OPTIMISATION OF PIPE RESTRAINT SPACING IN THE NEIGHBOURHOOD OF METAL CONTAINMENT, PRESSURE VESSELS OR OTHER EQUIPMENT

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Abstract

Final spacing of seismic restraints in seismic category piping is usually determined by trail and error method during the detailed dynamic analysis. A preliminary simplified dynamic analysis may reduce the computer costs of detailed dynamic analysis and bring a substantial saving in the number of the seismic restraints. However, when the influence of the relative linear and angular displacement of fixed points is considered additionally and the pipe forces and moments acting on the components cause excessive stresses, the new arising difficulties cannot be satisfactorily eliminated. In this situation it is necessary to repeat an expensive detailed dynamic analysis to reduce the value of the above-mentioned forces and moments by trial and error.
This paper presents a method of finding the optimum location of the seismic restraints in seismic category piping in order to obtain minimum joint forces and moments acting on the metal containment, pressure vessels or other equipment. Preliminary stress analysis reveals that the introduction of seismic restraints in the spacing between the support next to the component and the component itself has a decisive influence on the forces and moments acting from the piping system on the component. In this case it is possible to consider the pipe as simply supported at this support and to uncouple it from the rest of the piping system. From the study of a typical case it can be concluded that by this assumption the changes of the computed values of the forces and moments on the components remain within allowable limits.
The linear and angular displacement of the fixed point can be expressed using Castigliano's theorem as the derivative of the accumulated deformation energy to the force or moment.
By neglecting the deformation energy caused by shear or normal load the linear and angular displacement are obtained as:

$$u_i = \frac{\partial L}{\partial p_i} = \int \frac{M}{EI} \frac{\partial M}{\partial p_i} ds$$

Every piping system can be reduced to five simple shapes or combinations thereof. Stating the above equation for each of the five single shapes, the matrix equation relating forces or moments to linear or angular displacements may be obtained afterwards for every piping system. The forces and moments at the fixed point can be written at the same time as a function of the external loads. By superimposing the value of the force or moment in the fixed point, due to relative linear and angular displacement and due to external loads the equation giving the total value of force or moment may be obtained. Since the terms of this equation are constant for a given system, varying the pipe restraint spacing, will make the force or moment a function of pipe restraint spacing only. The minimum value of the function is found by utilizing a standard mathematical program for the optimization of polynomial functions