Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 213 (2018) 549–570

Procedia Engineering

www.elsevier.com/locate/procedia

7th International Conference on Fatigue Design, Fatigue Design 2017, 29-30 November 2017, Senlis, France

Aluminium weld fatigue: From characterisation to design rules

Z.Tahir[a*], R.Aso[b], T.Yates[c] , M.Bell[d] & A.Muse[e]

[a,b,c,d & e] *Gestamp Chassis, Skerne road, DL5 6EP, UK*

Abstract

In suspension design, traditionally subframes and links are welded structures, with one of the main design criteria being fatigue. Better understanding, correlation and correct design rules are vital to ensure safety and avoid over design that can lead to a reduction in competitiveness.

A known mesh modelling T-joint SN method is used to design the welds and is mainly driven from standards used for thicker panels seen in the construction and ship building industry.

To consider the thin sheet designs largely seen in automotive, Volvo & nCode have developed a new method based on structural stress and is known to be mesh insensitive. However, new difficulties emerged due to the clear separation between the membrane and bending behaviour needed for stress recovery. Specific tests need to be defined to ensure correct characterisation.

Gestamp has generated a new standard of design rules to ensure correlation in Weld-Ends and in Mid-Weld cracks and correct toe position definition to ensure accurate stress recovery, and give more beneficial input to process by better defining the weld torch position. New test specimens have been developed and intensive testing carried out to fully characterise the bending and tension behaviour and reduce the gap in predictions between Lap Weld and Fillet Weld. This methodology has been successfully used in suspension designs with high confidence and correlation.

These design rules have been used in conjunction with studying the effect of weld process and sequence on fatigue performance. Controlled distortion subframes, against high distortion subframes, have been tested to capture the benefit by reducing the fit-up gaps. Residual stresses are still a grey zone for Gestamp and further work is needed to better understand the effect.

Peer-review under responsibility of the scientific committee of the 7th International Conference on Fatigue Design.

Keywords: Aluminium, fatigue, welded joints, CAE SeamWeld, testing and distortion

1. Introduction

With the increase demand for reduction of weight and cost in the automotive industry, defining and correlating the design rules is becoming key to ensure accurate predictions in terms of fatigue performance to eliminate over-engineering. There is a clear correlation between robustness and accuracy of CAE (FEM) predictions and reduction

1877-7058 © 2018 The Authors. Published by Elsevier Ltd.
Peer-review under responsibility of the scientific committee of the 7th International Conference on Fatigue Design.
10.1016/j.proeng.2018.02.051

in cost and weight. Aluminium is seeing more widespread use in the automotive sector to reduce the weight and this drives a need to define new design rules and weld process control to ensure quality and safety.

Critical to defining these design rules is the analysis of the limits of the current methods and develop a range of testing to correlate all the predictions. Controlling the process and especially weld distortion is more important when dealing with aluminium due to high thermal conductivity and coefficient of thermal expansion which leads to larger heat affected zones and higher distortion compared to steel. In addition, penetration and fit-up gap have more effect compared to those seen in welding steel.

2. Nomenclature

σ_s	Structural stress
$\sigma_{nominal}$	Nominal stress
σ_m	Membrane stress
σ_b	Bending stress
σ_{weld}	Weld stress
f_x	Normal force to weld toe
m_y	Moment around weld toe axis
t	Thickness
r	Bending ratio
I	Bending interpolation function
m	Crack propagation exponent
r_{th}	Bending ratio threshold
$\Delta\sigma_b$	Bending stress range
$\Delta\sigma_m$	Membrane stress range
N	Number of cycles
a_b	Bending stress range intercept
a_m	Membrane tress range intercept
c_b	Bending fatigue strength exponent
c_m	Membrane fatigue strength exponent
a_s	Structural stress range intercept
c_s	Structural fatigue strength exponent
CAE	Computer aided engineering and corresponds to finite element method (FEM)
SE	Standard error
q	Inverse normal distribution for 99% probability
R	Testing ratio
UTS	Ultimate Tensile Strength
b_t	Measured weld bead thickness
h	Hypothetical weld bead thickness