2ND WORKSHOP ON APPLIED AND SUSTAINABLE ENGINEERING

MICRONIZATION OF HARD COAL USING HIGH-PRESSURE WATER JET METHOD

Jozef A. Borkowski, Michał Bielecki, Unconventional HydroJetting Technology Center, Koszalin University of Technology, Poland

INTRODUCTION

Comminution processes have found a wide application in many branches of minerals and materials processing. Intense comminution of materials, known as micronization, has been used in order to enrich minerals powders [6]. Often a method that utilizes high-pressure water jet has been implemented. [4-5]. The disintegration mechanisms of brittle materials in this method are very complicated [7]. Increase of water pressure leads to an increase in internal tensile stresses within the material with brittle ores being very susceptible to this attack. Moreover at sufficiently high water pressure, the kinetic energy of the particle increases to a level that generates an internal network of cracks. The intense penetration of water into the material creates and grows internal cracks and intensifies brittle fracture [8].

These phenomena have been typically used to implement hydro jetting methods of brittle material milling [1, 2]. In such conditions the disintegration of materials proceeds through gaps and micro-cracks in the material, intensifying at the grain boundaries. Such micronization provides a distinct increase in the surface area of the processed material. Beyond the basic idea this approach leads to a new technology that utilizes high-pressure water jet. This paper presents some research results of high-pressure water jet usability in the micronization of coal.

RESEARCH METHODICS

A specially designed construction of prototype of hydrojetting mill (Fig. 1) was used for coal disintegration. It is powered by a Hammelmann HDP 164 pump (p max =300 MPa, Q max =0.5 dm ^{3} /s) with an operating pressure range of 50-300 MPa and a water consumption between 0.2 – 0.5 dm ^{3} /s, depending on the coal tested. Such construction work is close to injector head work that is popularly used for creation of high-pressure abrasive-water jet. However in this particular case, fine coal is processed instead of abrasive material and it is accelerated and initially comminuted inside homogenized nozzle, which is made of sintered carbide. Created this way water-coal jet is directed on a target made of sintered carbide, where final comminution process is taking place. Three different types of coal were examined: hard-, brown-, and charcoal. One can comminute coal granulates in the mill that are of maximum size up to 2 mm with processing output flow rate of 50 g/s.

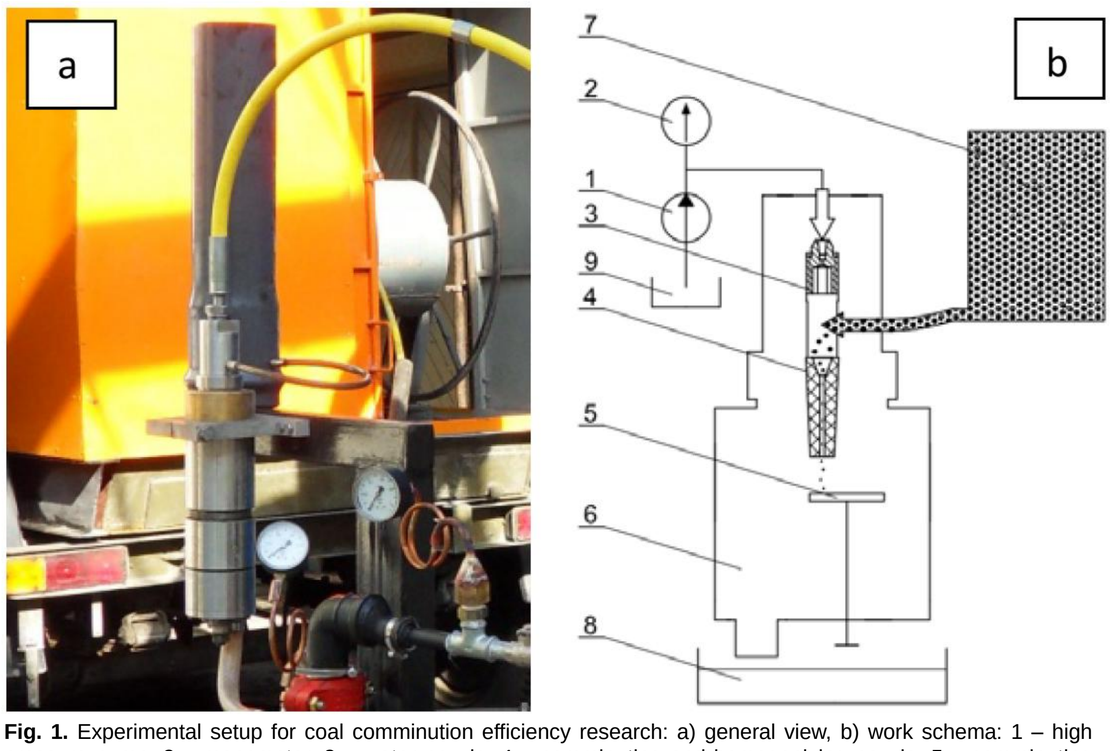

Fig. 1. Experimental setup for coal comminution efficiency research: a) general view, b) work schema: 1 – high pressure pump, 2 – manometer, 3 – water nozzle, 4 – comminuting and homogenizing nozzle, 5 – comminuting target plate, 6 – comminution chamber, 7 – feed container, 8 – product container, 9 – water tank.

