

Finite Element Method FEM

Dr Ing. Markus Thurneysen

Numerical simulation of a lathe

Calibration of the numerical eigenfrequency model using experimental measurement

Source : Tornos SA
Rue Industrielle 111
2740 Moutier
Suisse

Swiss type lathe Tornos DECO 20s



Lathe Tornos DECO 20s

Bar diameter max 20mm

Bar feeder Robobar SBF-532

Length of bars 3m



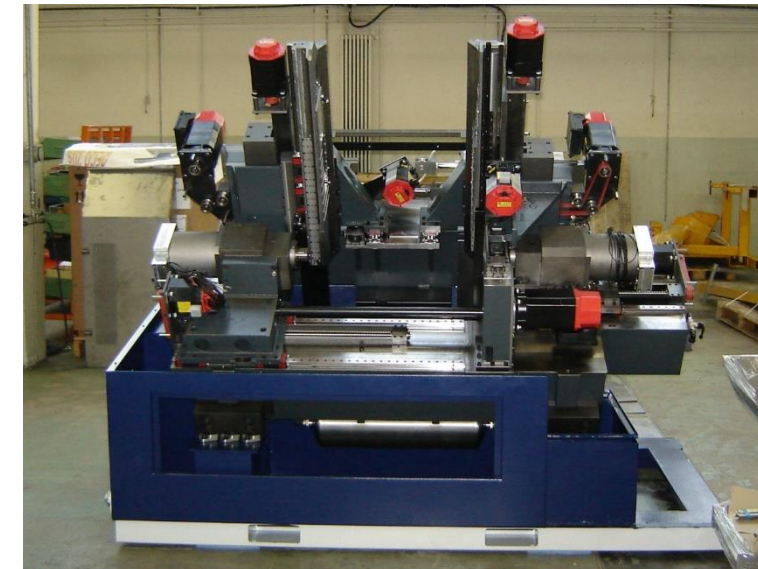
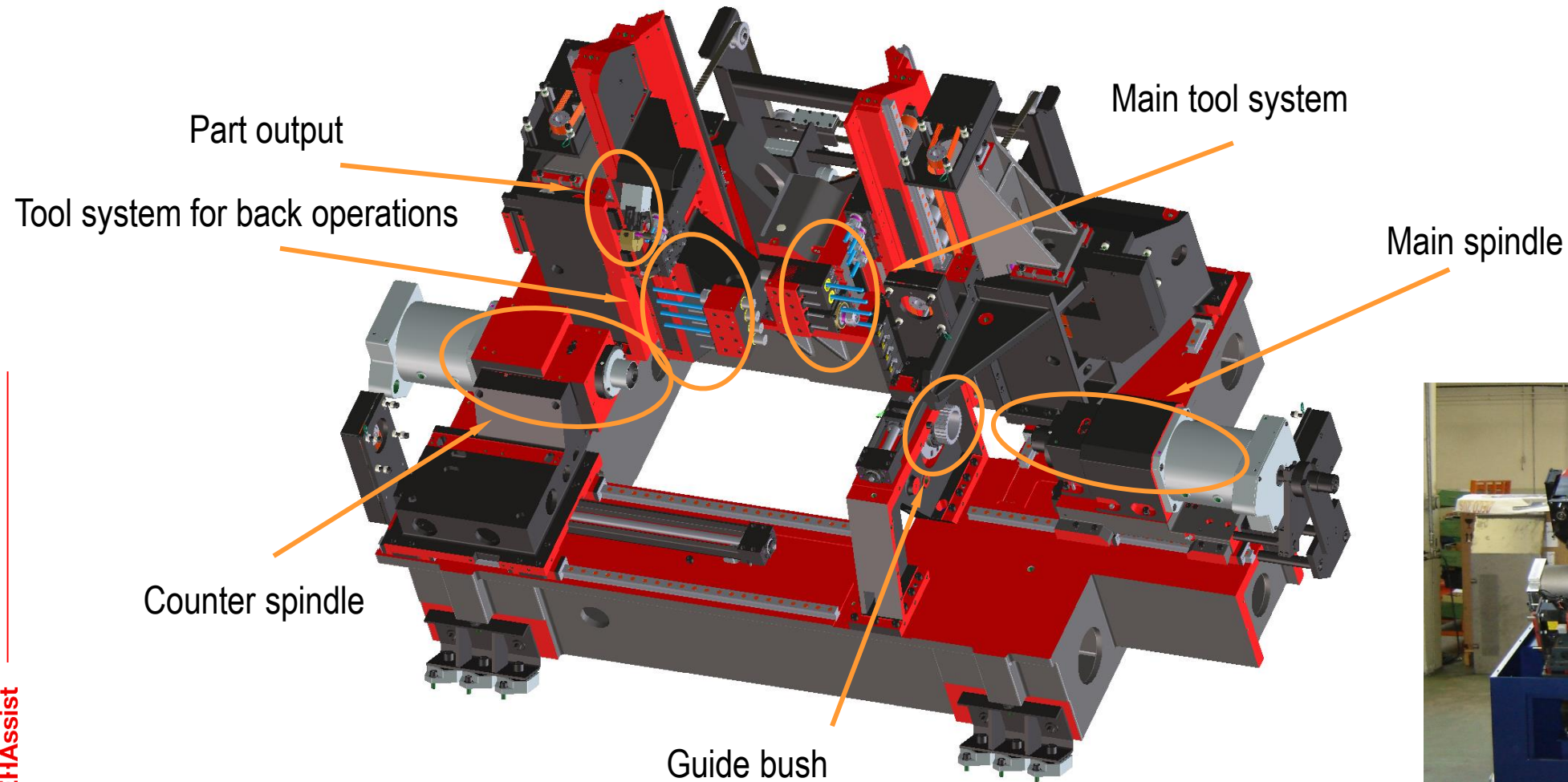
Turning parts

Length up to 10x the diameter

- Medical
- Automotive
- Connectors
- Watchmaking (not this machine)

