THE EFFECTS OF SUPPORT CLAMPS ON ELEVATED TEMPERATURE PIPING

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SUMMARY

The effects of local support clamp loads on low temperature ASME Class I (<800°F) piping systems generally have been neglected in the past. In liquid metal elevated temperature systems, where creep effects are significant, the clamp influence on pipe stresses and strains must be evaluated. The clamp-pipe interface load distribution is required for this evaluation. This paper presents the HEDL formulation of the non-linear finite element model used to determine the nonaxisymmetric load distribution between FFTF support clamps and the sodium piping. Further, the three dimensional finite element model used to find the hoop and meridional stresses in the pipe due to these nonaxisymmetric load distributions is described. Results from both models are discussed. Typical stresses induced into the pipe by the clamp preload forces, and by subsequent dead weight and seismic loads, are given.

The FFTF pipe clamp assemblies consist of: two nearly semi-circular steel clamp bands; two clamp-up bolts; two compression type Belleville spring stack-ups; and several rigid insulation blocks. The two clamp bands are bolted together around the pipe with a Belleville spring stack-up on each of the clamp-up bolts. The rigid blocks of insulation separate the clamp bands from the pipe and form the structural and thermal path between them. The Belleville spring stack-ups are preloaded so they maintain a nearly constant load on the clamps when the clamp bands open up to follow the pipe thermal expansion. This action achieves the desirable effect of maintaining the preload and its induced pipe stresses nearly constant during thermal cycles. The blocks of insulation allow the steel band of a clamp, which is supporting a 1200°F pipe, to operate at 300°F.

In prior plant pipe analyses where the effects of support clamp loads have been considered, analysts have relied on assumed load distributions between the clamp and pipe. These assumptions generally took the form of sine and cosine load distributions. While this approach may be adequate for low temperature systems, it can lead to unconservative results when applied to high temperature large size piping. To overcome the deficiencies of this analysis technique, a two-dimensional nonlinear finite element model, which included the clamp, insulation blocks and pipe, was formulated. The model accounted for all load conditions including preload, dead weight, and seismic forces applied to the clamp and radial thermal growth of the pipe. The resulting load distributions on the pipe were highly nonaxisymmetric, far different from those generally obtained using trigonometric functions.

These nonaxisymmetric load distributions were applied to a three dimensional finite element model of the pipe. The resulting stress distributions were considerably different than obtained by traditional methods. For example, the maximum hoop stresses in a sixteen-inch pipe were nearly 40 percent higher under clamp preload forces than a cosine load distribution predicted. In addition, the model gave meridional stresses which are additive to the primary pipe stresses due to overall systems loads. When these increased stresses are considered for the life of an elevated temperature piping system, it is apparent they cannot be neglected.