

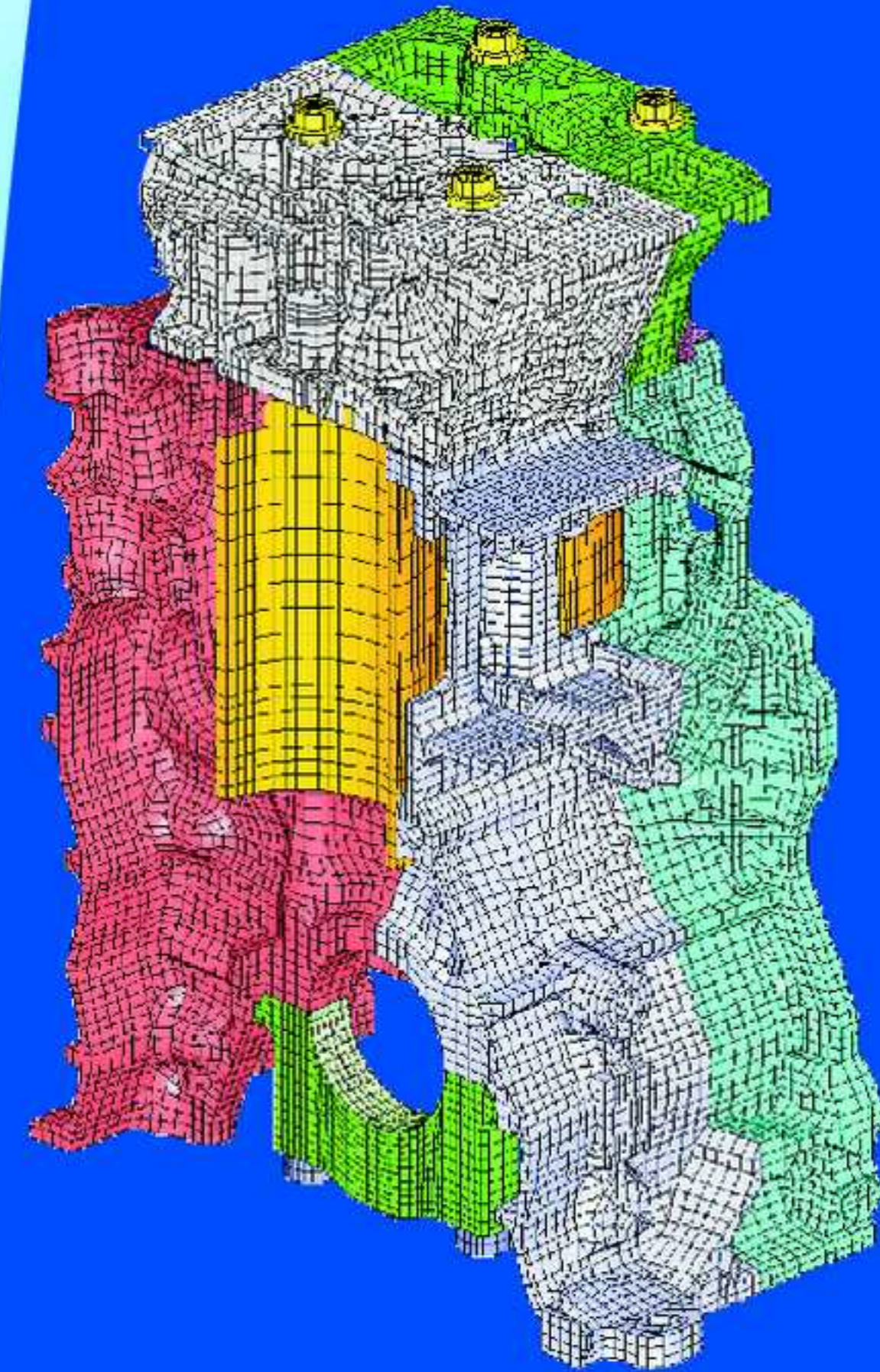
# PERMAS



## Nonlinear Powertrain Analysis

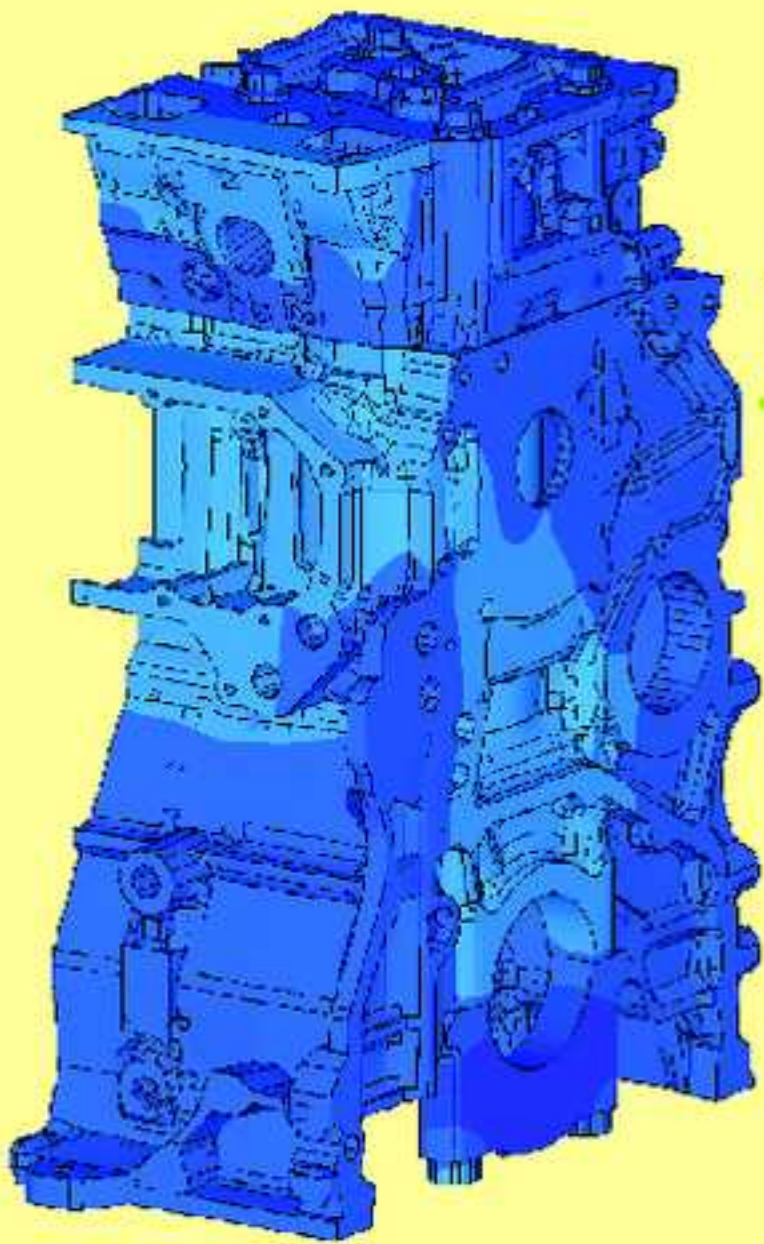
Large and complex models:

