20th International Conference
ENGINEERING MECHANICS 2014
Svratka, Czech Republic, 12 – 15 May 2014

METHODS OF DETECTING THE UNDESIRABLE OBJECTS ON BELT CONVEYORS

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Abstract: *The paper presents the methods of detecting the undesirable objects (stones, not coal rocks) on belt conveyors. Among methods which can be applied are: a method utilizing the X-rays, an ultrasonic method, a sorting set and a thermal imaging method. A stone or another undesirable object which gets to belt conveyor can damage it. But if an undesirable object gets to the transporter, the system should detect and remove it.*

Keywords: Gangue, Conveyor belt, Defect detection, Separating, Lignite coal.

1. Introduction

Conveyor belts are important components for the opencast mining. Therefore, they should be modernized. Constant streamlining of their action supports the development of the mining, but thanks to modern technologies, a safety of work in the mine increases (http://www.ppwb.org.pl/wb/79/10.php). Extremely difficult conditions of the operation significantly influence on a durability of belt conveyors and on a belt of conveyor in particular.

The process is caused by (http://www.ppwb.org.pl/wb/79/10.php):

- non-axial structure of belt conveyors,
- insufficiently leveled structure of the transporter,
- exaggerated pollution of the space under the transporter,
- too big lumps of transported mining.

Waste, coming from a searched, recognized, stored ore deposit, is an extractive waste (Kotarska, 2012).

Waste rock can be:

- waste rock of the new mineshafts from currently conducted works connected with sinking,
- waste rock from the current mining,
- waste rock deposited in the objects of neutralizing (slag heaps).

Waste rock produced during the mining is mainly an unchanged natural element of the lithosphere built primarily of sandstones, dolomites, limestones, anhydrite, slates, marbles and gravels. An extract coming out of the waste rock contains the increased content of sulphates and dissolved substances.

Flotation waste rock is a mixture of coal dust, water, ash or sand of mineral resources. Material about the granularity from 0 to 0.5 mm and the content of ashes (non-inflammable permanent elements) is crossing 60 % (Kotarska, 2012).

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2. Methods Used for the Detection of Waste Rocks on Belt Conveyors

The lignite has characteristic properties and because of that it is possible to identify it. It is presented in the Tabs. 1 – 3.

Tab. 1: Chemical composition and the value of the density of the lignite (Kaczmarczyk, 2009).

Chemical composition				**Density[kg/m^3]**
C [%]	**H [%]**	**S+N [%]**	**O [%]**	920 ÷ 950
58 ÷ 78	4.5 ÷ 7.5	10 ÷ 35	0.8 ÷ 4	

Tab. 2: Contribution of analytical elements in the lignite (Kaczmarczyk, 2009).

Contribution of analytical elements		
Moisture content [%]	**Mineral matter [%]**	**Organic matter [%]**
50	10	40

Tab. 3: Group elements in the organic matter of the lignite (Kaczmarczyk, 2009).

Group elements in the organic matter						
Humic acids [%]	**Humins [%]**	**Bitumens [%]**	**Cellulose wadding [%]**	**Cellulose [%]**	**Residual vegetable matters [%]**	**Mineral charcoal [%]**
13 ÷ 85	7 ÷ 81	80	70	40	2 ÷ 8	2 ÷ 80

In order to detect the waste rock on belt conveyors one should apply an appropriate method. Therefore such methods which enable detection of an undesirable object in mining product are discussed below. Comparison of these methods should help to choose the best one in terms of the detection of waste rocks.

2.1. Method utilizing the X-rays

X – ray scanner, which scan a mining product is installed on the initial stretch of belt conveyors. Next, the data from the scanner is controlled appropriately through the special program.

In the Fig. 1 is shown the structure system of the detection of waste rock. The program analyzes the image of a given part of mining products. The value of density of lignite is well-known and it amounts to 920 ÷ 965 kg/m^3. A standard of the greyness scale is based on this value. If any undesirable object gets on the conveyors belt, it is automatically detected because it has parameters which are other than the standard. In case of detecting an undesirable object on belt conveyors, the program stops the conveyors belt, the object is removed and then the program resumes action.

