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EXPERIENCE WITH COKE TEST OVENS

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INTRODUCTION

Coking coal in test ovens is the final test a coal can undergo before industrial trials. While laboratory tests like the free swelling index, Gieseler plastometer and dilatometry measure parameters known to be important during the coking process, only test ovens produce a product that looks like industrial coke and one which can be further tested in a similar manner.

Petrographic analysis and laboratory coal tests may be used to bracket the expected coke strength of a coal or coal blend with some level of confidence. For example we place much confidence in the petrogaphic method of Sharpiro and Grey for predicting coke strength of Appalachia coals but have found difficulties applying it to western Canadian coals.

Experience has shown test ovens reflect changes in coke strength that occur industrially as coal blend composition, coking rate, moisture and pulverization are changed.

The coal producers of CCRA use test ovens as an aid in mine planning, coal cleaning, marketing and quality control.

The cokemakers of CCRA use test ovens to confirm expected coke strengths.

Proposed changes in blend composition or significant change in a coal are first explored by petrography. The preferred method of strength confirmation is the 460-mm width oven operated at 6% moisture - a value close to industrial and one which results in a coal bulk density just a little higher than the industrial average and a coking rate of 25 mm/h. For carefully sampled coal and coke, test oven coke stability factors are then very similar to those measured at the industrial wharf, Fig. 1.

Other test oven coke properties, however, are markedly different. For example coke abradability as measured by the ASTM hardness factor is lower for the test ovens, Fig. 2. The apparent specific gravities are also lower, Fig. 3, as are in general the strengths after reaction CSR.

We conclude from these results that we are still testing a coal and not replicating industrial coking. By changing the operating conditions of the test oven we can reproduce most, perhaps all the properties of the industrial cokes. For example, if the coal is charged to

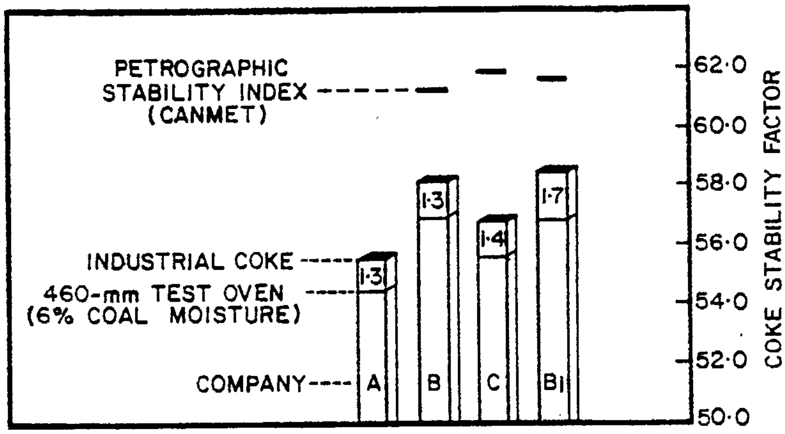

Fig. 1 Comparison of the strength of industrial wharf cokes, 460-mm test oven coke (6% moisture) and the petrographic predicted strength

