What's new in MEMS Pro V8.2 and v8.4 Highlights

Platform Support

- MEMS Pro v8.2 supported OS:
  - Windows:
    - *XP*
    - *Windows 7*
    - *Windows 8*
  - OS types
    - *32 bits*
    - *64 bits*

64 bit engine

- Larger models can now be made
  - > 4GB can be address
  - Engine has no memory limit

SoftMEMS API

- 3D Models can be made from inside a “C” program or inside Matlab
  - Supports GDS read in
  - Fabrication process read in from a file
  - 3D Model generation
  - Cross-section generation

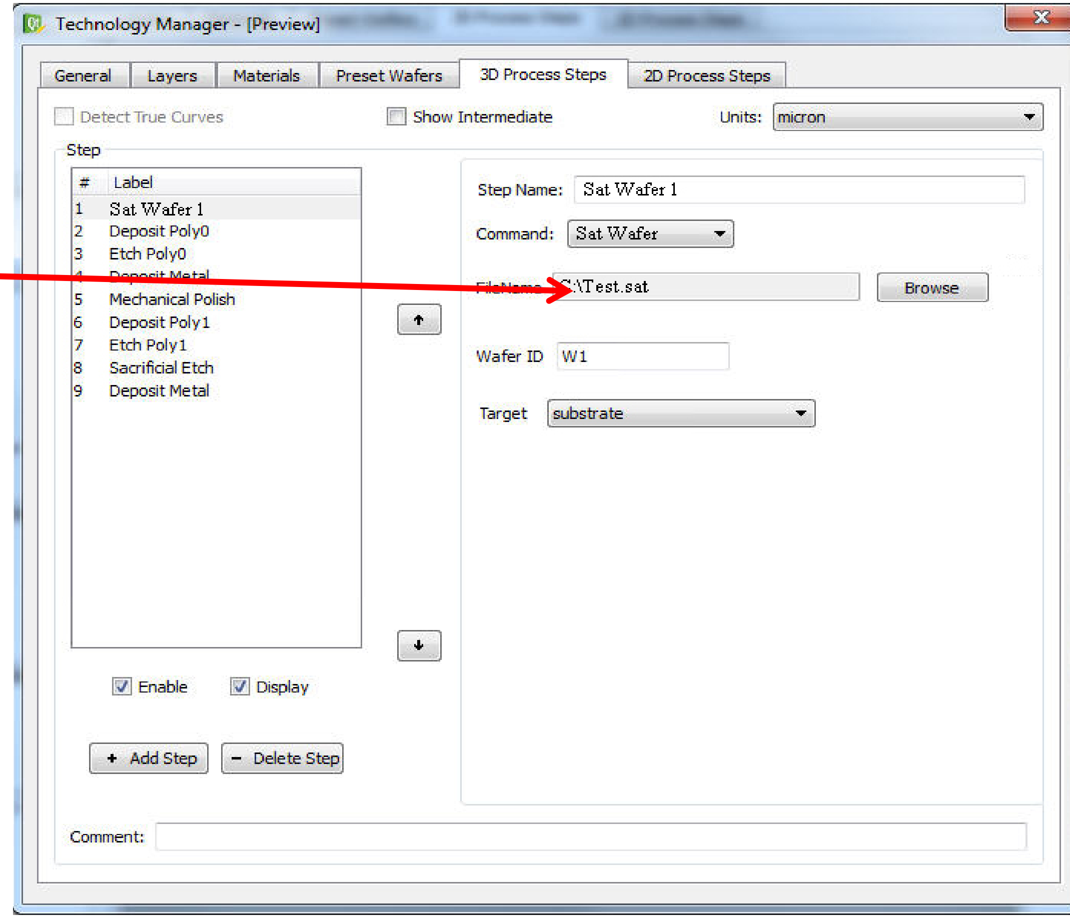
```
//ConsoleProgressHandler consoleProgressHandler;
ModelGenerator *mg = new ModelGenerator();
mg->generate3DModel("testGds.gds", "testGds.mpd", "gds.sat", "Cell0");
return 0;
```

SoftMEMS Batch mode

- 3D Models can be run from a batch script on UNIX, LINUX or PC to generate large models offline
  - Supports GDS read in
  - Fabrication process read in from a file
  - 3D Model generation
  - Cross-section generation

Import of model from previous processing

- Users can read in a file containing geometry and continue processing it with adding more process steps

