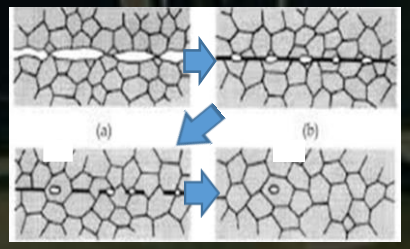
Lunar Mission One: Borehole Lining Stabilisation – Additive Manufacturing

- Lunar Mission One aims to perform an unmanned mission to the moon in 2024.
- The purpose of this mission is to drill a hole ranging from 10-100m in depth
- An archive containing data of life on earth in the borehole – both physical and digital records
- This project focused on methods to stabilise the borehole in-situ whilst minimising material mass and cost.

Ultrasonic Consolidation

Ultrasonic consolidation is a solid state additive manufacturing process. It requires temperatures approximately 40% of the melting point of the manufacturing material. An electrical current passes into ceramic rings (transducer) which oscillate at the frequency of ultrasound. These oscillations will pass through a solenoid into the materials. Through ultrasonic welding, the materials merge together.



Ultrasonic welding breaks down asperities and surface oxides

Advantages

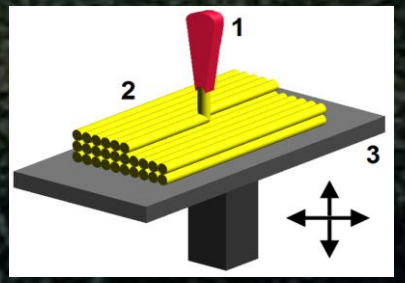
- No heat required, reducing energy use and saving money.
- Reduced contamination and more structural control.

Disadvantages

- Ultrasound vibrations could encourage the collapse of the borehole.
- Transducer can produce limited power, so limits the productivity of casing assembly.

Fused filament fabrication

AM technique in which a spool of molten thermoplastic is cooled to form layers, resulting in a 3D object. A thermoplastic spool is fed into a nozzle. The nozzle heats up the thermoplastic above its glass transition temperature. The thermoplastic is then extruded from the nozzle and cools immediately upon exit.it will then make contact with the borehole lining providing the first layer of casing.



Advantages

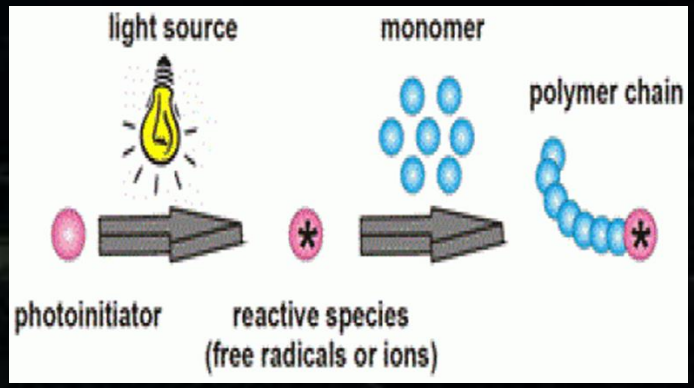
- Relatively quick process as material cools instantly as it leaves nozzle.
- No sensitivity to atmosphere (no carrier gas required)
- Uses durable materials.

Disadvantages

- Structural between layers of casing due to layering.
- Difficulty storing the spool of thermoplastic
- Thermoplastic may warp and bubble if temperature of nozzle too high.

Most Feasible Method: UV Stereolithography

AM technique that uses photo polymerisation to create a 3D structure through layering. A photopolymer resin is sprayed onto the surface of the borehole. Using an LED, UV light is focused onto the resin. As photopolymers are photosensitive to UV light, the resin will begin to harden. This process is repeated to form layers of casing.



Advantages

- Relatively fast process, as printing takes between hours and a day.
- Versatility in design, the resin can be applied in different amounts for different areas which accounts for fractures in the borehole lining.

Disadvantages

- Photopolymers are relatively expensive (Usually cost over £450 per kg) therefore the cost of the mission will be increased because of the amount of resin used.

The use of an UVA LED reduces any complication of applying the casing to the borehole lining as it only needs to be turned on. This method produces a strong, durable casing that will perform its function well.

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