Practical application of laser scanning in a mining environment

Since the inception of laser scanning it was used mostly in industries other than mining. Only fairly recent developments and the interest shown by the mining fraternity, has the laser scanning supporting industry reacted to the demand. A typical mine has all, if not more physical features than any other industry mentioned by manufacturers. The scope of this work is to demonstrate the work already being done, the possibilities and the benefits to the mining industry.

Keywords: *Dlaser; scanning; underground mine.*

I. Introduction

Industries and users who traditionally work with two-dimensional plans and schematic diagrams are increasingly discovering the advantages of three-dimensional planning and documentation tools through the use of 3D laser scanners. Capturing high resolution three-dimensional images of complex environments and geometries, large-volume 3D laser scanners provide a fast, efficient way to capture millions of data points for use in comprehensive 3D models or detailed reconstructions. 3D laser scanners are a versatile, accurate solution that allows companies to obtain data they previously could not help them to make more informed decisions while saving valuable time and money.

Laser scanners are non-contact devices that use either time-of-flight or phase-shift measurement technology to capture millions of discrete points of a real-world object or environment. Time-of-flight, or pulse measurement systems emit a single pulse of laser light, determining the distance to the surface by measuring the time of flight needed for the reflected light to come back to the distance sensor. Similarly, phase-shift systems also emit a laser light; however, in phase-shift technology, the laser is emitted at a specific frequency, and the reflection of this wavelength is “shifted” or “displaced” by its impact on a surface. The displacement of the reflected wave allows for the precise calculation of the distance between the point of impact and the scanner. In general, phase-shift scanners are faster, more accurate, and provide higher resolution data in comparison with time-of-flight scanners.

The laser is sent from the scanner onto a rotating mirror that projects a flat plane of laser light out from the scanner. The entire head of the scanner then rotates, sweeping the laser across the desired area. Objects in the path of the laser will reflect energy back to the scanner and the scanner will place a point in 3D space. The density of the points collected is controlled by the rotation speed of the scanner. The slower the scanner turns, the denser the pattern of points collected, while faster the scanner turns, the resulting point cloud is less dense. In this manner, millions of discrete measurements can be collected in a matter of minutes. The use of reference targets or objects in the scan environment can be used to tie together multiple scans, each on their own coordinate system onto a single, aligned coordinate system. This allows extremely complex environments to be documented quickly and accurately

II. Plant and equipment documentation

Mines typically has a fleet of varying types of equipment and plant. Although the different manufacturers of mobile plant and equipment provide orthographic drawings, in some instances, modular options or 3rd party modifications render such drawings irrelevant. Hence, the need arises to ascertain the correct physical dimensions by scanning each arrival of plant and equipment.

By recreating a 3 dimenional model and orthographic projected drawings, a to-scale representation can be used to simulate such plant in its real environment.

Excavation dimensions, positional placement of infrastructure and safe clearances can be determined and such parameters can be used for accurate design.

The following examples describes the workflow in order to design an underground roof supported pipeline installation.

- Pipe handler scanned on surface, accurate model and orthographic drawings created.
- A 300m tunnel with scans taken at 20m. Intervals, 4min. per scan, recording a total of 660M points with a density of 8mm per scan at a distance of 15m, were documented.
- After registering individual scans and geo referencing, the

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data was then edited by removing all irrelevant objects and services from the point cloud.

- Data was reduced to a user specified grid, meshed and edited.
- Orthographic sections at specified intervals were created.
- Using the pipe line design parameters and the 3D scanning models, all components were married to enable an accurate design.

Fig.1 Scan of pipe handler

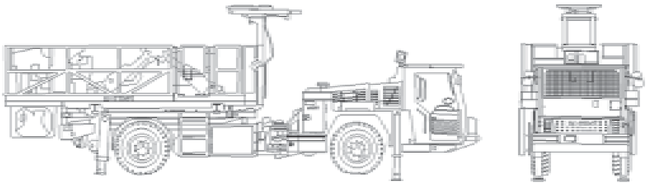

Fig.2 3D model of pipe handler

III. Documentation of underground excavations

Scanning of a tunnel

Individual scans at 20m intervals. 44M points per 4min scan.

Editing of data

Individual scans are registered with each other, geo referenced to the local survey grid and point data reduced to serve the purpose of the survey.

