
SKF

Dynamic Modelling of Roller Screws

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Outline

- Roller screw utilization and trends
- BEAST model of roller screws
- Some simulation results
- Verification
- Summary

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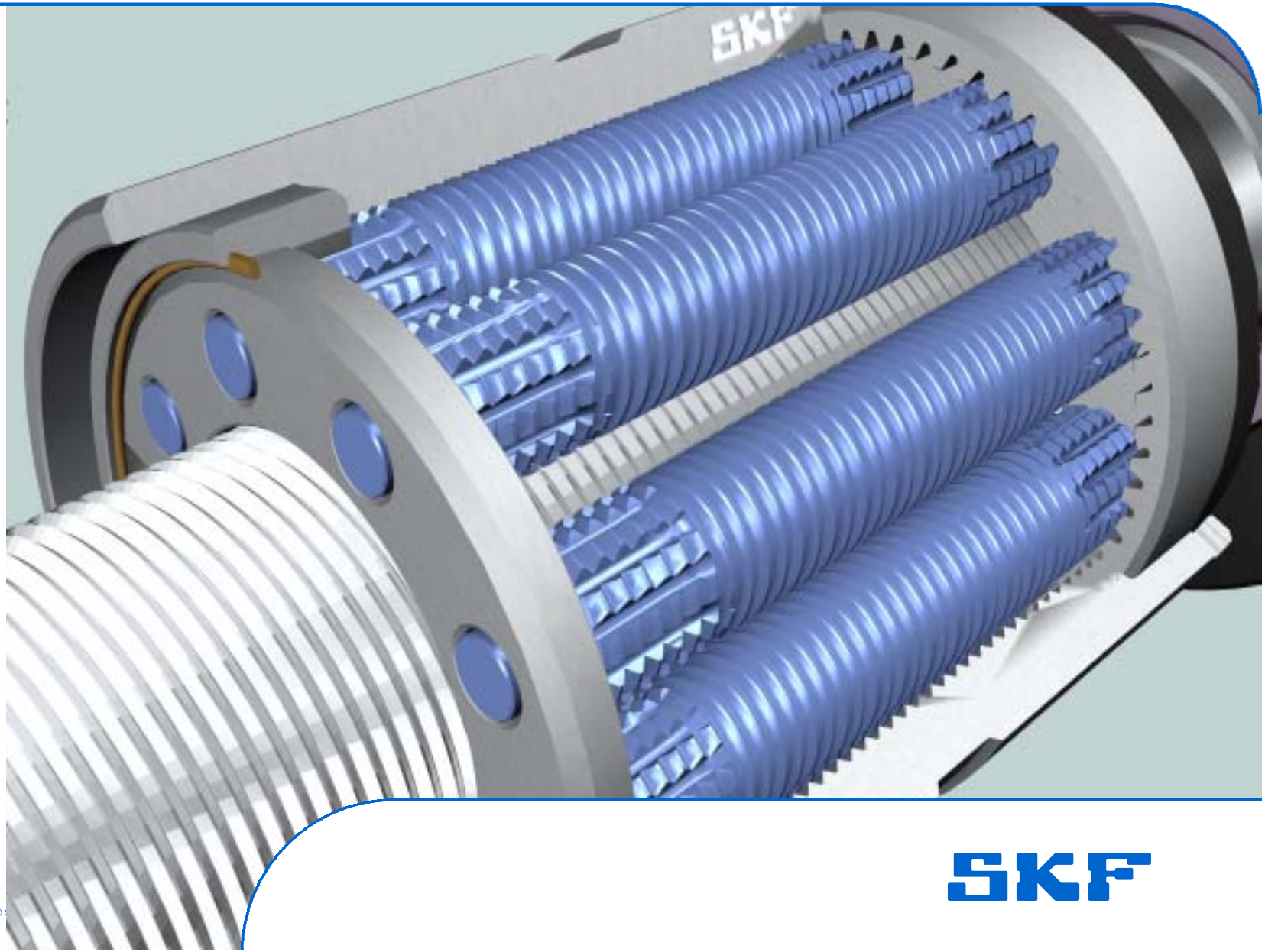
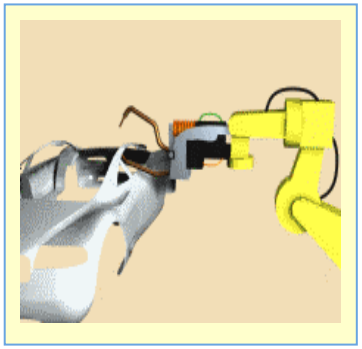
Roller screw utilization and trends

Planetary roller screw

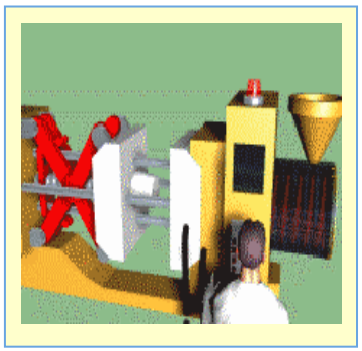


Roller screw applications

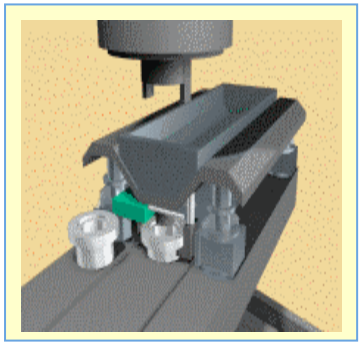
Industrial Guns



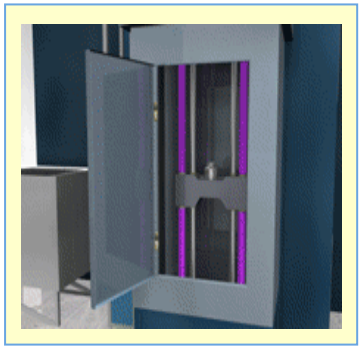
Injection Molding

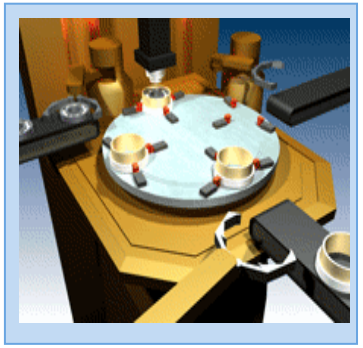


Steel industry

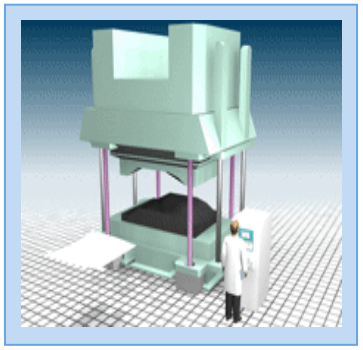


Broaches





Servo-presses



Heavy presses

Trends in the market

- The trend is to move from hydraulic to electro-mechanical system (power consumption, productivity, accuracy, flexibility, noise level, ...)
- The reason of this trend is mainly due to improvements of the AC servo motors, the driver, the electronics, etc
- Roller screws allows higher speeds, higher loads, and higher reliability compared to other solutions, e.g., ball screws, rack & pinion, pulley & belt, acme screws
- **BUT, better knowledge of the limits of the roller screw is needed, based on experience, tests, basic research, and calculation models**

