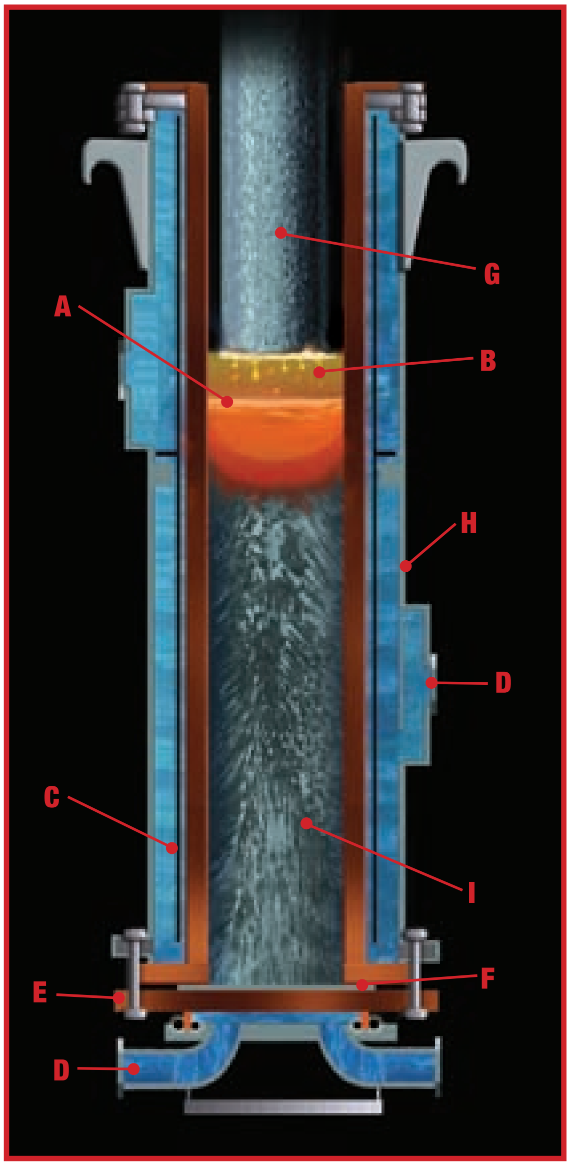
CONSARC
An Inductotherm Group Company

Electroslag Remelting Furnaces



A Molten Pool
B Molten Slag
C Water Guide
D Water Cooling
E Baseplate
F Clamped Starter Plate
G Electrode
H Water-cooled Mold
I Ingot

ESR — The Process

The ESR process involves the gradual melting of the lower end of a cast or forged electrode through a layer of molten metallurgically active slag into a water-cooled copper mold. The slag is usually calcium fluoride with the addition of lime, magnesia, and other oxides.

In its molten state the slag is electrically conductive and acts like a resistance heating element when a high current is passed between the electrode and the mold. With the continued passage of the electric current, the slag becomes superheated.

The electrode tip is immersed in this superheated slag and begins to melt. The immersion of the electrode in the slag is precisely maintained and a controlled melt rate is established. An advanced computer control system maintains the melt rate and electrode immersion utilizing custom designed algorithms taking into account measurements from the load beam weighing system, measurements of the furnace voltage (or resistance); and control of the power supply current.

The molten metal droplets sink through the lower density molten slag and re-solidify in the water-cooled copper mold. Through this process the slag-metal reactions dissolve inclusions and purify the metal as it falls through the molten slag.

After the process has continued for some time, a purified ingot having a controlled solidification structure is built up in the mold. The slag floating on top of the liquid metal pool also acts to prevent oxidation of the molten metal when melting in air. It is also common for the ESR process to take place in an inert gas environment to further prevent oxidation of the slag.

Toward the end of the process, the power is gradually reduced providing a controlled hot top. The resulting ingot is structurally sound, chemically homogeneous, and provides a high yield of useful product.

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Background - Consarc ESR Technology Breakthroughs

In the 1960s Consarc's engineers conceived a new approach to elctroslag remelting, quite different from others in use at the time. The resulting improvements in the efficiency and performance of the process established Consarc as the leading manufacturer of ESR systems worldwide.

What Consarc's engineers did was to combine the use of a "high fill ratio" electrode (an electrode whose diameter approached that of the crucible) with an AC line frequency furnace design in which the main power conductors were arranged coaxially around the melt zone. The high fill ratio electrode provides significant benefits including:

- reduced power consumption
- increased ingot quality
- improved ingot surfaces

The coaxial conductor system allowed the use of smaller, more efficient power supplies and decreased undesirable magnetic stirring of the melt. Moreover, it virtually eliminated the stray field eddy current heating of surrounding steelwork which had characterized all prior ESR furnace designs and allowed magnetic interaction between adjacent melts.