Mesh and edit surfaces

A triangulated mesh is created between points at a user specified grid, depending on the required accuracy tolerance. Inevitable occlusion, low reflectance or shadows in the data are filled in through the software's various algorithm options. Density of points is directly related to the accuracy of the mesh. Various options are available to reduce the volume of data.

Fig.3Tunnel scan

Sections

Sections at the required azimuth, dip and intervals are created.

Design

Combining all the acquired survey data and engineering design a more comprehensive and representative design can be produced. This benefits retrofit work underground, a neat and accurate installation and an accurate bill of quantities.

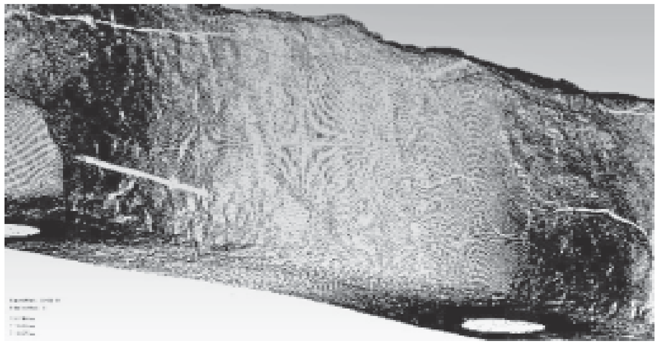

Fig.4 Edit scan data

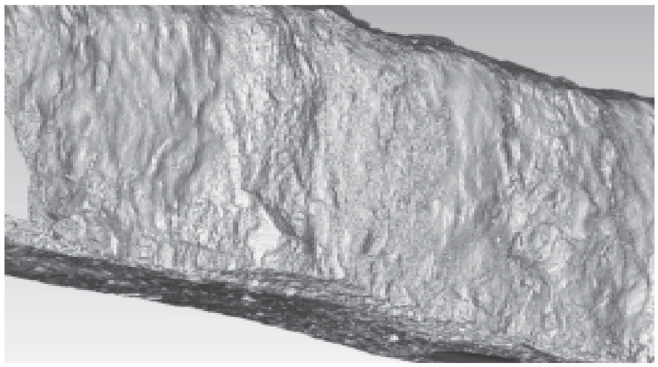

Fig.5 Mesh and edit surface

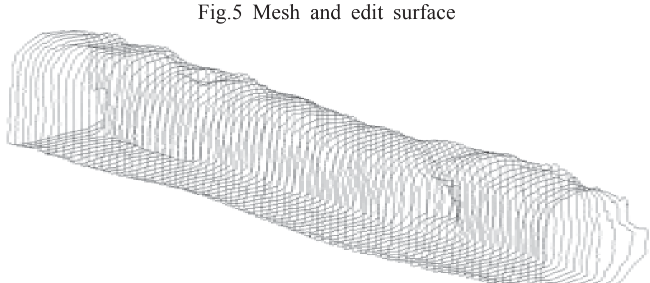

Fig.6 Section of the tunnel

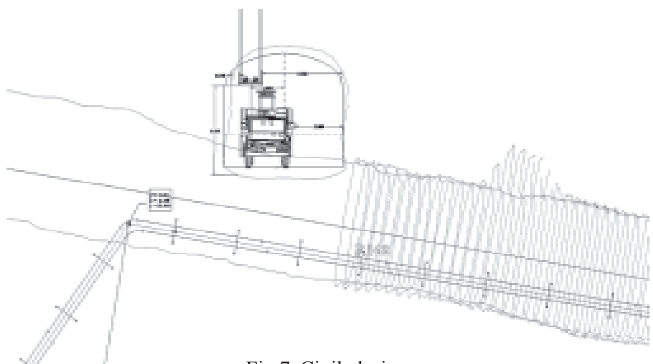

Fig.7 Civil design

IV. Underground infrastructure design

The argument always arise, whether an excavation should be designed to host the engineering design, or should the engineering design fit the excavation. This debate is not part of the scope of this work, but with accurate scanning of both, can certainly aid to address the gray area that exists.

The following are examples how 3D data can assist with design.

Underground Loading Points

This exercise had a twofold purpose, firstly to determine the required space for loading a truck and secondly to determine if this specific loader can sufficiently load this truck model. The question was raised if this loader/truck configuration was the right option.

