Remote Loading Project
(6 Foot Phase - Pre and Post Cleaning Jumbo Drill Holes)

September 2015 to March 2016
Work Package Report

TABLE OF CONTENTS

EXECUTIVE SUMMARY

The key points this month are:

- This Phase 2 project is complete, and successfully demonstrated that the mine tunnelling blast hole cleaning and loading process can be completed from at least 12 feet away from the active face. This distance removes the miner from the higher risk zone at the face.

- This Phase 2 project created a Proof of Concept piece of equipment, that could be used to learn from, leading to a commercial version ready for market, that can match and exceed present manual methods, while producing a consistent better quality of product

- The business case for mechanising this processing of cleaning and loading, with data attached includes the following potential benefits:

    - no risk or consequence to the operator
    - no associated strain injuries from cleaning the lifter holes on the floor
    - improved advance of the round through improved cleaning map data based sequencing of the holes
    - consistently shorter development cycles through the sequencing gain
    - the reduced scaling required at the face.

MINISTRY OF LABOUR EMULSION CLEANING TOOL REVIEW

Early February, the client Safety Department representatives and TesMan met with the Ontario Ministry of Labour in Sudbury. The team presented the concepts with discussion around the detail of the safety mechanisms for the proposed concept to be used for cleaning bulk emulsion from drill holes, before or after blasting. The response was positive and constructive regarding the process.

The MOL are reviewing the material and the proposed process and design. The final objective will be to accommodate all safety related suggestions into the design, fabricate a tool based on final features, and test it at the NORCAT Fecunis Mine in Levack, Ontario, with the assistance of ORICA providing a bulk emulsion loader to lead the test face. It is estimated that this may take place in April.

BOLTING AND SCREENING OF FACES AND HOODS ON EQUIPMENT

The standard of face support for the client is bolting and screening the top portion of the face. In poor situations this has been extended to cover the entire face.

A common cross Canada standard for extended or permanently stopped headings in a mine is a full bolt and screen of the face.

There are varying standards across Canada regarding protection of the worker at the face. The most common standard being adopted throughout the country is the use of extendable or permanent hoods on equipment that takes the worker close to the face, namely within around 5 feet. Examples of this type of equipment includes, backhoes, and loading baskets. Figure 1 is an example of some of the hoods in use.

Figure 1: Mechanical Hood on a Basket

TesMan Incorporated
1545 Maley Drive, SUDBURY, ON P3A 4R7
705-524-2888 or 705-665-8470
office@tesman.ca

Figure 2: Half Platform Hood on a Basket

TesMan Incorporated
1545 Maley Drive, SUDBURY, ON P3A 4R7
705-524-2888 or 705-665-8470
office@tesman.ca

Figure 3: Retractable Hood on a Basket

TesMan Incorporated
1545 Maley Drive, SUDBURY, ON P3A 4R7
705-524-2888 or 705-665-8470
office@tesman.ca

Figure 4: Fixed All Around Hood on a basket

TesMan Incorporated
1545 Maley Drive, SUDBURY, ON P3A 4R7
705-524-2888 or 705-665-8470
office@tesman.ca

Figure 5: A Fixed Hood on a Basket

FEEDBACK FROM OCTOBER AND MARCH DEMONSTRATIONS

The first series of demonstrations of the prototype / proof of concept were in October. The objective was the demonstration of the functions of cleaning the holes based on previous months mapping of cleaning process. The feedback from team observers was:

- It was possible to clean all holes

- It was possible to clean loose material off the lifter holes, after the round had been cleaned out by a scoop tram and then a backhoe, leaving small material, as shown in the November report
- The crew favoured starting the cleaning process with the standard ANFO non static / semi conducting cleaning hose. If they encountered an obstacle shy of the planned 14.5

foot drilled depth of the hole, then they fell back first on the endoscope to confirm if it was a blockage or a short drilled hole, finally the impact hammer to clear the blockages

- The average cleaning and loading process was a little more than double the regular time to clean and load manually.