The principles of this coaxial design are incorporated in all ESR furnaces produced by Consarc.

Electroslag Remelting Furnaces

Some Features of the Modern Consarc ESR Furnace are:

- Fully coaxial
- Precision electrode drive
- Fully automated melt control
- X-Y electrode centering
- Inert gas melting capable
- Dry air melting capable
- Slab ingot capable
- Liquid slag starting
- Dry slag starting
- Purpose designed AC power supplies

Consarc has built the world's largest single electrode static ESR with a final ingot weight of 110,000 kg. Consarc also builds electrode change furnaces utilizing withdrawal melt stations and two head three melt station furnaces combining both single electrode static and multiple electrode withdrawal melting into one system.

Static Furnace Configurations

Consarc's static ESR furnaces are available in the following standard sizes as well as custom sizes to meet any customer requirements. Slab (rectangular) ingot capabilities can also be added to static melt systems.

DESCRIPTION	20" (500 mm) ESR	26" (650 mm) ESR	30" (760 mm) ESR	36" (900 mm) ESR	40" (1000 mm) ESR	44" (1100 mm) ESR	48" (1200 mm) ESR
Maximum Ingot Weight	4,000 kg	6,000 kg	10,000 kg	15,000 kg	20,000 kg	30,000 kg	35,000 kg
Maximum Crucible Diameter	508 mm	650 mm	760 mm	914 mm	1016 mm	1117 mm	1219 mm
Baseplate Dimension	825 mm (32.5")	1016 mm (40")	1016 mm (40")	1219 mm (48")	1372 mm (54")	1372 mm (54")	1473 mm (58")
Power Supply Rating	15,000 amps	20,000 amps	25,000 amps	30,000 amps	35,000 amps	40,000 amps	40,000 amps
Maximum Ram Travel	90" (2286 mm)	90" (2286 mm)	90" (2286 mm)	90" (2286 mm)	90" (2286 mm)	90" (2286 mm)	90" (2286 mm)

Inert Gas Melting

900 mm Inert Gas Furnace

A new trend is emerging in ESR melting that involves melting of Oxygen and Nitrogen sensitive alloys under an inert gas enclosure. The major benefits of the inert gas melting system, besides very low oxygen and nitrogen levels, are as follows:

- The system is fully enclosed preventing the possibility of contamination from the melt shop during melting
- Different slags can be used because the oxidation of the slag is no longer a concern
- No deoxidant is required. Deoxidant has been shown to be a principal source of inclusions in ESR ingots.

For inert gas melting the crucible top is sealed by an enclosure, into which an inert gas is fed. The enclosure consists of three pieces, a bottom plate, a main enclosure and a movable top enclosure. The bottom plate has a central opening sized to fit onto a crucible of a particular diameter. The main enclosure is common to all crucible sizes. One main enclosure is supplied for each melt station. The top movable enclosure is integral to the furnace head and includes the ram seal assembly and exhaust ports.

1000 mm Inert Gas Furnace

The system is designed to operate at essentially atmospheric pressure, with a small, continuous flow of inert gas preventing entry of the surrounding air. A standpipe is used to bleed off excess gas as the inert gas periodically expands due to temperature changes caused by internal convective flows. Fumes escaping through the standpipe are extracted by the fume extraction plenum mounted atop the enclosure.

Because the system is totally enclosed within a protective atmosphere, a sealed slag feeder is used to prevent admittance of air to the enclosure. The slag feeder is purged with argon gas prior to adding the slag to the system.

1200 mm Inert Gas Furnace

An inert gas manifold with valves and flow meters is supplied in order to regulate the flow of argon gas from the customer's supply to the enclosures, as well as to the sealed slag feeder and to a purge hose. This purge hose is used for initial purging of a crucible that has just been loaded into a melt station. The system includes an oxygen monitor with pump, which can be connected to whichever station is melting, ensuring that a low level of oxygen is maintained throughout the melt. The oxygen monitor includes a local display, as well as an analog signal to the control system for monitoring and data logging. The inert gas system includes the necessary pressure regulators, flow meters, valves and particulate filters. Dry, cryogenic Argon is to be supplied by the customer.

NOTE: Because of the use of Inert Gas, Oxygen sensors should be placed inside the pit.

Proprietary High Current AC power supply (Reactor Based)

20,000 amps

40,000 amps

Capacitor Bank

Consarc is the only ESR furnace supplier that designs and builds our own custom designed AC power supplies. These units are specifically designed to meet the demanding requirements of the ESR melting application. This provides Consarc ESR customers with a single source responsibility for the complete ESR and power transmission system.