Hence, both vehicles were scanned and orthographic drawings produced.

These scale drawings were used to simulate the loading of a truck.

Various scenarios were simulated, such as safe stopping distance from the truck, approach angle, different floor heights and load distribution.

Multilevel Loading

Multiple scans were merged and sectional views created to demonstrate and support the design function of this loading point.

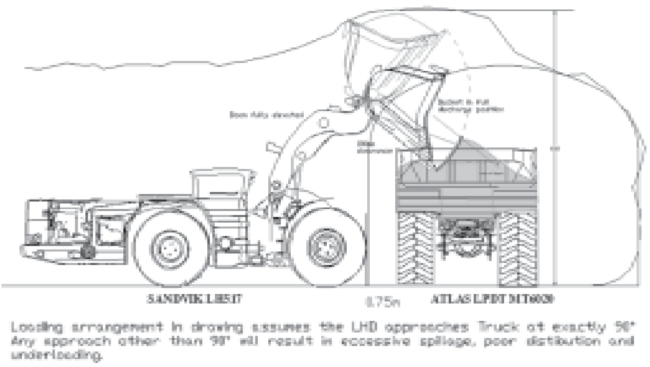

Fig.8 loading point design

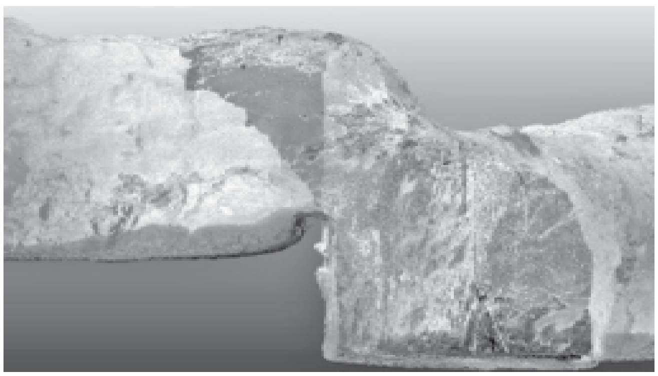

Fig.9 Scan of multilevel loading

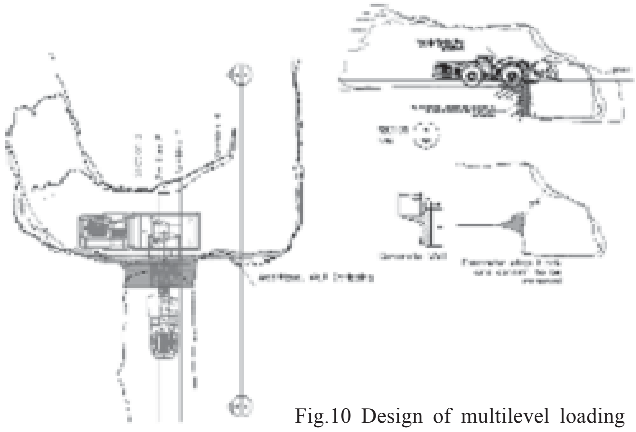

Fig.10 Design of multilevel loading

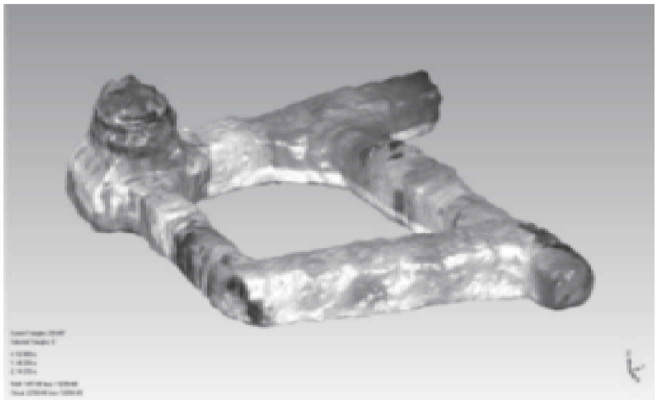

Fig.11 Survey of the total station excavation

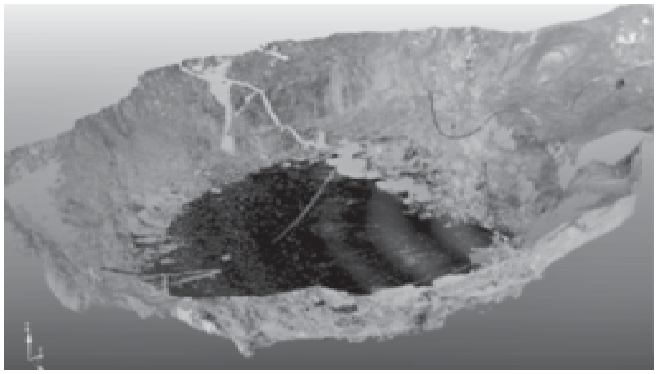

Fig.12 Point cloud of shaft station floor

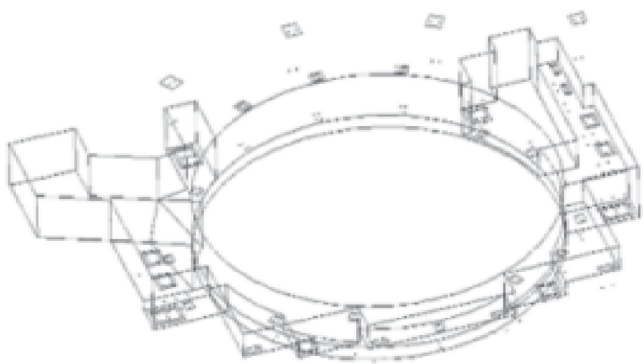

Fig.13 Civil design

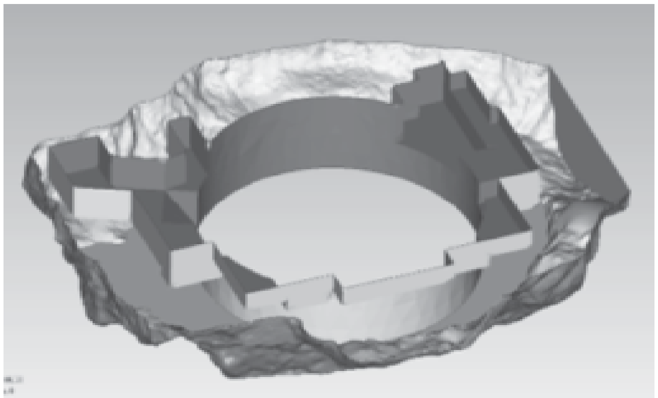