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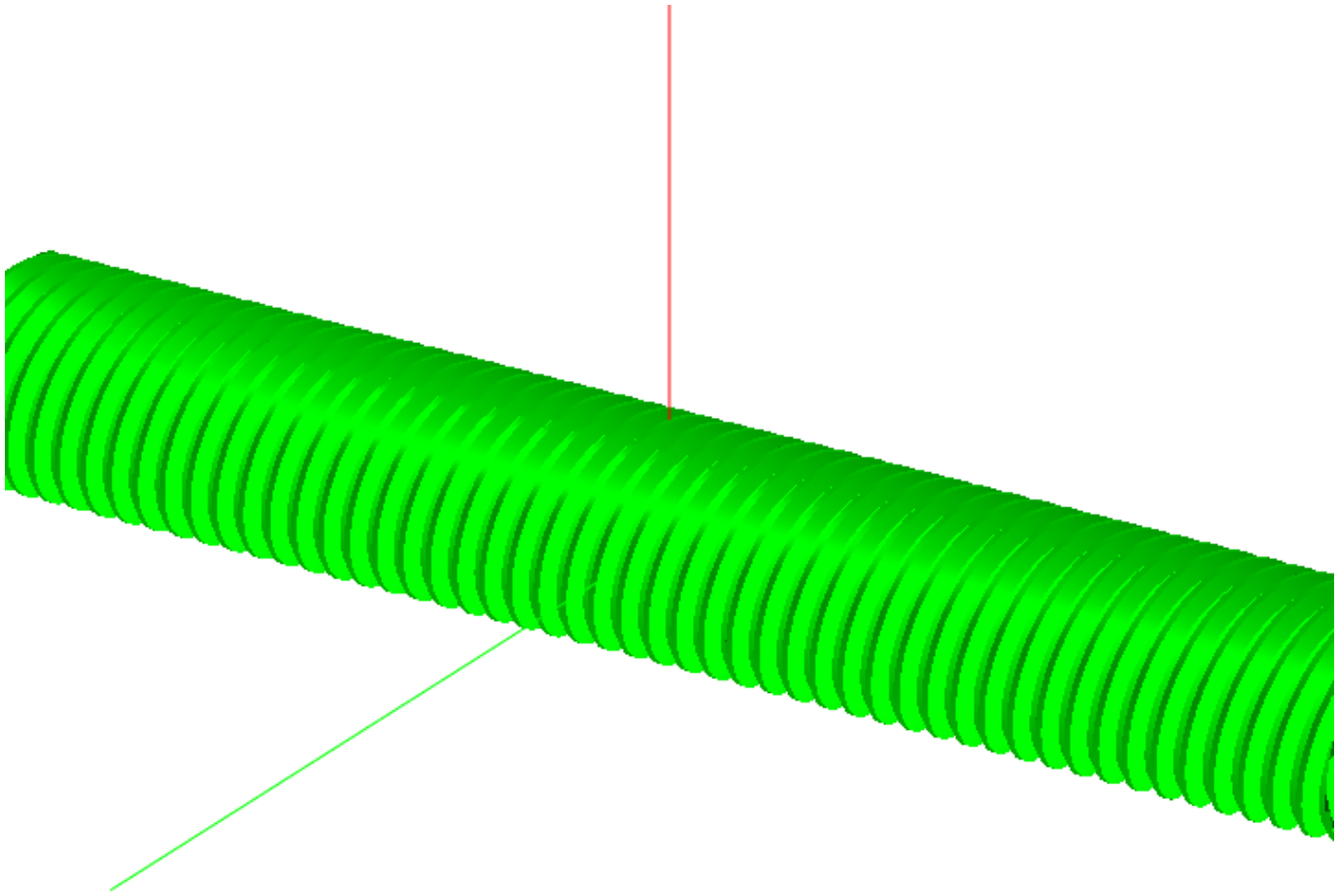
BEAST model of roller screws

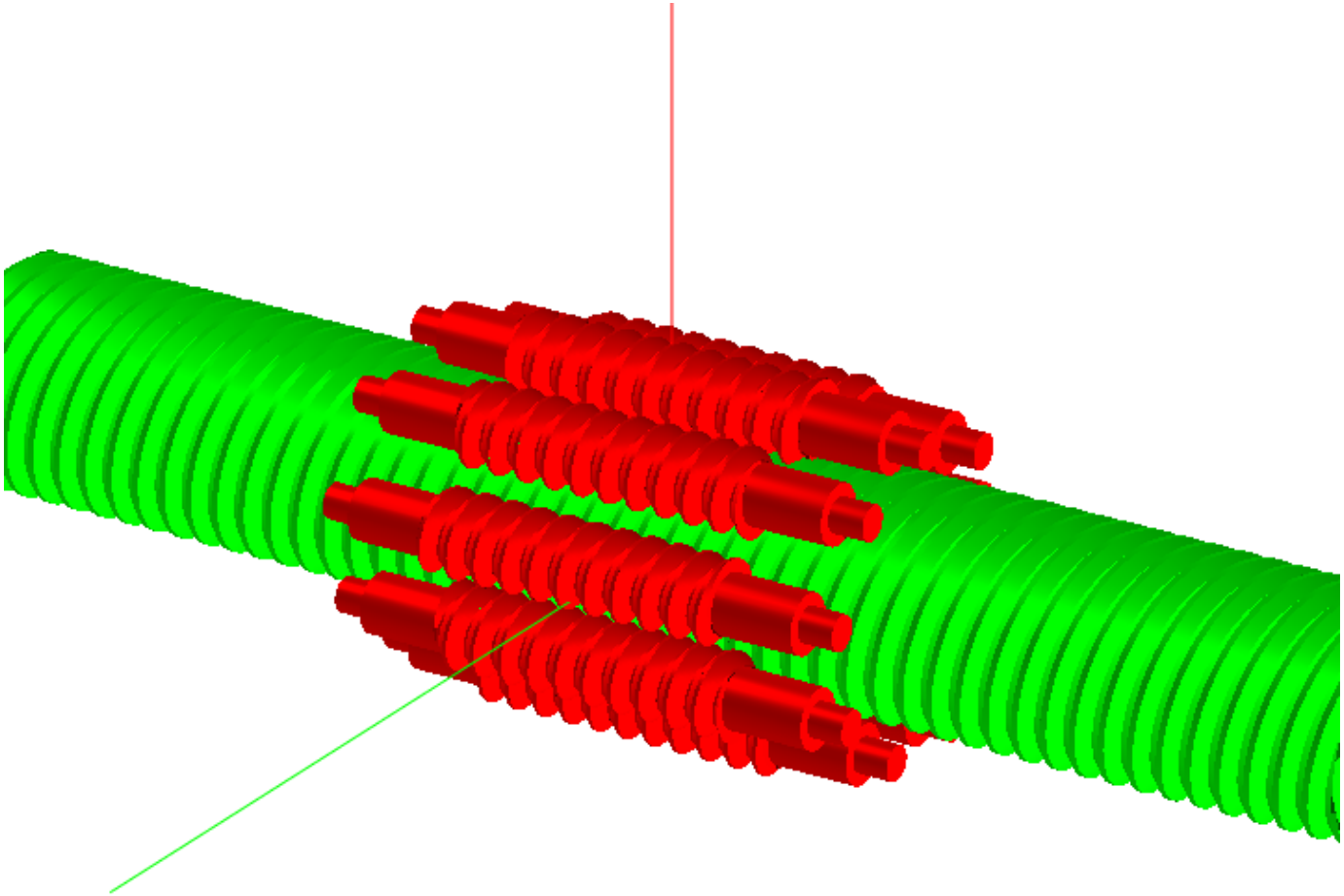
BEAST - a virtual test rig

- Multi-body simulation software
- Specialized in contact problems
- Detailed surface description
- Accurate tribology
- Application operating conditions
- Focus on creating understanding of systems with contacts
- BEAST was originally developed for rolling bearings, but can be used for any “contacting” machine element