Consarc offers only Saturable Core Reactor based power supply technology for use in our ESR furnace systems. All systems are internally water cooled by a dedicated, dual pump, closed loop, water pumping module which substantially reduces the overall power unit footprint, and offers exceptional reliability with low operating/maintenance costs.

Melt current is regulated by torridly wound saturable core reactors that connect to the primary of a single-phase step down transformer. Modulating DC saturating current applied to the reactors regulates the current output. The saturating current changes the impedance of the reactors and permits a, smooth, step less proportional method of current control.

Control of the saturating current is performed by a current controller triggering phase angle fired SCRs connected to the primary of a saturating transformer. A current sensing device situated in the primary of the main single-phase step down transformer provides feedback to the current controller.

The power supply components are located inside a completely enclosed NEMA 12 fabricated steel enclosure. Windows and lights are provided for visual observation of the various components within the power supply cabinets. Access to the controls section of the power supply is through front opening doors. Access to the high voltage section is via removable bolt on panels. For the benefit of maintenance personnel, lighting and a power tool outlet are provided in the interior of the enclosure.

Power units are available with ESR furnace systems or as stand alone replacements for existing ESR furnaces.

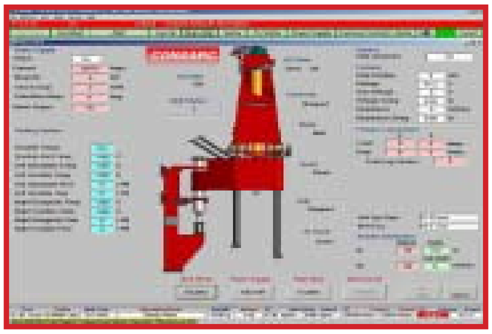
Automatic Melt Controls

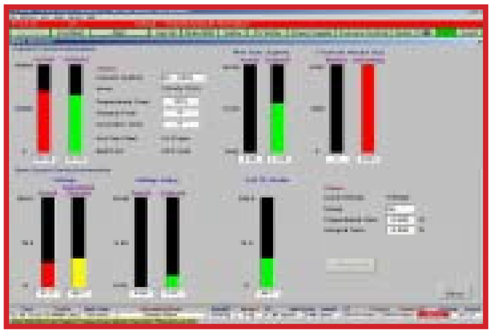
Consarc pioneered in Automatic Melt Controls in the early 1970's. At that time, before personal computers, melt rate was maintained using programmable calculators while operators adjusted the electrode immersion by changing the 'swing' voltage settings. 35 years later, Consarc is on its 7th Generation of Automatic Melt Controls.

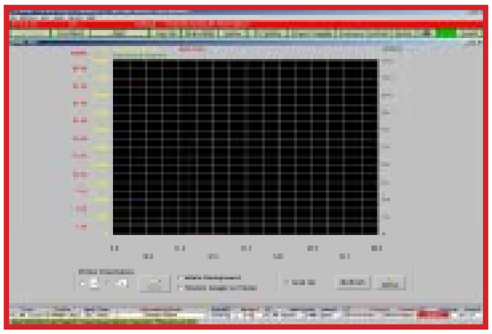
The Generation 7 Automatic Melt Controls are a full SCADA system (System Control And Data Acquisition) consisting of a PLC and a Personal Computer interface. The PLC controls the furnace logic functions and sequencing along with processing all of the melt rate calculations. Electrode immersion is maintained utilizing voltage (or resistance) swing control algorithm. The magnitude of the voltage (resistance) swing is a good indicator of the depth of immersion of the electrode in the slag, with high swing representing low (or no) immersion and low swing representing high immersion. The PC serves as the Human Machine Interface (HMI) to the furnace allowing components like water pumps to be controlled, remelt profiles to be created and stored, and furnace data to be logged, stored, and analyzed.

The Generation 7 remelt profile separates the melt into 3 segments – Ramp Up, Main Melt, and Hot Top. Each segment can be further broken into up to 10 sequences offering a nearly unlimited ability to customize and fine tune the remelt profile. Once the remelt profile is accepted, the operator initiates the power supply and start-up sequence. The control system automatically positions the electrode and sequences the power and drive systems depending on whether a cold slag start or liquid slag start to the melt is commencing. The entire melt progresses automatically through the segments until the hot top alarm weight is reached and the operator is prompted to turn off the power supply.

Full data logging is provided for all measured and set point data including power input, current, voltage, resistance, melt rate, ram travel, ram speed, water flows, water temperatures, alarms and errors. The software allows analysis by graphing multiple logged values at user selected time intervals. This allows a detailed look into the melt and is invaluable for process analysis and optimization.







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