COFTEC セミナー

題　目：Magnetic control of bubble flow in liquid metal

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概　要：
Bubble flow in liquid metal (LM) is eminent in industrial processes such as LM stirring, continuous casting, chemical reactions, fusion reactor cooling, etc., and can be controlled magnetically. In fact, modern continuous casting already involves control via static magnetic field (MF) & bubble flow. A major issue is that relevant bubble collective dynamics effects are not yet properly understood or have not been studied at all. The latter is necessary to determine the conditions under which industrial processes are feasible, and exactly how they are controllable. Computational fluid dynamics (CFD) reduced order models (ROMs), Euler-Euler & Lagrangian, are computationally affordable and crucial for analysis, but must reflect actual physics. ROMs require parameters like bubble collision, merging & splitting frequencies, etc., which are bubble size, flow field and MF-dependent. Modelling of continuous casting and other processes thus far is limited due to the lack of such phenomenological parameters, especially relevant for bubble interaction models. Coefficients for effective forces in Lagrangian models in MF are also unknown. This talk addresses the work towards the following. First, construct a parameter space map of magnetohydrodynamic bubble flow in LM for industrially relevant parameter ranges, with flow regime & (in-)stability regions, and respective criteria. Second, present well-documented guidelines for magnetic control of bubble jet/column shapes, ascension velocity, surrounding LM flow field, and other parameters relevant for industrial processes. Third, deliver physics-based and improved coefficients for bubble motion and bubble interaction models, derived from the existing datasets and the proposed new experimental diagnostics methods. And finally, develop a next-generation accessible experimental procedure for indirect diagnostics & optimization of bubble flow in industrial systems via downscaled model LM systems with combined X-ray, neutron or optical phase imaging, ultrasound Doppler velocimetry (UDV) & MF tailoring via Helmholtz coil-based MF systems. Finally, it is planned to discuss the potential of combined ultrasound computed tomography and UDV for a fully three-dimensional analysis.