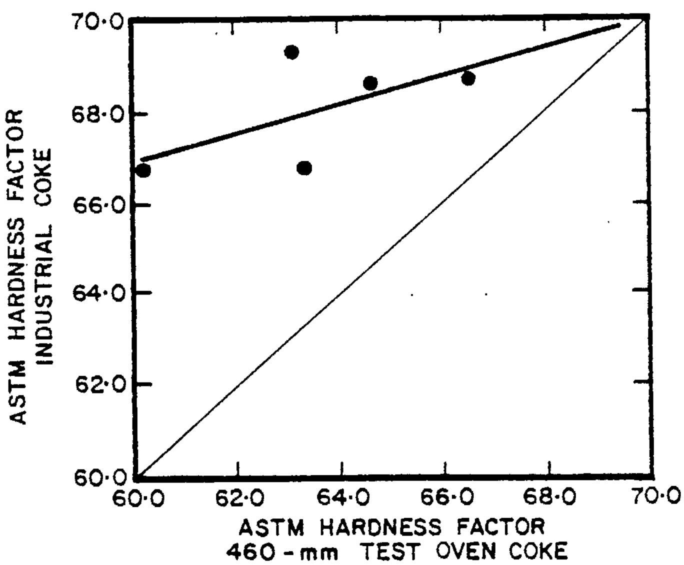

Fig. 2 Comparison of the ASTM hardness of industrial and 460-mm test oven cokes

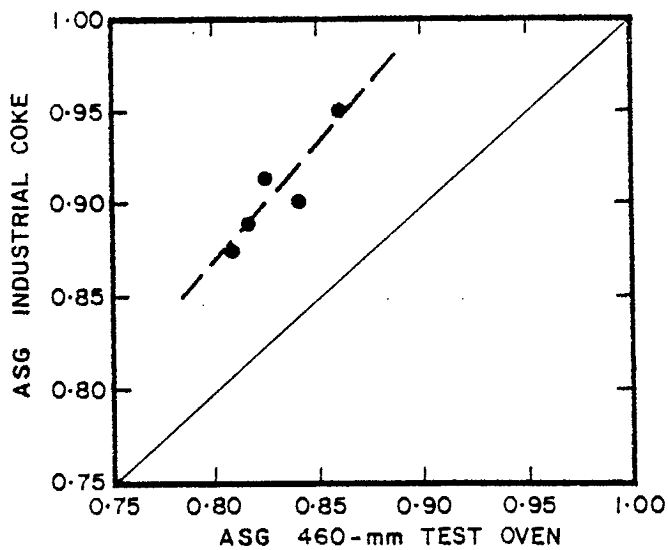

Fig 3 Comparison of the apparent specific gravity of industrial and 460-mm test oven cokes

the oven at 3% moisture the coke hardness factors become similar to the industrial. Stability factors for the test oven coke are then an average of 2.6 points too high, Fig. 4. In the same figure it is seen that a 310-mm width test oven also operated at 3% moisture, but at a faster coking rate 33 mm/h gives coke, with one exception, of much lower strength.

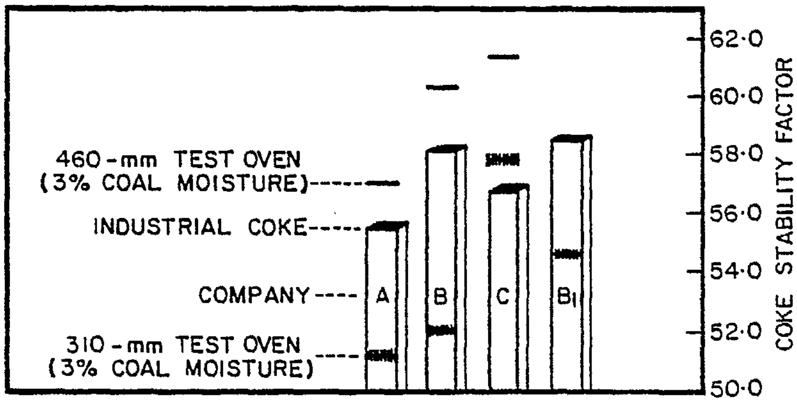

Fig. 4 Comparison of the strength of industrial wharf coke, 460-mm test oven coke (3% moisture), and 310-mm test oven coke (3% moisture).

By coking coal at different bulk densities in different test ovens we have come to the following general conclusions.

1. The stability factor increases with bulk density and decreases at faster coking rates.
2. Coke hardness factor and apparent specific gravity, while influenced to some extent by coking rate, are mostly dependent on bulk density. This is illustrated in Figs. 5 and 6 using the results of our technical exchange, which included five different tests ovens operated at different bulk densities and coking rates.
3. Regression analysis has shown that all industrial properties can be replicated in test ovens by changing the bulk density and/or the coking rate. But each property requires different conditions, sometimes markedly different. Thus it is not possible to replicate all the properties of an industrial coke at the same time.

