PERF010 – Elastic design of a full twin wheel in parallel

Summarized:

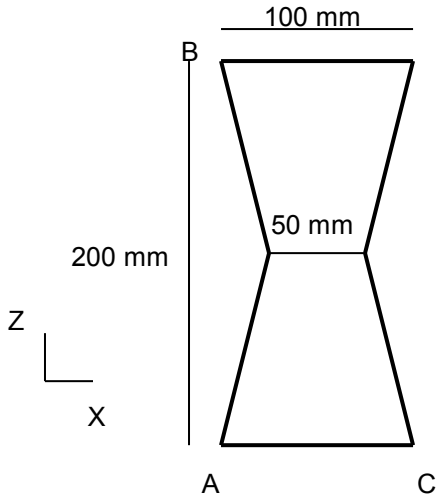
The purpose of this benchmark is to measure the parallel performances of an elastic design of a structure 3D massive subjected to a sinusoidal thermal loading.
This benchmark is directly inspired by PERF008, modelization A. The mesh is composed of meshes HEXA8, it comporteddls $4.9\,10^5$.

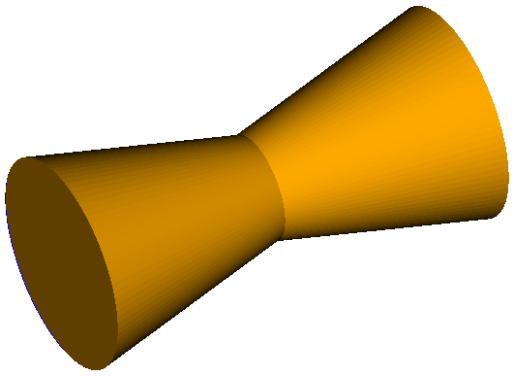
The eight modelizations differ by the computation options parallel:

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

1 Problem of reference

1.1 Geometry





1.2 Properties of the 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:

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

2 Reference solution

2.1 Method of calculating

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

2.2 Uncertainties

numerical Solution,

3 Modelization A

3.1 Characteristic of the modelization A

Many processors: 1

Modelization 3D:

Many nodes	166.397		
Number of meshes	187.680	Are:	
		SEG2	1.376
		QUAD4	25.792
		HEXA8	160.512

3.2 Functionalities tested

Command	Option	
AFFE_MODELE	MODELISATION	3D
AFFE_CHAR_MECA	DDL_IMPO	
AFFE_MATERIAU	AFFE_VARC	NOM_VARC
MECA_STATIQUE		
solver	METHODE	MULT_FRONT

3.3 Results

Quantity	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	(Mo) Memory		Number DDL	Time execution (MECA_STATIQUE) (dry)			
		Allocated	Used		USER	SYSTEM	USER+ SYS	ELAPSED
Linux 64 bits (ia64) "Bulls"	10.1.15	6500	6188.15	499.203	1525.92	56.25	1582.17	1592.04

4 Modelization B

4.1 Characteristic of the modelization B

Many processors: 2 (OpenMP)

Modelization 3D:

Many nodes 166.397
Number of meshes 187.680 Are:

SEG2	1.376
QUAD4	25.792
HEXA8	160.512

4.2 Functionalities tested

Command	Option	
AFFE_MODELE	MODELISATION	3D
AFFE_CHAR_MECA	DDL_IMPO	
AFFE_MATERIAU	AFFE_VARC	NOM_VARC
MECA_STATIQUE		
solver	METHODE	MULT_FRONT

4.3 Results

Quantity	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	(Mo) Memory		Number DDL	Time execution (MECA_STATIQUE) (dry)			
		Allocated	Used		USER	SYSTEM	USER+ SYS	ELAPSED
Linux 64 bits (ia64) "Bulls"	10.1.15	6500	6188.15	499.203	1557.33	46.64	1603.97	934.42

5 Modelization C

5.1 Characteristic of the modelization C

Many processors: 4 (OpenMP)

Modelization 3D:

Many nodes	166.397		
Number of meshes	187.680	Are:	
		SEG2	1.376
		QUAD4	25.792
		HEXA8	160.512

5.2 Functionalities tested

Command	Option	
AFFE_MODELE	MODELISATION	3D
AFFE_CHAR_MECA	DDL_IMPO	
AFFE_MATERIAU	AFFE_VARC	NOM_VARC
MECA_STATIQUE		
solver	METHODE	MULT_FRONT

5.3 Results

Quantity	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	(Mo) Memory		Number DDL	Time execution (MECA_STATIQUE) (dry)			
		Allocated	Used		USER	SYSTEM	USER+ SYS	ELAPSED
Linux 64 bits (ia64) "Bulls"	10.1.15	6500	6188.15	499203	1734.61	47.92	1782.53	651.26

