FORMA13 - Practical works of the formation “Analyzes dynamic”: dynamic under-structuring

Summary:

These tests correspond to practical works of the dynamic formation of *Code_Aster,* for the part “dynamic under-structuring”.
This TP is inspired by research program SICODYN.
One compares on a calculation of pump the techniques of under-structuring of CRAIG-BAMPTON and by method of interfaces with a direct modal calculation.

1 Problem of reference

1.1 Description of the problem

This TP is inspired by an international research program [1], seeking to determine uncertainties in the calculation of an industrial structure by comparing the results of various teams on the same material.

The objective of this modeling is thus to determine, by dynamic under-structuring, the first 10 Eigen frequencies of a pump used in a power plant. For the needs for the TP, the structure was simplified.

Initially, one proposes to use the most classical technique of the under-structuring: method of CRAIG-BAMPTON. Then in the second time, the method of the interfaces is used.

[1] Sylvie Audebert, international SICODYN benchmark one dynamic analysis of structure assemblies: variability and numerical-experimental correlation one year industrial pump, Mechanics & Industries/Volume 11/Resulting 06/November 2010 pp 439-451

1.2 Geometry

The pump is divided into three parts (cf Illustration 1: Pump divided into three parts) :

- the stage (in green)
- the volute (in blue),
- the suction pipe (in yellow).

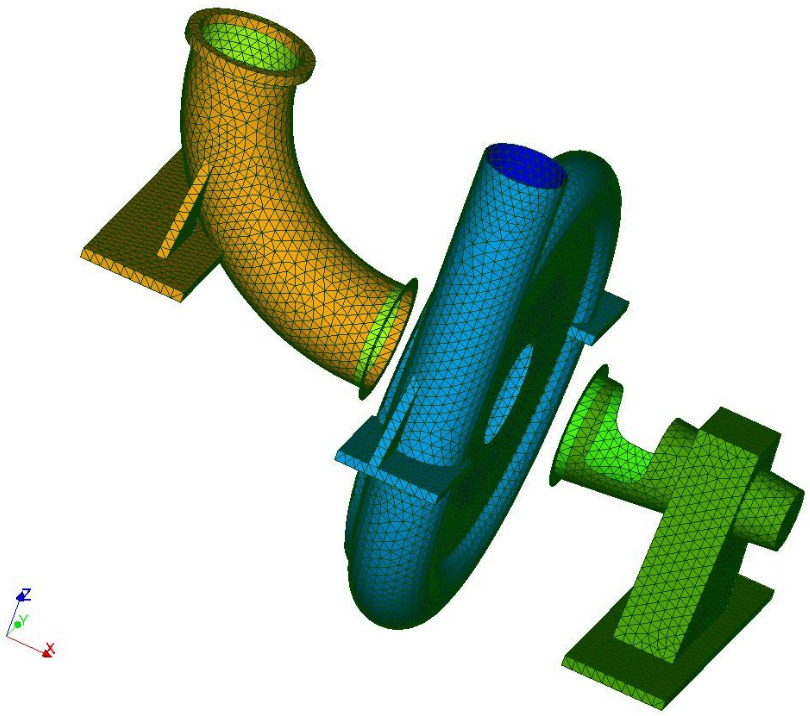


Illustration 1: Pump divided into three parts

One provides the grid of the three parts of the pump, like his complete grid (Illustration 2: Complete pump).

