Stabilization of Borehole Lining

Jamie Brooker | Mentor: Johannes Schumacher | Nuffield Project – Lunar Mission One

"The most inspirational Moon project since the Apollo landings!" – Project financing adviser - David Iron

Company

- Lunar Mission One, a crowdfunded mission to the moon.
- Originated in 2007 to increase space operations and discover further pioneering technology

Aims

- To inspire new generation about space, science, engineering and technology.
- Develop better drilling applications for operations on earth.
- Wider space exploration for the Moon, Mars and Comets

Mission Brief

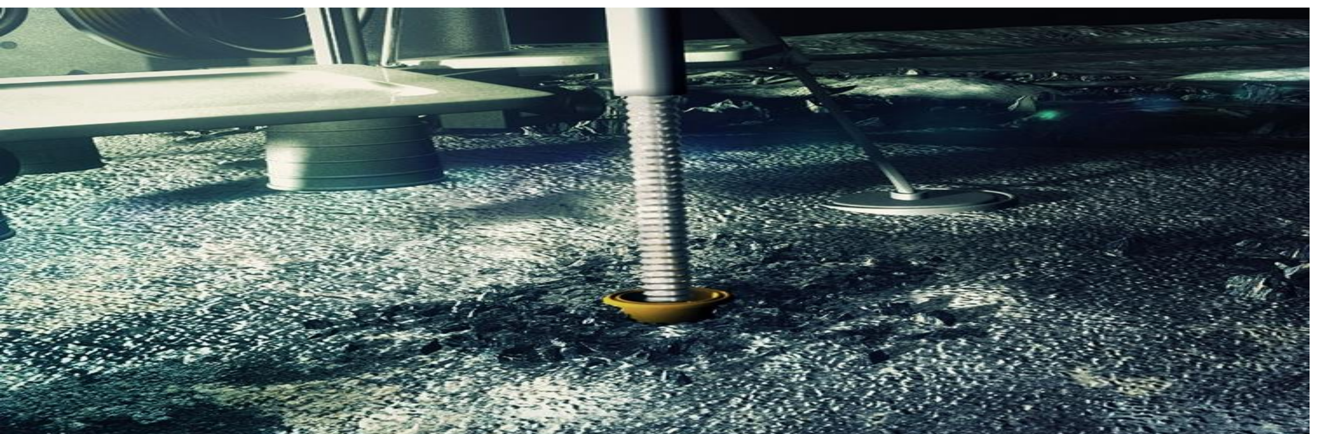
- Scheduled to launched 2024 (~10 year mission).
- An unmanned expedition on the moon.
- Deep drilling at the uncharted Lunar South Pole.
- Aligned to global exploration roadmap.
- Preserving an archive of the life on earth deep into moon surface.
- Commercial management with both public and private sectors .

Issue on 'Direct Influence'

- Borehole Lining;-
- Coring drill will require anchoring for additional forces
- Drilling vibrations may cause bore hole collapse
- Variation of Lunar rock composition is very broad

Resolution of Issue

- Stable and strong casing of borehole walls
- Simplest procedure e.g. (lining intervals every 20cm drilled/energy saving)
- Most capable mission capacity for this stage (least mass)
- Possible In – Situ drilling set up method



