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Techno-economic aspects of high current leads for fusion devices

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The superconducting magnets system (SCMS) of the fusion devices e.g. tokamak / stellarator consists of complex superconducting magnetics. In order to supply such high currents from the power supplies to the SCMS, many numbers of current leads (CLs) are required in the range of 4.5 K –300 K. As the studies revealed that based on the duty cycle of operation of fusion device, almost 25% - 30% of the total operation cost is just consumed by the CLs only. Therefore, an optimum, reliable and low loss CLs are essential for fusion devices. The studies include such CLs development using unitary (conventional heat exchanger) and binary (HTS or other superconductors module with metal or alloys heat exchanger) concepts.

The overall efficiency, Exergy flow and cryogen consumption as per operation duty cycle, analysis can predict the real operation cost of the device and can be compared with the capital investment to realize the massive savings by providing innovative solution. It would be possible if replacing the conventional CLs by innovative and techno-economically viable solution using MgB2 and Brass based overloaded CLs. This proposal has three folds benefits, the capital cost of the MgB2 materials is cheaper compared to HTS materials. The critical temperature of MgB2 is ˜ 39 K where the thermodynamic efficiency of the helium cryo plant is maximum. The last but not least, significant cost can be reduced by designing the CLs in overloaded mode using Brass. This type of engineering solution is quite unique and suitable for pulsed magnets of the fusion devices and till now not tried out. In this context, a techno-economic comparative studies have been carried out for different types of CLs are being carried out for the fusion devices. As a part of specific case study has been carried out for 50 kA / 30 pairs CLs in pulsed operation scenario. The cooling power required for the conventional CLs is 5 – 6 times higher than that of MgB2 and Brass based overloaded CLs and in case of HTS CLs the cooling power remains more or less same but there is significant saving in capital cost of factor of 2, if MgB2 and Brass based overloaded CLs will be used.

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