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

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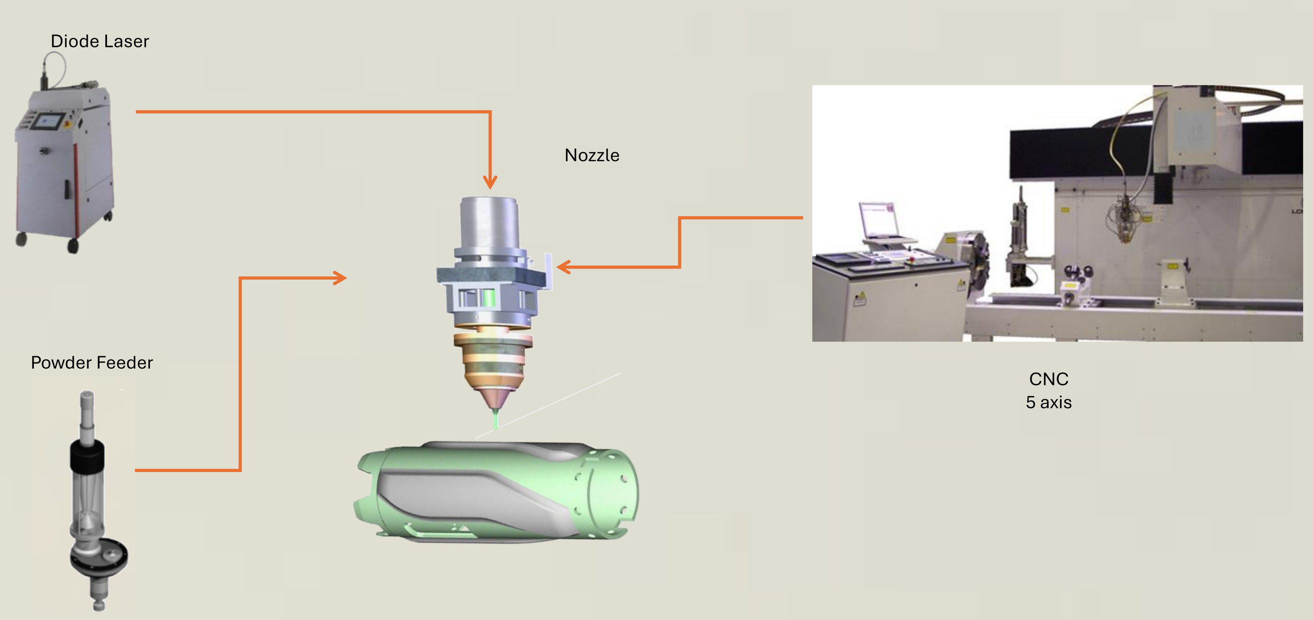
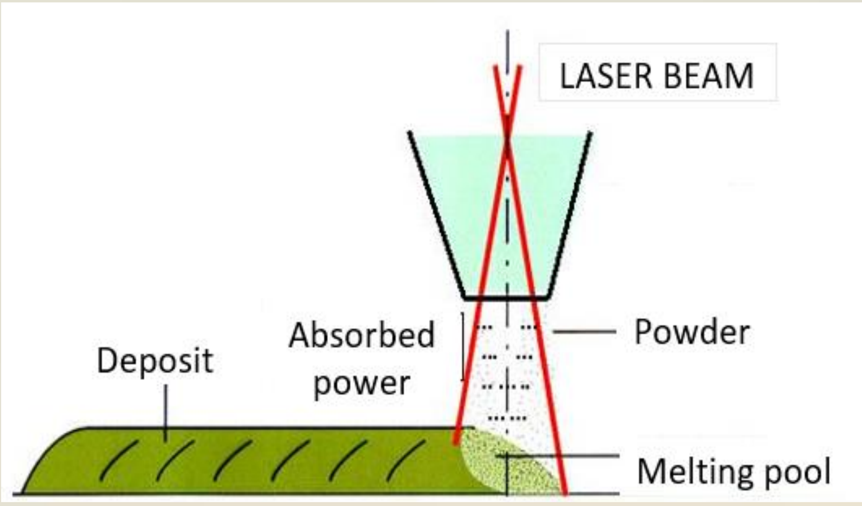
LASER CLADDING TECHNLOGY OVERVIEW