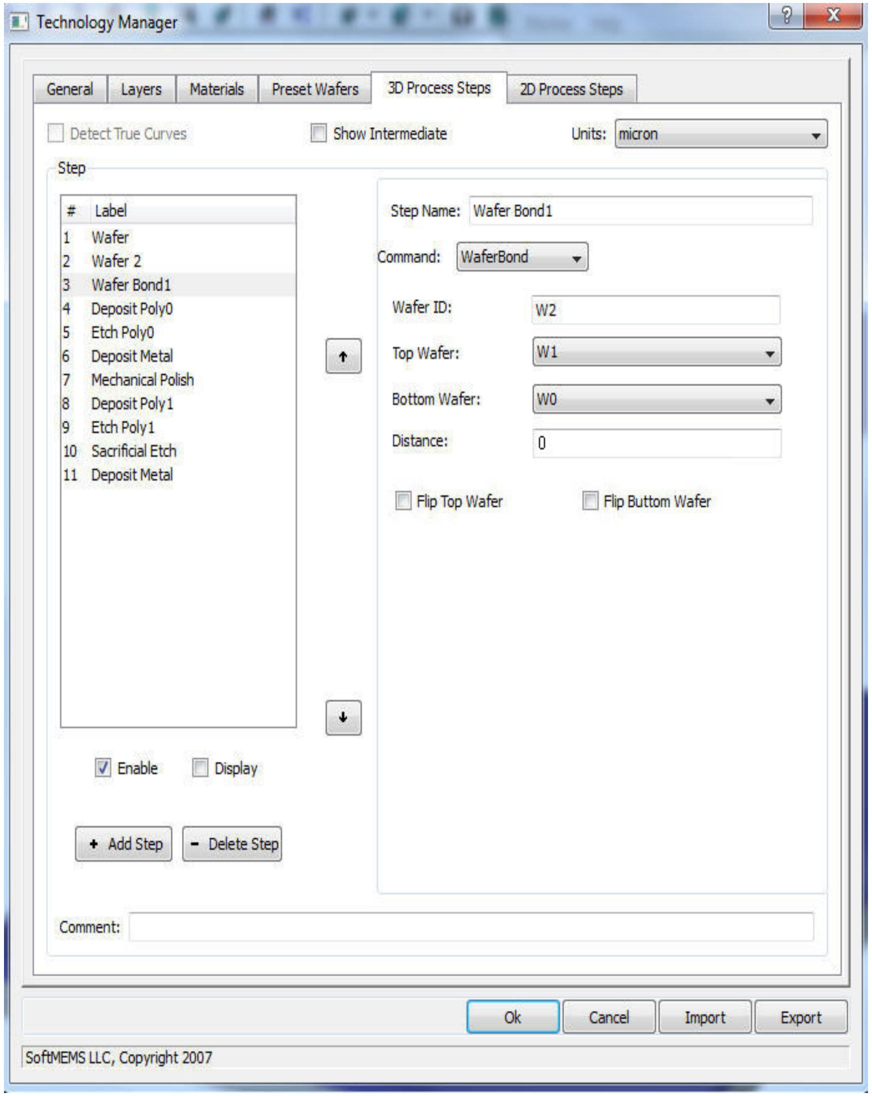


Process enhancements

- Enhancements to etch
  - Rounded corners for etch
  - Example: Ga etching

New Wafer Bonding Feature

- Wafer bonding now supports overlapped wafers for bonding surface features to cavities

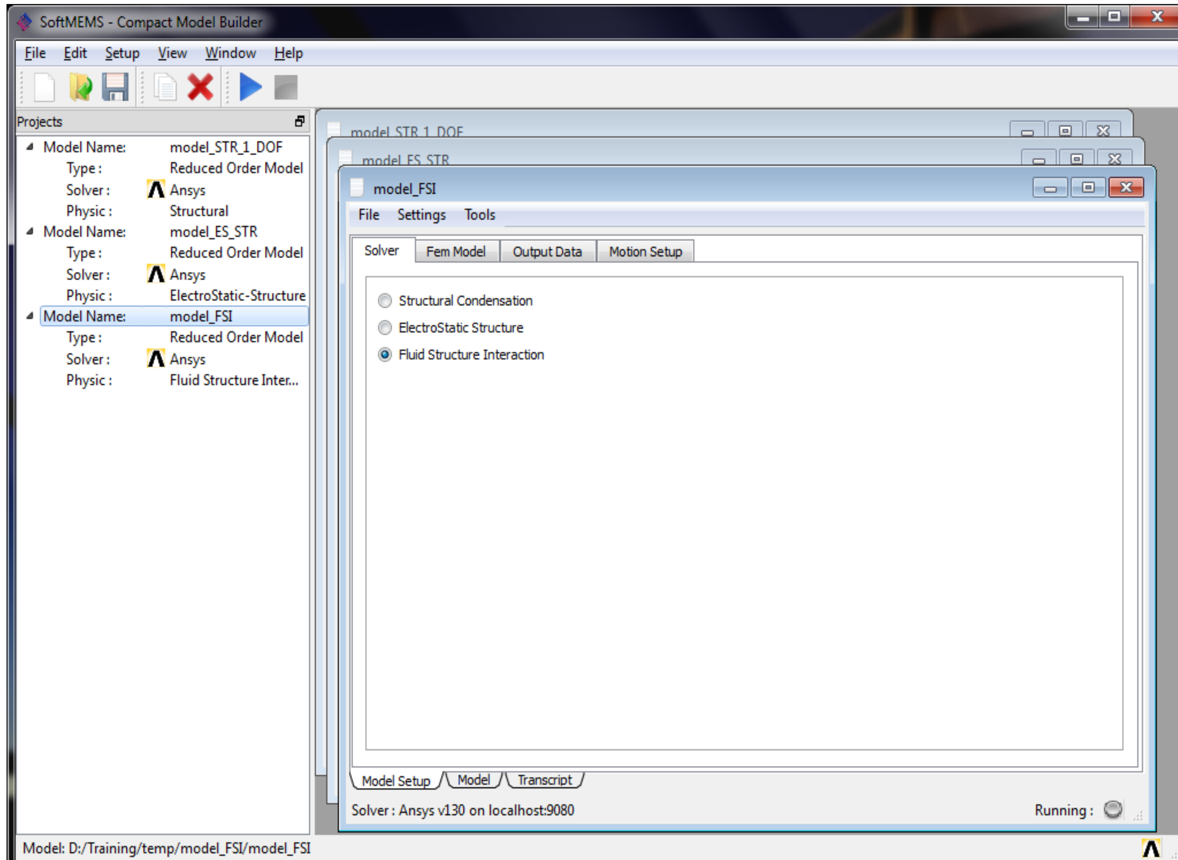


Compact Model Builder v1.0 (v8.4)

