GRINDABILITY DATA ON PENNSYLVANIA ANTHRACITES[1]

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As fine sizes of anthracite become more in demand for such applications as a blending inert with bituminous coal to make coke, filler material for pot liners in the aluminum industry and for electrodes in the carbon industry and as a pulverized fuel, information on anthracite's grindability characteristics becomes increasingly necessary.

Grindability data on anthracite have been collected from four producing and two consuming companies, and from one equipment manufacturer. Since the Hardgrove-Machine Method (1) (ASTM D 409-37T) has been recently accepted as standard and the tentative status of the Ball-Mill Method, (ASTM D 408-37T) has been withdrawn, only Hardgrove Indexes have been reported herein. In cases where Ball-Mill data were obtained, these values have been converted to approximately equivalent Hardgrove Indexes.

The Hardgrove Method uses a special grindability mill of the ring and ball type. The coal sample to be tested is air-dried and a 16 x 20 mesh fraction is obtained on repeatedly crushing and sizing. A 50-gram sample of this fraction is placed in the Hardgrove Machine and is ground for 60 revolutions. The resulting product is then sized on a 200-mesh sieve. The Hardgrove Grindability Index is calculated as follows:

Hardgrove Grindability Index $= 13 + 6.93W$ where W = weight of material passing the 200-mesh sieve, determined from the weight of the original sample (50 grams) minus the weight of the material retained on the 200-mesh sieve.

The ASTM Standards specify that the permissible variation between two or more determinations shall not exceed two per cent for the same laboratory and shall not exceed three per cent for different laboratories.

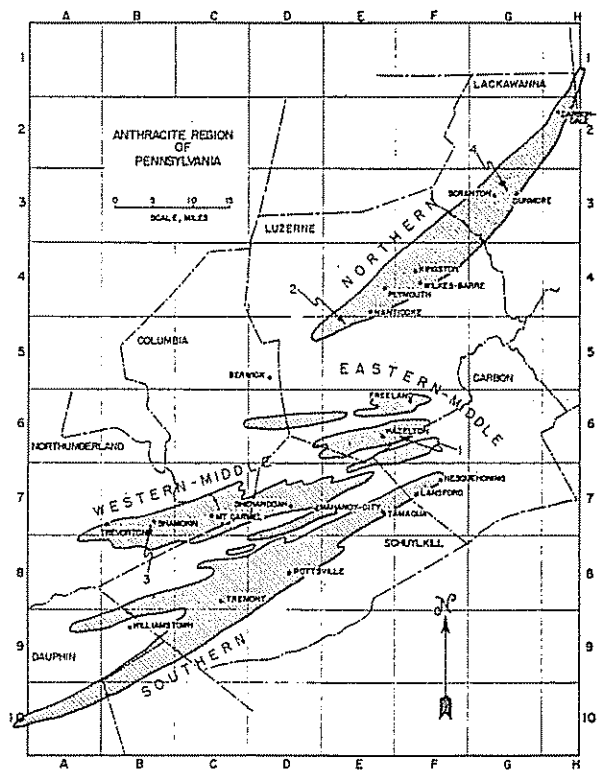

Fig. 1. — Origin of Anthracite Samples

The Hardgrove Indexes of anthracites have been tabulated, where possible, according to an area-location of the sample in a particular field in the anthracite region. Figure 1 is a grid-coordinate map of the anthracite region showing "Map Key" (for locating samples), fields, counties, and principal cities. The "Map Key," sample designation, proximate analysis (dry basis), and Hardgrove Grindability Index are given in Table I for the coal fields and for river coal.

Other grindability data, which could not be tabulated according to this system, are presented in Table II along with all available information as to sample designation, coal beds, proximate analyses, and general location.

[1] This paper was not presented at the Anthracite Conference. It is published as part of the Proceedings, however, because of the number of people inquiring about grindability of anthracite at the meeting and the non-existence of this data in the current literature.

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TABLE I. — Grindability of Anthracite

