# पदार्थ अनुसंधान एवं विकास के लिए प्रेरण लेविटेशन गालक

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# Induction Levitation Melter for Material Research and Development

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## Introduction

Induction Levitation Melter (ILM) is an advanced technology designed to produce ultrapure specimens of highly reactive metals and alloys with exceptional homogeneity. This method employs a water-cooled segmented copper crucible in an inert Argon or vacuum environment, allowing the magnetic field to penetrate and melt the metal charge. The process generates strong Lorentz forces, causing vigorous stirring in the melt and preventing contamination by levitating the molten mass away from the crucible walls. These features ensure uniform temperature distribution, higher achievable superheat, and minimized contamination, making ILM especially valuable for preparing samples used for development of new alloys.

## Development

The laboratory-scale ILM system (Fig.1) developed by Nuclear Recycle Group offered reliable performance in melting and homogenizing various alloys, producing small specimens (up to 25 g) for material characterization. Its high temperature availability, efficient vacuum operations, and the use of high-purity Argon ensured the preparation of ultrapure alloy buttons with excellent homogenization and utility for novel alloy development. The ILM has been subsequently used to produce specimens of various alloys including Ni – Ti – Fe alloy, Zr – Cu alloy, Ti – Al– V alloy, Zr – Nb alloy etc. for Materials Group R&D activities. Recognizing these advantages, the Materials Group, BARC engaged with Nuclear Recycle Group for a high-capacity ILM suitable for producing samples up to 100 g.

## Induction Levitation Melter for Materials Group

Nuclear Recycle Group has taken up the design of ILM of higher capacity, considering the requirement raised by Materials group. The main features of the design included -

**Crucible Design**: The new ILM features a 12-segment water-cooled copper crucible, with an internal cavity diameter of 50 mm and height of 45 mm. This allows for larger batch processing of up to 100 g charge and enhanced electromagnetic field distribution for optimal levitation and homogenization.

**Vacuum and Atmospheric Control**: A robust vacuum delivery system achieves up to $1x10^{-3}$ mbar within minutes, with integrated Argon purging, digital vacuum monitoring, and automatic safety interlocks for process stability and contamination avoidance.

**Power Supply and Coil**: The melter is powered by a 75 kW induction heating unit, providing variable frequency and efficient energy delivery for melting larger samples. Safety features include load-matching, surge protection, automatic shutdown, and continuous water cooling for both the induction coil and crucible.

**Cooling Arrangement**: A dual-loop, closed water cooling system ensures reliable operation under continuous industrial duty, with precise control over flow, pressure, and temperature for all subsystems. The Primary and secondary water circuit maintain system integrity and safe operating temperatures.

**Instrumentation and Control**: Centralized PLC-based automation provides real-time parameter display, touchscreen operation, integrated safety logic, fault monitoring, and rapid emergency response. Fiber-optic signal channels and noise-resistant architecture support consistent and reproducible melting operations.

Based on the above design features an Induction Levitation Melter (Fig.3) of 75kW capacity has been manufactured, installed and commissioned for Materials Group at Mod Labs, BARC Trombay. The system has been tested for melting and homogenization of SS, Al and Zr –SS alloys during commissioning trials.

## Summary

The non-contact levitation technology eliminates crucible contamination, crucial for high purity metals and research-grade alloys. The enhanced batch size of this new ILM enables various characterization studies and material property evaluations, which were not possible with small samples. The deployment of the new high-capacity ILM for Materials Group underscores its value for advanced alloy development, offering Materials Group and Nuclear Recycle Group a platform for collaboration in materials research. The equipment can provide necessary foundation for future process scale-up, alloy exploration, and fundamental metallurgical studies.

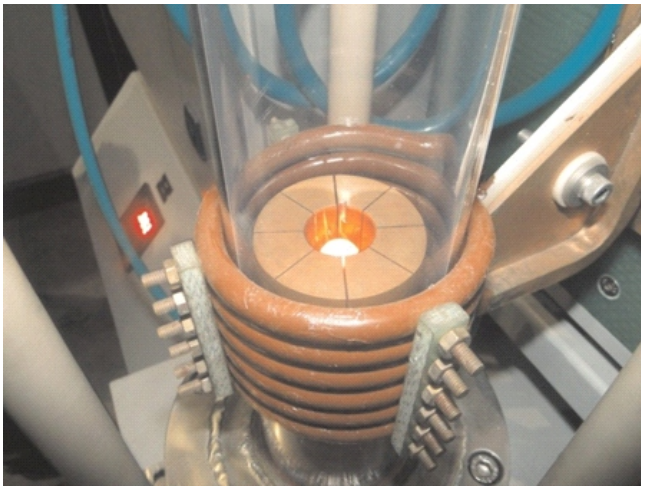

*Fig.1: Induction Levitation Melter produced in ILM.*

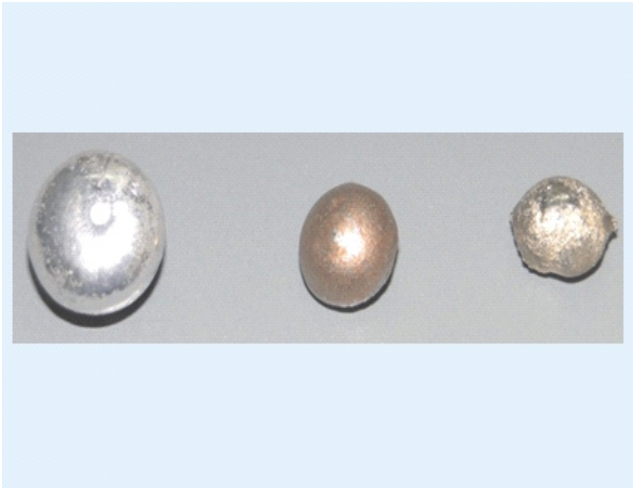

*Fig.2: Various Alloy samples.*

*Fig.3: Induction Levitation Melter installed at Modular Laboratory, BARC.*