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Ultra Large Scale Welding Simulation

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SUMMARY

In the construction of structures, joining process is necessary and welding technique is widely used because of its usefulness. However, residual stress and deformation occurs under the construction by using welding. And these residual stress and deformation cause the problem not only in construction, but also under working.

In order to solve these problems, quantitative prediction method is necessary. The most powerful tool to predict the residual stress and deformation is numerical simulation such as FEM. But even using numerical simulation, the prediction is very difficult because the region near the welding torch shows strong non-linearity and the non-linear region moves with the torch. So, computing time and memory consumption become very large and simulation scale is usually limited to welding joint level.

In this research, the authors proposed a new numerical method for welding mechanics based on the Dynamic Explicit FEM, named Idealized Explicit FEM. In the proposed method, the temperature step is divided into hundreds of time steps as implicit FEM and the displacements are computed for each time step based on dynamic explicit FEM until the whole system reaches the static equilibrium state. And, to achieve the static equilibrium state faster, modified mass and damping matrix are introduced. The modified mass and damping matrix are based on the Courant condition and the vibration theory, respectively. The proposed method and static implicit FEM are compared at the final path of multilayer welding of thick bead-on-plate to verify the validity and accuracy. The transient and residual deformation and stress distribution of the proposed method show good agreement with those of static implicit FEM. In addition, the computing time and memory consumption of the proposed method are 1/12 and 1/40 times shorter than those of static implicit FEM, respectively, in 243,243 degree of freedom model. It is found that the proposed method has an advantage in large-scale analysis whose nodal points are more than tens of thousands.

In addition, parallelization using Graphic Processing Unit (GPU) is applied to Idealized Explicit FEM to achieve much faster computation. The developed method is applied to large scale welding problem that has more than 1 million degree of freedom.

As a result, it is verified that the developed method is very useful to analyze the large scale welding mechanics problem that has almost the same simulation scale as the practical structures.