SDLV301 – cyclic Under-structuring: pump wheel

Summary:

The scope of application of this test is the modal analysis of the structures with cyclic repetitivity. The studied structure is a pump wheel; it is modelled by hexahedral elements volumes with 20 nodes (modeling 3D).
It is about an industrial test for which there does not exist analytical solution. The method of calculating is the cyclic dynamic under-structuring of Craig-Bampton.

1 Problem of reference

1.1 Geometry

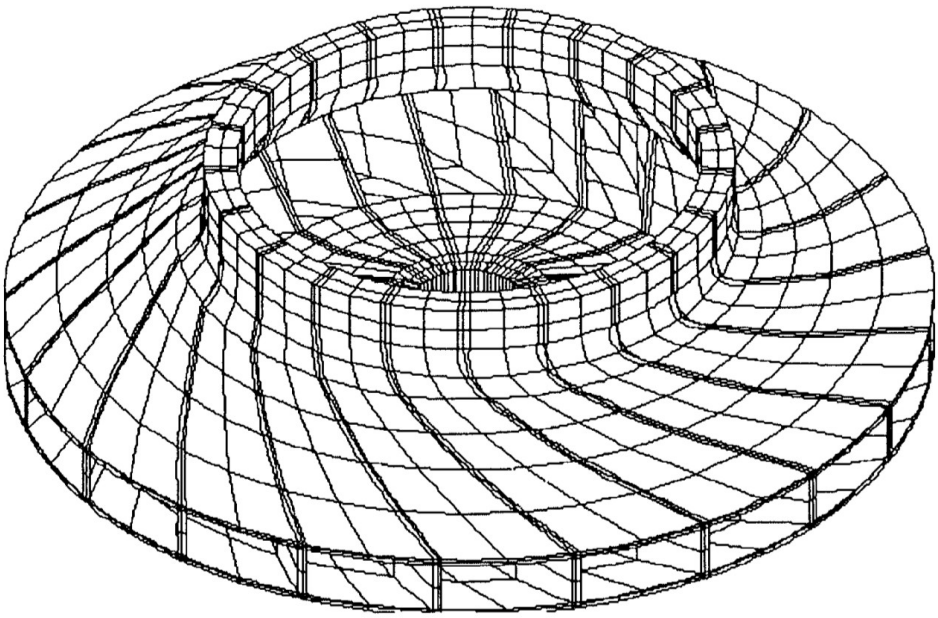

Figure 1.1-1 : Geometry of the problem

Figure 1.1 presents an overall picture of the structure: it comprises 21 sectors. The diameter of the hub is of $60\,mm$, the external diameter is of $480\,mm$.

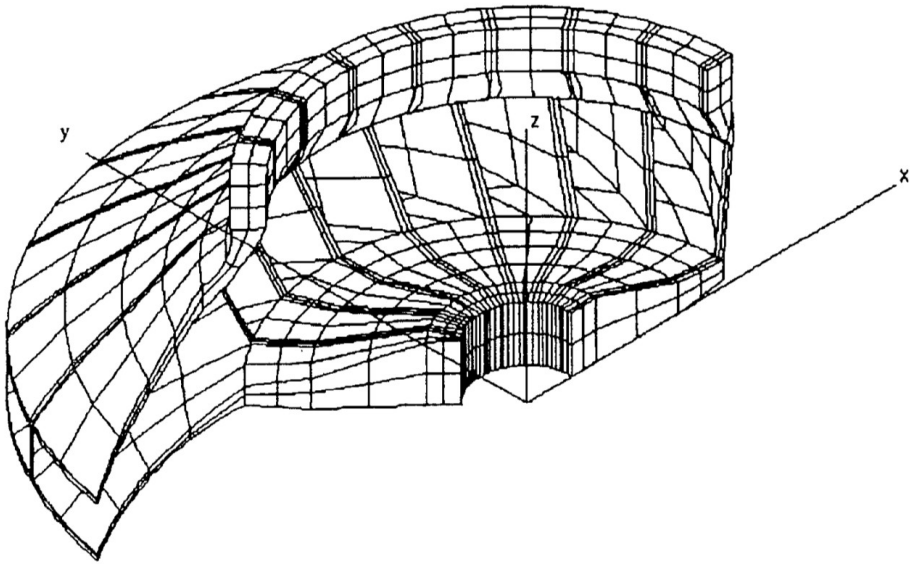

Figure 1.1-2 : Detailed sight of the geometry of the problem

Figure 1.2 shows a sight of detail including 8 sectors. The system of axes represented is the structural system $X\,Y\,Z$. Each point can be located in this system or, in an equivalent way, in a system of cylindrical axes. The axis of revolution of the cylindrical reference mark coincides with the axis Z and the azimuth coordinate q its origin in the plan has $X\,Z$.

The borders right-hand side and left of the sector are defined by the points which present, in the cylindrical reference mark, an angular variation equal to the aperture of the sector, that is to say $1/21^{ème}$ of $360°$. The points of the two borders go per pairs: the point of angle q minimum belongs to the right border, that of angle q maximum belongs to the left border.

