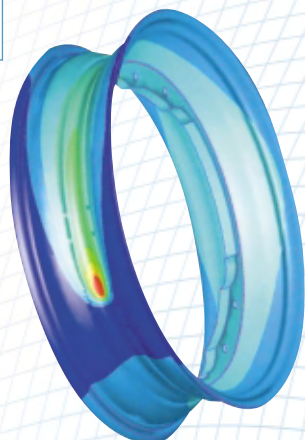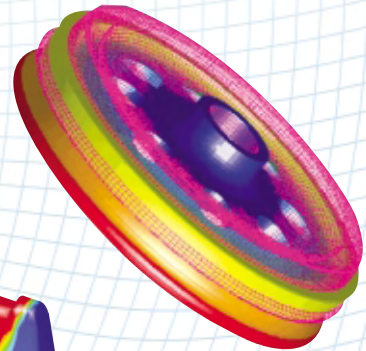ESI GROUP
THE VIRTUAL TRY-OUT SPACE® COMPANY
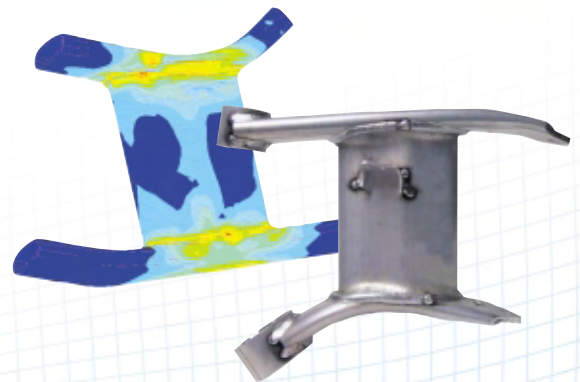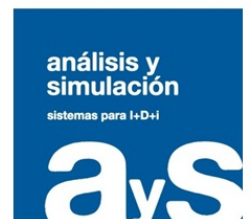
SYSWELD

Engineering Simulation Solution for Heat Treatment, Welding and Welding Assembly

Distribuidor oficial

análisis y simulación
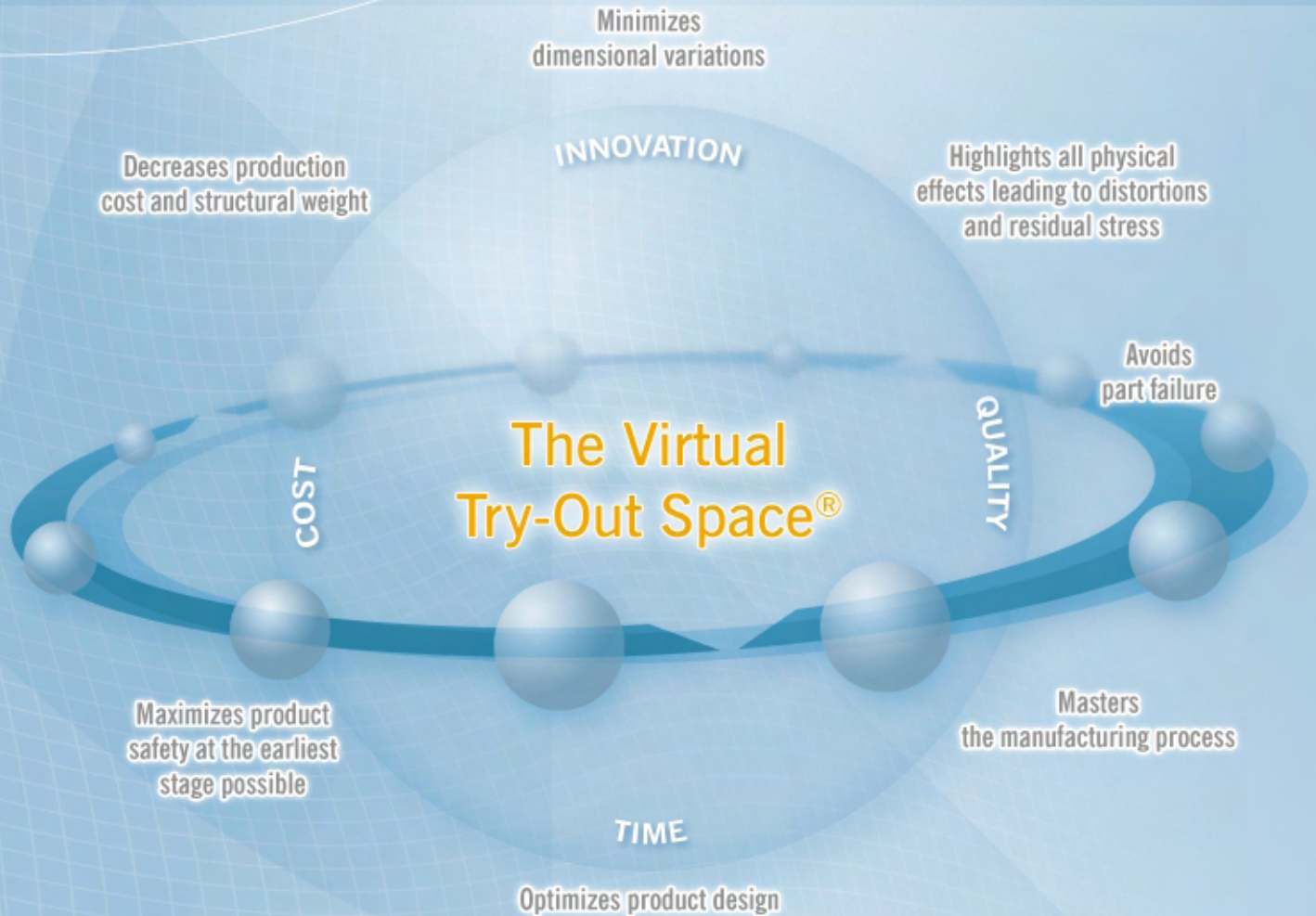sistemas para I+D+i

