様式Form

論 文 内 容 の 要 旨
Abstract of Dissertation

氏　名Name　DUONG DINH HAO

For last three decades, Friction Stir Welding (FSW), one of the solid-sate joining processes, has been widely applied in aerospace, shipbuilding, automotive, and railway industries. The FSW technology can be applied for the alloys those are difficult to be welded by normal fusion welding process, and it enables to produce dissimilar metals joints. The weldability of the FSWed T-lap joints has been investigated in literatures. In spite of these, few publications have been achieved success in the improvement of the strength of the joints. The formation of some undesirable defects such as tunnel defect, oxide line defect, kissing bond defect, *etc.* might be responsible for these problems. Among these defects, the kissing bonds were too difficult to be improved by applying only traditional single-pass FSW, especially at the retreating side (RS) in the FSW process. These results might be more pronounced in the failure under cyclic loadings. However, there is very limited knowledge from this aspect.

The aim of this work is to improve interface morphology and analyze the failure behavior of the FSWed T-lap joints. For this purpose, a dissimilar metals T-lap joint between AA7075 and AA5083 was fabricated. The first attention was paid on the fundamental formations of welding interface and its effect on the mechanical properties of the joints under various welding conditions. Thereafter, a new method was proposed to upgrade this interface. The failure behavior of the improved T-lap joints was also investigated under cyclic loading with focusing on the role of the kissing bonds (KBs) orientation. In addition, such a new concept that the interface is modeled by an equivalent crack has been proposed to make the analysis of the fracture behavior of the FSWed T-lap joints. Finite Element Analysis (FEA) is also applied to more quantitatively understand this failure.

The experimental results showed that the formations of interface with some defects, e.g. hook, kissing bond, and bonding line defects were found under various welding conditions. Here, increasing the welding rate or increasing probe length might reduce the hook defect size which played the significant role in the

mechanical properties of the joints; however, these changes might lead to the formation of the bonding line defects. The defects seemed to be too hard to be minimized by applying only single-pass welding. The applications of the double-pass FSW which could induce by reversed metal flow, and that of prove offset, significantly improved the interface morphology in terms of the KBs and the effective bonded width. Particularly, the joint efficiency was reached approximately 90% in comparison with the strength of AA5083 base metal under the optimized condition.

The crack was predominantly nucleated at the weld toe under the skin fatigue tests. The visible result showed that the KB-closing at interfaces during testing process might lead to stress concentration at two weld toes. In stringer fatigue tests, the crack initiations mostly nucleated in the interface of the KBs and then propagated obliquely into the skin AA5083 under the mixed mode failure. Here, the KB interfaces were comfortably delaminated to form two crack shapes that played an important role in the failure behavior of the T-lap joints.

In order to understand the present experimental results in systematically, a simplified fracture mechanics model via introducing a new parameter; "geometrical resistance factor of defects (GRFD)", was proposed. Here, the AA7075/AA5083 interface is represented by an equivalent defect or crack which is subjected to the corresponding equivalent stress intensity factor (SIF), and the increase in defect size is expressed by decrease in the GRFD, resulting in reduction in the allowable stress. The advantage of the double pass FSW process could be rationalized by the GRFD parameter, which was also supported by the FEA. These works suggest that the optimization of the FSW can be achieved by minimizing the defect size, by decreasing the GRFD, and by increasing the interface strength those can be attained by the change in the welding conditions via the control of metal flow in the FSW process.