- Incompatible part coupling
- Contact and bolt loading conditions
- Gasket elements (with nonlinear response)
- Nonlinear cast iron material law (under tension and compression)
- Temperature-dependent material
- Loading history (assembling and operating loads)
- Short run times by using parallelization

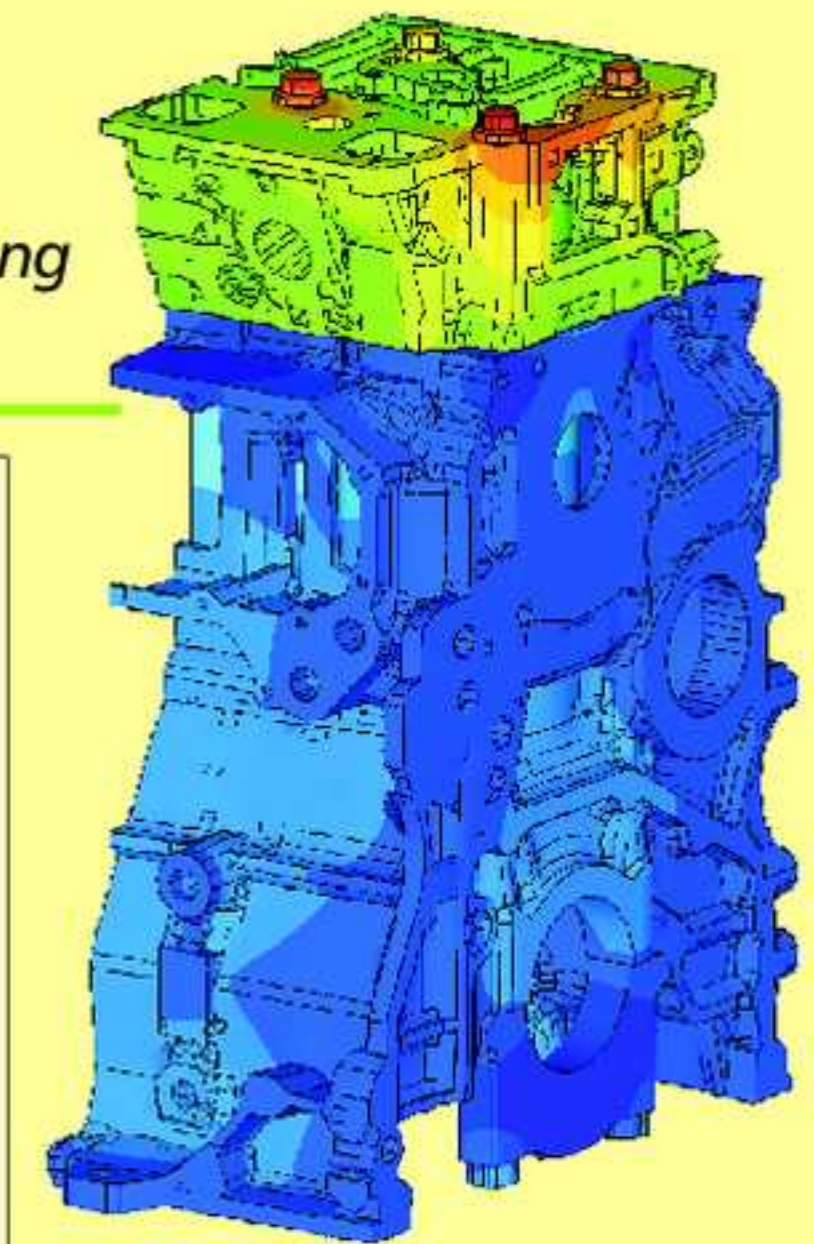
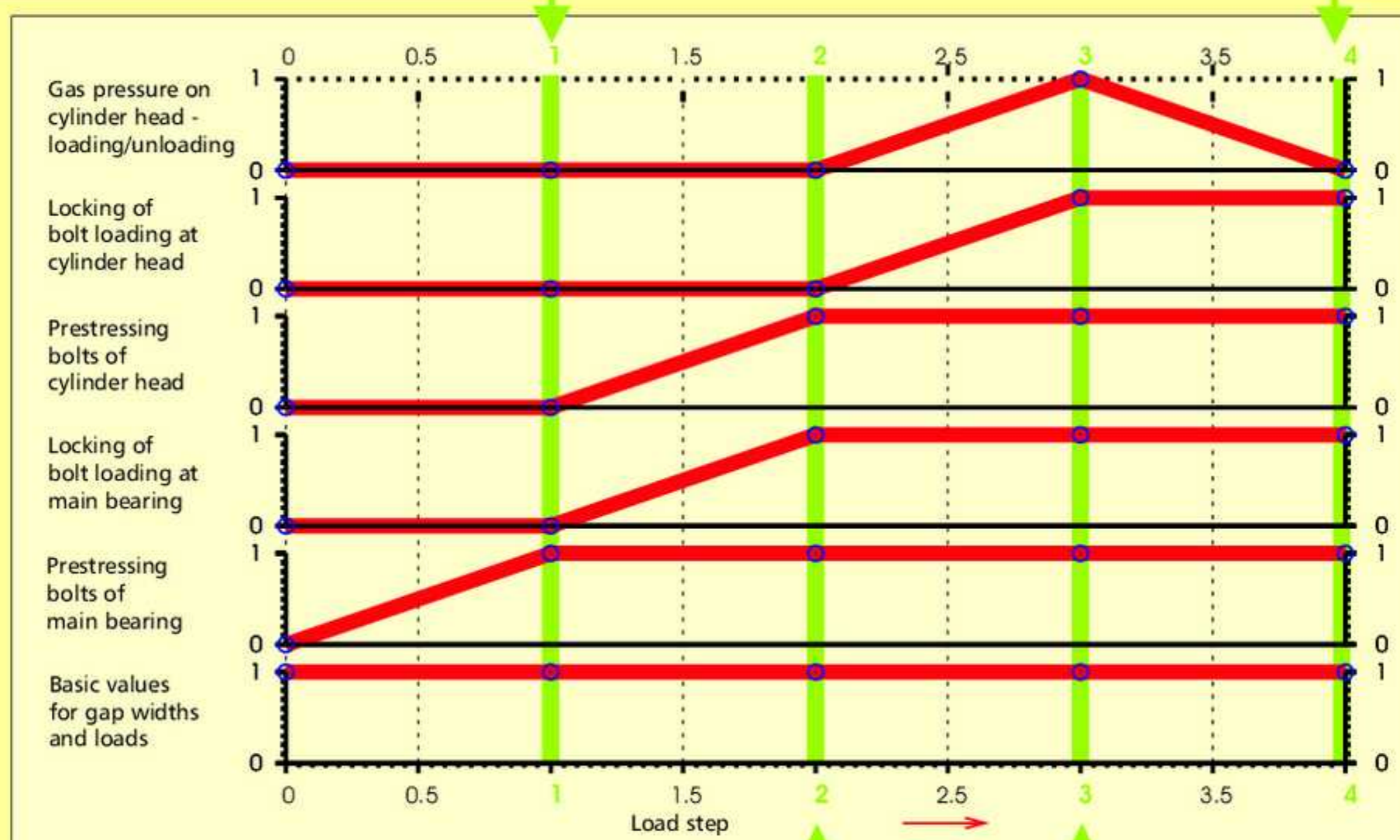