Source : Tornos SA

The latheTornos DECO 20s

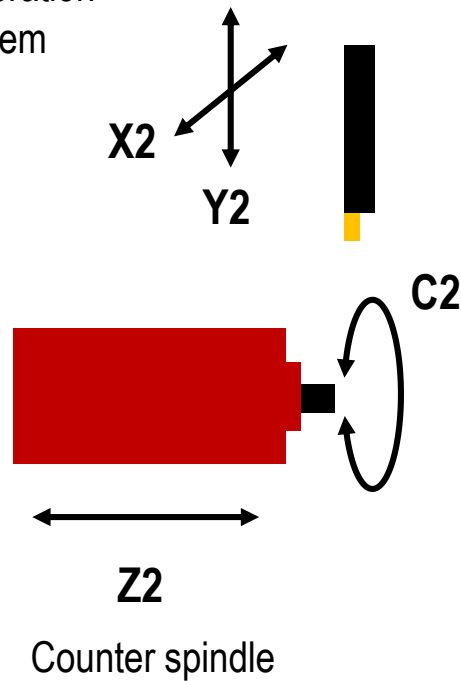


Source : Tornos SA

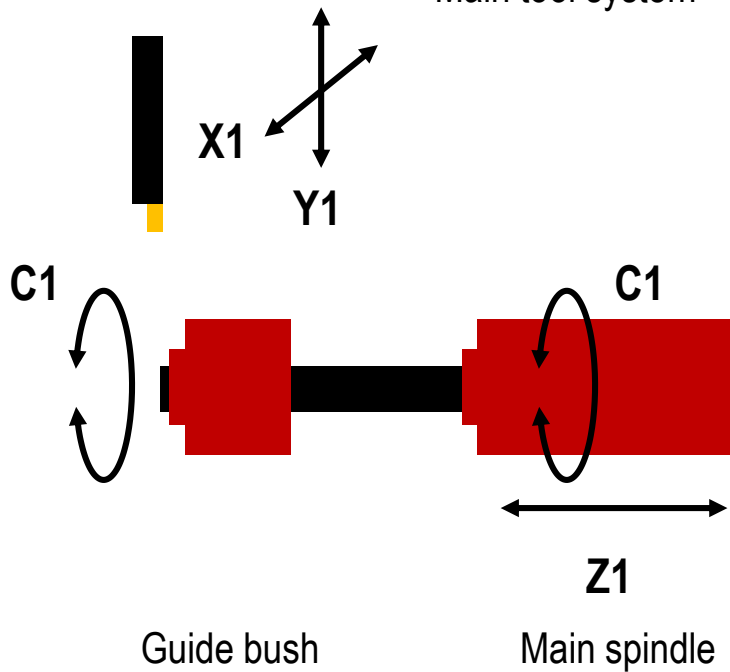
Kinematics of the Tornos DECO 20s

Tornos DECO 20s

Back operation
Tool system



Main tool system



Top view

Bar stock to be machined



Working principle

Tornos DECO 20s



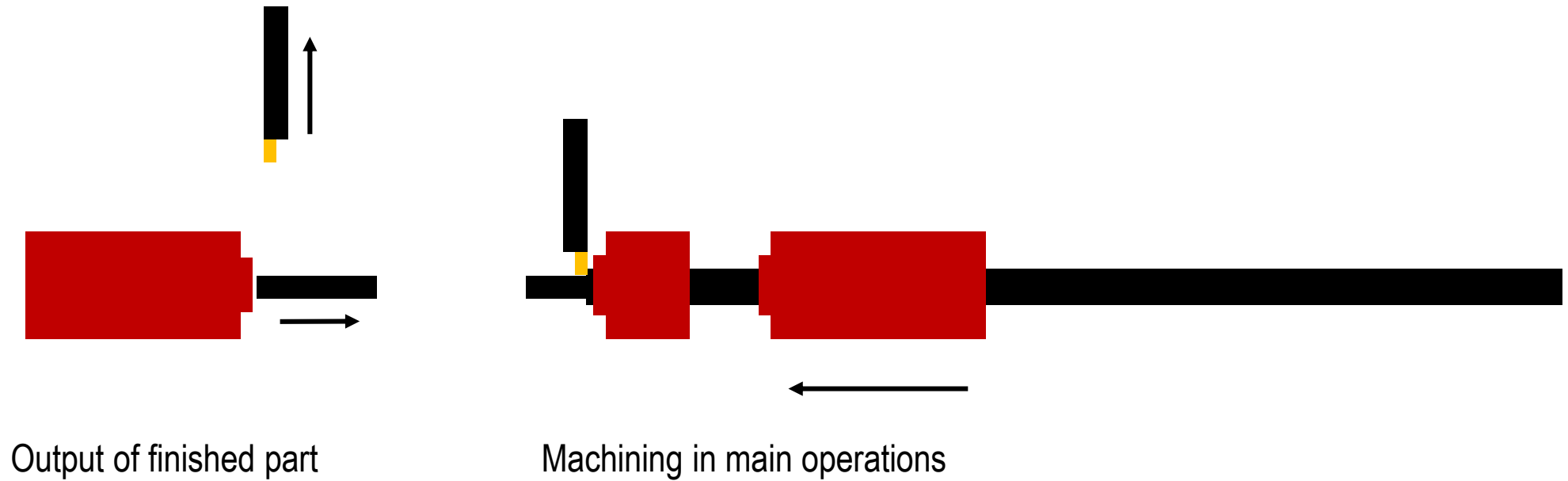
Machining in back operations



Machining in main operations, a new part is crafted

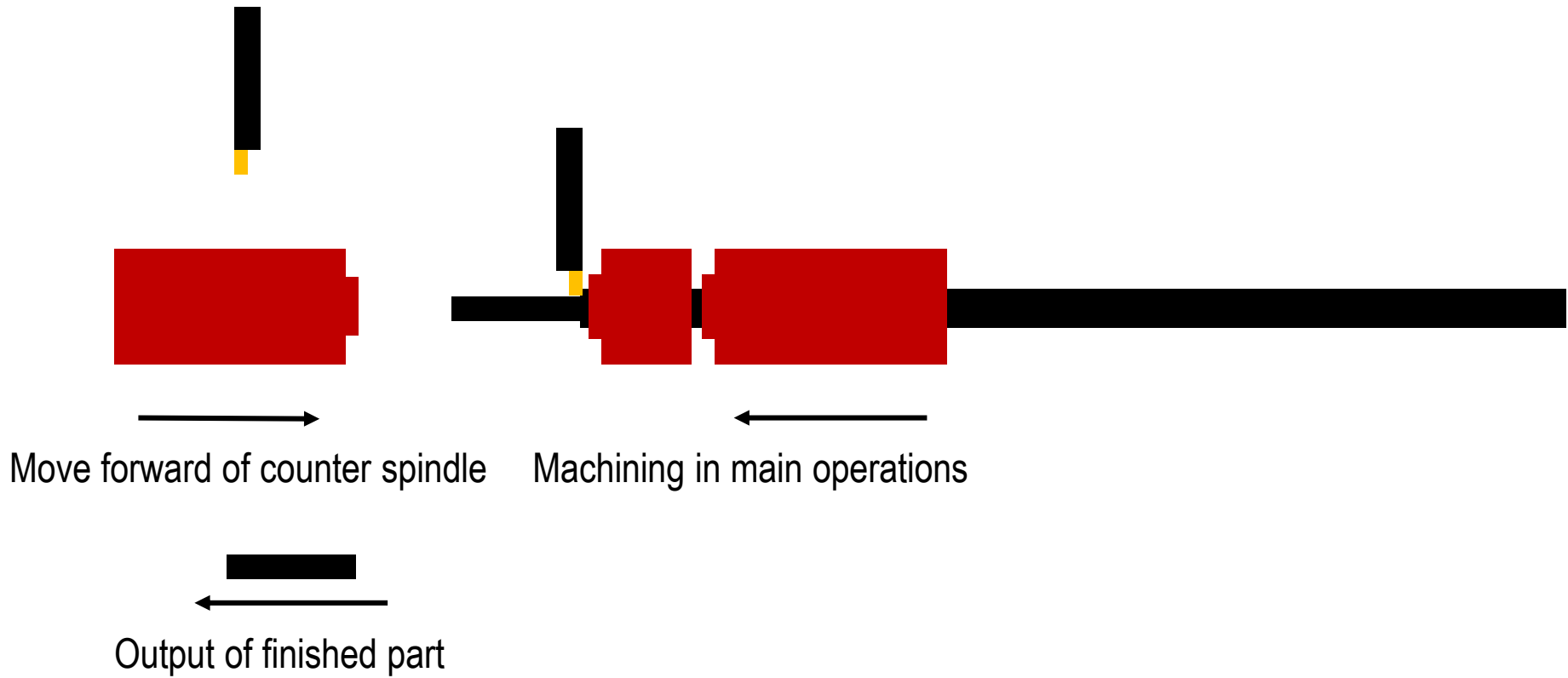
Working principle

Tornos DECO 20s



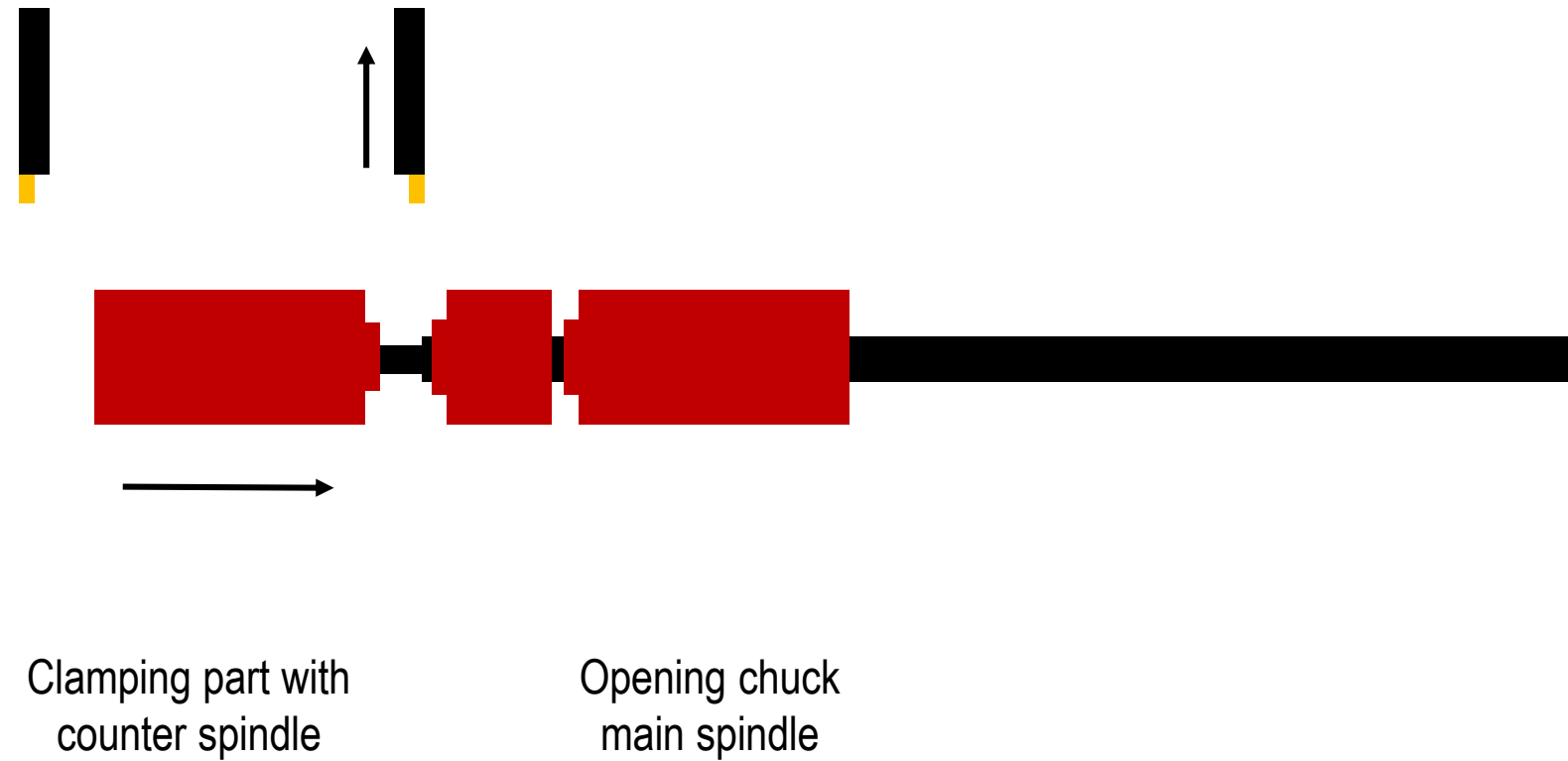
Working principle

Tornos DECO 20s



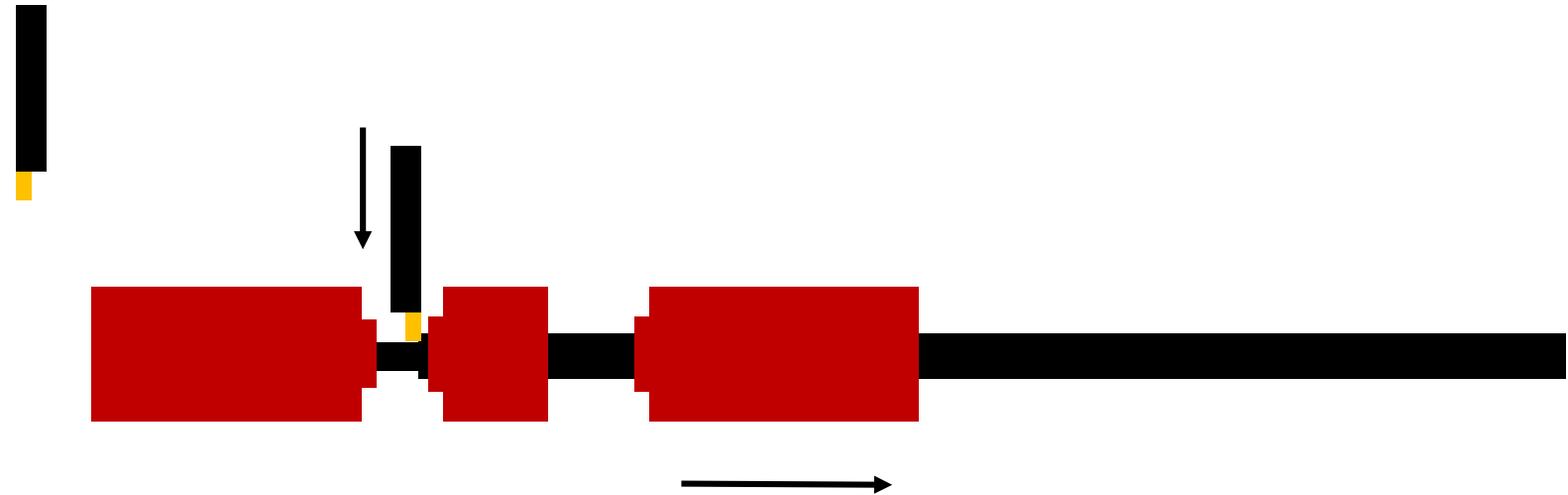
Principe de fonctionnement

Tornos DECO 20s



Principe de fonctionnement

Tornos DECO 20s