ays
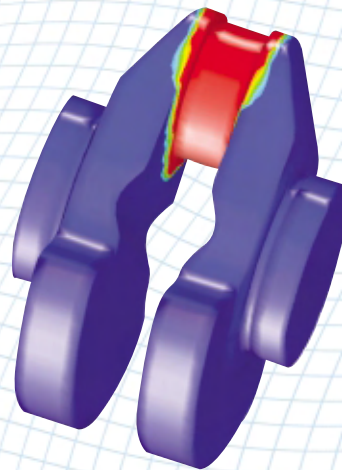
Tel 902 105 496
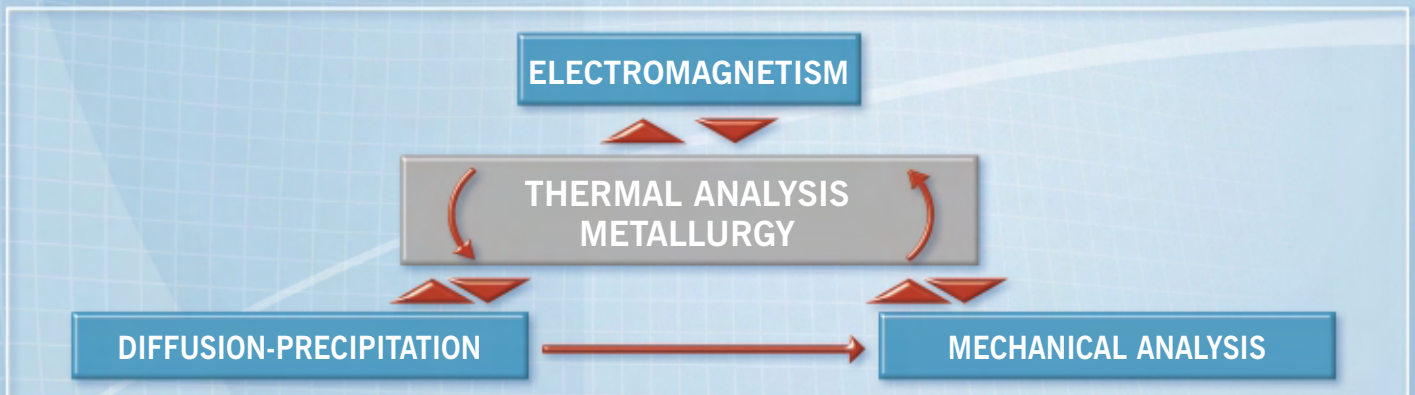ays@analisisysimulacion.com
www.analisisysimulacion.com

SYSWELD in the Virtual Try-Out Space

Simulation is the best approach to master design, manufacturing process and in-service problems at the earliest product stage possible.

Resulting from more than 20 years of development, SYSWELD is the leading tool for the simulation of heat treatment, welding and welding assembly processes, taking into account all aspects of material behavior, design and process.

Minimizes
dimensional variations

INNOVATION

Decreases production
cost and structural weight

Highlights all physical
effects leading to distortions
and residual stress

Avoids
part failure

COST

QUALITY

The Virtual
Try-Out Space®

Maximizes product
safety at the earliest
stage possible

Masters
the manufacturing process

TIME

Optimizes product design

"Looking behind the complex physics embedded in Heat Treatment, Welding and Welding Assembly"

ELECTROMAGNETISM

**THERMAL ANALYSIS
METALLURGY**

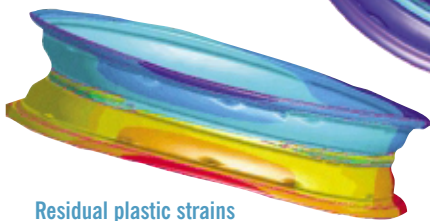**DIFFUSION-PRECIPITATION**   →   **MECHANICAL ANALYSIS**
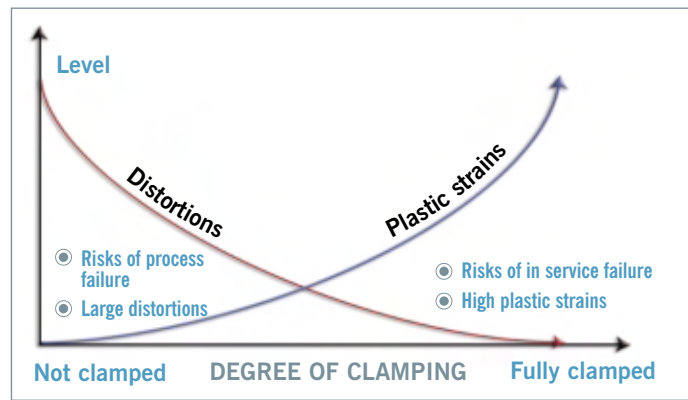
SYSWELD Meets Industrial Needs

Welding

Key success factors in the welding industry focus on eliminating as much as possible the distortions of structural assemblies and component repair, as well as addressing durability problems related to welding processes. Engineers involved in welding try to find the optimum between distortions, residual stresses and plastic strains by fully optimizing the process type and the process parameters, bringing understanding of their influence of the part shape and the resultant material behavior.

Low distortions due to a specific part clamping

Residual plastic strains

Finding out the process window:
Where is the optimum ?

- Risks of process failure
- Large distortions
- Risks of in service failure
- High plastic strains

Not clamped   DEGREE OF CLAMPING   Fully clamped

SYSWELD is a powerful tool that guides engineers to find out the optimum process parameters with respect to distortions, residual stresses and plastic strains.

Taking into account the typical engineering questions

- Is the manufacturing process feasible ?
- How long will the part last ?
- Which tolerances have to be achieved ?
- How can design flaws be avoided ?

Heat Treatment

Heat treatment is an indispensable step in the manufacturing of metallic products, especially in the automotive industry and in aerospace engineering. Critical success factors in the heat treatment market focus on safe processes, minimizing part distortions and improving durability. Engineers involved in heat treatment are looking for:

- Process feasibility,
- A minimum amount of distortions,
- A high resistance of contacting surfaces against wear,
- A specific microstructure fitting to the in-service purpose,
- A dedicated distribution of residual stresses.

