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APPLICATIONS OF LASER DISTANCEMETERS DISTO TO CONTROL SURVEYS OF MINE HEADINGS**

1. Introduction

Advanced electronics and computer methods have produced novel solutions to be utilised in survey measurements. Mechanical instruments used so far are now being modernised or replaced by electronic devices and computer-assisted techniques.

Mine surveying divisions are still on the lookout for cost-effective and easy-to use measuring instruments allowing most difficult and dangerous measurements in shafts and mine headings to be fully automatic.

While processing the measurement data, computer methods are of primary importance. For example, systems can be created that automatically process the measurement data to yield the desired outputs, usually in the form of graphic displays.

2. Control surveys of mine shafts using the distancemeters DISTO plus

Distance measurements needed to determine the geometry of guide strings (guide spacing) and of the operational distances (to assure the required redundancies for buntons, shaft linings and other shaft equipment) are still taken with the use of tape measures or other rigid devices. An alternative solution utilises telescopic slide callipers that enable on-line measurements of the frontal spacing between shaft steelwork elements and a prototype devices has already been fabricated [1].

A method of continuous distance measurements in a shaft is developed as a part of the research project 5 T12E 018 25 supported by the State Committee for Scientific Research in Poland.

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The method utilises a state-of the art distancemeter DISTO plus (Fig. 1) allowing wireless data transfer to a computer.

Fig. 1. Measurements of guide frontal spacing using DISTO plus laser distancemeters in the shaft Campi in the Bochnia Salt Mine

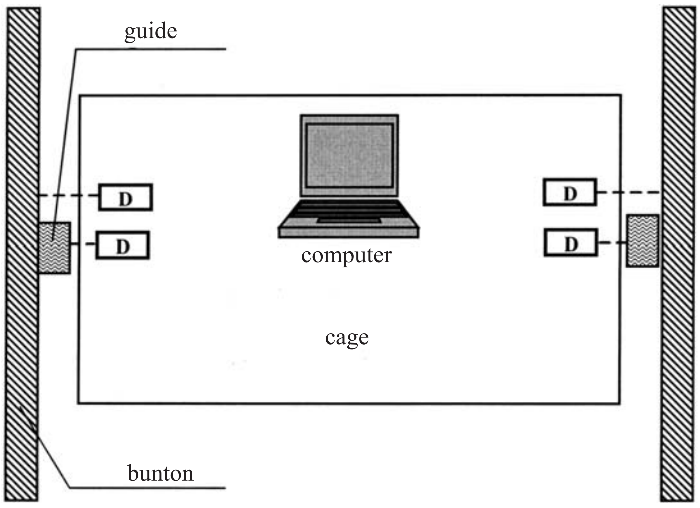

Fig. 2. Layout of the measuring equipment in a cage, configured to measure guide and bunton spacing

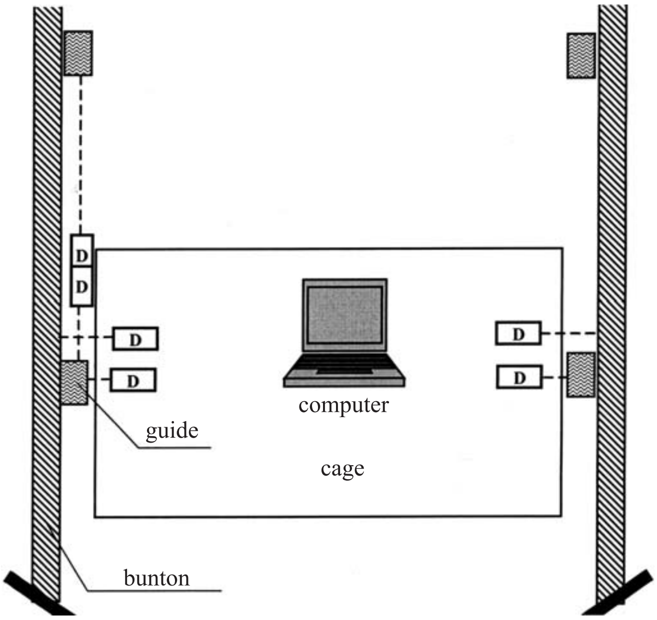

Fig. 3. Layout of the measuring equipment in a cage, configured to measure the guide frontal and lateral spacing and the bunton spacing

The underlying principle is shown schematically in Figures 2 and 3. At least two DISTO plus distancemeters are fixed in holders simply connected to conveyances during the measurements. Figure 1 shows the way the holder is positioned on the floor in a cage compartment and loaded accordingly. Depending on the number of available distancemeters, measurements can be taken of one (two distancemeters) to three (six distancemeters) frontal or lateral spacing distances between the guides or other redundancies involved in the design of shaft lining, buntons, shaft equipment or steelwork components.

