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Vacuum Induction Melting Furnaces

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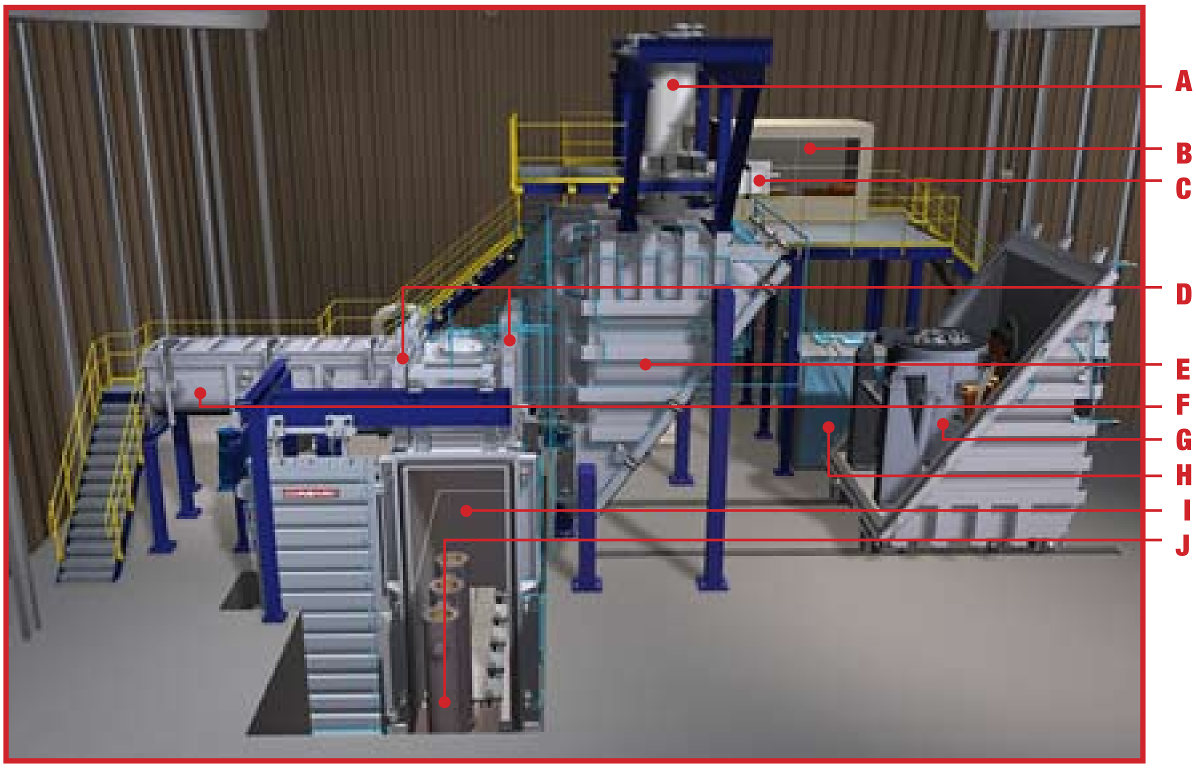
VIM — The Process



Vacuum Induction Melting (VIM) is the melting of metal via electromagnetic induction under vacuum. An induction furnace containing a refractory lined crucible surrounded by an induction coil is located inside a vacuum chamber. The induction furnace is connected to an AC power source at a frequency precisely correlating to the furnace size and material being melted.

Material is charged into the induction furnace under vacuum and power is applied to melt the charge. Additional charges are made to bring the liquid metal volume to the desired melt capacity. The molten metal is refined under vacuum and the chemistry adjusted until the precise melt chemistry is achieved. Impurities are removed by chemical reaction, disassociation, flotation and volatilization. When the desired melt chemistry is achieved, a preheated tundish is inserted through a valve isolated hot tundish insertion lock. This refractory tundish is positioned in front of the induction furnace and the molten metal is poured through the tundish, into the awaiting molds.

VIM is a process used to make superalloys, stainless steels, magnetic and battery alloys, electronic alloys, and other demanding high value alloys.

A Overmelt Charger
B Control Room
C Isolation Valve
D Isolation Valves (2)
E Melt Chamber
F Hot Tundish Charger
G Induction Furnace
H Induction Power Supply
I Mold Chamber
J Ingot Molds

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Vacuum Induction Melting Furnaces

Consarc has built the majority of the large VIM systems in production today worldwide. Companies producing the best masteralloy barstock for precision casting or electrodes for remelt operations are doing so in a Consarc VIM.

Some Features of the Modern Consarc VIM Furnace are:

- Rugged induction steel shell furnace
- Rapid exchange features for induction furnaces
- Efficient Inductotherm power supplies and auxiliary stirring
- Multiple chamber systems with mold chambers, charging chambers, and hot tundish insertion chambers
- Multiple charging systems for rapid feeding of charge material
- Multiple mold pouring via mold cars or turntables
- Low conductance 'wet' filters to protect vacuum pumps and minimize fire hazards
- Computer and PLC based controls with full SCADA
- Remote operation via CCTV

Consarc has built VIM systems with heat sizes to over 30,000 kg, systems specifically designed for hot liquid charging as well as cold charging, and systems utilizing multiple vacuum stages including steam injectors.

