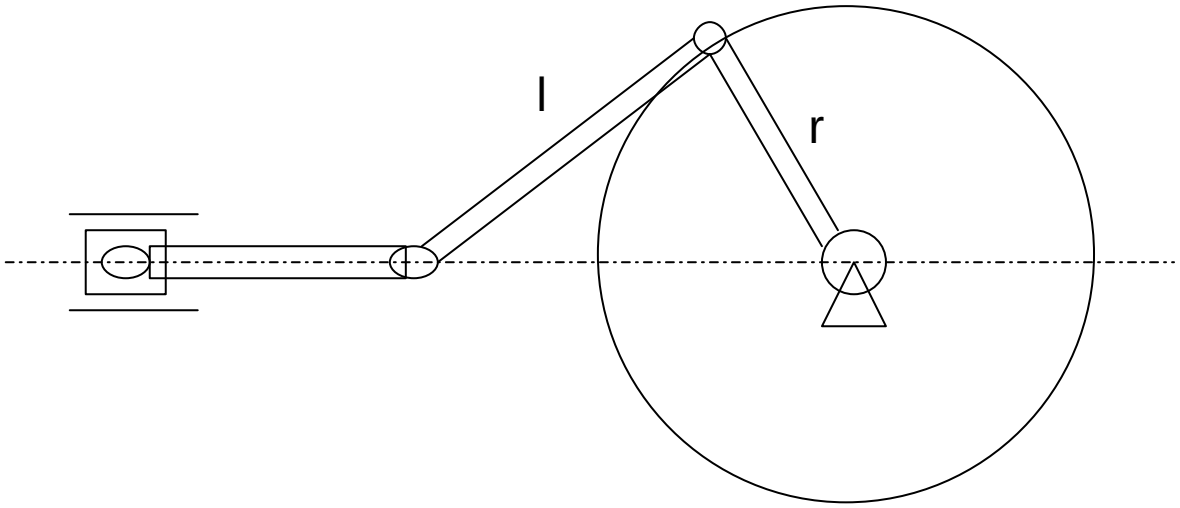
# Integration of modeFRONTIER / DEP

Application of Game Theory and direct mesh parameterisation in a structural optimisation test case (connecting rod)

# Summary

- Mechanical definition of test case (connecting rod)
- Model definition (CAD-Mesh)
- Direct mesh Parameterisation (by DEP)
- Optimisation workflow (modeFRONTIER)
- Analysis of results

