Idea of Identification of Copper Ore with the Use of Process Analyser Technology Sensors

Idea of Identification of Copper Ore with the Use of Process Analyser Technology Sensors

Leszek Jurdziak[1], Damian Kaszuba[1*], Witold Kawalec [1], Robert Król [1]

[1]Faculty of Geoengineering, Mining and Geology, Wroclaw University of Technology, ul. Na Grobli 15, 50-421 Wroclaw, Poland

E-mail: damian.kaszuba@pwr.edu.pl

Abstract. The Polish resources of the copper ore exploited by the KGHM S.A. underground mines are considered as one of the most complex in the world and – consequently - the most difficult to be processed. The ore consists of three lithology forms: dolomites, shales and sandstones but in different proportions which has a significant impact on the effectiveness of the grinding and flotation processes. The lithological composition of the ore is generally recognised in-situ but after being mined it is blended on its long way from various mining fields to the processing plant by the complex transportation system consisting of belt conveyors with numerous switching points, ore bunkers and shafts. Identification of the lithological composition of the ore being supplied to the processing plant should improve the adjustments of the ore processing machinery equipment aiming to decrease the specific processing (mainly grinding) energy consumption as well as increase the metal recovery.

The novel idea of Process Analyser Technology (PAT) sensors – information carrying pellets, dropped into the transported or processed bulk material which can be read directly when needed - is investigated for various applications within the *DISIRE* project (a part of the *SPIRE* initiative, acting under the *Horizon2020* framework program) and here is adopted for implementing the annotation the transported copper ore for the needs of ore processing plants control. The identification of the lithological composition of ore blended on its way to the processing plant can be achieved by an information system consisting of pellets that keep the information about the original location of the portions of conveyed ore, the digital, geological database keeping the data of in-situ lithology and the simulation models of the transportation system, necessary to evaluate the composition of the blended ore. The assumptions of the proposed solution and the plan of necessary in-situ tests (with the special respect to harsh environment of

2

conveying in underground mines in order to formulate the requirements of necessary robustness of pellets) and analytical investigations are presented.

1. Introduction

The productivity of metal ore processing depends on the identification of its parameters as they are key factors of the effectiveness of implemented technology of concentration. The variability of ore parameters is determined by the geological structure of the deposit. A uniform structure means relatively stable physical and chemical parameters of the ore which facilitates the appropriate adjustments of the concentrating processes. In a case of more complicated geology of a mined ore, finding the best solutions of ore processing is becoming a challenge.

The renowned copper ore lode in the South-West Poland mined by KGHM S.A. company in underground mines belongs to the most complicated deposits. As stated in [1]: "The Polish resources are among the most complex in the world, and these resources are additionally the most difficult to be processed. The main reasons for rating the Polish copper deposits as among the so-called difficult ones are due to the following factors:

- The relatively long flotation times as a result of slow kinetics of sulphide mineral particles,
- Three lithology forms occur at the same time, but in different proportions, thus having a significant influence on the grinding and flotation conditions,
- Fine and ultra-fine sulphide mineral particles require a fine grinding process.

The generalised structure of the deposit within the balance seam is presented on Figure1.
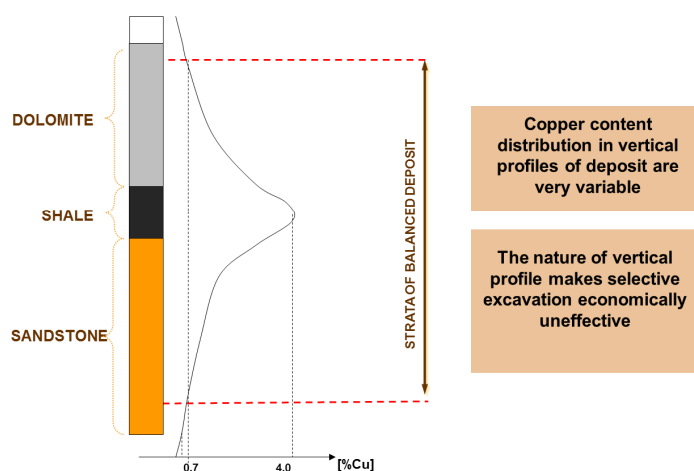

Figure 1. Structure of copper ore deposit in the KGHM S.A. underground mines in Poland