Fig.14 Civil design and actual excavation

CIVIL CONSTRUCTION

Shaft station excavation were scanned, civil design created in 3D and superimposed onto the excavation.

Clashes and clearances were determined by creating cross sections and inspected. Volumes of the excavation and the required concrete determined.

V. Mechanical and structural design

EXAMPLE OF STRUCTURAL STEEL ALIGNMENT

From the data collected, the following deliverables were obtained.

- Verticality of individual steel members
- Alignment of guides
- Positioning of shaft ropes

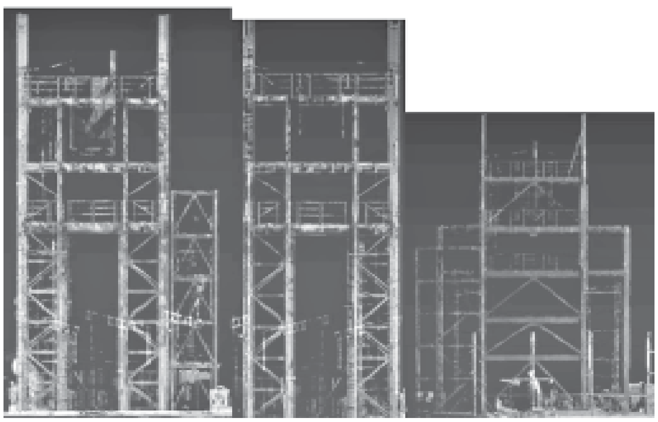

Fig.15 Steel alignment

VI. Shaft headgear sheave wheel alignment

All sheaves and deflector sheaves were aligned using scanning data and the centers each of rope confirmed. Points along the horizontal center of each shaft on three different floor levels were extracted and exported to produce as-built drawings.

