

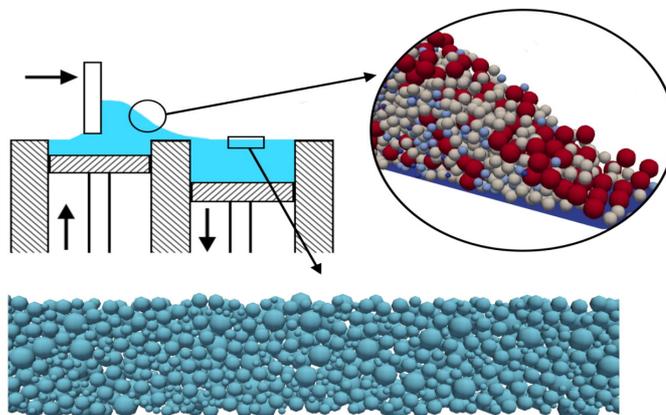
NUMERICAL SIMULATION AND EXPERIMENTAL VALIDATION OF THE SPREADING PROCESS IN ADDITIVE MANUFACTURING



Valerio Lampitella – Advisors: Prof. Antonello Astarita, Prof. Gaetano D'Avino

Curriculum: Tecnologie e Sistemi di Produzione

In the latest year Additive manufacturing has step into the limelight among the manufacturing technologies due to its flexibility, versatility and overall intriguing potentialities. In opposition to more traditional subtractive manufacturing technologies the additive manufacturing, also referred to as 3D printing or rapid prototyping, have virtually no limits regarding the shape of the part to build, being it that of external or internal features. Moreover, it enables for the production of fully customizable parts and geometrical complex parts without the additional burden of designing the productive process and any of the tools needed for the production (e.g. molds, tools etc.). In fact, using an additive manufacturing approach, no matter the geometry of the part to be printed the equipment requires no substantial adjustment. It is worth to mention that the term additive manufacturing refers to a broad family of technologies that share the same basic principles. The American Society for Testing and Materials (ASTM) defines the additive manufacturing as “n—a process of joining materials to make objects from 3D model data, usually layer upon layer, as opposed to subtractive manufacturing methodologies. Synonyms: additive fabrication, additive processes, additive techniques, additive layer manufacturing, layer manufacturing, and freeform fabrication” and some of the main technologies are the following: Binder jetting, an additive manufacturing process in which a liquid bonding agent is selectively deposited to join powder materials. Directed energy deposition, an additive manufacturing process in which focused thermal energy is used to fuse materials by melting as they are being deposited. Focused thermal energy means that an energy source (e.g., laser, electron beam, or plasma arc) is focused to melt the materials being deposited. Material extrusion, an additive manufacturing process in which material is selectively dispensed through a nozzle or orifice. Material jetting, an additive manufacturing process in which droplets of build material are selectively deposited. Example materials include photopolymer and wax. Powder bed fusion, an additive manufacturing process in which thermal energy selectively fuses regions of a powder bed. sheet lamination, an additive manufacturing process in which sheets of material are bonded to form an object. Among the number of diverse technologies, the more promising for the 3d printing of solid metal parts are the powder bed based. Moreover, the powder bed is present in several of the presented groups. Despite the aforementioned advantages of the powder bed based technologies some question are still open. Namely, the main issues are related to the repeatability of the process and to the stability of the mechanical properties throughout the printing chamber. Such discontinuities are probably related to the uneven characteristics of the powder bed in its loose state. In investigating the spreading process, one can resort to both an experimental and numerical approach.



However, it is worth to highlight the impact that the optimization of the spreading process can have on the final outcome of the additive manufacturing and on the characteristics of the final part. More specifically, identifying the spreading mechanism and how the process parameters influence the powder bed characteristics (i.e., the local packing fraction, the local layer thickness, the local surface roughness and the local particle size distribution) enables to select the optimal parameters and to tweak the whole process to match the theoretical values obtained. The objective of the 3 years of Ph.D. activities is to study the powder spreading process in powder bed based additive manufacturing technologies. The main scope of the work is to identify the state of the powder bed after the spreading process in order to identify how the process parameters influence the final outcome (i.e. the loose powder bed) and its characteristics (i.e. density, compaction, particle size distribution, particles segregation etc.) and therefore identify the optimal process parameters (i.e. the recoating device's speed, the powder layer thickness, the recoating device's material and shape) to avoid inhomogeneity, defects and to achieve an overall better quality of the powder bed. More specifically, the strategy is to use a calibrated numerical model based on the Discrete Element Method (DEM) to identify the spreading mechanism and to validate said numerical model using a purposely designed experimental device. Part of the activities will be related to the developing of a reliable strategy to detect the physical characteristics of the powder bed of interest.

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