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CANMET
Canada Centre for Mineral and Energy Technology
Centre canadien de la technologie des minéraux et de l'énergie

CANADIAN CARBONIZATION RESEARCH ASSOCIATION RESEARCH ACTIVITIES AT CANMET

STAFF OF THE COAL RESOURCE AND PROCESSING LABORATORY

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ENERGY RESEARCH PROGRAM
ENERGY RESEARCH LABORATORIES
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CANADIAN CARBONIZATION RESEARCH ASSOCIATION; RESEARCH ACTIVITIES AT CANMET

by

Staff of the Coal Resource and Processing Laboratory

INTRODUCTION

The overall objectives of CCRA research can be summarized:

1. To improve the quality of coke used in Canadian blast furnaces.
2. To improve the quality of cokes made from coal blends containing Canadian coals.
3. To expand the range of coals suitable for use in cokemaking practice in Canada.

The focus of this research lies in the operation of the technical scale ovens in Ottawa and Edmonton.

COMPARISON OF TECHNICAL AND COMMERCIAL OVENS

One critical feature of any applied research program is the ease with which the experimental results and conclusions can be transferred and used in the industrial environment for which they were obtained. This question is of vital importance in using the cheap, convenient technical scale oven to assess the characteristics of new coals or new technologies for conventional carbonization.

In cokemaking research this problem can be addressed by measuring how established industrial coal blends perform in both industrial and technical scale ovens. The importance of this question requires that CCRA continuously assess the relationships between Canadian steel company oven operation and CANMET technical scale oven operation.

A new program was commenced in 1979 to carry out a comparison experiment between the four steel company coke ovens and the CANMET ovens.

The program was intended simultaneously to establish the comparability of results obtained by CANMET and the steel company laboratories when using the same ASTM coal assessment procedures. Figure 1 shows the sampling and analysis routine that was established to carry out the comparative experiment.

A production 6000 kg sample of coal was collected over a two-day period in 500 kg increments at a location after coal pulverization. In this instance sampling was immediately downstream of a hammer mill. This coal was blended in Ottawa and samples transferred to the technical scale facilities in Edmonton.

A 3000 kg sample of coke was sampled downstream of one surge bin. The coke sample was subdivided for analysis in Ottawa, Edmonton, and at the company laboratories.

Carbonization of the test coal was performed in both Edmonton and Ottawa. Figure 2 shows the stability results obtained in the Ottawa 18" oven as a function of coal bulk density as charged. Carbonization at the standard coal bulk density (46.5 lb/ft^3 or 745 kg/m^3) and a flue temperature of 1125°C represents CANMET standard operation.

The coal blend of this company, when carbonized at the standard bulk density conditions, produced coke with a stability factor 1.4 units lower than the industrially made coke.

Figure 3 shows a correlation that has been developed between the two Ottawa technical scale ovens that allows extrapolation of this test data to the second Ottawa oven.

This study is continuing. A further series of experiments was completed in April using samples taken at a second Canadian steel works. Conclusions to date are that the 18" oven in Ottawa and the carbolite oven in Edmonton produce coke of comparable quality to the industrial product when using industrial coal blends. ASTM stability indices differ by less than 1.5 units.

We would be extremely interested to learn of Japanese experience and routines used in correlating technical and industrial scale ovens - particularly where Canadian coals are used in the coal blend.

COKEMAKING WITH CANADIAN COALS

A major investigation of the quality of coke(s) produced from blends of Canadian coals has shown that these blends produce cokes with chemical and physical properties suitable for the blast furnace.

Measured stability factors were compared with predictions made by three methods:

Petrography
Dilatation - "G" factor
Reflectance - Fluidity (modified MOF diagram)

Carbonizaton tests with binary blends of four different coals produced the coke stability and strength data illustrated in Figures 4 and 5.

The sulphur and ash contents of the cokes are illustrated in Figure 6. The western Canadian coals are seen to make significant contribution to sulphur reduction in the coke without going to unacceptable ash levels. The importance of these parameters is reflected in their relationship to blast furnace performance:

. 1 Stability unit	Coke rate changes by 1 kg/ton hot metal, 0.8% productivity
. 1% Coke ash	Coke rate changes by 15 kg/ton hot Metal, 3.0% productivity
. 0.1% Sulphur	Coke rate changes by 4 kg/ton hot metal, 0.8% productivity

SELECTIVE PULVERIZATION

Three different pulverization procedures were compared in this experimental program. A single blend with the composition illustrated in Table 1 was used throughout. The following pulverization methods were used:

Method 1. Each coal is pulverized at a constant mill setting (this is equivalent to conventional pulverization since each coal of a blend being pulverized behaves as though it had been pulverized separately).

Method 2. The mill setting is adjusted, so that the pulverization of each coal is the same (i.e. lower setting for softer coals and higher setting for harder coals).

Method 3. The coals are grouped according to their inert components content, and the high-inert low-fluid coals (B and D) are pulverized finer than the other coals.

The experimental results demonstrated that improvements in coke stability due to increased blend pulverization were greater than any improvements which occurred during selective component pulverization.

Selective pulverization, however, gave lower "bug dust" levels (coal below 100 mesh; 150 microns) in the experimental program. The differences were only apparent when the degree of pulverization increased above 80% below 6 mesh (3.3 mm).

Figure 7 shows the magnitude of the stability changes that were recorded.

PARTIAL BRIQUETTING

Currently, no Canadian company has found it necessary to practice partial briquetting of its coke oven charges. Indeed, it has been reported that the relatively fluid Canadian commercial blends would not benefit from application of this technology.

This investigation was undertaken by CCRA to evaluate partial briquetting as applied to commercial blends, to define potential reduction in low volatile coals that might result from use of briquetted charges and to establish replacement levels for the use of non-coking materials in metallurgical coal blends.