Map Key†	Sample Designation	Proximate Analysis, % (dry basis) V.M.	F.C.	Ash	Hardgrove Grindability Index
NORTHERN FIELD					
E4	Buck No. 4	6.0	82.2	11.8	32.7
E4	Mixed beds	.....	.....	.....	(36)
E4	Mixed beds	4.2	82.8	13.0	(32)
E5	Buck No. 3	4.7	82.2	13.1	35.9
E5	Mixed beds	.....	.....	.....	(37)
E5	Mixed beds	4.1	83.6	12.3	(35)
F4	Buck No. 4	6.0	82.2	11.8	35.5
C3	Buck No. 4	6.0	82.2	11.8	33.0
EASTERN-MIDDLE FIELD					
E6	Buck No. 3	3.2	84.9	11.9	41.4
.....	Buck No. 3	3.3	83.3	13.4	41.4
E6	Buck No. 4	3.3	84.3	12.4	44.2
E6	Buck No. 4	3.7	82.6	13.7	45.2
E6	Buck No. 4	3.1	87.3	9.6	40.3
.....	Buck No. 4	4.0	82.1	13.9	42.1
WESTERN-MIDDLE FIELD					
B7	Beds 7-11°	.....	.....	.....	(62)‡
B7	Beds 7-11°	.....	.....	.....	(48)
B7	Bed 8°°	.....	.....	.....	(52)
B7	Bed 8°°	.....	.....	.....	(39)
B7	Buck No. 4	8.2	80.7	11.1	62.0
B7	Buck No. 5	7.1	82.0	10.9	62.0
B7	Buck No. 4, 5	.....	.....	.....	61.8
B7	.....	.....	.....	.....	69.8
B7	Buck No. 4	9.3	79.4	11.3	65.3
B7	Buck No. 4	9.1	80.5	10.4	60.1
B7	Buck No. 5	10.0	77.2	12.8	69.8
B7	Buck No. 5	9.3	77.7	13.0	62.9
B7	Buck No. 5	.....	.....	.....	63.2
B7	Buck No. 4	8.3	79.3	12.4	62.9
B7	Buck No. 4	8.9	82.3	8.8	66.4
B7	Buck No. 5	8.3	79.8	11.9	68.1
B7	Buck No. 5	8.3	77.1	14.6	69.8
C7	Buck No. 4	6.1	81.6	12.3	50.8
C7	Buck No. 4	7.3	79.7	13.0	54.6
C7	Buck No. 4	6.4	82.8	10.8	50.8
C7	Buck No. 5	7.0	82.3	10.7	60.8
C7	Buck No. 5	6.4	83.5	10.1	54.3
C7	Buck No. 4	5.3	82.1	12.6	43.5
C7	Buck No. 5	5.7	82.1	12.2	42.8
D7	Buck No. 4	4.8	83.2	12.0	44.9
D7	Buck No. 4	4.4	82.8	12.8	46.3
D7	Buck No. 5	4.5	82.3	13.2	47.7
D7	Buck No. 5	4.8	82.5	12.7	44.2
D7	Buck No. 4	3.9	84.1	12.0	41.1
D7	Buck No. 4	4.4	85.4	10.2	32.4
D7	Buck No. 4	3.6	86.4	10.0	45.6
D7	Silt	5.5	73.2	21.3	58.0
D7	Buck No. 5	.....	.....	.....	45.6
.....	Silt	10.3	70.0	19.7	66.0
.....	Silt	7.7	60.2	32.1	59.4
.....	Silt	8.1	61.9	30.0	52.5
SOUTHERN FIELD					
A9	Creek Coal	.....	.....	.....	66.7
C8	Buck No. 4	.....	.....	.....	45.6
C8	Buck No. 4	.....	.....	.....	40.7
C8	Buck No. 4	.....	.....	.....	47.4
C8	Buck No. 5	7.5	76.0	16.5	59.4
C8	Silt	5.1	78.6	16.3	56.0
C9	Buck No. 5	.....	.....	.....	65.3
D8	Buck No. 4	.....	.....	.....	49.7
D8	Buck No. 4	5.1	80.0	14.9	42.5
D8	Buck No. 5	5.0	82.0	13.0	44.2
D8	Buck No. 5	.....	.....	.....	52.8
D8	Buck No. 5	.....	.....	.....	43.8
D8	Buck No. 5	.....	.....	.....	44.2
D8	Silt	5.3	76.1	18.6	63.6
D8	Silt	6.1	78.1	15.8	54.2
E7	Buck No. 4	3.8	78.3	17.9	48.0
E7	Buck No. 5	3.8	80.3	15.9	50.8
E7	Buck No. 5	.....	.....	.....	52.5
E7	Buck No. 5	.....	.....	.....	61.8
E9	Buck No. 5	6.4	79.2	14.4	45.9
F7	Buck No. 4°°°	4.1	80.0	15.9	51.8
F7	Buck No. 5°°°	4.5	79.5	16.0	55.3
F7	Buck No. 5	.....	.....	.....	54.6
F7	Buck No. 4°°°	4.1	78.3	17.6	49.0
F7	Buck No. 5°°°	4.0	80.2	15.8	54.6
F7	Buck No. 5	.....	.....	.....	55.6

