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

TesMan February 2015
Work Package Report

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EXECUTIVE SUMMARY

The key points this month are:

- The equipment and process design and peer review tasks are on schedule to deliver fabricated components by early April
- The process to finalise the legal elements of fabricating and using new safety devices in the explosive loading and also explosive cleaning processes has started with promising form
- It is becoming clear that the drill hole cleaning tools and methods could be beneficial to the normal development cycle as well as the future remote development cycle in terms of productivity and safety improvements

SUMMARY OF PROJECT STATUS

There are three phases of the project:

- October to December 2014 – Identifying and classifying the typical range of conditions that will be encountered in remotely cleaning the jumbo drill holes, and concepts of tools for the explosives blaster / loader that might deal with these conditions
- January to March 2015 – Designing and fabricating the robotic arm and feed process that is required to allow the blaster to complete the cleaning and loading from a range of 6 feet plus (2 m), mapping the detailed cycle steps of this remote development cycle, and addressing the legal aspects of mechanical loading with shock tube and cleaning emulsion from the blasthole in order to replace fresh emulsion for a clean reblast
- April to June 2015 – Surface assembly, programming and training followed by intense underground testing and use of the equipment in a prototype remote development cycle

The schedule is on track to date. More details on the fabrication schedule is included below.

IMPORTANCE OF CLEANING DATA

In the multitude of workshops and meetings completed in January and February the results of October, November and December have distilled to a single crucial learning that offers low hanging fruit benefit to probably every operating mine relying on drill and blast processes for tunnelling:

Between the jumbo face drilling part of the development tunnelling cycle, and the loading and blasting part of the same cycle, there is opportunity for a distinct drill hole cleaning cycle that generates data including but not limited to depth of the hole cleaned. This data can be used in a closed loop with the drilling and jumbo maintenance process, and the cleaning tools, to ensure that full length drill holes are fully loaded each and every time.

In this scenario, moving forward, there is additional valuable data, to assist in accurate diagnosis of poor blast results, which results in bootlegs on the tunnel face to manage. It also suggests that prior to this new data, we did not have enough information to identify the true cause of bootlegs on the tunnel face, a cheap way to improve advance rates.

APPLICATION OF IN HOLE TOOLS TO MANUAL CLEANING PROCESS

The in hole tools that have been developed , debris flushing tool and the impact tool, are scheduled to be tested in the present normal development tunnelling process through March and April, in time to be refined before May when the Arm and Custom Hose feed equipment comes underground for testing.

The object is for these tools to be available to use in this manual format in regular development wherever the loader / blasters need assistance cleaning, as early as late April.

By the end of June the aim is to have the hose feed ready to use in conjunction with these tools in the regular manual development process, as well as the remote loading processes, to add the data of recorded data to the hole cleaning process.

CLIENT SAFETY DEPARTMENT INVESTIGATIONS

In Phase 1 of this project the client safety department investigated the facts, acts and regulations around the hazard described in many manners including Snap Slap and Shoot. This is the effect of stretching and releasing a shock tube, and risking the detonator exploding. This required resolving to allow mechanical loading shock tube detonators in development small diameter blast holes.

In this phase of the project, Phase 2, the safety ceiling to address is the process of mechanically cleaning emulsion from a drill hole after blasting. The Client Safety Department investigated the rules and regulations pertinent to removing explosives and detonators after blasting.

In the course of March, the design solutions included in the design of the hose feed mechanism, and the conceptual design of a tool to flush emulsion from blast holes, will be investigated and approved for use in the workplace.

CLIENT SAFETY TEAM AND EXPLOSIVE SUPPLIERS FIRST WORKSHOP

The solution to managing the safety solutions of mechanical loading and mechanical emulsion removal is the design of tools that are considered safety devices. Any safety device in Ontario, Canada needs to meet the following conditions:

- It needs to meet the approval on the Ontario Ministry of Labour
- It needs to meet the Acts, Rules and Regulations of the Mining Acts of Canada and Ontario
- It needs to meet the design specifications of the explosive suppliers Explosive Regulatory Group

To ensure that the net benefit reaches the mining industry, the results need to be shared with the Ontario Mining Association.