Laser cladding technology utilizes a high-energy laser beam to melt and fuse a coating material onto a substrate surface. The process involves focusing the laser beam onto the workpiece surface, creating a small molten pool. Meanwhile, the coating material, typically in the form of a powder or wire, is simultaneously fed into the molten pool. As the laser moves along the substrate, the coating material melts and solidifies, forming a metallurgical bond with the substrate. This results in the deposition of a wear-resistant coating layer with excellent adhesion and minimal heat-affected zone. The precise control of laser parameters allows for customization of coating thickness, composition, and microstructure, making laser cladding suitable for a wide range of applications, including surface hardening, corrosion protection, and repair of worn or damaged components.

Laser Cladding Process Diagram





Metallurgical aspect and advantages:

- Heat input control (through the accuracy of the laser)
- Low dilution with the base material (< 1%)
- True metallurgical bonding
- Fine metalurgical structure due to high solidification rate
- High density deposit .025-.065 (no porosity)
- Limited distorsion
- Precision and reliability of the process
- Possibility to apply several layers of material
- Possibility to remanufacture

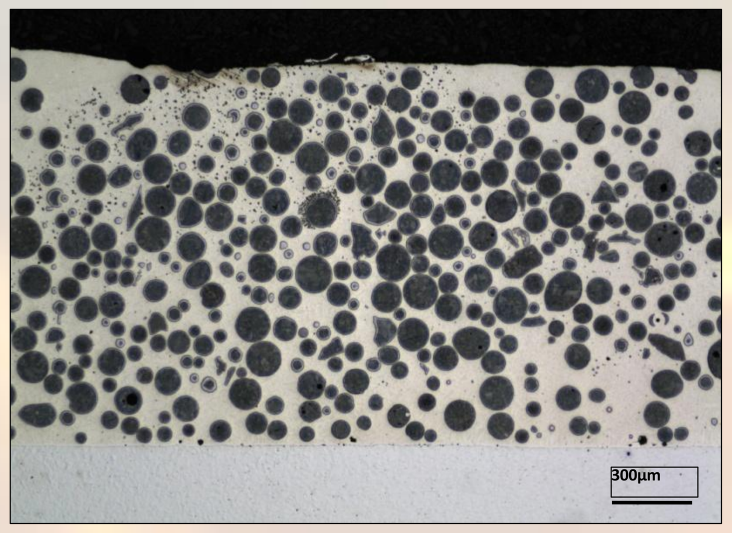
INTERNALLY TESTED MATERIALS

Technolase® 30S Nickel-based powder with Tungsten Carbide

Technolase® 30S is a powder for Lasercarb® - a type of laser cladding process.

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.

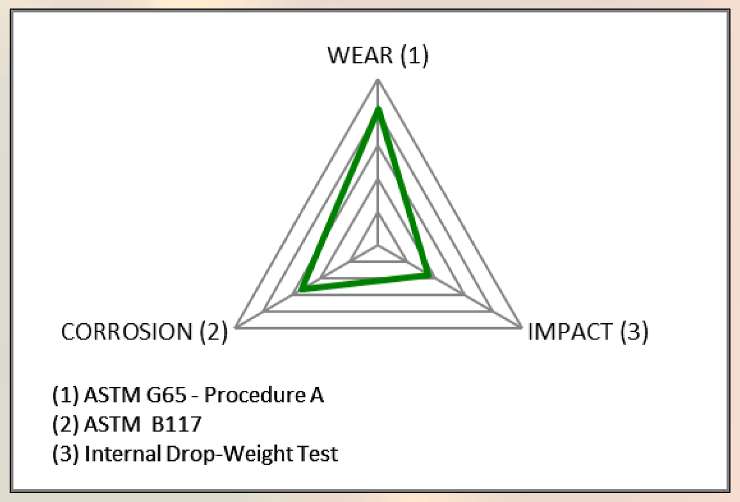
Technolase® 30S is the most employed powder from the Technolase® family , showing a great balance between wear and impact resistance