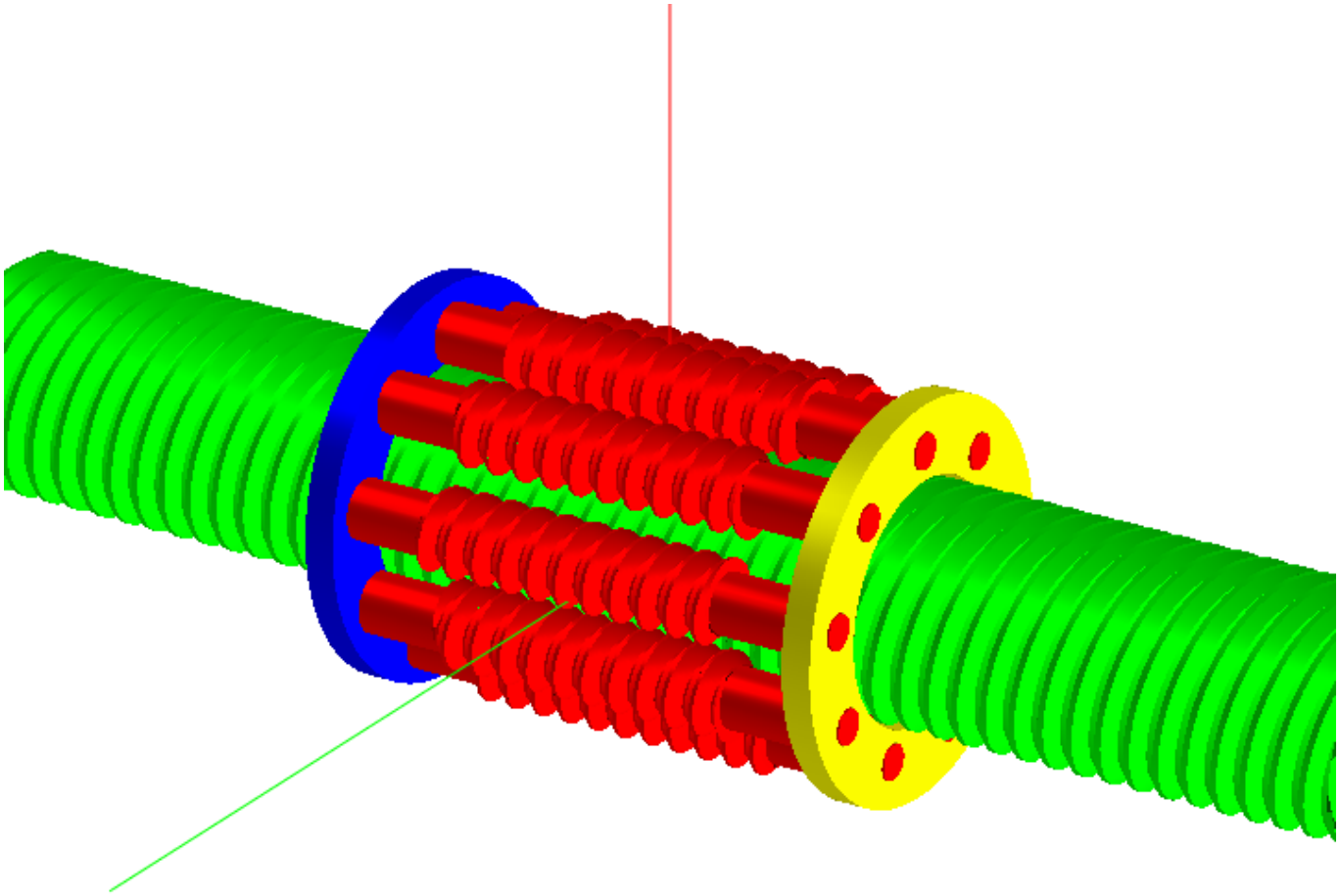
Main roller screw components - shaft



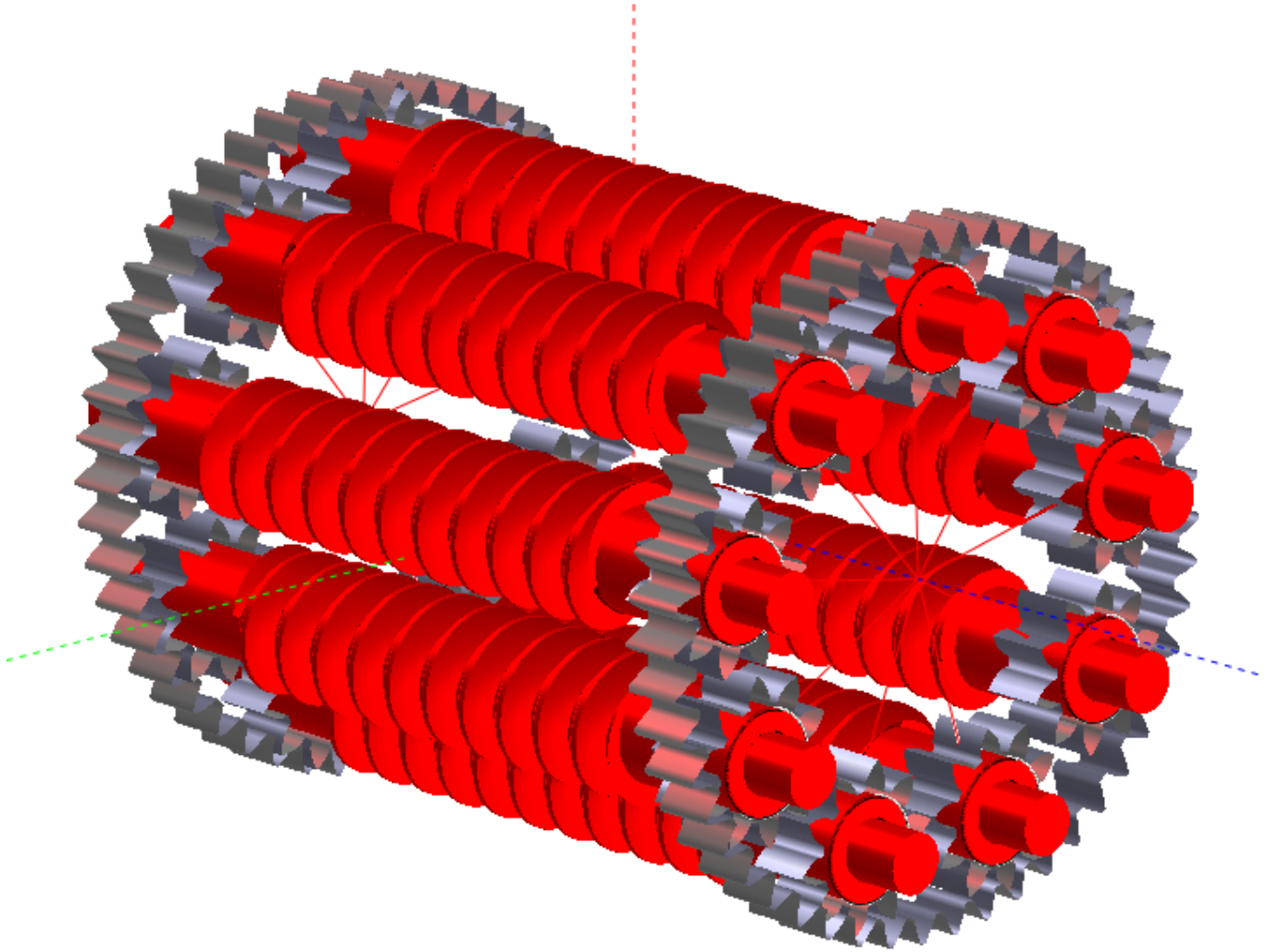
Main roller screw components - rollers



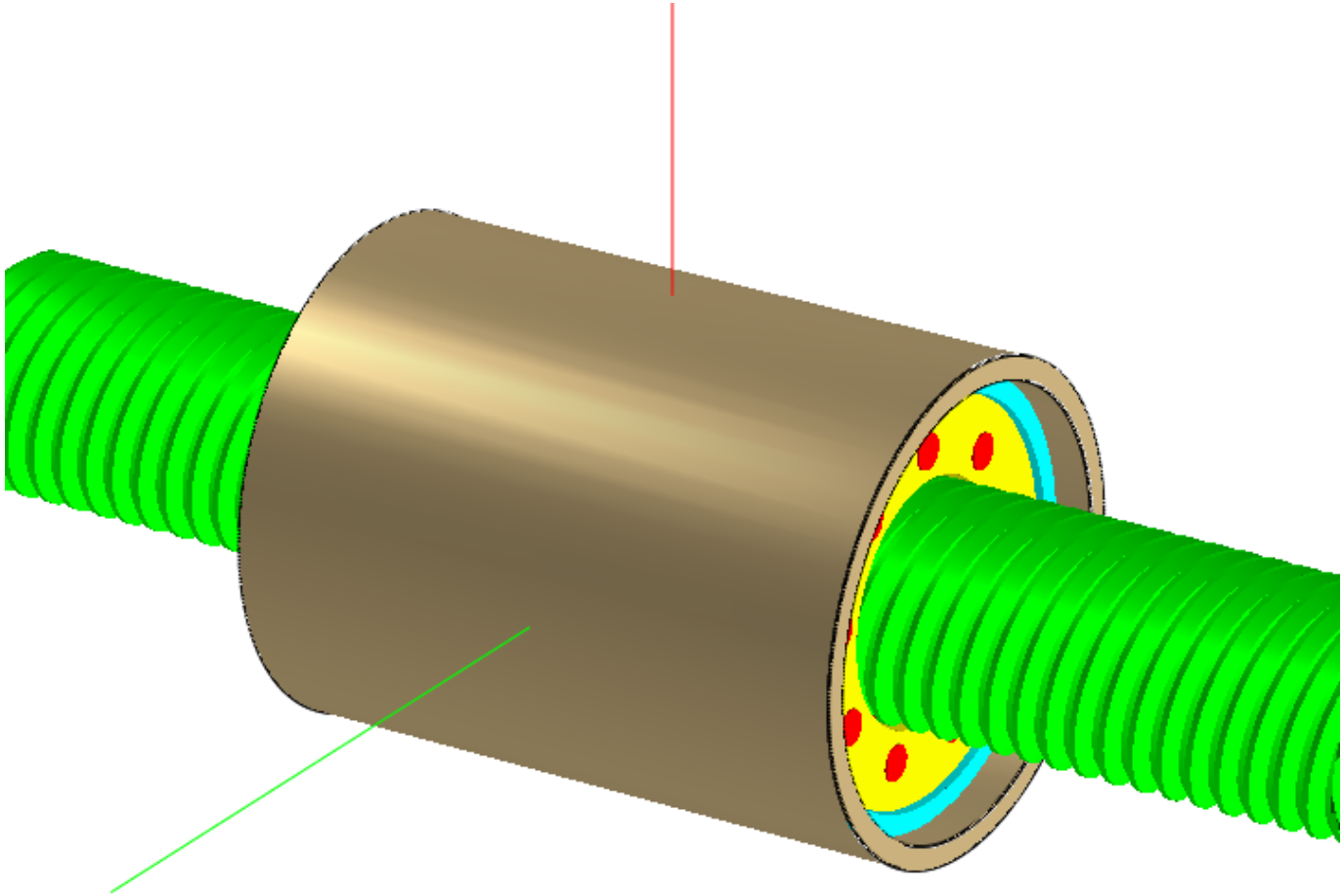
Main roller screw components – roller guides



Main roller screw components - gears



Main roller screw components - nut



Working mode of planetary roller screws

- Translates rotation to axial displacement.
- Rollers roll perfectly in the nut. This is ensured by the gear mesh.