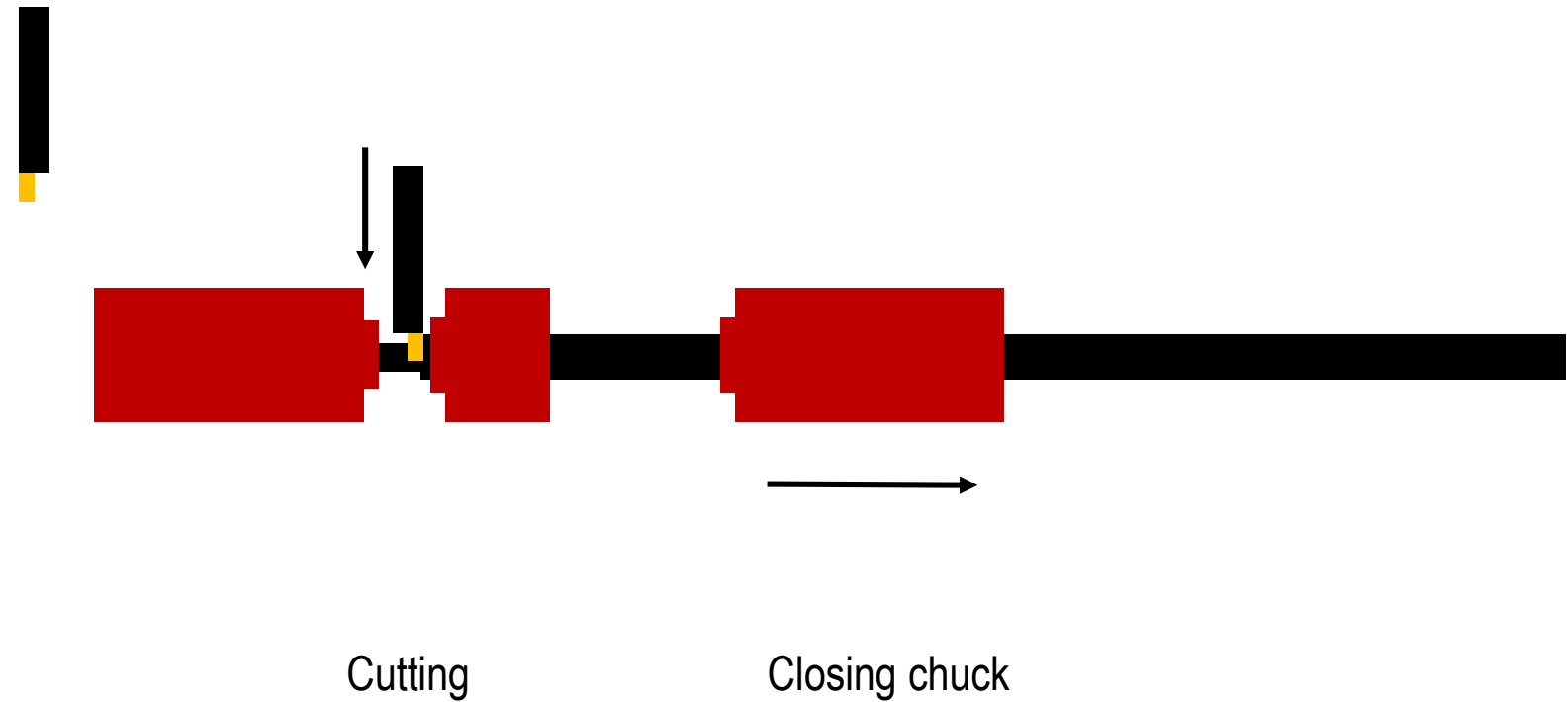
Move forward cutter

Move backwards main spindle

REHAssist

Principe de fonctionnement

Tornos DECO 20s

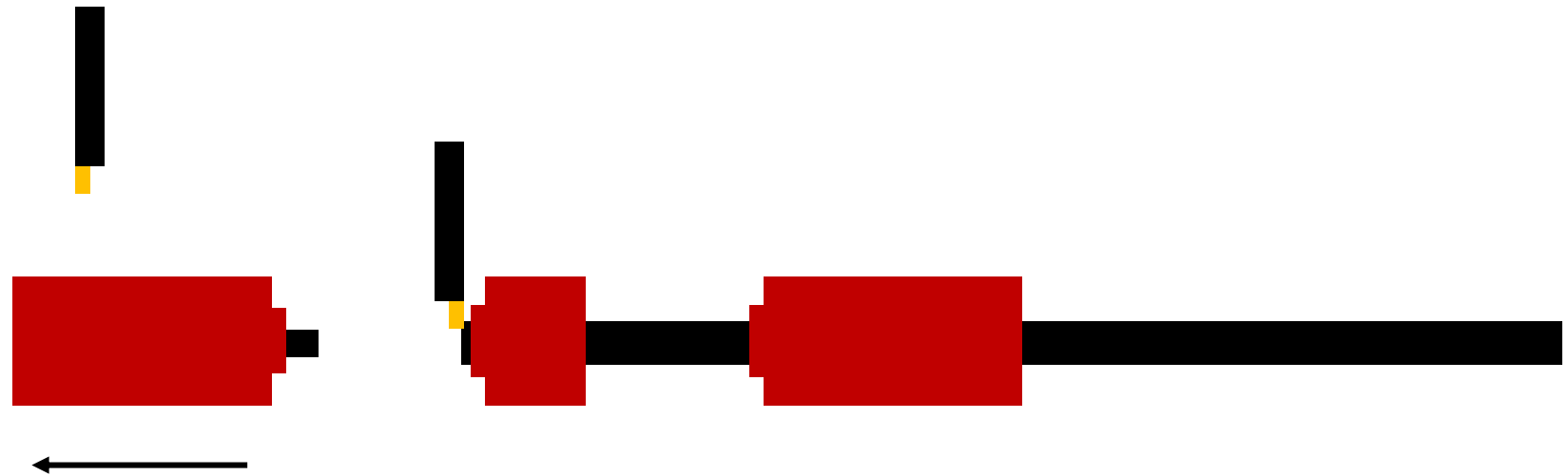


Cutting

Closing chuck

Principe de fonctionnement

Tornos DECO 20s



Move backwards counter spindle

Starting machining new

REHAssist

Principe de fonctionnement

Tornos DECO 20s



Machining in back operations



Machining in main operations, the cycle restarts

Numerical simulation

- Reduction of the developement time of new machines
- Numerical analysis from the beginning of the design phasis
- Optimisation of the parts geometrie in regard of the machine stiffness
- Eigenfrequency analysis of the complete machine
- Dimensioning of the de critical purchased parts

