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Thesis Title : NUMERICAL ANALYSIS OF ADDITIVE MANUFACTURING OF MARAGING STEEL

THESIS REPORT

Selective laser melting uses metal power to produce almost fully designed part. CAD data is being converted to a format suitable for additive manufacturing machine. That part is being produced layer by layer. Power is applied on the building platform with the re coater. Then the laser melts and completely fuses the powder according to the shape of part to be produced. Platform is then lowered to one-layer thickness and again a powder layer is applied. Process is repeated layer by layer and each successive layer fuses with other in order to form the final product. Density as nearly as cast part can be achieved using this process.

The main purpose of this thesis is the modeling of melt pool, estimation of temperature profile, maximum temperature and melt pool depth in maraging steel SLM components considering some common parameters of power, speed, spot size, penetration depth etc. Study and simulation is done using APDL part of ANSYS analysis software. The reason behind this popularity is its low weight combined with high strength and fracture toughness.

Temperature dependent properties are entered into the system for analysis. In present analysis a small cuboidal shape model is chosen to do the analysis. Model is having the dimensions of x = -0.6e-3 mm, y = 1.25e-3 mm, z = -0.8e-3 mm. After meshing the maximum number of nodes formed are 39401 and elements are 36818. These elements and nodes are selected to keep the simulation time and accuracy reasonable. Transient thermal analysis type is chosen with newton Raphson method for solution.

In this case, standard processing parameters are selected with speed ranging from 400 to 1000 mm/s and power from 80 to 120 W. Temperature and melt pool depth for 3 layers with combination of processing parameters is simulated. The final results of the simulation successfully matched with the experimental study done in the literature. A sample result of the simulation is shown below

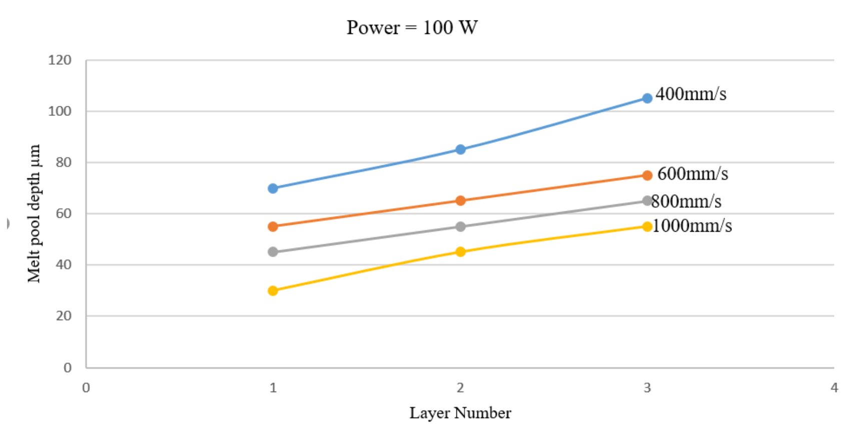

Figure 1 : Behavior of maraging steel

After finishing the thesis, a study of thermal behavior in 316 L. is also conducted. The main aim of the research was to study in detail the role of design of support structure on thermal behavior and its role in residual stress development. Standard processing parameters are chosen for the research. Based on the set of parameters pseudo-steady state time is evaluated. Thermal behavior including cooling rate, thermal gradient and solidification rate are evaluated by changing the design of support structure. It has been found that variation in design have significant effect on thermal behavior.

