Grindability of Coal – the new approach

Barbara Tora[1]

Meliteľnosť uhlia – nový prístup

The method of evaluation of grindability of hard coal and its blend is shown. The standard Hardgrove test is used as a base to work out this method. The essence of this method consists in the simulation of the milling process in a close circuit (mill-classifier) and the determination of energy consumption and quantity of product under the constant feed flow. The research equipment designed specially for this project is described.

Key words*: grindability, coal, Hardgrove method*

Introduction

Investigations which were carried out and the obtained results [6] have shown that the way of evaluating the grindability of minerals should be adjusted to the actual technological conditions.

When choosing and evaluating grindability the by given method one should especially take into consideration the following:

- The method of sample processing and its representativeness;
- The method of grinding (e.g. the mill construction, grinding in the close circuit, the size distribution of the product);
- The method of the elaboration obtained results (taking into consideration the energy consumption).

In the Bond method, the quantity of coal circulated inside of the mill is assumed theoretically.

In our method quantity of circulated coal is the result of the properties of the coal and the size of grains of the coal. The grindability of the coal could be evaluated on the base of quantity of the coal circulated inside the mill depending on the process parameters and the energy consumption.

Description of the research stand

The new roll - ball mill was constructed. The idea was to eliminate some faults of the Hardgrove mill.

The main differences are:

- possibility of changing the charge of milling elements;
- increase of the amount and the grain size;
- possibility of determining the energy consumption by measuring the rotary moment;
- possibility of simulating the milling process in a close-circuit similar to the industrial conditions.

In the Fig. 1. you may see a scheme of the projected mill. Basic technical data of this device are presented in Tab. 1. Laboratory mill J-AGH is made on the base of Hardgrove mill. Its sizes are twice as in the Hardgrove mill and as a milling factor we used 10 balls. The quantity of the sample is up to 500 g and the grain size up to 6mm. It is also possible to carry out the investigation of the milling process with rolls (in the place of balls) similar to those used in the MPS mills produced by Babcock.

During the investigation, one can measure:

- rotary moment;
- pressure force;
- time of the milling process.

The Collecting of the measured signals is automatic and it is done by a computer controlled system. This system consists of:

- pressure force and the torsion measurer made by HBM/Darmstatd;
- amplification system and A/D converter made by HBM/Darmstatd;
- computer PC 486

[1] *Barbara Tora, University of Science and technology - Akademia Górniczo- Hutnicza, Faculty of Mining and Geoengineering Wydział Górnictwa i Geoinżynierii Al. Mickiewicza 30, 30-059 Kraków, tel. +48-12 617 21 89, tora@agh.edu.pl*

(Recenzovaná a revidovaná verzia dodaná 9. 9. 2005)

All data can be visualised, saved and then processed using standard programs, for example Microsoft Office.

Tab. 1. Characteristic of the new laboratory mill J-AGH

Principle of action	**Roll-ball mill**
Pressure force	Max 15.0 kN
Rotation speed	Max 25 rotion/min
Quantity of sample	Max 400 g
Dimension of feed grain	Max 6 mm
Milling factor – balls	
Amount	10 pieces
Dimension	50 mm
Dimension of the feed grain	Less 6 mm

This mill's construction is more complicated then the Hardgrove mill. Also, the milling time is longer.

Investigation

The prepared coal samples were characterised as follow:

Calorific value Q^a	*23.200 kJ/kg*
Ash content A^r	*15 %*
Sulphur content S^r_t	*1,14 %*
Hardgrove Index	*52*

Tab. 2. Quantity of product in consecutive milling cycles.

Measurement number:	**1**	**2**	**3**	**4**	**5**	**6**
Feed [g]	200,00		275,00		350,00	
Cycle						
1	43,28	36,95	91,53	48,47	118,28	59,46
2	22,36	21,74	30,92	27,81	97,36	33,53
3	17,58	17,60	24,53	23,60	92,58	28,21
4	15,80	16,09	23,07	21,69	90,80	26,71
5	17,89	15,35	21,38	21,10	92,89	27,63
6	15,52	15,44	19,80	20,30	90,52	26,16
7	14,38	15,15	20,11	19,96	89,38	
8	14,38	15,03	20,03	20,36	89,38	
9	14,89	14,99		20,10		
10	14,41	14,39				
11		13,68				
12		14,11				
13		13,33				

Tab. 3. Energy consumption of milling process for one unit of product.

