Development of computerized stocktaking system in mine surveying for ore mineral volume calculation in covered storehouses

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Abstract. The article examines into the vital issues of measuring and calculating the raw stock volumes in covered storehouses at mining and processing plants. The authors bring out two state-of-the-art high-technology solutions: 1 – to use the ground-based laser scanning system (the method is reasonably accurate and dependable, but costly and time consuming; it also requires the stoppage of works in the storehouse); 2 – to use the fundamentally new computerized stocktaking system in mine surveying for the ore mineral volume calculation, based on the profile digital images. These images are obtained via vertical projection of the laser plane onto the surface of the stored raw materials.

1. Introduction
The majority of mining and processing plants use covered storehouses while performing their in-line procedures of mineral dressing or processing (Figure 1). Every month surveying specialists have to define the volume of the stored raw materials in such premises [1]. The performance of these works is rather difficult in some ways [2], mainly because of the constrained conditions, a number of obstacles (walls, separation partitions, etc.). Besides, it is often impossible to move across the surface of raw materials. The mineral dressing and treatment processes of ore minerals are constantly becoming more complicated which consequently requires prompt and accurate volume calculation. Therefore, the development of the computerized stocktaking system in mine surveying for the ore mineral volume calculation in covered storehouses assumes vital importance nowadays.
2. Materials and methods

Nowadays there have been developed ground-based laser scanning systems, which noticeably simplify the execution of these types of works. Nevertheless, 8-10 scanpositions on average are required to perform the survey of covered storehouses using the scanner [3]. This task is very time consuming. Besides, the ground-based laser scanning systems are very sophisticated and high-priced instruments (5-10 mln roubles), requiring highly-qualified specialists to carry out the survey and process the data.

Figure 2 shows the typical scheme of a covered storehouse with the products partitions. It is clear from the scheme that even if the ground-based laser scanning is performed, the survey of such a storehouse will take a lot of time and will require the stoppage of works in the storehouse for a long time as consequence [4].

Figure 3 shows the point cloud obtained according to the results of the laser scanning, where it can undoubtedly be seen the high particulars of the survey. However, after the cloud processing, the geomatics engineer extracts only the data necessary for the volumes calculation out of the all the available spatial information (Figure 4).
Besides, the programme [5] uses only the profiles constructed according to the models shown in Figure 4 to calculate the volumes (Figure 5).

Proceeding from the above-stated, the question arises: is it possible to obtain these profiles that are used for the immediate volume calculation straight away, avoiding all the processing operations and the usage of such costly equipment as laser scanner? [6]

3. Results and Discussion

The conceptual idea of the volume stocktaking system at storehouses is to obtain the profile digital images by means of vertical projection of the laser plane onto the surface of the stored raw materials.

The fundamental assembly arrangement consists of a digital calibrated photocamera, plane laser system, and a laser measuring tape. Moreover, a moving deck-platform is needed which can move along the whole storehouse (purpose-designed carriage, beam crane and the like), Figure 6.
Thus, when one knows the camera tilt, the distance to the laser plane and the camera calibration notice (focal distance, principal point coordinates, etc.), it is possible to execute the digital rectification onto the laser plane using the well-known photogrammetric formulae [7]. Then the authors obtain orthogonal images of the profiles that can be used right away to calculate the volumes by means of the vertical slice method.

The assembly prototype (Figure 7) has been created to prove the workability of the method. Besides, the experiment has been carried out simulating the storehouse under office conditions.

**Figure 7.** The assembly prototype

The conventional builder’s laser level was utilized as a plane plotting device. In order to obtain digital images, the digital camera with the wide-angle lens Nikon D70 was used. The assembly moved along the table edge, the marks were made every 10cm. It will be more convenient to determine the assembly position in real-life circumstances by means of a laser range finder. Figure 8 shows the example of a digital image of the projected laser plane onto the three-dimensional object.

**Figure 8.** The example of a digital image of the projected laser plane onto the three-dimensional object.
The images transformation for this experiment was performed via the package Terra Photo within the software solution Terra Solid. The profiles in the format *.dxf were obtained as the result of the processing, enabling to create the digital model of the object or to calculate the volume right away [8] (Figure 9).

Figure 9. The profiles in the format *.dxf.

4. Conclusion
In the final version, the developed system for the volumes monitoring should function automatically and remotely transfer data to the user’s computer. This way, it will be possible to look through the immediately calculated figures on the volumes one is interested in using specific programme. The above presented engineering conception of the computerized stocktaking system in mine surveying for volume calculation in covered storehouses can significantly simplify the mine surveyor’s work, enhance the performance quality and its operationability. It can also advance the planning of the inline technologies at the plant. Moreover, the described engineering development can be utilized in the other industrial spheres, for instance, for the grain volume calculation.

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