CLOSER LOOK: Solid-State Converter Power Circuit

A solid-state power converter consists of three sections: the rectifier section, the inverter section, and the output section, which includes the load coil and is usually located outside the power supply. Exhibit 665.1 shows an example of an enclosed power supply for an induction heating process.

The rectifier section converts 3-phase, line frequency voltage to direct current. The output of the rectifier section supplies energy for the inverter section. The inverter section converts the energy to a variable frequency for the output circuit. The variable output frequency controls the power delivered to the load.

The output section consists of a capacitor in parallel (current fed) or in series (voltage fed) with a coil. Capacitance and inductance operate at a resonant frequency, and as the output frequency approaches the resonant frequency, the power to the load approaches its maximum. The output power is very low at minimum frequency.

Induction Heating

Induction heating occurs when an electrically conductive material (load) is placed in a varying magnetic field generated by a coil (inductor) around or adjacent to the workpiece to be heated. The varying magnetic field induces current in the load. Heat is generated by the resulting I^2R losses in the load. Induction heating can be further subdivided into heating, melting, and welding.

Induction heating raises the temperature of the load to a temperature below its melting point, usually for the purposes of hardening, tempering, annealing, forging, extruding, or rolling. Frequencies used for heating range from about 50 hertz to 500 kilohertz. Power levels range from 5 kilowatts to 42 megawatts.

EXHIBIT 665.1 *Enclosed power supply for an induction heating process. (Courtesy of Ajax Tocco Magnethermic, Park Ohio Industries)*

EXHIBIT 665.2 *A solid-state induction welding machine. (Courtesy of Thermatool Corp.)*

Induction melting raises the temperature of the load to a temperature above its melting point, so the molten material can be alloyed, homogenized, and/or poured. Frequencies used for melting range from about 50 hertz to 10 kilohertz. Power levels range from 5 kilowatts to 16.5 megawatts.

Induction welding is primarily used in the manufacture of welded pipe and tubing. In this process, a high-frequency current is passed through an induction coil in the proximity of the conducting metal surfaces to be joined. Selected portions are heated nearly instantaneously to the forging temperature, then are joined under pressure to produce a forge weld. Frequencies used for welding range from about 100 to 800 kilohertz. Power levels range from 20 kilowatts to 1 megawatt. Exhibit 665.2 shows an induction welding machine used in the manufacture of pipe and tubing.

Dielectric Heating

Dielectric heating equipment is similar to induction heating equipment, except that it is used to heat nonmetallic materials as opposed to metals. Typical applications include the drying of textiles after dyeing, drying of water-based coatings on paper, preheating of wood fibers for the medium-density fiberboard (MDF) industry, welding of plastic materials, and food processing.

At radio frequencies, the material to be heated forms a dielectric when placed between metal capacitor plates connected across the output of the generator. A high-frequency alternating electric field is created between the electrode plates. The molecules vibrate in the dielectric field, causing dissipation of energy through the material and frictional heating of the dielectric material. At higher (microwave) frequencies, a similar process occurs, but the generator is coupled to a resonant cavity into which the dielectric material is placed.

The frequency of operation of dielectric heating equipment is considerably higher than for induction heating. These machines operate at the assigned radio frequencies of 13.56, 27.12, and 40.68 megahertz or at microwave frequencies of 915 and 2450 megahertz.

The power for these machines ranges from 0.5 kilowatt to 1 megawatt.