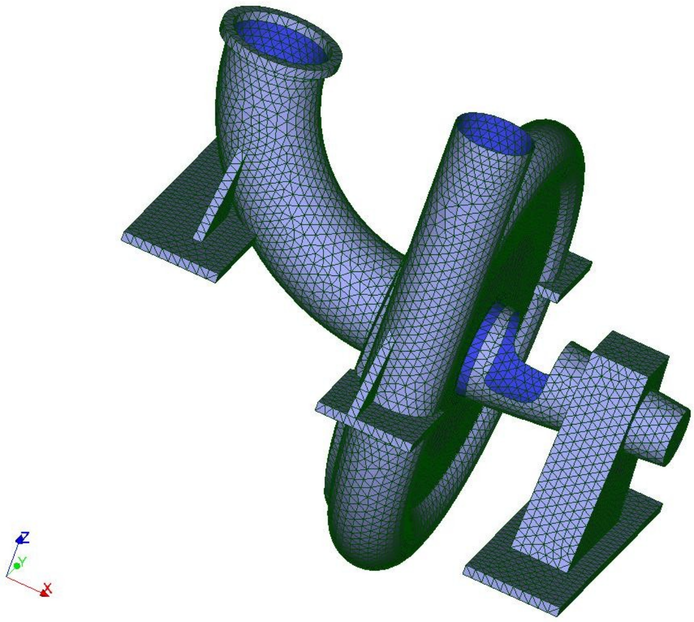


Illustration 2: Complete pump

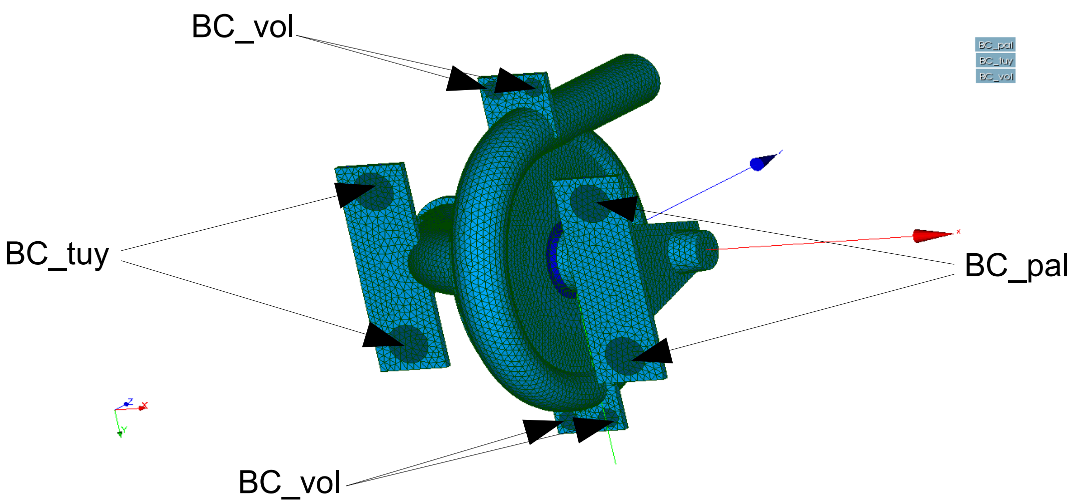
1.3 Properties materials

The pump is manufactured out of steel, isotropic elastic material linear of following characteristics:

- Young modulus $E=210\,000.10^{6}\,N/m^{2}$,
- Poisson's ratio $\nu=0.3$,
- density $\rho=7800\,Kg/m^{3}$

1.4 Boundary conditions and loading

The pump is fixed on the ground by embeddings on the stage, the volute and the pipe (respectively the group of nodes 'BC_pal', 'BC_vol' and 'BC_tuy').



2 Modeling A

2.1 Grid

One provides the grid of the three parts of the pump, like his complete grid. After having imported the grids in SALOME-MECA, one will take the time necessary to find the names of the groups necessary to the setting in data.
The grid is carried out in voluminal elements 3S in elements of plate DKT. The elements of plate correspond with a thickness of:

- $30\,mm$ for the stage (group 'Pal_2D')
- $50\,mm$ for the volute (group 'Vol_2D')
- $10\,mm$ for the pipe (group 'Vol_2D')

2.2 File of orders Aster

Principal stages of calculation with *Aster* are, for each substructure, the usual stages of setting in data:

Reading of the grid to the format `MED` (`LIRE_MAILLAGE ('FORMAT=' MED')`).
Definition of the finite elements used (`AFFE_MODELE`). Modeling '3D' and 'DKT'
Definition and assignment of material (`DEFI_MATERIAU` and `AFFE_MATERIAU`).
Assignment of the characteristics of the elements of plate (`AFFE_CARA_ELEM`).
Assignment of the boundary conditions (`AFFE_CHAR_MECA`).