Fig.16 Head gears sheave wheel

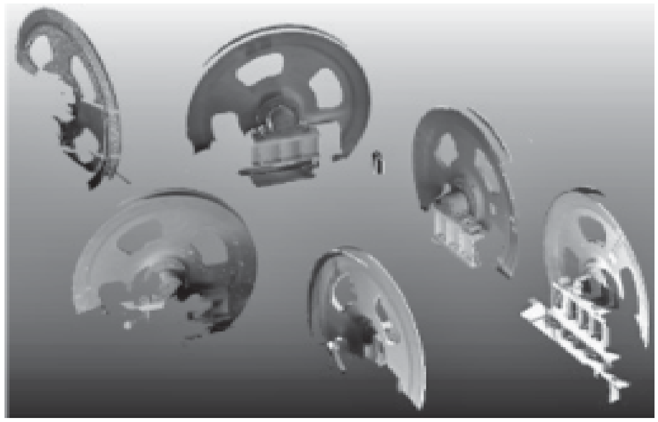

Fig.17 Head gears sheave wheel

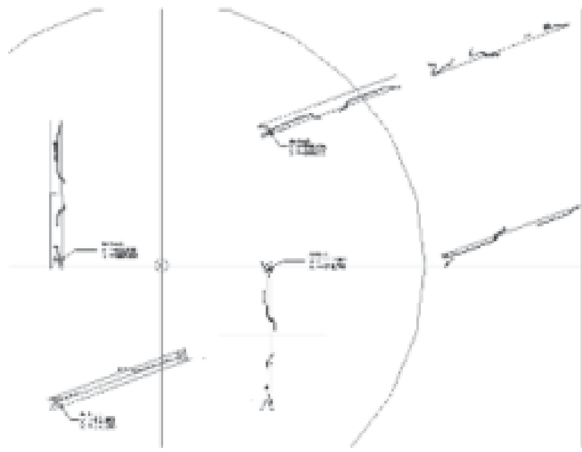

Fig.18 Shaft head gear sheave wheel alignment

VII. Quality control

SHOTCRETE APPLICATION QA

I order to monitor the quality of shotcrete application a laser scanner can be employed effectively and accurately.

First the development end face is cleaned and prepared for shotcrete. A very short time, as little as 4 minutes, is required to scan the complete area to be shotcreted. This procedure is repeated after the shotcrete application.