Sample Designation	Proximate Analysis, % (dry basis) V.M.	F.C.	Ash	Hardgrove Grindability Index
RIVER COAL				
Lower Susquehanna				
River Coal	.....	.....	14.2	(47)
River Coal, Flotation Product	.....	.....	17.6	(56)
River Coal, Coarse Flotation Prod.	.....	.....	.....	(45)
River Coal, Fine Flotation Product	.....	.....	.....	(60)
River Coal, Table Product	.....	.....	26.8	(47)
River Sand	.....	.....	93.2	(51)
88.8% minus 1/16"	7.8	74.9	17.3	28
83.3% minus 1/16"	7.8	72.5	19.7	30
85.6% minus 1/16"	7.9	71.5	20.6	33
100% minus 3/32"	6.7	74.8	18.5	41
Schuylkill				
98% minus 4 mesh	9.0	73.5	17.5	29

‡ Data in ( ) are converted from Ball-Mill indexes
† Refers to area-location in Figure 1
° Mammoth, Holmes, Primrose beds
°° Mammoth bed
°°° Mammoth, Orchard, Primrose beds

TABLE II. — Grindability of Anthracite

COAL BED	SAMPLE	PROXIMATE ANALYSIS, % (dry basis) V.M.	F.C.	ASH	HARDGROVE GRINDABILITY INDEX
CARBON COUNTY					
Mammoth, Orchard, Primrose	Buck No. 1	4.7	81.2	14.1	30
Mammoth, Orchard, Primrose	Pea	.....	.....	.....	33
LACKAWANNA COUNTY	(Northern Field)				
.....	.....	6.3	84.5	9.2	26
.....	Chestnut	5.9	87.5	6.6	21
LUZERNE COUNTY					
.....	Chestnut	5.7	88.4	5.9	24
.....	Buck No. 1	5.7	79.6	14.7	24
No. 5, Gamma, Buck Mt.	Buck No. 1	5.2	81.8	13.0	29
Mammoth, Buck Mt., Wharton	Buck No. 1	5.1	82.4	12.5	26
Mammoth, Buck Mt.	Bone	5.4	48.6	46.0	36
Pittston Stark Red Ash	99.5% minus 3/32"	3.4	82.7	13.9	33
Pittston Stark Red Ash	90.5% minus 3/32"	4.3	76.5	19.2	34
.....	Buck No. 3	.....	.....	.....	33
NORTHUMBERLAND COUNTY (Western-Middle Field)					
.....	Buck No. 4	7.7	79.9	12.4	61
.....	Buck No. 3	8.6	75.9	15.5	53
Buck Mt., Mammoth, Holmes	Buck No. 3	6.0	83.9	10.1	36
Buck Mt., Mammoth, Holmes	Buck No. 4	5.9	85.8	8.3	44
.....	.....	6.6	83.9	9.5	51
SCHUYLKILL COUNTY					
.....	Buck No. 3	7.2	80.8	12.0	46
.....	Buck No. 4	7.4	79.1	13.5	53
.....	Culm	.....	.....	.....	39-63
.....	Anthrafines	.....	.....	.....	50
.....	Buck No. 1	6.7	83.9	9.4	30
.....	Buck No. 4, River	6.1	76.2	17.7	43
Ridge to Tracy	.....	.....	.....	.....	35
Lykens 4 and 5	.....	.....	.....	.....	45
Mammoth, Buck Mt.	.....	5.9	80.8	13.3	30
Buck Mt., Holmes	.....	3.0	87.7	9.3	37
Buck Mt.	Buck No. 3	4.1	86.3	9.6	39
Buck Mt.	Buck No. 4	4.8	82.7	12.5	45
Buck Mt., Skidmore	.....	5.7	82.5	11.8	31
Buck Mt., Skidmore	.....	4.6	83.9	11.5	32

Some general conclusions are of interest regarding the survey of the grindability of anthracite.

(1) Anthracites of the Northern Field have the lowest grindability indexes, e. g., 32-36°.

(2) Anthracites of the Eastern-Middle Field have the next lowest indexes, e. g., 40-45.

(3) Coals in the Western-Middle Field appear to decrease in grindability index from very high to relatively low values in an easterly direction across the field.

(4) Southern-Field coals vary considerably in grindability index, but generally have indexes of intermediate values, e. g., ca. 40-55.

(5) For all coals, the grindability index increases with increasing volatile matter or, conversely, decreases with increasing fixed carbon. No satisfactory relationship between grindability and ash content could be obtained.

° Coals which are easiest to grind have the highest grindability indexes.

BIBLIOGRAPHY

(1) A.S.T.M. Standards on Coal and Coke, Committee D-5, pp. 620-632 (1949).

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