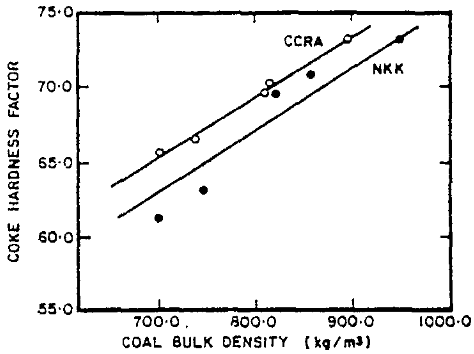

Fig. 5 Relation between the ASTM hardness factor and the bulk density of the coal in the oven.

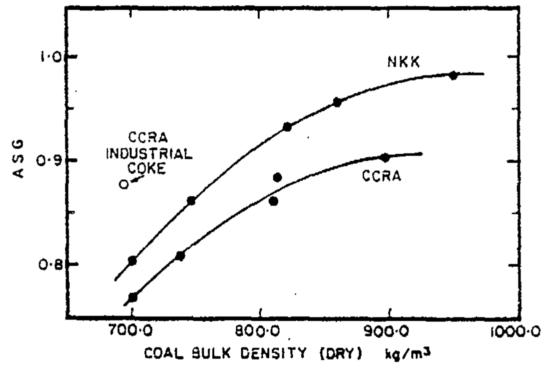

Fig. 6 Relation between the apparent specific gravity of coke and the bulk density of the coal in the oven.

Two problems arising from test ovens not replicating industrial coking are:

a) Coking Pressure

b) Interpretation of R&D carried out in test ovens.

a) Coking Pressure

A coal blend coked in test ovens at increasing bulk density will produce increasing maximum coking pressures. Generally there is a linear relationship between the coal bulk density and logarithm of the pressure. Fig. 7 is an example of such a relationship obtained in one oven. The CCRA and NKK blends follow a similar relationship Fig. 8. Can the test oven be operated to reproduce industrial pressure?

Our present, somewhat limited experience, suggests coking pressures in test ovens operated at typical industrial bulk densities are smaller and uncharacteristic of industrial pressures. That there is a difference appears probable as the coke properties are different. Now coking pressure is caused by gas pressure within the plastic coal layers which are at an intermediatary stage between coal and coke. The properties of these plastic layers will depend on both the physical properties of the initial state, coal bulk density, and that of the final, the coke. Experimentally, as we have seen, industrial coal bulk densities do not produce industrial coke properties in test ovens. We conclude therefore we do not know how to reproduce industrial pressures in test ovens. Instead we rely on pressure limits, proven historically, such as the Koppers test.

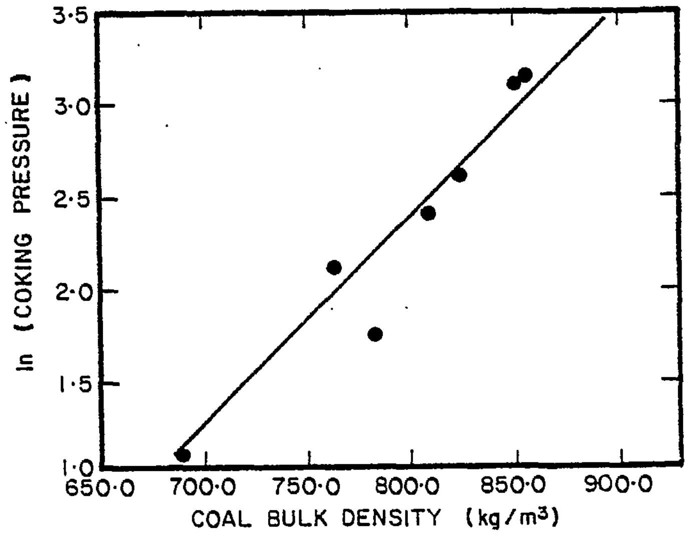

Fig. 7 Relation between $\log_e$ of the coking pressure and the bulk density of the coal in the 310-mm oven.