All figures are shown by courtesy of DaimlerChrysler AG, Commercial Vehicle Division in Stuttgart

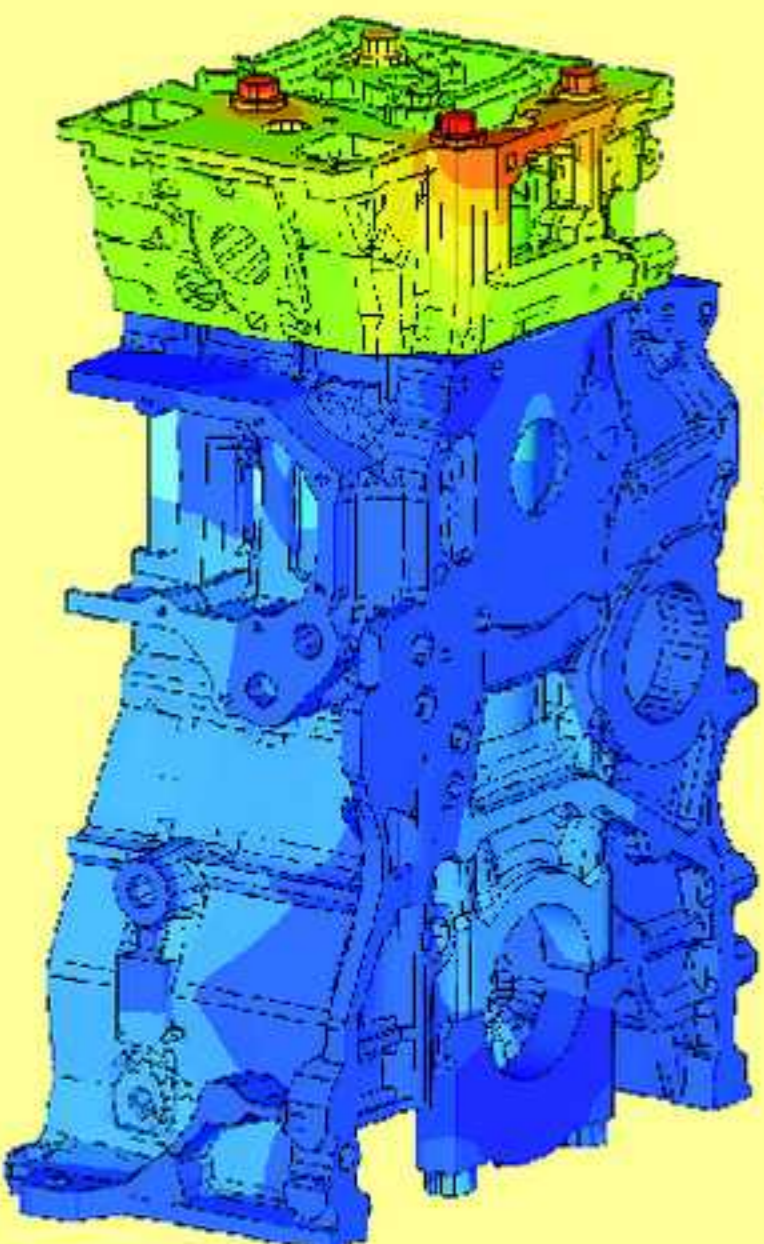
The pictures show the displacements after each load step