- The load is distributed over a large number of contacts, giving high load capacity.
- Shaft and nut may have several thread starts, to give higher axial speed and maintain a large number of contacts.

Roller screw analysis in BEAST

- Contact conditions
  - Contact pressure
  - Load distribution
  - Sliding speed
  - Friction
  - Smearing
  - Wear
  - ...
- Global conditions
  - Efficiency
  - Stiffness
  - Thermal management
  - ...

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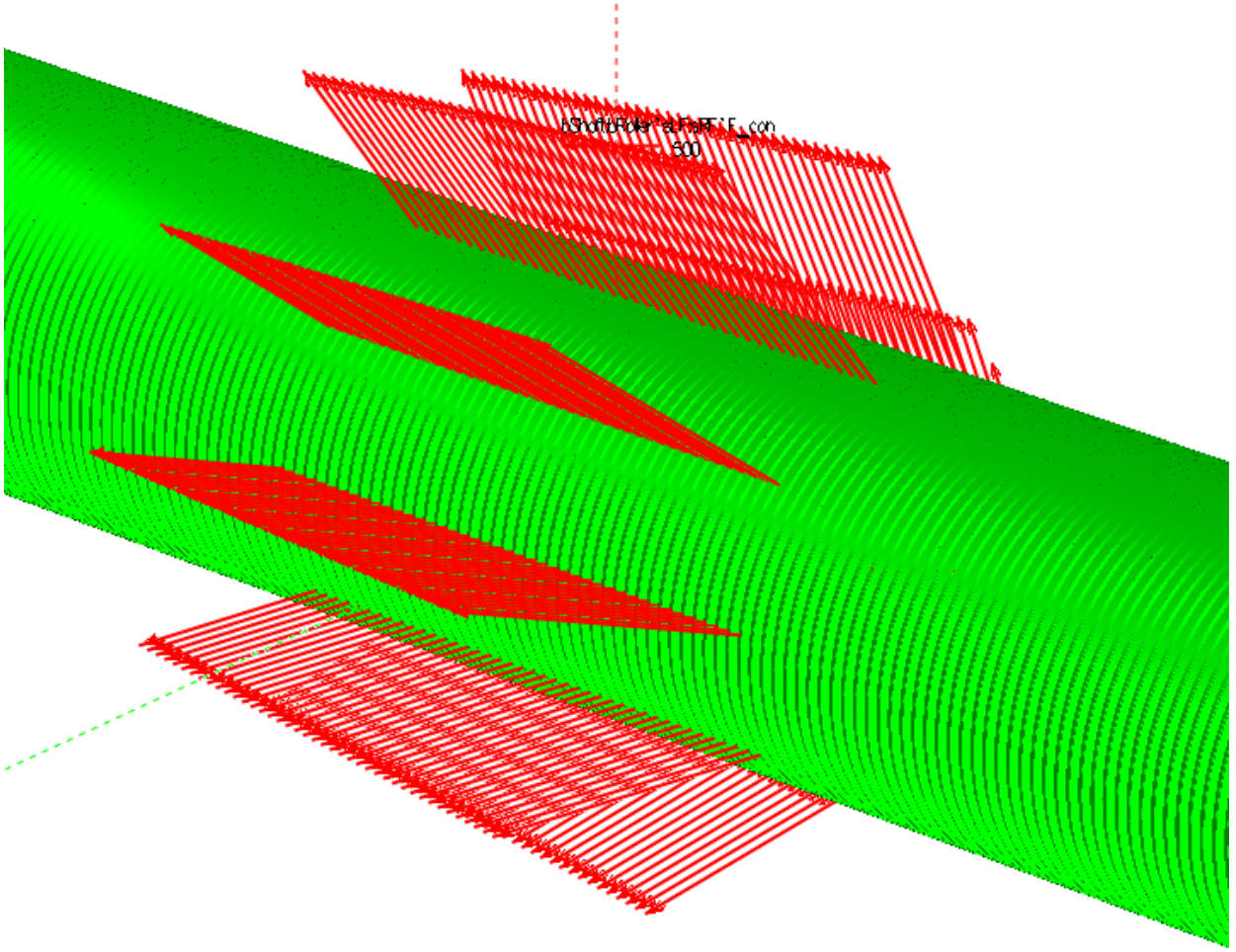
Some simulation results