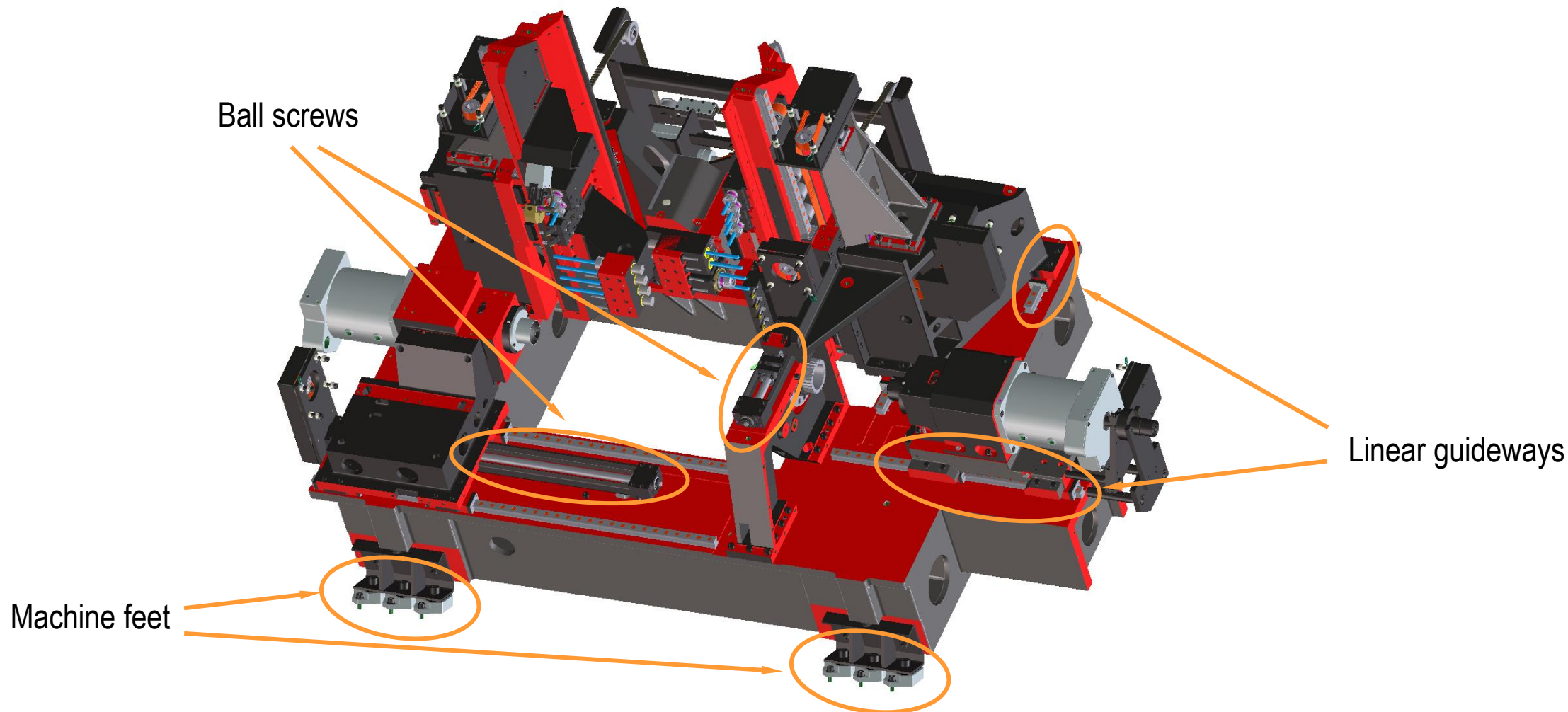
Constraints for the simulation model

- Machine components with high geometrical complexity
- Big number of mechanical parts (> 5'000 parts)

→ Huge numerical model

- Keep only the for the simulation relevant parts
- Simplify their geometry (no small holes, no chamfers, ...)
- Determine the for the simulation critical parts and adjust their properties as close to the reality as possible

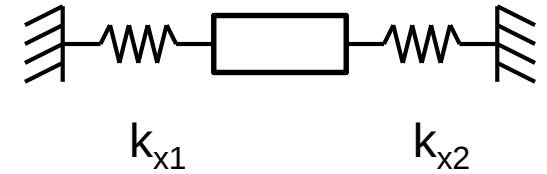
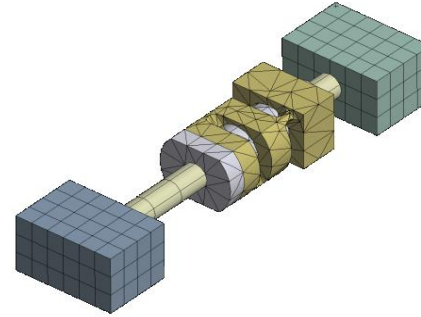
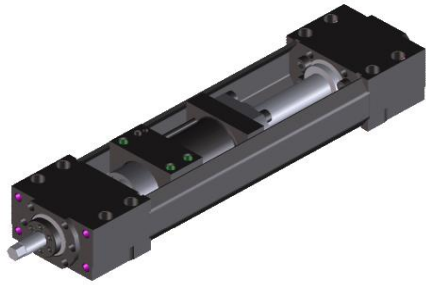
Determinations of the critical elements



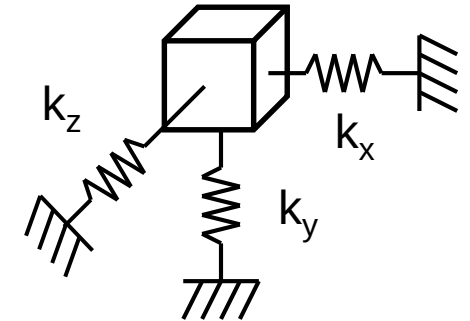
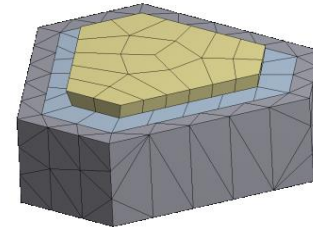
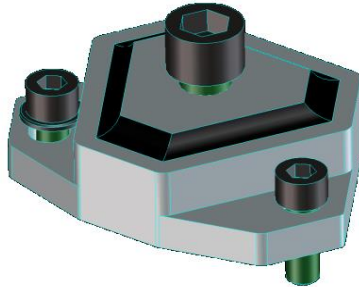
Source : Tornos SA

Part simplification

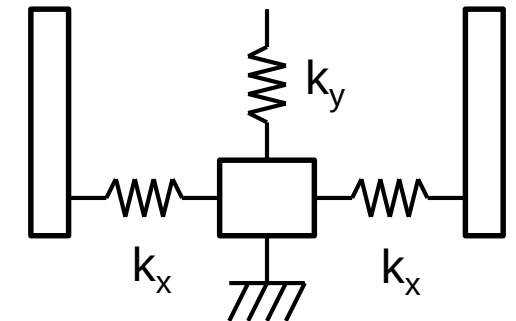
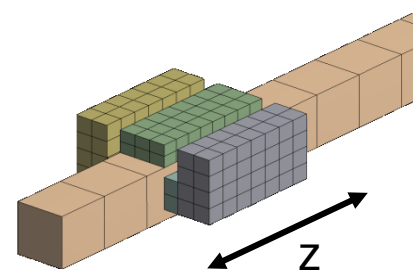
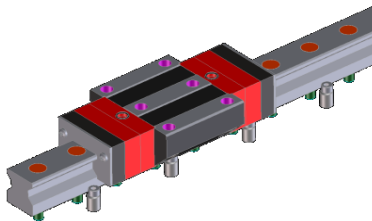
Ball screws