# Mechanical model: general data




**POWER DATA:**

Engine power P=50KW@2000rpm

Number of cylinders z=2

Max combustion pressure Pc=21bar

Piston head mass m=0.30Kg

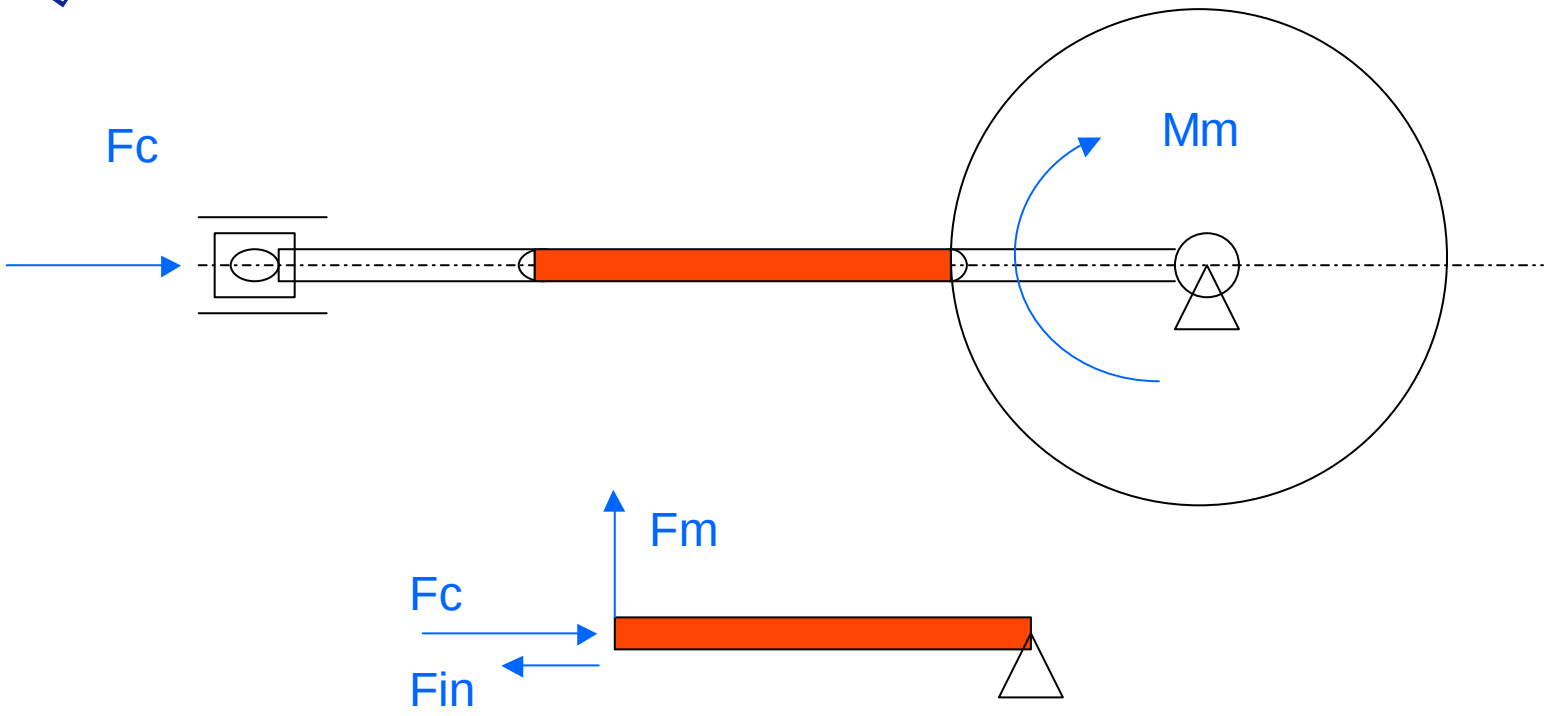
**GEOMETRIC DATA:**

Crank r=50mm

Connecting rod l=120mm

Piston diameter D=54mm

# Mechanical model:maximum load



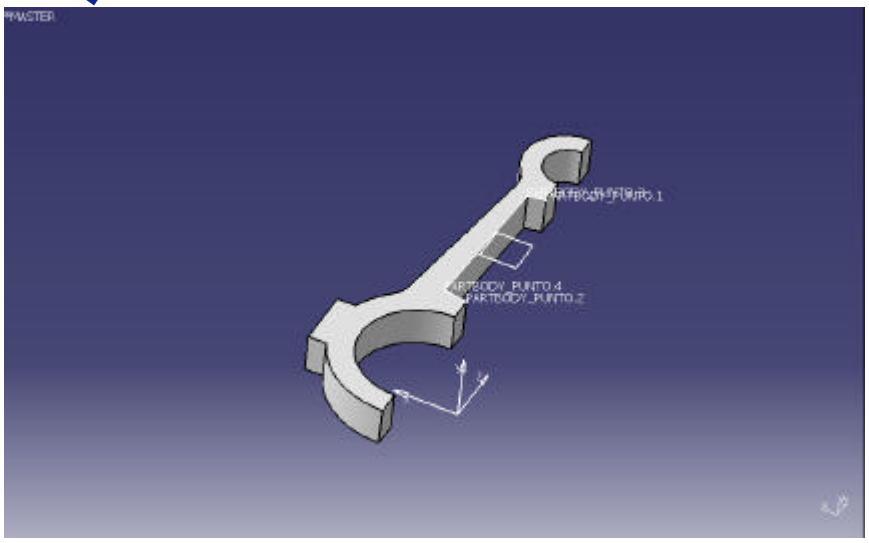

**LOAD DATA:**

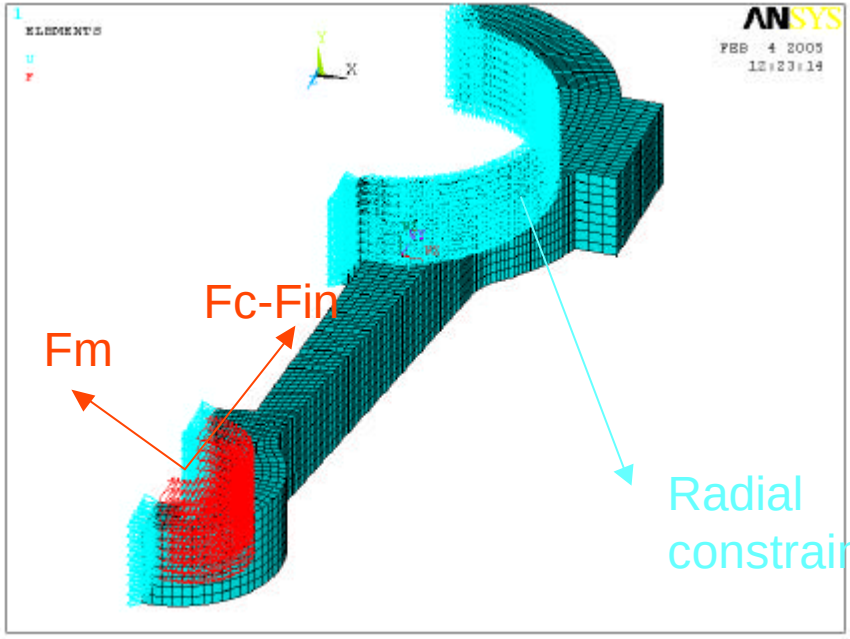
Combustion force Fc=Pc ? $D^2$ /4 = 4800N

