New materials for the 700 °C power plant: Creep behavior properties by comparison

Siempelkamp Prüf- und Gutachter-Gesellschaft tests materials for a new generation of power plants

Siempelkamp Prüf- und Gutachter-Gesellschaft mbH (SPG) is part of the Siempelkamp Group in the field of nuclear technology. The company, located in Dresden, has been the specialist for industrial services in the fields of strength calculations and testing of materials and components with an emphasis on creep-resistant materials for more than 50 years. In an interview with Dr. Andreas Thomas, Managing Director of SPG, Bulletin found out more about the company's portfolio and potential.

By Ralf Griesche

Dr. Thomas, what type of industrial services does SPG offer customers?

SPG offers services in the fields of material and component testing, plant inspections and production control as well as strength calculation (finite element method FEM). SPG has a DIN EN ISO/IEC 17025:2005 accredited testing laboratory for material and component testing and is a DIN EN ISO/IEC 17020:2004 accredited inspection facility for on-site service inspections of power plants and their components.

Plant inspections of power plant components made of creep-resistant materials are part of the portfolio of SPG. What demands are put on modern creep-resistant steels?

Definitely high demands. In the next 20 years the need for approx. 300,000 MW of electrical power will arise in Europe. Two thirds of this is due to the replacement of old plants which have a comparably low degree of efficiency and problems regarding their environmental soundness. About 100,000 MW of electrical power have to be generated newly at an increased power requirement of 1.5 % per year.

While maintaining the same energy mix, the gap in the energy supply has to be closed primarily by using high-efficient steam and gas power stations with an increased degree of efficiency and decreased CO_2 emissions. Target values for reaching a high degree of efficiency of ≥ 50 % include raising the steam temperature to approx. 720 °C and the steam pressure to approx. 350 bar. At this point creep-resistant steels and their welded connections come into play: The employed materials and their welded connections have to have a high creep rupture strength. For the design and operation of components used under high temperatures, for example, in turbines, boiler plants, and hot steam pipes, long-term supported material parameters are necessary because it can be assumed that the life expectancy of power plants can reach 30 years or 250,000 h respectively. At an allowable time extrapolation factor of 3 high temperature materials have to be tested 80,000 hours and longer in creep rupture tests – a tremendous testing challenge because all test parameters have be to kept constant over many years.

What technical test procedures do you use in this context?

One of the most important experiments is the standardized creep rupture test according to DIN EN 10291. This test determines the behavior of materials at high temperatures, for example, it determines the stress-time factor to breakage or up to a defined creep limit. The results are often the base for design curves, for example, of isotherms, creep rupture strength, or creep deformation laws which are the foundation for the design of high temperature components.

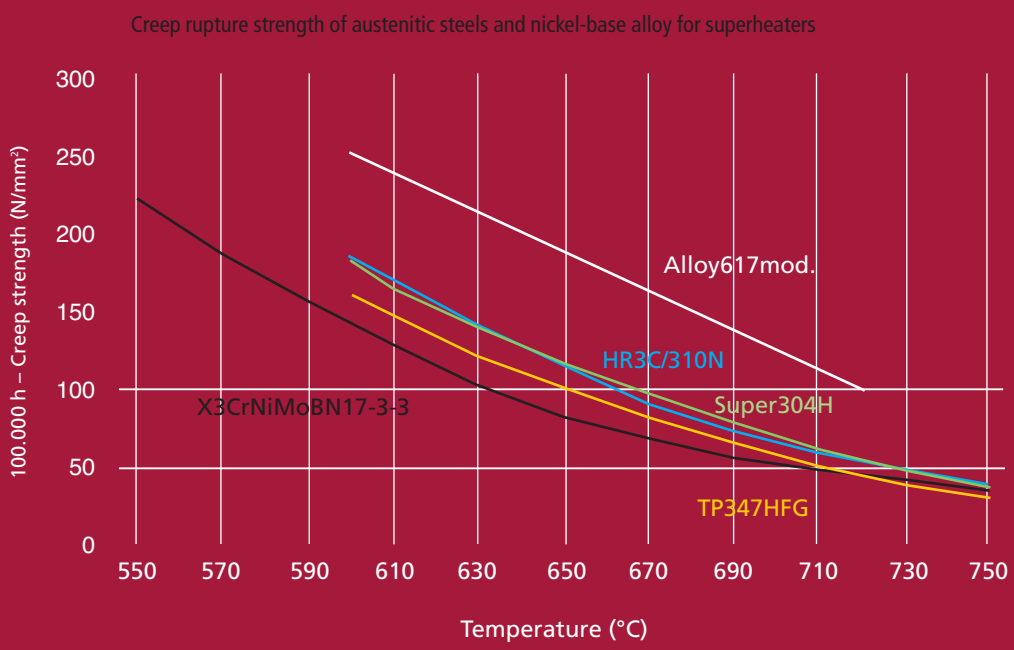
As far as research goes, where does SPG stand?