Machine feet



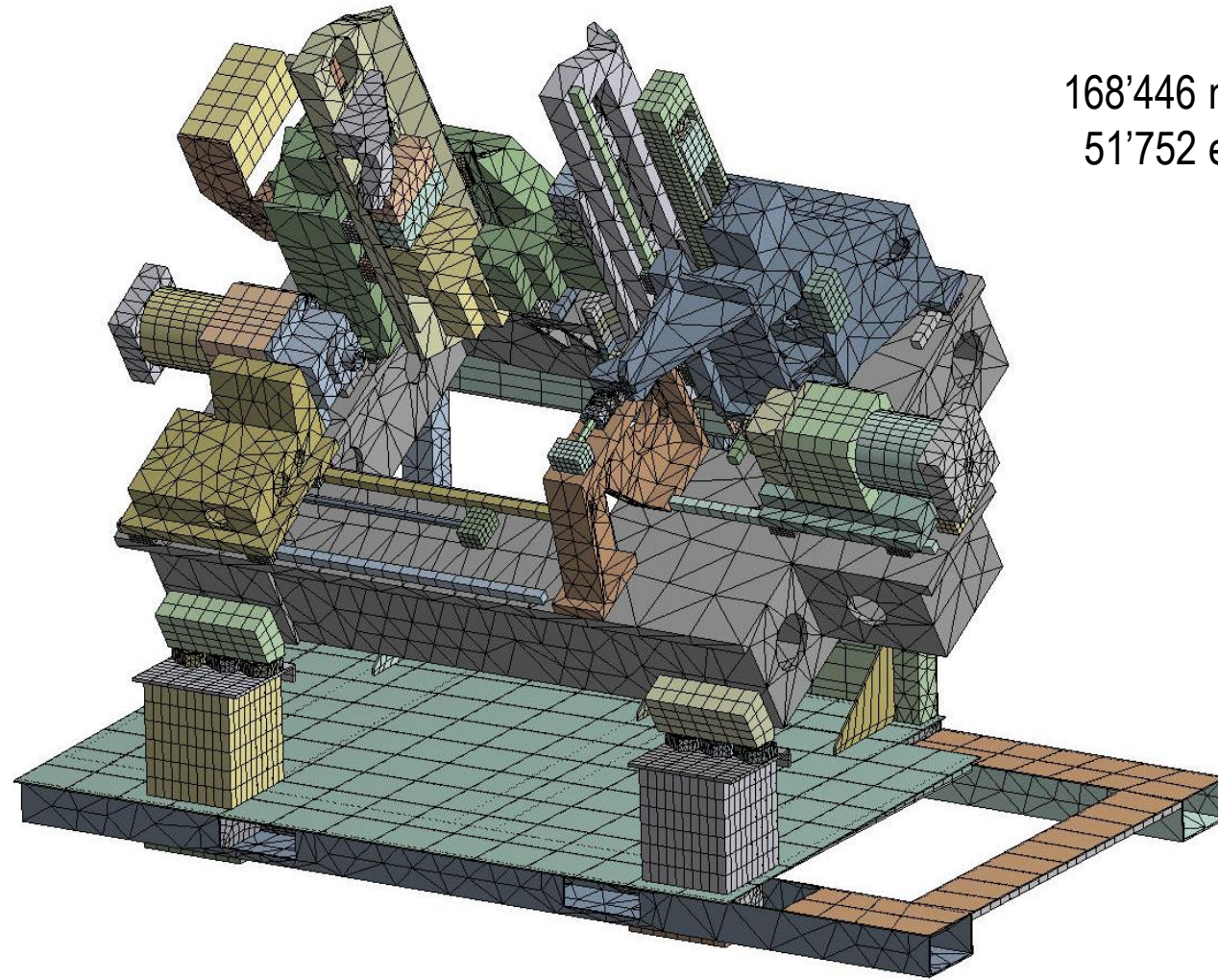
Linear guideways



Free Z motion between the slider and the rail

Source : Tornos SA

Numerical model fo the simplified machine



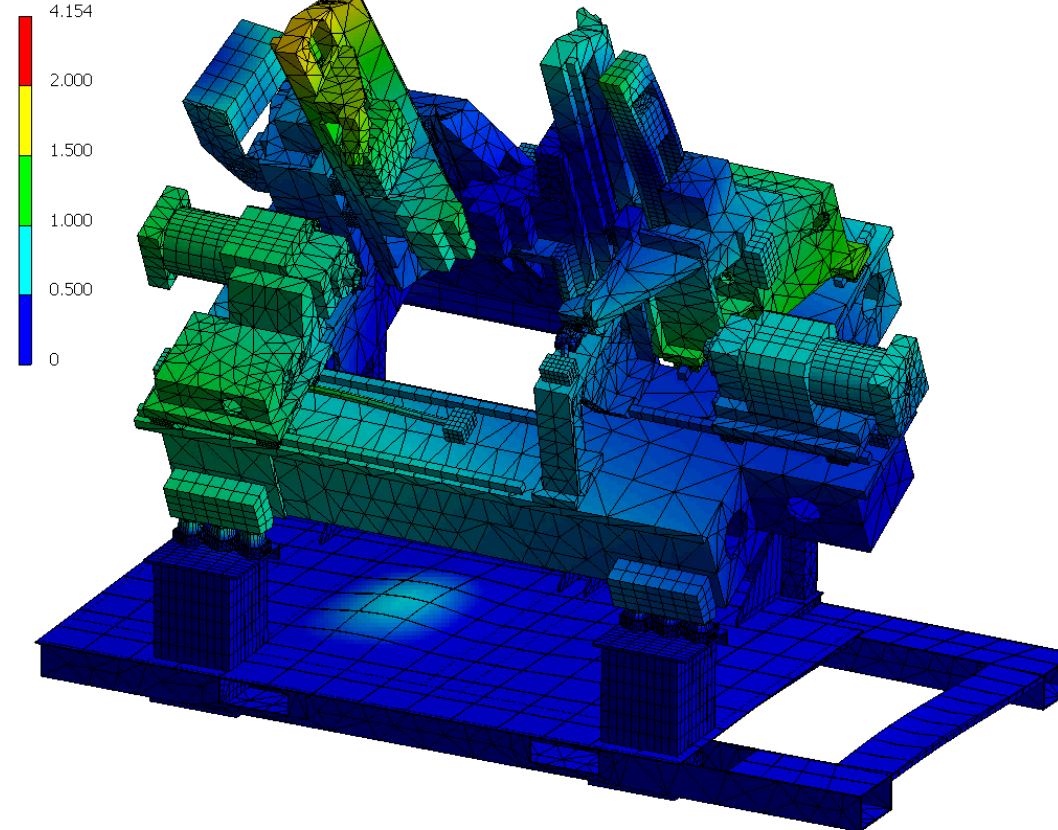
168'446 nodes
51'752 elements

Source : Tornos SA

Eigenfrequency analysis

17ème mode propre dans la plage (78.3778 -Hz)
Max: 4.154e+000
Min: 0.000e+000
2006/10/9 17:17

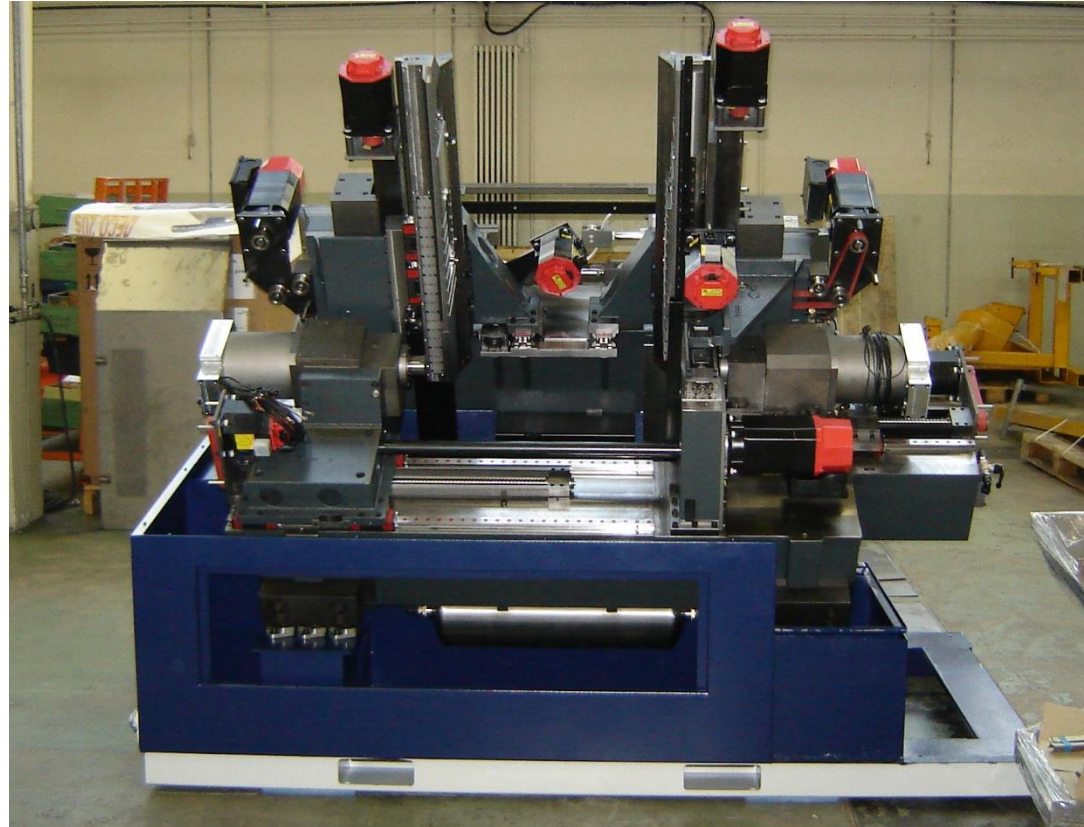
ANSYS100
WORKBENCH



Concordance between simulation and reality?