- The loading time alone was approximately equivalent to the regular mining process, namely 2 minute per hole or 2 hours for the entire round to be loaded

CAPPING CHOICES FOR 6 AND FOR 12 FEET BACK FROM THE FACE

The project looked at the entire development cycle, as shown in the earlier reports. After solving the cleaning and loading situation, there are a number of other choices to make, for the client to complete a cycle away from the face:

- Procedure to change bits on the jumbo without going close to the face

- Method to scale the face

- Type of capping process to use

A jumbo boom or the entire jumbo can always be retreated from the face to change bits and there are a number of scaling options available on the market. Capping however is a little more complex, and there is a significant complexity and cost difference between the choices. The choices available are as follows:

- Non Electric Shock Tube Caps– Series of Different Timed Delays fired with Detonator Cord

- Non Electric Shock Tube Caps– Identical Delay Bunching without a detonator cord

- Electronic Caps

- WiFi Caps

The strategy with connecting caps a distance of 6 feet from the face was described in the earlier reports, as using a grounded non static sheppard hook to pull them to the loader basket, if

necessary hang them from a wire across the back, and lead the firing circuit back to the main firing line.

The physical and financial risk of each process is as follows, to be considered in making a choice of how to connect and fire a round without approaching the face closer than 6 feet:

- **Non Electric Shock Tube Caps with differing delays** – most economical cap type, but not suitable for hanging long tails from the holes, due to the risk of the shrapnel from the detonating cord piercing the shock tubes and rendering them non fireable resulting in misfired holes

- **Non Electric Shock Tube Caps with identical delays** – most economical cap, these caps are bundled and require no detonating cord which making them totally suitable as a choice of a round requiring a long tail to hang from the holes to any distance

- **Electronic Caps -** cost approximately 6 times the cost of a non electric shock tube, and no risk of misfire with tails hanging from the holes. A suitable choice.

- **WiFi Caps** – cost is the highest but unknown. Presently being testing in large production holes but not available to development sized packaging for approximately 10 to 12 months, and no tails will be required. A suitable choice.

INFIELD ANALYSIS OF PROOF OF CONCEPT EQUIPMENT FOR PRODUCTION DESIGN

After the initial demonstration of the cleaning function of the equipment in October 2015, the equipment was kept UG for testing by TesMan working with the client.

The prototype equipment was used to clean, load, and unload ANFO, with nonel and electronic caps. This process was completed over a period of approximately 9 weeks. The objective was to be fully prepared for the loading and blasting of tunnel faces.

LOADING AND FIRING A ROUND WITH ANFO AND ELECTRONIC CAPS

Of the capping choices described above, the first round loaded and fired was completed with ANFO as the blasting agent and using electronic blasting caps. ORICA supervised the programming of the IKON system available in the client mine for production.

The round was loaded and fired successfully.

RESULTS AND IMAGES FROM EXTENSIVE TESTING OF THE PROTOTYPE UNIT

Although the prototype equipment took longer to clean and load a round than the manual process there were quite significant improvements. These improved results and capabilities are the basis of the business case for even the slower prototype process:

- Risk – the entire clean and load process, including the cleaning of the lifters (after the backhoe is complete), was accomplished using the arm, with the operator removed from the risk zone in front of the face, by a distance of 14 to 15 feet (the actual arm extended length is 12 feet).

- Strain – the physical strain induced in the lower back and upper extremities of the operator while picking material out of the lowest row of holes, the lifters, was completely bypassed through the use of the auger tool.

- Advance – the ability to address the plugged 12% of the holes typically found in the tunnel face entirely through the use of the impact tool, verified by the endoscope, reduced the occurrence of reduced advance in any of the holes (see Figure 6 showing a button at the bottom of a hole at only 10 feet versus planned 14.5 feet).

- Advance – the ability to map the cleaned depths of all of the drill holes, enabled the miner to plan the firing sequencing of the drill holes to avoid reliance on any short drilled holes, which are common as observed in every face measured in differing quantities, from 2% to 15%. The faces of the blasted round were sound with very little loose and no bootleg.

- Maintenance – there was an observable difference between drillers and jumbo combinations. Some jumbos were kicking out before the hole was finished to full depth on auto retract far more frequently than others. The tracking of the number of short drilled holes through the use the cleaned hole data provides a feedback loop for the maintenance department to follow up during regular service intervals.

- Depth – similarly the cleaning data identified that some drillers more than others consistently drill short holes, while some drillers take the time to run the steel after auto retract to ensure the hole is at full depth.

- Flushing – also some drillers take time after running their steel to the toe of the hole, to flush and reflush the holes to make sure that they are left as clean as possible. This task made a significant difference to the cleaning and loading cycle.