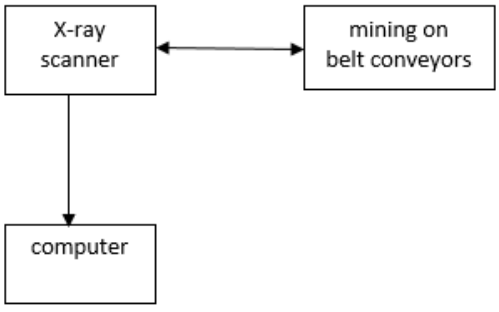

Fig. 1: Structure of the detection system of waste rocks (Pustulka, 2013).

A mobile X – ray scanner is designed to detect waste rocks on the belt conveyors. A mobile X – ray scanner of the AutoClear 150180 company is made as a model of the standard (Pustulka, 2013).

2.2. Sorting set

A classification of coal is based on account of the size of grains. Thanks to that, it is possible to design the system which separates the mining products.

The technological cycle of the sorting set starts when the material is found in the intake hopper, placed above the shaking screen. This intake hopper allows to point the stream of material for the shaking screen or to avoid that and slide it directly to the conveyor belt. By proper placing the intake hopper above the shaking screen, a classification of materials is held basing on the size of mesh of sieves. In the next step, products of classification are placed on appropriate belt conveyors. Each product is stored on the cones or it is directly given to the means of transport.

A possibility of classification on the basis of the size of coal grains of mining product is an advantage of this system. Thanks to such a system, there is a possibility of detecting an undesirable object, e.g. of waste rock.

This method isn't giving the 100% warranty on detecting undesirable objects (http://mifama.com.pl/files/resourcesmodule/@random4537640a142d9/1161934047_Glowne_produkty.pdf).

2.3. Thermal imaging method

The thermography consists of the measurement of the infrared radiation emitted by objects.

Thanks to applying the thermographic camera with IR and MSX resolution, different objects may be controlled. The thermal imaging method allows to detect undesirable objects on belt conveyors.

The values of thermographic camera radiations are registered in the infrared region of $0.9 \div 14$ μm. The dependence of value of the radiation intensity on the temperature is also well-known. The thermography allows to observe the differences of the temperature between various parts of working devices as well as between different objects. It is assumed that temperature of an undesirable object e.g. of a stone is different from the temperature of coal (http://www.leren.pl/termowizja.html).

2.4. Ultrasonic defectoscopy

Due to properties of ultrasound, one can distinguish (Andruszkiewicz, 2009), (Sliwinski, 2001):

- method of the echo,
- method of the shadow also the method of letting in,
- method of the resonance,
- TOFD method (time of flight diffraction).

Conduct of research with ultrasonic method relies on (Andruszkiewicz, 2009), (Sliwinski, 2001):

- entering ultrasonic waves into an object (of resilient waves), i.e. mechanical pulses about frequencies greater than 20 kHz; scanning the surface of the object is required;
- detection of signals, which were triggered by waves going through objects.

In case of detection of undesirable objects on belt conveyors the best method applied is a method of the echo which relies on: producing and entering impulses of ultrasonic waves into studied material and their receipt after straying from the material defect or limiting areas.

It is assumed that impulses of an ultrasonic wave are different in case of an undesirable object in mining product than when there is no such an object in mining product. It allows to detect and identifying this object (Andruszkiewicz, 2009), (Sliwinski, 2001).

3. Conclusions

Because of the characteristic properties of lignite, it is possible to identify the presence of undesirable objects in mining product basing on an analysis of these properties.

The paper presents methods enabling such identification. A proper application of these methods helps to detect the waste rock on a transporter. Among them are: method utilizing the X-rays, sorting set, thermal imaging method, ultrasonic defectoscopy.

Each of methods mentioned above can be used for detecting a stone in a mining product. The most accurate is an X-ray method to which utilization gives a higher probability of detecting an undesirable object.

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