As mentioned the actual structure of ore can vary significantly and the ore mined in particular mining fields consists of individual mix of these three lithology forms. This is visualised by the views of digital block model of the copper ore created for two unconnected (but not too remote from one another) mining zones. On the figure 2 the upper zone consists of carbonates (dolomites, streaky dolomites) and shale while the lower zone – of thin layer of shale on the top with sandstone (without carbonates).
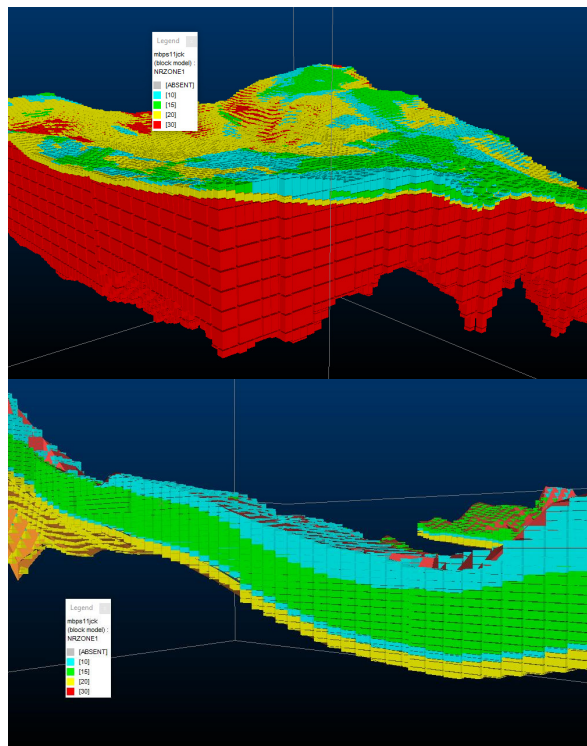

Figure 2. Visualisation of the study structural block model of the balance ore from two mining fields of one KGHM S.A. mine: (source: Datamine Studio)

In the KGHM S.A. underground mines the room-and-pillar mining system was adopted which means that ore is mined simultaneously from many active faces in several mining fields. Therefore, even if the particular portion of mined ore would be identified in-situ and assigned with the actual lithology compound it is then transported by the complex system of belt conveyors (see Figure 4.) where it is blended with other portions of ore mined in another mining fields. The lithological compound of the mixed ore is at the moment unpredictable. The rising needs of improving the copper ore concentrate grinding and flotation system productivity in the KGHM S.A. lead to continuous efforts of looking for the new solutions in ore processing technology [3]. As the lithological structure of ore has a great impact on effectiveness of ore grinding and floatation, the identification of the ore

4

preceding its delivery to the processing plants is considered to be a key information for the suitable settings of the processing equipment aiming to increase the metal recovery as well as decrease the specific energy consumption. The proposal of the solution is presented below.

2. DISIRE Process Analyser Technology approach

In 2015 the DISIRE (Distributed In-Situ Sensors Integrated into Raw Material and Energy Feedstock) research project grouping 15 partners from several European countries was launched within the HORIZON 2020 framework [5, 7]. The project is focused on the idea of use of the Integrated Process Control (IPC) for the improvement of heavy industry processing by the implementation of Process Analyser Technology (PAT) sensors embedded into the processed (or transported) raw material for storing and reading vital information (Figure 3).
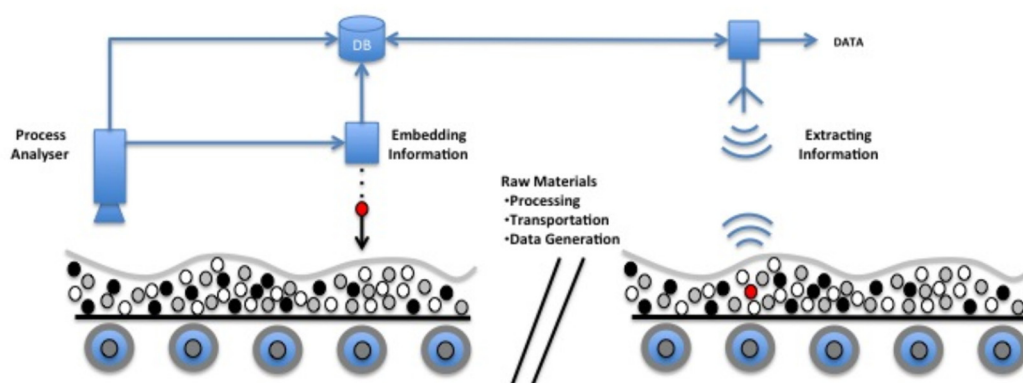

