good
		SI 96·8–96·1, AI 73–72		13·6–15·7		13·1–15·2	F: Fair
		SI 96·0–95·1, AI 71–68		15·8–18·8		15·3–18·3	P: Poor
		SI 95·1, AI 68		>18·8		>18·3	VP: Very poor

† The approximately equivalent strength and hardness values, with reference to the modified micum index values taken from Table I, have been derived using data from a previous publication[1]).

It must be stressed that the limits and classification adopted are purely arbitrary, introduced mainly for convenience in comparing, interpreting, and discussing coking results obtained.

Some approximate data relating modified micum indices to B.S. shatter and abrasion indices have also been appended to Table I.

Results obtained when coking a standard blend in the three types of oven, and applying different methods of charging, appear in Table III. From this table it is interesting to note that with the type of blend in question, a marked improvement in coke quality, in particular with regard to resistance to abrasion, can be achieved by resorting to dry or stamp charging.

TABLE III

RESULTS OBTAINED WHEN COKING A STANDARD BLEND* IN THREE TYPES OF OVEN AND APPLYING DIFFERENT METHODS OF CHARGING

Oven†	Charging method‡	Characteristics of cokes					
		Ash, % (dry basis)	Mean size, mm	Modified micum indices[1]		Quality assigned using the index	
				M'_{40}	M_{10m}	M'_{40}	M_{10m}
IS	M	16·7	87·2	65	15·2	G	F
IS	D	16·5	85·6	68	10·8	G	VG
N	M	16·7	91·5	71	19·0	G	F
N	S	16·9	114·0	76	10·4	VG	Ex
N	D	17·0	95·1	77	11·9	VG	VG
W	M	16·7	95·9	70	20·4	G	F
W	S	16·9	113·6	77	12·3	VG	VG
W	D	17·0	99·5	76	13·8	VG	VG

*Composition of the standard blend used in the investigation:
DNC : 22 per cent } Coking coal from Natal.
Northfield : 8 per cent }
Navigation (SACE) : 45 per cent } Blend coking coal from
Springbok : 25 per cent } Witbank-Middelburg.

†IS : Iscor's commercial ovens. (Mean width: 16 in.)
N : Institute's narrower experimental oven. (Width: 15 in.)
W : Institute's wider experimental oven. (Width: 18·9 in.)

‡M : Normal top charging of moist coal. (7-8 per cent moisture)
D : Dry charging (blend predried to about 1-2 per cent moisture before top charging).
S : Stamp charging (only with experimental ovens).

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