Inertial force(? ?=-???Fin=m? $^2$ r (cos ? ??r/lsin2 ? ??? ?m? $^2$ r =600N

Momentum force Fm=Mm/l=[P/(? ?z???l=1040N

# Model definition: CAD-ICEM-ANSYS



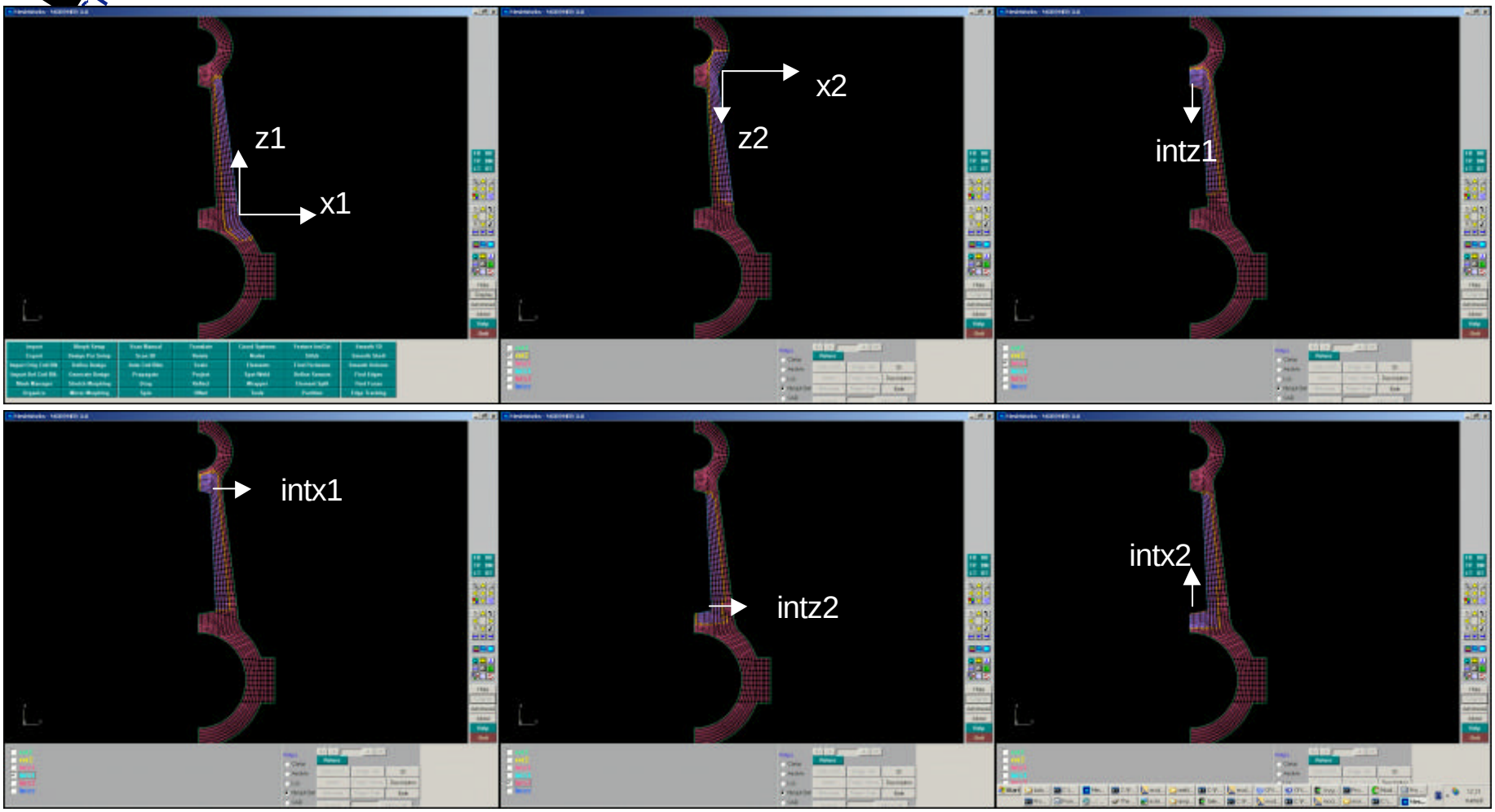



Geometric model is produced by **CATIA V5**

Hexahedral mesh is generated by **ICEM** (8,000 nodes)