6 Modelization D

6.1 Characteristic of the modelization D

Many processors: 1

Modelization 3D:

Many nodes 166.397
Number of meshes 187.680 Are:

SEG2	1.376
QUAD4	25.792
HEXA8	160.512

6.2 Functionalities tested

Command	Option	
AFFE_MODELE	MODELISATION	3D
AFFE_CHAR_MECA	DDL_IMPO	
AFFE_MATERIAU	AFFE_VARC	NOM_VARC
MECA_STATIQUE		
solver	METHODE	MUMPS
	OUT_OF_CORE	"OUI'

6.3 Results

Quantity	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	(Mo) Memory		Number DDL	Time execution (MECA_STATIQUE) (dry)			
		Allocated	Used		USER	SYSTEM	USER +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 (manager memory of *Code_Aster*)
(M): memory used with more by MUMPS

7 Modelization E

7.1 Characteristic of the modelization E

Many processors: 2 (MPI)

Modelization 3D:

Many nodes 166.397
Number of meshes 187.680 Are:

SEG2	1.376
QUAD4	25.792
HEXA8	160.512

7.2 Functionalities tested

Command	Option	
AFFE_MODELE	MODELISATION	3D
AFFE_CHAR_MECA	DDL_IMPO	
AFFE_MATERIAU	AFFE_VARC	NOM_VARC
MECA_STATIQUE		
solver	METHODE	MUMPS
	OUT_OF_CORE	"OUI'
	MATR_DISTRIBUEE	"OUI'

7.3 Results

Quantity	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	(Mo) Memory		Number DDL	Time execution (MECA_STATIQUE) (dry)			
		Allocated	Used		USER	SYSTEM	USER +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 (manager memory of *Code_Aster*)

8 Modelization F

8.1 Characteristic of the modelization F

Many processors: 4 (MPI)

Modelization 3D:

Many nodes 166.397
Number of meshes 187.680 Are:

SEG2	1.376
QUAD4	25.792
HEXA8	160.512

8.2 Functionalities tested

Command	Option	
AFFE_MODELE	MODELISATION	3D
AFFE_CHAR_MECA	DDL_IMPO	
AFFE_MATERIAU	AFFE_VARC	NOM_VARC
MECA_STATIQUE		
solver	METHODE	MUMPS
	OUT_OF_CORE	"OUI'
	MATR_DISTRIBUEE	"OUI'

8.3 Results

Quantity	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	(Mo) Memory		Number DDL	Time execution (MECA_STATIQUE) (dry)			
		Allocated	Used		USER	SYSTEM	USER +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 (manager memory of *Code_Aster*)

9 Modelization G

9.1 Characteristic of the modelization G

Many processors: 8 (MPI)

Modelization 3D:

Many nodes 166.397
Number of meshes 187.680 Are:

SEG2	1.376
QUAD4	25.792
HEXA8	160.512

9.2 Functionalities tested

Command	Option	
AFFE_MODELE	MODELISATION	3D
AFFE_CHAR_MECA	DDL_IMPO	
AFFE_MATERIAU	AFFE_VARC	NOM_VARC
MECA_STATIQUE		
solver	METHODE	MUMPS
	MATR_DISTRIBUEE	"OUI'

9.3 Results

Quantity	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	(Mo) Memory		Number DDL	Time execution (MECA_STATIQUE) (dry)			
		Allocated	Used		USER	SYSTEM	USER +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 (manager memory of *Code_Aster*)

10 Modelization H

10.1 Characteristic of the modelization H

Many processors: 16 (MPI)

Modelization 3D:

Many nodes 166.397
Number of meshes 187.680 Are:

SEG2	1.376
QUAD4	25.792
HEXA8	160.512

10.2 Functionalities tested

Command	Option	
AFFE_MODELE	MODELISATION	3D
AFFE_CHAR_MECA	DDL_IMPO	
AFFE_MATERIAU	AFFE_VARC	NOM_VARC
MECA_STATIQUE		
solver	METHODE	MUMPS
	MATR_DISTRIBUEE	"OUI'

10.3 Results

Quantity	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	(Mo) Memory		Number DDL	Time execution (MECA_STATIQUE) (dry)			
		Allocated	Used		USER	SYSTEM	USER +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 (manager memory of *Code_Aster*)

11 Summary of the results

Machine	Aster	MOD.	Nb. DDL	Memory (Mo)		Time execution (MECA_STATIQUE) (dry)			
				Allocated	Used (*)	USER	SYSTEM	USER+SYS	ELAPSED
Linux 64 bits (ia64) "Bull"	10.1.15	A	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 the modelizations 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.