ABRASION RESISTANCE OF HARDFACING MATERIALS AND TECHNIQUES FOR LUNAR APPLICATIONS. INTRODUCTION TO LASERCLADDING.

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Introduction: For the lunar excavation activities, the abrasive nature of the lunar regolith has to be addressed.

Any formation cutting activity is subject to material loss of the cutting components due to wear & abrasion. Many wear resistant materials and techniques have been created in the past to address this issue.

When protective coating for the base material is considered, there are two main aspects to keep in mind:

1) The technology used to apply the protective layer.
2) The protective material itself. Different industries have different names for it: hardfacing, coating, overlay etc.

In this poster a relatively new concept will be presented – laser cladding.

Laser cladding is a laser welding process where individual weld beads are aligned and stacked onto a substrate material[1].

For the purpose of this discussion tests of the two wear resistant coatings will be considered.

Discussion. The same wear resistant material can develop different properties (hardness, abrasion resistance etc.) depending on how they are applied to the base material. Pic 1 is an example of achieved hardness with Stellite 6 coating:

Welding process	Hardness Stellite 6
Torch applied	38-44HRC
TIG	40-44HRC
PTA	46-48HRC
Laser	50-52HRC

Fig 1. Hardness of Stellite 6 based on different processes.

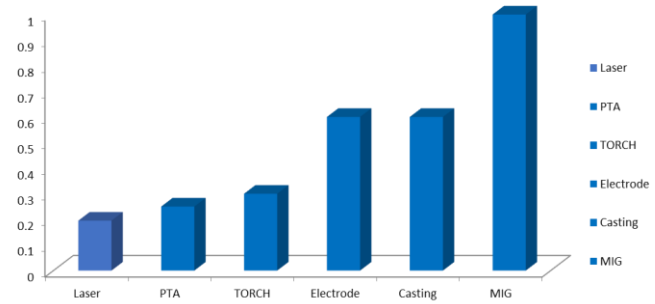


Fig.2 Mass loss based on different hardfacing processes [2]

There are other advantages of laser cladding over other types of hardfacing [3]:

- True metallurgical bond
- Low heat affected zone
- Low porosity
- Complex geometry

This study[4] demonstrated that laser cladded tungsten carbide (Material 2) has superior performance in drilling and excavation of the regolith, compared to similar hardened products. Material 1 is closely following Material 2 in this comparison.

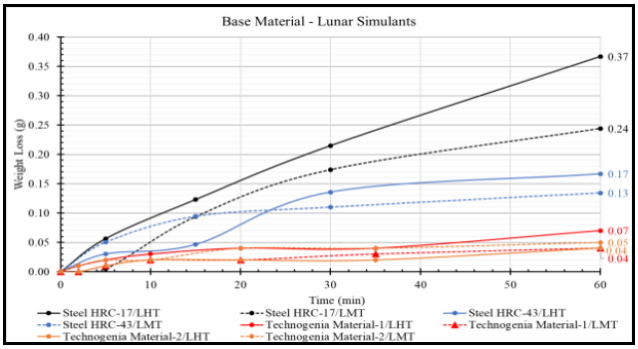


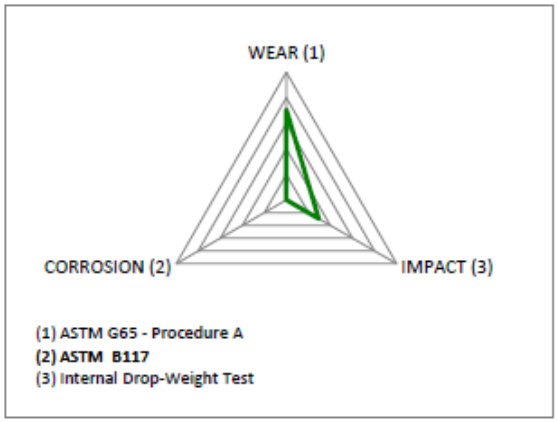
Fig 3. Soil Abrasion Test Results - CSM Sand [4]

Both materials outperformed other types of hardfacing materials during the test.

Material 1[5] **:** The powder is designed to improve the performance of components operating in environ-

ments where both impact and severe abrasive wear occur.

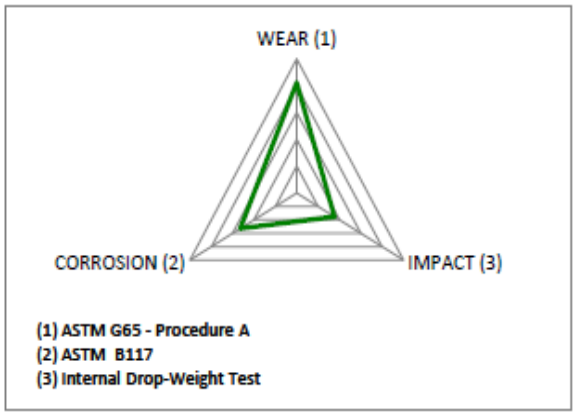
Key Characteristics:
Coating density: 6.5 - 7.5 g/cm3
Hardness: 64 HRC



Material 2:

The hard phase provided by Spherotene® (spherical cast tungsten carbides) combined with a nickel-based matrix translates to high abrasion resistance with fair impact resistant properties and an overall great resistance to corrosion. This material shows a great balance between wear and impact resistance.

Key Characteristics:
Coating density: 11.0 - 12.0 g/cm3
Hardness: Matrix 47 HRc, Hard Phase 2700HV0.2
Composition: 60% WC, 40% Matrix.



Material 2 seems like a perfect solution for many terrestrial application. Would this be the best material for drilling in the lunar regolith? The concern about weight of the material comes to mind. It can be adjusted by the composition of hard phase and matrix as well as by the applied thickness.

Conclusions. While superiority of laser cladding over other types of hardfacing technologies is hard to argue against, the choice for protective coating for excavation in lunar regolith has a development path ahead.

Some key input parameters to consider while developing the coating are lunar regolith particle size and shape, composition, presence of sharp edges, impact processes, moisture content.

The key output parameters would be the desired hardness, layer thickness, desired abrasion/impact/corrosion resistance.

A composite material with tungsten carbide hard phase could be a good solution once the desired key parameters are defined.

References:

[1] P. Cavaliere (2021) *Laser Cladding of Metals*, Springer (pp 1-2), Lecce, Italy

[2] Institut de soudure France (French Welding Institut)

[3] S. K. Selvaraj et al. (2020) *Performance Comparison of Advanced Ceramic Cladding Approaches via Solid-State and Traditional Welding Processes: A Review*

[4] Ishaq M, Rostami J et al (2023). *The Impact of Abrasion Resistant Materials on Performamance and Tool Life of Lunar Surface Exploration and Mining Units: an Experimental Study.*

[5] Mouradian Y (2019) *Technogenia Product Data Sheets Handbook.*