Structural analysis is performed by **ANSYS 8.1**

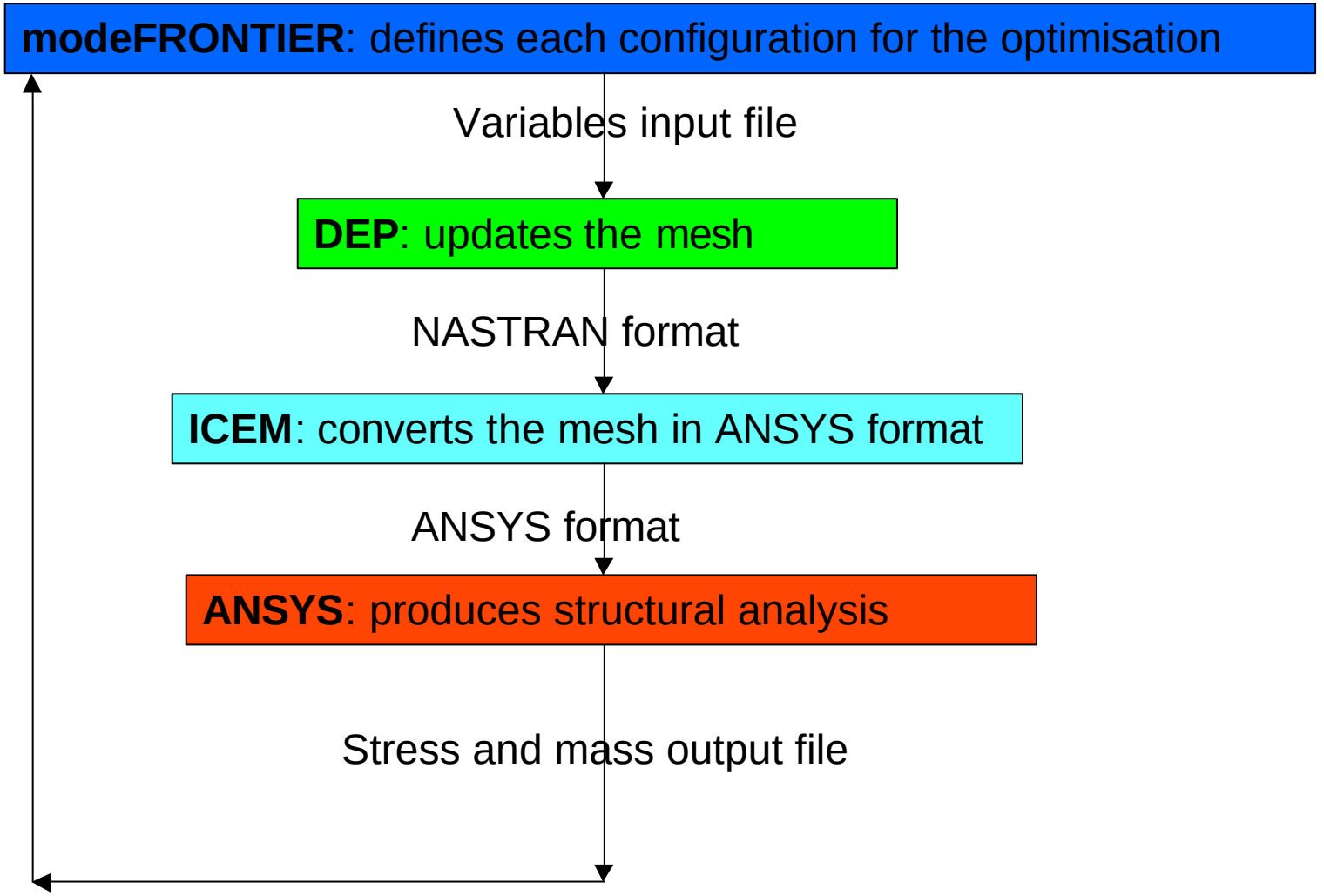
# Parameterisation using DEP