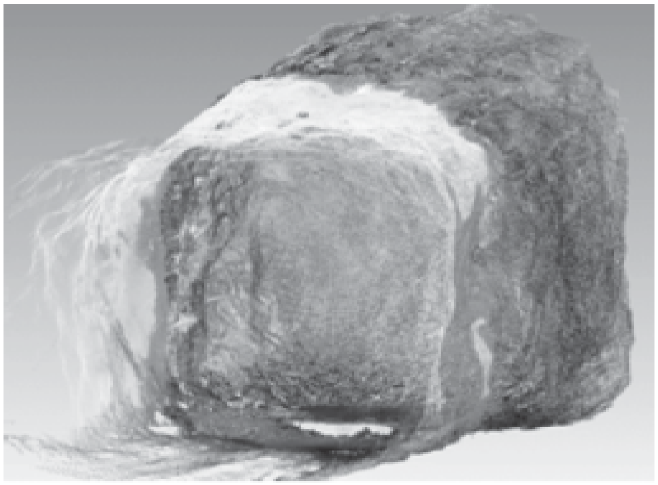

Fig.19 Scan before shotcreate

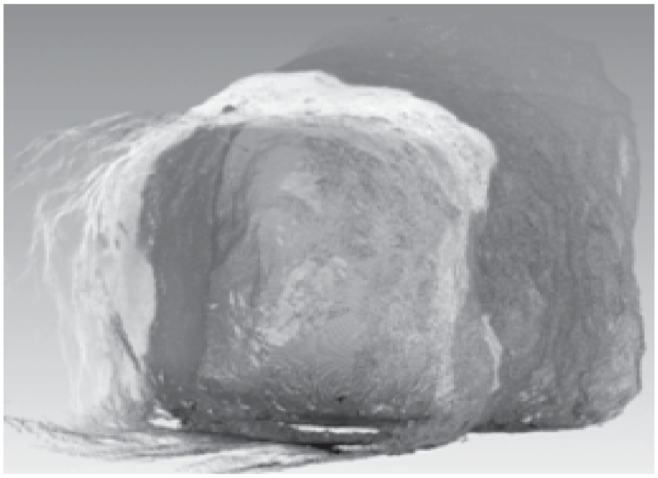

Fig.20 Scan after shotcrete

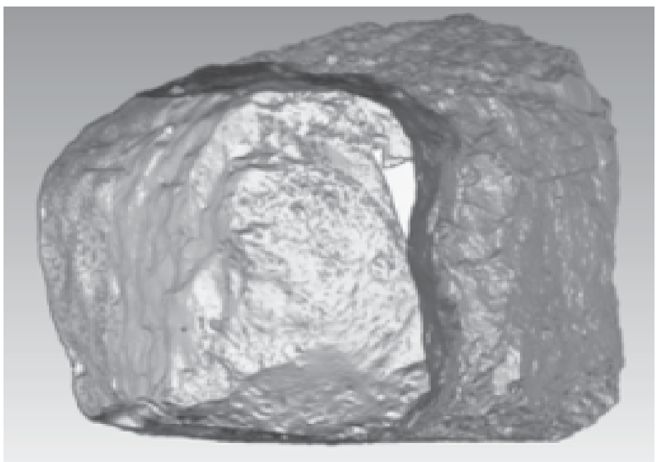

Fig.21 Scan before shotcreate

As can be seen from the scan images, the freshly applied areas can be defined. With both surfaced models in real space, this area is isolated in both models. Both open ends of each model is closed off to create a water tight solid. The volume

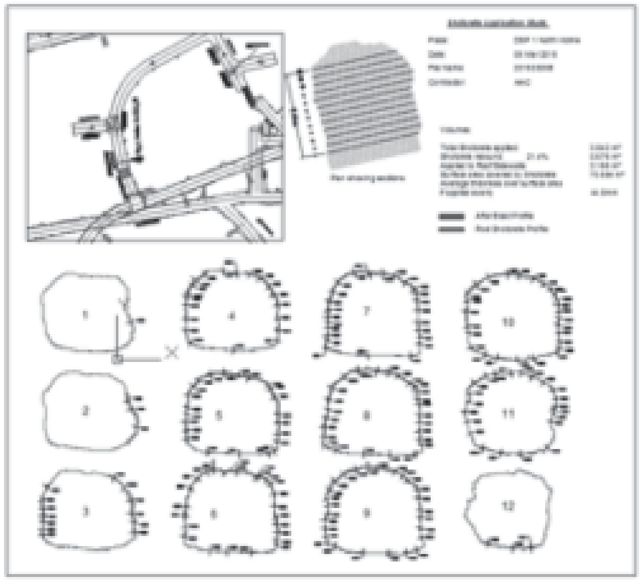

Fig.22 Sections of short creating

of shotcrete is then calculated by subtracting the individual model volumes. Cross sections at any interval are then generated through both models and the thickness applied can be studied.

Also can the amount of rebound along the floor and corners be determined. With this information, the mixture proportions can be analyzed and optimized.

Rock Support

Every rock bolt and cable anchor can be documented for quality assurance. Rock support patterns can be verified against design and geotechnical analysis and can test the effectiveness of support. The scan images can be used to identify each anchor, point added and exported to a 3D support plan.

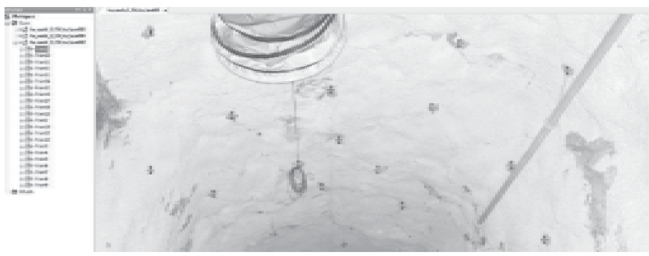

Fig.23 Sections denoting the rock bolt

VIII. Peripherals

Truck Load Factor study

Trucks loads are randomly scanned as they exit the mine. This enables us to monitor under and overloading and also provide a better truck load factor.

Tonnage and swell factor of In situ and loose material

A pre and post cleaning scan is performed to determine the in situ material broken. All the material that originated from this blast gets dumped on an even surface and documented. This material then gets weighed to determine the tonnage. By determining the volumes of each stage a factor for volumetric mass density and percentage swell can be determined.

