DEVELOPMENT OF A NON-RADIOACTIVE DENSITY METER

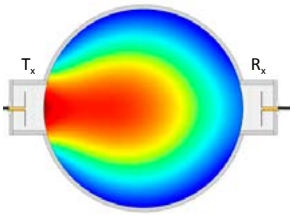
INTRODUCTION

The management of the slurry system plays an important part of a slurry shield TBM operations. Bentonite slurry is used for maintaining face stability and transporting cuttings to the surface. This requires continuous monitoring and control of flow rates and density. The current method for measurement of density is by means of a radio-active (*RA*) source and a detector. Disadvantages of using a radioactive source are numerous, in particular with regard to safety, handling and storage of the device.

IHC has developed a new density meter, the so-called RF meter, which employs harmless radio waves to measure the density of the slurry. This new technology has a proven track record in the dredging industry and can be used as standard equipment; it requires no special permits and is completely safe.

PRINCIPLE

The method is based on the fact that water has a very high dielectric permittivity, compared to permittivity of typical soil constituents. Due to this contrast, the permittivity of waterbased slurry is a strong function of amount of solid particles present in it. Hence, the *volumetric concentration of solids* can be calculated from the permittivity of the mixture.



The measurement is done by a pair of antennas fitted to the slurry pipeline. The transmitting antenna (T_x) creates an electromagnetic field, which penetrates the mixture in the pipe. Field is sensed by the receiving antenna (R_x). Solids present in the carrier fluid affect the received signal amplitude and phase. Those parameters are measured by an electronic circuit, and used for calculation of the concentration.

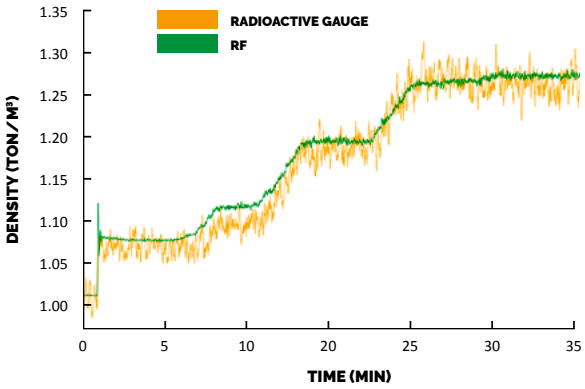
TUNNELLING-RELATED TESTS

In order to provide versatile and reliable measuring equipment for slurry shield TBM operations, a special measurement algorithm has been developed for bentonitebased slurries. The electrical properties of the bentonite fluid and its impact on the measurement had to be assessed.

To experimentally verify the operation of the RF meter in a relevant environment, a custom-made slurry circuit in the IHC laboratory has been used. The circuit contains a 500 mm measurement pipe, which works with double principle: *RF* antennas are fitted next to a RA source and detector. *RA* was considered a *reference measurement*. This test setup enables the recreation of a typical slurry TBM process in the laboratory. Two situations were of particular interest: excavation and build-up of fines after passing through the separation plant.

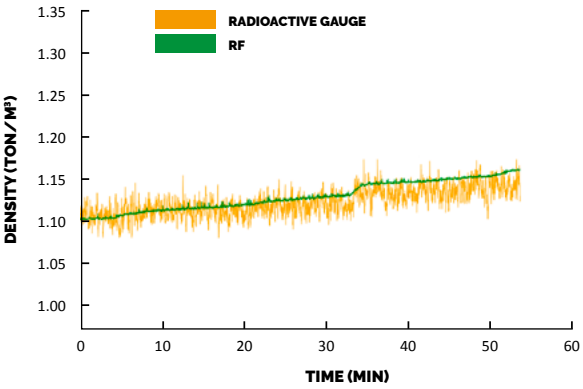
EXCAVATION EXPERIMENT

The circuit was filled with bentonite slurry, density of 1.015 t/m^3, obtained from the TUNNEL-GEL™ PLUS from Baroid. Subsequently, portions of sand and gravel were gradually added to the mixture, until density of 1.28 t/m^3 was reached.



BUILD-UP OF FINES EXPERIMENT

Clay powder Mahlon FT-204 has been used to simulate density increase through fines enrichment. This material was mixed with water and added in small portions to the circuit, which was already running with bentonite and sand mixture. A slow rise of density was observed.



CONCLUSIONS

It has been confirmed experimentally that the RF system can detect solids concentration in bentonite-based slurries, with an accuracy comparable to the conventional RA - radioactive gauge. Density of slurry containing gravel, coarse sand, fine sand as well as clay can be measured accurately by the system.

The RF density measurement system is safe to use and suitable for monitoring the density in slurry shield TBM's, in both the feed line and the return line, as well as in the separation plant.