POLISHING PROCEDURES FOR IMPROVING SUPERFICIAL QUALITY WITH ADDITIVE LAYER MANUFACTURED PARTS USED IN TYPICAL AEROSPACE/PROPULSION APPLICATIONS

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Additive Manufacturing technology, particularly Selective Laser Melting (SLM), has revolutioned the manufacturing industry, opening up new opportunities in several sectors and in particular in the field of space propulsion. The ability to create intricate geometries with integrated features offers numerous advantages, leading to a significant boost in performance. An example is represented by the combustion chambers with integrated regenerative cooling channels, where key advantages are reflected on the components in several ways:

1. Thermal and general performance efficiency;
2. Fuel Consumption Reduction;
3. Enhanced Reliability and Operational Durability;
4. Weight and Engineering Reduction.

Furthermore, the use of Additive Manufacturing technology often helps to reduce costs associated with waste material (during the reworking), as it enables the production of near-net-shape components with advanced geometries. This becomes particularly advantageous for expensive materials, such as Invar or nickel-based superalloys.

However, it is crucial to emphasize a significant disadvantage of components printed using Additive Manufacturing, which is the high surface roughness. This roughness negatively affects the performance of the components.

The main effects are related to pressure losses caused by increased gas flow resistance due to rough surfaces. This results in reduced efficiency in thermal energy transfer and fluid acceleration. Additionally, lower surface finish quality increases the risk of fractures and structural failures.

To mitigate this disadvantage, in-depth study of polishing procedures employed on surfaces created through Direct Metal Laser Melting (DMLM) is essential.

Some promising approaches involve the use of abrasive particles, for example in Vibratory Polishing (VP) or Abrasive Fluidized Bed Machining (AFBM), that has proven effective for polishing components manufactured using Additive Layer Manufacturing (ALM). During the vibratory polishing process, metal parts are placed in a tumbler with an abrasive media and water. The tumbler vibrates, causing metal parts to rub against the media until the metal parts are polished as needed. They then may go through a drying or cleansing process. AFBM consists of a granular medium, such as fine sand or abrasive microspheres, which is fluidized by a flow of gas or liquid. Fluidization creates a dynamic environment where abrasive particles interact with the surface of the component to be polished, gradually smoothing out irregularities and surface roughness.

Figure1 - As built vs superficial polished Inconel part

The proposed techniques offer several advantages, including:

1. Improved Surface Finish: Abrasive particles smooth the surfaces, reducing roughness and enhancing aesthetic appearance.
2. Efficient Removal of Unwanted Materials: Abrasive particles act as polishing agents, effectively removing unwanted materials present on the component's surface.
3. Adaptability to Various Geometries: Fluidized beds are adaptable to different component geometries, including those with complex shapes or curved surfaces.
4. Control of Process Parameters for Repeatability: Process parameters for polishing using fluidized beds can be controlled and adjusted to achieve repeatable and high-quality results.

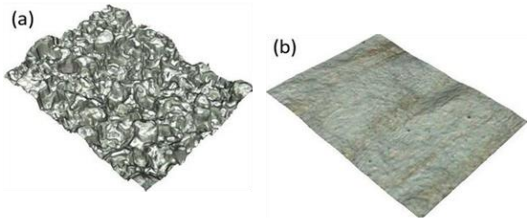

Figure2 – Surface roughness before and after polishing treatment with fluidized beds

Also other parallel superficial finishing technology will be explored like tumbling, laser polishing in association with the printability analysis of several materials of Nichel based super-alloy (typical of aerospace application).

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