Load step 1: Tightening bolts of main bearing

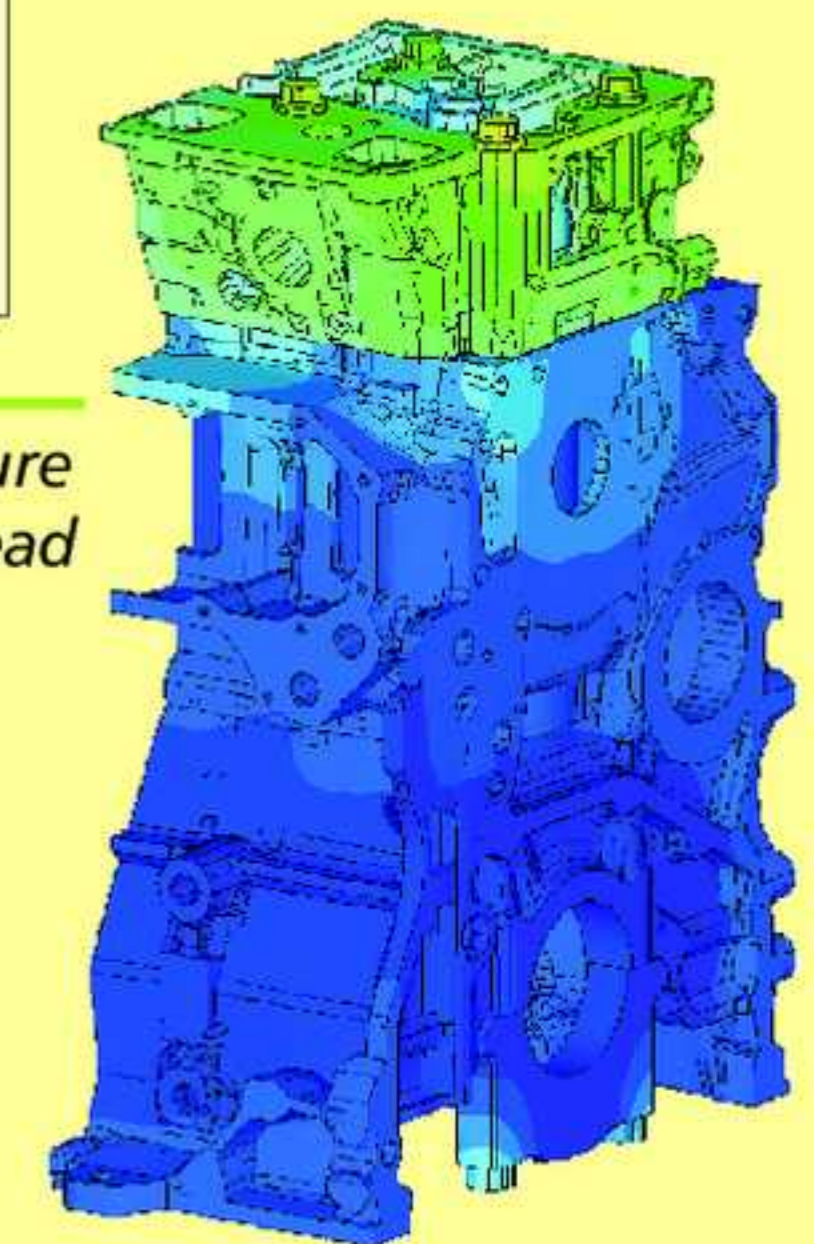


Load step 4: Unloading of cylinder head



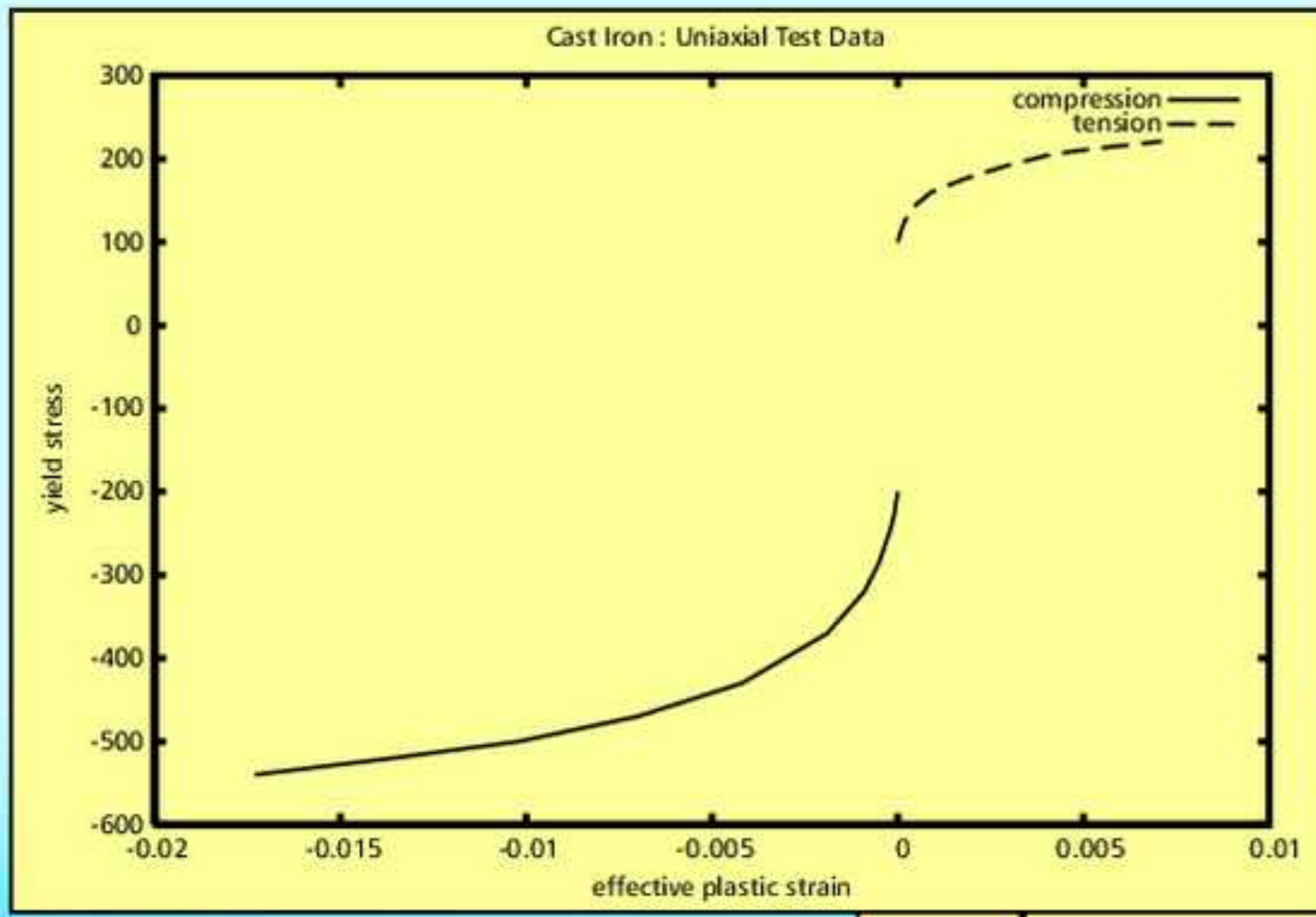
Load step 2: Tightening bolts of cylinder head

