論文の内容の要旨

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Magnesium alloys is one of candidate materials which have been applied in many car components especially in powertrain system. Magnesium alloys have advantages such as higher specific strength, ductility and impact resistance over other structural materials such as steels and aluminum alloys. From a survey of many research works, magnesium alloy engine blocks were reported to show unpleasant self-loosening phenomenon called bolt load loss after exposed to elevated temperature. After bolt load loss occurred, tight connection of bolted joint will be lost. When bolt load loss is combined with the mechanical load such as external loading or vibration, the leakage and failure of the bolted joint due to fatigue and wear will be caused. For this reason, it is important that the bolt load loss behavior of magnesium alloy bolted joint is taken into account in the bolted joint design for high temperature application. In the present study, the mechanism of bolt load loss of magnesium alloy bolted joint was clarified. Moreover, the effect of bolt material on bolt load loss behavior was also studied and discussed. Furthermore, since the analysis of bolted joint required empirical information about creep behavior, which was one of main factors for bolt load loss, such as stress exponent, basic creep behavior of magnesium alloy was also examined. The contents of the present dissertation are divided into six chapters as follows;

Chapter 1: Introduction — Basic knowledge of bolt and bolted joint are briefly introduced in this chapter. Moreover, the fundamental of bolted joint design and the loosening behavior of bolted joint are described. Besides, the literature reviews of bolt load loss of magnesium alloy are summarized. Finally, the scope and the objective of the present work are clarified.

Chapter 2: The Mechanism of Bolt Load Loss Behavior of Magnesium Alloy at Elevated Temperature — The bolt load loss tests of the AZ91D bolted joint clamped with a commercial steel SCM435 bolt were carried out at room temperature and high temperature by monitoring the bolt loads in situ. From the results, it was found that compressive creep deformation in AZ91D plates was a main cause leaded to bolt load loss behavior after exposed to high temperature. Compressive creep in AZ91D plates was found to induce by temperature and the mismatch of thermal expansion coefficient between SCM435 bolt and AZ91D plates.

Chapter 3: The Bolt Load Loss Behavior of Magnesium Alloy AZ91D Bolted Joint Clamped with Aluminum Alloy A5056 Bolt at Elevated Temperature — The effect of bolt material on the bolt load loss behavior of magnesium alloy bolted joint was studied by using the AZ91D bolted joint clamped with an aluminum alloy A5056 bolt. The bolted joint clamped with an A5056 bolt showed better performance of bolt load loss behavior compared with that of SCM435 bolt because it has lower mismatch between bolt material and AZ91D plates. Under lower initial bolt load, compressive creep deformation of AZ91D plates played an important role in driving bolt load loss. At higher initial bolt load, compressive creep in AZ91D accompanied with plastic deformation in A5056 bolt was found to be the cause of bolt load loss. High friction at thread region was found to decrease the tightening limit of A5056 bolt and leaded to plastic deformation.

Chapter 4: The Bolt Load Loss Behavior of Magnesium Alloy AZ91D Bolted Joint Clamped with Magnesium Alloy AZ31 Bolt at Elevated Temperature — The effect of similar material between bolt and joint on the bolt load loss was studied by using the bolted joint between magnesium alloy AZ91D plates and magnesium alloy AZ31 bolt. From the results, it was obvious that the AZ31 bolt had advantages in improving bolt load loss behavior compared to the SCM435 bolt and the A5056 bolt as well in increasing tightening load limit compared to the A5056 bolt.

Chapter 5: Creep Behavior of Magnesium Alloy AZ91D — Basic tensile and compressive creep behavior of an extruded magnesium alloy AZ91D was investigated under constant engineering stress. From the results, creep exponents were found to be different between tension and compression. While the creep exponent used in the creep analysis is used to be one obtained from tensile creep test, it should be obtained from compressive creep test when the structure was under compressive creep. In addition, the change of true stress during tension and compression creep test under constant engineering stress was discussed. The estimation method of creep deformation behavior under a constant true stress was originally proposed in this study.

Chapter 6: Conclusion — The general conclusion of the present work was presented in this chapter. The key findings of the present work represent~~s~~ as the basic information for engineering design of bolted joint for high temperature applications as well as the possibility for the application of magnesium alloy bolt to magnesium alloy joints.