Measurement number:	**1**	**2**	**3**	**4**	**5**	**6**
Feed [g]	200,00		275,00		350,00	
Cycle						
1	22,15	28,57	7,78	12,08	5,21	20,81
2	46,40	45,98	15,68	29,90	5,68	32,97
3	54,12	54,51	25,85	26,03	10,31	35,86
4	58,41	60,97	49,02	53,00	10,19	37,36
5	53,90	63,02	52,13	50,69	10,68	35,13
6	61,80	66,01	51,32	52,01	9,87	36,06
7	62,06	64,59	50,66	54,80	10,20	
8	67,39	66,70	49,62	47,66	11,01	
9	64,39	66,56		47,89		
10	62,67	69,58				
11		71,74				
12		64,95				
13		66,70				

Investigations were carried out in three series for samples with the following weights:

200, 275 and 350 g

The milled material had the following grain sizes:

0 – 2,8 mm (samples 1 and 2)

0 - 4 mm (samples 3 and 4)

0 – 5,6 mm (samples 5 and 6)

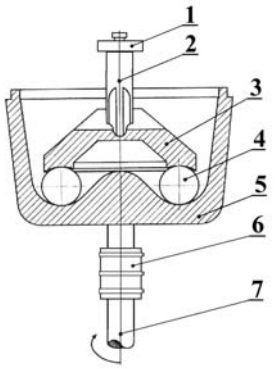

Fig. 1. 1 – Force sensor – C2 (HBM), 2 – Upper shaft transferred force of pressure, 3 – Upper grinding unit (ring), 4 – Grinding balls, 5 – Lower grinding unit, 6 – Sensor of rotary moment – SK5/55 (HBM), 7 – Lower shaft drive lower grinding unit.

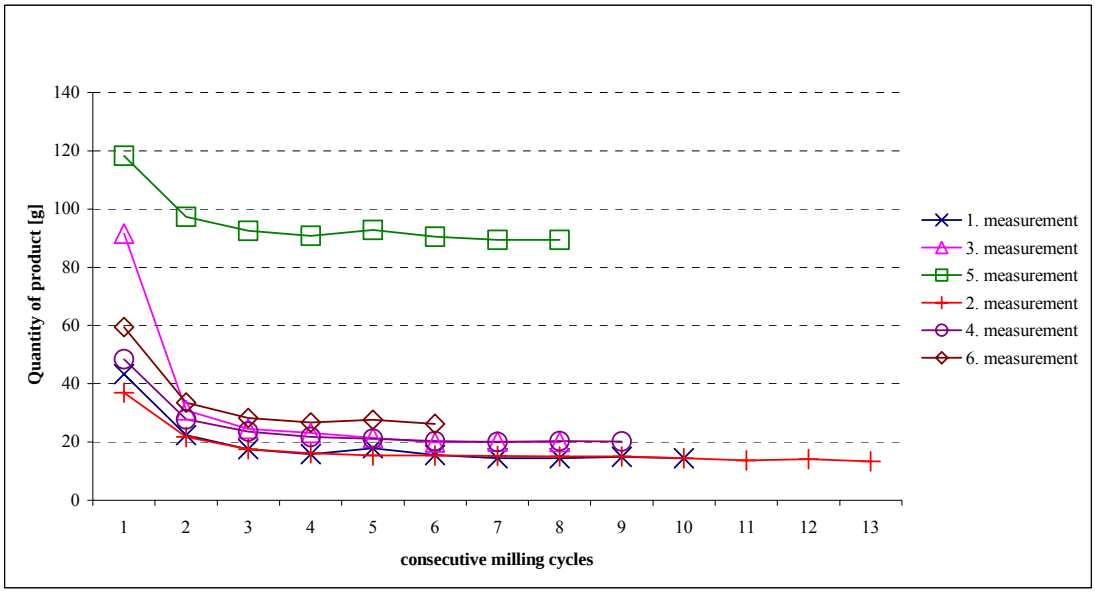

Fig. 2. Dependence of the energy consumed in one unit on the consecutive milling cycles