Measurement data are transmitted using the Bluetooth technology and recorded on a portable computer. Recording times in the distancemeters are synchronised and the measured spacing values are then computed as the sums of measured distances from the two guides.

The on-line measurement option allows the distance measurements with the frequency about 3 Hz, so measurements can be taken from a cage, being hauled slowly in a shaft. At the hauling speed 0.5 m/s, measurements of the guide spacing can be taken every 0.2–0.3 m (in the vertical). With DISTO plus distancemeters mounted in the cage, the guide spacing measurements can be taken while the conveyance is slowly moving up or down. The conveyance position (depth) is signalled on a computer at times it passes the subsequent buntons. These measurements can be taken when the conveyance is moving up or down. For hauling velocity 0.5 m/s the measurements of a distance between the guides in the shaft 500 m deep do not take longer than 40 min and can be performed by one person. The method is cost-effective and convenient, measurements are safe and contact-less. The on-line measurement option and the fact that measurements can be taken whilst the cage is moving place the method among laser scanning techniques.

To verify the novel method is industrial applications, three series of guide spacing measurements were taken in the shaft Campi in Bochnia. Guide frontal spacing was measured in one shaft compartment during the three rides of a conveyance- two rides up, one down. The cage was hauled up for the fourth time after the distancemeters were positioned beyond the guides' plane to measure the distance to the shaft lining and buntons. The measurement data are plotted in Figures 4–6.

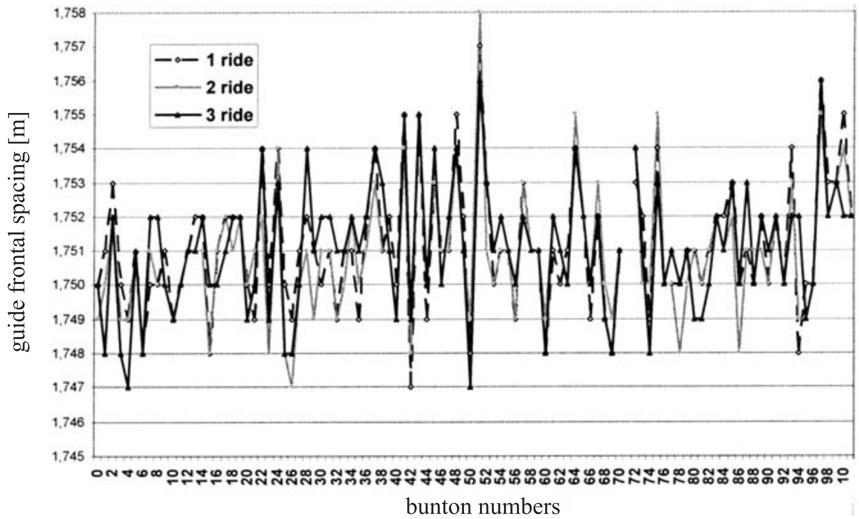

Fig. 4. Frontal spacing between two guides (values obtained in three rides)

