Importance of Weld Flashing in Design of Welded Components

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Flushing of welds besides providing aesthetic outlook could lead to improved fatigue behaviour. Design rules available in the nuclear codes are brought to the notice of the users of non nuclear design codes. Guidelines are provided in the paper for the welded components where flushing of welds could be specified.

INTRODUCTION

Failure of welded components at weld location is of concern to the pressure vessel and piping industry. Weld left in the aswelded state is likely to be poor in fatigue in comparison to base material because of geometric irregularities such as reinforcement. Failure of reheater tubes of sodium heated steam generator at weld location(l) has been atributed to leakage of cold water in the hot state and excessive weld reinforcement in comparison to basic tube thickness of 2 mm. This short note gives the effect of weld reinforcement on fatigue behaviour and provides guidelines where flushing of welds could be specified.

Effect of Weld Reinforcement on Fatigue Life

Feel of the effect of weld reinforcement and importance of weld flushing on fatigue behaviour can be obtained from the simplified rules given for design of piping in ASME Section III Class 1 nuclear power plant components (2).

For every pair of load sets, Sp is calculated. Alternating stress intensity is equal to one half of the value of Sp. By use of design fatigue curve, acceptable number of cycles can be calculated.

$$Sp = K1C1\frac{PD}{2t} + K2C2\frac{Do}{2I}Mi / + \frac{1}{2(1-\upsilon)}$$

$$K3\,E\alpha \left| \Delta T1 \right| + K3\,C3\,E \left| \alpha a\,Ta - \alpha b\,Tb \right| + \frac{1}{1-} E\alpha \left| \Delta T2 \right|$$

C1, C2, C3	Secondary stress indices
K1, K2, K3	Local stress indices
Po	Range of service pressure
Do	Outside diameter
t	Nominal wall thickness
I	Moment of inertia
Mi	Resultant moment due to combination of design mechanical loads
Eα	Modules of elasticity (E) times the mean coefficient of thermal expansion ( )
υ	Poison's ratio
T1, T2	Temperature range for complete details refer to the code.

Table 1 : Stress Indices

Piping products and joints	C1	K1	C2	K2	C3	K3
Straight pipe remote from welds	1.0	1.0	1.0	1.0	1.0	1.0
Longitudinal butt welds in straight pipe						
a) flush	1.0	1.1	1.0	1.1	1.0	1.1
b) as-welded t> 3/16"	1.1	1.2	1.2	1 3	1.0	1.2
c) as-welded t< 3/16"	1.4	2.5	1.2	1 3	1.0	1.2
Girth butt welds between nominally identical wall thickness items						
a) flush	1.0	1.1	1.0	1.1	0.6	1.1
b) as-welded	1.0	1.2	1.0	1.8	0.6	1.7
At the intersection of longitudinal butt weld in straight pipe with a girth r Butt weld	C1,K1,C2,K2, C3, K3 indices shall be taken as the product of espective indices					

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The benefit of flushing the welds is determined for certain cases (See Table 2) encountered in the industry using the simplified S- N relationship

S^5N = Constant
S — Alternating stress intensity
N — Number of cycles

Table 2

Location	Predominant loading nature	Ratio of number of cycles for flush weld to as-welded case	
Heat exchanger tube to tube weld (seamless tubes)	Thermal (Temp. gradient across the tube wall) (start-up operation-shut-down)	K3 effect	8.8
Bimetallic weld in piping operating at elevated temp. (Cr-Mo to Ss 304/316)	Thermal (start-up operation - shut - down)	K3 C3 effect	8.8
Rolled & welded piping at location Girth butt weld	Thermal (Piping expansion stress) (Start-up Operation - shut-down)	K2 C2 effect	27

Definition of Flush Weld

Flush weld is not simply grinding off the excessive reinforcement on the outside of the piping weld joint. For use of Table-1, flush weld in the above mentioned code is defined as follows :

The total thickness (both inside and outside) of the weld reinforcement shall not exceed 0.1 t (t:nominal wall thickness). There shall be no concavity on either the interior or exterior surfaces and the finished contour shall not have any slope > 7 deg.(See Fig. 1).

Aswelded welds are those welds not meeting the special requirements for flush welds.

Recommended Locations for Specifying Weld Flush

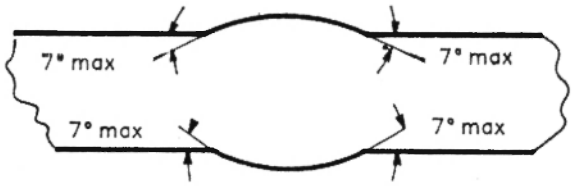

FIG.– 1

based on overall operating experience reported on welded joints in pressure vessels and piping, it is worth specifying weld flush/grinding of the weld for the following cases :

- Dissimilar weld joints in piping operating at elevated temperature like Cr-Mo ferritic steel to austenitic stainless steel 304/316 grade. The joint could be executed with extra thickness and machining could be specified on outside and inside. Inside machining will also help in removing weld root defects, if any. Outside ground flush alone can be specified for cases in which inside is not easily accessible for grinding or machining.
- Outside ground flush of the butt welds of heat exchanger tube to tube weld with significant temperature gradient on the tube wall during steady state.
- Outside and inside ground flush (inside wherever possible) of butt welds in piping operating at elevated temperature of plants operating on shift basis (start up-shut down on daily basis for example).

REFERENCES

1. Avalnche J, Hugla M and Martin L, Phenix steam generator sodium- water reaction incidents, IWGFR specialists meeting on steam generator failure and failure propagation experience, Sept 1990.
2. ASME Boiler and Pressure Vessel Code ASME Section III Class 1 components.