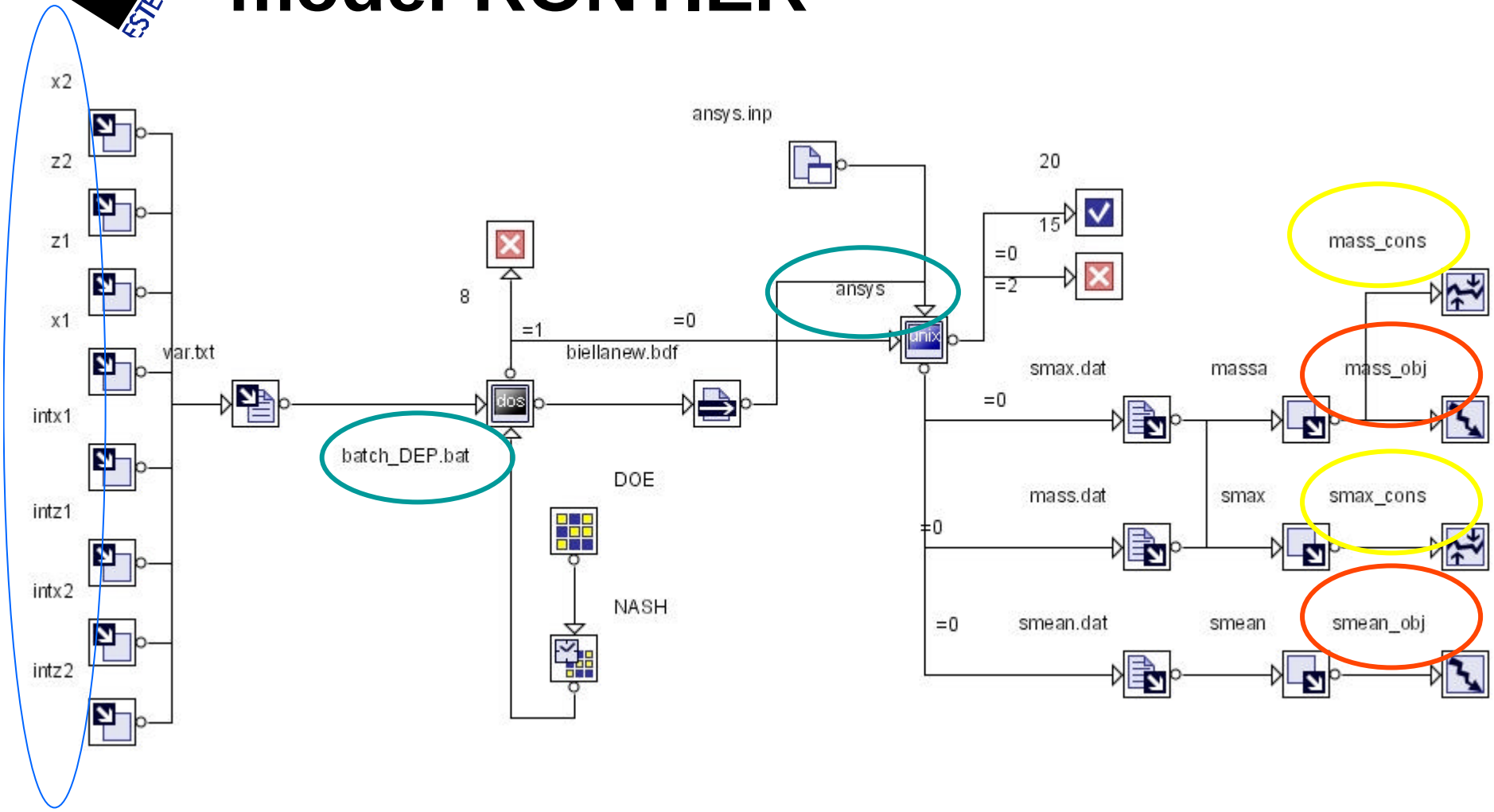

8 variables, linked to 6 sets: control nodes, deformable nodes, fixed nodes

Less than half an hour of work!

