Design of Experiments Techniques Applied to Numerical Simulation of Microwave-Assisted Debinding of MIM/CIM Parts

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DoE techniques can be successfully applied to numerical simulation, in order to reduce the number of simulations runs and to investigate non trivial interactions among the variables. In this case, a series of "virtual experiments" is performed, and the simulation results are used as a measure of the expected results. This approach is particularly useful when a large number of physical experiments are not feasible, due to lack of time or high costs, and when optimisation procedures involve many interacting variables and multiple conflicting objectives.

The debinding process is a preliminary step, prior to sintering, which consists of the removal of the organic binder used during forming of metal or ceramic "green" parts. Debinding can be performed either by chemical methods (solution) or thermal methods (melting or oxidation), or a combination of the two. Generally, the thermal debinding process requires a very slow and controlled heating in order to avoid generating overpressures in the green parts which could induce distortions, cracking or unwanted porosity and roughness.

Microwave assisted thermal debinding of parts obtained by Metal Injection Moulding (MIM) or Ceramic Injection Moulding (CIM) could benefit from the heating selectivity, having the organic binder to preferentially absorb microwaves, thus accelerating the conventional process, which has to rely on heating by conduction. This is particularly useful when dealing with ceramic powders having low thermal conductivity, but also more conductive materials can be treated faster if the maximum temperature difference inside each part is kept low.

The software Design Expert v.6 was used to reduce the number of virtual experiments needed to gather information regarding the optimisation, in terms of speed, heating homogeneity and energy efficiency of the early stages of the microwave assisted debinding of MIM/CIM parts in an existing 2-feeds multimode applicator operating at 2.45 GHz. The software Concerto 4.0 (Vector Fields, U.K.) was used to perform the virtual experiments. The obtained model was used to determine the optimum debinding conditions, which were experimentally tested in the multimode applicator, operating at 2.45 GHz. Sample characterisation, before and after sintering, was used to confirm the validity of the obtained results.