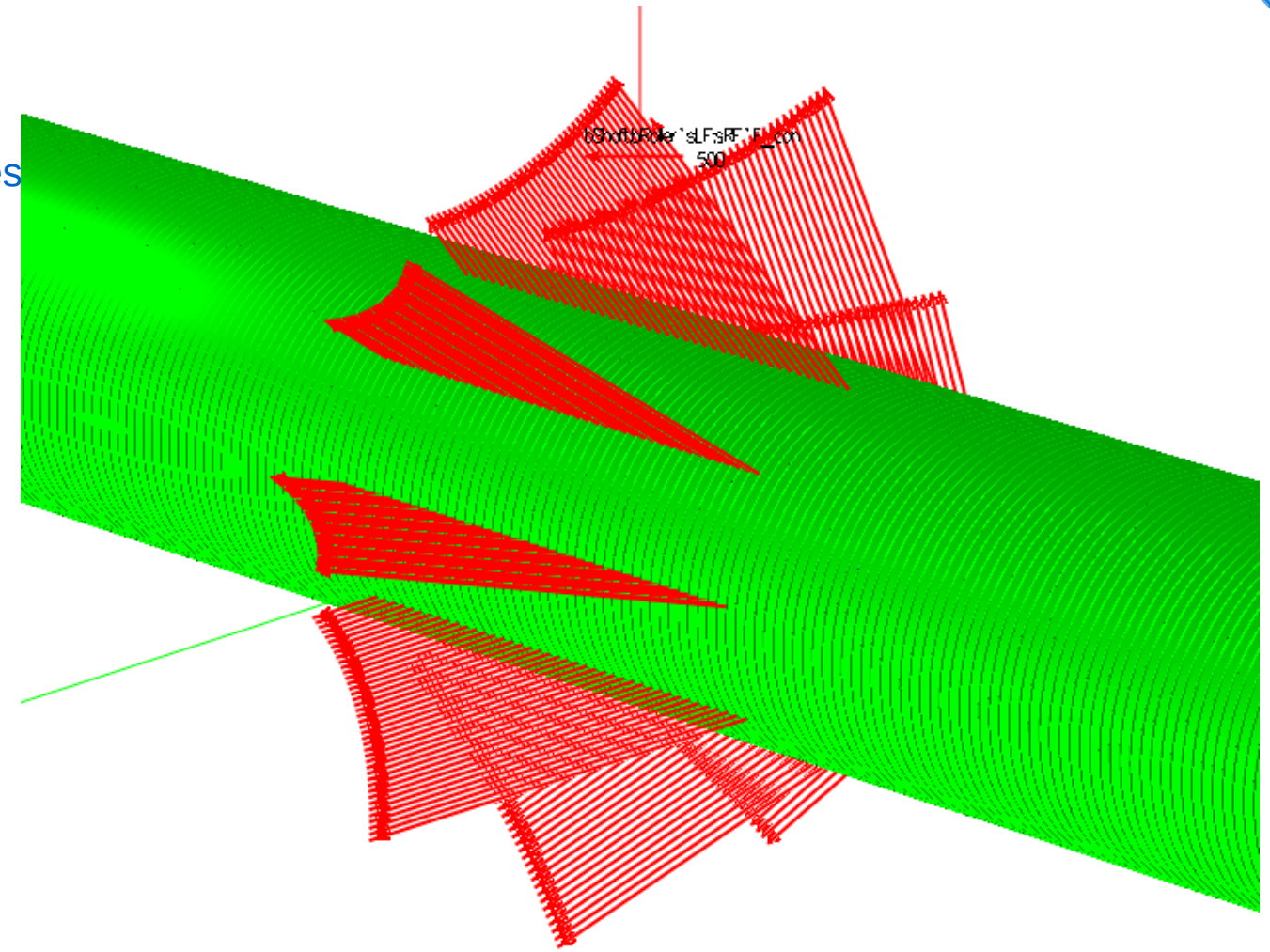
Roller – shaft contact force distribution

- Perfect geometry
- No clearance
- Structurally rigid bodies



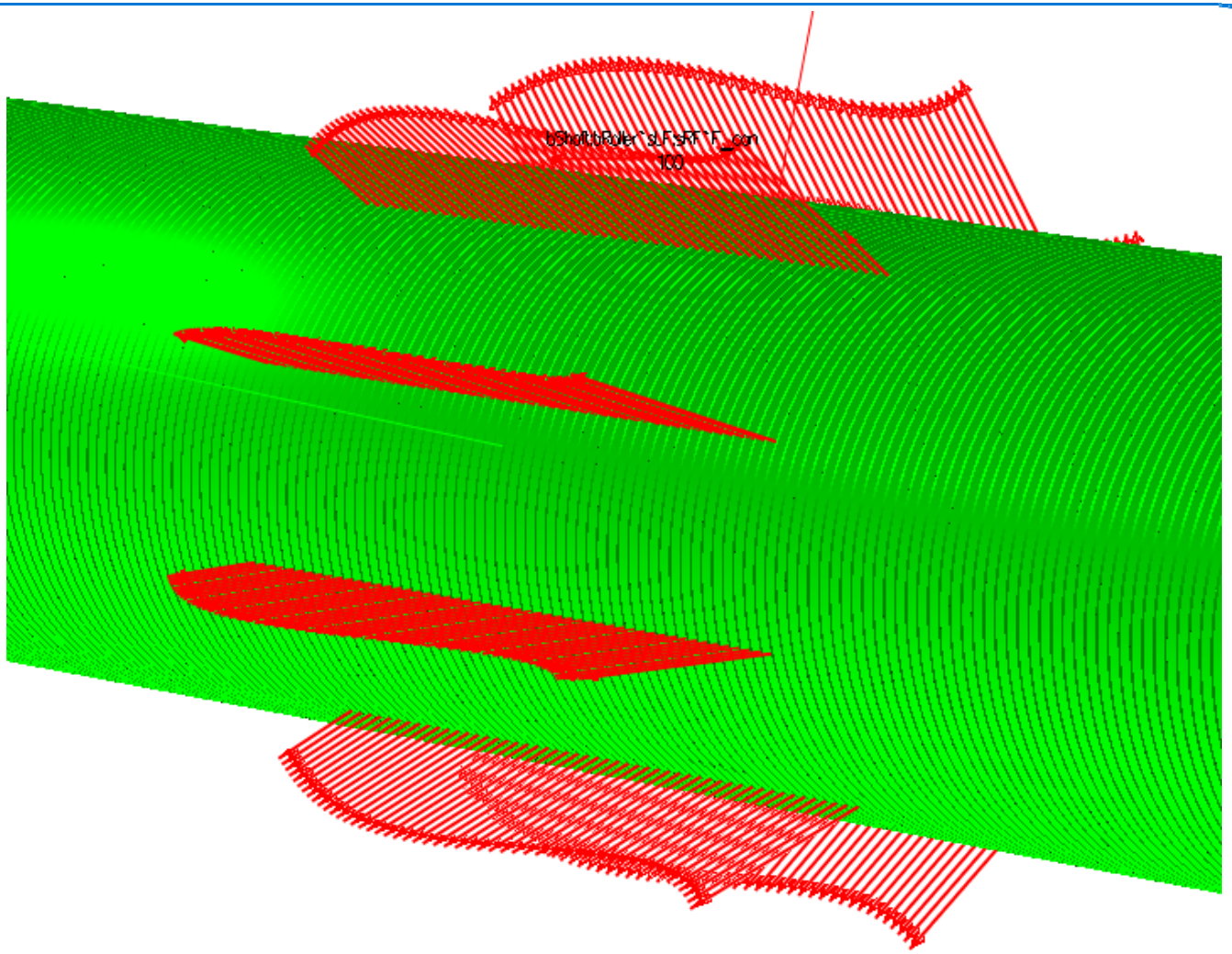
Roller – shaft contact force distribution

- Perfect geometry
- Clearance
- Structurally rigid bodies



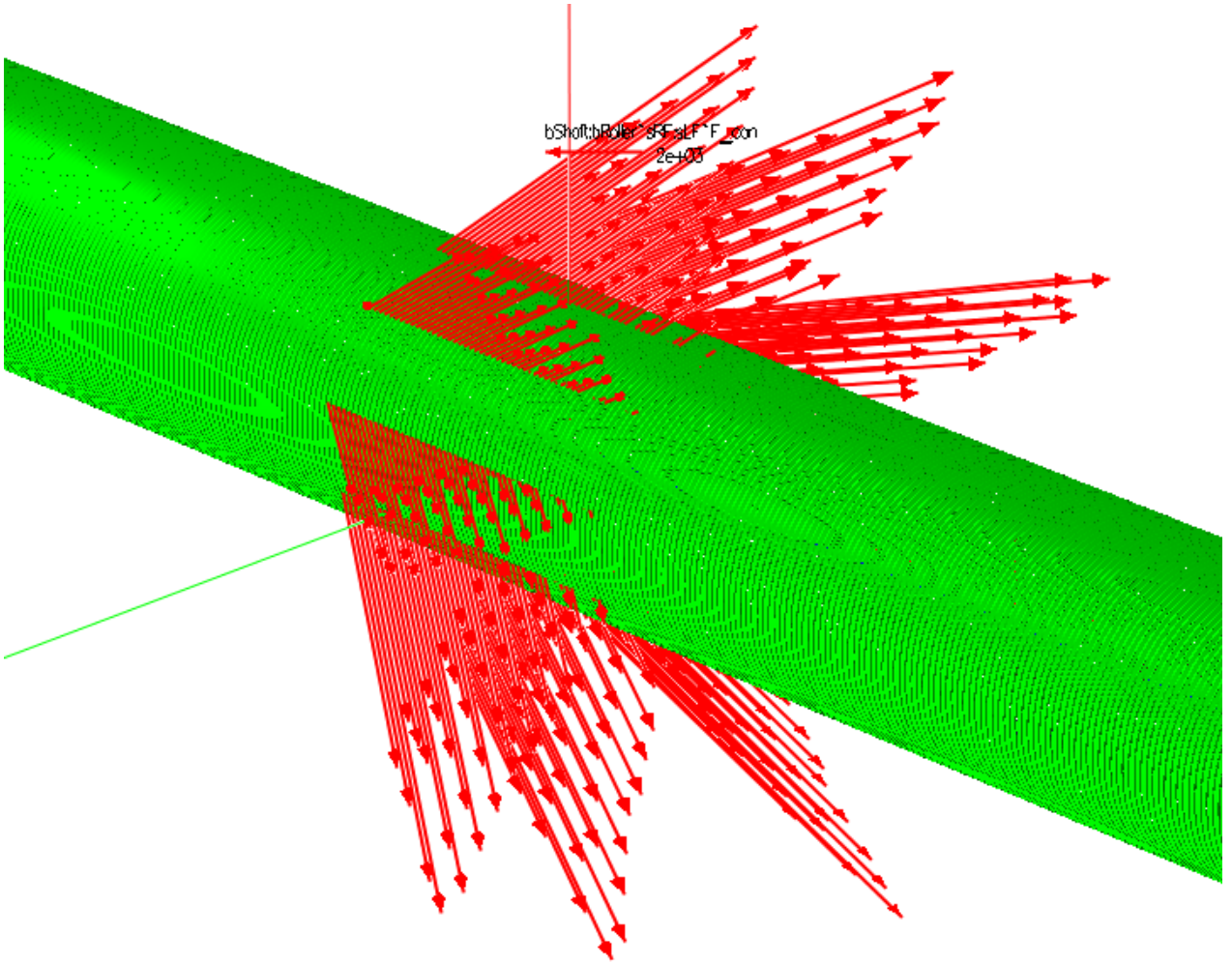
Roller – shaft contact force distribution