Then the construction of the macronutrients, their assembly, the modal calculation of the assembled structure, the construction of the skeleton, the restitution of modal calculation on the skeleton and, finally, the impression of the modes:

Creation of the substructures (`CREA_ELEM_SSD`)
Assembly of the substructures (`ASSE_ELEM_SSD`)
Modal calculation (`CALC_MODES`)
Construction of the skeleton of visualization of the total modes (`DEFI_SQUELETTE`)
Restitution on the skeleton (`REST_SOUS_STRUC`)
Impression of the modes to format MED (`IMPR_RESU`)

They are to specify during creation the substructures the type of under-structuring to be used. Here, we have:
`TYPE=' CLASSIQUE'`

2.3 Results

The compared sizes are the frequencies of the first 10 clean modes of the pump obtained during the direct calculation carried out on the total grid with those obtained by under-structuring on the pump divided into three parts.

Mode	**Direct modal calculation** (Hz)	**Calculation by SSD** (Hz)
1	58.32	58.32
2	123.47	123.55
3	155.27	155.31

4	190.57	190.77
5	224.85	225.71
6	230.77	232.99
7	249.22	252.73
8	259.38	260.00
9	261.07	262.40
10	278.07	284.77

It is noted that the frequencies calculated by the two methods are very close.

One will be able to as check in SALOME-MECA as it is also the case of the modal deformations.

