Summary of Dissertation

題　目　　　A rate-sensitive strength estimation of pipe joints made of Fe-SMA and an enhancement of its shape memory effect by impact training process

（鉄基形状記憶合金製管継手の速度に依存した強度の評価と衝撃トレーニングによる形状記憶効果の向上）

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Low-cost iron-based shape memory alloy (Fe-SMA) with their unique properties have been applied widely to pipe joints. It is possible that a strong fastening state might be achieved by the tightening pressure acting on the inner surface of the joint made of Fe-SMA and the outer surface of the steel pipe after the thermal tightening process due to shape memory effect (SME). In order to enlarge its application, it is important to further improve the SME while reducing costs.

In Chapter 2, the effect of the diameter expansion, which is a step in the manufacturing process of the joint made of SMA on tightening pressure is investigated. Three different diameter expansion methods including radial expansion method, unidirectional pressing method, and bi-directional pressing method, are used to expand the diameter of the joints made of Fe-SMA. As a result, bending fracture strength can be improved effectively by merely changing the diameter expansion method, and bending fracture strength decreases with increasing deformation rate. However, two kinds of rate sensitivity on the axial strength can be obtained. Axial joint strength decreases with an increase in the deformation rate in the range of 8.3×10^{-3} to 8.3 mm/s. When the deformation rate exceeds 8.3 mm/s, it can be found that axial joint strength increases with an increase in deformation rate.

On the other hand, shape memory training process which is the simplest and most effective approach to improve SME in Fe-SMA is also adopted. Firstly, in Chapter 3, the conventional impact testing machine based on spilt Hopkinson pressure bar (SHPB) technique is improved by introducing double momentum trap method. Then, the measurement of volume resistivity for capturing real-time martensitic transformation are improved by introducing four-probe and active-dummy techniques and verified. Then, in Chapter 4 and 5, the SME of Fe-SMA under tensile and compressive training process at quasi-static and impact loading strain rate are evaluated, as well as the real-time SIMT behavior by the measurement of volume resistivity. Also, the samples after each cycle are characterized to understand the mechanism by means of differential scanning calorimetry (DSC) and electron backscatter diffraction (EBSD) analyses. As a result, SME improved significantly with six training cycles under impact tensile loading conditions. Volume resistivity measurements and microstructure observations reveal that threshold stress reductions, changes in transformation temperature and single variant have a positive effect on SME under impact loading. While for the results under compression, the maximum ratio of shape recovery can be achieved up to 113% under the impact loading with 5 training cycles. Finally, in Chapter 6, the main findings of the dissertation are summarized and recommendations for future research are given.