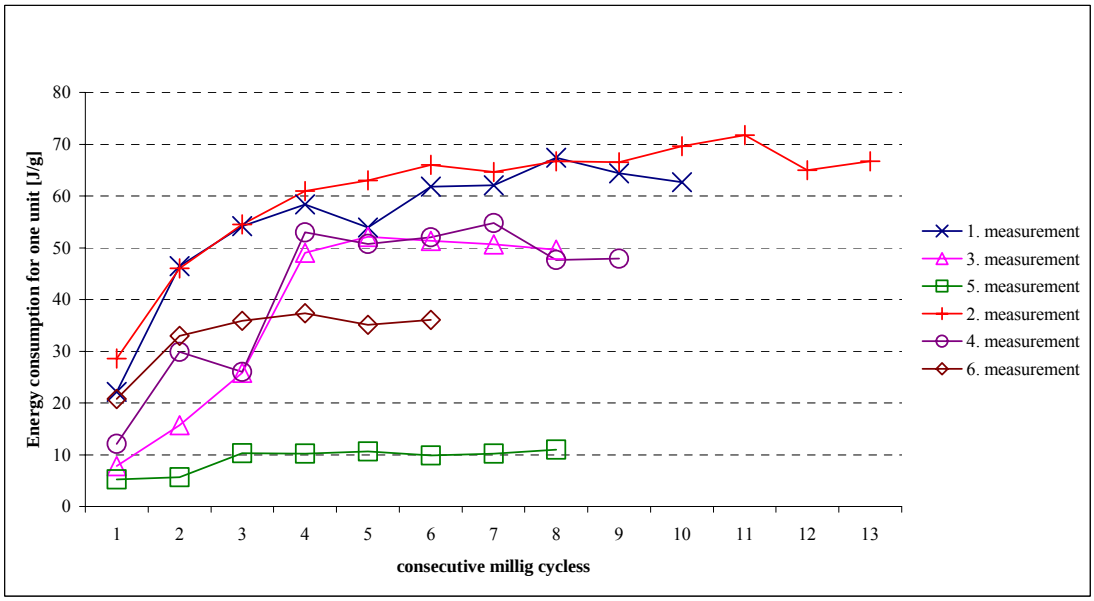

Fig. 3. Dependence of the quantity of the product on the consecutive milling cycles

Results

A new method of the grindability measuring completes the standard Hardgrove method, withdrawing its faults:

- bigger (c.a. 10 times) and more representative sample is used;
- the milling process is carried out in a close circuit (similarly to the industrial condition);
- energy consumption of the milling process is determined for three samples, which differ in their grain size.

The new method of the evaluation of grindability of hard coal and its blend is shown. The standard Hardgrove test is used as a base to work out this method. This method allows to take into consideration the energy consumption during the milling process. The essence of this method consists in the simulation of milling process in a close circuit (mill-classifier) and the determination of the energy consumption and quantity of the product under the constant feed flow. Our results will complete the Hardgrove method and will help to better characterise coal. At the same time, investigations in the industrial scale are carried out. These investigations will verify this new method. Also a new mathematical model of the milling process [7] is being elaborated. It will be used to predict the behaviour of coals in industrial conditions.

Acknowledgement: The work has been performed as a part of the Project No 10.10.100.862 financed by Akademia Górniczo-Hutnicza, Kraków, Poland.

References:

[1] Schönert, K.:Energetische Aspekte des Zerkleiners spröder Stoffe. *Zement - Kalk - Gips 1979, nr 1.*
[2] Hardgrove. R., M.: Grindability of Coal. *Transactions of the American Institute of Mining and Metallurgical Engineers 1932, Vol. 54, paper FSP-54-5.*
[3] Woyciechowski, W.: Untersuchungen zum Mahlverhalten von Kohlen nd Kohlenmischungen.Ph Thesis, *Technische Universität Clausthal 1995*.
[4] Żelkowski, J., Woyciechowski, W., Strugała, A.: Oznaczanie podatności przemiałowej metodą Hardgrove'a - przegląd doświadczeń. *Zeszyty Naukowe Politechniki Śląskiej. Górnictwo Z. 231. Gliwice 1996*.
[5] Woyciechowski, W.: Ocena podatności przemiałowej węgli energetycznych, *VIII Konferencja „Aktualne problemy budowy i eksploatacji kotłów", Szczyrk, 1998 r.*
[6] Tora B., The Method of Evaluation of Hard Coal Grindability, *10 th European Symposium on Comminution, Dusseldorf, ref. B4.2, 2002*.
[7] Tora, B., Kogut, K,: Węglowe mieszanki energetyczne. Właściwości, mielenie i spalanie, Uczelniane wydawnictwa naukowo-dydaktyczne AGH, Kraków 2005.