Table 2 shows the conditions used in the production of matrix coal and the briquettes. The reference standard for the program was an unbriquetted charge; in each subsequent test the briquettes comprised 30% of the total charge.

Four commercial steel company blends were examined as conventionally crushed charges, as 30% partially briquetted charges and as crushed briquetted charges.

The average results for the test series are presented in Table 3.

- Overall a stability increase of 4 units was recorded.
- This was accompanied by an acceptable increase in oven wall pressure.
- Coke oven productivity was maintained.

A series of experiments with binary high-volatile (3 coals) + low volatile (1 coal) blends were carbonized loose and partially briquetted.

The results in Figure 8 show that the partial briquetting technique would allow reductions in the low volatile component between 8 and 13% of the total charge without deterioration in coke quality.

A further series of experiments with non-coking materials <u>incorporated into the briquettes only</u> showed that only selected materials were acceptable substitutes in the coal blend. The results are illustrated in Figure 9. No non-coking material could be tolerated above a concentration of 30% in the briquettes (10% in the blend) without deterioration in coke quality.

FUTURE PROGRAMS

Coal Beneficiation

A CCRA program which was started in January 1980 has the objective of establishing the role of the coal ash component in coke stability.

A series of western Canadian coals are to be washed to different ash levels, and the resultant washed product examined analytically, petrographically and in technical scale oven trials.

The initial results are not yet complete. However, Figure 10 indicates the changes that have been recorded with acceptable commercial yields from the washery plant.

Coal Additives

A new program to establish the effect of pitch and bitumen additives on coke quality is planned for 1980/81.

Coke Quenching

A second new program to establish the effect of wet and dry quenching rate on coke quality is planned for 1980/81.

Table 1 - Composition of the coal blend used in selective pulverization studies

Coal	Percent of blend	Coal Properties			
		Volatile content (D.A.F.)	Fluidity D.D.P.M.	Hardness Hardgrove Index	F.S.I.
A	15	Low-volatile 20.4%	68	93	8 1/2
B	15	Med.-volatile 23.9%	86	92	6 1/2
C	35	High-volatile 34.6%	23440	55	8
D	35	High volatile 39.4%	483	44	3 1/2

Table 2 - Partially briquetted coal charges

Parameters	Test conditions
Matrix coal:	
Pulverization level	80 ±5% minus 3mm
Moisture	6%
Oven bulk density	744 kg/m^3 (DB)
Coal for briquetting:	
Addition	Non-coking coal added to briquette only
Pulverization level	90 ±5% minus 1mm
Briquettes:	
Amount	30% of the charge
Binder	6% roofing asphalt (softening point 77°C)
Size	30 x 30 x 18 mm pillow-shaped
Moisture	1.2 to 1.8%

Table 3 - Average results for commercial blends

Parameters	Loose charge	30% briquettes	30% crushed briquettes
Coal blend properties			
Moisture, %	6.0	4.7	5.9
Oven bulk density, kg/m^3	756	814	764
Carbonization results:			
Gross coling time, hr.	18.0	19.8	18.8
Coking rate, mm/hr	25.4	23.1	24.3
Max wall pressure, kPa	2.5	3.6	2.2
Coke yield, %	71.9	71.8	70.6
Coke physicals:			
Coke mean size, mm	64.1	63.8	63.7
ASTM stability	52.8	57.0	54.6
ASTM hardness	62.4	66.6	63.9

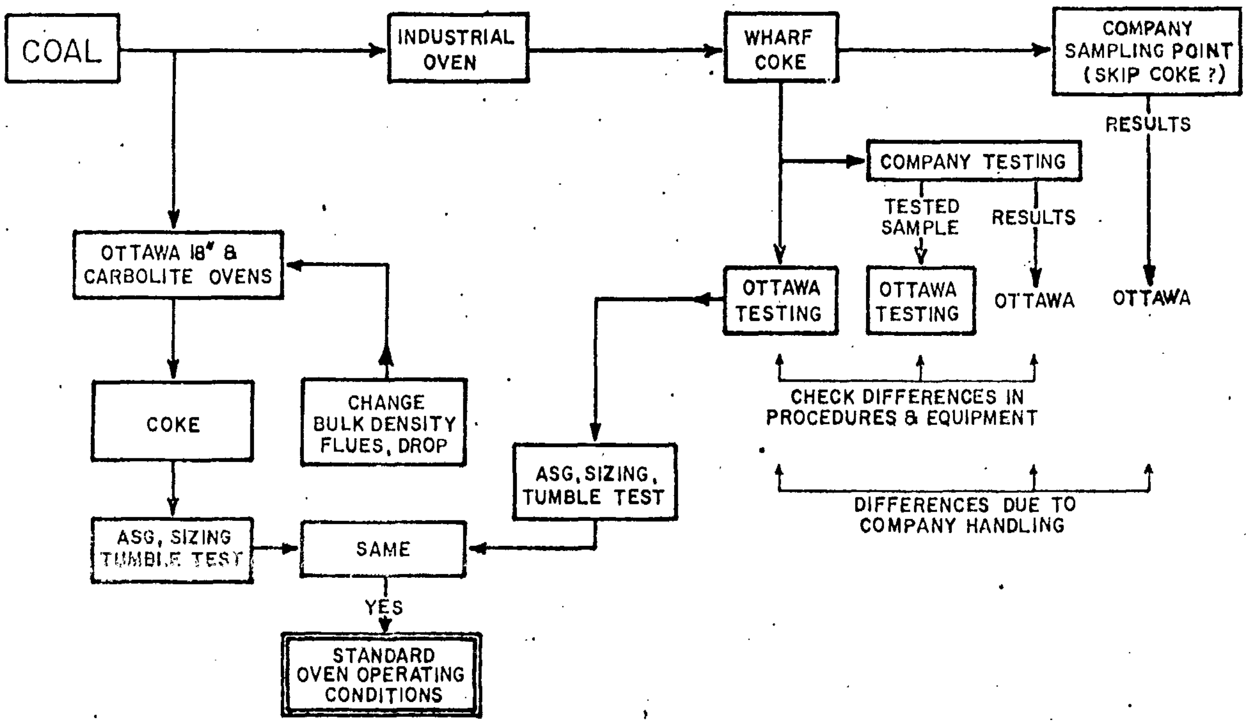

Fig. 1 - Sampling and analysis routine for commercial and technical oven comparisons.