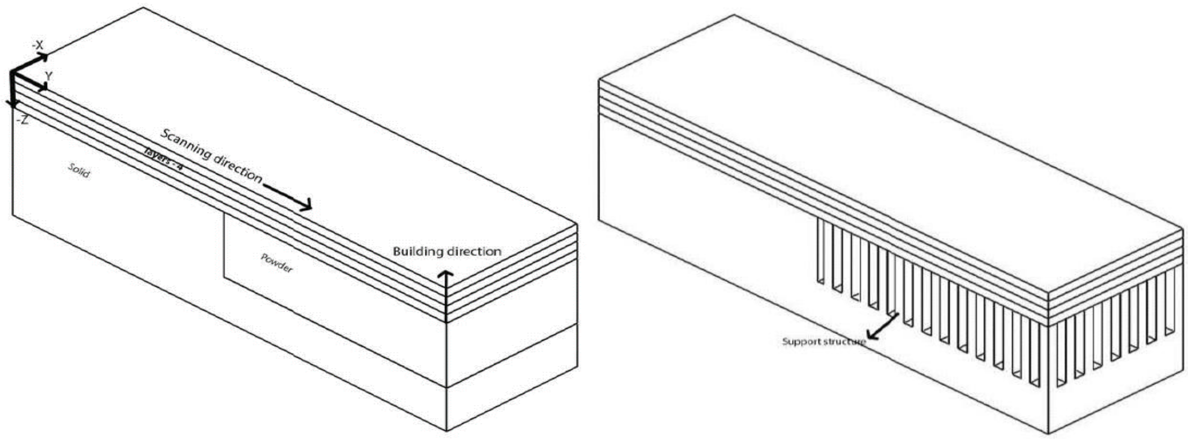

Figure 2: Design of various support structure

As thermal gradient, cooling and solidification rates play a vital role in the size of grain, their distribution and morphology so their study and control is of paramount importance.

Apart from support structure, energy density also effects thermal gradient. For instance, the behavior of thermal gradient along layers, power and with different structure is shown below.

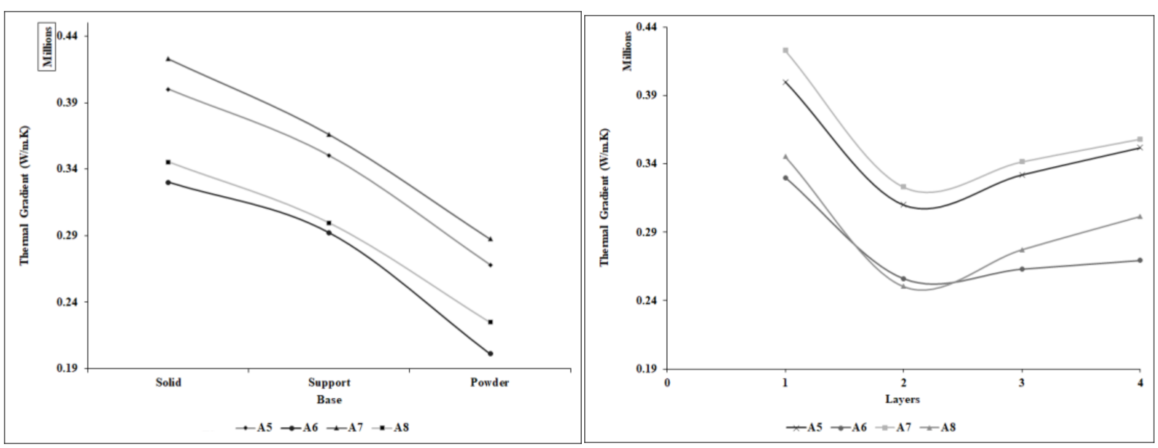

Figure 3: Thermal gradient (a) at different bases in the first layer, and (b) along the layers on a solid base

Cooling rate was also found to have shown a similar trend as thermal gradient with respect to type of support structure. The surface at the bottom within a layer keep experiencing heating and cooling effect until the surface above are not solidified. This adds thermal stresses in the bottom of the layers during heating and cooling sequences. Similar behavior was experienced in all the analysis with underlying solid elements.

The variation of solidification and cooling rate is also investigated properly along the melt pool depth and were found decreasing along the direction perpendicular to scanning within solidification range. While thermal gradient was found rising.

So by investigating the effect of support structure and control of processing parameters, it is possible to control the thermal behavior which in turn could control the grain formation and final part properties.