Experimenting concept/Results

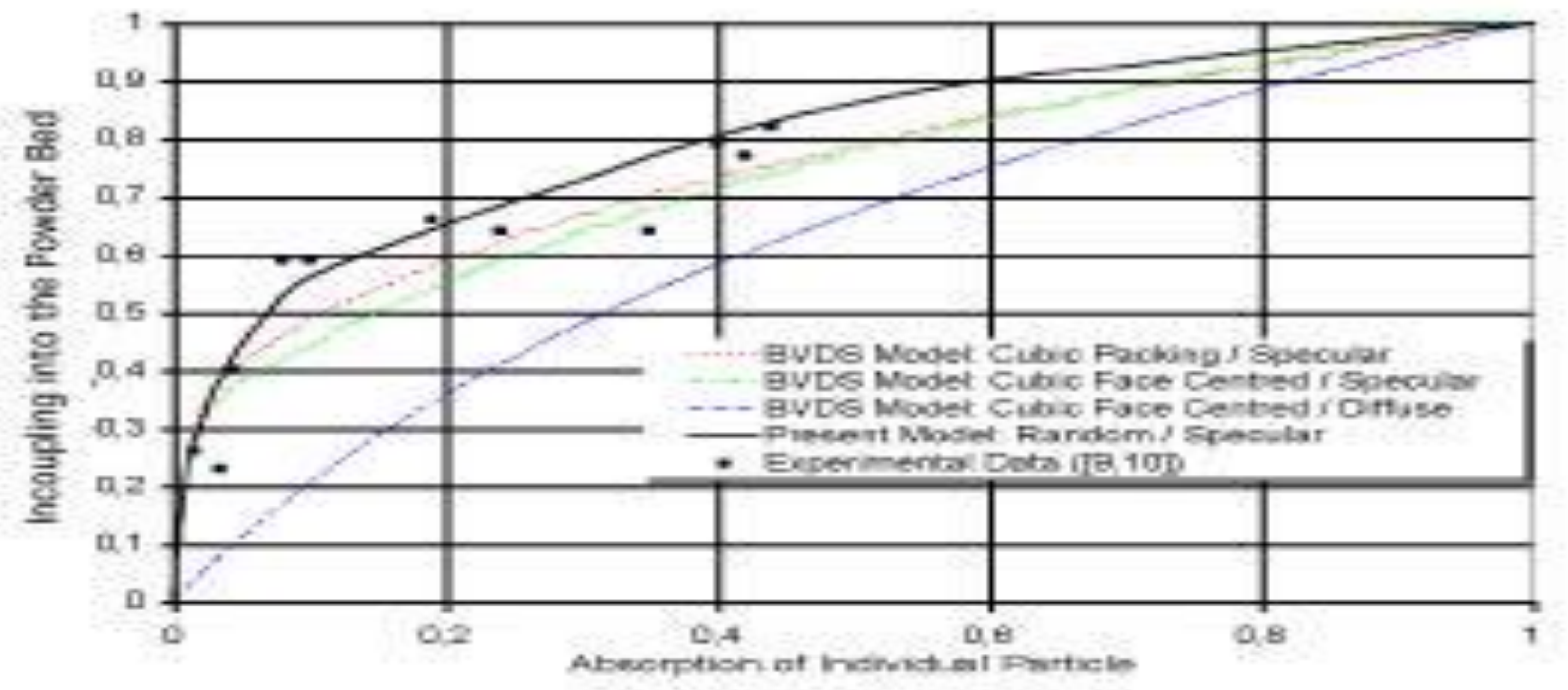
To gain a better understanding and control of the Selective Laser Sintering (SLS) process, simulating the energy absorption and penetration in SLS. Using Fe-Cu and WC-Co powder mixtures which are then irradiated by Nd-YAG laser an evaluation can be given. An analytical ray-tracing model evaluates the total energy in coupling (the ratio between the absorbed and the total input energy) in the powder from the laser, the optical penetration of the laser beam (energy absorption profile in the powder bed depth), for estimating the sintering zone dimensions (thickness/depth and width of a sintered laser track. The experiment is based on following assumptions; A two powder mixture of perfect spheres, all particles are randomly distributed in the space, laser beam strikes the powders perpendicularly to the powder bed surface, particles have a specular reflectivity, absorption coefficients are independent of the incident angle and of the temperature and the powder bed is a vacuum. All energy in pores of powder are conserved – where the impingement of the laser beam is a ratio of absorption and reflection.

Feasible Solution

A method that can be manipulated to accommodate specific parameters. Direct laser sintering involves particles absorbing enough energy to lose density without melting. These particles reform around others , clump together and fuse. This creates a hard, dense casing. SLS is a method that could conserve resources better by sintering specified areas.