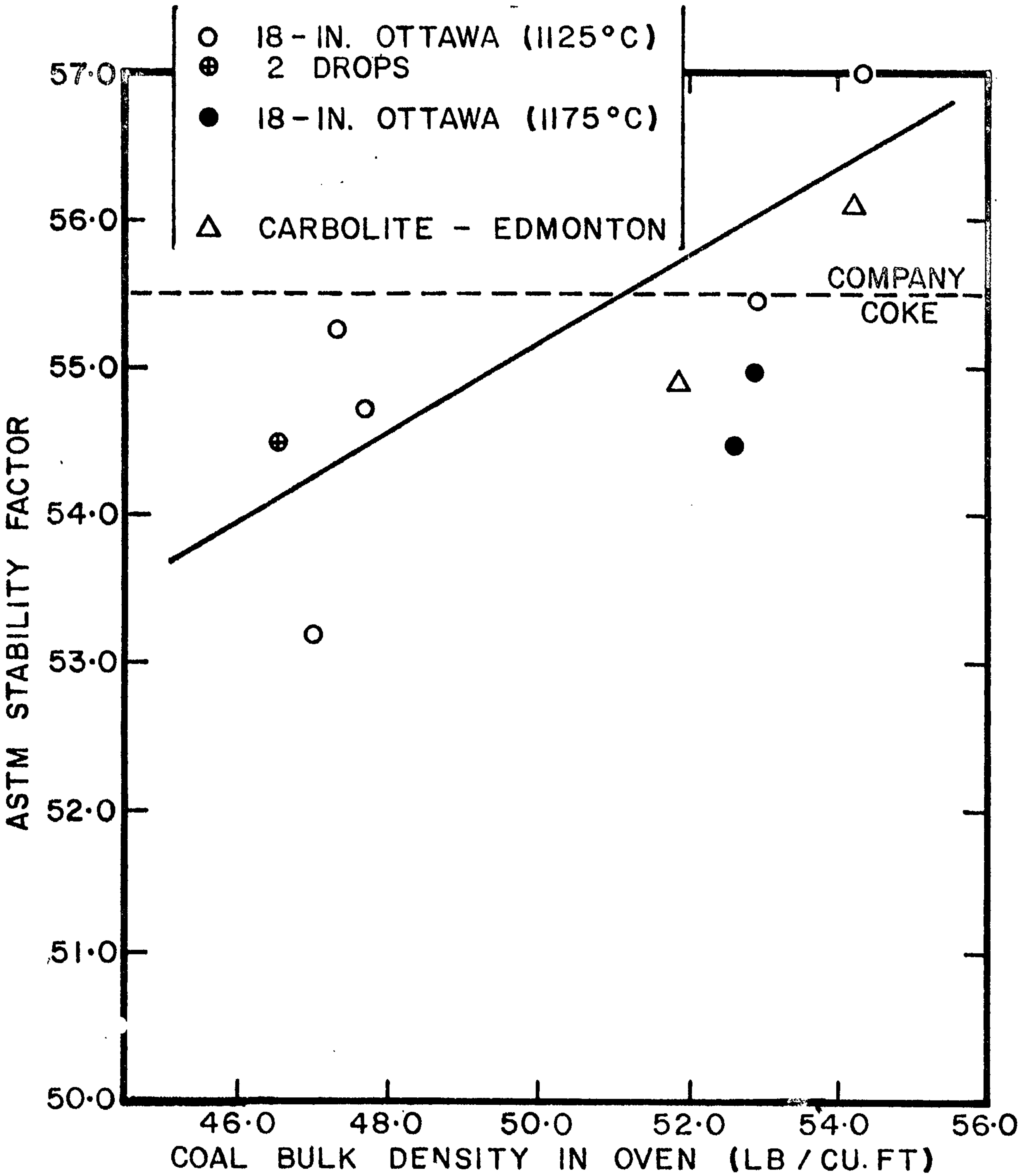

Fig. 2 - The stability of coke from the technical scale ovens

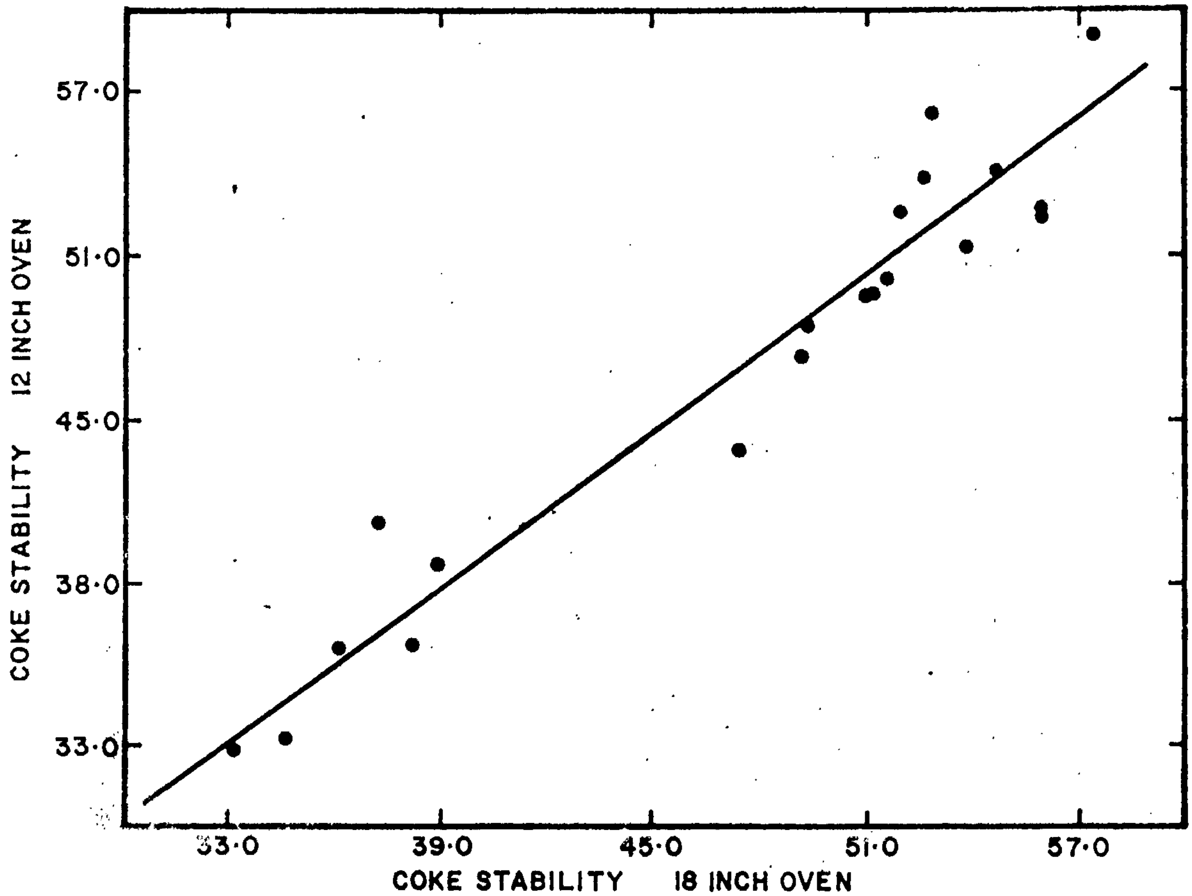