Figure 3. Application of the DISIRE concept in the pelletizing process [5,7]

The sensors (pellets) could be used for annotating the mined ore for the needs of identification its compound. The successful implementation of their use requires a proper information environment to provide the input data and to analyse the "conveyed" ore annotating data to derive the expected output.

3. Proposed solution

3.1. KGHM S.A. information base

The KGHM S.A. implements versatile advanced information systems for supporting the main industrial processes of copper ore mining, transport and concentrating. The following specialized elements are considered to be the key ones:
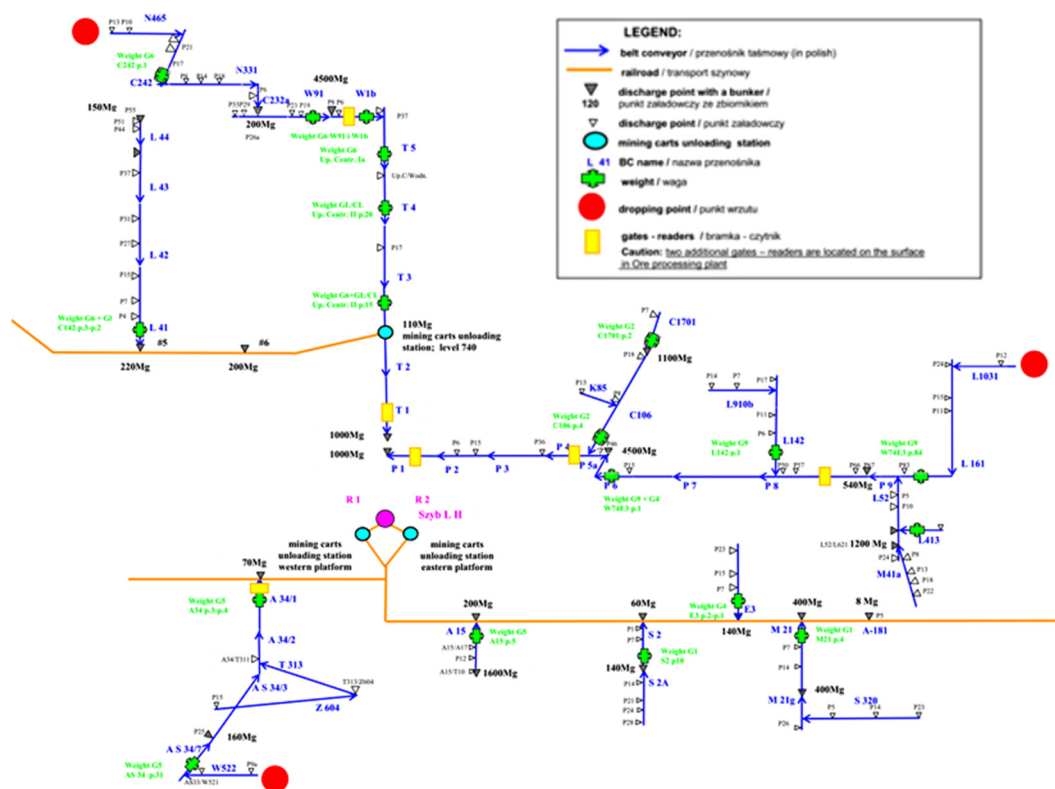- Digital database of geological data and 3-D structural and quality geological model of the copper ore deposit – Orebody Model; the 3-D model (built in *Datamine Studio*) is under construction yet,
- Digital 3-D model of underground developments and mining fields – Mine Model,

- Mine advancing plans and mine scheduling – Mine Plan; these plans are under conversion to the integrated 3-d digital environment (with the use of the specialised software *Datamine Studio 5D Planner*),
- Control systems for managing the work of belt conveyor systems – BC Control,
- Specialised systems for optimisation of managing and grinding of ore in the concentrating plants: *FloVis, MillVis, ConVis*[2, 8] – Ore Processing Control.

