Advanced Manufacturing of Spirals for Mineral Separation with Integrated Smart Sensing

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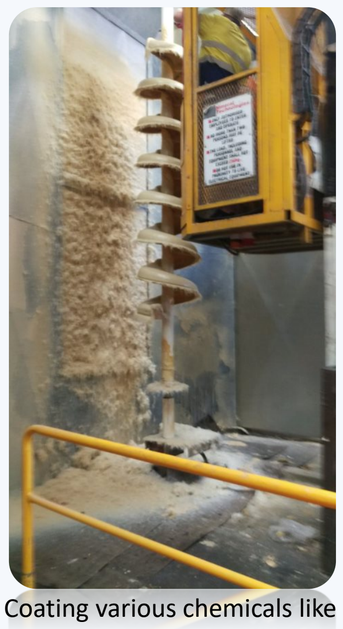
Motivation

Gravity Separation Spirals (GSS) are vital to the mining industry for separating mineral-rich slurry into its different density components. The slurry is pumped to the top and, then the spiral slope naturally helps separate the slurry due to the different particle density. Spiral profile can be slightly varied for every customer, depending on the mineral they separate.

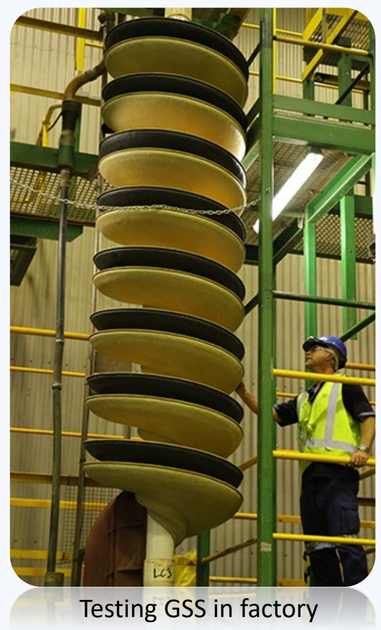
Traditional mould-based manufacturing has the following inherent drawbacks:

- Significant tooling costs
- Uneconomical mass customisation for different mineral types
- Worker exposure to hazardous materials

A mould used to manufacture GSS



Coating various chemicals like fibreglass and polyurethane



Testing GSS in factory

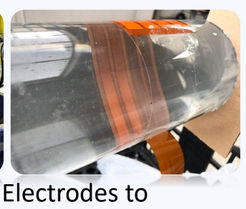
Research and Development Project

The research project is focused on developing a 3D printer to print GSS, which can avoid the drawbacks inherent to the traditional GSS manufacturing process. Another objective of this project is to embed sensors into the 3D-printed GSS for remotely monitor the operational conditions, fault diagnosis, and predictive maintenance. 3D printed sensors are being developed instead of embedding conventional sensors where possible since they are low-cost and can be integrated into the large build volume of the structural material without compromising the mechanical integrity of the object.

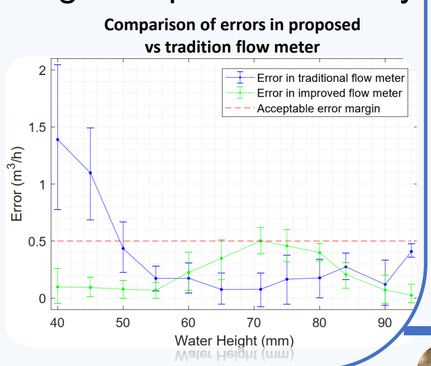
Improved Flow Meter

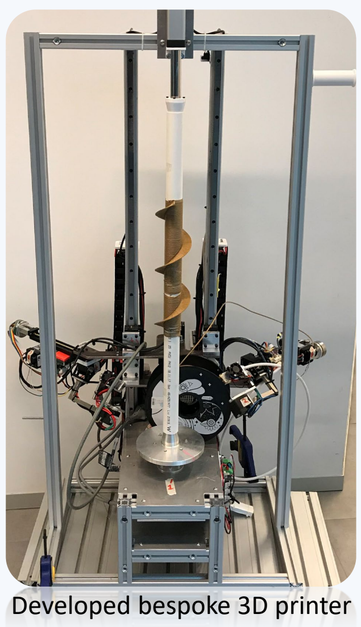
Aim: Develop a flow meter which can perform well with partial liquid levels.
Outcome: Combining ultrasonic flow meter and capacitance-based level sensing to improve accuracy.

