PERF010 – Elastic design of a full twin wheel in parallel

Summary:

The objective of this CAS-test is to measure the parallel performances of an elastic design of a massive structure 3D subjected to a sinusoidal thermal loading.
This CAS-test is directly inspired by PERF008, modeling A. the grid is composed of meshs HEXA8, it comprises $4.9\,10^5$ ddls.

Eight modelings differ by the options from parallel calculation:

1) Sequential modeling a:, solvor MULT_FRONT
2) Parallel modeling b: (OpenMP), 2 processors, solvor MULT_FRONT
3) Modeling C: parallel (OpenMP), 4 processors, solvor MULT_FRONT
4) Modeling D: sequential, solvor MUMPS
5) Modeling E: parallel (MPI), 2 processors, solvor MUMPS
6) Modeling F: parallel (MPI), 4 processors, solvor MUMPS
7) Modeling G: parallel (MPI), 8 processors, solvor MUMPS
8) Modeling H: parallel (MPI), 16 processors, solvor MUMPS

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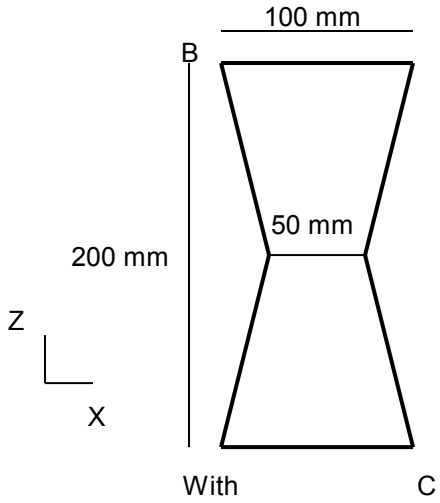
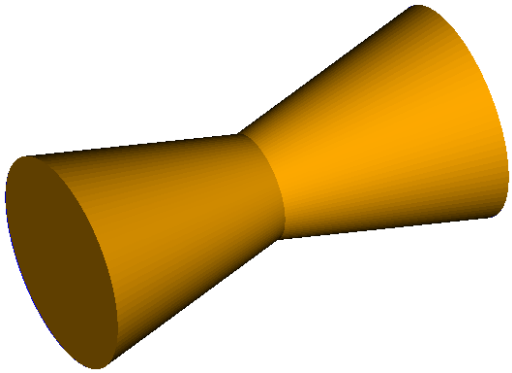
1 Problem of reference

1.1 Geometry





1.2 Properties of material

- $E=5.10^{11}\,Pa$
- $\nu=0.3$
- $\rho=9800.\,kg/m^3$

1.3 Boundary conditions and loadings

Imposed displacements:

A	:	$DX=DY=DZ=0.$
B	:	$DX=DY=0.$
C	:	$DY=0.$

Imposed thermal field:

$$T=\cos(z/\pi)$$

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2 Reference solution

2.1 Method of calculating

The result of reference (displacement maximum following the axis X and Y) was obtained by making the average of the displacements calculated during several calculations.

2.2 Uncertainties

Digital solution,

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3 Modeling A

3.1 Characteristics of modeling A

Many processors: 1

Modeling 3D:

Many nodes	166,397			
Many meshs	187,680	That is to say:		
			SEG2	1,376
			QUAD4	25,792
			HEXA8	160,512

3.2 Features tested

Order	Option	
AFFE_MODELE	MODELING	3D
AFFE_CHAR_MECA	DDL_IMPO	
AFFE_MATERIAU	AFFE_VARC	NOM_VARC
MECA_STATIQUE		
SOLVEUR	METHOD	MULT_FRONT

3.3 Results

Size	Reference	Code_Aster	Relative error (%)
DEPL MAX DX	5.2E-5	5.19E-5	-0.19
DEPL MAX DY	2.6E-5	2.595E-5	-0.19

3.4 Environment of execution

Machine	Version	Memory (Mo)		Number DDL	Time execution (MECA_STATIQUE) (dryness)			
		Allocated	Used		TO USE	SYSTEM	TO USE +SYS	ELAPSED
Linux 64 bits (ia64) "Bull"	10.1.15	6500	6188.15	499,203	1525.92	56.25	1582.17	1592.04

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4 Modeling B

4.1 Characteristics of modeling B

Many processors: 2 (OpenMP)

Modeling 3D:

Many nodes	166,397			
Many meshs	187,680	That is to say:		
			SEG2	1,376
			QUAD4	25,792
			HEXA8	160,512

4.2 Features tested

Order	Option	
AFFE_MODELE	MODELING	3D
AFFE_CHAR_MECA	DDL_IMPO	
AFFE_MATERIAU	AFFE_VARC	NOM_VARC
MECA_STATIQUE		
SOLVEUR	METHOD	MULT_FRONT