Load step 3: Pressure load on cylinder head

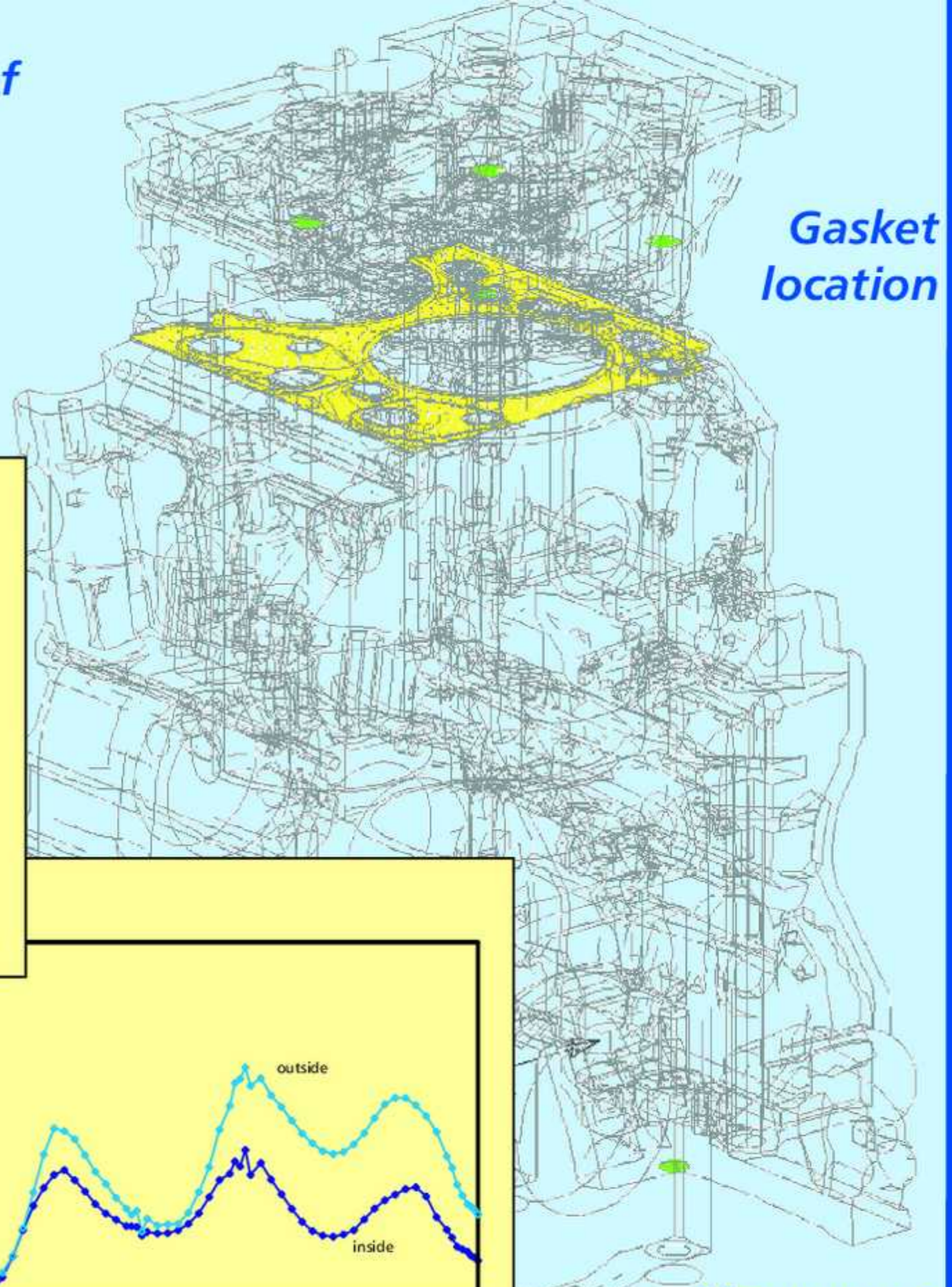


**The loading history controls the analysis workflow**



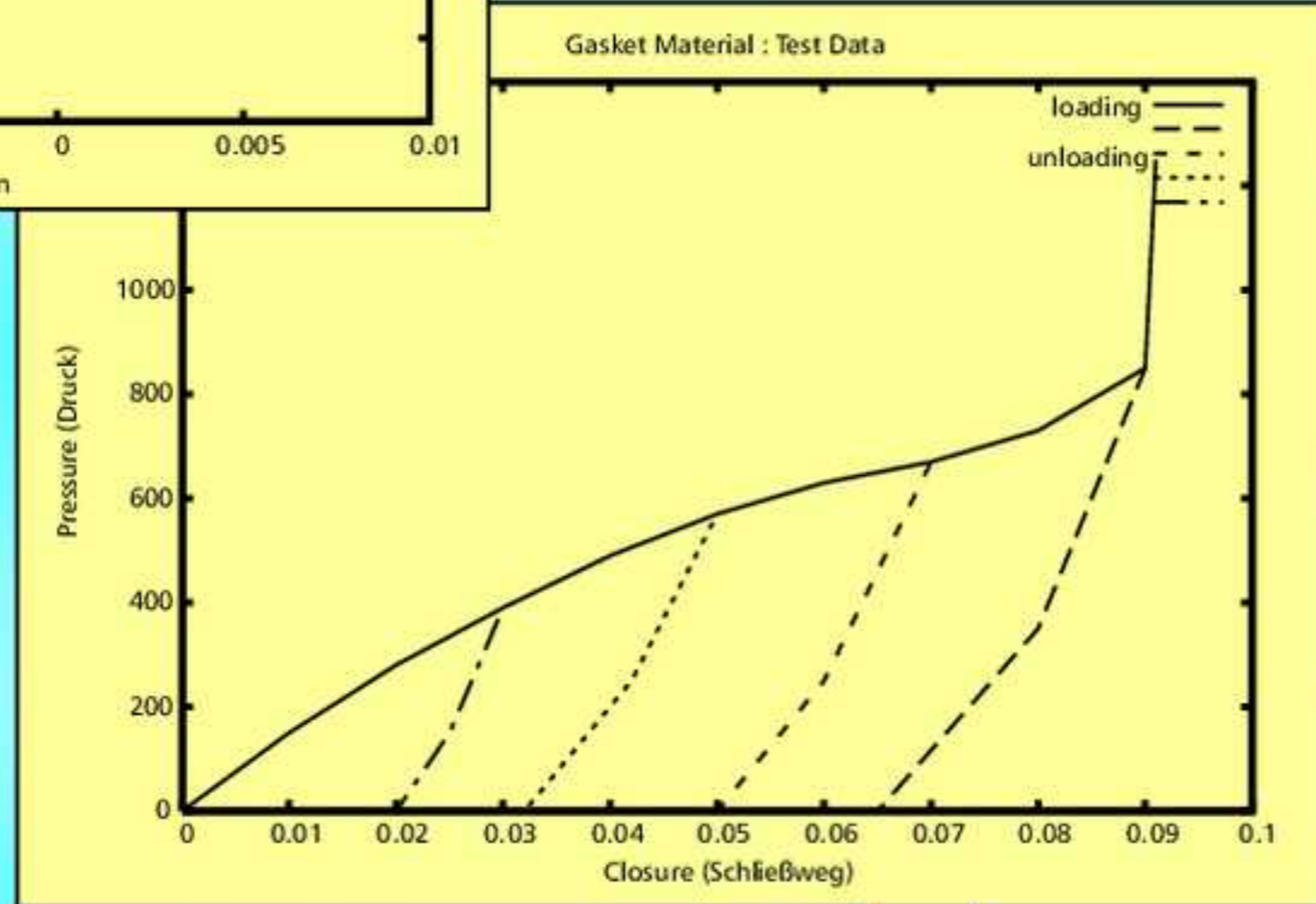


Stress-strain curve of a cast iron material

