Influencing Factors on the Strength of Formed Coke Produced from Copreheated Coals

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The formed coking process of Hunter valley (slightly fusible) coal through the copreheat-treatment was studied using A240 as a coking additive to reveal the effects of copreheat-treatment and carbonization conditions on the strength and reactivity of the resultant formed coke. The conditions were found to influence the properties of the coke in a compensating manner.

INTRODUCTION

A recent objective in the coking industry is to develop the technology to produce solid formed cokes of high mechanical and chemical strength from low rank coal.

The authors have repored that such a coke was produced by a series of coking process, copreheat-treatment of coal with additive, grinding, forming, carbonization and calcination, where the copreheat-treatment conditions and the kind of additive were very influencial on the properties of fomed coke [1,2].

In the present paper, the effects of copreheat-treatment conditions, particle size of copreheat-treated coal, forming pressure and heating rate of carbonization were examined to find facile procedure for the better formed coke.

EXPERIMENTAL

Coal and additive used in the present study were summarized in Table 1 together with their ultimate analyses. Experimental procedure was illustrated in Fig. 1. Coal and additive mixture at the prescribed mixing ratio was copreheat-treated under variable conditions listed in Table 2. The copreheat-treated coal was carbonized at variable heating rate after forming under variable pressure. Properties of calcined coke were examined in terms of tensile strength and CO_2-reactivity at 1000°C.

RESULTS & DISCUSSION

Effects of particle size of copreheat-treated coal

Table 3 shows the effects of particle size of copreheated coal on the tensile strength of

Table 1 Ultimate analyses of coals and pitches

Sample	C	H	N	O[b]	
			(wt%)		
Hunter Valley[a]	83.1	5.4	1.9	9.2	0.4
A240	91.3	5.5	0.2	-	-

a) dry, ash free basis
b) caluculated by weight difference

Table 2 Copreheat-treatment conditions

heating rate (°C/min)	HTT (°C-min)	Abbreviation
10	410-120	A
10	420- 60	B
150	450- 15	C
150	480- 8.0	D
150	480- 8.5	E
150	480- 10	F
150	500- 5.0	G
150	500- 6.0	H
150	500- 9.0	I
150	500- 10	J

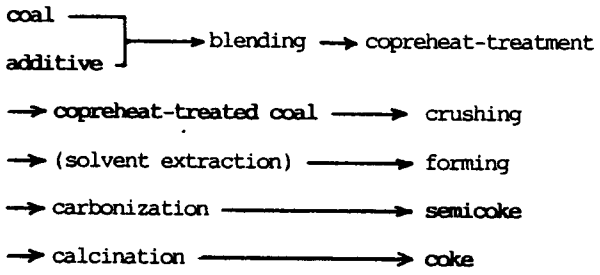

Fig.1 Experimental procedure.

Table 3 The effects of particle size of the copreheat-treated coal on the tensile strength of the coke

copreheat treatment condition	particle size (μm)	moulding pressure (kg/cm^2)	tensile strength (kg/cm^2)
A	- 149	450	116
(410°C-120 min)	149 - 250	450	128
	250 - 430	450	68
E	- 149	200	121
(480°C-8.5 min)	149 - 250	200	54

carbonization conditions: 10°C/min, 600°C-12 min
calcination conditions: 5°C/min, 1200°C-240 min

calcined coke. Both copreheat-treated coal **A** and **E** exihibited high strength when they were ground less than 149 μm (100 mesh).

Effects of forming pressure and heating rate in carbonization

Fig. 2 shows the effects of forming pressure on the tensile strength, where the particle size of copreheat-treated coal and heating rate in the carbonization were -149 μm and 10 °C/min, respectively. The tesile strength of cokes depended strongly on the forming presure which was adjusted to the copreheat-treatment conditions. The tensile strengthes of cokes prepared from **C** and **D** (milder coditions) decreased along with the increase of forming pressure, although those of **E** and **F** (severe conditions) decreased along with the increase of forming pressure. **H** required higher pressure than 200 kg/cm^2 to provide a solid coke.

