Fatigue of self-piercing riveted joints in aluminum alloy 6111

Li Huang, Haiding Guo, Yandong Shi, Shiyao Huang, Xuming Su

PII: S0142-1123(17)30095-6
DOI: http://dx.doi.org/10.1016/j.ijfatigue.2017.03.006
Reference: JIJF 4269

To appear in: *International Journal of Fatigue*

Received Date: 7 January 2017
Revised Date: 1 March 2017
Accepted Date: 5 March 2017

Please cite this article as: Huang, L., Guo, H., Shi, Y., Huang, S., Su, X., Fatigue of self-piercing riveted joints in aluminum alloy 6111, *International Journal of Fatigue* (2017), doi: http://dx.doi.org/10.1016/j.ijfatigue.2017.03.006

Fatigue of self-piercing riveted joints in aluminum alloy 6111

Li Huang[1,2], Haiding Guo[2], Yandong Shi[1], Shiyao Huang[1] and Xuming Su[3]

[1]*Ford Motor Company, Nanjing, 210000, China*
[2]*Nanjing University of Aeronautics and Astronautics, Jiangsu Province Key Laboratory of Aerospace Power System, Nanjing 210016, China*
[3]*Ford Motor Company, Dearborn, MI, 48124, USA*

ABSTRACT

The fatigue behavior of self-piercing riveted (SPR) joints of aluminum alloy 6111-T4 has been experimentally and numerically investigated in current study. The dominant fatigue failure mode under tensile-shear (TS) loading is the corner crack at riveted hole with approximate quarter-elliptical crack front, and interrupted tests revealed that the crack growth life was much shorter than crack initiation life. A fatigue parameter, Smith-Watson-Topper (SWT) was proposed for crack initiation prediction in the 3D finite element analysis, while a structural load based crack growth approach was introduced for crack growth life estimation. Good agreement was found between predictions and experimental results.

Keywords: self-piercing riveted joint; fatigue; SWT; crack initiation; crack growth;

1. Introduction

Self-piercing riveting (SPR) is a joining process by driving a rivet directly into two or more layers of materials to forms a mechanical interlock without piercing out of the bottom layer. As shown in Fig. 1, the riveting process of SPR can be described by the following four steps : a) clamping, b) piercing, c) flaring, and d) releasing. As an alternative of resistance spot welding (RSW), SPR is an efficient and economical material joining method to ensure success of lightweight strategy in automotive industry. SPR can be used to join similar or dissimilar metals or even non-metals [1-4], and is a critical technique in the body in white (BIW) manufacturing. Currently the durability design methodology of SPR still mainly comes from the old experience on RSW. A thorough understanding of fatigue mechanical behavior of SPR experimentally and numerically is required to meet the challenge of virtual design and durability assessment for the modern automotive.

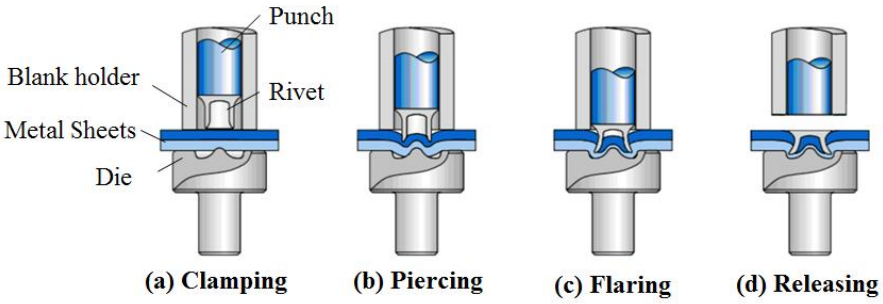

Fig. 1. Self-piercing riveting process [5]

Joint fatigue is one of the major concerns in durability design of body structure, and extensive researches have been conducted on continuous joint or spot joints for automotive applications in the last several decades. Comprehensive fatigue and static tests on aluminum SPR joint were conducted[6-10], and experimental results revealed that fatigue crack could have multiple initiation sites, including faying surface, contact surface between upper sheet and rivet hole as well as lower sheet and rivet hole, which was very similar to the fatigue failure of