Minerals Engineering 95 (2016) 59–65

Contents lists available at ScienceDirect

Minerals Engineering

journal homepage: www.elsevier.com/locate/mineng

Control of coal separation in a jig using a radiometric meter

S. Cierpisz *, M. Kryca, W. Sobierajski

Institute of Innovative Technologies EMAG, ul. Leopolda 31, 43-170 Katowice, Poland

ARTICLE INFO

Article history:
Received 17 November 2015
Revised 10 June 2016
Accepted 12 June 2016
Available online 21 June 2016

Keywords:
Coal preparation
Discharge control in a jig
Radiometric density meter
Natural radiation from coal

ABSTRACT

A new monitoring system based on the monitoring of natural radiation emitted by the material in the separation zone of a jig compartment has been developed and tested in parallel with a radiometric density meter and a conventional float. The authors investigated the correlation between the separation density monitored by the meter and the intensity of the natural radiation. The correlation coefficient was ca. R = 0.973 and the standard deviation of the measurement in regression with the density meter indications was $s_c = 0.034$ g/cm^3. This shows that after a float as the measuring unit in a control system is replaced by a natural radiation monitor, one can expect good stabilisation of the separation density. The paper discusses advantages of such systems over float-based systems.

1. Introduction

The beneficiation process of fine coal in jigs consists of two phases: stratification of coal grains in the bed according to their density and then splitting the stratified material into the product and the discharged refuse. At first, during subsequent water pulsations induced by opening and closing of air valves, the stratification of coal grains takes place due to varied velocity of their upward and downward movement.

Grains of low density migrate to upper layers and grains of high density migrate to lower layers of the bed. The material travels horizontally on a screen along the jig compartment with the flow of water.

The stratification of grains due to their density is not perfect, because the velocity of their upward and downward movement depends in part on their diameter, shape and the way in which the material loosens within a given pulsation cycle. The distribution of coal density fractions in the bed, characterized by the imperfection factor *I*, has been investigated by many researchers (e.g. Diendonne et al., 2006; Tavares and King, 1995 and Cierpisz, 2012, 2015). The imperfection factor *I* is defined as the ratio of the probable error *Ep* and the separation density ρ_{50} ($I = Ep/\rho_{50}$) (King, 2001).

Fig. 1 shows the distribution of coal density fractions for an ideal and a real stratification process. The maximum mass of the product of the desired quality (ash content) can be achieved for the ideal process when the imperfection $I = 0$. The stratified bed is then, in the end part of the jig, split into the product which overflows the end wall of the compartment and the refuse (or middlings) discharged through the bottom gate. The separation density (cut point) is established by the tonnage of the discharged bottom product (opening of the discharge gate). The separation density depends also on the tonnage of raw coal feeding the jig, and its washability characteristics. Fig. 2 illustrates the influence of variations in the separation density on product parameters.

The mass of the product is always greater when the separation density is constant over a given period of time - even if in spite of its variations the process renders the same average ash content. Hence, the conclusion is to stabilise the separation density at the desired value as accurately as possible. The simulation analysis presented by Cierpisz (2012) focused on the impact that fluctuations in separation density have on the economic effects of a jig operation. The influence of the imperfection factor was also investigated. The main results of the analysis are shown in Figs. 3 and 4.

The analysis was performed for raw coal washed in a three-product jig at the separation densities of 1.5 and 1.8 g/cm^3. Percent contents (in brackets) of density fractions in raw coal were: <1.35 g/cm^3 (40%), 1.35–1.50 g/cm^3 (12%), 1.50–1.65 g/cm^3 (4%), 1.65–1.80 g/cm^3 (4%), 1.80–1.95 g/cm^3 (12%, >1.95 g/cm^3 (30%) (average ash in raw coal was 35.5%). In the analysis, an increase in the imperfection by 0.02 resulted in the decrease of the product tonnage by $\Delta Qc = 1.0\%$. In this case, separation densities were set to ensure the same ash content in products (for $I = 0$ the change in tonnage was accepted at $\Delta Qc = 0$). The influence of their fluctuations on the product tonnage turned out to be nonlinear; for ±0.04 g/cm^3 the decrease in the product tonnage was ca. 0.5% and for ±0.12 g/cm^3 it was ca. 5.0%.

* Corresponding author.
E-mail address: Stanislaw.cierpisz@polsl.pl (S. Cierpisz).

http://dx.doi.org/10.1016/j.mineng.2016.06.014
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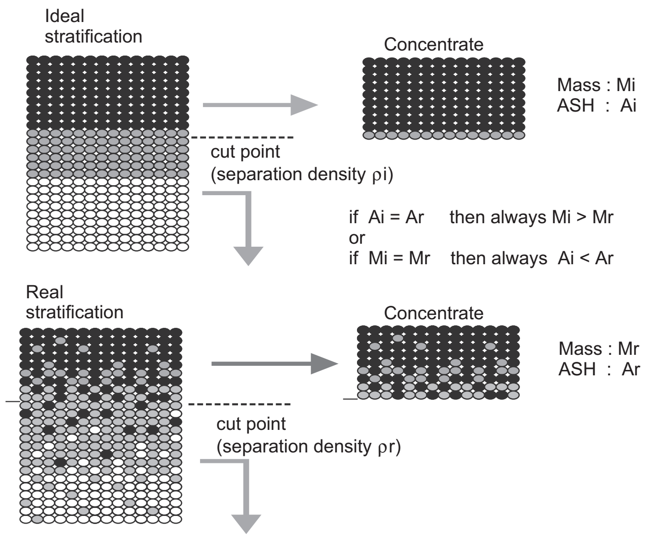

Fig. 1. Illustration of a jig imperfection and its influence on product parameters.