By deliberate manipulation of the chemical and metallurgical structure of a component, mechanical properties such as hardness, yield stress and tensile stress are selectively controlled.

Distortions can be minimized and forming of cracks can be detected and avoided.

Distortions of a crankshaft after quenching
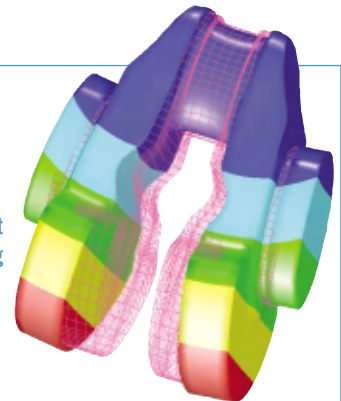
Compressive stresses on the rolling surface of a train wheel

SYSWELD enables the coupled modeling of complex physical phenomena such as electromagnetism, heat transfer, diffusion and precipitations of chemical elements, phase transformations and mechanics.

SYSWELD, the Driving Force for Welding Simulation Technology, from Process...

Temperature field

Material transformations

Distortions

Residual yield stress distribution

Residual plastic strains

Stresses due to welding and in-service loading

Continuous welding of a motorcycle rim

SYSWELD, the complete solution for handling virtual welding

SYSWELD guides engineers to:

◉ **Evaluate residual distortions**

Assembling a structure requires sequential continuous and/or spot welding joints. Therefore, defining the welding sequence and the places where the parts will be welded is crucial for the correct completion of the welding assembly process. Simulation allows prediction and minimization of distortions which generate an increase of the overall product quality as well as drastic cost saving.

◉ **Minimize residual stresses**

Simulating the welding process aims to control the process in a way that minimizes the stress gradient and tensile surface stresses. As a result, lifetime of a part increases as fewer cracks appear after load cycles. Compressive stresses can also be detected on the surface of the component, therefore improving part quality and avoiding corrosion risks due to tensile stresses.

◉ **Study the sensitivity of geometry, material and process parameters**

Used in the design phases, SYSWELD decreases costly design errors. At each step of the development cycle, the cost of corrections gradually increases. SYSWELD helps to optimize part geometry, materials and process parameters during the early stages of a new design cycle avoiding expensive engineering changes that could occur later.

◉ **Optimize the welding process**

SYSWELD allows user-defined weld sequencing and control of the weld manufacturing parameters such as velocity, energy input and many others.

SYSWELD answers engineers' questions

Empowered by the Advisor technology, an automatic solver, and a multi-physics post-processor, SYSWELD takes into account multiple factors such as:

◉ *Process parameters,*
◉ *Part geometry,*
◉ *Thermal, metallurgical and mechanical material behavior.*

SYSWELD features a comprehensive material database that covers the major steels and aluminum alloys in the market.

SYSWELD simulates all major Welding processes

◉ **Continuous welding**
  - Laser,
  - MIG,
  - Electron-beam,
  - ...

"The challenge in the nuclear industry is to increase the life span of components. Welding repairs are categorized using SYSWELD on many different kinds of defects."

◉ **Resistance and Spot welding**

"Spot welding is very common in the automobile industry. With the coupling between electromagnetism, heat transfer, metallurgy and mechanics, this process is accurately simulated with SYSWELD."
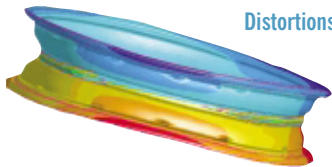
... to Application

AUTOMOTIVE INDUSTRY
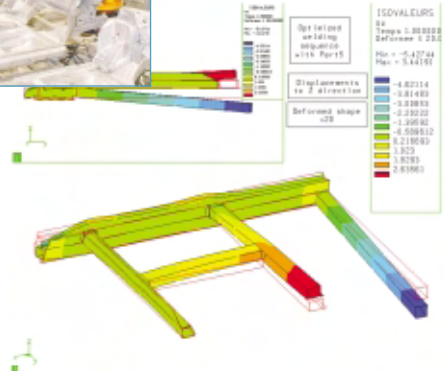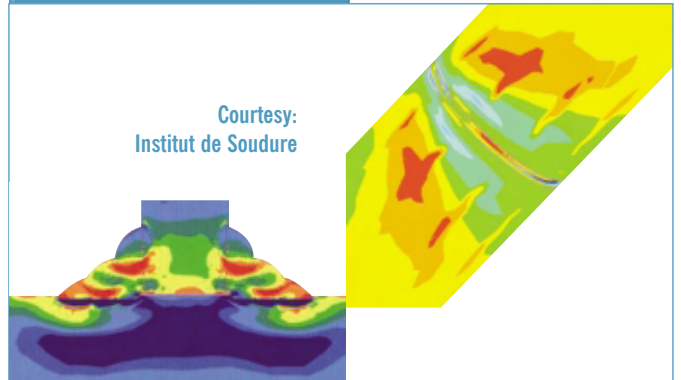### Welded Assemblies
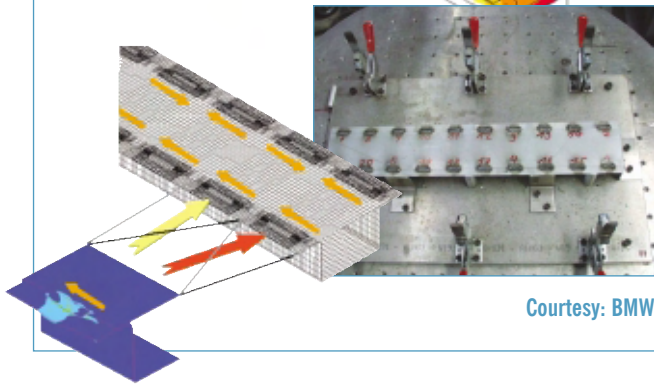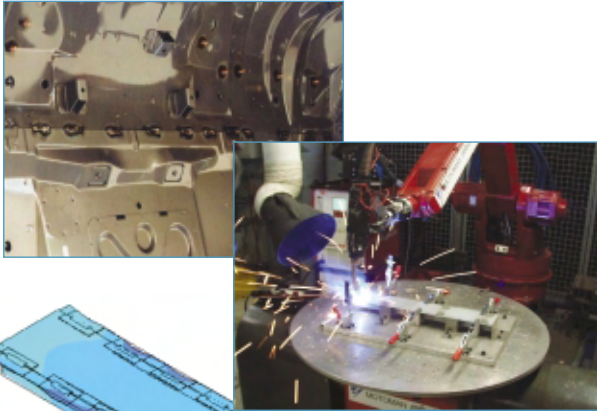
Courtesy: BMW