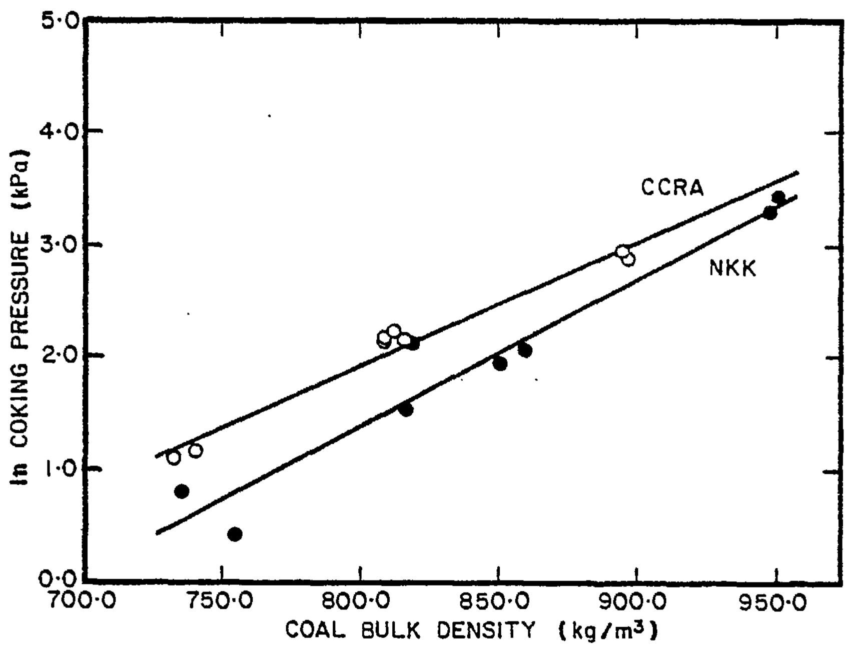

Fig. 8 Relation between $\log_e$ of the coking pressure and the bulk of the NKK and CCRA coal blends in the ovens.

This situation is not totally satisfactory as:

1) it is preferable to know actual industrial pressure;
2) it may unduly limit blending possiblities and hence improvement in coke quality;
3) it makes evaluation of newer technologies, in test ovens such as partial briquetting or preheating, difficult as the standard Koppers conditions cannot be used.

Furthermore the Koppers test is not beyond criticism. It specifies the oven design, coal pulverization and extreme coking conditions (1% moisture, 1343°C flue temperature) but limits are not placed on the values of coal bulk density in the oven. This will very with details of oven charging and coal properties.

The problem manifests itself in our technical exchange. In the Koppers test the CCRA blend had a bulk density of 897 kg/m and produced a pressure of 18.1 kPa slightly in excess of the Koppers limit 14 kPa. The NKK blend had a considerably higher bulk density 950 kg/m^3 and produced a pressure of 28.5 kPa, twice the test limit. Yet, as Fig. 8 shows the NKK blend always produces lower pressure at any particular coal bulk density than the CCRA blend and may therefore in some respects be considered a safer blend.

b) Interpretation of R&D Programs

CCRA relies heavily on test ovens to investigate coking technologies that it considers may prove useful. Examples are coal preheating, partial briquetting, selective pulverization and coking additives. It is therefore important to consider to what extent improvements in test oven coke will be reflected in industrial operations. Industrial proving trials have only infrequently been possible.

Generally it is believed the test ovens will continue to reflect industrial changes in the coke strength, the property most important to cokemakers. The regressions of individual companies that relate industrial stability to the petrographic index of the blend, its pulverization, moisture (or bulk density) and the coking rate are still considered to apply. The problem of ensuring safe coking pressures and predicting other coke properties, outlined previously, remains.