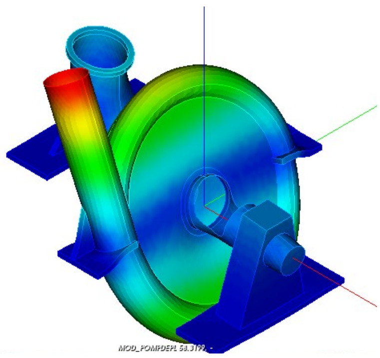


Illustration 3: Mode 1 of direct modal calculation

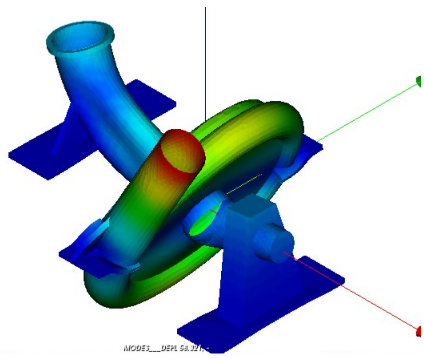


Illustration 4: Mode 1 of calculation SSD by Craig and Bampton

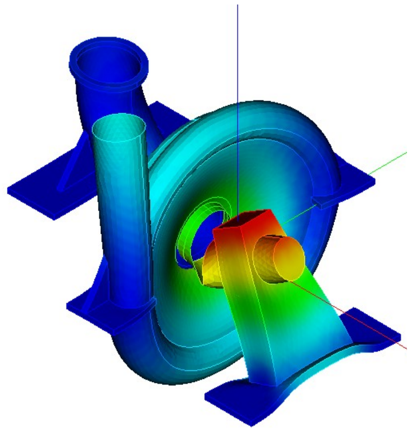


Illustration 5: Mode 2 of direct modal calculation

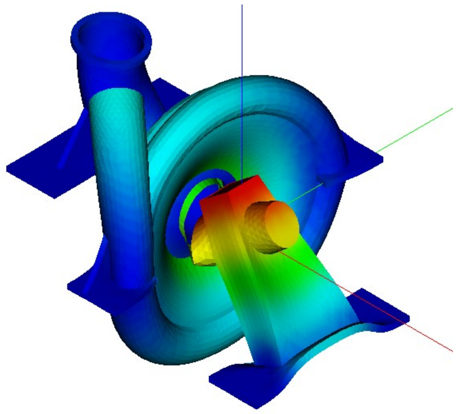


Illustration 6: Mode 2 of calculation SSD by Craig and Bampton

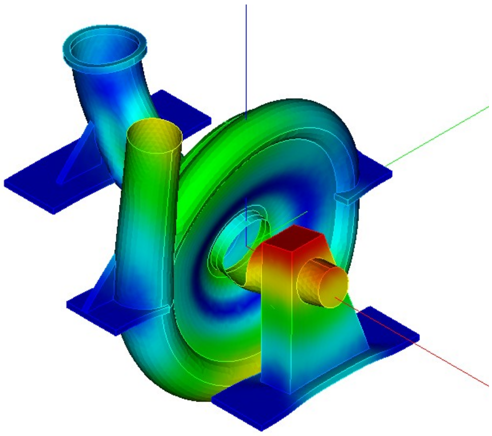


Illustration 7: Mode 3 of direct modal calculation

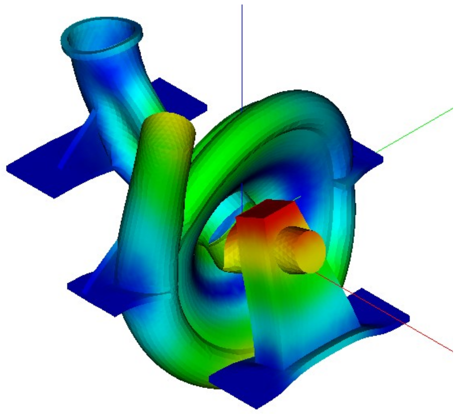


Illustration 8: Mode 3 of calculation SSD by Craig and Bampton

On the other hand the method of dynamic under-structuring classical of Craig & Bampton is relatively expensive. In the following part one proposes to employ the method of interface. Though slightly more complex, by limiting the number of modes of connection between the substructures, it clearly increases the effectiveness of the technique of under-structuring.

3 Modeling B

3.1 Grid

One provides the grid of the three parts of the pump, like his complete grid. After having imported the grids in SALOME-MECA, one will take the time necessary to find the names of the groups necessary to the setting in data.
The grid is carried out in voluminal elements 3S in elements of plate DKT. The elements of plate correspond with a thickness of:

- $30\,mm$ for the stage (group 'Pal_2D')
- $50\,mm$ for the volute (group 'Vol_2D')
- $10\,mm$ for the pipe (group 'Vol_2D')

3.2 File of orders Aster

Principal stages of calculation with *Aster* are, for each substructure, the usual stages of setting in data:

Reading of the grid to the format MED (LIRE_MAILLAGE ('FORMAT=' MED')).
Definition of the finite elements used (AFFE_MODELE). Modeling '3D' and 'DKT'
Definition and assignment of material (DEFI_MATERIAU and AFFE_MATERIAU).
Assignment of the characteristics of the elements of plate (AFFE_CARA_ELEM).
Assignment of the boundary conditions (AFFE_CHAR_MECA).

Then the construction of the macronutrients, their assembly, the modal calculation of the assembled structure, the construction of the skeleton, the restitution of modal calculation on the skeleton and, finally, the impression of the modes:

Creation of the substructures (CREA_ELEM_SSD)
Assembly of the substructures (ASSE_ELEM_SSD)
Modal calculation (CALC_MODES)
Construction of the skeleton of visualization of the total modes (DEFI_SQUELETTE)
Restitution on the skeleton (REST_SOUS_STRUC)
Impression of the modes to format MED (IMPR_RESU)

They are to specify during creation the substructures the type of under-structuring to be used. Here, we have:

```
TYPE=' RITZ'
TYPE_MODE=' INTERFACE'
```

3.3 Results

The compared sizes are the frequencies of the first 10 clean modes of the pump obtained during the direct calculation carried out on the total grid with those obtained by under-structuring on the pump divided into three parts.

Mode	**Direct modal calculation** (Hz)	**Calculation by SSD** (Hz)
1	58.32	58.43
2	123.47	146.72

3	155.27	185.43
4	190.57	196.71
5	224.85	229.52
6	230.77	236.14
7	249.22	256.57
8	259.38	263.87
9	261.07	275.37
10	278.07	287.58

It is noted that the frequencies calculated by the two methods are rather close.
One will be able to as check in SALOME-MECA as it is also the case of the modal deformations.