Sebastien Cases

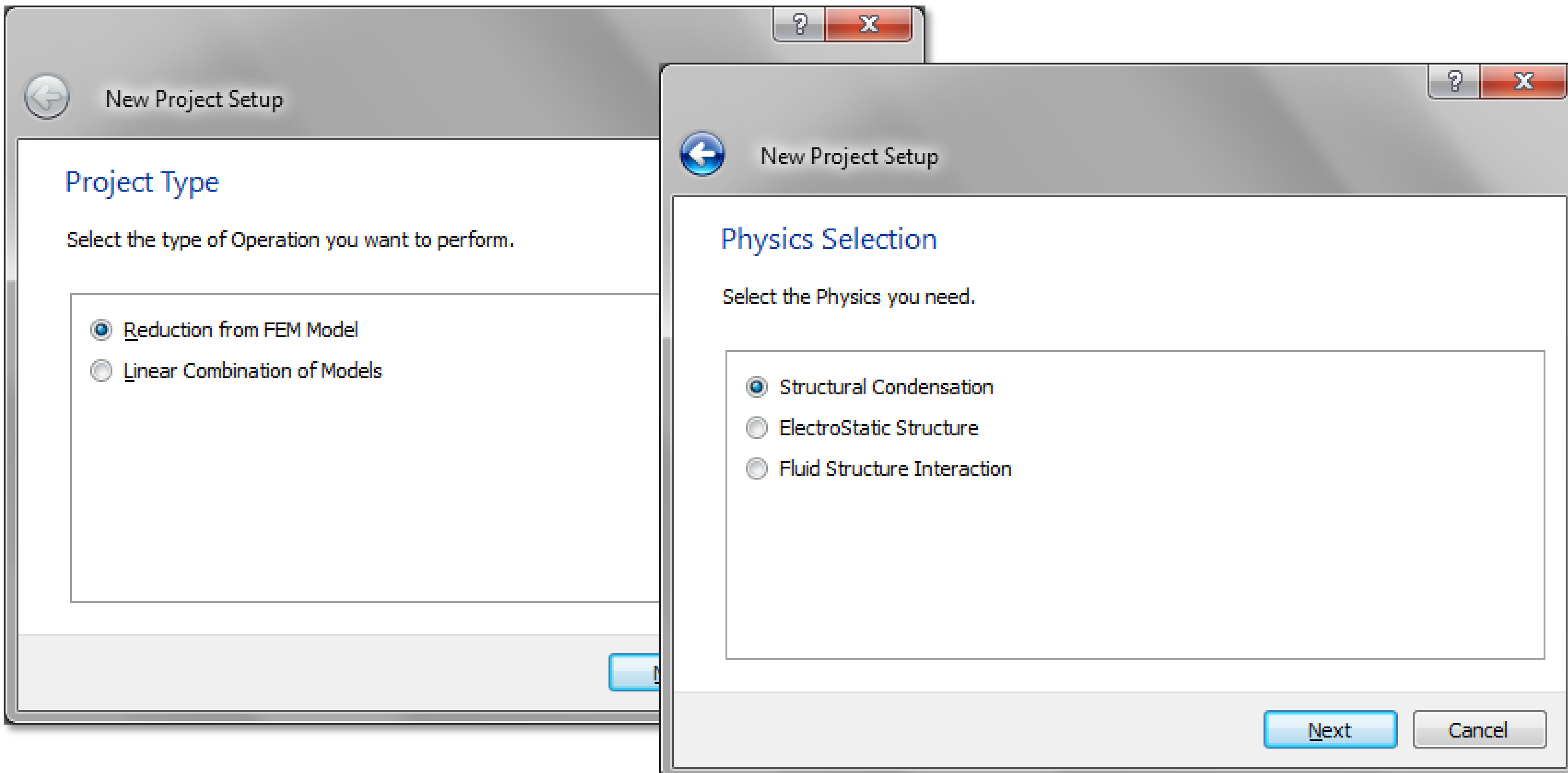
What’s New ?

- New Interface
- Multi Project
- Concurrent Simulations
- Several Solvers Configurations
- New Features



New Interface ..

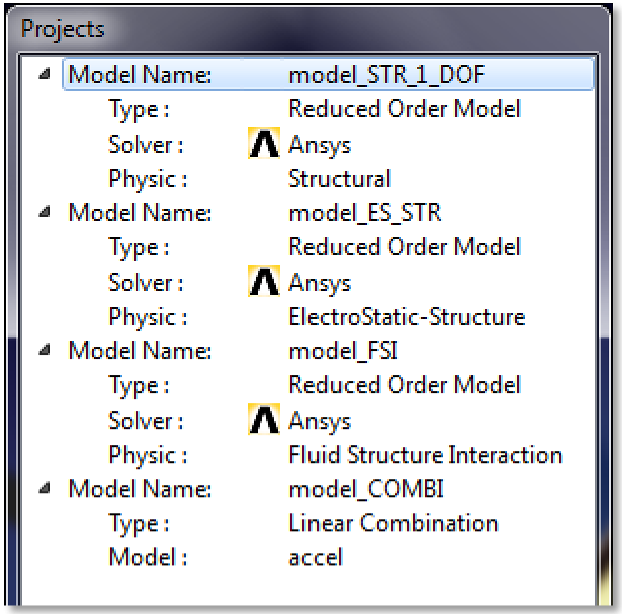
- … Based on Wizard to ease new data capture



Multi Project

- Multiple projects can be opened at the same time

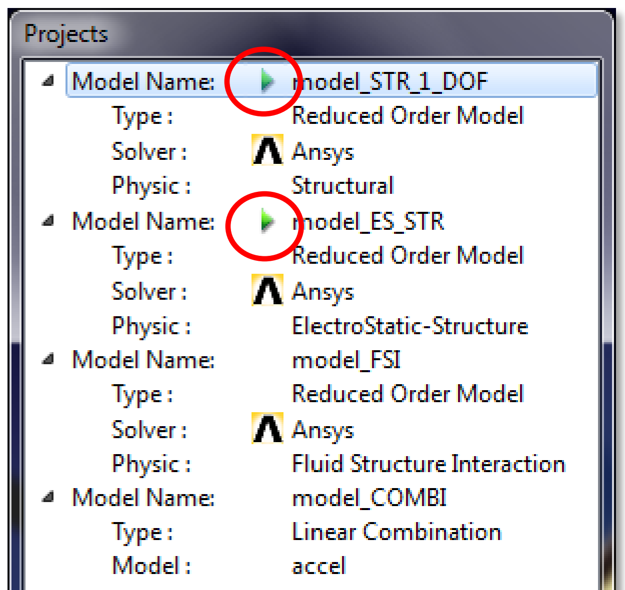
- Projects Explorer allowing to have a quick summary of the model and allowing to easily switch between them