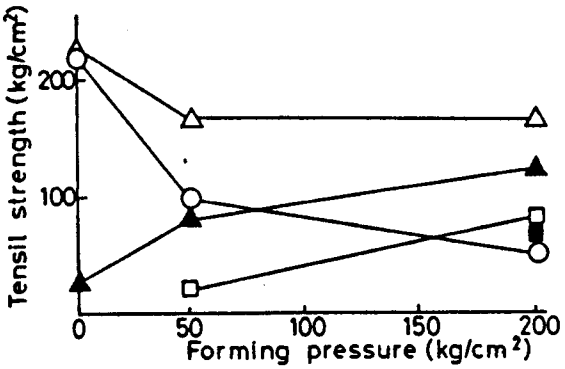

Fig. 2 The effects of moulding pressure on the coke strength.
○: **C** (450°C-15 min), △: **D** (480°C-8.0 min), ▲: **E** (480°C-8.5 min), □: **F** (480°C-10 min), ■: **H** (500°C-6.0 min)

Effects of heating rate in carbonization were summarized in Table 4. The tensile strength of coke from **C** and **D** decreased by the increase of heating rate in the carbonization, while those from **E**, **I** and **J** increased by the increase of heating rate. The copreheated coal prepared under rather milder conditions (around 450 °C within 15 min) exhibited better fusibility at the carbonization stage, providing a solid formed coke of high strength when carbonized in a vessel without moulding pressure at a low heating rate. In contrast, higher forming pressure as well as heating rate resulted in a expanded coke of low stength. The copreheat-treated coals prepared under severe conditions (at higher temperature than 480 °C for longer soaking time than 8.0 min) did not fuse well when carbonized at a lower heating rate without forming pressure, resulting in the low strength. These severely copreheat-treatmented coals required to exhibit high strength higher pressure around 200 kg/cm^2 and smaller particle size less than 100 mesh before forming. A high heating rate at the carbonization was also favorable for the high strength.

Such results suggest that the amount of volatile matter, its released rate at the carbonization stage and the size of pore remained after the forming affect the fusibility and adhesion extent of copreheat-treated coal particles in the carbonization stage.

Table 4 Effects of heating rate at the carbonization stage on the tensile strength of the coke

copheheat-treatment conditions[1] (°C-min)	heating rate at carbonization (°C/min)	moulding pressure (kg/cm^2)	tensil strength (kg/cm^2)
C	3.0	50	236
(450-15)	10	50	100
D	3.0	50	277
(480-8.0)	10	50	180
E	3.0	200	82
(480-8.5)	10	200	121
I	1.0	400	108
(500-9.0)	10	400	278
J	1.0	400	155
(500-10)	10	400	262

1) see Table 2

Table 5 CO_2 reacativity of formed cokes at 1000°C

copreheat-treatment conditions (°C-min)	moulding pressure (kg/cm^2)	heating rate at carbonization (°C/min)	CO_2 reactivity r (X10^{-3}g/g min)
coke-A[a]	-	-	3.2
coke-B[b]	-	-	18
B(420-60)	200	10	3.3
E(480- 8.5)	200	10	2.8
G(500- 5.0)/HI[c]	510	10	10
G(500- 5.0)/BI[d]	510	10	16
H(500- 6.0)	400	60	3.7
I(500- 9.0)	450	10	3.5

a) comercially available coke
b) coke prepared in laboratory from Hunter Valley coal without moulding
c) hexane insoluble fraction
d) benzene isoluble fraction

The gasification reactivity

Fine grained mosaic anisotropy was developed in the whole cokes thus produced, of which CO_2-reactivities at 1000 °C was low and comparable to that of a commercial blast furnace coke. The HI or BI fraction of a copreheated coal produced cokes of very high strength (>300 kg/cm^2), however, their reactivities were very high. Many micropores (<1 μm) observed by SEM in the cokes may enhance the reactivity although they are indifferent to their strength at this low strength level. The effects of copreheat-treatment and carbonization conditions on the coke quality will be mechanistically discussed by relating them mutually.

REFERRENCES

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