Ph.D. COURSE IN INDUSTRIAL ENGINEERING – XXX CYCLE

Student: Paolo Argenio

Supervisor: Prof. Vincenzo Sergi, Prof. Fabrizia Caiazzo

Abstract of the thesis

In the industrial field the employment of innovative fabrication technologies is emerging to the purpose of cost reduction and flexibility. In particular, great interest is addressed to additive manufacturing (AM) techniques, which allow to obtain complex parts based on CAD models. AM enables the fabrication of parts with complex geometry that are impractical to be manufactured using conventional subtractive manufacturing methods.
Basically, all of the AM techniques employ the same basic principle: the final component is fabricated by means of layer by layer addition of the material.
Today, in addition to plastic material, several metallic materials including steel, aluminium, nickel-based superalloys, cobalt-base alloys and titanium alloys may be processed to full dense parts with properties complying with the requirements of industrial applications. There has been particular interest in aerospace and biomedical industries owing to the possibility for high performance parts with reduced overall cost for manufacturing.
For the aerospace industry this could lead to a reduction of required raw materials used to fabricate an in-service component, which is known as the "buy-to-fly" ratio. AM could also lead to new innovations for lightweight structures for several applications. Repairing and overhaul of in-service parts is possible as well. Furthermore, AM provides the potential to enable novel product design which would be impossible to be managed using conventional subtractive processes.

The research activity has been focused on ***Additive Manufacturing of metal alloys for aerospace applications***. Namely, these topics have been investigated:

- Redesign and production of moulds for investment casting of turbine blade with powder-bed based additive manufacturing instead of conventional technique of machining by CAD/CAM technologies.

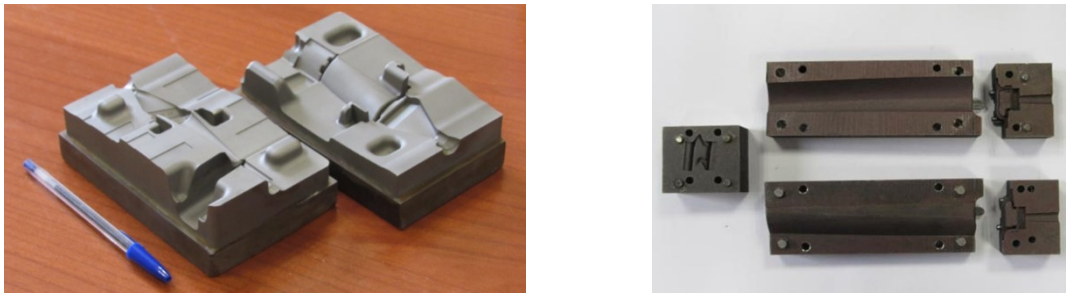

Figure.1: AM-made investment casting moulds for turbine blade

- Job-design and optimization with powder-bed based additive manufacturing. Application of this process has been investigated as an advanced industrial prototyping tool to manufacture Inconel 718 turbine blade at a pre-design stage before flow production. The mechanical properties of the base metal has been discussed via tensile testing.

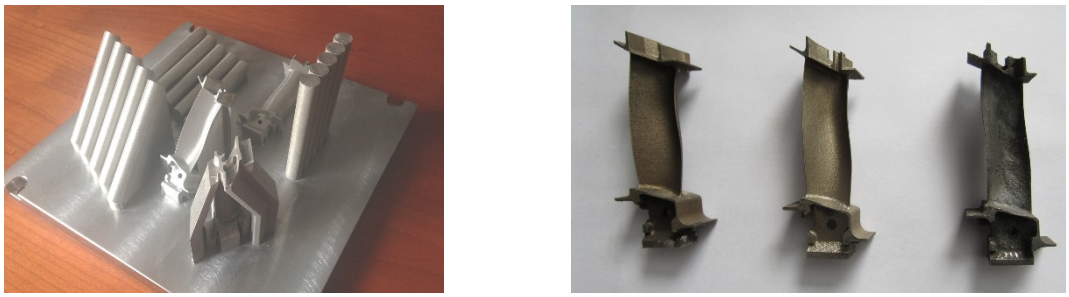

Figure.2: AM manufacturing Inconel 718 turbine blade

- Repair and overhaul of condemned parts of high complexity and expensive manufacturing cost with Directed Metal Deposition (DMD) of powder.
  This process is receiving increasingly interest in aerospace industry since it allows minimal distortion of the work-piece, reduced heat-affected zones and better surface quality in comparison with conventional coating and repairing techniques such as arc welding or plasma spraying.

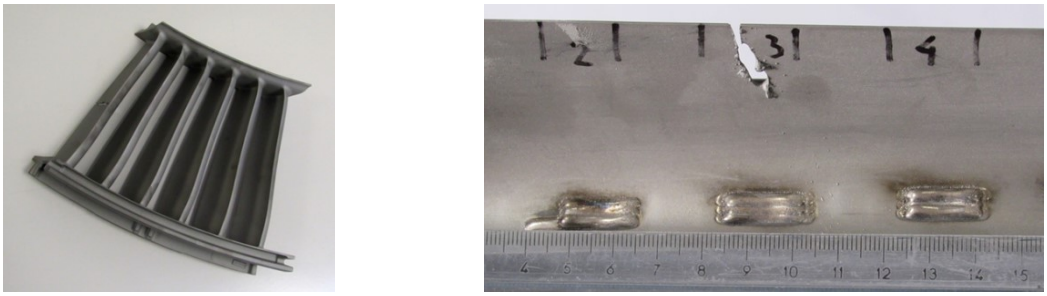

Figure.3: nozzle guide vane repaired with DMD of powder

- Optimization: since surface quality may limit the application of the AM part if compared with conventional metal manufacturing processes such as machining, proper means to address the surface roughness must be investigated.
  Extensive research, experimental trials and computational prediction are hence aimed to optimization of the processing parameters and the exposure strategies to set up the process, nevertheless, post-process is required. Surface modification by means of laser beam is effective as possible post processing treatment over stainless steel components resulting from AM, in order to improve the surface topography.

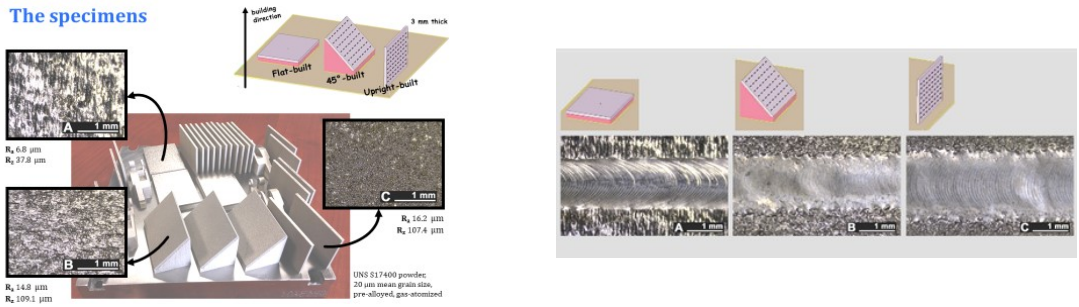

Figure.4: optimization of surface quality of AM specimens