Heating Billets ready for Diecasting

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Take an aluminum alloy billet 6 in diameter and 20 in long. You have to heat one every minute to uniform slush consistency (585 º C) ready for diecasting.
Convection and radiant heating cannot make the required speed or put the heat uniformly throughout the volume. The center would still be cold while the outside is melting.

Consider **induction heating** using a water-cooled coil around the axis of the billet (looks like a bar electromagnet). This technique can put heat deep into the billet.

If you have mathematical talents, some knowledge of magnetic fields and experience on your last few jobs you can calculate the magnetic flux density and frequency that will provide the required heat input. Then you can calculate the power to put into the coil. You can now juggle with number of turns and cross section of the coil conductor; these being dictated largely by the power needed and the coil voltage you want to use.
The billet becomes the secondary of a loosely flux-linked transformer. Its induced current circulates in a concentric cylinder pattern round the billet axis. The current density therefore the power density, (watts/cc) increases with radius (called **skin effect**). This heat distribution is nothing like as bad as with convection heating - but you still have to deal with the threat of the skin melting before the inside does.
Two factors can work for you.
1. The good **thermal conductivity** of the alloy speeds up evening out of the heat.
2. Skin effect becomes less and power density becomes more uniform as you reduce the **frequency** of the ac supply.
There is a limit to how low you can take the frequency because the power put into the billet comes down as the square of frequency. A combination of calculation and testing yields an optimum frequency around 18Hz for this billet size.

Your knowledge of temperature distribution inside the billet will be very limited. This is important for process investigation and development. A normal sheathed thermocouple even with the junction welded just inside the tip does a poor job of picking up the surface temperature. A good and economical solution is the **billet probe** or **foundry probe –** a pair of spring-loaded spikes, usually of Chromel and Alumel. These make a thermocouple in intimate thermal contact when you prod the billet. The spikes are connected by thermocouple extension cable to your temperature indicator. The metal you are prodding completes the hot junction but makes no thermoelectric interference with the measurement. Surface measurements taken along the length and at different radii at the billet end, along with your knowledge of speed of **heat diffusion** give you some idea of temperature distribution. You can take these measurements when the power is on and temperature rising also when power is off and temperature is evening out. A uniformity of some 5 - 10 º C is attainable at the final temperature of 585 º C. Numerical methods of computation such as **finite element modelling** can give a fairly accurate picture of the temperature profile. Your final test is of course the quality of the casting.

Your **power-supply** will be a rectifier/inverter with output frequency adjustable over the range optimum for your range of billet sizes. The power source can be **any three phase 50 or 60 Hz service** normally found at industrial locations.
Efficiency. With this particular case, of the 200kW of power that comes from the 60Hz supply you will get about 50% into the billet. The rest goes into losses in the inverter, induction heater coil, metalwork and cabling.

Temperature Monitoring. Most temperature monitoring systems will be defeated by the high level of interference from some 200kW of ac magnetic field.

I recommend that here you look to established makers of industrial temperature controllers and indicators. They have seen and learned to design against every kind of interference. Note that you are looking for some 30mV of dc signal in an electromagnetic storm

Power Monitoring.

As production monitoring tools you need instruments for power (kW) and energy (kWh) usually combined in one unit. The power level during the heating cycle and the integrated dose of energy into the coils will be critical measurements.

Production Rate

The complete heating cycle of a billet takes about 5 minutes so to achieve the aforementioned rate of one per minute you need five parallel heating stations starting successively one minute apart to deliver one billet per minute to the die.

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I thank Bradley Controls for the information used in this column.

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