- Perfect geometry
- No clearance
- Elastic bodies

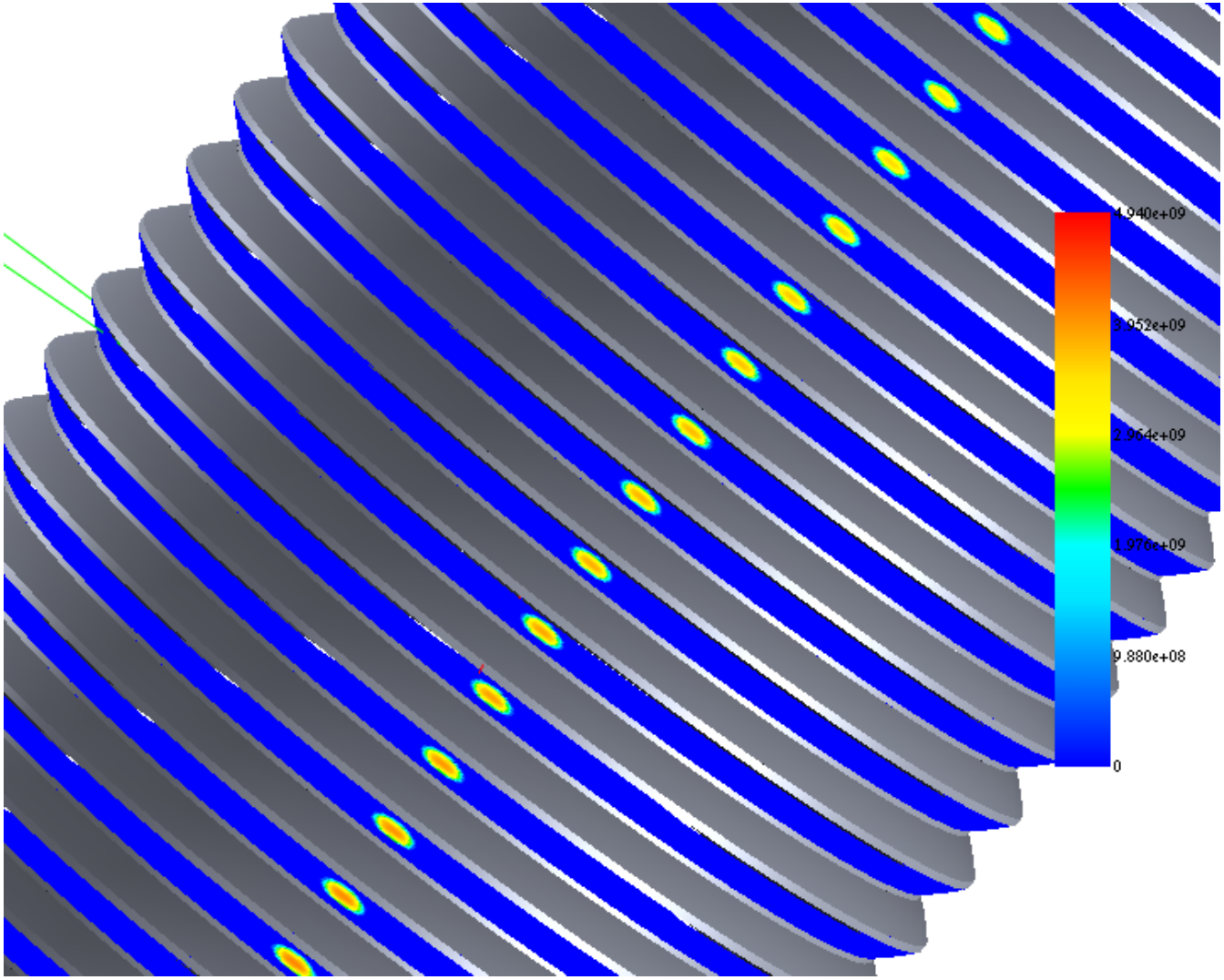


Roller – shaft contact force distribution

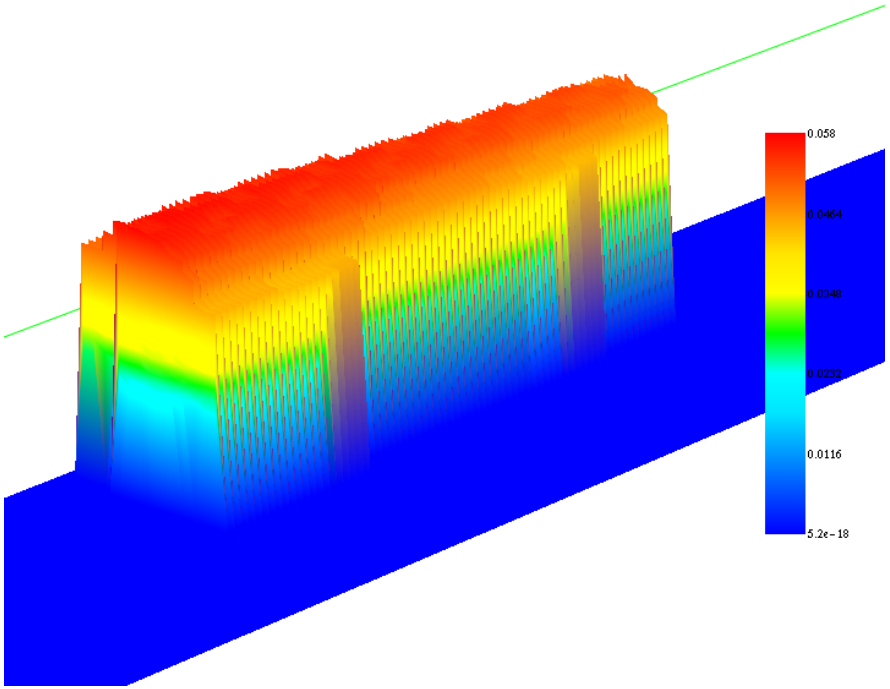
- Geometrical deviations
- Clearance
- Elastic bodies



