FORGE®
SOLUTION FOR THE AEROSPACE INDUSTRY

MATERIAL FORMING SIMULATION
“FRISA started evaluating commercial FEA software in 2004 and finally landed on Forge in 2005. At that time our decision was mainly motivated by the fact that it was the only code on the market capable of performing non-isothermal ring rolling simulations in a stable manner and within a user friendly environment. Since then our interaction with Transvalor has grown into a long term collaborative relationship that has enabled us to tailor Forge to meet our engineering requirements and production challenges. We have also expanded the use of Forge to almost all processes involved in our operation: from ring rolling to heat treatment and grain size prediction.

Nowadays simulation plays a central role in our everyday engineering work and new product development would be unthinkable without it. During this time we have witnessed and tested the improvements made to Forge in terms of computation time, solution accuracy and ease of use and we are confident that future developments, rooted in research, will only increase the added value of our investment. Every year we are eager to learn what improvements the new version will bring.”

Omar Saldivar,
Product Engineer
FRISA FORJADOS - Santa Catarina - Mexico
We, at Transvalor, perfectly understand the challenges of supplying forged aerospace components. Since the beginning of the 1980s, FORGE® has been developed in partnerships with major European engine and aerospace component manufacturers.

In recent years, in addition to the standard material flow and forging flaws prediction, FORGE® has been used at the design and R&D level to predict in-use properties of the forged components.

**FORGE®**

is the solution to:

- Design best quality components
- Achieve in-use properties requirements
- Minimize real scale try-outs
- Extend die life
- Optimize and consolidate quotations
- Increase yield
Accuracy first

FORGE® is an advanced research and development analysis tool for high technology forged components.
Simulation result quality lies in the software’s capability to address a number of key topics.
FORGE® embeds a wide range of models for:

- part material behaviour: viscoplastic, elasto-viscoplastic, elasto-plastic
- friction laws: Coulomb, Tresca, viscoplastic, ...
- heat transfer coefficient laws: for various ambient media conditions and for various contact conditions with the dies. More complex models, for example with non-uniform HTC, are also available.
- damage criteria: Latham&Cockroft, Lemaître, Oyane, Shark skin, Rice Tracey...
- recrystallization laws in order to predict the microstructure evolution during the complete process. These laws are based on 3 models:
  - Dynamic recrystallization
  - Static/Post-dynamic recrystallization
  - Grain growth

Customer own models can also be defined as user subroutines and used with FORGE®.

- Unique multi-body capability within a single mesh.

Grain size distribution prediction in an INCONEL 718 aerospace disk. FORGE® predictions show a good correlation with experiment.

“The analysis carried out with FORGE® to model the evolution of defects in Aeroengine disk forging would not have yielded results this close to experimental values on many other metal forming software products. FORGE® has a unique multi-body approach to modeling such complicated phenomena which enhances the simulation capabilities of processes.”

Rajiv Shivpuri, Manufacturing Research Group
Ohio State University, Columbus OH USA
FORGE® includes an extensive material database specific to the aerospace industry (nickel based alloys, titanium alloys and stainless steel alloys). Also featured is a direct interface to SenteSoftware Ltd JMatPro and the possibility to integrate proprietary end-user tabulated data.

Recrystallization data for some superalloys and stainless steel alloys are also available within FORGE®.
All specific equipment kinematics are available within FORGE®:

- counter blow hammer with multi blows capabilities in a single simulation including waiting time
- screw press
- hydraulic press: isothermal forging and multi-speed presses
- equipment stiffness taken into consideration
- multi-directional moving dies
- ring rolling mill including feed control mandrel/feed control main roll and centering rolls.

*Simulation of a profiled ring with FORGE®*
Optimize equipment use and predict deflection

FORGE® provides accurate prediction of forging load, as well as stresses, strains, temperature, abrasive wear, ... in all the dies. This is achieved thanks to an embedded fully coupled part-dies analysis feature.

FORGE® also predicts press load and deflection at any time of the process.

![Deflection prediction at the beginning of finisher stage for a blade forged on a screw press](image1)

![Prediction of xyz forces of finisher stage for a blade forged on a screw press](image2)

*Interforge 65 000 ton hydraulic press © Aubert & Duval*
Unmatched remeshing technology

With no limitation on the number of nodes and elements and with stable remeshing.