OTHER RELATIONSHIPS

Coke strength indices

CANMET uses 50x75mm coke in the JIS drum, not plus 50mm coke as specified in the standard. This is indicated by placing (modified) or (mod) after the index, eg DI^{30}_{15} (mod). For 45 different samples of coke it has been determined that DI^{30}_{15} is an average of 0.5 points lower than DI^{30}_{15} (mod) and that DI^{150}_{15} is 0.7 points lower than DI^{150}_{15} (mod).

Figure 9 shows that for the data generated in our exchange program there is some correlation between the strength indices used in Japan and those used in North America. A better relationship exists between the JIS DI^{150}_{25} (mod) and the stability factor indices, Figure 10. Using CANMET's data bank on coke quality, Figure 11 confirms that there is a useful relationship between these two indices.

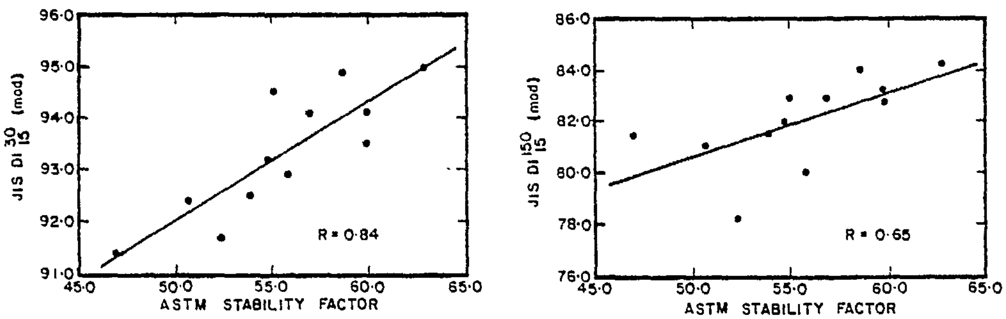

Fig. 9 Relation between the coke strength indices normally used in Japan, DI^{30}_{15} and DI^{150}_{15}, and the index used in North America, stability factor.

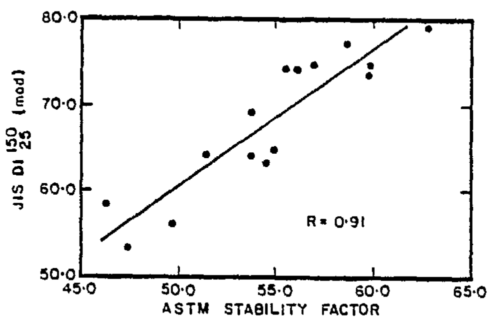

Fig. 10 Relation between DI^{150}_{25} and the stability factor

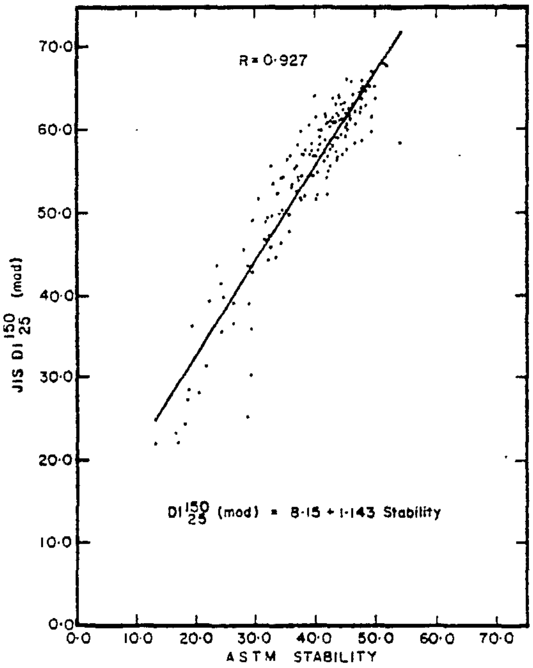

Fig. 11 Relation between DI_{25}^{150} (mod) and the stability factor from CANMET data bank.