1.2 Properties of material

Young modulus	$E=2.1\times10^{11}\ Pa$
Poisson's ratio	$\nu=0.3$
Density	$\rho=7800.0\ kg.m^{-3}$

1.3 Boundary conditions and loadings

Imposed displacement:

Embedding of the hub of the wheel	$DX=0$, $DY=0$, $DZ=0$

Imposed rotation:

Wheel	$\omega=2000\ \mathrm{rd.s^{-1}}$

2 Reference solution

2.1 Method of calculating used for the reference solution

One is interested specifically in the clean modes in inflection. The frequencies are compared with those obtained numerically by means of software the SAMCEF software. The technique of calculation used is a method of direct cyclic symmetry, without recourse to a modal base.

2.2 Results of reference

The modal analysis was carried out with three grids of different smoothnesses. The table below provides the first four double frequencies corresponding to each of the three grids for various number of revolutions.

Modes	Eigen frequencies (Hz) Number of revolutions: $0\ \mathrm{rd.s^{-1}}$		
	160 elements	540 elements	1280 elements
1.2	442.1	440.3	438.6
3.4	1452.	1436.	1428.
5.6	3342.	3311.	3297.
7.8	4855.	4828.	4812.

Number of the modes	Eigen frequencies (Hz) Number of revolutions: $2000\ \mathrm{rd.s^{-1}}$		
	160 elements	540 elements	1280 elements
1.2	409	406.8	404.9
3.4	1431.	1414.	1407.
5.6	3335.	3304.	3290.
7.8	4852.	4824.	4809.

The results of references used in modelings of this test are those of the grid with 160 elements.

2.3 Uncertainty on the solution

Digital solution obtained by an external software.

3 Modeling A

3.1 Characteristics of modeling A

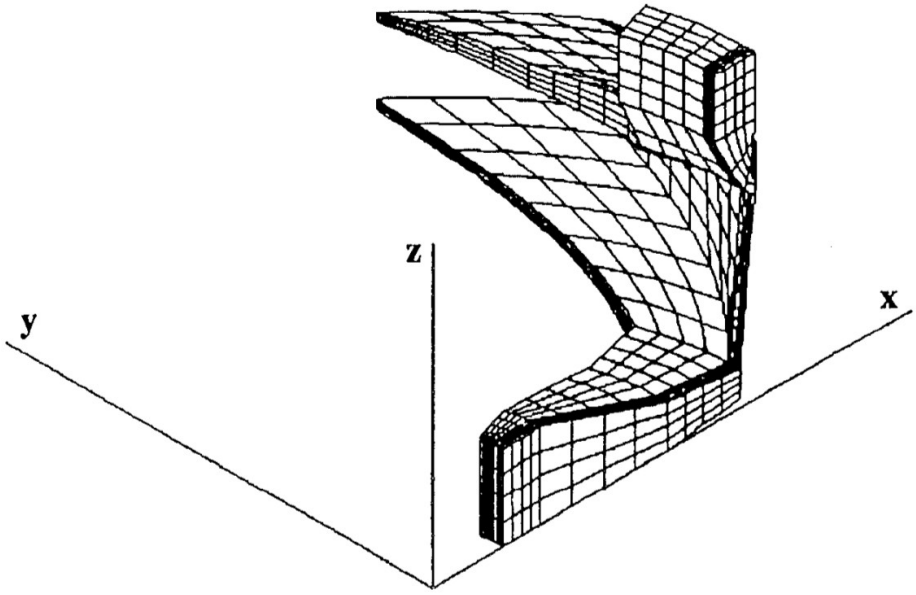

Figure 3.1-1 : Grid of a sector of the geometry of the problem

Only one sector is with a grid, its angular opening is of $1/21^{ème}$ of $360°$ (modeling 3D).
Calculation does not take into account the rotation of the structure.

3.2 Characteristics of the grid

Many nodes: 1077
Many meshs and types: 160 HEXA20

3.3 Sizes tested and results

Modes	Value of reference	Type of reference	Tolerance (%)
1.2	442.1	'SOURCE_EXTERNE'	3.0
3.4	1452.0	'SOURCE_EXTERNE'	3.0
5.6	3342.0	'SOURCE_EXTERNE'	3.0
7.8	4855.0	'SOURCE_EXTERNE'	3.0

4 Modeling B

4.1 Characteristics of modeling B

Modeling is identical to modeling A, with a number of revolutions of $2000\,\mathrm{rd.s^{-1}}$ around the axis Z.

4.2 Characteristics of the grid

See modeling A.

4.3 Sizes tested and results

Modes	Value of reference	Type of reference	Tolerance (%)
1.2	409.0	'SOURCE_EXTERNE'	3.0
3.4	1431.0	'SOURCE_EXTERNE'	3.0
5.6	3335.0	'SOURCE_EXTERNE'	3.0
7.8	4852.0	'SOURCE_EXTERNE'	3.0

5 Summary of the results

Modeling A of this industrial test makes it possible to validate the order MODE_ITER_CYCL for an interface of the type Craig Bampton on a structure of which $1/21^{ème}$ is represented by 160 elements. The results, compared with another computation software, are satisfactory.

Modeling B makes it possible to validate the order MODE_ITER_CYCL with taking into centrifugal account of stiffness. The got results are satisfactory.