Typical Lasercarb® overlay cross-section of Technolase® 30S

General Facts		
Classification		**Carbide Blend**
Application		**Wear**
Coating process		**Laser Cladding**
Service temperature		**≤ 500°C (930°F)**
Hard phase/Matrix ratio		**60/40 (w%)**
Chemistry	Matrix	**Ni-B-Si**
	Hard Phase	**WC-W2C**
Carbide Morphology		**Spherical**
Key Characteristics		
Coating density		**11.0 - 12.0 g/cm3**
Hardness	Matrix	**47 HRC**
	Hard Phase	**2700 HV0.2**
Standard layer thickness		**1.0 - 1.5 mm (0.040 - 0.060 in)**
Multilayer		**Yes (2 max)**
Roughness1		**1.0 - 1.5 µm (40 - 60 µin)**
Machinable		**No[2]**
Cracking sensitivity		**Yes**
Porosity sensitivity		**No**

[1] After "standard" grinding (with a diamond wheel)
[2] Part has to be ground



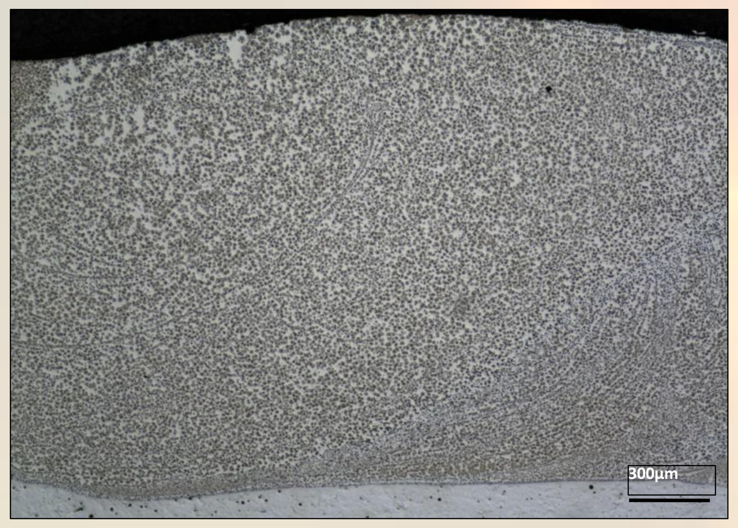
Technolase® 30S properties

R706 Iron-based powder

R706 is a powder for Lasercarb®, a laser cladding process.

The powder is designed to improve the performance of components operating in environments where both impact and severe abrasive wear occur.

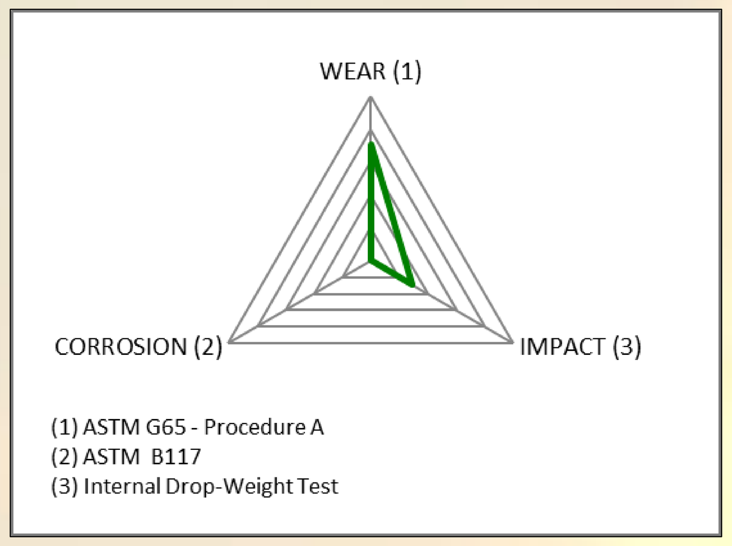
It has a martensitic structure with finely dispersed hard vanadium carbides giving excellent wear characteristics and a consistent high hardness together with a good impact resistance.