First stage comminution was achieved using a jaw crusher (LAB-01-65) set to produce isometric particles of grain sizes close to #2 mm. The research of hydro-jetting comminution of this material prepared examined the following conditions:
- nominal water pressure: 100, 150, 200 and 250 MPa,
- water nozzle diameter d_w =0,7 mm,
- type and diameter of comminuting and homogenizing nozzle Rl_2-1: d_h = 2,4mm;
- target stand-off distance s=10mm.

Special fraction analyzer Analysette 22 Micro Tec was used for testing different particles of comminuted coal. It enables fast results valuation of particles size range of 80 nm do 2 mm. FEI Quanta 200 microscope equipped with chemical analyzer type EDAX Genesis XM 2i was used to observe comminuted fine coal surface.

HARD COAL MICRONIZATION

In order to achieve high efficiency of coal burning process one should obtain proper particles comminution. Exemplary distributions of hard coal particles are presented in Fig. 2. However as it occurs the water pressure increase leads to difference in comminution. Examples that illustrates such tendencies are analogical distribution plots obtained for jet pressure of 250 MPa (Fig. 3). Such almost 2 times higher water jet pressure increase leads to distinct comminution of hard coal.

Analysis of fine hard coal particles distribution diagrams shows that single stage hydrojetting comminution let to evaluate micronization degree. For example, for water pressure of 150 MPa even 90% of particles reaches dimensions range 0÷123 μm. In turn, higher water pressure of 250 MPa causes that 90% of particles gives dimension range 0÷71 μm respectively.

Fine granularity of coal particles is limited by their specific surface increase what intensifies burning process. However, as it comes out from microscopic analysis hydrojetting micronization of coal causes specific development of created particles. Such a surface looks like shredded lamella additionally enlarging total work surface of these particles. Morphology examples of such particles being a part of new fuel type made of hard coal are presented in Fig. 4.

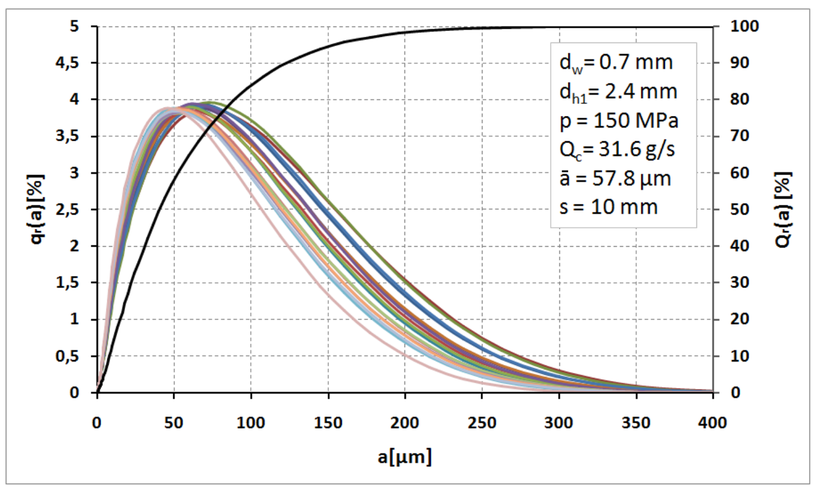

Fig. 2. Distributions of hard coal particles fraction comminuted with water pressure of 150 MPa.

Estimated simulation results realized for lamellar morphology of coal particles created during water jet comminution point out that their real surface increases even up to 100,000 times comparing to specific surface of usual fine coal. Such feature is very important taking into account efficiency of bio-chemical coal conversion into new generation fuel [7].

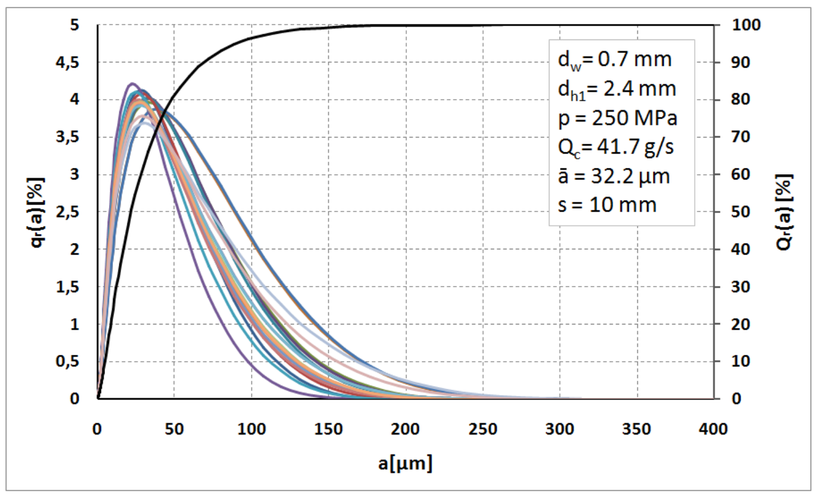

Fig. 3. Distributions of hard coal particles fraction comminuted with water pressure of 250 MPa

