SDNL112 - Vibratory damage of origin of a clotheshanger of steam generator

Summarized

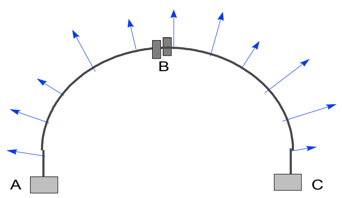
This case of validation is intended to check the NON-regression of the features necessary to computations of damage of vibratory origin of the tubes of steam generators: vibratory fatigue and wear by shocks on an obstacle. The computation of the vibratory response is realized by method ITMI of Temporal Integration by Integral Method established in operator DYNA_VIBRA. For that, one studies the nonlinear dynamic response of a tube of steam generator subjected to an external flow. This tube is unstable and comes to impact a support with clearance.

One calculates initially the effects of the coupling fluid-elastic (variation of the frequency and the damping of structure) according to the rate of flow, then the vibratory response of structure for a rate of flow given, and finally wear by shocks or the vibratory fatigue of structure.

1 Problem of reference

1.1 Geometry

the studied structure is connected at the curved zone of a tube of steam generator. It is supposed to be clamped at its two ends A and C ; these last are supposed to correspond on the way of the tube in the plate top transom of a steam generator. At the point B top of the clotheshanger (still called apex), the structure is guided in a support with clearance.



Appear 1.1-a: Diagram of the curved zone of a tube of GV, supposed to be clamped in last plate braces, guided in a support with clearance

the structure is comparable to a beam of hollow circular section overall length of $1{,}74329\,m$ and which understands $250{,}43\ mm$ of right part at each end of the tube.

Diameter external of the tube : $22{,}22\ mm$
Internal diameter of the tube : $19{,}68\ mm$

1.2 Material properties

the values of the characteristics of the various elements of structure are the following ones:

Tube out of internal Inconel

$$E=2{,}02\ 10^{11}\,N/m^2 \qquad \nu=0{,}3 \qquad \rho=8330\ kg/m^3$$

600 Fluid: the modelled internal fluid is water under pressure with high temperature; its density ρ_i is supposed to vary in a linear way along the curved zone, enters A and C, of $738{,}58\ kg/m^3$ with $731{,}16\ kg/m^3$.

External fluid: the tube is supposed to be immersed in a diphasic mixture over all its length; the flow of the mixture is transverse with the clotheshanger in any point. The equivalent density of the mixture is obtained using the formula:

$\rho_e=\alpha\,\rho_{gaz}+(1-\alpha)\rho_{liquide}$, where α indicates the voluminal gas rate.

This density seems being understood enters $84\,kg/m^3$ and $150\,kg/m^3$. A density equivalent is allotted to the dynamic system during the computation of its fluid modal base at rest; this equivalent density includes the density of the internal fluid, that of structure and that fluid external; the inertial effect of this last is evaluated via a coefficient of added mass.

1.3 Boundary conditions and loadings

the structure is embedded at the points A and C. A support with clearance is positioned at the point B ($jeu=1{,}20\ mm$). A random loading distributed, transverse on the tube, is imposed on $(A-C)$. This loading is defined, on the one hand using a profile velocity along the excited zone, and on the other hand using an adimensional spectrum of excitation.

1.4 Initial conditions

the tube is initially at rest, which results in null displacements and velocities at initial time.

2 Reference solution

2.1 Method of calculating used for the reference solution

See references [bib1], [bib2] and documentation of *Code_Aster* on the algorithms of dynamic computation in nonlinear with shocks.

2.2 Results of reference

In the absence of experimental results available, only the NON-regression of the results is tested.

2.3 Bibliographical references

1.N. GAY: “Software FLUSTRU, version 3.0.1, Note of principle - GAY

2.HT-32/97/014/A.N., S. GRANGER: “Presentation of a method of the coupling fluid-elastic in nonlinear mode”, HT - 32/94/015/A.

3 Modelization A

3.1 Characteristic of the modelization

the geometrical and material properties of the model are those presented higher. The tube is modelled using beam elements right of Timoshenko: POU_D_T. It is broken up into 60 elements distributed out of six sections.

The nodes A and C are blocked in the directions x, y and z in translation and rotation.

The damping of fluid structure at rest is of 0,4999%.

3.2 Characteristics of the mesh

the nombre total of nodes used for this mesh is of 61.
Meshes are 60 and of type SEG2.
Mesh file is written with the Aster format .

3.3 Stages of computation

the profile rate of flow and the parameters taking into account fluid-structure coupling are defined using operators DEFI_FONC_FLUI and DEFI_FLUI_STRU. One taking into account calculates the modal parameters of structure in the forces fluid-elastics using operator CALC_FLUI_STRU. The definition of the random excitation is carried out by calling upon operator DEFI_SPEC_TURB. The excitation is projected on modal base using operator PROJ_SPEC_BASE. The inter-spectrums of modal response are calculated using operator DYNA_SPEC_MODAL. One from of deduced the auto-- spectrums from displacement to the nodes by calling upon operator REST_SPEC_PHYS.