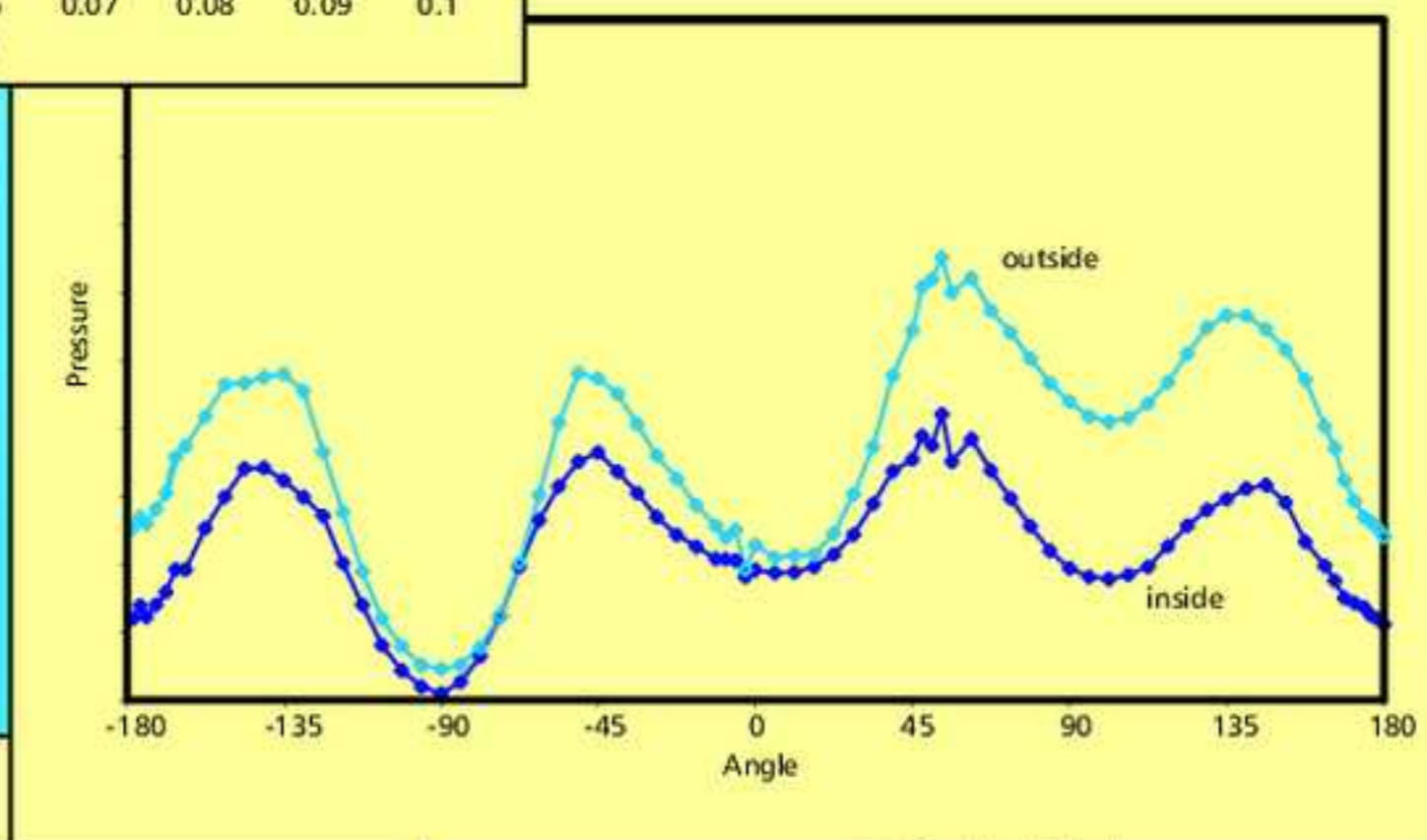


Gasket location

Typical characteristic of gasket loading and unloading



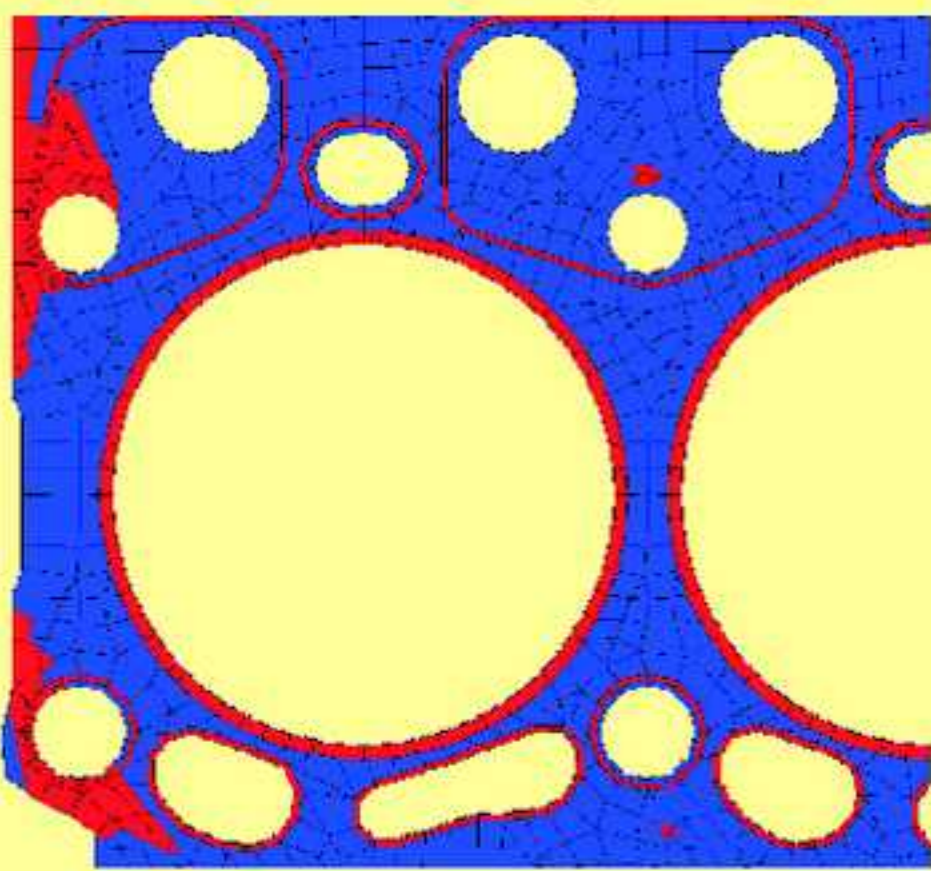
Pressure distribution at stopper over the angle as direct result