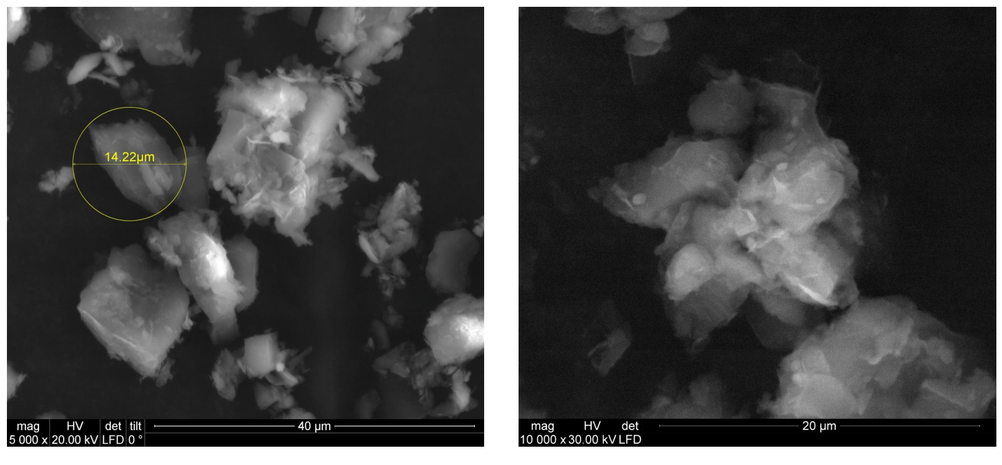

Fig. 4. SEM pictures of hard coal showing different stage of their specific surface development

CONCLUSIONS

Presented results of fine hard coal comminution with high-pressure water jet technique let to formulate the following important conclusions of general character:
- Small coal resistance for stretch stresses causes that water jet technique usage for comminution is very effective.
- Processing of hard coal with water pressure of 150 MPa causes that even 90% of particles reaches dimensions range 0÷123 μm. In turn, higher water pressure of 250 MPa causes that 90% of particles gives dimension range 0÷71 μm respectively.
- Hydrojetting coal micronization causes that created particles surface has very often a shredded lamellar form and thanks to that their real surface increases even up to 100,000 times comparing to specific surface of usual fine coal.

REFERENCES

[1] AMICK P., LYNCH G.E., NELKIN G.A., STULTZ J., ZEH C.M. 1996. *The Clean Coal Technology Program. The Wabish River Coal Gasification Repowering Project*. Topical Report, No. 7, pp. 1-22.
[2] BIELECKI M. 2011. *Examining of geometrical and hydraulic parameters influence of high-pressure hydro-jetting mill on different materials comminution* (in Polish). Science Seminar of UHJT Institute. Koszalin University of Technology.
[3] BORKOWSKI P., BORKOWSKI J., BIELECKI M. 2011: *Coal disintegration using high pressure water jet*. International Conference Water Jet 2011: Research, Development, Applications. Ostrava, pp. 73-84.
[4] BORKOWSKI J., BORKOWSKI P. 2010. *Innovative applications of hydro-jetting technologies* (in Polish). Conference of Polish Academy of Science. Kołobrzeg.
[5] BORKOWSKI P. 2010. *Basis of high-pressure hydro-jetting technologies* (in Polish). Monograph of UHJT Institute (ISSN 0239-7129, ISBN 978-83-7365-207-1), Koszalin.
[6] BORKOWSKI P., BORKOWSKI J. 2010. *Coal comminution with high pressure water jet*. 20th International Conference on Water Jetting. BHR Group (ISBN: 978 1 85598). Graz, Austria, pp. 141-146.
[7] BORKOWSKI P., BORKOWSKI J. 2009. *High-pressure water jet application for coal conversion into new generation fuel*. Unconventional and HydroJetting Technologies. Monograph of UHJT Institute (ISSN 0239-7129), Koszalin, pp. 43-54.
[8] BORKOWSKI P., BORKOWSKI J. 2009a. *Comminution of different materials with high-pressure water jet*. Unconventional and HydroJetting Technologies. Monograph of UHJT Institute (ISSN 0239-7129), Koszalin, pp. 493-500.