Typical Lasercarb® overlay cross-section of R706

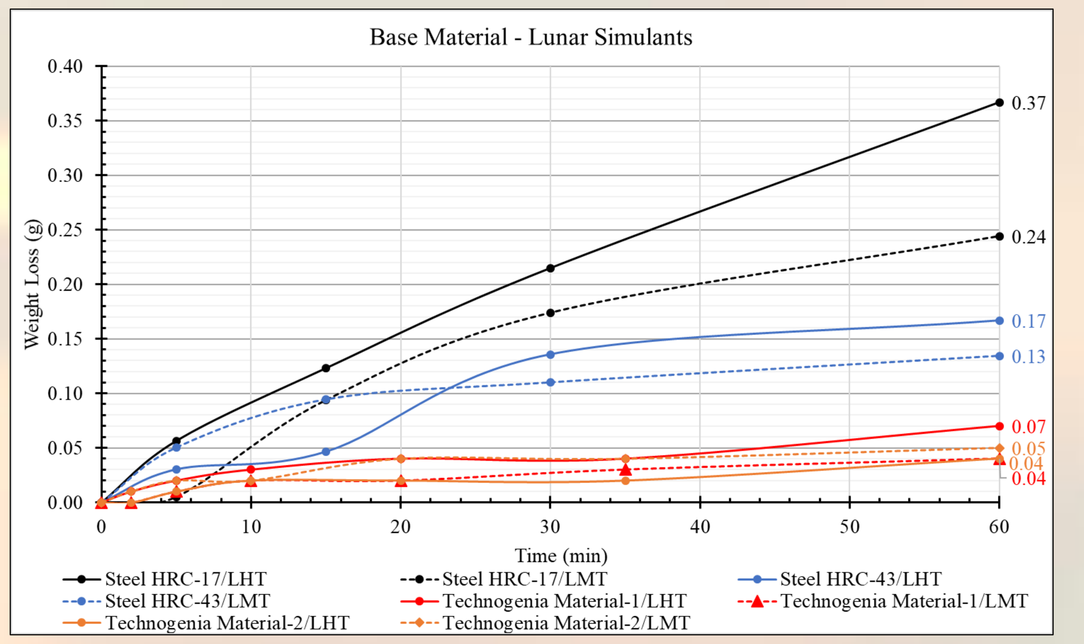
General Facts	
Classification	**Iron-based alloy**
Application	**Wear**
Coating process	**Laser Cladding**
Service temperature	**/**
Chemistry	**Fe-Cr-Ni**
Key Characteristics	
Coating density	**6.5 - 7.5 g/cm3**
Hardness	**68 HRC**
Standard layer thickness	**0.040 - 0.060 in (0.8 - 1.5 mm)**
Multilayer	**/**
Roughness1	**0.8 - 1.0 µm (30 - 40 µin)**
Machinable	**No[2]**
Cracking sensitivity	**Yes[3]**
Porosity sensitivity	**No**

[1] After "standard" grinding (with a diamond wheel)
[2] Part has to be ground
[3] Crack-free overlays are achievable



R706 properties

MATERIALS TESTED WITH CSM



Tested at Colorado School of Mines using the SAI (Soil Abrasion Index) test machine with support of Dr Jamal Rostami & Muhammad Ishaq

CONCLUSIONS & FUTURE WORK

Using hardfacing materials is indispensable in the lunar mining environment due to the extreme conditions present on the Moon's surface. Lunar mining equipment faces significant wear and abrasion from the harsh lunar regolith, which contains abrasive particles that can quickly degrade exposed surfaces. Hardfacing materials provide essential protection by forming a durable and wear-resistant coating on mining equipment components. These coatings help extend the lifespan of equipment, reduce maintenance downtime, and ensure optimal performance in lunar mining operations. By incorporating hardfacing materials into equipment design and maintenance strategies, lunar mining operations can enhance efficiency, productivity, and overall mission success in the challenging lunar environment.

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 Met-als, 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 Ap-proaches via Solid-State and Traditional Welding Processes: A Review
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Acknowledgement

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