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Molten Salt Energy Storage System for a DEMO Operated in Pulsed Mode

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Steady-state electricity production has always been considered an essential requirement for a fusion reactor, but there are significant physics and technological challenges to be overcome before steady-state operation of such a device can be achieved. As part of the so-called "Fast-Track" approach to commercial fusion power development, design studies on a DEMO device are being carried out in Europe. Under the "Fast-Track" scenario, DEMO is the single step between ITER and a commercial Fusion Power Plant. The reference European DEMO is a steady-state device with an output power of $1GW_e$. Recognising the challenges which need to be met for steady-state operation of DEMO, an examination of the consequences of operation of this device in pulse mode is included as part of the European study.

To achieve the continuous delivery of power to the grid from a pulsed device, some form of energy storage system is necessary, capable of storing energy during the pulse and delivering electricity to the grid during the dwell time. A number of possible methods have been previously investigated and it was concluded that thermal energy storage using molten salt appeared to be the most effective and most economical solution.

Molten salt energy storage systems are well known and have been used in applications as simple as heating houses (capturing heat in daylight and giving it off during the night). These applications are low power applications; real energy production related applications are known in the solar industry. In existing industrial facilities, the latent heat of a molten salt is always used, but involving a phase transformation (melting) the associated heat of fusion is added to the heat storage capacity of the system. Although solidification of the melt during heat recovery poses serious problems (drastically changing thermal conductivity), and this is why such methods are mostly in experimental phase, phase change materials (PCMs) are probably the best candidates for use in high power applications like fusion reactors.

The power output of the DEMO device during operation is $1GW_e$, and with a pulse duration of 4-8 hours and a dwell time of only 5-20 minutes, supply to the grid and re-ignition of the plasma would require several hundred megawatts from the storage system to maintain the power output within acceptable limits.

An intense search for available technologies regarding molten salt energy storage has been carried out, and possible salts and systems to meet the required duty will be presented and directions of research proposed. Metal hydrides could be the best candidates for such a system from many aspects, like very large heat of fusion and, moreover, an option for combining heat of fusion with heat of chemical reaction, thereby increasing the latent heat based thermal storage capacity. This latter offers controlled recovery of heat and even partial direct conversion of heat to electricity by thermally regenerative electrochemical cells. Pros and contras for such systems envisaged will be discussed and feasibility for a DEMO analysed.