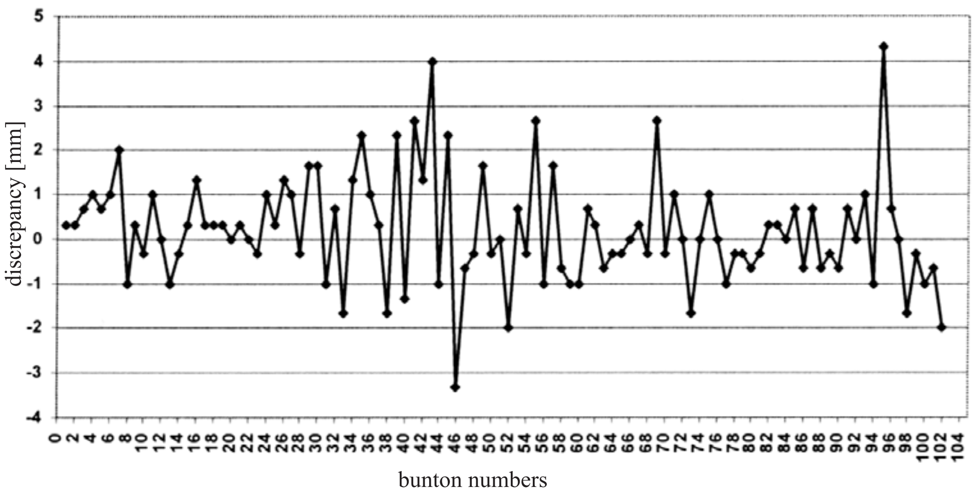

Fig. 5. Differences between the measured guide spacing value obtained by the conventional method and with the use of DISTO plus distancemeters

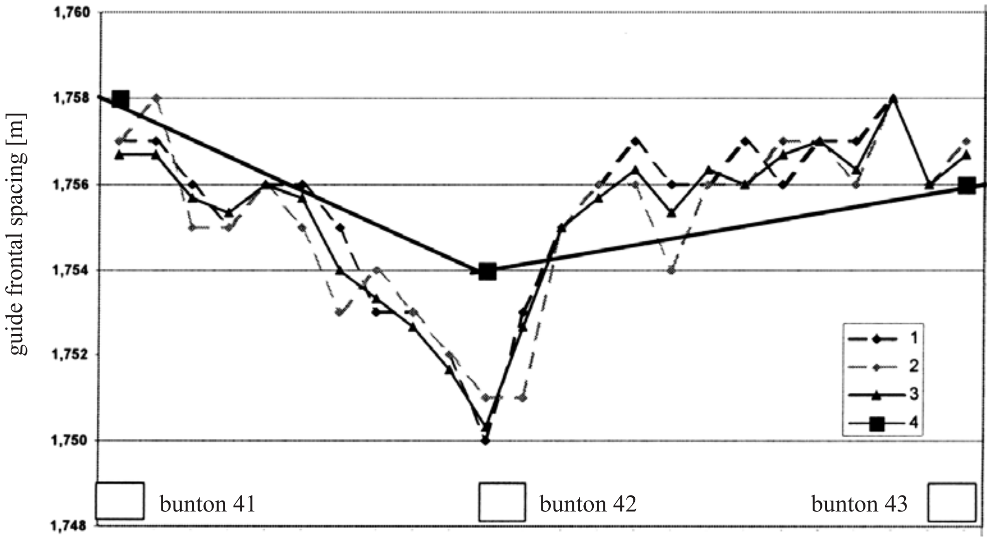

Fig. 6. Guide front spacing between buntons 41–43 (1–3 – measurements taken with DISTO plus, 4 – conventional measurement)

Table 1. Results of measurements taken with DISTO plus distancemeter (for a northern guide)

Time [ms]	Measured value	Key code
10:19:57.613	0.396	–
10:19:57.953	0.000	15
10:19:58.073	0.396	Bunton spacing 3 m
10:19:58.384	0.397	
10:19:58.744	0.397	
10:19:59.115	0.396	
10:19:59.556	0.396	
10:20:00.176	0.396	
10:20:00.547	0.396	
10:20:00.887	0.400	
10:20:01.238	0.400	
10:20:01.568	0.401	
10:20:01.899	0.000	15
10:20:02.490	0.400	–

The key code 15 corresponds to the cage ride on the bunton level. This code signal brings the distance measurement data to zero (Tab. 1).

Distances were measured between the guide and one DISTO plus distancemeter over the guide span of 3 m, between the two subsequent buntons. A single measuring procedure takes from 0.12 to 0.62 s, about 0.3 s on the average. Variations of the measured distances correspond to the changes of the conveyance position with respect to the guide, which in turns is associated with the variations of clearances between the guide and the guide shoes. The comparison of measured distances from the guide in subsequent conveyance travels reveals to what extent the conveyance path during the ride should be reproducible.

By adding the measured distances to the "base line" length between the distancemeters, the guide spacing can be obtained. Plots in Figure 4 confirm a good reproducibility of results. The maximal differences between thus obtained distances are less than 2 mm. This value can be treated as a standard error involved in the method. Measurement data obtained with the use of DISTO plus distancemeters are then compared with values measured by conventional techniques. The comparison is shown in Figure 5.