4.3 Results

Size	Reference	Code_Aster	Relative error (%)
DEPL MAX DX	5.2E-5	5.19E-5	-0.19
DEPL MAX DY	2.6E-5	2.595E-5	-0.19

4.4 Environment of execution

Machine	Version	Memory (Mo)		Number DDL	Time execution (MECA_STATIQUE) (dryness)			
		Allocated	Used		TO USE	SYSTEM	TO USE +SYS	ELAPSED
Linux 64 bits (ia64) "Bull"	10.1.15	6500	6188.15	499,203	1557.33	46.64	1603.97	934.42

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5 Modeling C

5.1 Characteristics of modeling C

Many processors: 4 (OpenMP)

Modeling 3D:

Many nodes 166,397
Many meshs 187,680 That is to say:

SEG2	1,376
QUAD4	25,792
HEXA8	160,512

5.2 Features tested

Order	Option	
AFFE_MODELE	MODELING	3D
AFFE_CHAR_MECA	DDL_IMPO	
AFFE_MATERIAU	AFFE_VARC	NOM_VARC
MECA_STATIQUE		
SOLVEUR	METHOD	MULT_FRONT

5.3 Results

Size	Reference	Code_Aster	Relative error (%)
DEPL MAX DX	5.2E-5	5.19E-5	-0.19
DEPL MAX DY	2.6E-5	2.595E-5	-0.19

5.4 Environment of execution

Machine	Version	Memory (Mo)		Number DDL	Time execution (MECA_STATIQUE) (dryness)			
		Allocated	Used		TO USE	SYSTEM	TO USE +SYS	ELAPSED
Linux 64 bits (ia64) "Bull"	10.1.15	6500	6188.15	499203	1734.61	47.92	1782.53	651.26

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6 Modeling D

6.1 Characteristics of modeling D

Many processors: 1

Modeling 3D:

Many nodes	166,397			
Many meshs	187,680	That is to say:		
			SEG2	1,376
			QUAD4	25,792
			HEXA8	160,512

6.2 Features tested

Order	Option	
AFFE_MODELE	MODELING	3D
AFFE_CHAR_MECA	DDL_IMPO	
AFFE_MATERIAU	AFFE_VARC	NOM_VARC
MECA_STATIQUE		
SOLVEUR	METHOD	MUMPS
	OUT_OF_CORE	'YES'

6.3 Results

Size	Reference	Code_Aster	Relative error (%)
DEPL MAX DX	5.2E-5	5.19E-5	-0.19
DEPL MAX DY	2.6E-5	2.595E-5	-0.19

6.4 Environment of execution

Machine	Version	Memory (Mo)		Number DDL	Time execution (MECA_STATIQUE) (dryness)			
		Allocated	Used		TO USE	SYSTEM	TO USE +SYS	ELAPSED
Linux 64 bits (ia64) "Bull"	10.1.15	6500	1362.46 (A) 2619 (M)	499,203	1471.82	30.79	1502.61	1523.18

(A): memory used with more by JEVEUX (administrative memory of *Code_Aster*)
(M): memory used with more by MUMPS

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7 Modeling E

7.1 Characteristics of modeling E

Many processors: 2 (MPI)

Modeling 3D:

Many nodes 166,397
Many meshs 187,680 That is to say:

SEG2	1,376
QUAD4	25,792
HEXA8	160,512

7.2 Features tested

Order	Option	
AFFE_MODELE	MODELING	3D
AFFE_CHAR_MECA	DDL_IMPO	
AFFE_MATERIAU	AFFE_VARC	NOM_VARC
MECA_STATIQUE		
SOLVEUR	METHOD	MUMPS
	OUT_OF_CORE	'YES'
	MATR_DISTRIBUEE	'YES'

7.3 Results

Size	Reference	Code_Aster	Relative error (%)
DEPL MAX DX	5.2E-5	5.19E-5	-0.19
DEPL MAX DY	2.6E-5	2.595E-5	-0.19

7.4 Environment of execution

Machine	Version	Memory (Mo)		Number DDL	Time execution (MECA_STATIQUE) (dryness)			
		Allocated	Used		TO USE	SYSTEM	TO USE +SYS	ELAPSED
Linux 64 bits (ia64) "Bull"	10.1.15	6500	1207.86 (A)	499,203	821.07	18.71	839.78	847.34

(A): memory used with more by JEVEUX (administrative memory of *Code_Aster*)

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8 Modeling F

8.1 Characteristics of modeling F

Many processors: 4 (MPI)

Modeling 3D:

Many nodes	166,397			
Many meshs	187,680	That is to say:		
			SEG2	1,376
			QUAD4	25,792
			HEXA8	160,512

8.2 Features tested

Order	Option	
AFFE_MODELE	MODELING	3D
AFFE_CHAR_MECA	DDL_IMPO	
AFFE_MATERIAU	AFFE_VARC	NOM_VARC
MECA_STATIQUE		
SOLVEUR	METHOD	MUMPS
	OUT_OF_CORE	'YES'
	MATR_DISTRIBUEE	'YES'