Source : Tornos SA

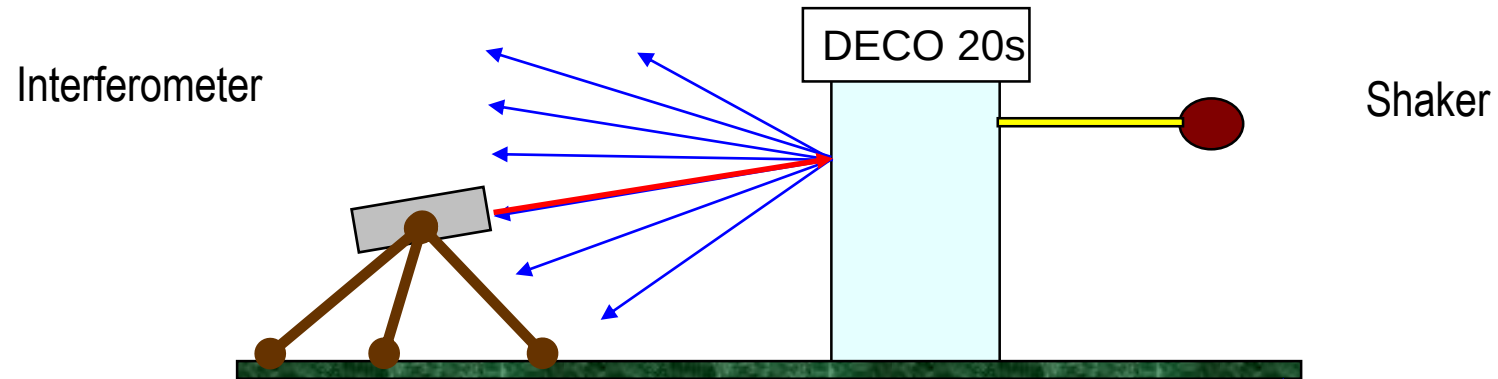
Experimental verification



Prototype DECO 20 Sigma

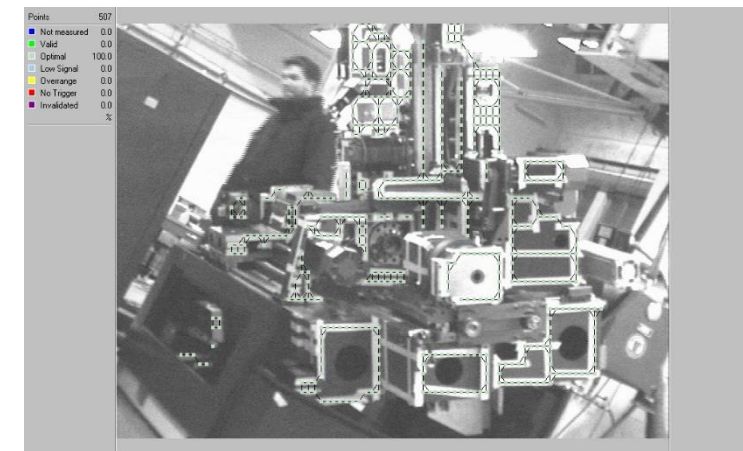
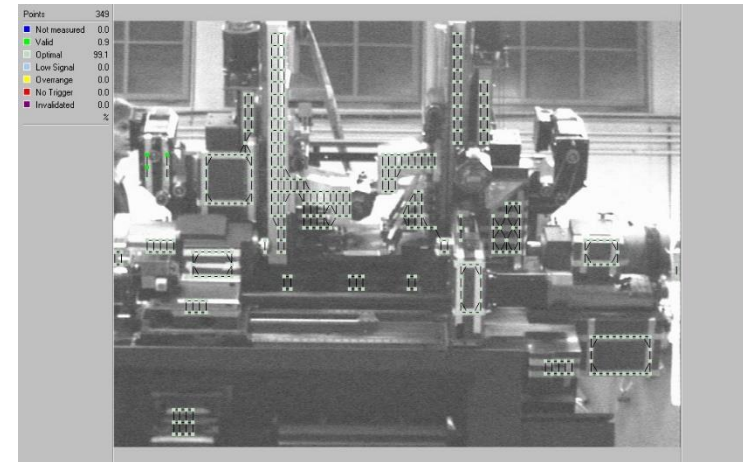
Source : Tornos SA

Measurement equipment



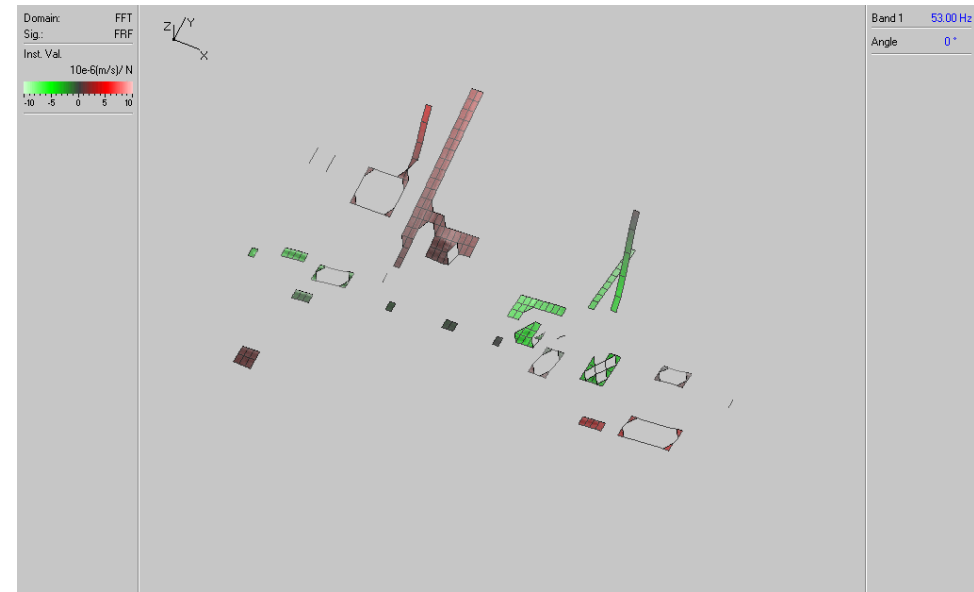
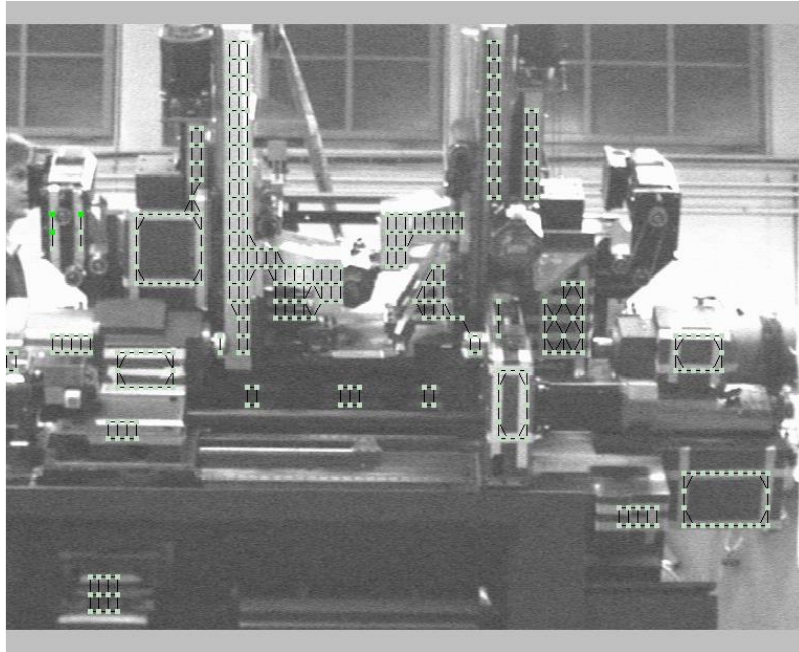
Source : Tornos SA

Scan with the interferometer



Source : Tornos SA

Visualisation of the results



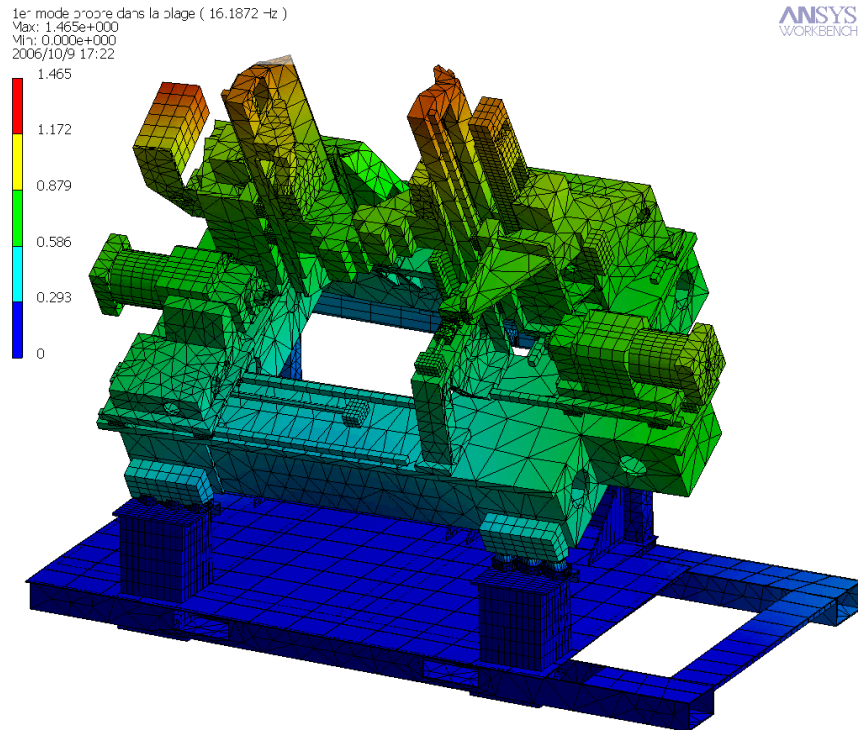
Source :