Concurrent Simulations

- Multiple simulations can be ran at the same time

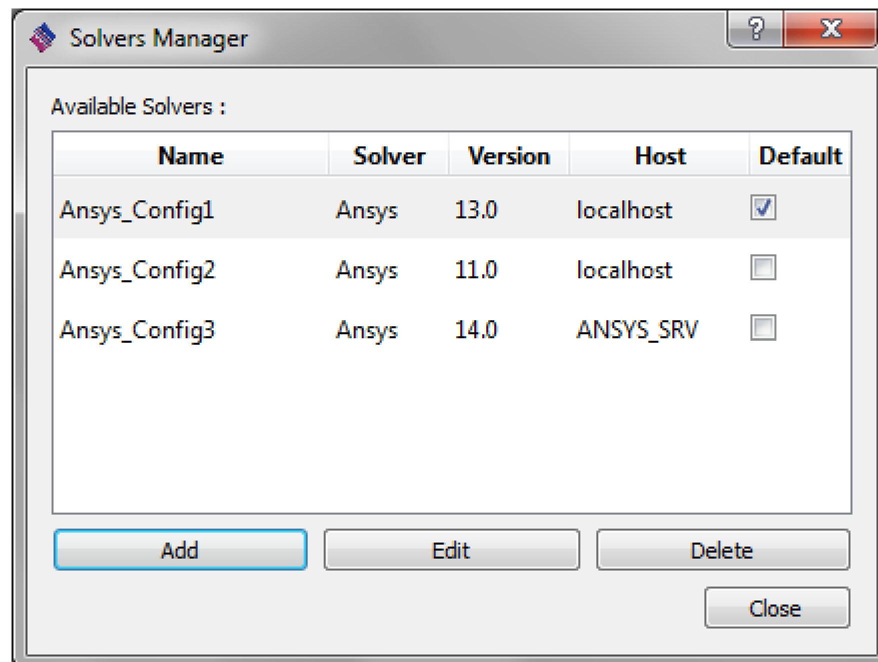
- Projects Explorer reporting the current activity



Solvers Managements

- Different Ansys Configurations can be setup enabling user to easily switch between them in 1 click.

- Allows configuration of
  - Multiple versions of Ansys
  - Ansys running on another computer/server with higher memory and CPU



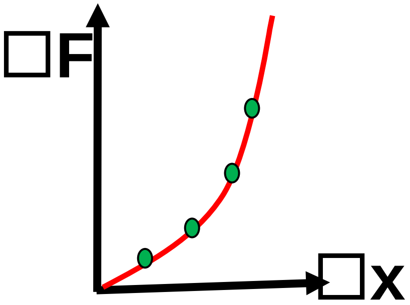
New Features

- Structural Systems :
  - Non-Linear Stiffness extraction
  - Support of Pre-stressed geometries

- Electrostatic-Structural Systems :
  - Non-Linear Electrostatic effects extraction