Apart of these specialized systems, in the KGHM S.A. there exists a solid base of business information system providing necessary amenities for storing, networking and providing with required data.

3.2. The proposed workflow

The DISIRE PAT sensors (pellets) can help to derive information stored in the Orebody Model (OM), Mine Model (MM), Mine Plan (MP) and BC Control (BCC) in order to provide the data for the needs of all ore processing control systems.

Figure 4. The underground transportation system in the "Lubin" KGHM copper ore mine with the proposed (for tests) locations of pellet dropping points (red bullet points) and pellet readers (yellow squares, 2 others are located on the surface on the entrance to the concentrating plant)

6

Pellets with the suitable annotation could be dropped into the bulk of copper ore while it is being discharged by trucks or loaders onto the division belt conveyor loading point (Figure 4) and then – after being transported with the ore onto the entrance to the concentrating processes – read (with the use of RFID equipment) to make the assessment of ore lithology. The planned workflow of process of identification of ore lithology is presented on 3 consecutive sheets (Figure 5) with the use of IDEF0 scheme (explained on the right).
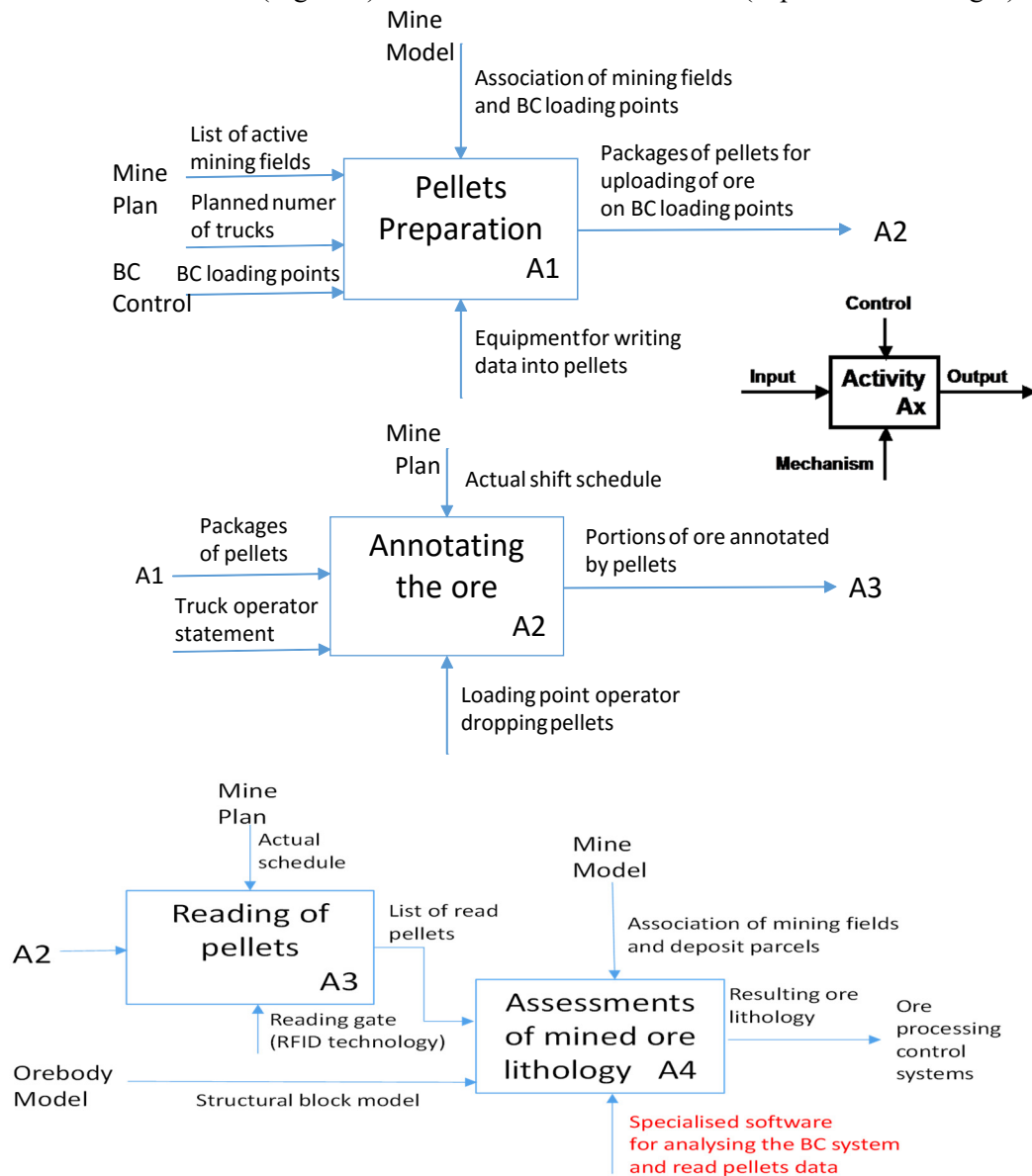