NRCtech SA
PSE-C
CH-1015 Lausanne

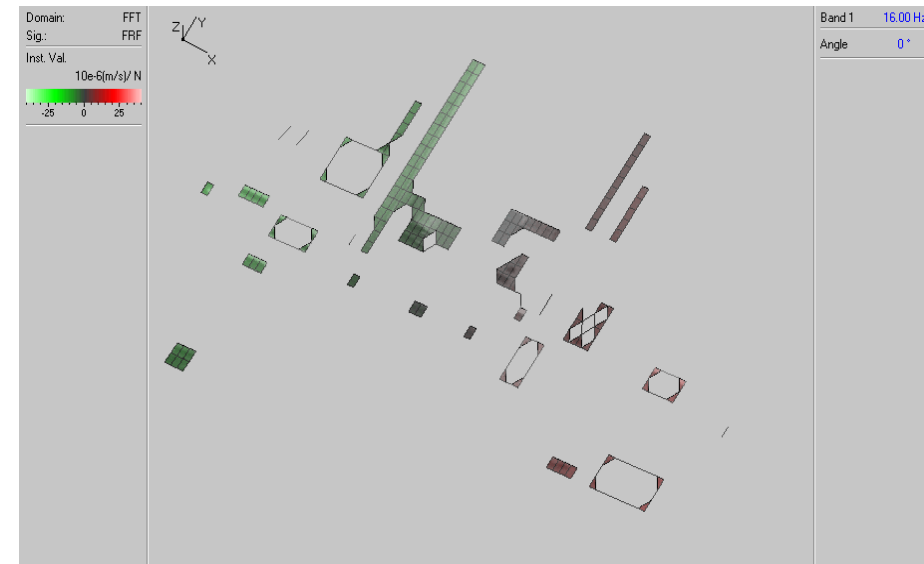
Source : Tornos SA

Comparison calibrated model - reality

Solid mode



ANSYS100
WORKBENCH



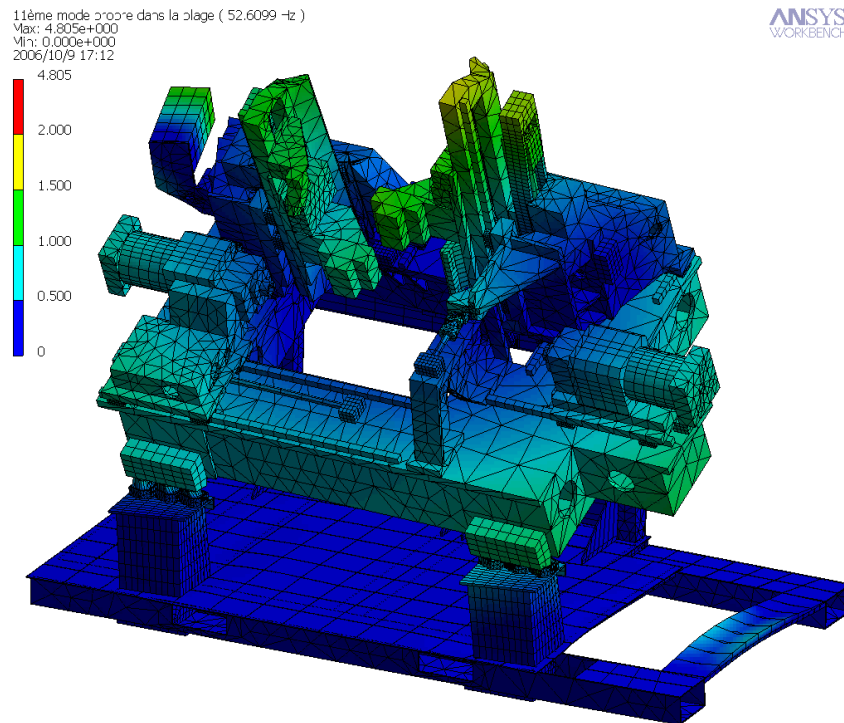
16 Hz

16,2 Hz

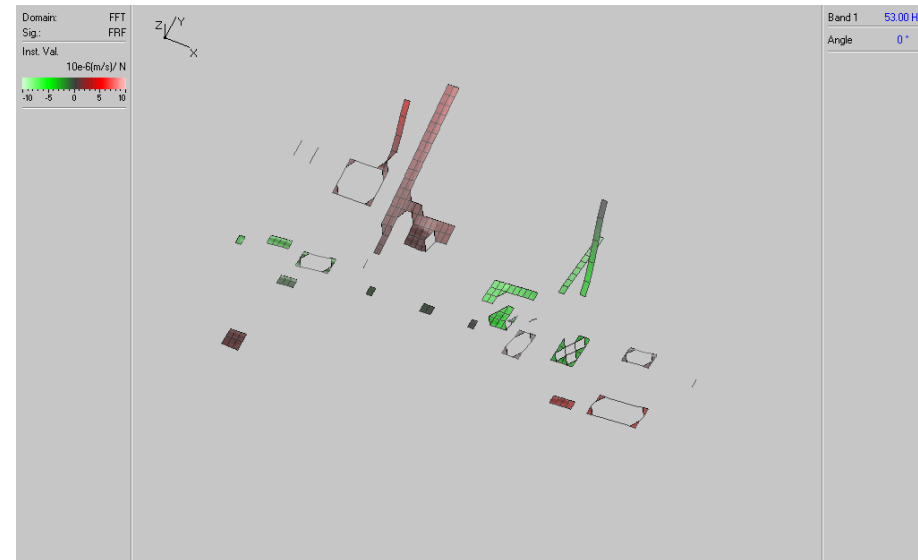
Source : Tornos SA

Comparison calibrated model - reality

First eigenfrequency of the machine



52,6 Hz

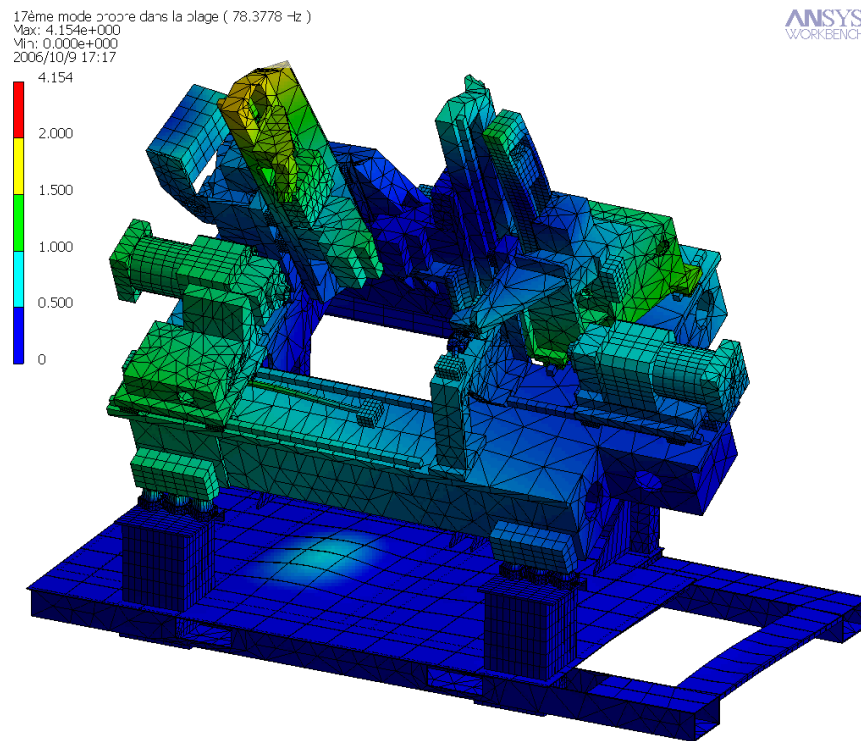


53 Hz

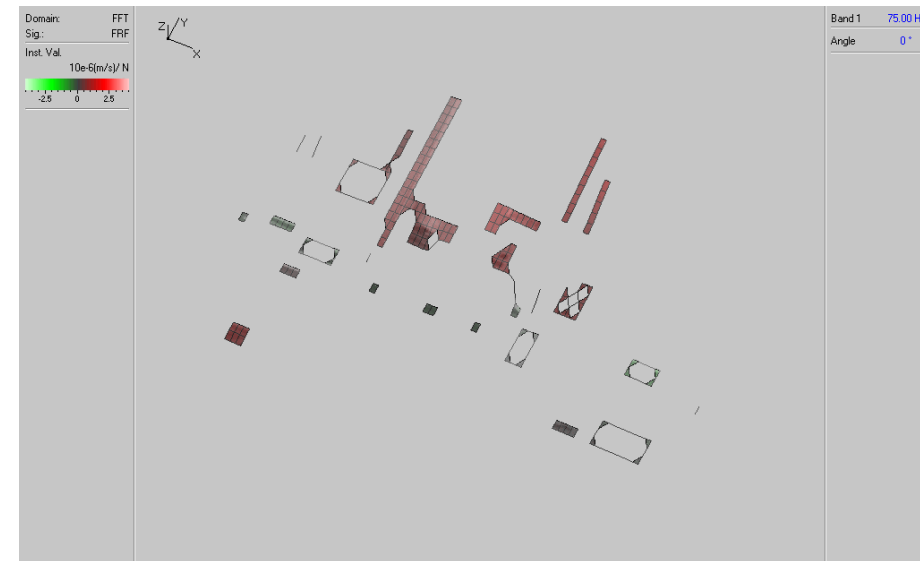
Source : Tornos SA

Comparison calibrated model - reality

Eigenfrequency of the machine



78,4 Hz

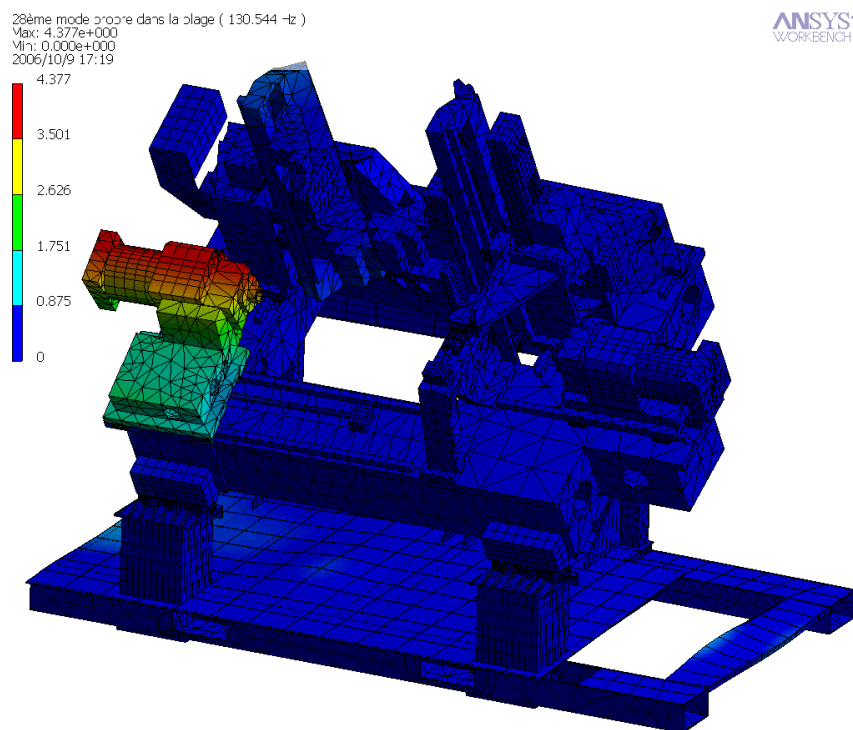


75 Hz

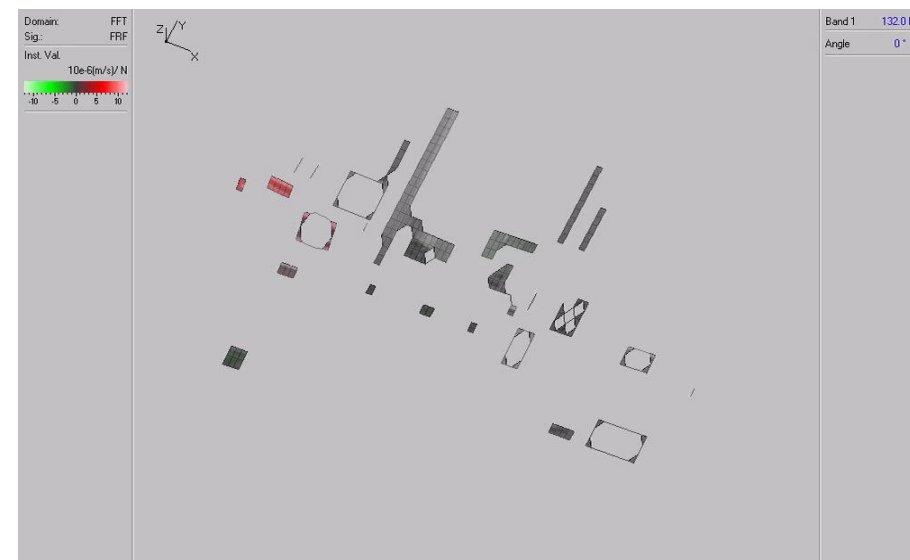
Source : Tornos SA

Comparison calibrated model - reality