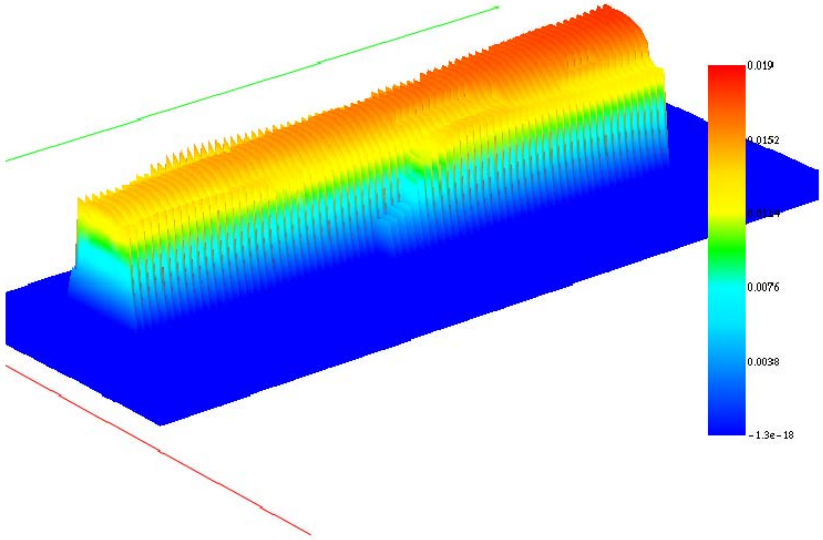
Roller – shaft contact pressure distributions



Roller – slip speed distributions



Roller - Shaft



Roller - Nut

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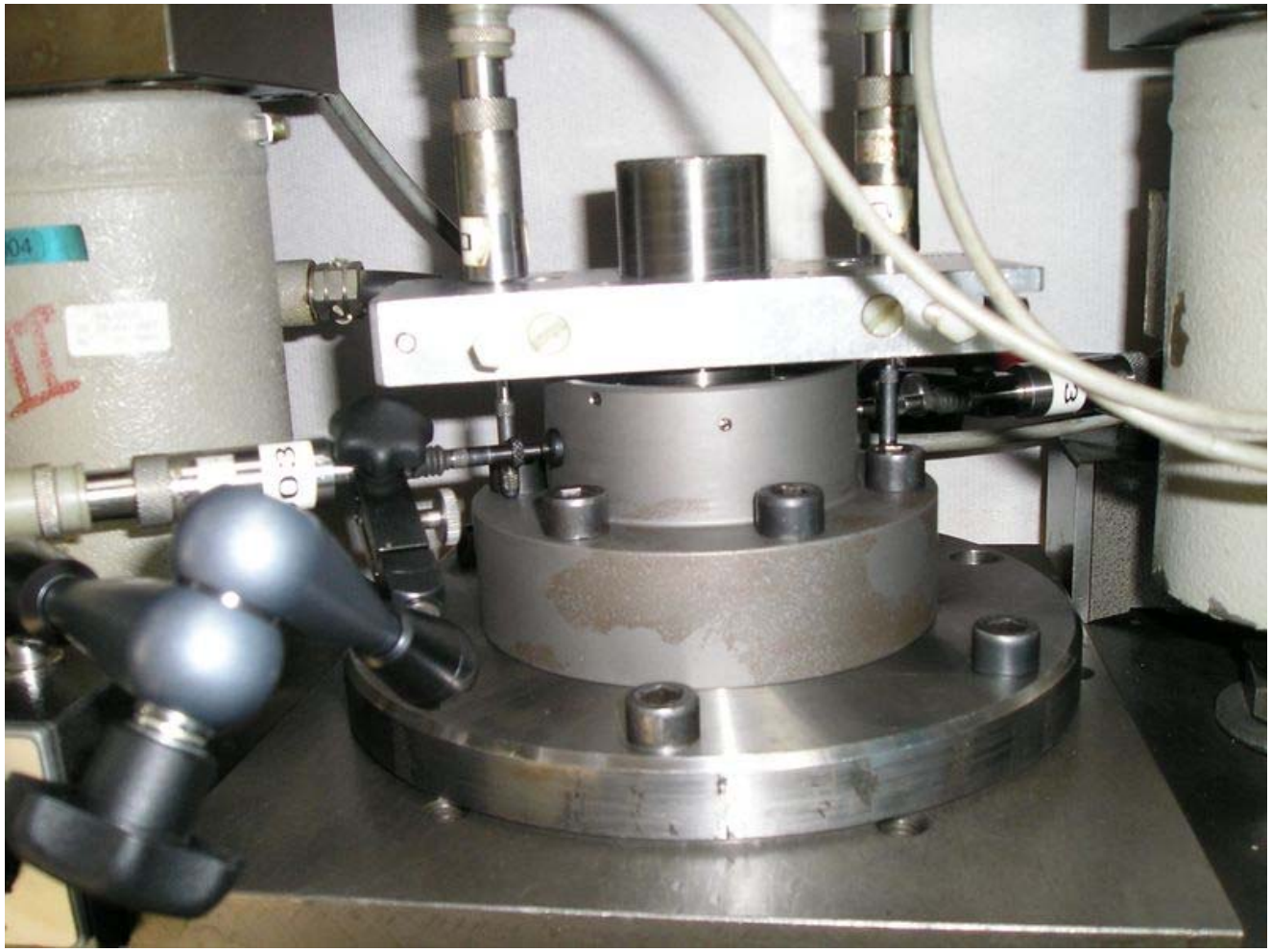
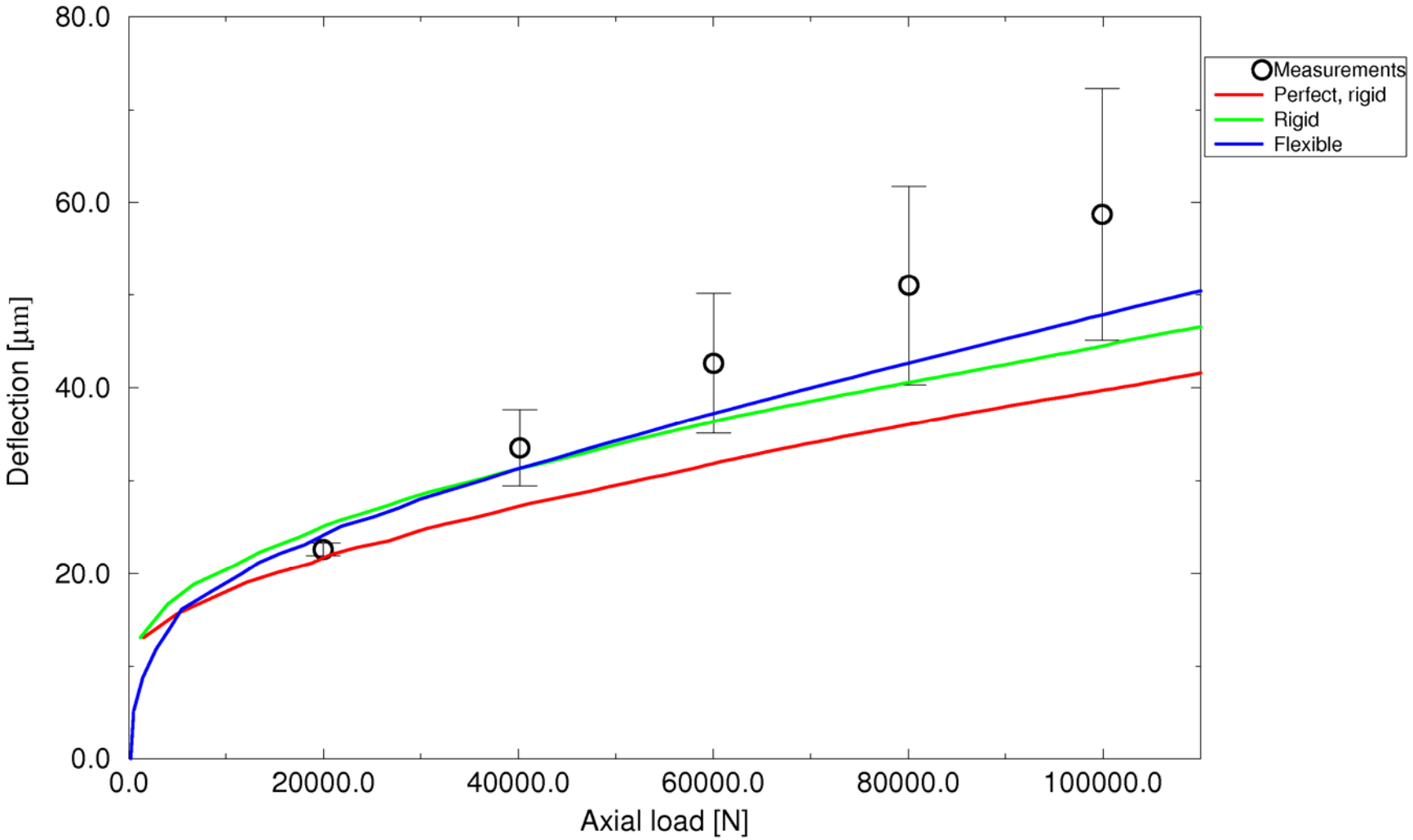
Verifications

