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Application of Deep Learning to Inverse Design of Microstructure in Structural Material

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Extended Abstract

In this study, we develop an inverse analysis framework that proposes a microstructure for dual phase steel (DP steel) that exhibits high strength and ductility. The microstructure of DP steel consists of a soft phase (Ferrite) and a hard phase (Martensite). The DP steel is widely used because of its significant mechanical properties. However, the problem of DP steel is the trade-off between strength and ductility. For the material development of DP steels, it is necessary to find a microstructure which achieves high strength and ductility. In recent years, many studies have been conducted inverse analysis to propose material microstructures that satisfy such requirements for mechanical properties [1, 2].

The proposed inverse analysis is achieved by repeatedly performing random searches on a model that combines a generative adversarial network (GAN), which generates the DP steel microstructure, and a convolutional neural network (CNN), which predicts the maximum stress and working limit strain from the DP steel microstructure. GAN is trained using images of the DP steel microstructure generated by the phase-field method. CNN is trained using images of the DP steel microstructure, the maximum stress and the working limit strain calculated by the dislocation-crystalline plasticity finite element method. The product of the normalized maximum stress and the working limit strain is used as the score for high strength and ductility. The framework is developed by combining the trained GAN and CNN, and the inverse analysis proposes a microstructure with a finer martensitic phase.

References

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