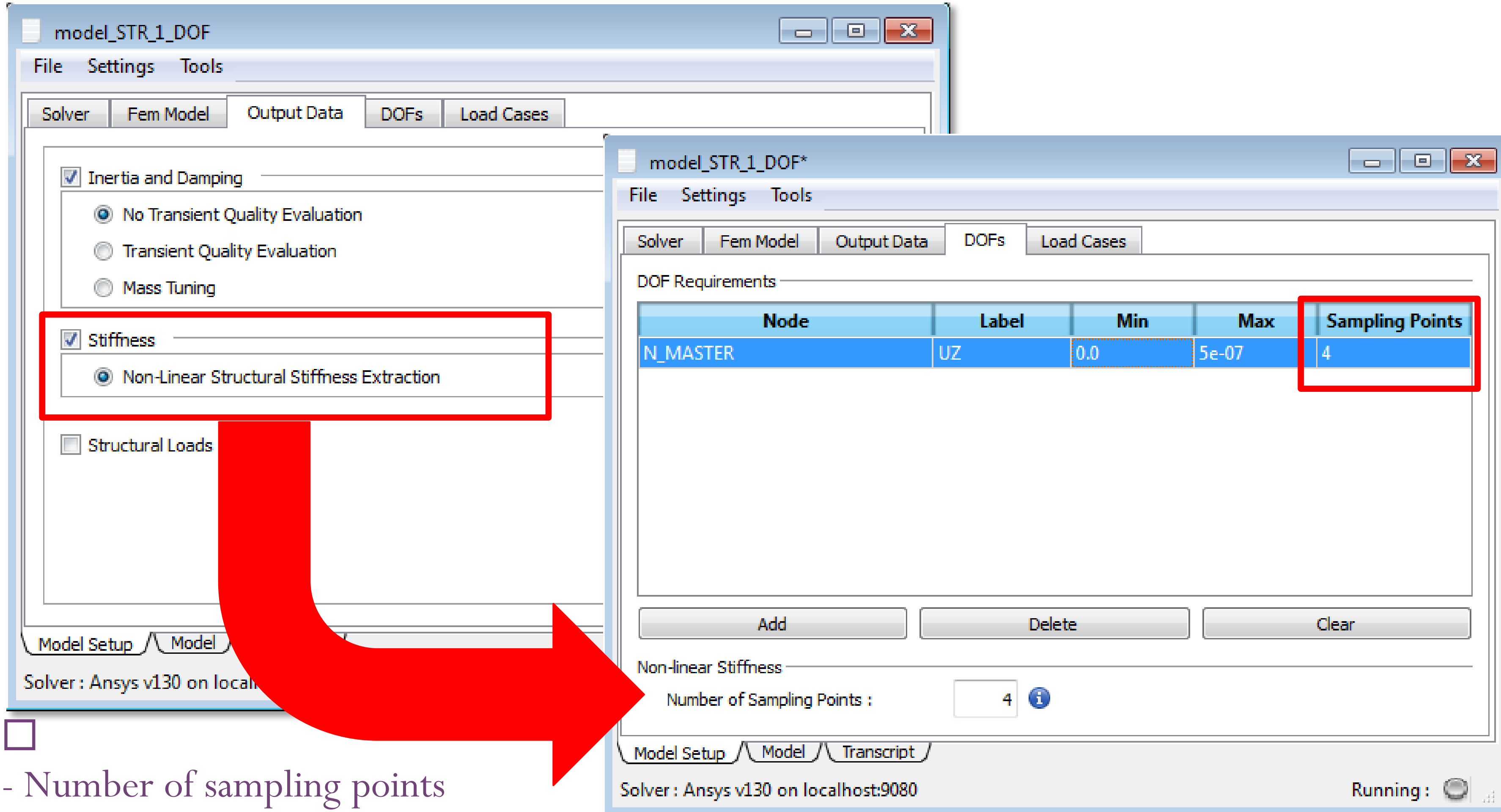
Non Linear Stiffness Extraction

- Non-Linear Stiffness extraction, also called Spring Hardening Effect
  - Generation of deformed structures in Ansys (NL static solutions) under predefined displacements
  - Resultant Force extracted from Ansys for each sampling point allowing to get an expression of the force in function of displacement $F = k(x) \cdot x$



  - where $k(x) = k_1 \cdot x + k_2 \cdot x^2 + k_3 \cdot x^3 + hot$

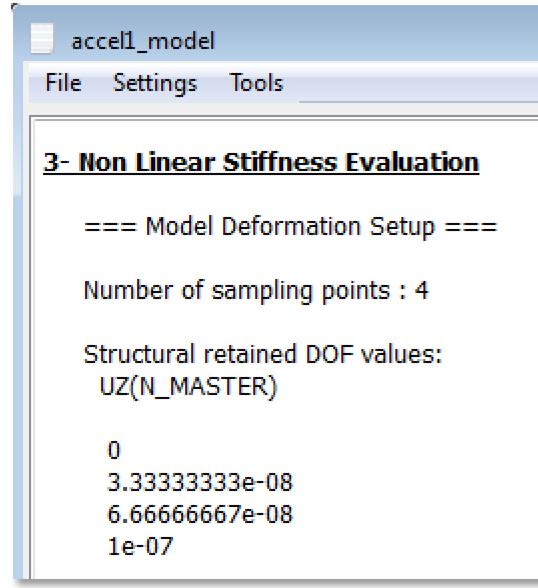
Non-Linear Stiffness



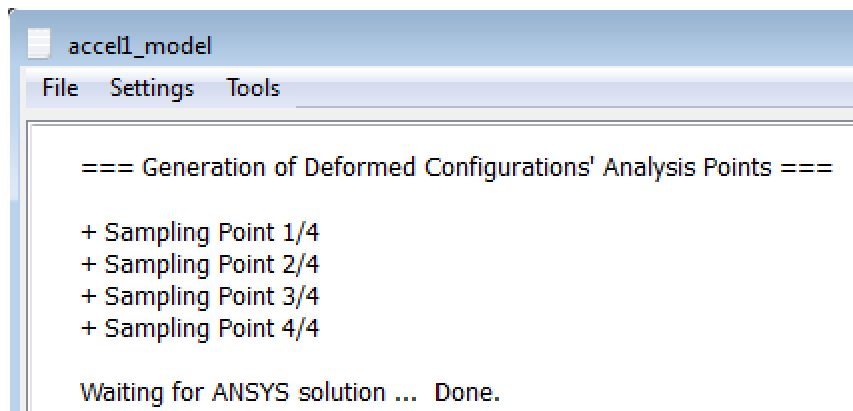
- Number of sampling points

Non-Linear Stiffness

- According to the DOF definition the sampling points are reported

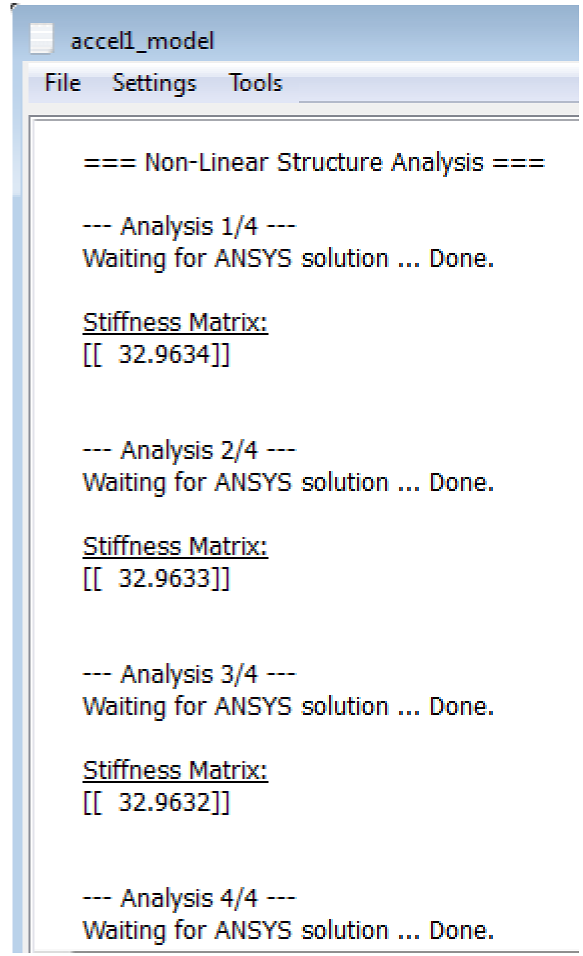


- Then Ansys generates the deformed geometries



Non-Linear Stiffness

- Finally the analysis are performed on each deformed geometry
- The force is extracted and the Stiffness Matrices computed



Non-Linear Stiffness

- The polynomial expression is extracted and a report for each sampling point is displayed.