Figure 5. The DISIRE PAT workflow of identification of ore lithology

The specialise software for analysing the BC system and read pellets data (in red on Figure 5) has to provide with the information even in the case of loosing of some pellets. The simulation module helps to make the assessment of resulting ore compound. Simulations of ore flow in the underground copper ore mines transportation system were already performed [4].
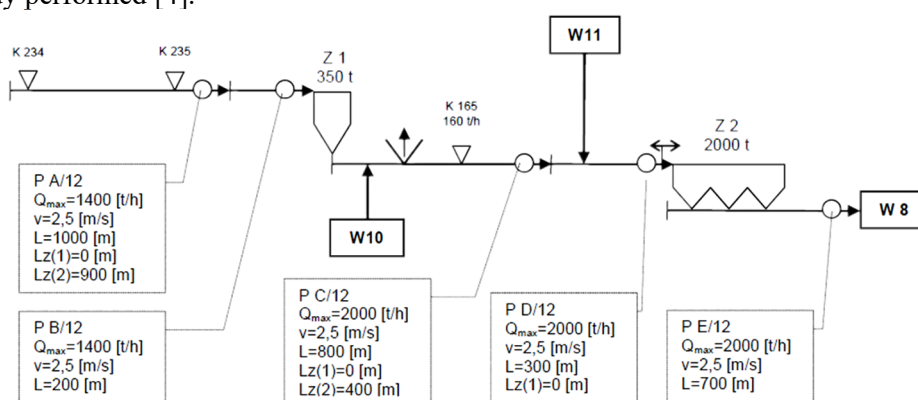

Figure 6. Modelling of BC transportation system with bunkers [4]

4. Conclusions

The problem of identification of the differentiated lithological compound of copper ore mined in the KGHM S.A. underground mines on its delivery to the ore concentrating divisions is presented. This identification can be achieved by the complex use of existing or being implemented information systems supported by the DISIRE Process Analyzer Technology (PAT) pellets embedded into the conveyed ore for annotating each particular portion of mined material when uploaded onto a conveyor.

The flow of information and methods of its processing is proposed. The planned in-situ experiments as well as theoretical investigations including digital simulations and testing of necessary workflow od processed data are under development within the DISIRE project.

Acknowledgement(s)

References

[1] Bazan, B., Kasinska-Pilut, E., Garbacki, M., Bazan-Krzywoszanska, A., 2014.Propulsion Investigation of the impeller radial velocity and copper mineralogy influence of the Cu scavenger flotation recovery in KGHM Polska Miedz S.A. Concentrators (Proceedings of the Mineral Engineering Conference MEC2014, 2014)

[2] Konieczny, A. et al., 2011. Application of visualisation systems for controlling operating parameters of flotation machines in KGHM S.A. division of

8

concentrators, Górnictwo i geologia 2011, tom 6, zeszyt 2 (in Polish)
[3]   Konieczny, A., Bazan, B., 2012. Challenges and difficulties of comminution processes in KGHM PM S.A. Division of Concentrators (MEI Conference Comminution 2012)
[4]   Kulinowski, P., 2005. Simulation model of a belt conveyor system, Transport Przemysłowy 3(21)/2005 (in Polish)
[5]   DISIRE Newsletter nr 02//November 2015
[6]   Tello, P., Weerdmeester, R., 2013. SPIRE ROADMAP Consultation document (www.spire2030.eu, 2013)
[7]   http://spire2030.eu/disire (2015)
[8]   http://www.ameplus.pl/_pdf/ameplus_flovis.pdf