Volume conservation is guaranteed. Multimaterial capability is available with the use of a unique mesh.

Solving, remeshing and mapping between prior and subsequent meshes are done in parallel.

Final mesh of Titanium alloy fan blade consisting of 1,030,000 elements
HPC

High Performance Computing

Market leader in parallel computation and numerical techniques to reduce computation time

Pioneer in parallel computation, FORGE® offers the highest scalability allowing more accurate results within very short computation time.

FORGE® runs on various Windows and Linux platforms, from standard workstations to multi-core High Performance Computing clusters.

Computation time versus number of computer cores for the ring rolling simulation of a super alloy aerospace part with recrystallization calculation.

Prediction of grain size during the ring rolling simulation of a nickel-based aerospace part
FORGE® is the expert simulation tool to design high quality components

FORGE® provides high accuracy prediction of temperature, strain, strain rates, stresses as well as many other fields.

Fully coupled thermal computation or mechanical/thermal computation between component and dies is possible offering the highest result accuracy.

Temperature distribution in the dies during the simulation of an Inconel 718 disk forging
Design and validate the complete forging sequence, save on material costs by reducing physical tryouts with FORGE® comprehensive simulation capabilities

FORGE® makes it fast and easy to predict accurately the final shaped and any forming flaws like underfillings or folds/laps. FORGE® also embeds cutting edge features like backward and forward tracking of points or surfaces, multi-body calculation for specific aerospace defect tracking.

With FORGE® get it right the first time, reduce cost and increase profits.
FORGE® provides the highest flexibility with unlimited access to the Graphical User Interface for 64-bit pre and post processing. License fees are related to the number of computer cores regardless of the number of users. Extra flexibility benefits are:

- Job scheduling
- 2D and 3D automatic transitions between stages
- Dynamic token allocation across multiple and remote sites (Floating License)
- Solver support for up to 64 cores in parallel (one simulation can be executed on 64 cores concurrently)
- Token borrowing

All processes and all features mentioned in this brochure are available in the FORGE® software with no additional cost.
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Transvalor, leading Software Editor of Material Forming Numerical Simulation

Transvalor has developed an extensive suite of high performance simulation software that addresses a wide range and variety of forming processes, for metallic solid and liquid materials as well as for polymers:

FORGE® for extensive hot, warm and cold metal forming,
COLDFORM® for cold metal forming
THERCAST® for ingot casting and continuous casting,
Rem3D® for plastic injection & composites molding.

Transvalor products provide the manufacturing and engineering intelligence to a wide range of industries Automotive, Aerospace, Energy, Medical, Oil and Gas and many others.

Transvalor success comes from a comprehensive expertise of the forming processes and an unyielding capability to innovate. The value of Transvalor Material Forming Simulation Solutions can also be measured in business terms as they dramatically reduce production costs, shorten time to market and accelerate the delivery of innovative products.

As such we help our customers

• Gain a deeper and broader understanding of their material behavior as well as their processes,
• Optimize and shorten their design process by almost eliminating the slow and painful “trials and errors” in the shop-floor,
• Increase manufacturing quality.

Transvalor is born of Research and has maintained a strong association with the Center for Material Forming (CEMEF), a research center of prestigious MINES ParisTech, whose main activities are centered on material forming and numerical computation.

This partnership provides a constant flow of advanced scientific developments that translate into innovative new functionalities to Transvalor’s products for the benefit of our customers.

Besides its headquarter located in France, Transvalor has a worldwide presence with a comprehensive network of distributors, offices and subsidiaries for both marketing and support activities.

TRANSVALAR S.A.
Parc de Haute Technologie
694, avenue du Dr. Maurice Donat
06255 Mougins Cedex - France
Phone: +33 (0)4 92 92 42 00
Fax: +33 (0)4 92 92 42 01
Email: marketing@transvalor.com

ISO 9001
BUREAU VERITAS Certification

Transvalor has been certified ISO 9001: 2008 by the Bureau Veritas Quality International (BVQI) for the development, industrialisation and licensing of computed-aided engineering software and related services. This certification shows the will of Transvalor to progress and to answer better its customers’ expectations.