MPIDS Colloquium

MAX-PLANCK-GESELLSCHAFT

Turbulent convective heat transfer in liquid metals

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The interest in heat and mass transfer in liquid metals is largely stimulated by their application as coolants in nuclear reactors, fusion reactors and space power plants. The sodium has become the traditional coolant in existing fast neutron reactors and the use of heavy metals, lead and lead alloy with bismuth or lithium, is considered in prospective nuclear and fusion reactors. The peculiarity of liquid-metal coolants is associated, in particular, with their high thermal conductivity, which is much higher than the thermal conductivity of other types of coolants, and a relatively small kinematic viscosity (small Prandtl numbers). This means that molecular thermal conductivity makes a significant contribution to the heat transfer not only in the boundary layer, but also in the turbulent core of the flow. Therefore, the results of experimental studies of free and mixed convection of metal in pipes and long vessels oriented at different angles to the direction of gravity in the presence and absence of a magnetic field are extremely important for the design of reactor plants. The results of such studies can be used both in the design of new reactor facilities and for verification of simulation codes used in nuclear power engineering.

We discuss the features of experimental studies of convective heat transfer in liquid metals and we present an overview of results of three series of experiments on turbulent convection in liquid metals. The first series includes studies of free turbulent convection of sodium in cylinders of various lengths inclined at different angles to the direction of gravity. The experiments are carried out in ICMM (Perm). The second series of work was carried out at MPEI in cooperation with JIHT (Moscow) and deals with studies of heat transfer under conditions typical for tokamak blankets, in which the joint influence of mass forces of various nature - electromagnetic force and buoyancy force - is significant. Hydrodynamics and heat transfer were studied in mercury pipe flows under strong magnetic field and different orientation with respect to gravity and the vector of magnetic field induction. The last series refers to problems of non-ferrous metallurgy and concerns the study of turbulent magnesium convection in the titanium reduction reactor.

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