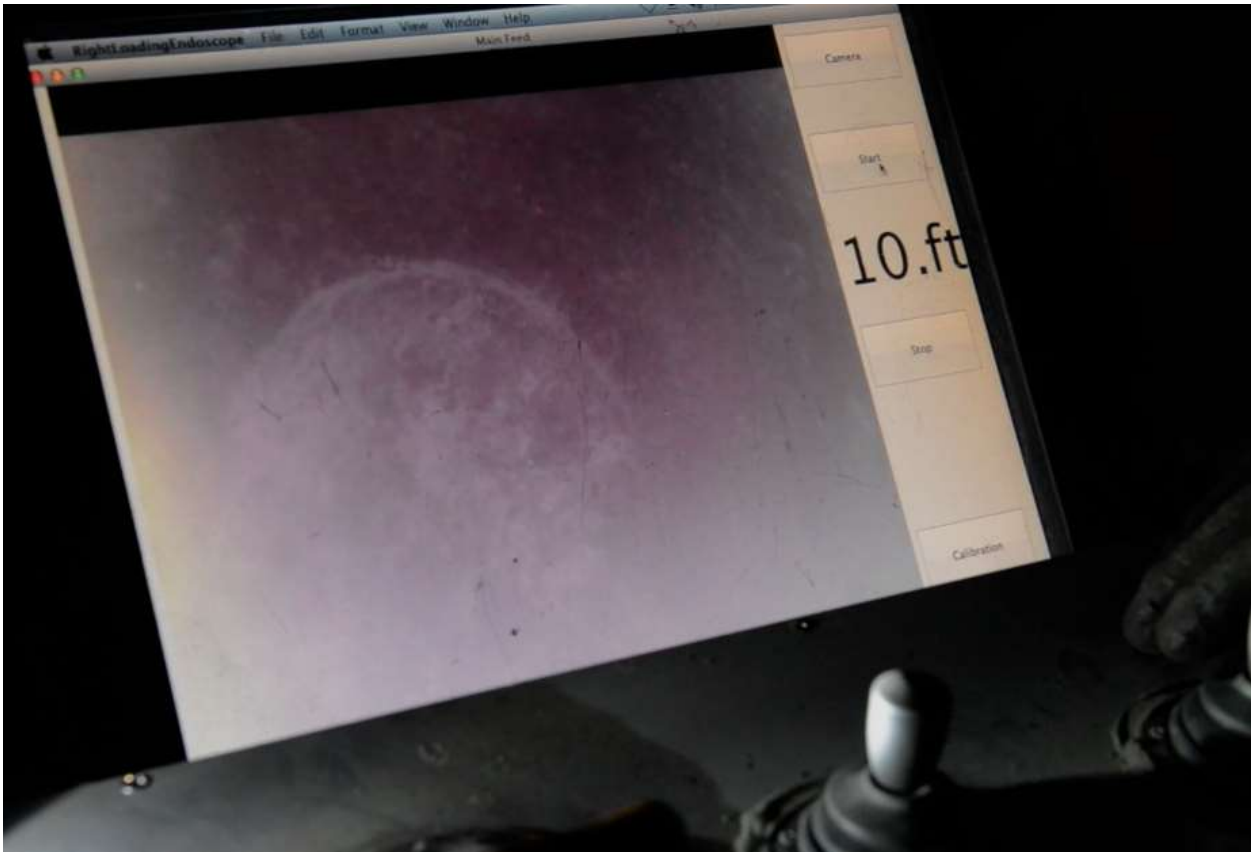

Figure 6 - Showing a Round Drill Button Impression at the Bottom of a Hole at only 10 Feet of Depth Versus Planned Depth of 14.5 Feet.

The following is a series of images describing the standard process of cleaning and loading a blast round in a typical large face. These images are captured from a video of the process also shown on the website:

- Figure 7 – The Face of the Basket Without the Equipment
- Figure 8 – The Face of the Basket in Position Against the Equipment Storage Pallet
- Figure 9 – The Locking Handles Securing the Basket to the Equipment
- Figure 10 – Checking and Releasing the Tools Ready for Use
- Figure 11 – Feeding the Impact Hammer into the Delivery Unit Ready for Use
- Figure 12 – Placing a Detonator Into the Loading Hose
- Figure 13 – Loading a Drill Hole with ANFO

Figure 7 – The Face of the Basket Without the Equipment

TesMan Incorporated
1545 Maley Drive, SUDBURY, ON P3A 4R7
705-524-2888 or 705-665-8470
office@tesman.ca

Figure 8 – The Face of the Basket in Position Against the Equipment Storage Pallet

Figure 9 – The Locking Handles Securing the Basket to the Equipment

Figure 10 – The Equipment in Folded Travel Position with Tools on Reels

TesMan Incorporated
1545 Maley Drive, SUDBURY, ON P3A 4R7
705-524-2888 or 705-665-8470
office@tesman.ca

Figure 11 – Feeding the Impact Hammer into the Delivery Unit Ready for Use.

