Fuel Pool Cooler

Passive fuel pool cooling at high capacity

Spent fuel cooling with natural convection to yield high cooling capacity with simple system design

After power uprates and new design requirements, a high amount of decay heat must be removed from the spent fuel. Common fuel pool cooling systems are connected directly to the pool. Hence, a postulated break of the suction or injection line leads to a partial loss of water inventory inside the pool and consequently to a complete loss of the fuel pool cooling system (all redundancies affected). Passive and high efficient heat removal is required directly inside the fuel pool without removing water from the pool.

The Fuel Pool Cooler is a U-tube heat exchanger inside the fuel pool which allows efficient heat removal. On primary side, natural convection is established to take advantage of the whole water inventory. This is realized by high capacity heat removal and by guide plates which are placed in a vertical position around the heat exchanger. On secondary side, forced mass flow is provided by an active cooling system. Optionally, a mobile fire fighting system can provide forced flow, e.g. in case of station blackout. The component was successfully tested in full scale for pool temperatures of 20 - 80 °C and different secondary side mass flows. It showed heat transfer capacities of up to 7 MW. The inlet and return line of the heat exchanger are routed upwards above the water level, where the penetrations are located. In case of a line break inside one redundancy of the new fuel pool cooling system, no water is lost from the fuel pool. In addition, only the affected redundancy is lost whereas the remaining trains are still available to ensure pool cooling.

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Key features of scope

- System engineering
- Component design, scaling
- Procurement
- Installation
- Commissioning

References:

- Full scale tests 2008-2009 at INKA test facility, Karlstein, Germany
- Development of KERENA reactor

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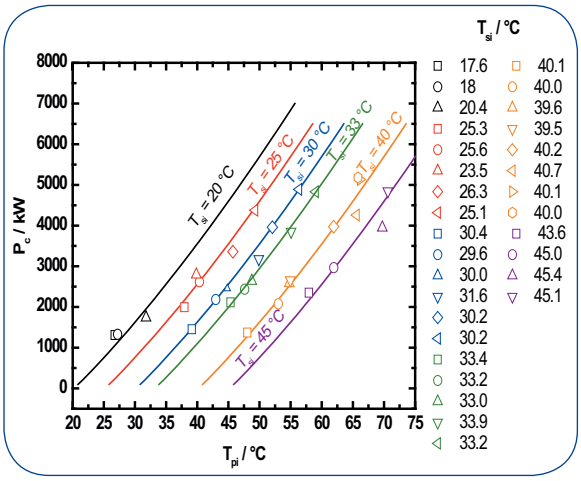
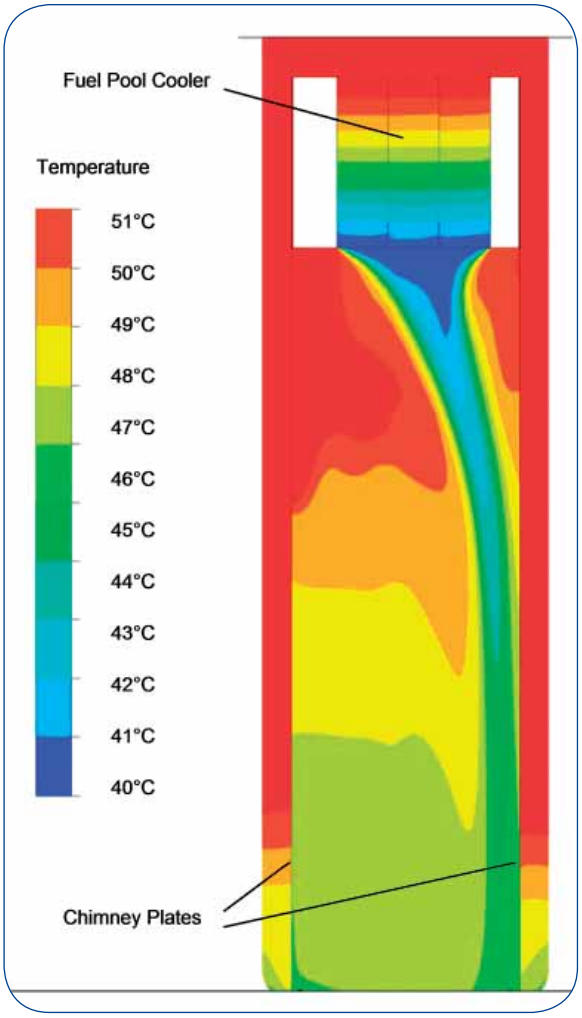
High performance with simple design

During the passive heat removal inside the pool via the Fuel Pool Cooler, no coolant is removed from the fuel pool. The number of coolers and the operating parameters can be easily adapted to the required heat removal. With a secondary side mass flow of 75 kg/s and a temperature of 25 °C for example, a total number of only four Fuel Pool Coolers are able to keep the pool temperature below 50 °C during normal operation. Here, a total decay heat of the spent fuel of up to 16 MW is assumed. The passive working principle on the primary side saves electrical power and I&C control. The primary side system does not contain any auxiliary equipment and no moving parts.



Measured heat transfer capacity as a function of pool temperature T_{pi} for various cooling water temperatures T_{si} and a mass flow of 75 kg/s on secondary side.



Temperature distribution around Fuel Pool Cooler inside fuel pool determined by Computational Fluid Dynamics (CFD) calculations

Your Benefits at a Glance

- **High efficient heat removal from the fuel pool with natural circulation on primary side**
- **Secondary side forced mass flow either by active cooling system or (in case of station blackout) by mobile fire fighting system**
- **Simple, maintenance-friendly, scalable design**
- **No loss of fuel pool water and only partial loss of fuel pool cooling system in case of a pipe break**

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