Between 1957 and 1989, when SPG was part of a company by the name of Kraftwerksanlagenbau KAB, approx. 100 single oven units were operated in the creep lab. In the beginning of the 90s the power plant steel P91 (X10CrMoVNb9-1) was gradually introduced. SPG played a part in the research of the P91 steel.

What milestones have you set since then?

We achieved a creep rupture strength characteristic value of 100,000 hours which conforms to a test duration of 12 years. Furthermore, we extended our testing capacities to 145 single oven units and adjusted their measurement and control technology to the increased demands during this time. Here, we profited from the

Power plant



Component

View of a creep rupture test lab with single oven units

experience we gained through our involvement in national and international research projects such as CCG, HIDA, INTEGRITY, WELDON, COST522, and COST536. Part of this knowledge includes the fields of automatic data acquisition, digital temperature control and online creep strain measurement.

What is the advantage for the customer?

On the basis of our equipment and our knowledge SPG operates one of the largest testing labs for creep rupture tests in Germany. Because we are operating single oven units we can react quickly and flexibly to many different customer requirements

What is the capacity utilization rate of the laboratory and who are the customers that commission Siempelkamp to perform tests?

New customers from all over Europe, extended opportunities to carry out creep rupture tests and creep crack research as well as an increasing need for further research of new power plant materials resulted in an improved utilization of our testing lab.

Our customers are, for example, Babcock Hitachi Oberhausen, Benteler AG, BMW, Böhler Schweißtechnik, DOW CHEMICAL, Enpar Sonderwerkstoffe, E.ON, Elringklinger, Hitachi Europa, MPA Stuttgart, Siemens Mülheim, Steinmüller, Vallourec & Mannesmann, Vattenfall, BHR Essen and ABB (Switzerland), AMT (Australia), Avedøre (Denmark), Böhler Edelstahl (Austria), Morandini (Italy) and SERCO (UK).

The materials for the new generation of power plants tested by SPG in the creep laboratory include martensitic steels such as P91, P92 and VM12-SHC, austenitic steel types 304, 310 and 347, and nickel-base alloys (e.g., alloy 617), their weld metal deposits as well as different welded connections.

Which guidelines can be used to evaluate the creep rupture test?

In addition to DIN standards, guidelines and recommendations have been compiled nationally as well as internationally to help evaluate creep rupture tests. They guarantee comparable and authoritative test results from creep labs and support the evaluation of the test results for design curves.

On a national level the Verein Deutscher Eisenhüttenleute (VDEh) in Düsseldorf has compiled, within the German consortiums for "creep-resistant steels" and "high-temperature materials" (AGW/AGHT), guidelines for the procedure and evaluation of creep rupture tests. These consortiums, to which SPG actively contributes, present a pool of material and plant manufacturers, research institutions, and associations. The consortiums AGW and AGHT were the first facilities in the world doing joint research in the field of high-temperature materials and have for decades been compiling especially long-term creep data. The European Creep Collaborative Committee (ECCC), to which SPG contributed for several years, has developed continuing recommendations for the procedure and evaluation of creep rupture tests.