LPS involves a powder (singular or a two part mixture), a scraper to displace the powder . Smaller particles with lower melting points bind the larger particles used for structuring . These SLS/LPS could then be alternated throughout the initial 20m and the full 100m as a way to maintain a constant lining density.

Results



Potential Solutions

Laser Cladding

- Combination of metal powder and Laser. Coaxial nozzle deposits powder into laser axis creating a melt zone that is fused onto a substrate through a heat affected zone (HAZ).

Advantages:

- Creates thicker layers offering higher densities.

Disadvantages:

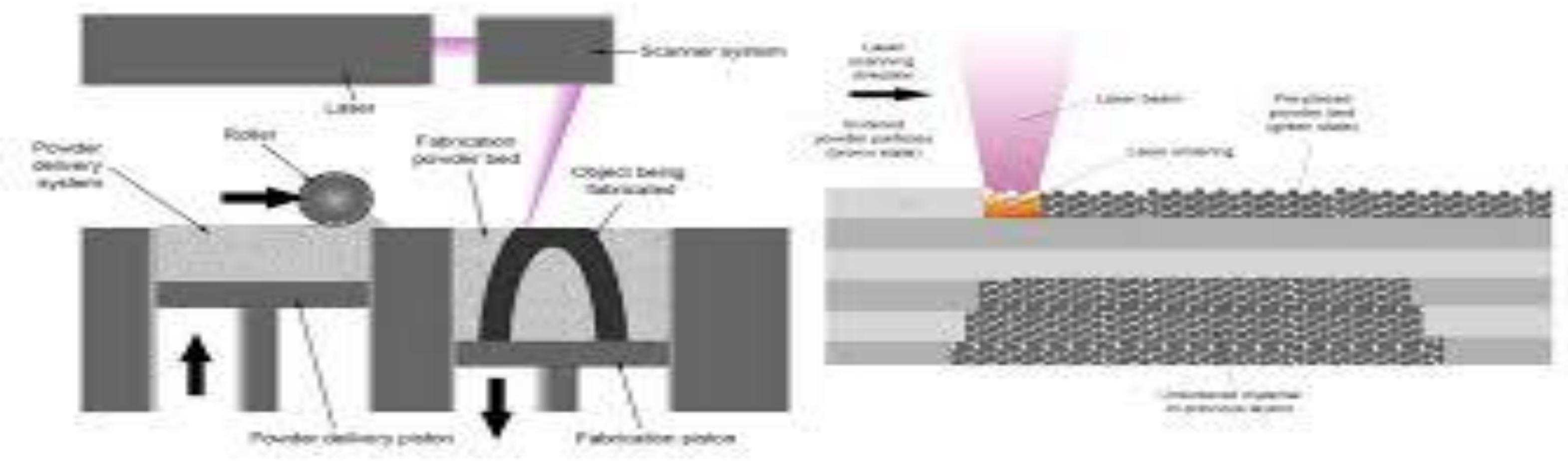
- High energy output lowers efficiency.
- More complex method regarding additional powder and parameters.

Laser sintering SLS/LPS

- Many approaches with this method. - Directly sintering surfaces of materials involves particles absorbing enough energy for their densities to alter. Particles clump together and fuse in place creating a strong, hard and dense casing.
- SLS conserves resources by selectively sintering specified areas (Those of low porosity).
- LPS involves a powder mixture, scraper to spread powder, different melting points of particles. Variation in melting points allows one powders particles to bind the others.

Advantages

- Simplified method compared to cladding.
- Cheaper, less energy consumed.



Fibre Applications

Advantages:

- Fibres offer more efficiency, from lightweight to better durability and vibration resistant.
- Fibres can generally be drawn into wires hundreds of meters long and maintain a very small diameter.
- Have additional reflective capabilities of visible light (Total internal reflection)
- Offer low power loss
- Could be used for communications while being able to conduct electricity from solar power.

Disadvantages

- First-mission critical uses in a space environment are at early stages for this technology to be labelled reliable for space exploration.