BUCKLING ANALYSIS OF THE HOT LINER OF THE AUSTRIAN PCRV-CONCEPT

(BEULBERECHNUNG DER HEISSEN DICHTHAUT DES ÖSTERREICHISCHEN SBB-KONZEPTES)

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SUMMARY

This paper deals with the buckling of the liner of a prestressed concrete pressure vessel.

In operation the internal pressure presses the liner against the insulating concrete. The liner is supported by bolts in the insulating concrete around it. The internal pressure and the temperature decrease in case of an accident like the fracture of the piping. For a precise buckling analysis it is necessary to consider the buckling of the liner with falling pressure and temperature step by step.

In assumption of ideal elastic-plastic material behaviour the highest possible buckling temperature is the one at which the steel begins to yield. After reaching the yield point no increase of temperature forces and no buckling are possible.

The buckling is considered in two different ways. First it is the consideration of the whole cylinder with the theory of minimum potential energy. Secondly it is the consideration of one buckle on a cylindrical ring. This buckle possibly arises from imperfections of the material and the geometric form.

The method of minimum potential energy sets up an integro-differential equation with parts of extension and bending energy and the strain energy. In the last one stabilizing pressure and two-dimensional temperature forces can be included. For the solution an assumption is made for the radial, circumferential and axial displacement components. In the stability criterion of the potential energy the partial differentiation of the amplitude of the displacements must be zero. This condition leads to three linear homogeneous equations with the amplitudes as the unknown. By making the coefficient determinant zero one gets as a result the critical buckling temperature.

Before the buckling the liner lies directly at the rigid concrete cylinder. The radial contact pressure between the rigid cylinder and the liner stays in balance with the crircumferential internal forces of a cylindrical liner element. At the moment of buckling the element lifts up from the concrete and the radial external forces disappear. The element is pressed back again to the rigid cylinder by the circumferential internal forces. Therefore a buckling of an ideal axisymmetric cylinder by contact pressure to be caused by temperature, prestressing or creeping seems impossible.

Buckling analyses with calculation methods as mentioned above give buckling loads and good conformity of the buckling shape.

Moreover some experiments of the liner with contact pressure show buckling as a result of imperfections.

If the liner buckles by an accident in spite of the anchorage it does not break. A fatigue analysis with the greatest possible bending stresses of the buckled liner demonstrates that the vessel can be put in operation again after one-time-buckling because the internal pressure presses the buckle back again. But the danger of a fatigue fracture exists after buckling several times.