Space Frame Welding

Courtesy: Audi

HEAVY INDUSTRY
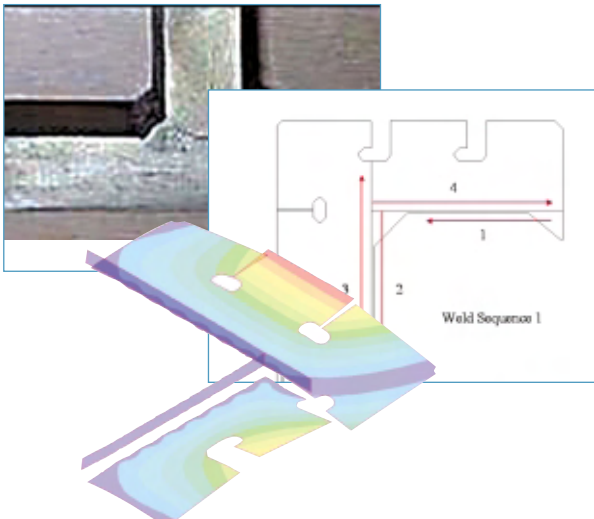### Multilayer Welding

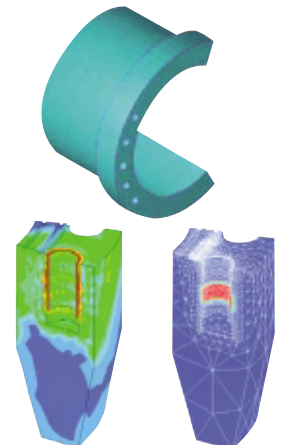Courtesy:
Institut de Soudure

SHIPBUILDING INDUSTRY
Welded Assemblies

Weld Sequence 1

NUCLEAR INDUSTRY
Weld Repair
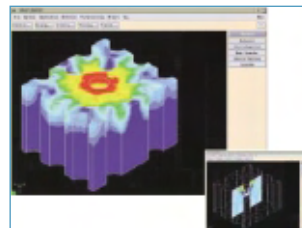
Courtesy: Vitkovize

SYSWELD

SYSWELD/GEOMESH CAD DATA IMPORT/EXPORT

SYSWELD/GEOMESH provides graphical modeling capabilities for manipulating FE meshes. Native CAD data is imported, automatically cleaned and prepared for FEM analysis.
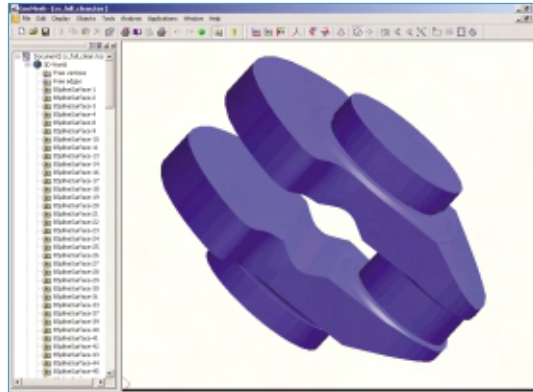
Meshing capabilities and group concept

SYSWELD/GEOMESH provides engineers with powerful algorithms for the generation of FE models. Patch independent surface meshes and fully automatic volume meshing (hexahedrons, tetrahedrons) is available for welding and heat treatment analysis. The group concept allows simple and complete interfacing to any existing meshing tool, and so the definition phase of the numerical problem is extremely short and simple.

Native CAD model of a crankshaft

Comprehensive Material database

SYSWELD features a comprehensive material database. The thermal, mechanical and metallurgical material properties are quite complex and depend on temperature and phases. Included are major steels, aluminum alloys and gray iron.

Cost-effective, SY... from an easy han... friendly set of too... engineers with lim... in FEM technolog... optimize heat trea... and welding asse... Compared to a tri... approach, SYSWE... solution to reduce... time. Therefore it... drastic minimizat... prototypes, leadin... a high return on i...

Hexahedral mesh of a crankshaft. ... dedicated to heat treatment analy... the thickness.

SYSWELD advisors working the engineering way

The advisor technology radically reduces the time needed to set up computations for heat treatment, welding and welding assembly simulations. SYSWELD offers a fully intuitive process-driven methodology to set up simulations through three types of advisor:

- Heat treatment advisor,
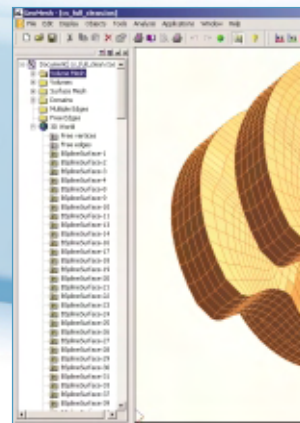- Welding advisor,
- Assembly advisor.

in Action

SWELD benefits

ds-on and user-

ls. It enables

nited knowledge

y to control and

atment, welding

mbly processes.

al-and-error

ELD is the key

e cost and lead

generates a

ion of physical

g to

nvestment.