A team has been assembled to complete the required hazard analysis and approval process, which includes the Client Safety Departments, and the Explosive Suppliers Dyno Nobel and Orica in Ontario.

PROCESS OF PRODUCT DESIGN APPROVAL

Before a new product can be brought onto a Client property TesMan has multi step process:

- Underground evaluation of the work to be completed by the equipment
- Search through many different industries to identify an applicable off the shelf tool
- Conceptualisation of solutions that might work
- Design of the equipment (Version 1)
- Peer Review by Specialist for Critique
- Design to accommodate improvements (Version 2)
- Legal Review for Safety Devices (described above)
- Fabrication
- Testing before release in the work place for refinements

This process is described in the attached document ("Remote Loading Design Flow Chart V 3"0, and includes where TesMan might utilise sub contractors for detailed drawings under TesMan supervision.

ROUND UP OF DESIGN V 1.0 PEER REVIEWS AND CRITIQUES

(1) Robotic Arm Design and Peer Review:

- This is a 2 degree of freedom range of motion design with a 3rd degree introduced by the ability of the arm to be moved manually side to side for transport or extreme reaches
- The single mid point pan and tilt joint allows 360 rotation in x as well as y axis, although this range of motion is limited to slightly less with mechanical stops for simplicity of design
- The arm is capable of reaching 12 feet and carrying a 40 lb load at the end of this reach
- The total arm design weighs in at 140 lbs to be adaptable to most infield boom and basket loading packages, although a thorough engineering review and stamp / sign off is required before mounting the equipment on a basket.
- The pan and tilt is highly gear reduced as well as worm gear torque protected smoothing the motion and increasing the sensitivity of placement on the face, and dramatically reducing the electrical current requirements of the vehicle
- The entire design is robust, with few moving parts and scale able to be applicable other mining applications.
- ABB, the global mining supplier of mine hoists and electrical haulage trucks is also a global supplier of robotic arm, completed a review of the conceptual design with their own teams, and in the form of consulting to support the project, forwarded their critique
- ABB supports the 2 DOF for this prototype application, as well as motor choices although for commercialisation a heavier set of motors is recommended for a longer life in the field.
- ABB recommends using the motor supplier controller boards for their efficiency and industrial robustness

- ABB has offered to review the final design elements and cycle process for further input, and will be involved in the actual tuning and testing underground.

(2) Hose Feed Design and Peer Review:

- The hose feed includes a live calibration process of the torque measuring processes to ensure that the required ceiling of torque applied to the shock tubes can never be exceeded. To ensure live calibration, two separate methods are used and compared to each other in the TesMan controller software. First the motors electrical loads are calibrated for torque applied, second an inline torque sensor has been included, and thirdly twice a year the hose feed is checked against an external mechanical torque measuring process.
- To allow the blaster to replicate the rotation twist they apply manually to move the loading or cleaning hose past obstructions or poor drill hole wall conditions, the hose feed can similiarly rotate the hose left of center and right of center 12 degrees always coming back to zero degrees to ensure no twisting of the detonator cable
- On the exit of the hose feed are a series of brushes to clean off the loading or cleaning hose
- Also on the exit of the hose feed are rotary encoders to measure depth of hose and rate of feed or retract to project on the touch screen for the blaster to measure and record loaded depth.
- The speed and torque of feed are available also to allow emulsion to be loaded through this hose feed
- The difference in speed of encoders and feed wheel records any slippage in the hose feed
- The force applied to the hoses is adjustable manually during service periods
- Atlas Copco, Normet and ABB have reviewed the designs for the Hose Feed and are in the process of generating critique for improvement to complete the planned equipment Peer Review for TesMan

(3) Controller and Screen Design and Peer Review:

- For the prototype cycle TesMan will be renting their own industrial touch screen housing to mount on the loading basket, as well as their own power management and controller boards to be mounted inside the screen housing, and programming of all motor controls and sensor reading for the controllers
- The controllers will read the encoders in the hose feed and robotic arm
- The controllers will control the hose feed and robotic arm motors through their own custom speed controllers
- The controllers will feed this information back to the touch screen for projection and recording for the miners operating the process
- The touch screen will also show the video feedback from the cleaning tool endoscope for the blaster

- These controller designs and touch screen industrial hardened and protected packages have been proved through thousands of hours of underground operation and exposure in other TesMan products and do not require a Peer Review for this application
- All wiring processes will be Peer Reviewed by ABB before fabrication, including the controller and screen power supply and protection

(4) Mounting and Transport Design and Peer Review:

- The goal during March is to complete and Peer Review (ABB) the entire mounting package for the equipment to the loading basket and also to the custom transport base
- The mounting package will include the pallot base that the loading basket and drop the arm and equipment onto, for storage and transport in and out of the mine.
- Maclean Engineering is presently involved in the design and will be the Peer Review for this equipment
- This quick fit process accommodates the lack of level floors in the mine, the need to attach and remove the equipment for service and repair, in a cage able and boom truck suitable format for transport

(5) Post Drill Tools Design and Peer Review:

- The fabrication of the flushing and impact in hole tools is complete and under hazard review.
- Any modifications will be completed and designs updated
- These tools will then be reviewed for approval by the Client Mines for use underground
- These tools will be tested rigorously in the workplace and modified if necessary before May 01 2015
- The Client Blasters and Client Safety Department will be the Peer Review on these tools

(6) Post Blast Tools Design and Peer Review:

- When the approval process for the designed emulsion and anfo flushing tools has been determined (described earlier in this report) the final design of the tools will be fabricated
- These tools will be tested rigorously in the workplace and modified if necessary before May 01 2015
- The explosive suppliers, Orica and Dyno Nobel, as well as the Client Safety Department will lead the product Peer Reviews

DEVELOPMENT CYCLE PLANNING PROGRESS

This is the second month of reviewing the details of the prototype development of the development cycle. The review is being completed with the operations planner for the mine, and the Client Safety Department will be included in a final Peer Review of the proposed cycle before final implementation. In February the individual steps of the prototype process completed are:

- The sequence of actions is completed specifically for the area that the cycle testing will take place which presently includes bolting the entire face of the tunnel before loading to protect the miners from the risk of air or strain bursts, or falls of ground from the face
- The actual units of equipment are generally described and in March will be finalised to ensure the chosen loading basket is suitable for mounting the robotic arm with tools
- A specific area has been chosen for the testing of the prototype equipment as well as the final training of the operators, that is outside of normal production pace of activity, in May 2015
- A specific work area has been identified for the final full paced production testing in June 2015
- The full range of methods and tools has been listed for the process

The next phase of this cycle planning is to schedule testing of all these steps and methods individually in the full production area, to ensure they are effective.

The attached file ("Prototype Cycle V 3") shows the stage of development of this cycle map.

PROJECT COMMUNICATION PROCESS

- CAMIRO (.ORG) has kept their members up to speed on progress
- All project participants have received the reports and designs as they have been completed
- An email list to all interested parties has been kept current
- After an initial delay the project website page will be active in March
- The first quarterly review with sponsors executive teams has been completed

MARCH WORK PLAN

Completion dates in 2015 for the individual tasks is added to their descriptions in the table below:

Basket Stress Map	Accelerometer (3) on Maclean basket	Cancelled
Arm V 2 Fabrication	For assembly / programing by TesMan	March 31
Feed V 2 Fabrication	For programming by TesMan	March 31
Controller Programming		April 15
Mounting Package Design V 1	Concept Completed	March 15
Mounting Fabrication V 1	Including Maclean Attachments	March 31
Flushing Tool V 2 Testing UG	Stainless Steel Final Version	March 31
Impact V 2 Testing UG	Stainless Steel Final Version	March 31
Bow Tie Hazard Review	Client Safety Department Facilitator	March 31
Explosives Workshop 2	With Ministries	April 15