8.3 Results

Size	Reference	Code_Aster	Relative error (%)
DEPL MAX DX	5.2E-5	5.19E-5	-0.19
DEPL MAX DY	2.6E-5	2.595E-5	-0.19

8.4 Environment of execution

Machine	Version	Memory (Mo)		Number DDL	Time execution (MECA_STATIQUE) (dryness)			
		Allocated	Used		TO USE	SYSTEM	TO USE +SYS	ELAPSED
Linux 64 bits (ia64) "Bull"	10.1.15	6500	1140.78 (A)	499,203	430.72	11.05	441.77	442.03

(A): memory used with more by JEVEUX (administrative memory of *Code_Aster*)

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9 Modeling G

9.1 Characteristics of modeling G

Many processors: 8 (MPI)

Modeling 3D:

Many nodes 166,397
Many meshs 187,680 That is to say:

SEG2	1,376
QUAD4	25,792
HEXA8	160,512

9.2 Features tested

Order	Option	
AFFE_MODELE	MODELING	3D
AFFE_CHAR_MECA	DDL_IMPO	
AFFE_MATERIAU	AFFE_VARC	NOM_VARC
MECA_STATIQUE		
SOLVEUR	METHOD	MUMPS
	MATR_DISTRIBUEE	'YES'

9.3 Results

Size	Reference	Code_Aster	Relative error (%)
DEPL MAX DX	5.2E-5	5.19E-5	-0.19
DEPL MAX DY	2.6E-5	2.595E-5	-0.19

9.4 Environment of execution

Machine	Version	Memory (Mo)		Number DDL	Time execution (MECA_STATIQUE) (dryness)			
		Allocated	Used		TO USE	SYSTEM	TO USE +SYS	ELAPSED
Linux 64 bits (ia64) "Bull"	10.1.15	6500	1090.81 (A)	499,203	404.68	9.54	414.22	415.84

(A): memory used with more by JEVEUX (administrative memory of *Code_Aster*)

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10 Modeling H

10.1 Characteristics of modeling H

Many processors: 16 (MPI)

Modeling 3D:

Many nodes	166,397			
Many meshs	187,680	That is to say:		
			SEG2	1,376
			QUAD4	25,792
			HEXA8	160,512

10.2 Features tested

Order	Option	
AFFE_MODELE	MODELING	3D
AFFE_CHAR_MECA	DDL_IMPO	
AFFE_MATERIAU	AFFE_VARC	NOM_VARC
MECA_STATIQUE		
SOLVEUR	METHOD	MUMPS
	MATR_DISTRIBUEE	'YES'

10.3 Results

Size	Reference	Code_Aster	Relative error (%)
DEPL MAX DX	5.2E-5	5.19E-5	-0.19
DEPL MAX DY	2.6E-5	2.595E-5	-0.19

10.4 Environment of execution

Machine	Version	Memory (Mo)		Number DDL	Time execution (MECA_STATIQUE) (dryness)			
		Allocated	Used		TO USE	SYSTEM	TO USE +SYS	ELAPSED
Linux 64 bits (ia64) "Bull"	10.1.15	6500	1067.97 (A)	499,203	223.57	9.03	232.60	238.85

(A): memory used with more by JEVEUX (administrative memory of *Code_Aster*)

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11 Summary of the results

Machine	Aster	MOD.	Nb. DDL	Memory (Mo)		Time execution (MECA_STATIQUE) (dryness)			
				Allocated	Used (*)	TO USE	SYSTEM	TO USE +SYS	ELAPSED
Linux 64 bits (ia64) "Bull"	10.1.15	With	499,203	6500	6188.15	1525.92	56.25	1582.17	1592.04
		B	499,203	6500	6188.15	1557.33	46.64	1603.97	934.42
		C	499,203	6500	6188.15	1734.61	47.92	1782.53	651.26
		D	499,203	6500	1362.46	1471.82	30.79	1502.61	1523.18
		E	499,203	6500	1207.86	821.07	18.71	839.78	847.34
		F	499,203	6500	1140.78	430.72	11.05	441.77	442.03
		G	499,203	6500	1090.81	404.68	9.54	414.22	415.84
		H	499,203	6500	1067.97	223.57	9.03	232.60	238.85

(*) for modelings with MUMPS (D, E, F, G, H), the memory used indicated is that of Aster, it does not include that necessary to MUMPS.

It is noted that the parallel performances OpenMP make it possible to reach an effectiveness of 60% with 4 processors.
In MPI with MUMPS, one reaches more than 80% of parallel effectiveness with 4 processors, and one is maintained to 40% to 16 processors. One in addition notes the progressive reduction in the quantity of memory required by processor thanks to the distribution of the matrix.

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