Fig. 3 - The coke-stability correlation between the two Ottawa ovens

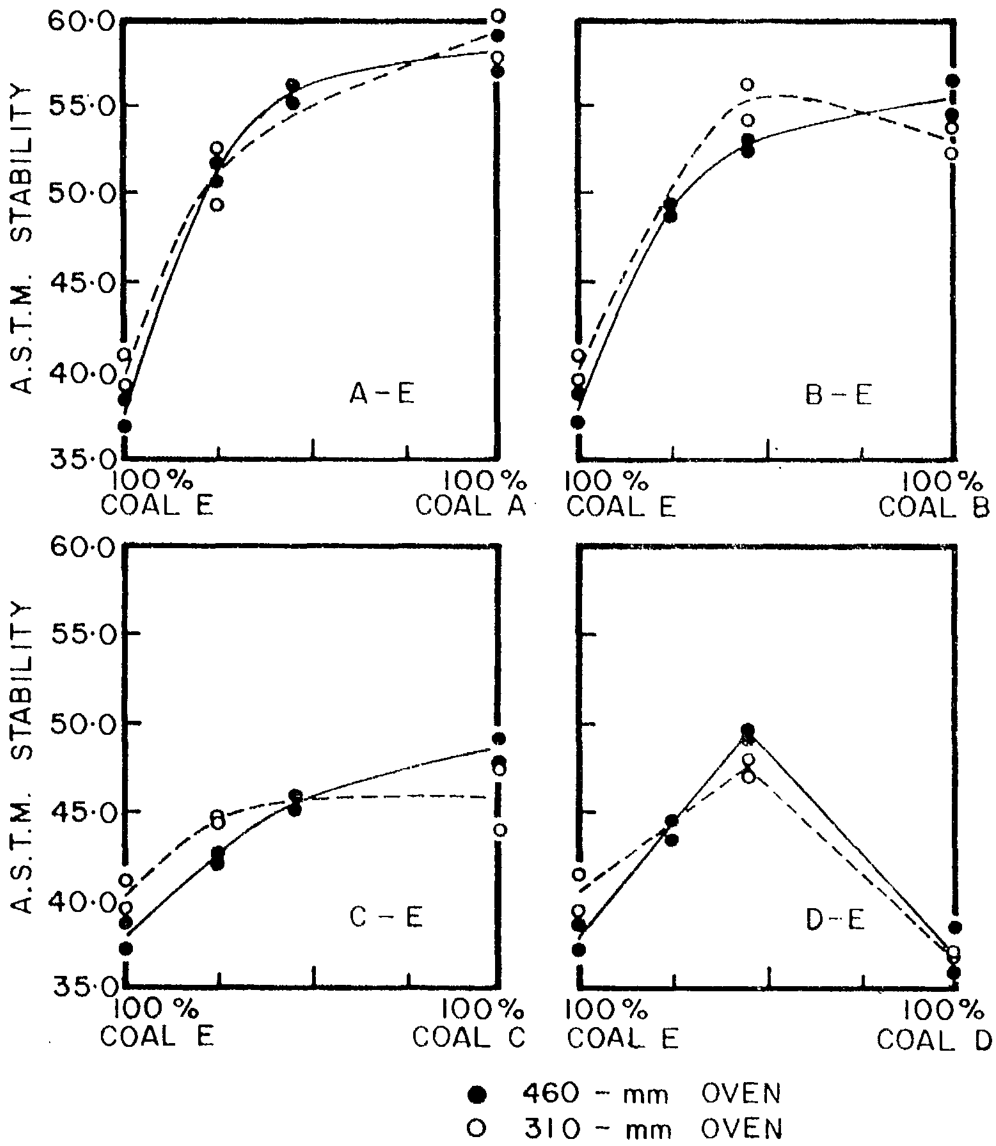

Fig. 4 - The stability of coke from binary blends of Canadian coals

