

Fracture Mechanics Approach for Evaluating Fatigue Life of Butt Welded Joints: The Effect of Stress Concentration

Chung-Hung Lin and Sin-Hwa Her
 National Cheng Kung University
 Tainan, Taiwan, China

ABSTRACT

The total fatigue life(N_f) is considered to be the sum of fatigue initial life(N_i) and propagation life(N_p). In this study, the fatigue tests were carried out with the use of butt welded joints and base metal test specimens to evaluate N_p . The growth rate($da/dN - \Delta K$) of embedded cracks in thickness direction did not agree with that in weld bead direction when nominal stress are adapted. This is attributed mainly to stress concentration effect arising from geometrical irregularities of weld reinforcement. The degree of the stress concentration affect growth rate and the proportion of N_i to N_f are discussed. Finally, referring to the test results, the size of initial flaw of butt welded joints is purposed.

KEY WORDS: fatigue life, stress concentration, crack propagation, initial flaw

INTRODUCTION

It is well known that the fatigue life used in S-N curve generally means the number of cycles to failure and is usually expressed by a symbol of N_f or N_t . For welded structures, the process of fatigue failure due to repeated loads normally consists of two major stages, the crack initiation and crack propagation, and naturally N_f is considered to be the sum of initial life N_i and propagation life N_p . The fatigue life N_f obtained from fatigue tests might vary more than ten times even applied loads are the same, therefore, we might understand how the initial stage and propagation stage affect the scatter more if the proportion of N_i (or N_p) to N_f could be identified.

Fatigue crack generally initiate at high stress regions. For butt-welded joints, undercut and geometric discontinuity are responsible for the high stress concentration. However, for practical purposed, undercut and geometric discontinuity are not only very versatile but also difficult to control, and subsequently N_i becomes very hard to predict. As to the approach in the crack propagation process, the well-known Paris' law[1] is effective to evaluate the crack growth rate. Therefore, if we have concrete data of the material parameters C, m and stress intensity threshold level ΔK_{th} of Paris law, and take the

effect of stress concentration into account appropriately then the prediction of N_p will become possible.

In this study, we use strain-gauge to monitor the development of fatigue cracks and introduce beach mark during the propagation process to yield the growth rate. The stress distribution around the weld toe was evaluated by FEM and based on Raju-Newman solution[2], stress intensity factor of embedded crack is calculated. Using the above mentioned data and experimented results, fracture mechanics approach for evaluating fatigue life of butt welded joints is achieved.

The aims of this paper are to:

- 1)clear the effectiveness of stress concentration on growth rate of embedded crack.
- 2)find out the proportion of N_p to N_f and check whether fracture mechanics analysis to evaluate the total fatigue life is possible or not.
- 3)estimate the size of initial flaw of butt welded joints.

EXPERIMENTAL PROCEDURE

Material and Specimens

All the specimens were fabricated from mild steel plate with a thickness of 8mm. Mechanical properties and chemical composition are given in Table. I.

Table. I:Mechance properties and chemical composition of base metal.
 mechanical properties:

yield stress (MPa)	tensile strength (MPa)	elongation (%)
313.5	453	28.7

chemical composition(weight percent):

C	Si	Mn	P	S
0.14	0.24	0.77	0.22	0.11