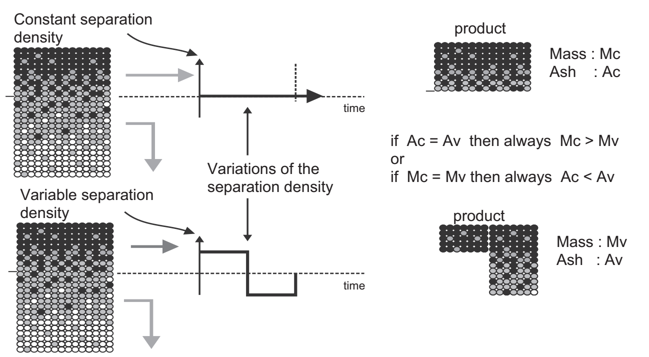

Fig. 2. Influence of variations in the separation density (cut point) on product parameters.

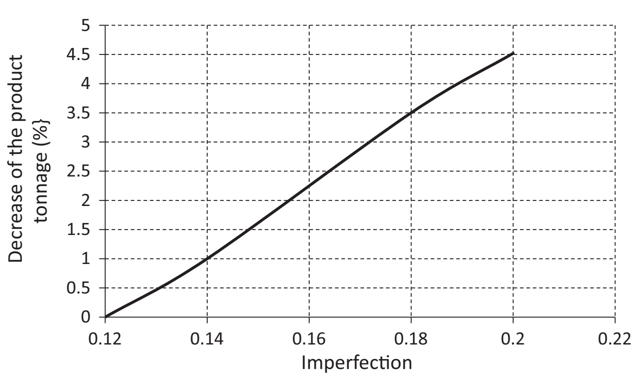

Fig. 3. Influence of the imperfection on the product tonnage (constant ash content).

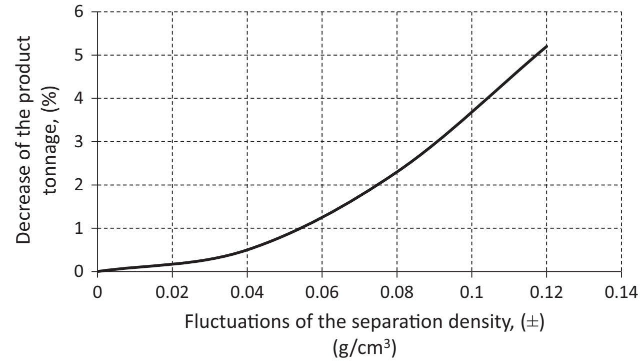

Fig. 4. Influence of fluctuations in the separation density on the product tonnage (constant ash content).

The above results indicate that the operation of a refuse discharge system in a jig plays an important role in the final results of coal separation process defined in terms of tonnage and quality of the product.

2. Refuse discharge system with a float

The most popular refuse discharge control systems in jigs use a metal float to monitor the thickness of the heavy fraction in a jig compartment. Fig. 5 presents their simplified schemes. The main task of a refuse discharge system is to stabilise the separation density in a jig. Although the float is the main sensor, its operation as a measuring unit has not been adequately studied so far. Its shape (cuboids, cone, "fish"), dimensions and density may depend on the capacity of a jig, type of washed raw coal and the compartment of a jig (discharge of waste or middlings).

Two types of refuse discharge systems applied in Polish jigs (Komag) have been described by Bedkowski et al. (2002) and Bartoniek et al. (2006). These authors apply two types of cuboid floats shown in Fig. 5: type (A) which is relatively big (height $H_f = 30–35$ cm) and type (B), which is smaller (height $H_f =$ ca. 20 cm). The operation of float systems highly depends on changes in the tonnage of the raw coal feed. Significant changes in the feed tonnage change the position of the float with respect to the layer of the chosen density. This results in the fluctuations in the separation density. Controllers applied in these systems are responsible for additional errors as they are usually based on proportional ("P") algorithms of control. Fluctuations of the separation density in jigs with float discharge systems have been investigated by Cierpisz (2012).

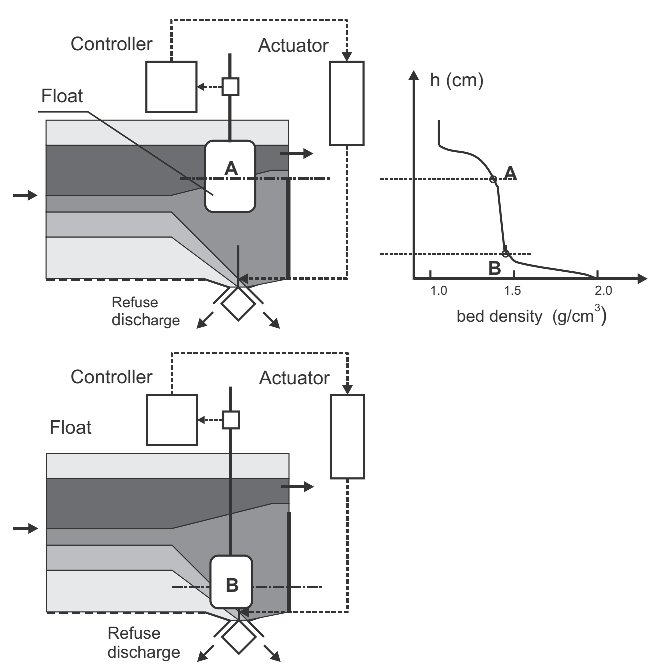

Fig. 5. Two types of refuse discharge systems with floats.