# Optimisation loop



# Optimisation workflow in modeFRONTIER



# Algorithms settings

**Objectives**:

- minimise mass of the connecting rod
- minimise mean value of stress

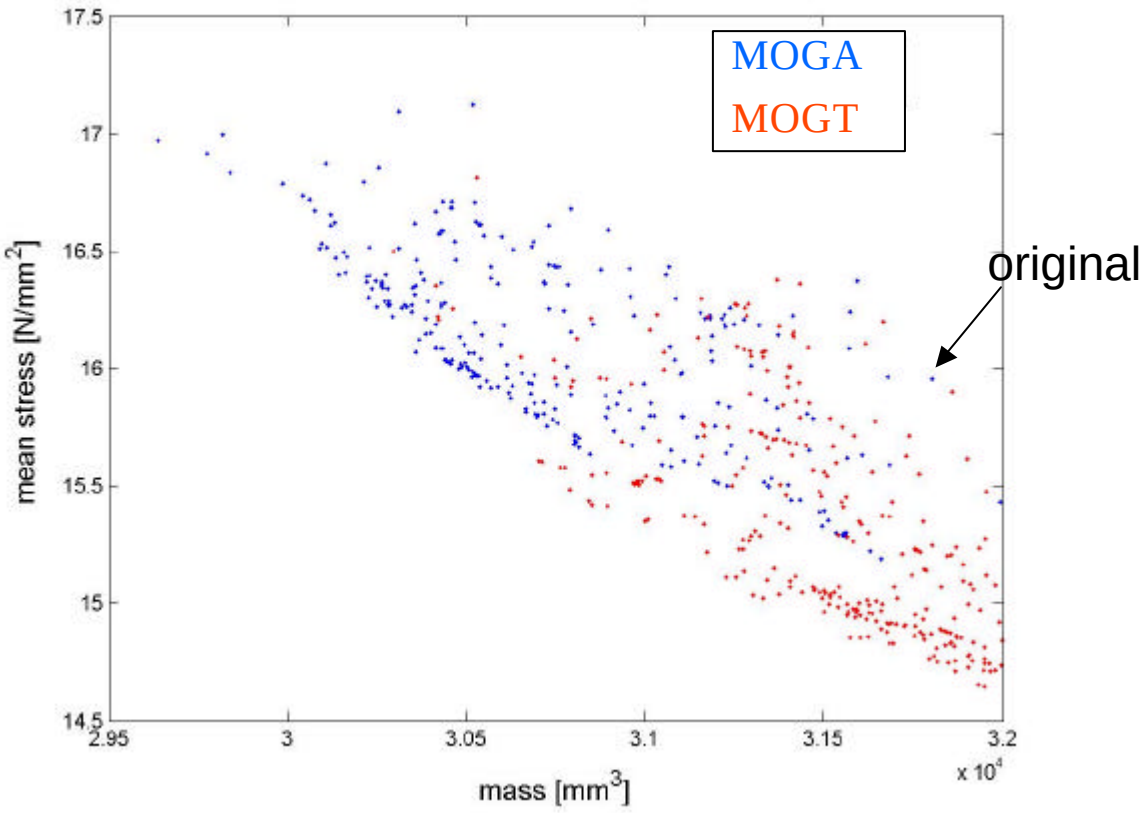
**Constraints**:

- max stress < 70 $N/mm^2$ (original geometry max stress)
- conrod volume < 32000 $mm^3$ (original geometry volume)

**ALGORITHMS**:

- MOGT (multi-objective game theory)
- MOGA (multi-objective genetic algorithm)