Heat transfer coefficient wizard

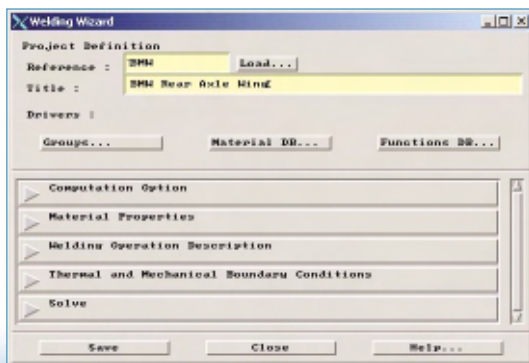**Compressive stresses displayed on the distorted structure**

The layered mesh generator is sis from the surface and through

Straightforward and simple workflow, from the definition of the project to the start of the computation

Multiphysics Post-Processor

The multiphysics post-processing capabilities provide instantaneous process information for the evolution of:

◉ Temperature field,
◉ Heating and cooling rates,
◉ Metallurgical structure of the material,

◉ Distortions,
◉ Stresses,
◉ Yield stress of the modified material,
◉ Plastic strains.

Result analysis

SYSWELD provides a variety of techniques for reviewing process results including:

◉ Contour plots,
◉ Iso-lines and Iso-surfaces
◉ Vector-Display,
◉ x-y diagrams,

◉ Symbol plots,
◉ Numerical representation,
◉ Cutting planes,
◉ Animations.

Automatic solver

The SYSWELD solver provides an automatic solution for welding and heat treatment problems, covering all related complex mathematics and material physics. Depending on temperature, phases and proportion of chemical elements, thermal and mechanical properties are computed including phase transformations enthalpy, melting and solidification of material, large strains, plasticity and transformation plasticity.

Graphical user interface: efficiency, flexibility

The interface comprises engineering tools to adjust all necessary process parameters and a straightforward and simple workflow, as part of the heat treatment, welding and assembly advisors.

SYSWELD, the Driving force for Heat Treatment Simulation Technology, from Process...

Temperature field

Phase transformations

Distortions

Residual yield stress distribution

Residual plastic strains

Residual compressive stresses

Through hardening of a train wheel

SYSWELD, the complete solution for handling heat treatment technology

SYSWELD performs simulations taking into account all physical phenomena involved in the heat treatment process. It provides extended databases for materials – phases and temperature dependent - and quenching media. The numerical methods implemented are highly optimized for the computation of heat treatment processes.

Specific technical capabilities are provided for the Finite Element modeling of the heat treated structure. The requested high quality in computed results requires a refined layered mesh from the surface through a few millimeters of thickness of the part. For 2 dimensional structures, a guided layered mesh generator is available. For 3 dimensional structures, a fully automatic layered hexahedral mesh generator is accessible for solid parts of any complexity. As a result, SYSWELD drastically reduces the time to mesh parts while offering high quality Finite Element models.

SYSWELD answers engineers' questions

From the start of the software to the start of the computation it usually takes 30 minutes or less, including Finite Element modeling. Even 3D computations of distortions and residual stresses are performed in less then one day. As a consequence, answers are provided more efficiently to the basic questions from heat treaters and designers:

◉ Is the selected heat treatment process feasible ?
◉ Is the selected steel feasible ?
◉ Is the selected quenching media suitable ?
◉ Is the process window safe against process tolerances ?
◉ Is the part hard where it should be hard ?
◉ Is there any crack risk occurring during the process ?
◉ Are the obtained distortions acceptable ?
◉ Are the residual compressive stresses high enough and well positioned ?

The heat treatment product solution is especially suited for heat treatment job shops, which need to ensure the feasibility of a heat treatment process within one day.
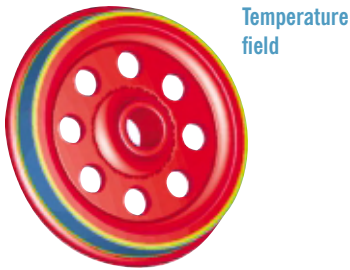
SYSWELD simulates all major heat treatment processes

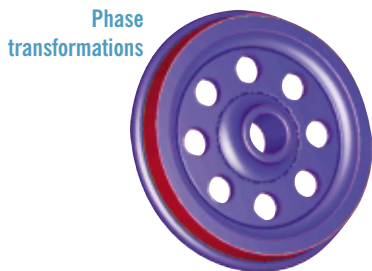*SYSWELD computes and optimizes all basic steps of the heat treatment process:*

◉ Austenitization for surface hardening
◉ Austenitization for through hardening
◉ Quenching, austempering, martempering and tempering

SYSWELD simulates the following processes:

◉ Surface hardening
   • Induction   • Laser
   • Electron beam   • ...
◉ Through hardening
   • Direct   • Austempering
   • Martempering   • ...
◉ Thermo-chemical heat treatment
   • Carburizing   • Nitriding
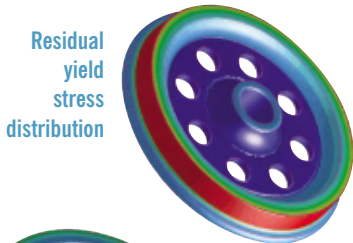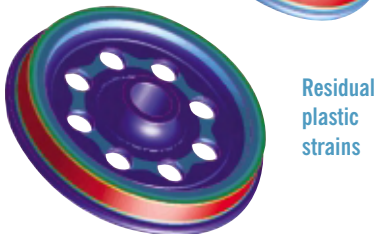   • Carbonitriding   • ...
◉ Tempering
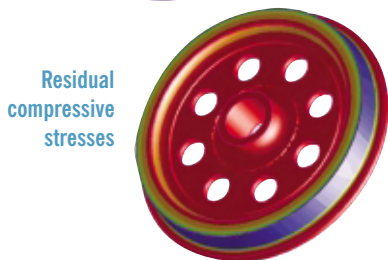
Typical CCT diagram
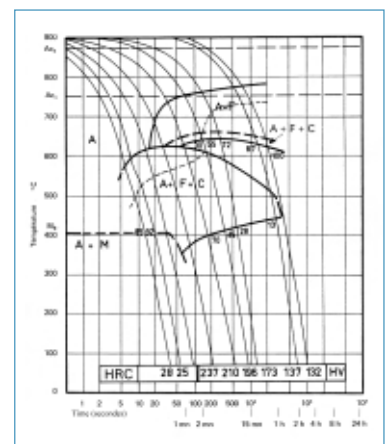
... to Application