Local frequency of the counter spindle



130,5 Hz

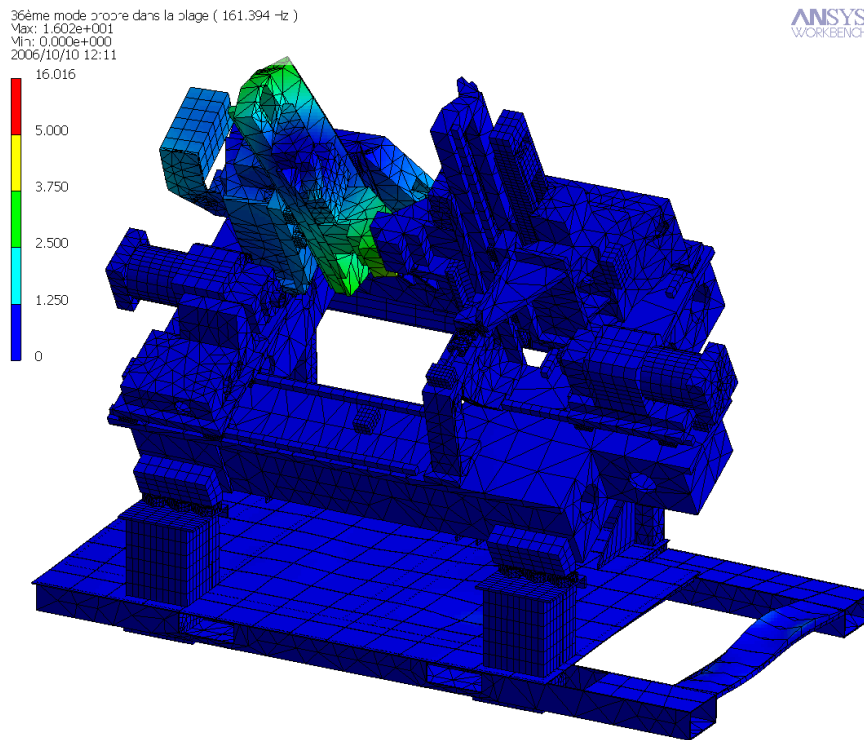


132 Hz

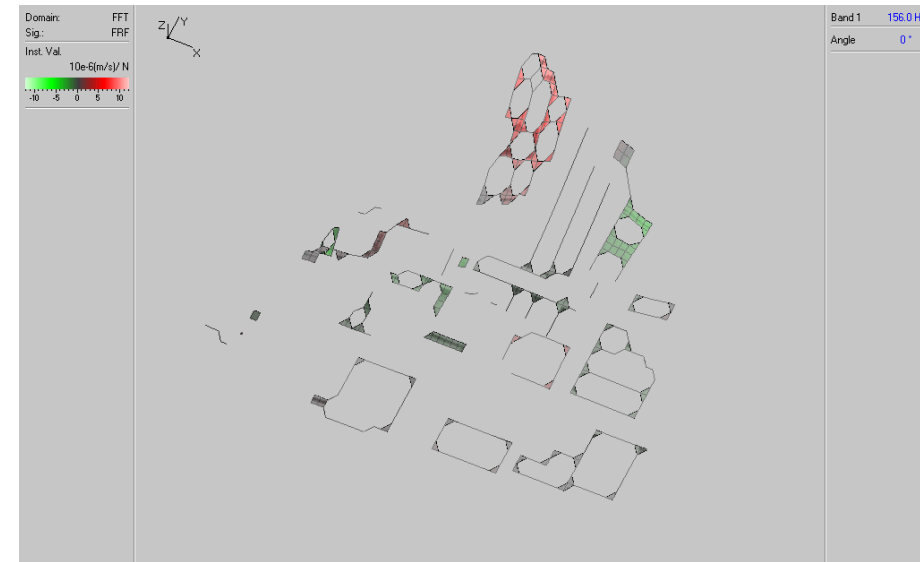
Source : Tornos SA

Comparison calibrated model - reality

Local frequency of the back-operation tool-system



161,4 Hz

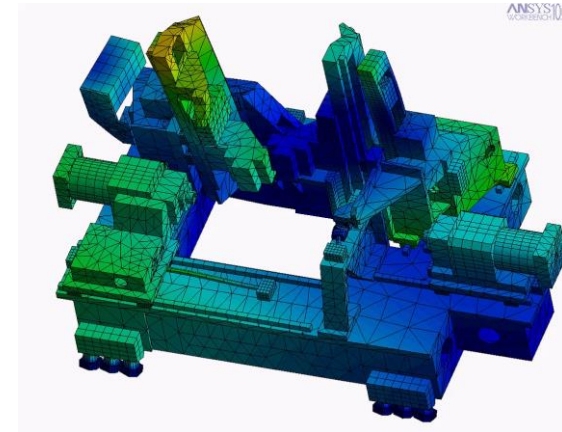
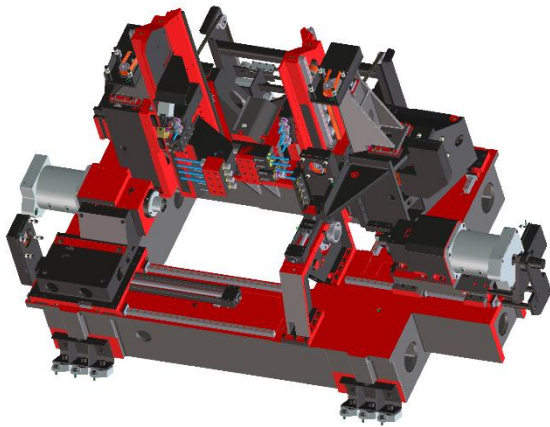


156 Hz

Source : Tornos SA

Synthesis

- Numerical model validated
- Large simplification of the geometrie of the mechanical parts
- Keep only the for the simulation relevant parts
- Calibrated model for the critical parts
- Match between calibrated simulation and measurements better than 90%
- Reduced calculation time, less than 2 heures



Source : Tornos SA