Generally, VIM Systems fit into 2 categories:

MASTER ALLOY

Heat sizes to 10+ tonnes

ELECTRODE

Heat sizes to 30+ tonnes

Masteralloy VIM Systems

Masteralloy VIM systems are generally in the range of 1-10 tons and are characterized by their ability to pour many multiples of small diameter ingots configured on a mold car or turntable. Masteralloy ingots are commonly as small as 73 mm ($2^7/_8$") and as large as 254 mm (10") in diameter and generally about 1.2m (48") tall. Consarc Masteralloy VIM systems commonly incorporate the following features:

- Overmelt Chargers for primary bucket charging of high density charge materials like balls and briquettes, temperature probe insertion, sample taking, and late alloy additions.
- Custom designed water-cooled overmelt isolation valves incorporating vacuum seal protection when open for increased reliability.
- Vibratory Side Feeders for primary charging of low density charge materials like casting returns, gates, risers, and sprues.
- Unidirectional Induction Stirring (UDS)
- Three stage vacuum pumping system incorporating oil sealed rotary pumps (or dry type screw pumps), roots type mechanical blowers, and oil vapor booster pumps for finalizing vacuum levels in the 10^{-3} torr range.
- Oil wetted vacuum filters for control of pyrophoric additions such as NiMg.
- State-of-the-art safety systems incorporating overpressure relief valves and argon purging
- Hot Tundish insertion chargers configured to insert an externally preheated refractory tundish into the pour position within a few minutes.
- Multiple ingot row pouring by furnace/tundish advance or mold turntable advance
- Programmable control of mold car / turntable movement
- Forced Gas cooling
- Computerized control and SCADA systems
- Rapid Exchange Furnace Systems – Allows a hot furnace to be removed with external cooling and a second preheated furnace to be installed quickly, without the need to make or break furnace tilt connections or insulated electrical connections.

Electrode VIM Systems

Electrode VIM systems are the largest VIM systems with some heat sizes over 30T. Electrode VIM's typically pour several electrode mold setups which could be as much as 5m in length. Consarc Electrode VIM systems commonly incorporate the following features:

- Large Capacity Overmelt Chargers for primary bucket charging of high density charge materials like balls and briquettes. Charge weights to 5T are possible depending on the furnace refractory dimensions. Large capacity chargers incorporate dual hoists to allow controlled opening of charge buckets.
- Custom designed water-cooled overmelt isolation valves to over 1.3m in diameter incorporating vacuum seal protection when open for increased reliability.
- Secondary Overmelt devices for temperature probe insertion, sample taking, and late alloy additions.
- Vibratory Side Feeders for primary charging of low density charge materials like casting returns, gates, risers, and sprues.

- Frequency Modulated or Unidirectional Induction Stirring (UDS)
- Three stage vacuum pumping system incorporating oil sealed rotary pumps (or dry type screw pumps), roots type mechanical blowers, and oil vapor booster pumps for finalizing vacuum levels in the $10^{-2}/_{-3}$ torr range.
- Oil wetted vacuum filters for control of pyrophoric additions such as NiMg.
- Large Electrode VIM systems may incorporate Steam Ejector or Steam hybrid vacuum pumping systems
- State-of-the-art safety systems incorporating overpressure relief valves and argon purging

- Hot Tundish insertion chargers configured with dual vertical isolation valves such that metal is poured in between valves rather than through valves.
- Deep tundishes on large furnaces can contain stopper rod assemblies
- Computerized control and SCADA systems
- Rapid Exchange Furnace Systems – Allows a hot furnace to be removed with external cooling and a second preheated furnace to be installed quickly, without the need to make or break furnace tilt connections or insulated electrical connections.

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VIM - Chamber Design

Consarc designs a static VIM melting chamber which is adequately sized and designed to operate in this harsh environment. The system is designed to operate for many consecutive melting cycles without the need to break vacuum for cleaning or furnace charging between melts. This simple design philosophy ensures that the VIM furnace offers the highest possible productivity in operation.

Access to the melt chamber containing the induction melting unit is in accomplished in two ways.

Rollaway Head

Rollaway Head Furnaces have the following features:

- Good access to the furnace top and spout
- Simple power supply buss
- Good ability to inspect the lining and furnace coil
- Able to frit lining or perform wash heat in open air

Door Mounting

Door Mounted Furnaces have the following features:

- Very easy access to melt chamber for cleaning
- More complicated power supply buss required
- Easy access to all of coil
- Less platforming required since no head movement

VIM — Pouring Design

Consarc designs all VIM furnaces such that the pouring is accomplished by inserting a tundish in line with the direction of pour, not perpendicular to the direction of pour, and without the use of a launder, as is required in tilting chamber type systems (VIDP). This significant design criteria means that Consarc VIM furnaces have the following advantages:

- Shorter tundishes - less refractory cost
- Shorter tundishes - easier handling from external preheater to tundish insertion chamber
- Shorter tundishes - less pouring superheat required
- Less pouring superheat required - less gas (such as [N]) in solution at time of pour
- Less gas in solution at time of pour -possibility of removal of precipitated non metallic inclusions (such as TiN) by filtering
- Tundish in line with pour stream - ability to pour rapidly
- Ability to pour rapidly - possibility of bottom filling of molds (uphill casting)

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