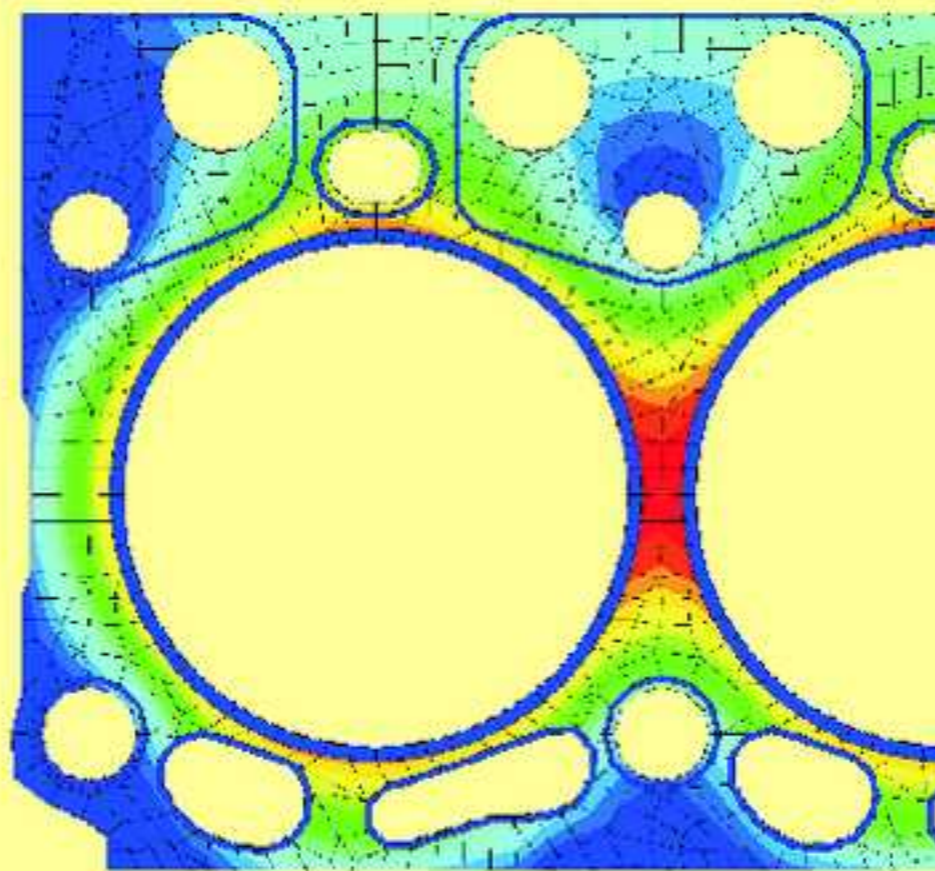
Results for gasket after load step 3

Many more XY results can be directly generated (like for the distortion of the cylinder bore)

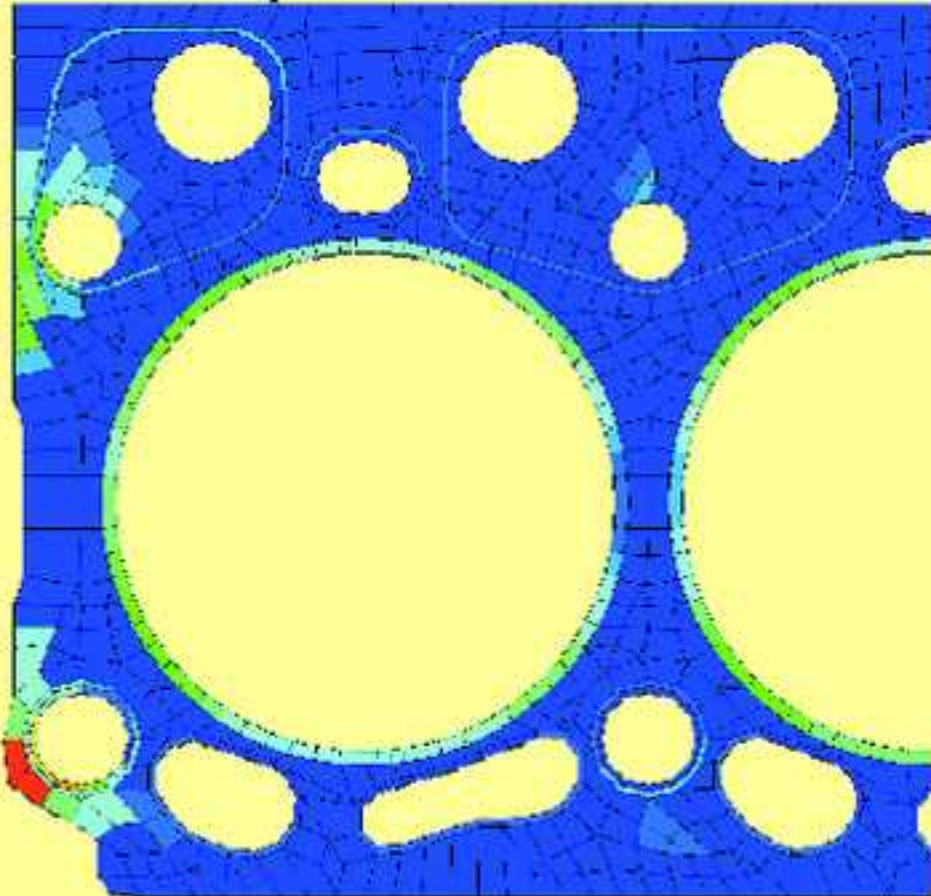
Contact status (red=contact, blue=no contact)