4 Results of the modelization A

4.1 Values tested

the tests ensure non regression code and relate to eigenfrequencies, reduced damping and the RMS in displacement.

4.2 Remarks

The computation is carried out with 4 modes and only one rate of flow of $4.811\,m/s$.

5 Modelization B

5.1 Characteristic of the modelization

the geometrical and material properties of the model are those presented higher. The tube is modelled using beam elements right of Timoshenko: POU_D_T. It is broken up into 60 elements distributed out of six sections.

The nodes A and C are blocked in the directions X, Y and Z in translation and rotation.

The damping out of fluid at rest of structure is of 0,4999%.

5.2 Characteristics of the mesh

the nombre total of nodes used for this mesh is of 61.
Meshes are 60 and of type SEG2.
Mesh file is written with the Aster format .

5.3 Stages of computation

the profile rate of flow and the parameters taking into account fluid-structure coupling are defined using operators FONC_FLUI_STRU and DEFI_FLUI_STRU.

- One calculates the modal parameters of water structure at rest using operator MODE_ITER_SIMULT.
- One taking into account calculates the modal parameters of structure in the elastic forces fluid - using operator CALC_FLUI_STRU.
- The definition of the random excitation is carried out by calling upon operator DEFI_SPEC_TURB. The excitation is projected on modal base using operator PROJ_SPEC_BASE.
- One calculates the random excitations over one determined period, by means of operator GENE_FONC_ALEA.
- For temporal computation, one recovers the forcing functions and one uses the temporal integration method by the integral method established in operator DYNA_VIBRA. This computation makes it possible to study the nonlinear dynamic response of a tube of steam generator subjected to an external flow.
- The operator of postprocessing used in order to evaluate the fatigue of the tube is then POST_FATIGUE.

6 Results of the modelization B

6.1 Values tested

the tests ensure non regression code and relate to displacements like on the office plurality of the damages.

6.2 Remarks

The computation is carried out with 4 modes over a total period of simulation of 1 second. It is carried out for only one rate of flow ($4{,}811\ m/s$) per direct integration with the integral method. The values tested are the damage and interval RMS of displacement for 1 and 100 cycles at the node of shock. The computing time and the number of pullings making it possible to define the excitation, are too weak to obtain a suitable average statistical representation random phenomenon. Therefore this case test constitutes only one case test of NON-regression. To obtain more representative mean values, it is enough to lengthen the period of computation and the number of pullings.

7 Modelization C

7.1 Characteristic of the modelization

the tube is modelled using beam elements right of Timoshenko: POU_D_T. It is broken up into 60 elements distributed out of six sections.

The nodes A and C are blocked in the directions X, Y and Z in translation and rotation.

The damping out of fluid at rest is of 0,4999%.

7.2 Characteristics of the mesh

the nombre total of nodes used for this mesh is of 61.
Meshes are 60 and of type SEG2.
Mesh file is written with the Aster format .

7.3 Stages of computation

the profile rate of flow and the parameters taking into account fluid-structure coupling are defined using operators FONC_FLUI_STRU and DEFI_FLUI_STRU.

- One calculates the modal parameters of water structure at rest using operator MODE_ITER_SIMULT.
- One taking into account calculates the modal parameters of structure in the elastic forces fluid - using operator CALC_FLUI_STRU.
- The definition of the random excitation is carried out by calling upon operator DEFI_SPEC_TURB. The excitation is projected on modal base using operator PROJ_SPEC_BASE.
- One calculates the random excitations over one determined period, by means of operator GENE_FONC_ALEA.
- For temporal computation, one recovers the forcing functions and one uses the temporal integration method by the integral method established in operator DYNA_VIBRA. This computation makes it possible to study the nonlinear dynamic response of a tube of steam generator subjected to an external flow.
- The operator of postprocessing used in order to evaluate the wear of the tube is then POST_USURE.

8 Results of the modelization C

8.1 Values tested

the tests ensure non regression code and relate to displacements like on value RMS of displacement following OY.

8.2 Remarks

The computation is carried out with 4 modes over a total period of simulation of 1 second. It is carried out for only one rate of flow ($4{,}811\ m/s$) per direct integration by the integral method. The values tested are the powers of wear to the node of shock. The computing time and the number of pullings making it possible to define L `excitation, are too weak to obtain a suitable average statistical representation random phenomenon. Therefore this case test constitutes only one case test of NON-regression. To obtain more representative mean values, it is enough to lengthen the period of computation and the number of pullings.

9 Conclusion

the single goal of this benchmark is the checking of the NON-regression of the computation channels GEVIBUS - *Code_Aster* during the joint use of operator `DYNA_VIBRA` with method ITMI of temporal integration by integral method and of the operators of post-analyzes of fatigue and wear. With the sight of the got results, one can consider that the NON-regression of *Code_Aster* is ensured for time.