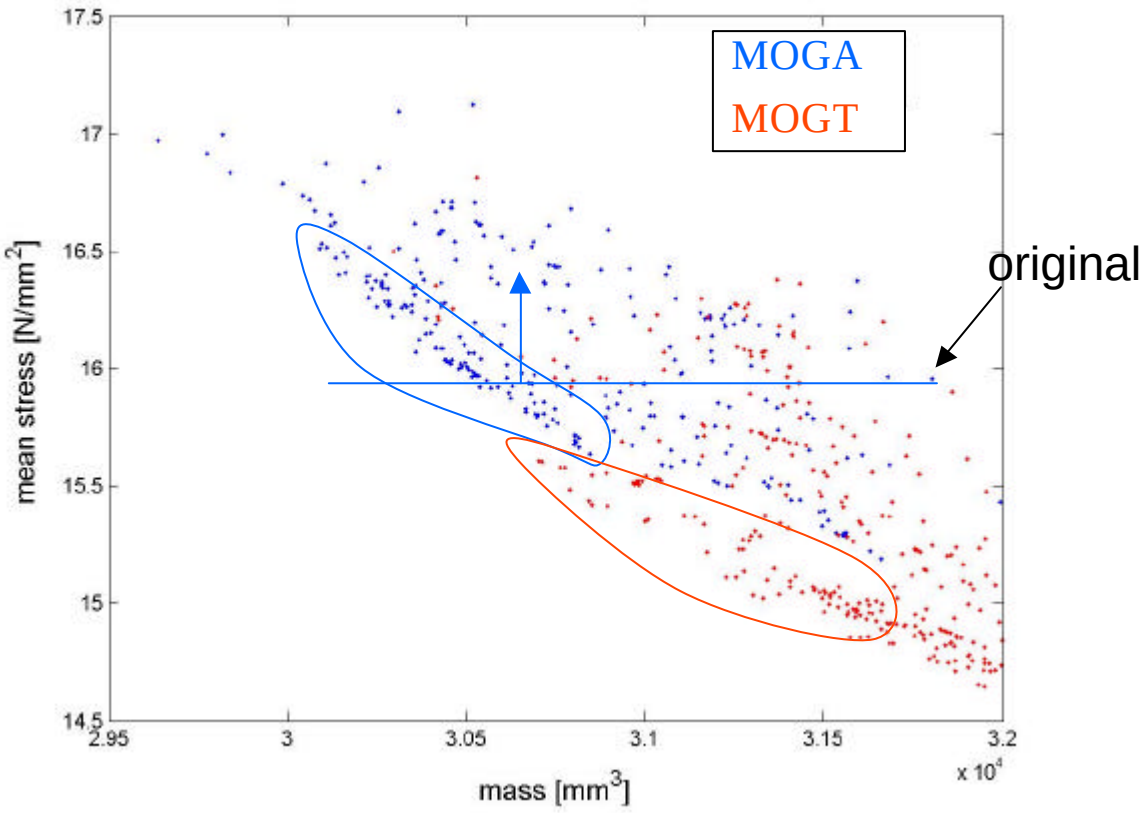
# Results using MOGT and MOGA




**MOGA**: 20 generations of 20 individuals=**400** total runs (278 feasible)

**MOGT**: Nash equilibrium after **360** runs (281 feasible)

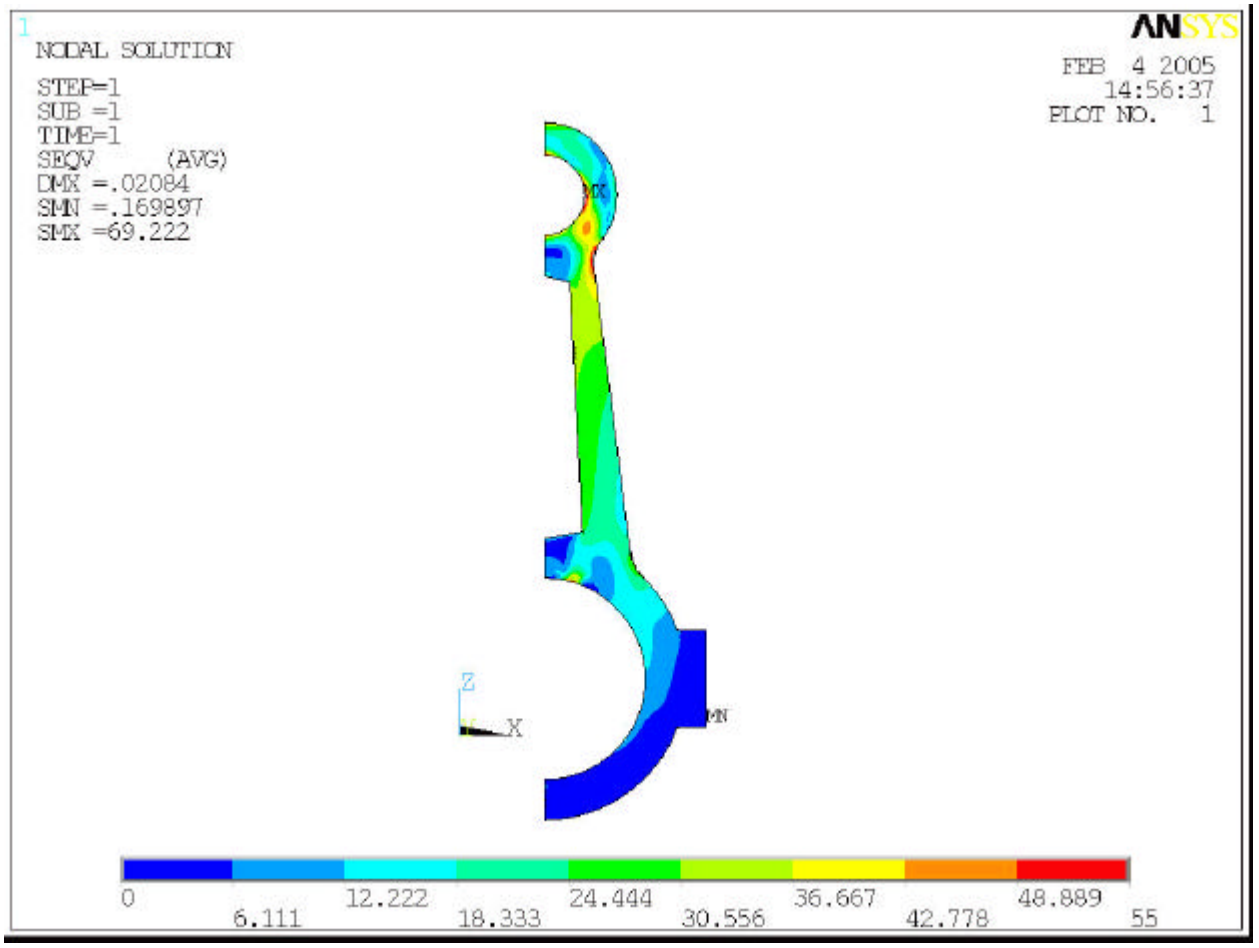
# Results using MOGT and MOGA



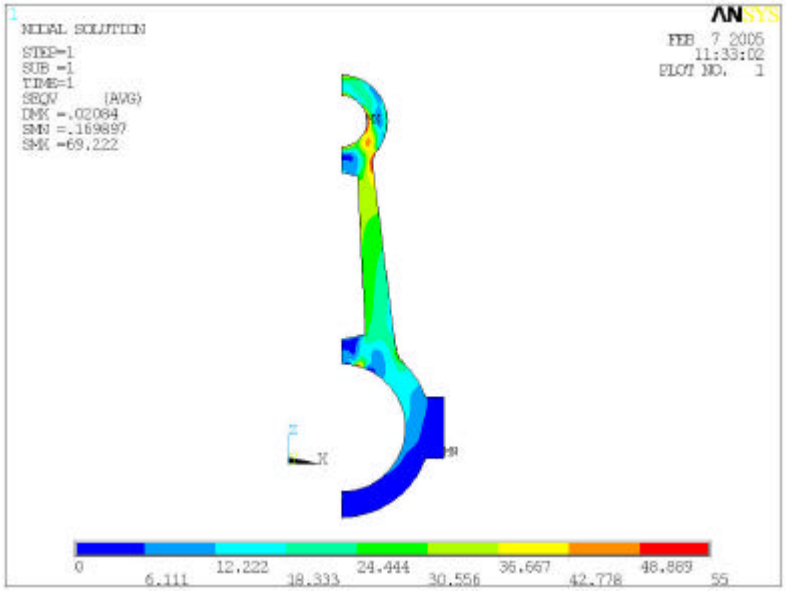

Pareto front found by **MOGA** presents low values of mass, but most of points exceeds original mean stress

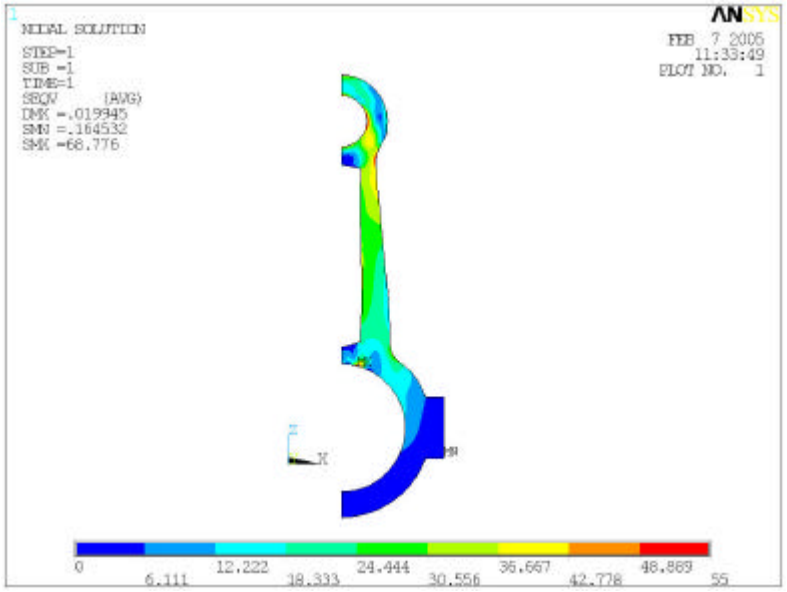
Pareto front found by **MOGT** presents optimal values for both mass and mean stress

# Optimisation history



# Comparison original and best




Original config.

Volume 31617mm$^3$

Mean stress 16.1 N/mm$^2$

Max stress 69.2 N/mm$^2$

Best config.(MOGT)

Volume 30852mm$^3$

Mean stress 15.4 N/mm$^2$

Max stress 68.7 N/mm$^2$

# Conclusion

- An integration of DEP (Parametric Mesh Morpher), ANSYS (structural analysis) and modeFRONTIER (optimisation environment) has been shown

- MOGA and MOGT were tested in the optimisation of a connecting rod (minimise mass-minimise mean stress)

- Direct Mesh Parameterisation seems to be a valid alternative to CAD Parameterisation (only if the geometry variations are limited)