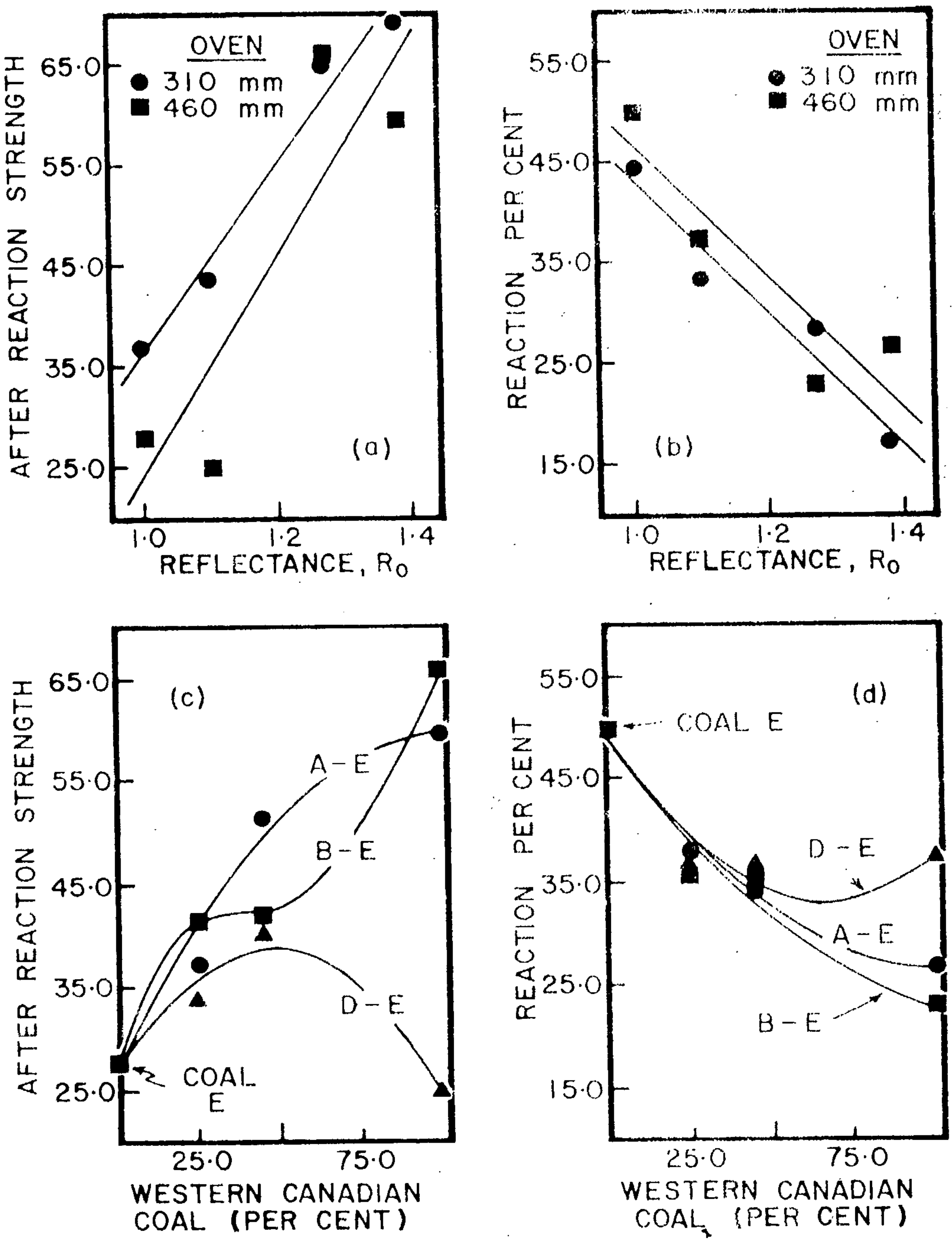

Fig. 5 - The after reaction characteristics of coke produced from binary blends of Canadian coals.