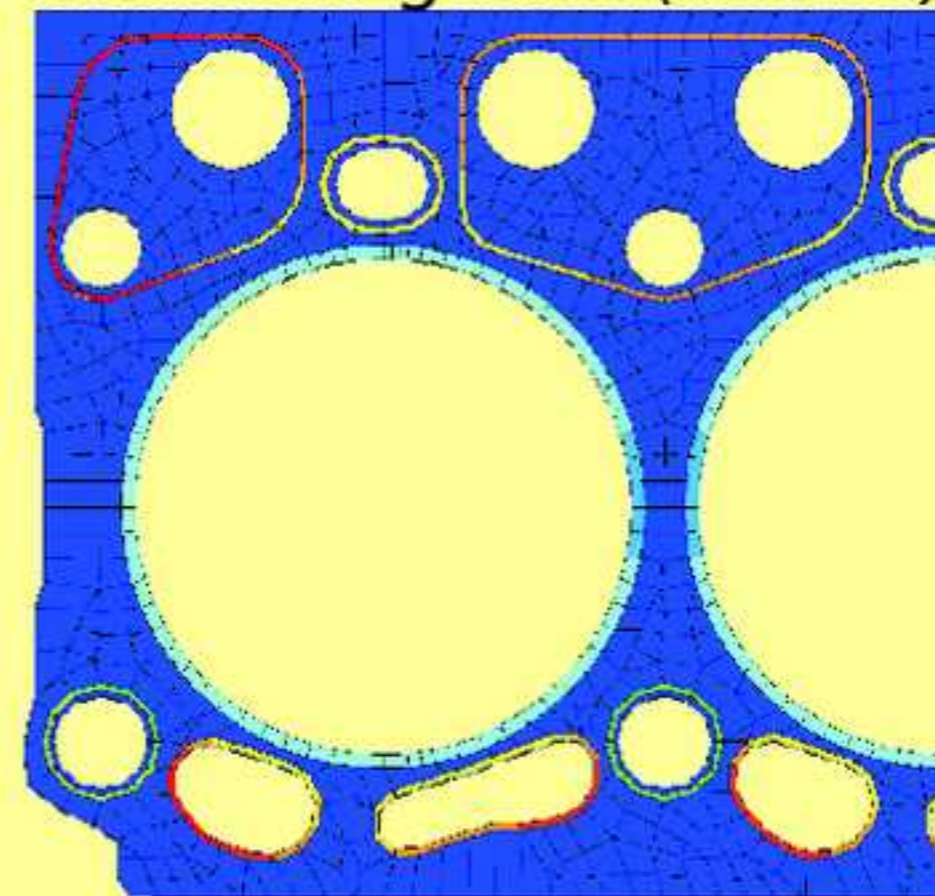
Current gap widths



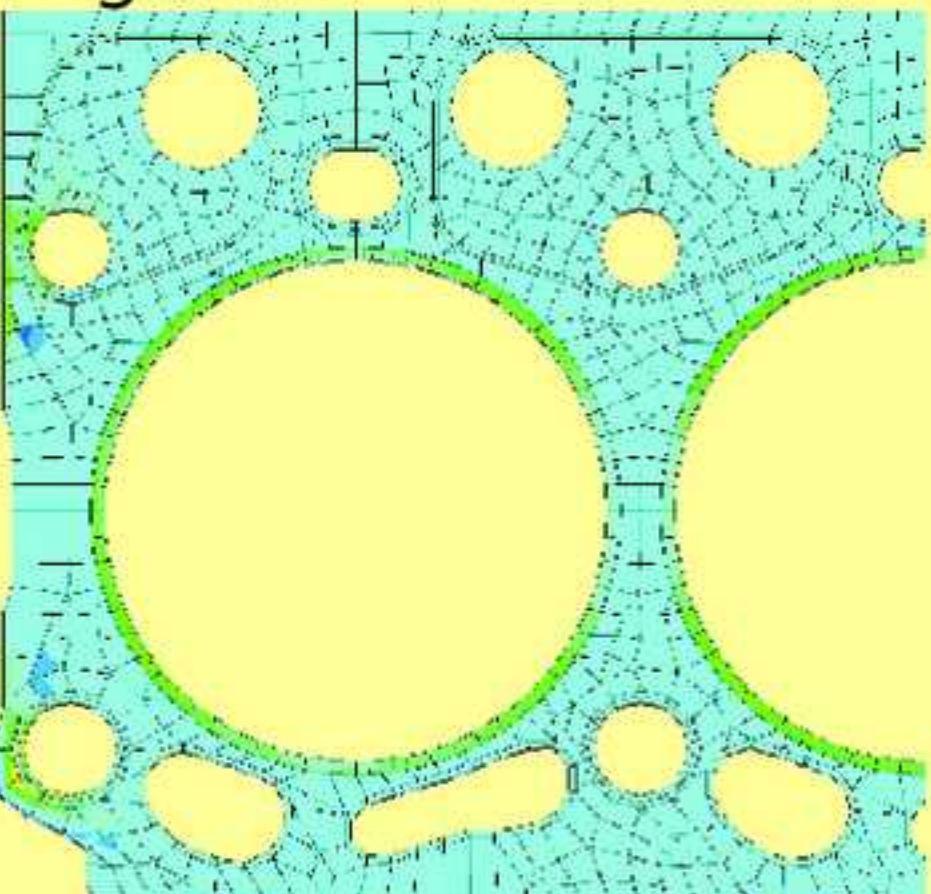
Gasket pressure



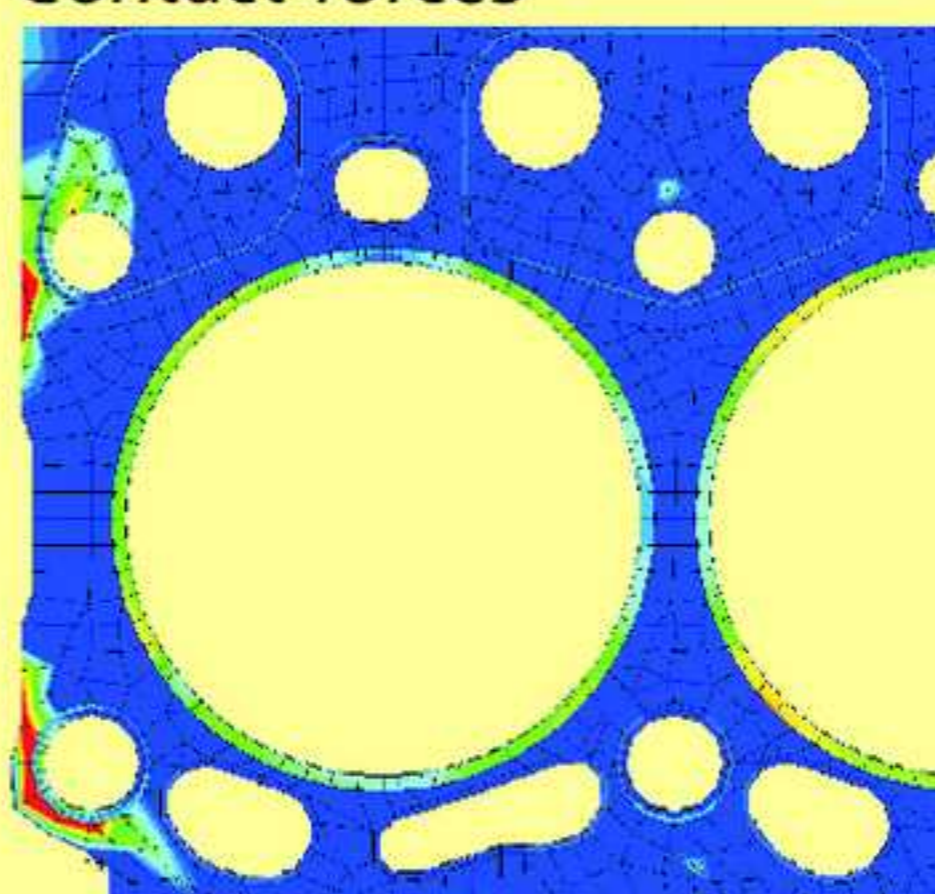
Relative displacements normal to gasket (closure)



Stresses normal to gasket



Contact forces



- More powertrain analyses:**
- **Nonlinear and transient heat transfer**
  - **Coupling of heat transfer and subsequent stress analysis**
  - **Dynamics and acoustics**

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