DESIGN, ANALYSIS AND CONSTRUCTION OF THE HOT-WORKING CAST IRON PRESSURE VESSEL (PCIV)

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SUMMARY

The hot-working prestressed cast iron pressure vessel (PCIV) used as reactor pressure vessel for helium-cooled high-temperature reactors to produce electrical power or process-heat is a consistent extension of the cold-working PCIV-concept.

Design and construction of hot-working PCIV's is based on the requirements of a liner that can be inspected, checked, and repaired at a radiation level of approx. 0,5 mr/h on the outside of the vessel and on the reference geometries for the power station (core cavity with directly attached heat exchangers) and for the process-heat plant (single cavity concept). For both design concepts cylinders, top-slabs, and bottom-slabs of the PCIV's will be assembled from a number of cell-structured blocks. The cast iron blocks will be tied together by the horizontal and vertical prestressing systems to form the vessel. A liner made of high-ductile steel, placed on the inside surface of the PCIV, will make it gas-tight.

The hybrid-system, consisting of prestressing steel, cast iron and liner will be partially prestressed in a cold and pressureless state. Full prestress will be achieved by temperature differences and temperature strains of prestressing steel, cast iron, and liner at increasing vessel temperatures and increasing gas pressure. The analysis of important components at various levels of prestress and for different loading conditions will be shown. The lay-out of the vessel and the blocks has been carried out in such a way that operating conditions will cause essentially compressive stresses and that cross sections with direct tensile stresses can be avoided.

The design of the cast iron blocks takes into consideration voids for the shielding material, ducts for the longitudinal tendons and penetrations for the control rods of the shut-down system and on the other side requirements like ultrasonic testing, simple casting shapes, high rigidity, low temperature-gradients and small tooling and assembly costs. The typical cast iron blocks of the cylinder and the slabs are shown in detail. Small ducts in the vessel will be designed as armored conduits anchored in the cast iron wall. Large ducts will be coated with a liner and closed off by prestressed cast iron slabs.

Heat losses of the vessel will be limited by an insulation at the outside of the vessel. Because there is no inner insulation the liner, which borders directly on the cast iron but which is not anchored to it and therefore requires inside stiffeners, will be exposed to cold-gas of 300 °C. This high temperature load can be handled without any problem by the cast iron and liner materials in contrast to the temperature sensitive concrete. The vertical prestressing system, which is placed in channels in the cast iron wall will be protected against high temperatures by concentric insulation and a special cooling system. The horizontal prestressing system on the vessel surface will be kept at low temperatures by special supporting elements.

With the concept described above a hot-working prestressed cast iron pressure vessel with a hot liner that is not anchored to it will be brought to technical realization for the first time.