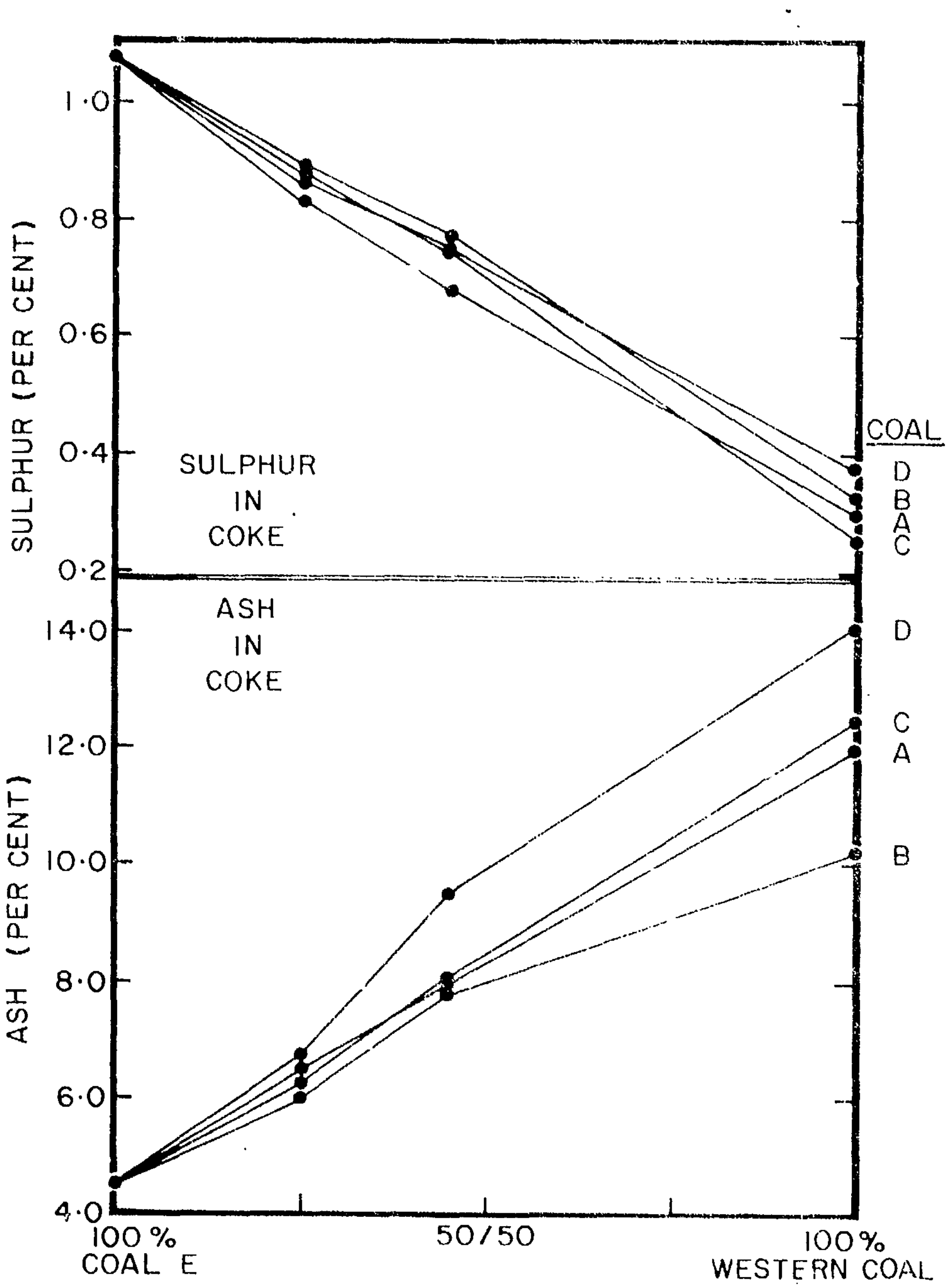

Fig. 6. - The sulphur and ash content of cokes produced from binary blends of Canadian coals.