Coking pressure

Results from our exchange program show that the maximum coking pressure on the oven wall is about one half the maximum gas pressure at the oven centre, Fig. 12. Other results obtained at CANMET show good relationships for a particular oven (Fig. 13 is an example) but suggest there are minor differences between different ovens.

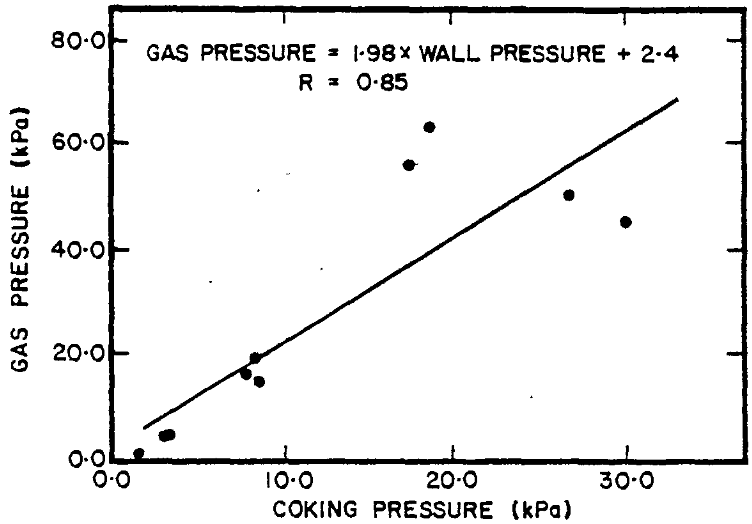

Fig. 12 Relation between the maximum coking pressure on the oven wall and the maximum gas pressure at the oven centre.

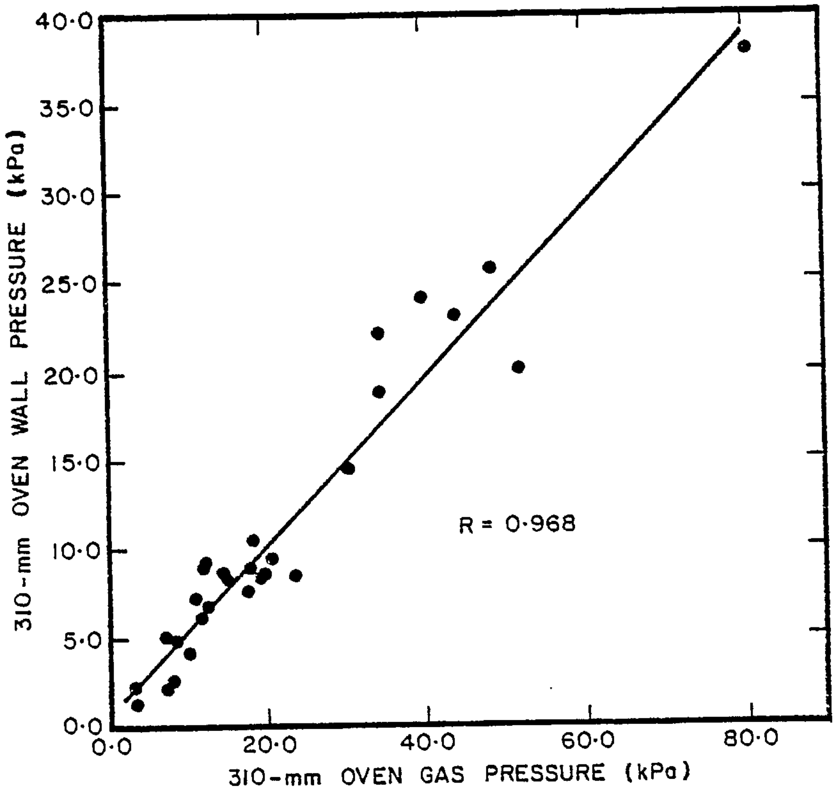

Fig. 13 Relation between the wall pressure and gas pressure in 310-mm oven.