The average difference between the distances measured by the two methods is 0.9 mm. The maximal difference of 4 mm was registered on the 42-nd bunton's level. In order to adequately account for this discrepancy, the results obtained for the two guide sections, below and above the 42-nd bunton, were analysed (see Fig. 6). It seems that the registered difference of 4 mm might be the consequence of misidentification of points the measurements were taken.

The obtained value are indicative of errors in conventional measurements, showing major reduction of the guide spacing (7 mm) on the level of the 42-nd bunton in comparison with the neighbouring buntons.

3. Measurements of horizontal and vertical cross-sections of mine workings using a laser scanner

A prototype laser scanner was fabricated in the Department of Mine Surveying AGH-UST, as a part of the research project 5 T12E 018 25, sponsored by the State Committee for Scientific Research. It comprises a laser distancemeter DISTO plus integrated with a computer-controlled step motor. The DISTO distancemeter is rotated by a step motor with the step of 1 grad. The construction of the device allows the scanning in the horizontal (Fig. 7) and vertical (Fig. 8) plane.

Preliminary tests of a prototype device were conducted in the corridor of the AGH-UST university building C-4. The purpose of these tests was to determine the reproducibility of results, measuring range and the optimal rpm.

Figures 9 and 10 show horizontal and vertical cross-sections of a corridor, measured with a laser scanner, the data processing was supported by Excel and Auto CAD.

The horizontal cross-section (Fig. 9) obtained with the use of a laser scanner is compared to that obtained using conventional techniques. The maximal discrepancy between the two methods (4 cm) is registered in the corner sections. In the remaining parts the maximal differences are less than 6 mm. Measurement data obtained by the two methods are summarised in Table 2.

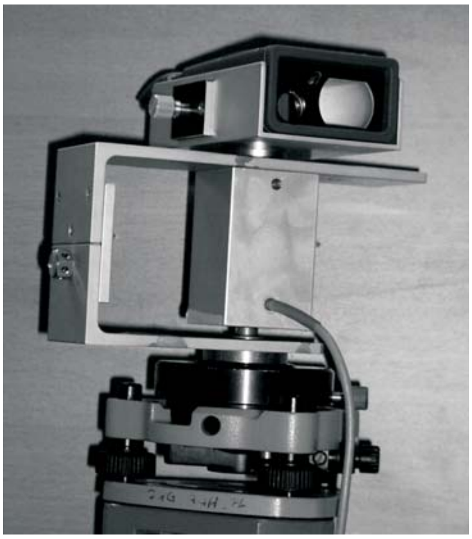

Fig. 7. Laser scanner integrated with a DISTO plus distancemeter set for scanning horizontal cross-sections

Fig. 8. Laser scanner integrated with a DISTO plus distancemeter set for scanning vertical cross-sections (complete with a recorder – a laptop)

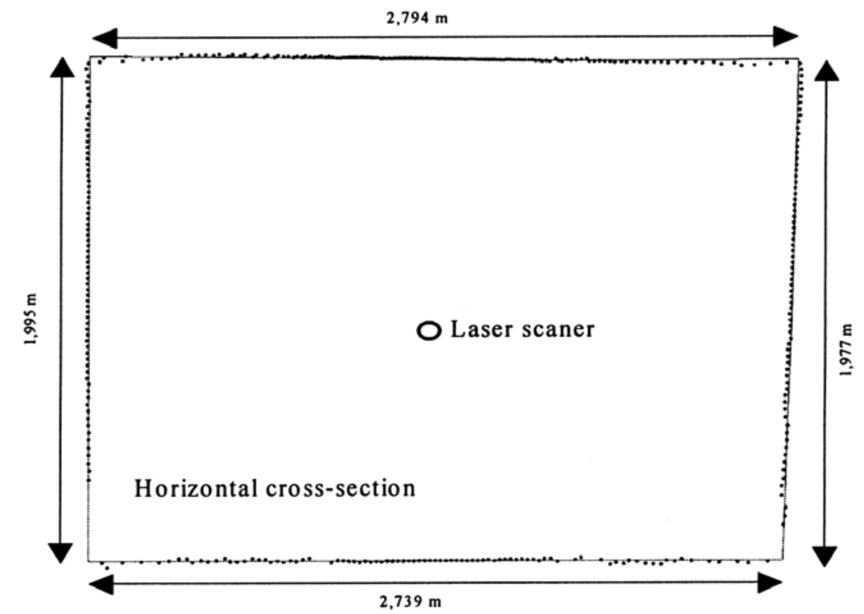

Fig. 9. Vertical cross-section of the corridor (in the building C-4) obtained with the use of a laser scanner (separate points) and by the conventional method (continuous line)