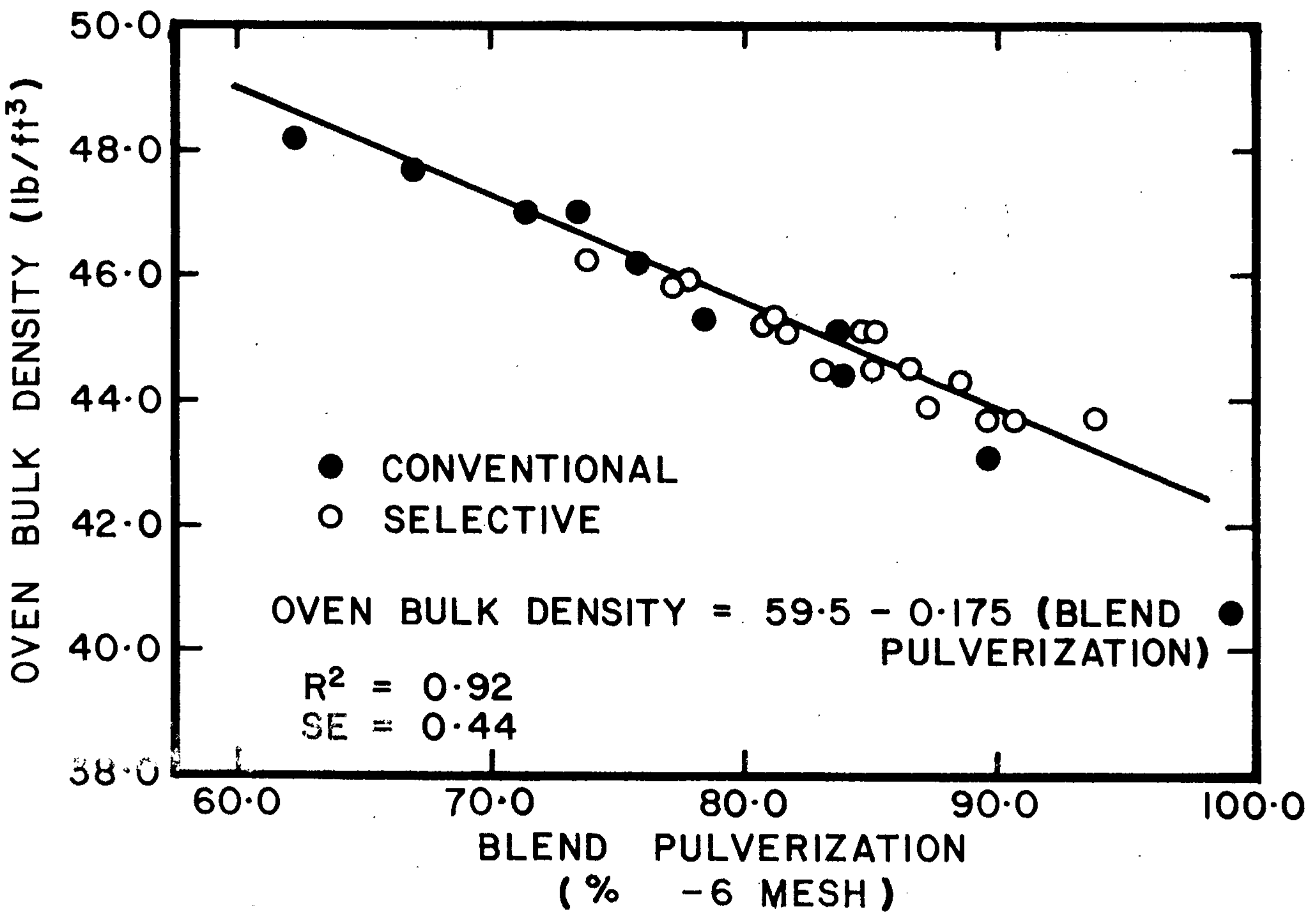

Fig. 7 - The effect of selective pulverization on coke quality

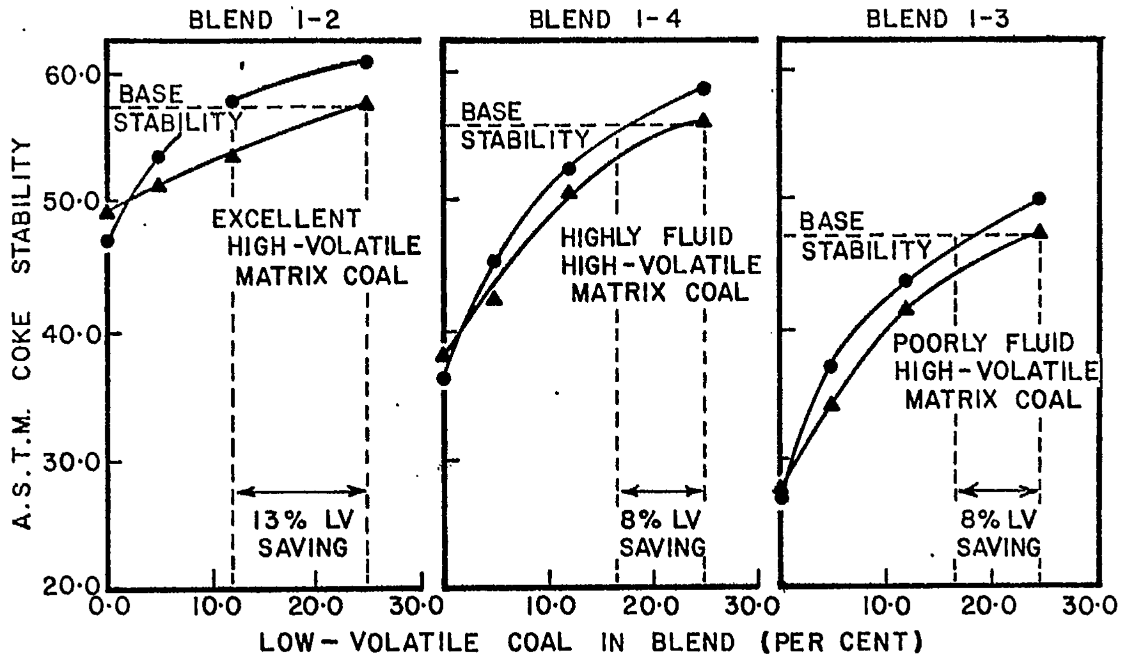

Fig. 8 - The effect of partial briquetting on low-volatile coal requirements in a coal blend.

