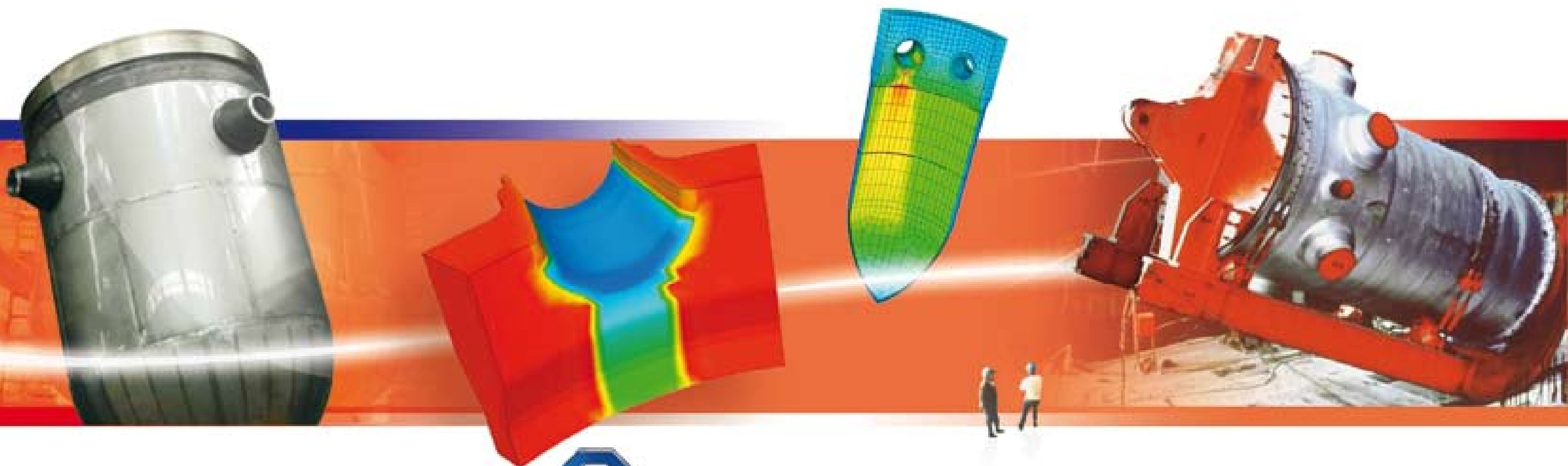
TÜV SÜD

Certifying nuclear power plants with Abaqus FEA from SIMULIA



Overview

Challenge

TÜV SÜD needed to ensure the safety of nuclear plant reactors by identifying and correcting problems that threaten the longevity of the plants.

Solution

The company uses Abaqus FEA to evaluate nuclear plant integrity by analyzing stress loads over a wide range of scenarios.

Benefits

Abaqus FEA from SIMULIA plays an integral role in ensuring that nuclear facilities comply with safety regulations and meet longevity requirements.

"The Abaqus FEA calculations helped evaluate compliance of the vessel to regulatory safety requirements."

Wolfgang Hienstorfer
Head of the department of structural analysis
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Ensuring longer life spans and safety of nuclear plants

Designed to last 30 to 40 years, the systems, structures, and components of nuclear plants can change with time and use. Components can wear out, corrode, or degrade; instrument and control systems may become obsolete as technologies evolve. Complicating the issue, the properties of critical materials may change through heat and neutron irradiation.

Identifying and correcting longevity issues can extend the operating license of a plant by several decades, which is why upgrading older facilities is a major focus of nuclear regulatory bodies and plant operators. TÜV SÜD, a leading global technical service corporation in Filderstadt, Germany, independently tests, inspects, and certifies nuclear facilities for licensing by the German government. Wolfgang Hienstorfer, head of the department of structural analysis at TÜV SÜD, and his team are responsible for identifying and correcting longevity issues that help extend the operating license of a plant and that ensure new facilities a lifetime of safe operation. "The structural integrity and operational management of nuclear facilities must be secured far into the future - whatever the type or age of the plant," said Hienstorfer.

FEA assists safety evaluation

To assist in the evaluation of nuclear plant integrity, Hienstorfer's group relies on Abaqus FEA from SIMULIA. "Abaqus is a very useful and powerful tool for many aspects of our work," said Hienstorfer. "The processes of sensitive industrial facilities are very complex, and FEA helps us evaluate the safety margins in a more sophisticated way."

TÜV SÜD uses Abaqus to analyze stress loads over a wide range of scenarios such as rapid temperature and/or pressure changes, airplane impact, earthquakes, and radiation embrittlement. The software is used to analyze everything from key mechanical components - including pumps, piping systems, vessels, supports, and tanks - to fuel assemblies, building structures, and lifting devices.

Strict standards for nuclear reactors

An ongoing focus of regulators is the reactor pressure vessel (RPV), the steel "heart" of the power plant that houses the nuclear fuel rods. A nuclear power plant using fission to produce steam that drives electric generators is subject to temperature and pressure stresses similar to those at any kind of steam facility. But the possibility of pressurized thermal shock (PTS) affecting a radiation-embrittled RPV is unique to the nuclear industry: bombardment from neutrons can, over time, alter the molecular makeup of the metal from which an RPV is built, making the vessel more prone to structural damage under stress. In a classic loss-of-coolant (LOC) scenario, a broken pipe in the primary system deprives the reactor core of vital coolant, and the hot vessel (300° C) is then subjected to extreme PTS as colder water (at 30° C) is rapidly piped into the vessel to cool the core and shut the reactor down.

UN International Atomic Energy Agency (IAEA) standards require that RPVs have a proven ability to withstand this kind of event in order to receive certification for operation. "You have to document the damage tolerance of the systems, structures, and components of a plant to pass inspection," said Hienstorfer. "FEA is integral to that analysis. FEA can be used for virtual testing to provide guidance for new designs in the early stages of product development, as well as for performance assessment of existing components under simulated stress conditions."

Modeling an RPV and simulating PTS with Abaqus

TÜV engineers used Abaqus/CAE to build and mesh computer models of the vessel and the four water pipe nozzles that fed into it. The TÜV SÜD team then used Abaqus/Standard for linear elastic simulation of the rapid cooling of the vessel, calculating the effects of a large increase in tensile stresses on the inner vessel wall. The effect of the high pressures under which the system would operate was also incorporated into the models; an elastic/plastic Abaqus simulation predicted where the greatest surface and/or volumetric stresses would occur in the system.

FEA facilitates regulatory compliance

The RPV in this example passed TÜV SÜD's simulation testing, indicating that its walls and nozzles would withstand the extreme conditions of an LOC event over a 40-year lifespan. "The Abaqus FEA calculations helped evaluate compliance of the vessel to regulatory safety requirements," said Hienstorfer.

According to Hienstorfer, successful design, development, and maintenance of nuclear power facilities are challenges that must be managed from both an organizational and an engineering viewpoint. He sees FEA as playing an integral role in both operational evaluation and ongoing monitoring of nuclear facilities to help comply with regulations designed to ensure the world's growing energy needs can be met safely. "We depend on FEA for computer modeling and virtual testing of reactor pipelines, vessels, and materials under extremes of stress and time," he said. "It definitely provides guidance to engineers building safety and longevity into their nuclear power plant designs."

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Images courtesy of TÜV SÜD

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