Table 2. Comparison of measurement data obtained by the two methods

Parameter	Laser scanner	Conventional method	Discrepancy
Surface area	5.475 m²	5.489 m²	0.014 m²
Circumference	9.544 m	9.510 m	0.034 m
Height:			
left wall 0.0 m	1.995 m	1.995 m	0.000 m
0.7 m	1.983 m	1.990 m	0.007 m
1.4 m	1.979 m	1.980 m	0.001 m
2.1 m	1.978 m	1.973 m	0.005 m
right wall 2.8 m	1.967 m	1.977 m	0.010 m
Width:			
floor 0.0 m	–	2.739 m	–
0.7 m	2.756 m	2.762 m	0.006 m
1.0 m	2.770 m	2.773 m	0.003 m
1.3 m	2.784 m	2.780 m	0.004 m
1.6 m	2.799 m	2.787 m	0.012 m
ceiling 2.0 m	2.809 m	2.794 m	0.015 m

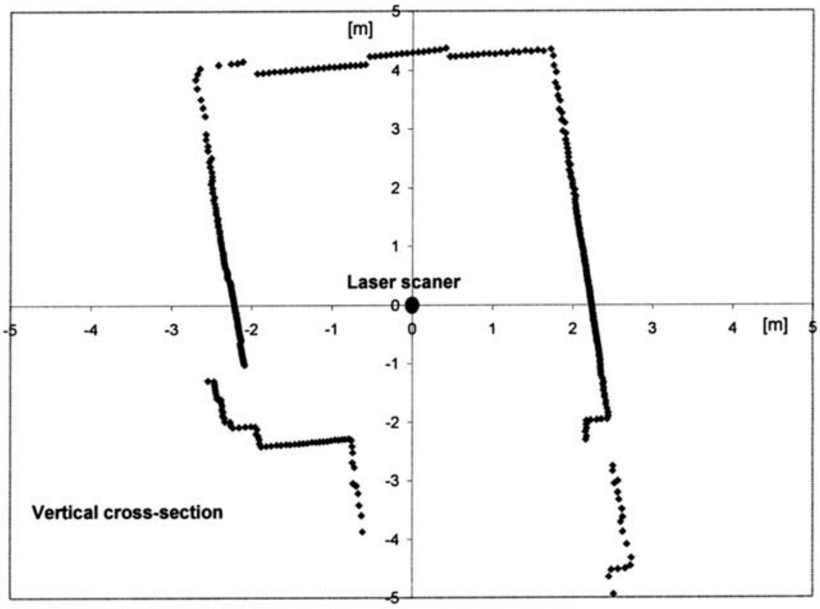

Fig. 10. Horizontal cross-section of the corridor (in the building C-4) obtained with the use of a laser scanner

A few points seem to be missing, which is the consequence of screening or too large distance from the scanner (Fig. 10). The measuring range is found to be in excess of ten meters, though according to the manufacturer's specification that should be 80 m. The reasons for such considerable reduction of the DISTO plus measuring range in scanning applications are: measurements taken with a mobile device, low frequency of "tracking" mode measurements, and deterioration of laser beam quality when reflected from the controlled surface.

4. Conclusions

Test results fully confirmed the adequacy of the novel method for measuring guide spacing and of the measurement technique utilising a laser scanner. Measured guide spacing values give us additional information about the reproducibility of the conveyance path with respect to the guides and actual operational clearances obtained on that basis. Measurements can be taken every 0.25 m (in the vertical) during the conveyance ride at 0.5 m/s. Depending on the actual configuration of two Disto plus distancemeters inside the conveyance, measurements can be taken of the guide spacing and of the distance between the guide and the shaft lining. The standard error is found to be ±2 mm, which agrees well with the manufacturer's specification (±1.5 mm). This is quite satisfactory for this type of measurements.

Preliminary tests confirmed the excellent performance of a laser scanner in measurements of horizontal and vertical profiles.

References

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