**D1 Project Description**

**PROJECT TITLE**

**Dielectric Sensor System for Intelligent Mud Management using MudMasters®**

**PROJECT QUALITY AND INNOVATION**

**Rational & Aims**

Background

The mining industry with its worldwide export of important minerals forms the backbone of Australia’s economy now and in future. An inevitable consequence of the mining operation is the production of mine waste that has to be safely deposited in tailings storage facilities (TSFs). The recent failures of some TSFs have once again revealed their structural weaknesses, and the threats that are posed by these unique structures to human health, our environment and the economy. Statistics have proven that TSFs fail more frequently than similar structures used as water storage facilities. The main reason for the higher probability of failure of TSFs is the lack in sufficient compaction of the tailings material during deposition and subsequent consolidation. The threats posed by TSFs could be significantly reduced if the tailings material could be more effectively compacted ideally during deposition. One increasingly attractive solution to accelerate densification of mine waste already with its deposition is Accelerated Mechanical Consolidation (AMC) (Fig. 1).

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|  | **Day 1**    **Day 31** | **Day 14**    **Day 43** |
| Fig. 1: Operation of MudMaster® by Phibion Pty Ltd in a copper mine with visible changes of the tailings surface during operation indicating the increase in soil strength. | | |

Significance

Tailings storage facilities need to be constructed and operated in a way that allows the permanent and safe storage of mine waste. There are a variety of technologies that can be used to enable safe storage of tailings. Nearly all technologies require significant capital expenditure on processing operations to dewater tailings prior to tailings deposition. These technologies are all sourced from international providers. Only one technology, AMC, can deliver a similar high-density tailings solution without the need for capital expenditure. AMC is also the only technology developed solely in Australia. This project is significant, since AMC using MudMasters® increases the density of the deposited mine waste by accelerated dewatering ultimately improving the safety of TSFs. Furthermore, the rapid dewatering allows the early reuse of water in the processing plant, which is significant for many mining operations. From an economic point of view, more mine waste can be stored in TSFs if a higher density can be achieved during deposition, which may lead to smaller footprints of TSFs. Ultimately, the closure of TSFs can be simplified and its long-term stability improved, if MudMasters® are used throughout the operation of these structures.

Challenges

MudMasters® move using two Archimedean spirals. The vehicle can float in thin suspensions with the Archimedean spirals acting like inefficient propellors similar to a motor boat. With increasing compaction, when the frictional behaviour of soil starts to influence the performance of the MudMaster® the operation becomes similar to a tracked vehicle. As a consequence, operation of the MudMaster® changes significantly with increasing density. Dewatering of the tailings using MudMasters® occurs due to:

* Drainage of water to the surface, from where it can gravitationally flow to a drainage channel,
* Overcoming of hindered sedimentation, which prevents further consolidation due to self-weight only, and
* Increased evaporation as the soil surface is kept water saturated and thus evaporation at its maximum.

AMC is an emerging tailings management technology. Increasing exposure of this technology to the mining industry requires collection of dewatering tailings data of sufficient robustness to support a TSF business case. Furthermore, the type of tailings sometimes does not allow the operation of the MudMaster® using a human operator. The application of MudMasters® for tailings management can be improved if the following key questions are mastered:

* Which sensing technology can be used to measure the change in tailings density continuously during the operation of the MudMaster®?
* How can the MudMaster® be automatized using information on the density of the soil?
* How can the overall operation of the MudMaster® be optimized based on a comprehensive overview of the density covering the complete surface of the TSF?

Equipped with the appropriate sensing technology, the MudMaster® can be considered as a moving testing facility collecting information on the TSF that can be used at a later stage to assess its long-term geotechnical and environmental stability. For this purpose, the sensing technology needs to allow the measurement of other parameters besides of the density, such as clay content, mineralogy, particle size distribution and metal content.

Overall aim

The overall aim of this project is to develop a sensing technology based on the measurement of the dielectric permittivity for selected frequency windows to quantify the density of tailings as the main targeted information and further parameters that allow a more comprehensive characterization of the tailings allowing the automation of the MudMaster® and an overall optimization of tailings management.

General approach

Preliminary studies of the project partners including the partner organization within a multi-disciplinary Innovation Connections project have proven that the dielectric permittivity can be quantified using directed antennas mounted in an array on the MudMaster®. This approach will be further developed within the proposed ARC Linkage Project. The basic idea is to quantify the dielectric permittivity non-invasively for targeted frequency windows and to use mixing equations to relate these permitivities with soil physical parameters. By doing so, the tailings material within the TSF can be characterized comprehensively. This information can then be further processed to control and predict the quality of the mud farming operation. Laboratory investigations of the project partners have shown that parameters, such as metallic content and particle size distribution can be quantified from this kind of dielectric measurements.

Specific objectives

In order to achieve the before mentioned aim, the following specific objectives have to be targeted:

Obj 1: Development of a non-invasive sensing system to be mounted on the MudMaster® for selected frequency windows that cover a wide frequency range including calibration procedures.

Obj 2: Development of a probe that allows the direct measurement of the dielectric permittivity over a wide frequency range that can be used for calibrating the non-invasive sensing system.

Obj 3: Development of mixing equations for quantifying targeted soil parameters and state variables and to provide a comprehensive database that can be used to optimize and predict the success of mud farming.

Innovation

The main innovation of this proposal is the quantification of the density of mine waste based on non-invasive measurements of the dielectric permittivity. There is no method currently available, which would allow a continuous quality control of the effect of AMC for TSFs. Further innovations are the development of a cone penetration sensor that would allow ultra-wide band dielectric measurements in a frequency range of mHz to GHz and the development of mixing equations, which are required to relate the dielectric permittivity with soil physical parameters. Such a system would indeed allow the introduction of a intelligent tailings management ultimately resulting in the long-term to safer TSFs from a geotechnical and geoenvironmental point of view.

Deliverables

The fundamental investigation of the physical mixing equations to relate the dielectric permittivity to soil physical parameters will ultimately lead to an overall improved understanding of the mechanical behaviour of tailings material. Besides the development of high frequency antennas and a cone penetration sensor, further deliverables will be a Neural Network that is required to analyse the non-invasive dielectric measurements, on site calibration procedures and a database on dielectric and soil physical parameters.