Case hardening of gears

Comparison of gear distortions
with various carbon enrichments

Low and high carbon content

Courtesy: Ford
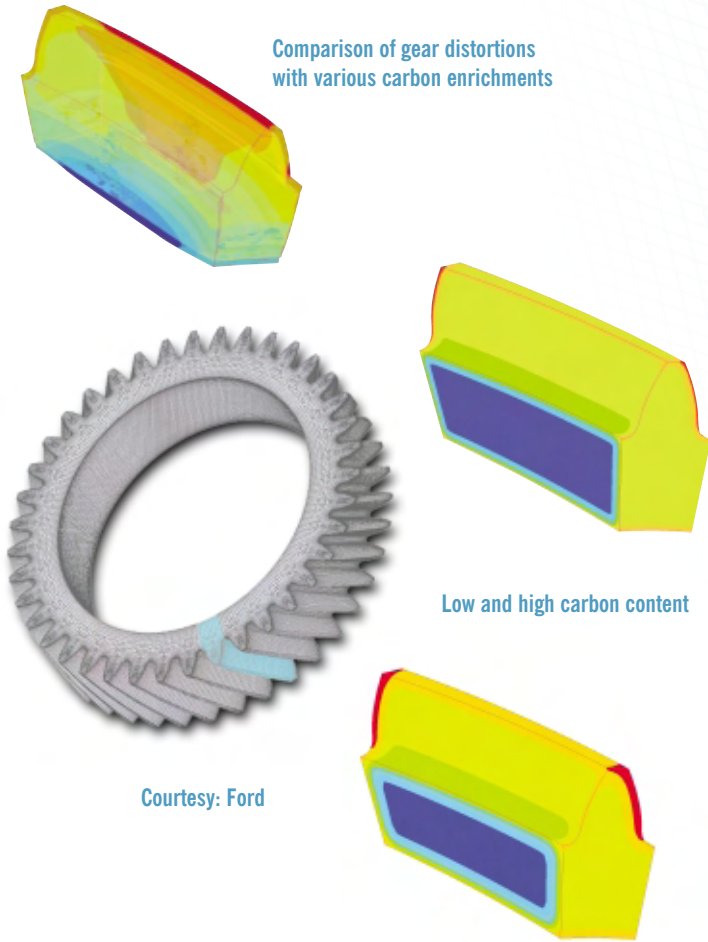
Heat treatment process
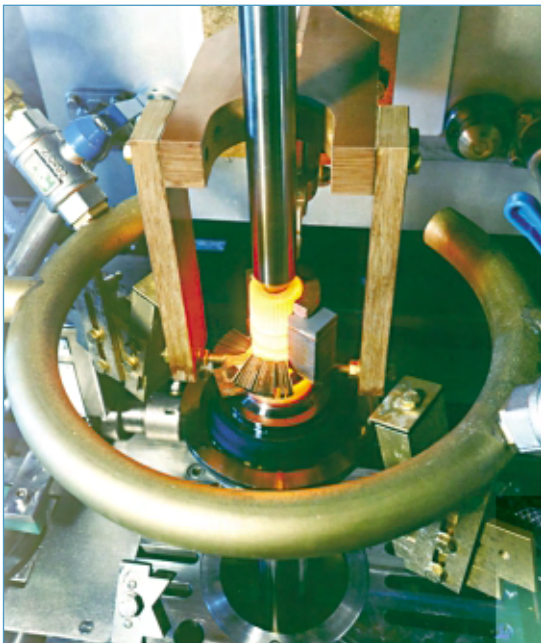
Courtesy: EFD Induction Group
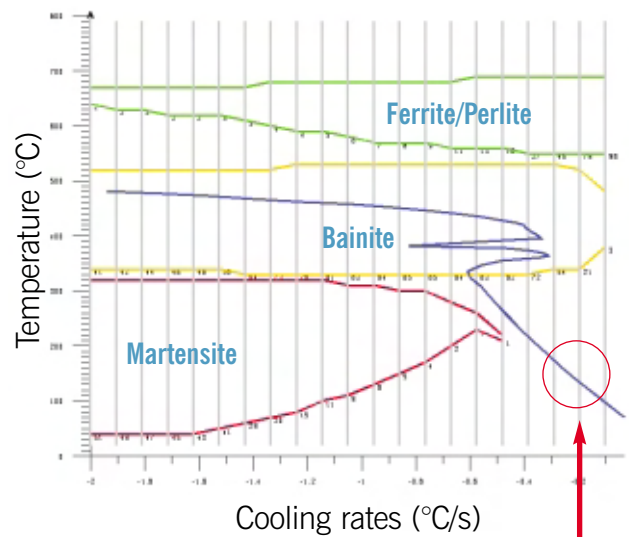
Surface heat treatment of a crankshaft
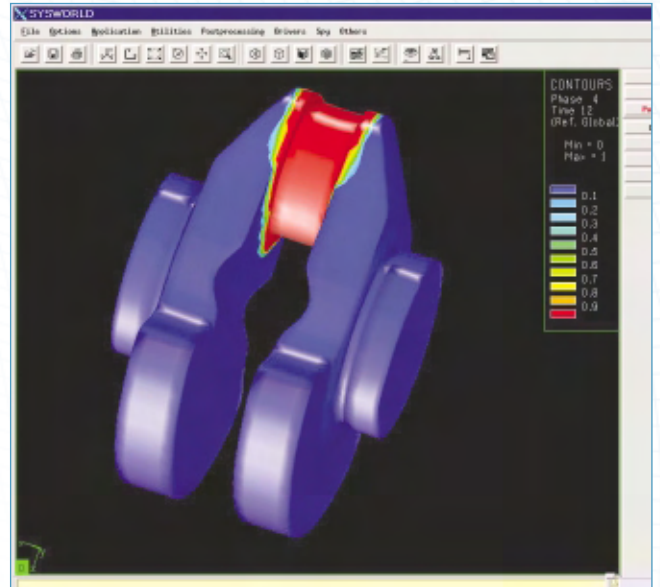
Judgement of process feasibility and stability against process tolerance

Cooling rates over temperature in the
CCT-diagram, for any critical point of the structure.

