Clean, Quiet, Cost-Effective Metals Melting

The Process
In very general terms, an induction melting furnace can be defined as an apparatus that induces an electric current in the electrical conducting charge material to be melted. This is done by electromagnetically coupling the charge with the coil carrying an alternating current. The current in the coil induces eddy currents in the charge which heats and melts the metal.

The two most common induction melting furnace designs are the coreless furnace and the channel furnace. Coreless melting furnaces have a refractory envelope that contains the metal and is surrounded by the coil. Operating on the basis of the transformer principle, the charge acts as a single secondary turn, thereby producing heat when power is applied to a multiturn primary coil. When the metal is molten, agitation occurs naturally due to electromagnetic forces. This stirring action is inversely proportional to the square root of the frequency and directly proportional to the power. Mixing and melting rates can be controlled by carefully selecting frequency and power.

Channel induction furnaces were used initially as molten metal holders, but are now used for some melting applications as well. An inductor, comprised of a water-cooled coil, is the energy source. A channel is formed in the refractory through the coil, and this channel forms a continuous loop with the metal in the main part of the furnace. The hot metal in the channel circulates into the main body of the metal in the furnace envelope and is replaced by colder metal.

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Unlike the coreless induction furnace, a source of primary molten metal is required for the startup of a channel furnace. These furnaces do have lower surface turbulence within the main metal bath. Thus, coreless furnaces are more acceptable where gas pickup and volatile metal alloy loss is a problem. Hence, channel induction furnaces are often desirable for holding metal at temperature.

While channel furnaces are all line frequency, coreless furnaces are either line frequency (60 Hertz), medium frequency (200 Hertz through 1,200 Hertz) or high frequency (over 1,200 Hertz). Line frequency furnaces are slow to start from a cold charge. This has resulted in growing use of medium and higher frequency units. Improvements in frequency converters and lower costs have also aided acceptance.

Advantages of Induction Melting

- **Higher yield.** The absence of combustion reduces oxidation losses. This can amount to 2 to 7 percent yield savings in aluminum melting.
- **Fast startup from cold.** Full power from the power supply is available, instantaneously, thus reducing the time to reach working temperature.
- **Flexibility.** No molten metal is necessary with medium frequency coreless induction melting, facilitating repeated cold starting and frequent alloy changes. Cold charge-to-tap times of one to two hours are common.
- **Natural stirring action.** Medium frequency units can give a strong stirring action resulting in a homogeneous melt.
- **Cleaner melting.** No by-products of combustion means cleaner melting and no high-cost pollution control systems.
- **Safe automatic operation.** Precise control of power through automation requires furnace attendance only for charging, tapping, and metallurgical measurements.

- **Compact installation.** High melting rates can be obtained from small furnaces. A coreless furnace capable of melting 2,500 lbs./hr. of aluminum has a crucible measuring 3' in diameter by 6' in depth.
- **Reduced refractory needs.** Due to compact size in relation to melting rate, induction furnaces require much less refractory than fuel-fired units. New hydraulic ram systems allow relining times to be greatly reduced as old worn linings can be quickly “pushed out” for easy replacement.
- **Better working environment.** Induction is much quieter than gas furnaces, arc furnaces, or cupolas. No combustion gas is present and waste heat is minimized.
- **Energy conservation.** This is an important feature of induction melting compared to other processes. The introduction of advanced solid-state converters has raised the efficiency of frequency conversion to over 97 percent. Energy efficiency in melting, ranging from 55 to 75 percent, is much better than combustion processes.
- **Declining capital costs.** Through a combination of increased electric efficiency and faster melt rates, the cost of equipment per useful kilowatt of heating capacity has actually decreased after adjusting for inflation.
Typical Applications

Metal Melting

Aluminum - The use of coreless induction units for melting aluminum has gained acceptance in recent years. Higher yields, more uniform quality, and greater thermal efficiency are all responsible. When aluminum is melted using fossil fuels, oxidation losses can range from 2 to 20 percent. Electric induction melting can reduce these losses to only a few percent. The stirring action of induction improves quality by balancing chemical composition and bath temperature. Thermal efficiency for coreless melting of aluminum is approximately 55 to 65 percent compared to 20 to 50 percent with gas-fired reverberatory units. Channel furnaces, which have been successfully used in Europe, have even higher efficiencies, 70 to 75 percent.

Iron - Coreless furnaces are widely used for melting all grades of cast iron. These compact units ranging up to 70 tons in capacity offer foundries close control of chemistry and temperature as well as operating flexibility. Compact size is a definite advantage. Charge material can be either light or heavy scrap, including pig iron, and the use of direct reduced pellets has been demonstrated. Usually no separate pollution control equipment is needed compared to the expensive investment required for a cupola. Coreless furnaces can efficiently be used as holding furnaces in conjunction with other melting units. This procedure is called duplexing. If slower melting rates are acceptable, attractive off-peak power rates can be utilized.

Steel - Coreless induction furnaces have gained wide acceptance for the melting of both carbon/low-alloy and high-alloy stainless steels in foundry applications. The advantages listed for iron melting apply for steel as well. Recently, medium-frequency coreless melting is beginning to be used to provide liquid iron for finishing in a basic oxygen furnace (BOF) or an argon-oxygen-decarburization (AOD) unit.

Other metals - Other important applications for induction are for melting zinc, brass, bronze, and other nonferrous metals and alloys.

Metal Holding

Channel induction furnaces are primarily used for holding metal previously melted either in coreless furnaces or in cupolas or gas-fired furnaces. Off-peak power rates can often be utilized with heavy melting in low power rate periods. For one hour of holding, the additional value of energy required usually varies from 4 to 18 kWh per ton of molten metal.
**SUMMARY**

Induction furnaces are well-established for the melting and holding of iron, steel, aluminum, zinc, brass, and copper. High efficiency and the ability to precisely control the rate of heat input make this electric-based technology fully competitive with alternative direct-fired processes in many applications. New developments in variable-frequency power supplies, improved refractory linings, high-power inductor designs, furnace heat recovery, and computer control of furnace operations offer the potential for further significant improvements in furnace efficiency, productivity, and in the range of materials to which induction melting can be applied. For further information consult the Electric Power Research Institute reports: 1) "Induction Melting of Metals: State-of-the-Art Assessment," EM-4508, April 1986; 2) "Electricity and Industrial Productivity," EM-3640, 1984, and 3) CMP Report "Melting of Aluminum by Electricity," CMP No. 91-3.

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**FURNACE SIZE** (in.)

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<th>LINING THICKNESS</th>
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<th>HEIGHT</th>
<th>HEIGHT WITH COVER</th>
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Representative dimensions for iron melting coreless induction furnaces.

Source: Inductotherm

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