Burst pressure and leak rate from fretted SG tubes

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1. Introduction

Steam generator(SG) tubes of a pressurized water reactor(PWR) have suffered from various types of corrosion, such as pitting, wastage and stress corrosion cracking (SCC) on both the primary and secondary side[1]. Recently, fretting/wear degradation at the tube support region has been reported in some Korean nuclear power plants. In order to prevent the primary coolant from leaking to the secondary side, the tubes are repaired by a sleeving or plugging. It is important to establish the repair criteria to assure a reactor integrity and yet maintain the plugging ratio within the limits needed for an efficient operation.

The objective of the burst test is to obtain a relationship between the burst/leak rate and the shape of the fretted flaws machined with an electro discharge machining (EDM)

2. Experimental

Two types of simulated fretted flaws were machined on SG tubes of 195 mm in length. One of them is shown in Fig. 1. The outside diameter and wall thickness of the tubes were 19.05 mm and 1.09 mm, respectively. The tubes were high temperature mill annealed alloy 600, of which the yield strength and tensile strength were 241 MPa and 655 MPa, respectively. The room temperature pressure test facility consisted of a water pressurizing pump, and a test specimen section and a control unit[2]. The maximum pressurizing capacity is about 52 MPa(7500 psi). Water leak rates just after a ligament rupture or burst were measured by a balance; water coming out of the failed tube was collected in a plastic container for a designated time, and the leak rate was calculated by dividing the amount of water by the time. The water flow rate through the tubes and the pressures versus the time were recorded on a computer. Evolutions of a crack opening during the pressurization were recorded using a conventional digital camera.

3. Results and Discussion

Fig. 2 is a typical behavior of the pressure and leak rate during the water pressurization on a fretted tube specimen. The tube of which the defect depth is 70% of the tube wall(TW) showed a burst pressure of 37 MPa. The pressure is much lower than that of the unflawed tube;66.9 MPa[3].

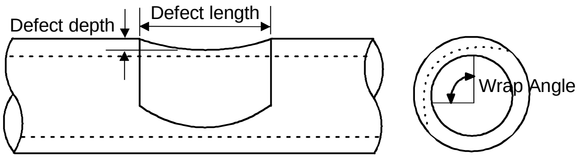

Fig.1 Schematic of an elliptical wastage(fretted) specimen [after NUREG CR/0178, 1979]

Burst pressures of the tubes having different defect depth and different wrap angle are shown in Fig. 3. Burst pressures of 30~ 40 MPa were obtained for the tubes of 70 % TW defects. For the tubes of 90% TW defects, burst pressures of 15~ 20 MPa were recorded, which are higher than

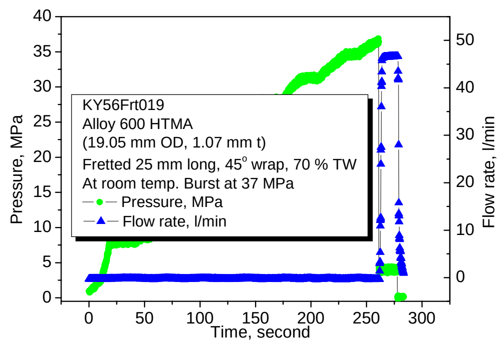

Fig. 2 Burst pressure and leak rate of a fretted tube(KY56frt019)

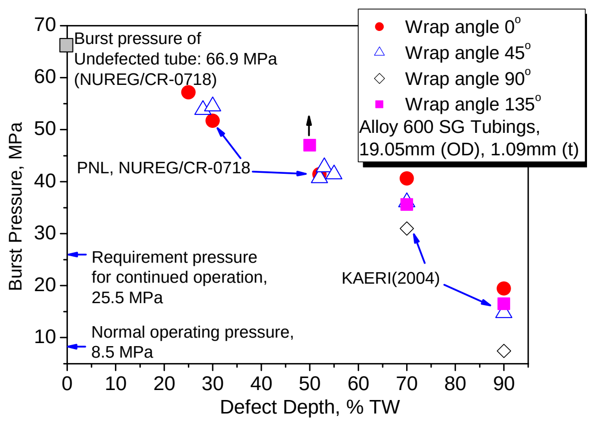

Fig. 3 Effect of defect depth on burst pressures of fretted tubes

that of a pressure difference of the normal operating pressure difference between the primary and the secondary side of the tube. The burst pressure showed a wrap angle dependency as indicated in Fig. 4; as the angle increased, the pressure decreased with an exception of a 135 degree of the wrap angle.

Flow rates from the burst tubes are illustrated as a function of the wrap angle in Fig. 5. The flow rate increased with the wrap angle. It implies that a thin wall of the larger wrap angled specimens was torn easier, then showed a larger defect opening than that of the small wrap angled specimens. Features of the burst tubes are shown in Fig. 6, which shows a larger flaw opening for the 135 ^{o} wrap angled specimens than for the 0 ^{o} wrap angled case.

4. Conclusions

1)There is a high safety margin in terms of a burst pressure in normal operating condition even for the 70 % fretted tubes.

2)Fretted tubes with a 50 % TW did not show a burst

3)Burst pressure depended on the defect depths rather than on the wrap angle

4) The tube with a wrap angle 0^{o} showed a fishmouth fracture, whereas the tube with 45^{o} wrap angle did a three way fracture

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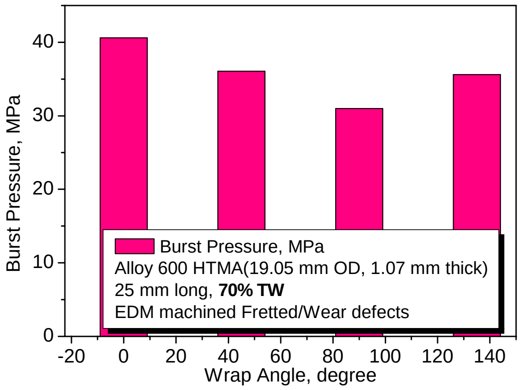

Fig. 4 Effect of wrap angle on the burst pressure of fretted tubes

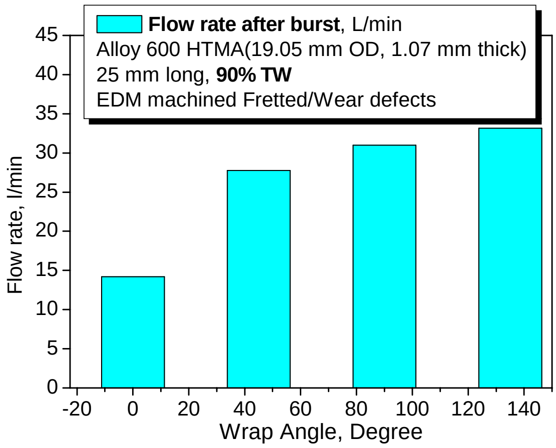

Fig. 5 Effect of wrap angle on flow rate of fretted tubes