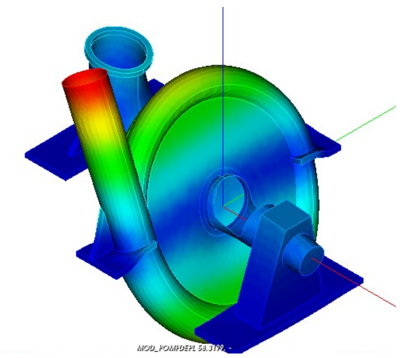


Illustration 9: Mode 1 of direct modal calculation

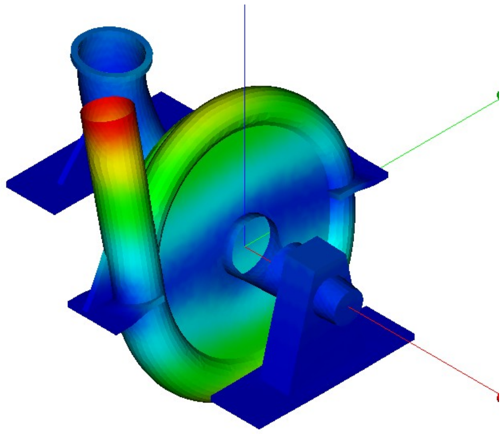


Illustration 10: Mode 1 of calculation SSD by the method of the interfaces

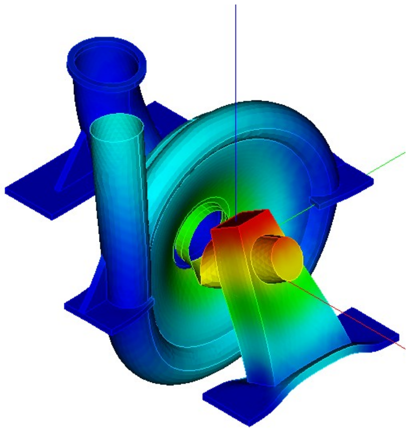


Illustration 11: Mode 2 of direct modal calculation

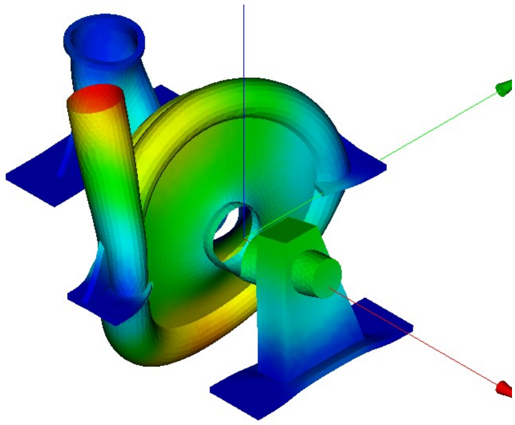


Illustration 12: Mode 2 of calculation SSD by the method of the interfaces

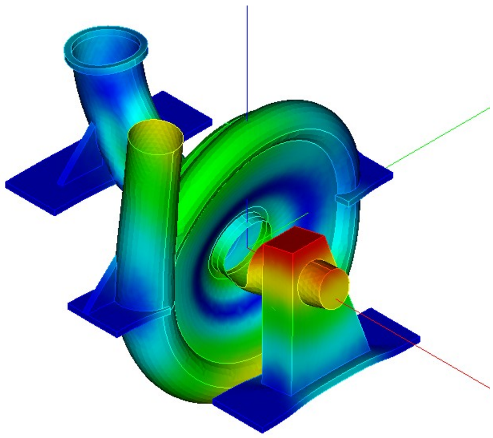


Illustration 13: Mode 3 of direct modal calculation

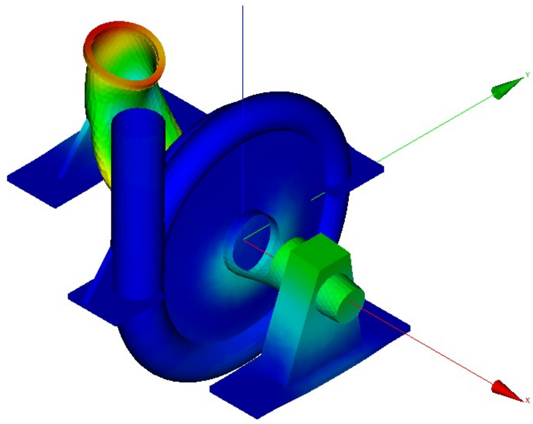


Illustration 14: Mode 3 of calculation SSD by the method of the interfaces