Ferrite/Perlite

Bainite

Martensite

Temperature (°C)

Cooling rates (°C/s)

Cooling rates are too low to give martensite at a critical point of the structure.

SYSWELD in the Virtual Try-Out Space

SYSWELD is not only a simulation tool, it is also a design optimization tool, created to help you gain competitive advantage.

Paving the way towards the digital factory
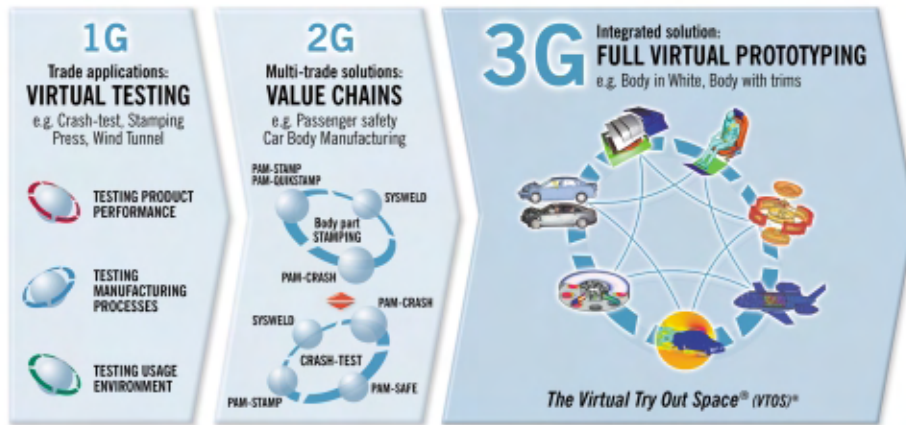
Companies within the heat treatment, welding and assembly markets face high pressure to reduce costs and lead times, as well as to increase part quality. These objectives can be achieved by focusing on manufacturing process optimization and part improvement. To better respond to industrial constraints, ESI Group pursues its continuous collaborative development of SYSWELD and helps engineers to reduce the number of prototypes leading to the migration towards the digital factory.

Chaining stamping and welding simulation

ESI Group's value chain for Virtual Manufacturing products includes PAM-STAMP, the integrated stamping solution to master the complete manufacturing chain from die design feasibility to stamping validation and optimization. Chaining with SYSWELD brings state-of-the-art manufacturing prediction.
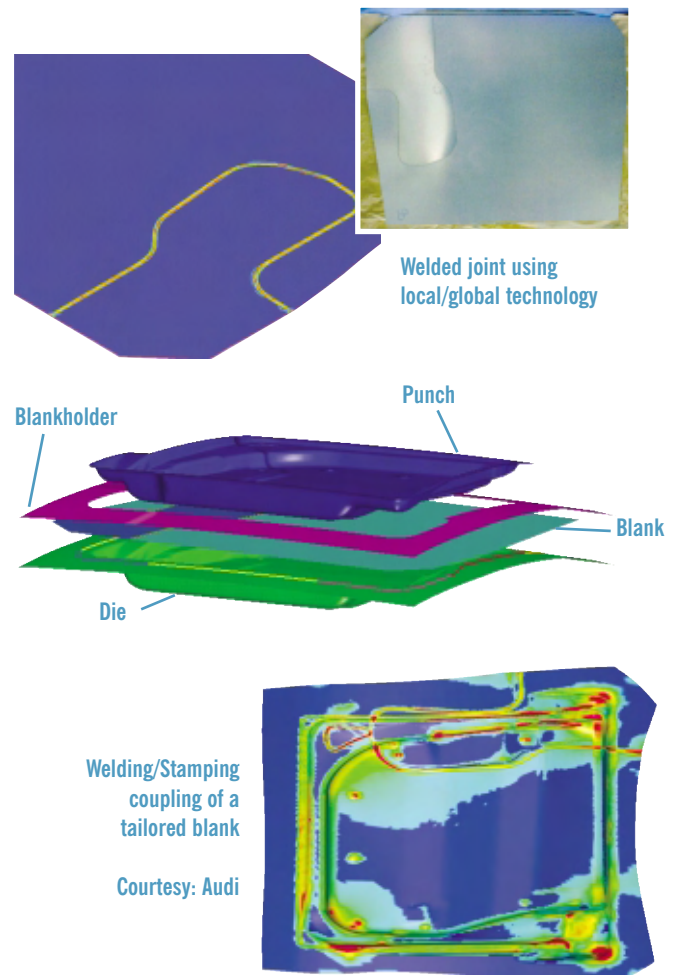
Chaining SYSWELD and PAM-STAMP

Welding tailored blanks generates material changes around the welding joints that influences the stamping behavior. Chaining SYSWELD and PAM-STAMP provides the user with key data about changes in material properties like yield stress reduction. The residual stresses from welding are taken into account for the spring back simulation.