Transducers of ultrasonic flow meter



Electrodes to measure liquid level

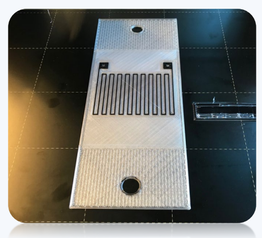




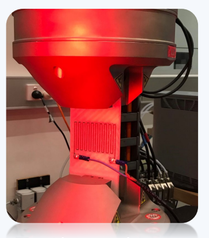
Developed bespoke 3D printer

3D Printed Strain Gauge

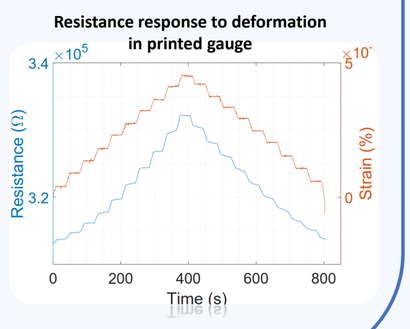
Aim: Embedded 3D printed strain sensor to measure long-term creep.
Outcome: Conductive carbon filament-based traces change resistance depending on the deformation.



3D-printed strain gauge

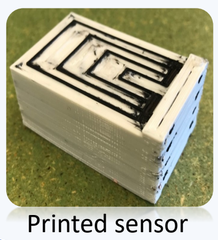


Testing using Instron machine

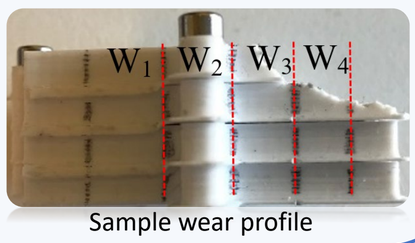


3D Printed Wear Profiling Sensor

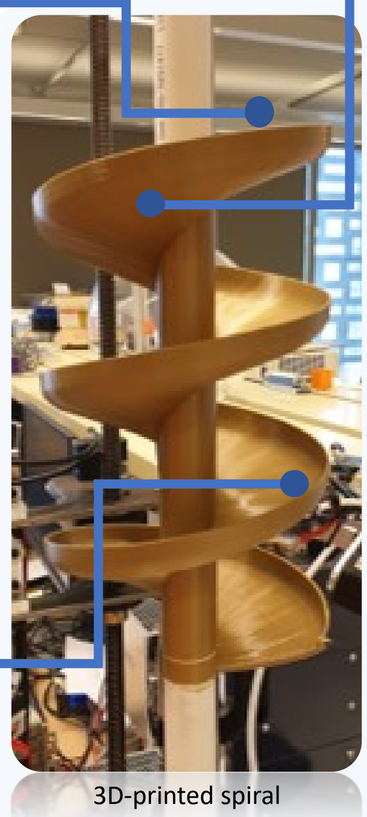
Aim: Embedded 3D printed wear sensor which can measure the severity of wear as well as the location.
Outcome: Uses conductive filament to print a pattern that changes resistance based on both the wear depth and location.



Printed sensor



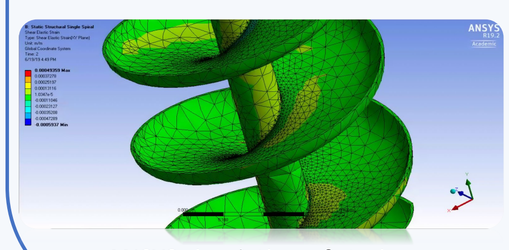
Sample wear profile



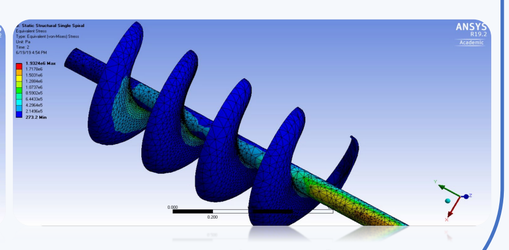
3D-printed spiral

Sensor Placement Problem

Aim: Identify sensor locations to optimise information gain and minimise printing difficulty.
Outcome: Simulated forces spiral subjected to obtain force distribution and define a cost function related to difficulty in printing and use optimisation methods to get sensor locations.



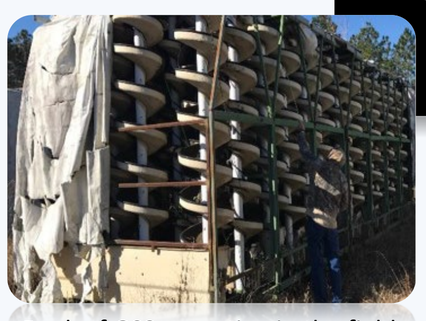
ANSYS simulation of strain



ANSYS simulation of stress

Benefits to the Industry

- Currently, spirals are shipped worldwide, thus shipping the printer instead of spirals will:
  - Reduce transportation cost
  - Reduce damage during transportation
- Easily customisable for different minerals
- Troubleshoot issues remotely and fault prediction
- Provide feedback to operators onsite to change operational parameters to optimise the output



Bank of GSS operating in the field

Locations GSS are shipped

Acknowledgement

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