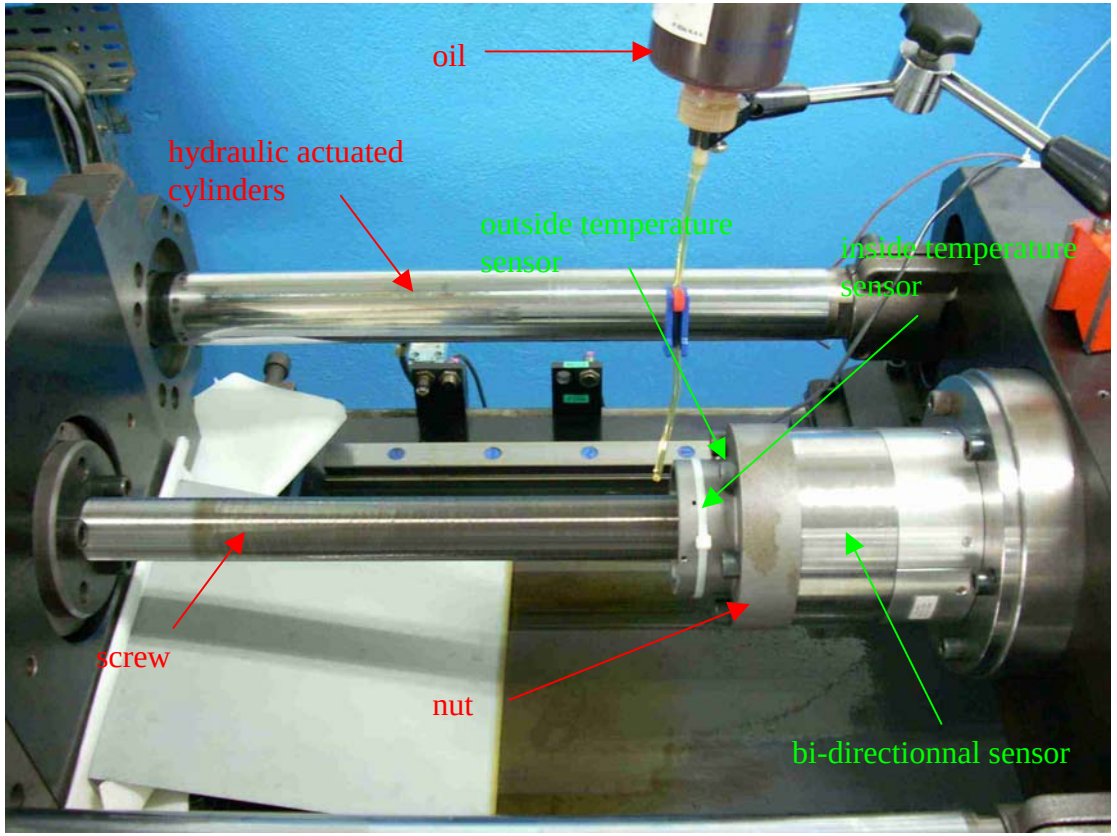
Stiffness



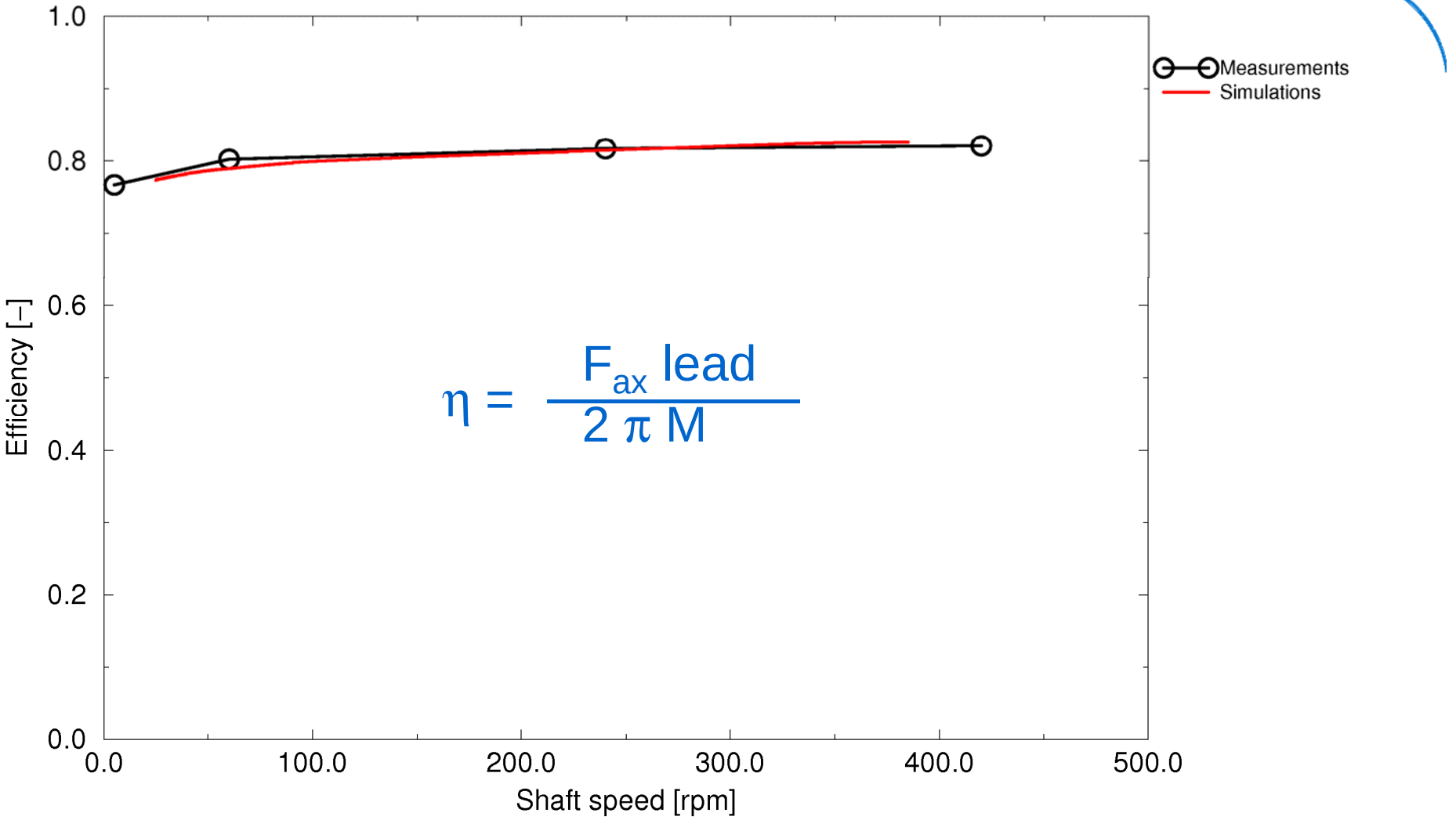
Stiffness


80.0
60.0
40.0
20.0
0.0
Deflection [µm]
0.0
20000.0
40000.0
60000.0
80000.0
100000.0
Axial load [N]
Measurements
Perfect, rigid
Rigid
Flexible

Efficiency


oil
hydraulic actuated cylinders
outside temperature sensor
inside temperature sensor
screw
nut
bi-directionnal sensor

Efficiency


1.0
0.8
0.6
0.4
0.2
0.0
Efficiency [–]
0.0
100.0
200.0
300.0
400.0
500.0
Shaft speed [rpm]
Measurements
Simulations
$\eta = \frac{F_{ax}\ lead}{2\ \pi\ M}$

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Summary

Summary

- Roller screw is a growing segment
- Roller screws are high performance, but complex machine elements
- Simulation models will:
  - help building product understanding
  - facilitate product optimization
  - provide a basis for right-sizing