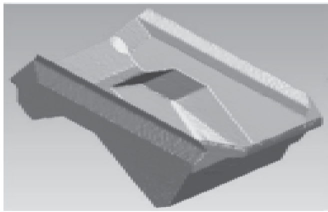

Fig.24 Empty mine truck

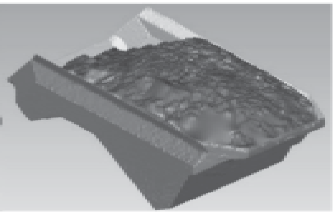

Fig.25 Loaded mine truck

Fig.26 Scan of the pile of the muck

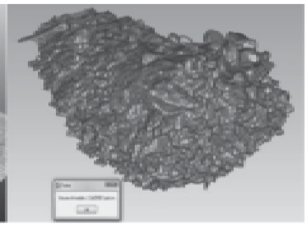

Fig.27 3D Model of muck

Inaccessible and dangerous cavities

Any excavation can be documented, provided the instrument can be safely inserted into such cavity. Scanners are available that can be operated remotely, thus leaving exposed only the scanning instrument. It is up to the individual how to achieve this task.

Open Stope excavations

A safe, inexpensive and effective method to insert the instrument is by means of a lightweight segmented boom and wheeled carriage into the bottom of an open stope. The spheres,which will be part of the scanning data and which the software will identify as references, are placed near for referencing the scan to the survey grid.

The scanner is then remotely operated. The total time the instrument is exposed to falling debris can be as little as 4 minutes, depending on the scanner employed.

