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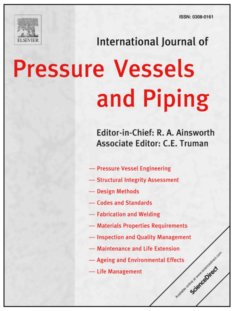

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Study of ratchet limit and cyclic response of welded pipe

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Abstract Ratcheting and low cycle fatigue are failure mechanisms observed in components subjected to cyclic temperature and mechanical loads. Ratcheting is a global failure mechanism which leads to an incremental plastic collapse of the component whereas low cycle fatigue is a localized mechanism which leads to crack initiation. It is exacerbated by grooves, notches and changes in the geometry of the component. To estimate the remaining life of the component and predict its failure mechanism, it is important to understand how it responds to various combinations of cyclic loads. This paper includes investigation of the ratchet limit and the plastic strain range, which is associated with the low cycle fatigue, of a circumferential butt-welded pipe by using the ratchet analysis method which includes Direct Steady Cycle Analysis (DSCA) within the Linear Matching Method Framework (LMMF). The pipe is subjected to a constant internal pressure and a cyclic thermal load. The investigation is carried out by varying 1) material properties of the weld metal (WM); 2) ratio of inner radius to wall thickness; 3) weld geometry. Within the specified ranges, yield stress and the ratio of inner radius to wall thickness affect the ratchet limit curve. The cyclic thermal load plays a crucial role compared to the internal pressure in influencing the ratchet limit curve. It is observed that the pipe experiences thermal ratcheting at lower yield stress values of the WM. The results obtained are combined to create a limit load envelope, which can be used for the design of welded pipes within the specified ranges.

Keywords Welded Pipe, Linear Matching Method, Ratcheting, Low Cycle Fatigue, Direct Method

1 Introduction

A circumferential butt welded pipe subjected to a cyclic thermal and/or a mechanical load can behave in one of the three manners, namely shakedown, reverse plasticity (plastic shakedown) or ratcheting. The structure is said to be under elastic shakedown when an elastic response is obtained after the first few load cycles [1]. Beyond the elastic shakedown limit, the body exhibits either plastic shakedown or ratcheting. In certain cases, it is acceptable for the body to be under plastic shakedown as long as the

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