Study, development, and fine-tuning of manufacturing process of complex geometry parts by additive manufacturing of multiphase materials

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Additive manufacturing (AM) is a process that allows objects with complex geometries to be made by layered material deposition. AM is considered an environmentally friendly manufacturing technology compared to traditional subtractive technologies because layered material deposition occurs only where it is needed, rather than depositing excess material and then discarding it. Optimized, lightweight geometries and environmental impact during the life cycle of the part must be considered in the design phase.

By 3D printing, additive technology allows materials to be assembled by making graded structures of functional properties (electrical, thermal, mechanical properties) and physical properties (e.g., porosity) that can meet the growing demand for multifunctional materials. There are different technologies for 3D printing, some methods use materials that fuse (fused deposition modelling, FDM), sinter (selective laser sintering, SLS), or react to produce layers (Multi jet Fusion, MJF).

FDM technology presents a versatility of materials suitable for production to make durable composites with complex and porous geometries and show a high degree of precision and repeatability compared to other 3D printing technologies; it is also an easy-to-use technology and ideal for the realization of multifunctional nanocomposites from the electrical, thermal and mechanical points of view [4]. The major limitation of this technology is the scarcity of functional materials, which are necessary in order to take full advantage of the technology and thus make responsive structures with graded properties and capable of exhibiting anisotropic behaviour with respect to specific properties (e.g., antibacterial properties and mechanical properties). In order to solve this issue, it may be extremely useful to implement and develop the concept of composite materials, which are made by dispersing fillers, usually inorganic and nanosized, within a polymer matrix and controlling their dispersion, spatial distribution, and filler-polymer interface. These parameters govern the transfer of properties from the filler to the composite, allowing for a composite with structural and also functional properties.

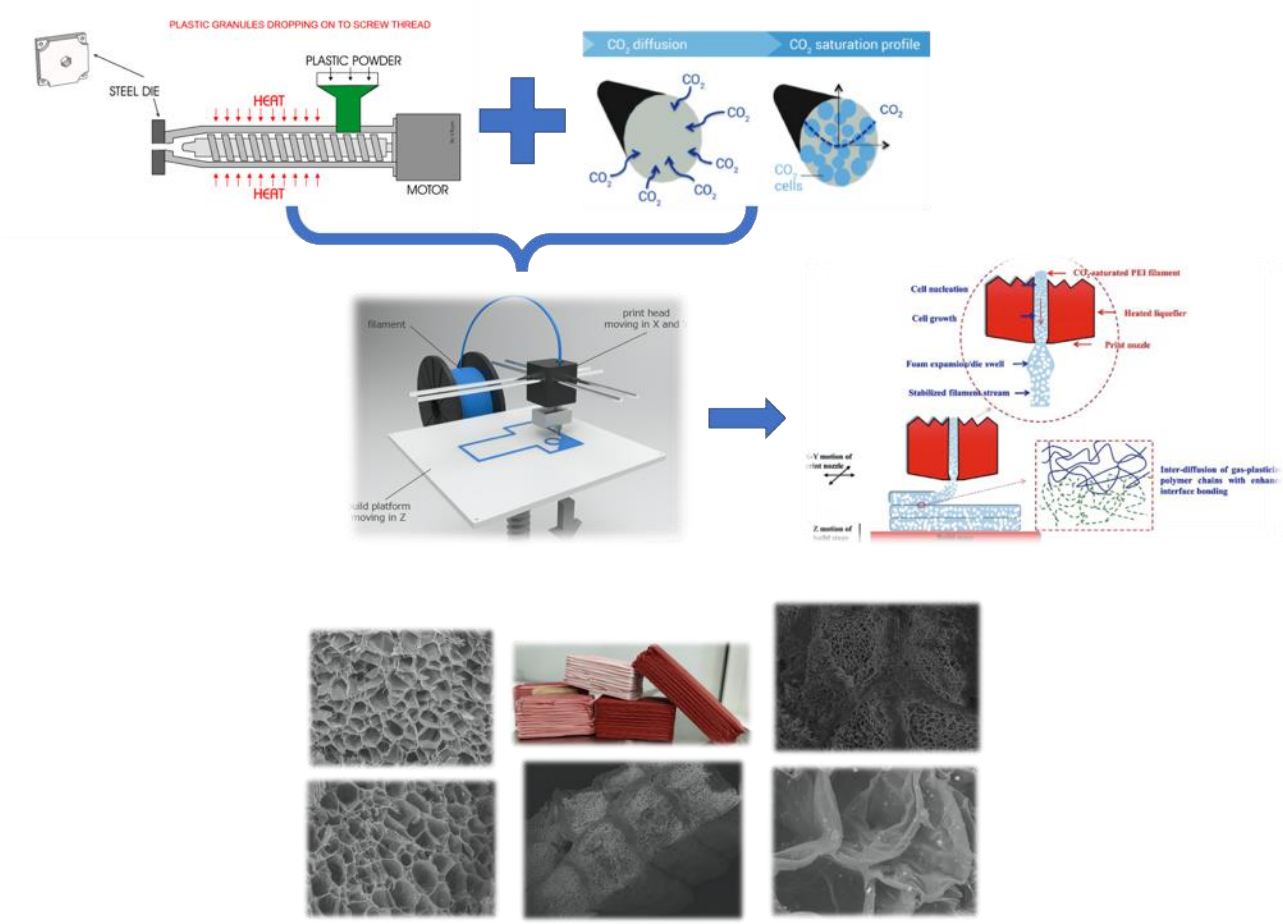
PROJECT OBJECTIVES

One of the main issues concerning AM manufacturing, it turns out, is precisely the design of parts that have geometries designed for this technology and that can be printed with the help of as few or even no supports as possible and, above all, in the shortest possible time. However, the main issue in the field of additive manufacturing technologies concerns the realization of multifunctional nanocomposites with high geometric precision and containing excessive energy consumption during the process phase.

Therefore, the project aims to study and develop technologies and methods to control the intrinsic properties of multifunctional materials and, the reduction of energy consumption due to the Additive Manufacturing process by modulating the printing speed, printing temperature and resolution.

The project was divided into steps in such a way that the objectives set and the time taken to achieve them could be easily monitored, without prejudice to the monitoring of the proper progress of the project. In particular, a brief explanation was made of the objective to be achieved in that specific step, in terms of modus operandi and timing. There are some steps and they involve the following:

- evaluation of the intrinsic structural properties of the nanofillers dispersed in the polymer by standard preparation and innovative method;
- evaluation of functional properties (mechanical, thermal, morphological) of 3D printing samples;
- evaluation of printing parameters, (extrusion temperature and extrusion speed) for energy consumption reduction;
- mechanical, microstructural and physical properties of printed parts.



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