Fig.28 Scanning in the stope

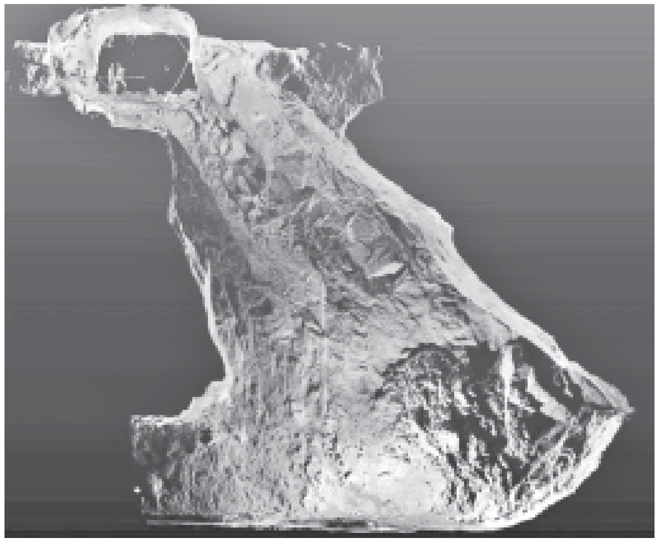

Fig.29 Scan stope between top and bottom drive

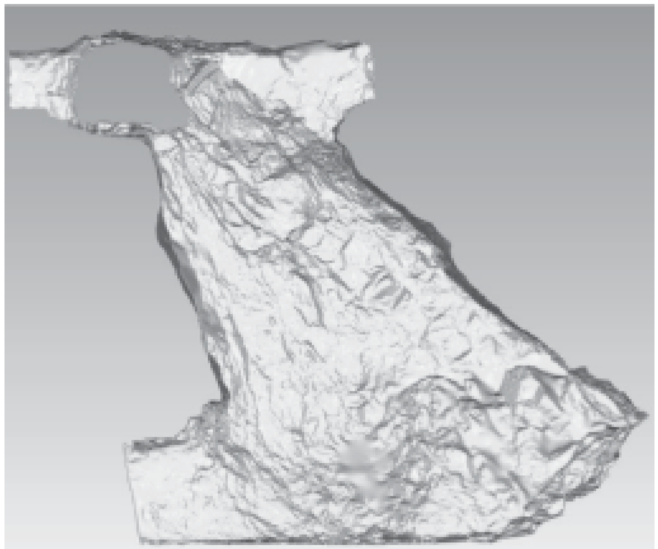

Fig.30 Sections denoting the stope

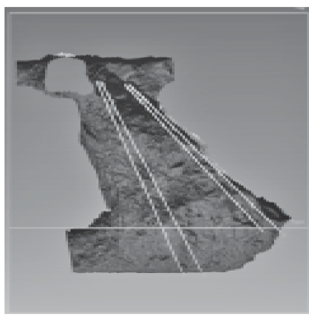

Fig.31 Stope ring

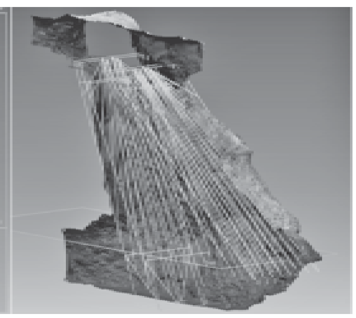

Fig.32 Stope rings

Multiple scans showing the top drive before the stope was excavated and the stope measured from the bottom.

Stope scan data surfaced and edited. Boolean operations in the software allow for surface and solid inclusions and exclusions and an excavated stope volume can be calculated.

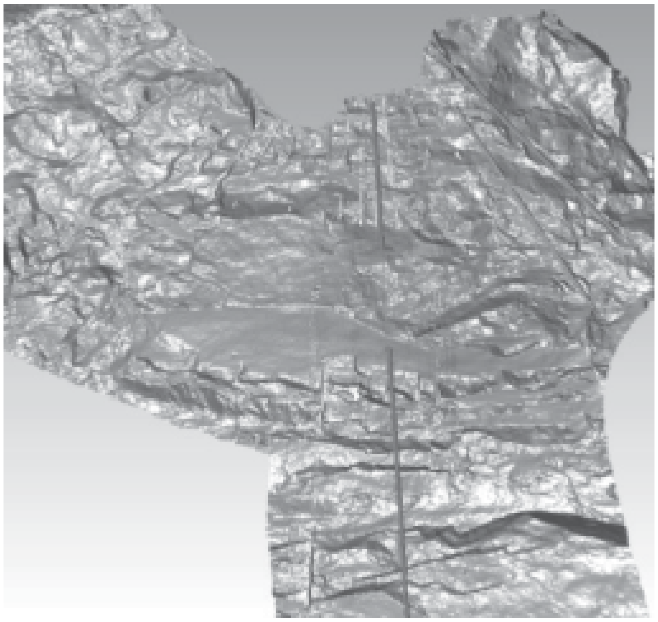

Fig.33 Excavated stope and drilling actual

From the examples below, the design can be tested against the actual.

Drilling actuals, sockets and barrels can easily be identified and compared against design.

Conclusion

As can be seen from the laser scanning examples above, has only touched the surface of all the possibilities.

There is geological and geotechnical mapping fields that can be explored. With the extensive number of new software packages that support laser scanning, this can surely enhance every technical discipline on a mine.

Due to the nature of obtaining data in a remote manner, safety to personnel is greatly enhanced. Inaccessible places that was previously estimated, can now be documented with great accuracy.

Data can now be shared, from a virtual tour inspecting scanning images, to survey, geology, mechanical, electrical, geotechnical, design engineers.

STUDY ON THE APPLICATION OF FUZZY CONTROLLER IN HYDROSTATIC TRANSMISSION SYSTEM OF HEAVY EARTH MOVING MACHINES

(Continued from page 160)

Nevala et al [5] proposed a resilient anti-slip system for the HST system which was employed in forest tractor. CANbus and fuzzy control were the tools which helped in achieving the aim of developing an energy efficient system. The prime concern was to discover the fault i.e. wheel slippage instantly so that necessary measures could be taken to minimize wear on the surface of the wheels. The applied methodology could work significantly well in case of mechanical transmissions and its prime idea of measuring technique can do wonders in specialized fields. The test result was found to be matching with theoretical assumptions which justify the proposed analytical approach.

Conclusion

This paper throws light on the various applications and modifications of the fuzzy logic controller to solve the real time issues related to the hydrostatic transmission of the off road vehicles which are employed in difficult terrain. The off road vehicles are subjected to wear, wheel slippage, various wind load and other non-linearities such as uncontrolled speed which makes their task even more cumbersome. Due to these above situations, the cost of operating the vehicle also goes up as there is significant loss of fuel too. Hence, the need of the hour is to develop an adaptive fuzzy logic controller which can adjusts itself according to the vehicle dynamics and operating conditions and which would come handy in solving the faults associated with the heavy machines.

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