Welded joint using local/global technology

Blankholder · Punch · Blank · Die

Benefits:

- Improved products and tooling design
- More accurate process simulation
- Reduced tooling modifications

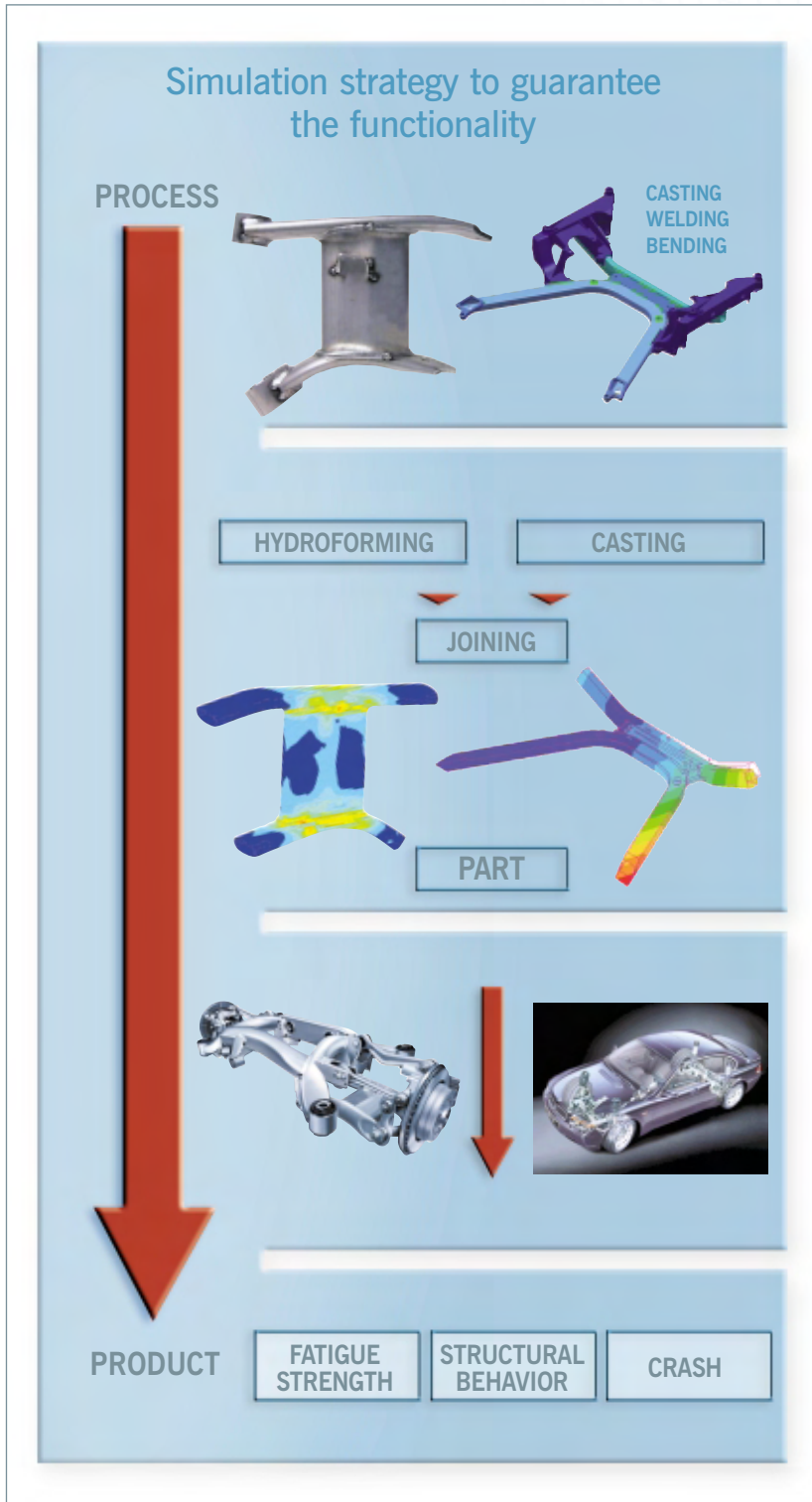### Chaining PAM-STAMP and SYSWELD

Welding stamped components made from aluminum and steel alloy is today the mission-critical operation for body-in-white and suspension systems. Combining PAM-STAMP and SYSWELD brings an accurate assessment of real blank thickness, change in material, distortions, residual stresses and residual plastic strains.

Welding/Stamping coupling of a tailored blank

Courtesy: Audi

SYSWELD Masters Joining Technology

Simulation strategy to guarantee the functionality

PROCESS

CASTING
WELDING
BENDING

| HYDROFORMING | CASTING |

JOINING

PART

PRODUCT

| FATIGUE STRENGTH | STRUCTURAL BEHAVIOR | CRASH |

Car manufacturers are under high pressure to decrease weight, costs, time-to-market and increase quality by optimizing heat treatment and welding processes at the earliest stage in the design process.

A car component is manufactured from different parts which are stamped, cast, bent, then welded and connected together to fit the welding assembly requirement.

SYSWELD is the ideal simulation tool for improving the welding and welding assembly processes, ensuring better part quality.

It provides realistic input data for subsequent structural behavior, durability and crash analyses. It is a unique engineering solution tool, which can lead to unsurpassed productivity gain.

SUPPORTED PLATFORMS:
PC and Unix workstations

References and partnerships

Arcelor, Audi, BMW, Bechtel Bettis, Bosch, Corus, DaimlerChrysler, Delphi, EADS, Ford, Framatome, Fuji Electric, GKN, GM, Hawtal Whiting, Hyundai Heavy Industry, Japeic, Knolls Atomic Power, Korean Heavy Industries, Mitsui

Babcock Energy Ltd, POSCO, PSA Peugeot-Citröen, QinetiQ ltd, Renault, Rolls-Royce Aerospace, Samsung Heavy Industry, SKF, Toshiba, Toyota, Vallourec, Volvo, Wagon, ZF, ...

Distribuidor oficial

About ESI Group

ESI Group is a pioneer and world leading provider of digital simulation software for prototyping and manufacturing processes that take into account the physics of materials.

ESI Group has developed an entire suite of coherent, industry-oriented applications to realistically simulate a product's behavior during testing, to fine tune the manufacturing processes in synergy with the desired product performance, and to evaluate the environment's impact on product usage.

ESI Group's product portfolio, which has been industrially validated and combined in multi-trade value chains, represents a unique collaborative, virtual engineering solution, known as the Virtual Try-Out Space (VTOS), enabling a continuous improvement on the virtual prototype. By drastically reducing costs and development lead times, VTOS solutions offer major competitive advantages by progressively eliminating the need for physical prototypes.

ESI GROUP
THE VIRTUAL TRY-OUT SPACE® COMPANY