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AN INHERENT STRAIN HOMOGENIZATION METHOD FOR FAST PREDICTING RESIDUAL STRESS DISTRIBUTION IN PART-SCALE ADDITIVE MANUFACTURING SIMULATION

Jun LIU[1]*

[1] Institute of High Performance Computing, A*STAR, 1 Fusionopolis Way, #16-16 Connexis, 138632, Singapore. liuj@ihpc.a-star.edu.sg

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3D printing, or additive manufacturing (AM) is nowadays a hot topic in advanced manufacturing area, and attracts a lot of researcher's interests. Compared with traditional subtractive manufacturing, this technique has great advantage in producing component with very complex geometry, which cannot be produced by traditional method. A large variety of materials can be manufactured by different types of AM techniques, such as FDM, SLA, SLM, etc. From which, SLM (Selective Laser Melting) is a kind of powder-bed based method, which can be used to manufacture metal material, and has been widely investigated in aerospace/defence area.

However, the very complex printing process greatly inhabited the popularity of AM technique. Tens of thousands of dollars may be required to successfully print an acceptable component by trial-and-error methods. Distortion and warping easily occurs during printing because of large residual stress.

In order to reduce the time and money cost of AM process, numerical simulation becomes a powerful tool to make this manufacturing technique more efficient. However, because of the complexity nature of AM, the time-scale and length-scale may vary from micro-second/micro-meter (melt pool scale), to tens of hours/tens of centimetre (part scale), which greatly increase the difficulty of simulation. Researchers have developed numerous numerical approaches to investigate the physics at different length scale, such as CFD at melt pool scale, DEM at power scale, phase-filed method at grain scale, and thermal-mechanical coupling FEM at meso-scale [1]. However, considering the effect of multi-scale physics and conduct the part-scale simulation is still a challenge.

In recent years, several commercial software has been developed, based on the concept of inherent strain method. This method is a kind of homogenization simplification approach, which can fast predict the residual stress without online calculating the complex melt-pool/microstructure evolution [2]. MSC, Ansys, GE, Autodesk, and several start-up companies are all competitors in the market. Each software has its own strength and short-comes, and very few details have been released as they are all commercial software.

In this work, we mainly focus on using the inherent strain methods on the power-based AM process, specifically the SLM method. A systematic investigation on how to implement the inherent strain method on both the part and support structure region will be conducted.

Information from micro-scale and meso-scale simulation will be adopted to evaluate the inherent strain value. The result will be validated by experiments.

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