- The reference stiffness (from Ansys) is compared to the Approximated one (polynomial value) at the same point.

accel1_model

File Settings Tools

4- Non-Linear Stiffness Accuracy Estimation

Accuracy estimation: K_1_1

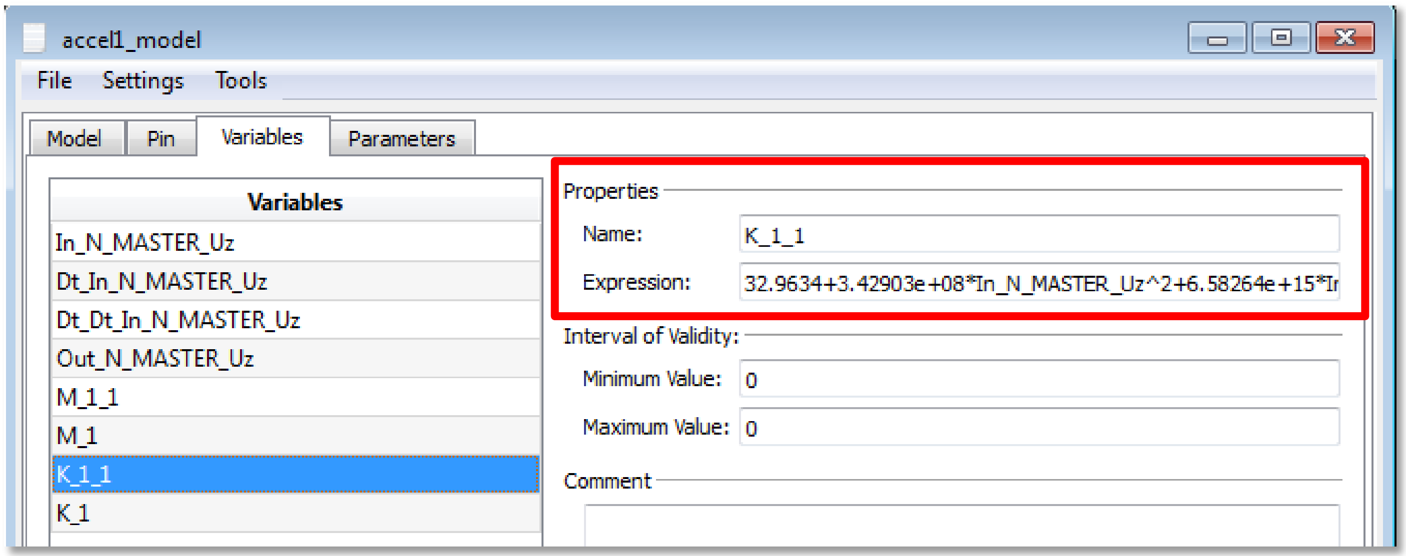
Point	Reference	Approximation	Difference
1	32.9633728	32.9633728	0
2	32.9633039	32.9633039	0
3	32.9632372	32.9632372	7.10542736e-15
4	32.9631742	32.9631742	0

Mean absolute value = 32.963272

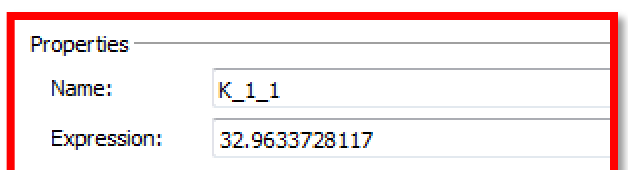
Maximum absolute difference = 7.10542736e-15(2.15555888e-14 %)

Non-Linear Stiffness

❖ The Behavioral model is finally generated with the stiffness set as a polynomial expression