Figure 12 – Placing a Detonator into the Loading Hose.

TesMan Incorporated
1545 Maley Drive, SUDBURY, ON P3A 4R7
705-524-2888 or 705-665-8470
office@tesman.ca

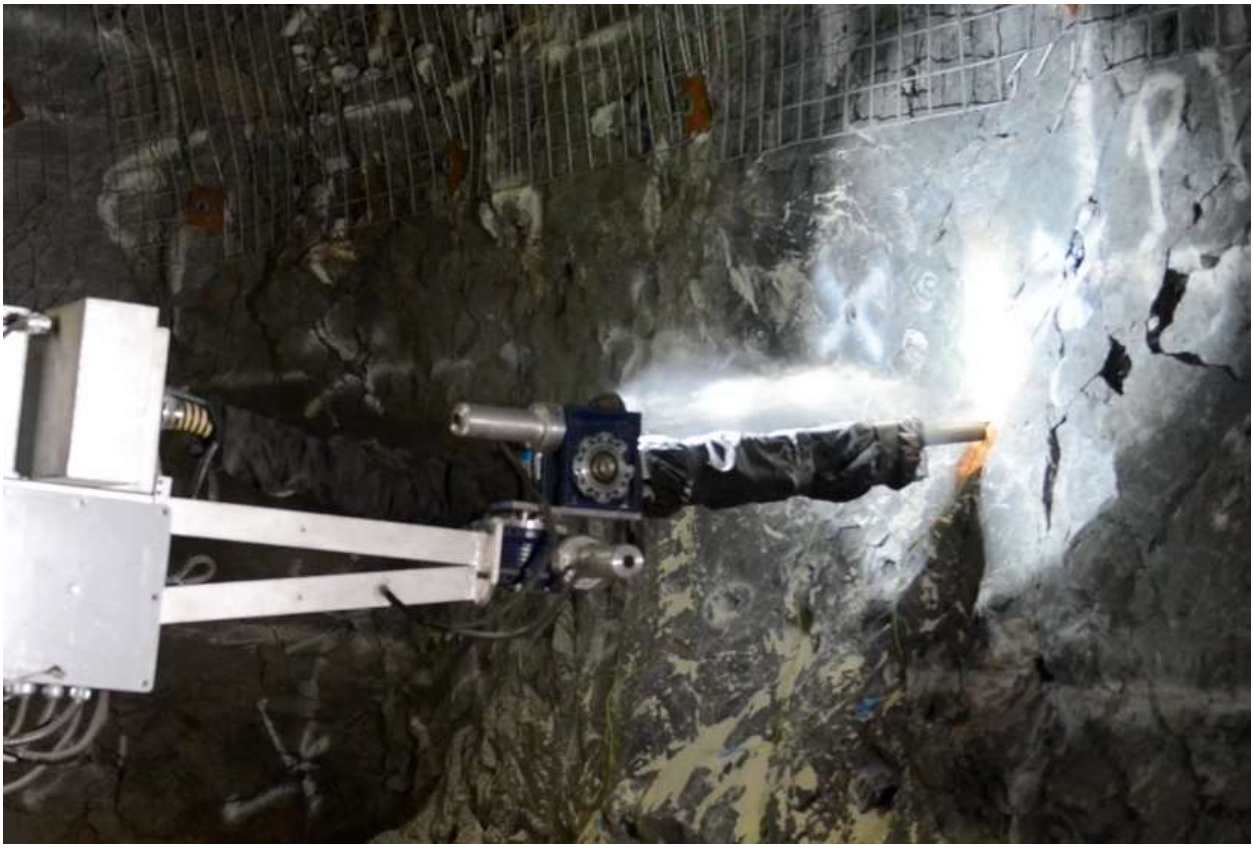

Figure 13 – Loading a Drill Hole with ANFO

CONCLUSION OF PROJECT

If there are any questions regarding the learnings of the project please contact the TesMan office at the contact information on the bottom of each page.

The next step for TesMan and their client is focussing on getting a commercial version to the market for all the mines.

OBJECTIVES FOR THE COMMERCIAL VERSION OF THE EQUIPMENT

The prototype proved the capability of the new mechanised process, but in order to be able to become effective, the commercial version of the equipment must be able to meet the following goals:

- Weight the same or less than the prototype (320 lbs) with the Centre of Gravity as close to the basket as possible

- Capable of cleaning and loading the face at least as quickly as the present manual process or as close to the manual process cycle time as reasonably possible