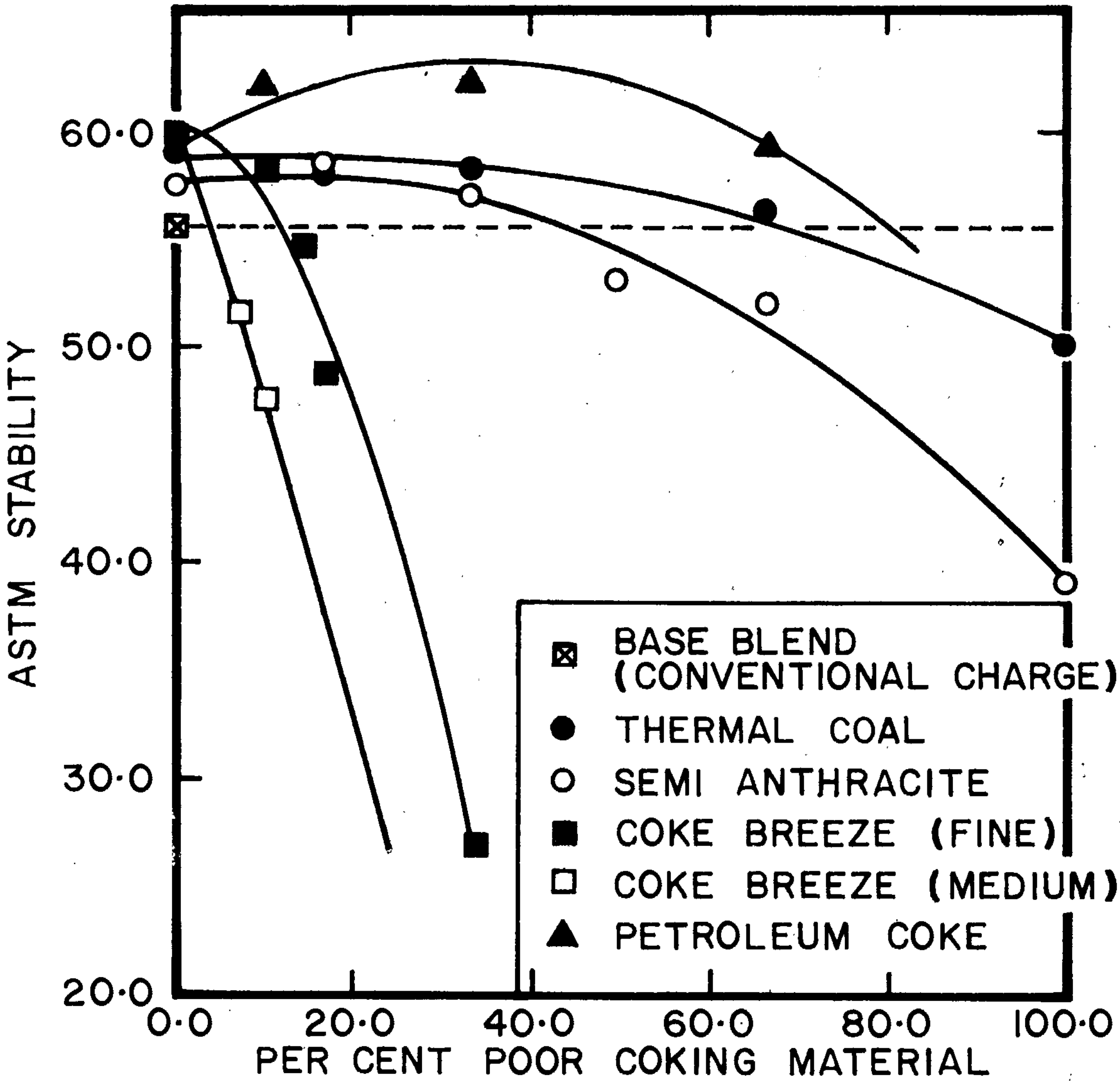

Fig. 9 - The addition of non-coking materials to partially briquetted coal blends.

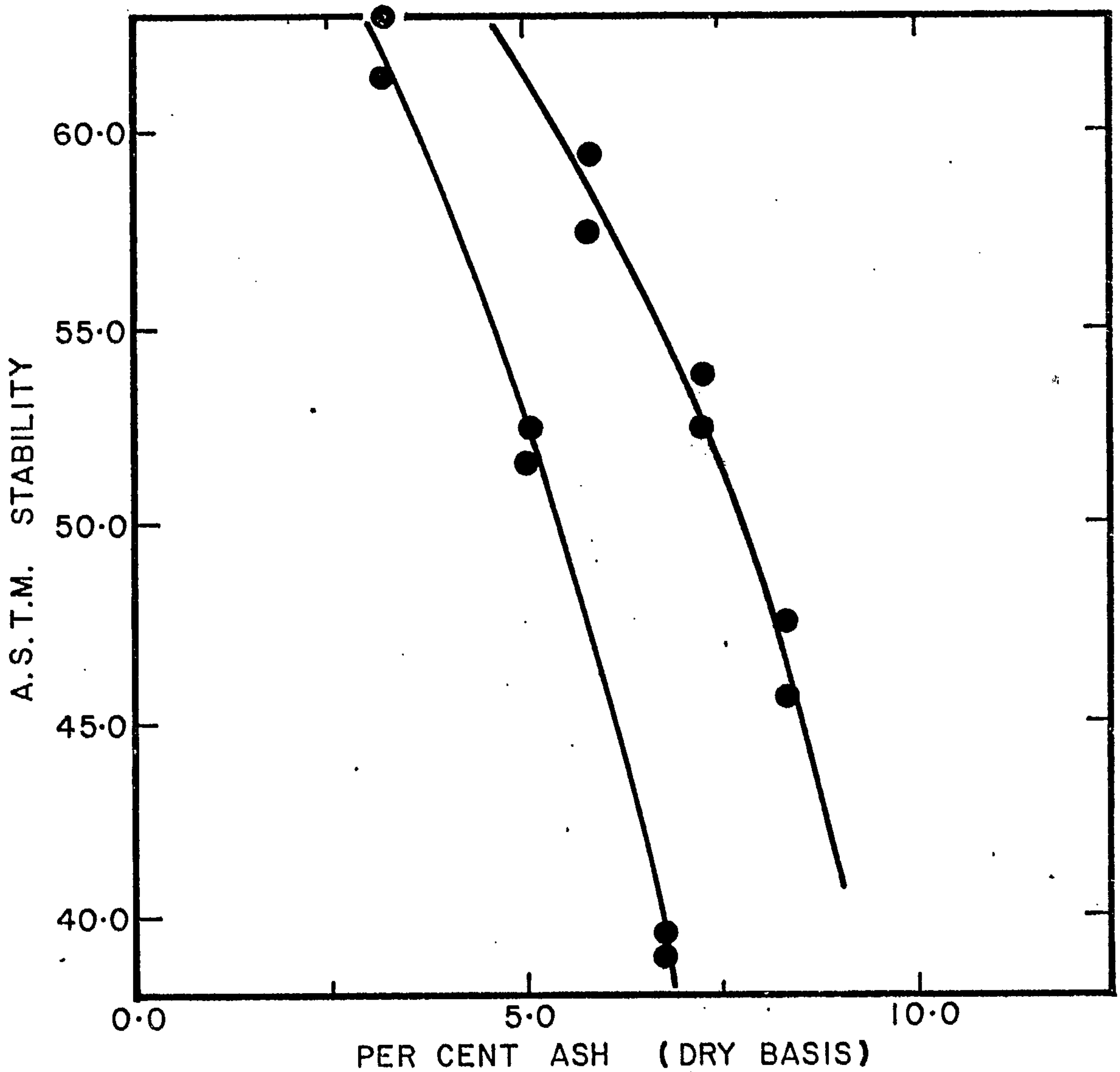

Fig. 10 - The relation between coke quality and ash level after beneficiation of two western Canadian coals.