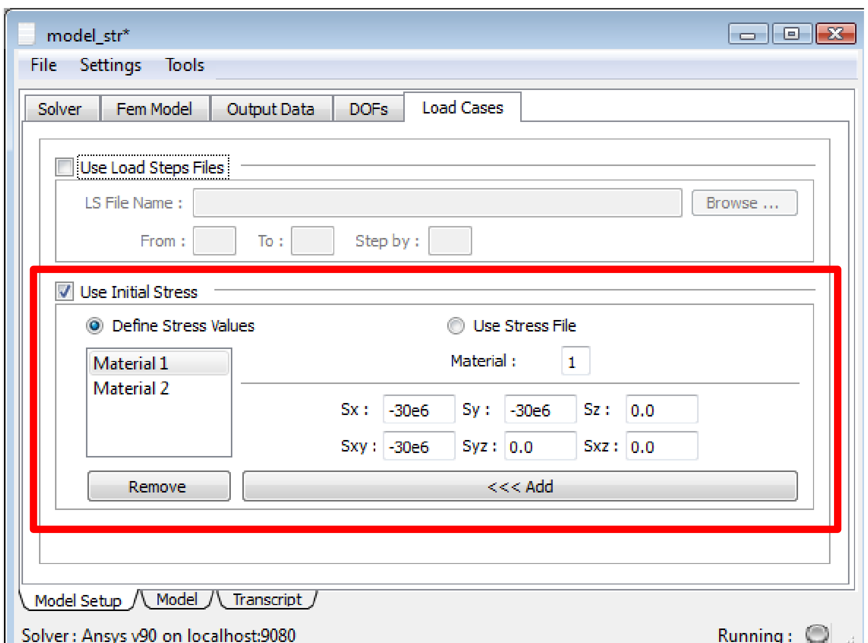


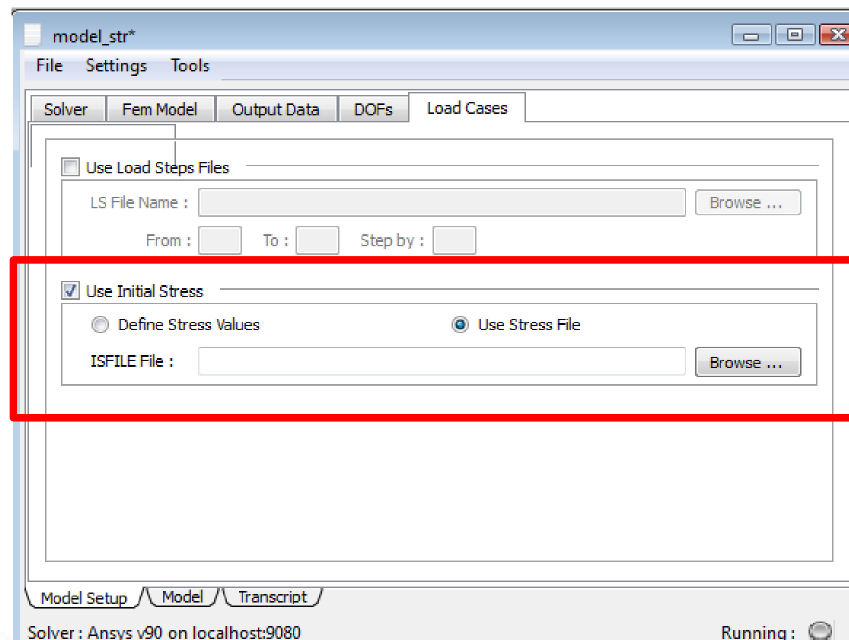
☐- To compare to the expression of the Linear Stiffness Coefficient



Initial Stress Extraction

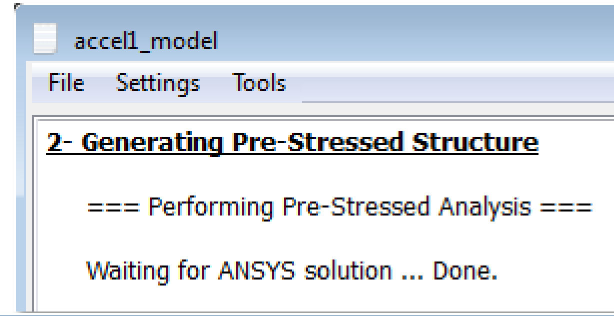
- Initial Stress can be applied onto geometrie's material through the 'Use Initial Stress' box
- The values can be entered in the interface for each material or, when it exists, an Ansys ISTRESS file can be loaded



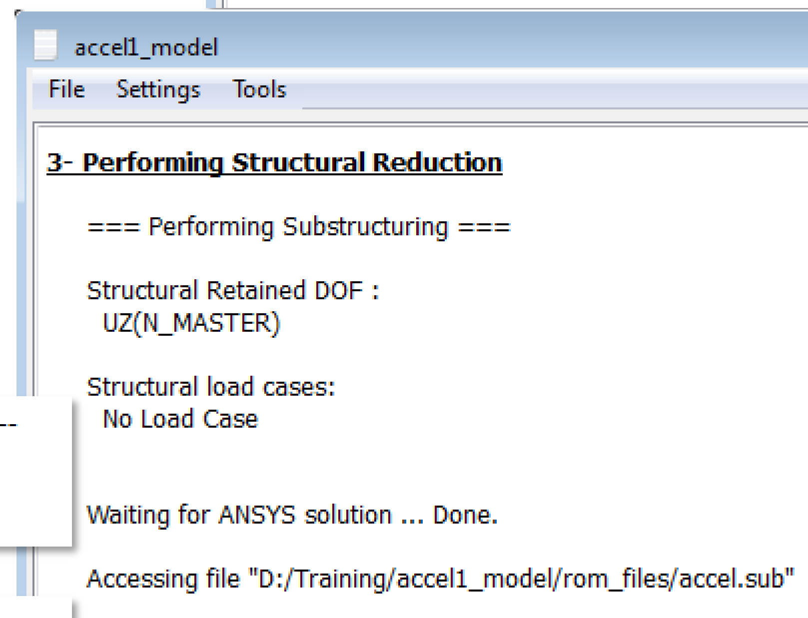


Initial Stress

- First, an non-linear static analysis is performed to generate the pre-stressed struture

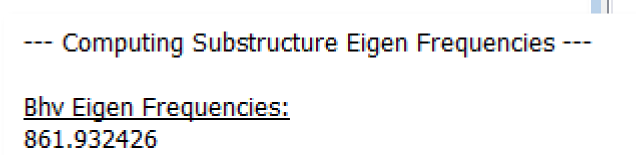


- Then the Substructuring stage is started from the previous analysis



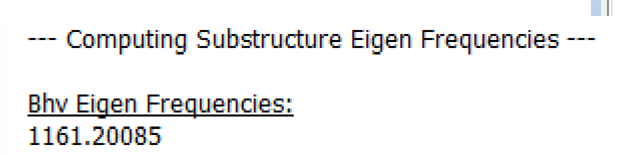
⇒ **No stress**

☐ **Eigen Frequency**



⇒ **Pre-stressed**

☐ **Eigen Frequency**



Non Linear Electrostatic Effects

- Non-Linear Electrostatic effect, also called Spring Softening Effect

  - In FEM formulation, the structural model is defined as follow:

$$M\ddot{x} + D\dot{x} + Kx = \sum_k F_k + F_{coupling}(x,\{V\})$$

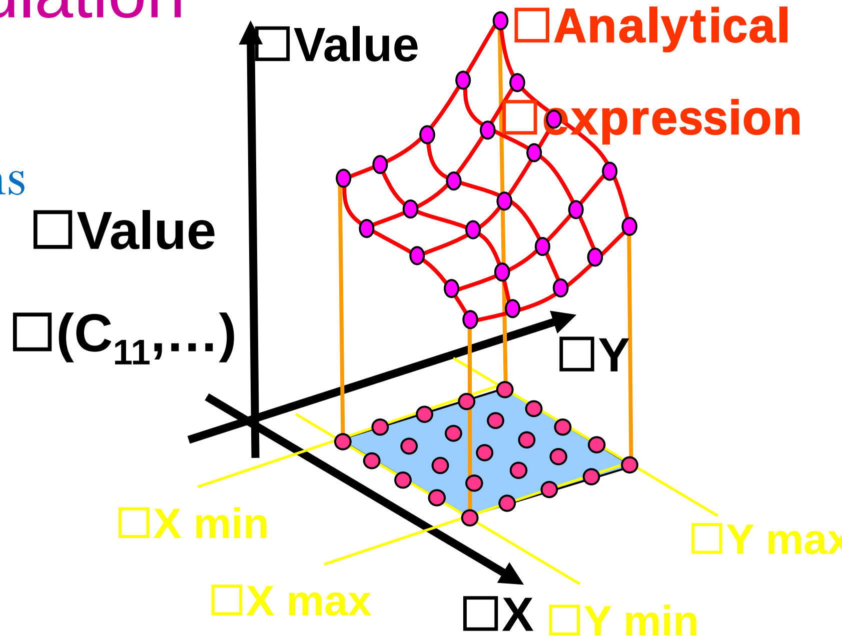
  - The non linear coupling loads term Fcoupling is defined by :

$$\{F_{coupling}(x,\{V\})\} = \frac{1}{2}\{V\}^T[\partial_x(C(x))]\{V\}$$

  - Where the capacitance matrix [C] depends only on the structural configuration : $[C(x)]$

Non Linear Electrostatic Effects

❖ Principle of Capacitance Formulation



- ❖ Generate a set of model configurations
  - ☐ *Each Configuration corresponds*
  - • *to a x value*
- ❖ In each of the configuration
- ➢ compute [C(xk)]

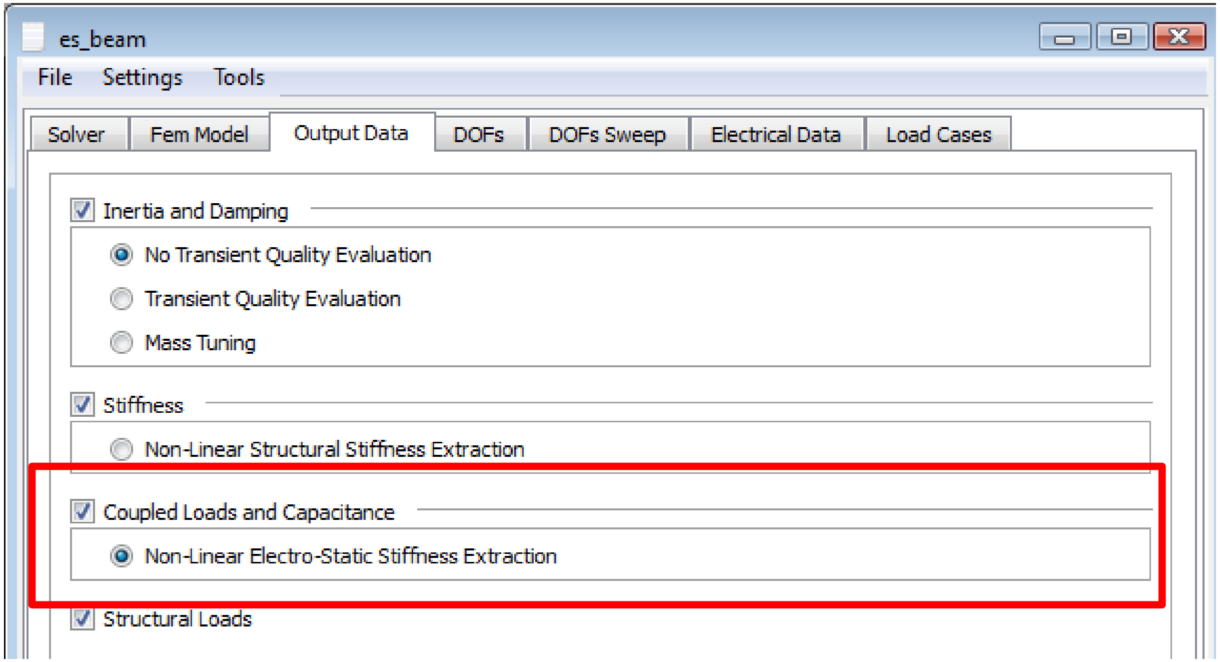
$$C(x) = \frac{1}{p_0 + p_1 \cdot x + p_2 \cdot x^2 + p_3 \cdot x^3 + hot}$$

- ❖ Extract analytical expression for each value using a polynomial fitting

Non Linear Electrostatic Effects

- New option to allow the non-linear Electrostatic stiffness extraction based on non inverted polynomial expression of the Capacitance

$$C(x) = C_0 + C_1 \cdot x + C_2 \cdot x^2 + C_3 \cdot x^3 + hot$$



Non Linear Electrostatic Effects

- In both Cases (Linear and non-linear) the deformed geometries are generated.
- Then, Ansys extracts the Capacitance values between the conductors for each deformed geometry.
- The difference is mde only at the behavioral model generation step where, the polynomial expression is defined as being inverted (better static results) or non-inverted (spring softening capabilities)

Non Linear Electrostatic Effects

- Inverted Capacitance expression results:

4- Capacitances Accuracy Estimation

Accuracy estimation: C_1_1

Point	Reference	Approximation	Differenc
1	0.0233312298	0.0233312298	0
2	0.022135	0.022135	0
3	0.0211047433	0.0211047433	0

Mean absolute value = 0.0221903244
Maximum absolute difference = 0(0 %)

- Non-inverted Capacitance expression results:

4- Capacitances Accuracy Estimation

Accuracy estimation: C_1_1

Point	Reference	Approximation	Differenc
1	0.0233312298	0.0233312298	0
2	0.022135	0.022135	-3.4694469
3	0.0211047433	0.0211047433	-3.4694

Mean absolute value = 0.0221903244
Maximum absolute difference = 3.46944695e-18(1.56349537e-14 %)