VIBRATIONAL ANALYSIS OF THE SUPERPHENIX INTERNAL SHELLS

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SUMMARY

The geometry of the internal shells of SUPERPHENIX is somewhat complicated: they are mainly axisymmetric with some special parts non-axisymmetric, like pumps and heat exchangers crossings.

The flow going out of the reactor core or the heat exchangers strikes some of these shells and induces vibrations. Due to the long expected life of the plant, without possibility of intervention on the shells it is necessary to verify that the vibrational level is sufficiently low and that there is no risk of fatigue.

A first estimate of that vibrational level has been made by calculation. This present paper explains the formalism used and describes the main steps of the calculation:

— Estimation of the fluctuating pressures:

At a first step, the fluctuating pressures have been estimated, using the fundamental studies of R. J. GIBERT on simple flow singularities. Later, measurements have been made on a one-fifteenth scale model (Laboratoire National de l'Hydraulique — CHATOU). The spectral shapes are somewhat different, but in the frequency range of interest, the level is similar. A crude estimation of the correlation length of the fluctuation has also been deduced from the test results.

— Calculation of the structural resonances:

A first study has been made without sodium to calculate the influence of the pump and heat exchangers crossings on the tank and baffles shells. The lowest modes in air (~ 3 Hz) are effectively due to a coupling effect between the tank modes and the rigid body movement of the crossings shells, acting as an added mass, variable with the type of mode considered.

In sodium, the resonant modes cannot be obtained by simple formulae of added mass and it is necessary to study the movement of the sodium between the shells, which is done by using the finite element method applied to the overall shells and liquid system. A comparison between the modes in air and in sodium shows the variable effect of the liquid on the different modes (shapes and frequencies). The lowest frequency is near 0.3 Hz. The crossings have rigid body movement and do not modify the shells modes and frequencies because their added mass is much smaller than the mass of tanks and sodium.

— Amplitudes:

The applications of the fluctuating pressure field on the resonant modes gives the amplitude of vibration. For the design studied, the corresponding strains and displacements are significantly smaller than the allowable limits.

Experimental tests are performed on simple models to validate the calculation methods and understand better the phenomena involved in various situations.

— Axisymmetric shell resonances with and without water.

— Flow induced damping effects in annular flows.

— Vibrations of pumps and heat exchangers in the cold sodium region.