

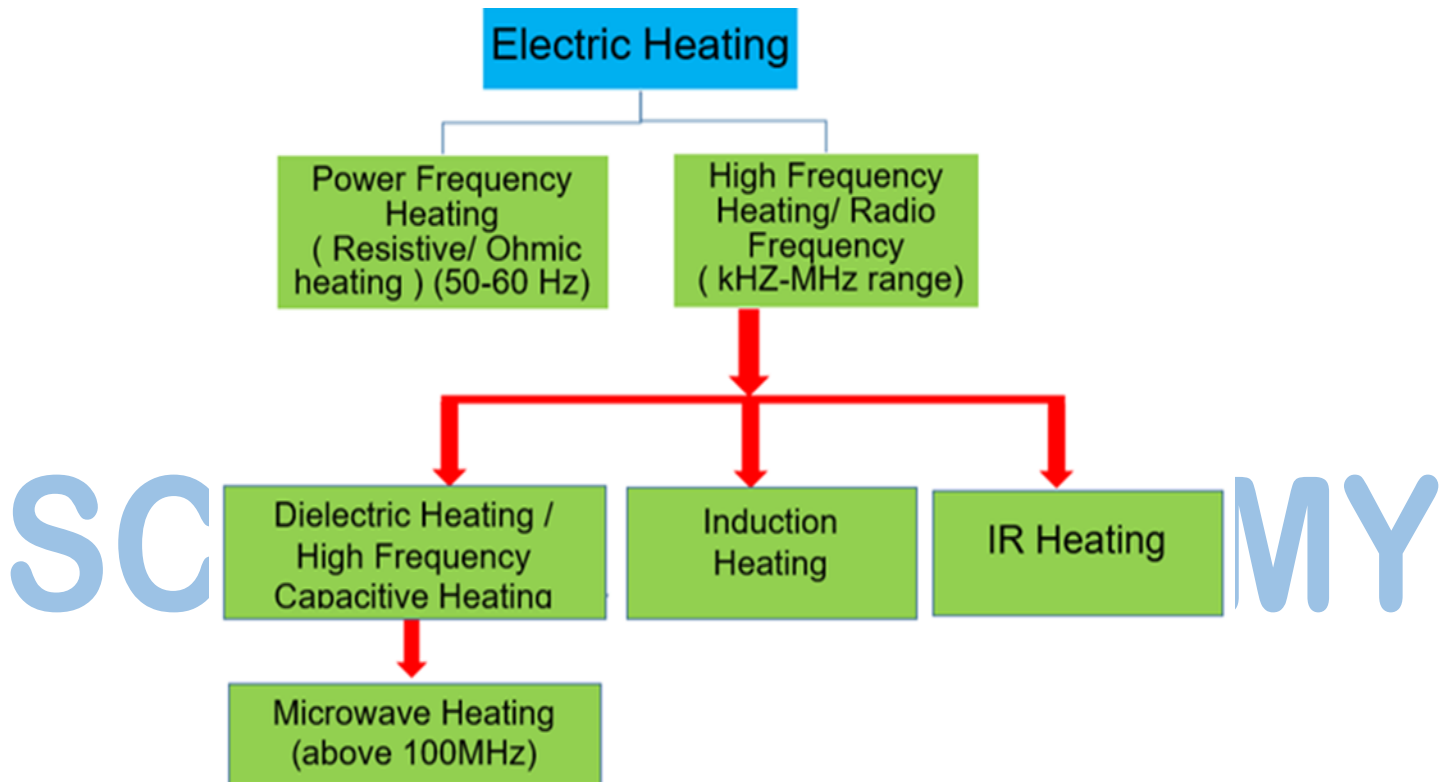
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Electric Heating

Electric Heating is a process in which electrical energy is converted to heat energy. According to the *Joule's Law* the resistance Loss $I^2 R t$ is used to producing the heat from electrical energy for various industrial purposes like electric heating, welding etc.

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Classification of Electric Heating

Power Frequency Heating

1. Electric Resistance Heating

Electric Resistance Heating is defined as “the heat produced by passing an electric current through a material that has **high resistance**.” As the current passes through the material, ohmic losses (**$I^2 R$ losses**) occur. These losses cause the conversion of electrical energy into heat.

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There are two methods of electric resistance heating:

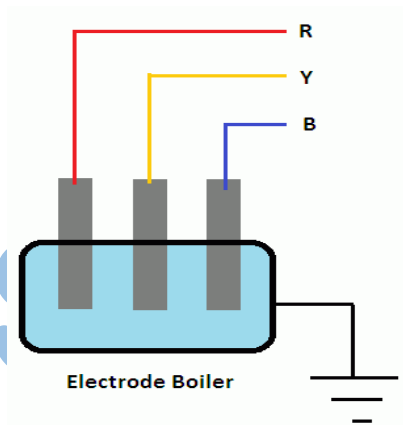
1. Direct electric resistance heating
2. Indirect electric resistance heating

1. Direct electric resistance heating

In **direct** electric resistance heating, the current is passed **directly through the material** that has to be heated, for example, **resistance welding, electrode boiler, salt-bath furnace**.

Direct electric resistance heating

Current is passed through the fluid to be heated via electrodes



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2. Indirect electric resistance heating

In **Indirect** electric resistance heating, the current is passed through a highly resistive material placed inside an oven, for example **room heaters, immersion heaters, resistance ovens, domestic and commercial cooking and heat treatment of metals**.

Indirect electric resistance heating

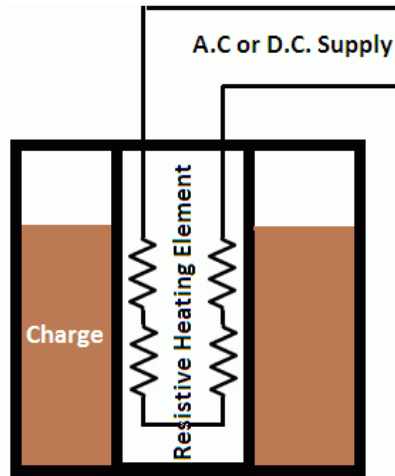
In the indirect resistance heating, the current does not flow through the body to be heated but it flows through the resistance elements which get heated up. The **heat is then transferred** from the heating element to the charge mainly by **radiation or convection**

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Indirect electric resistance heating

Immersion Heaters (e.g. of Indirect Resistance Heating)



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High Frequency Heating

1. Induction Heating

Induction heating is the process of heating an electrically conducting object (usually a metal) by **electromagnetic induction**, through heat generated in the object by **eddy currents**.

An induction heater consists of an electromagnet and an electronic oscillator that passes a high-frequency alternating current (AC) through the electromagnet. The rapidly alternating magnetic field penetrates the object, generating electric currents inside the conductor, called eddy currents. The eddy currents flowing through the resistance of the material heat it by Joule heating.

An important feature of the induction heating process is that **the heat is generated inside** the object itself

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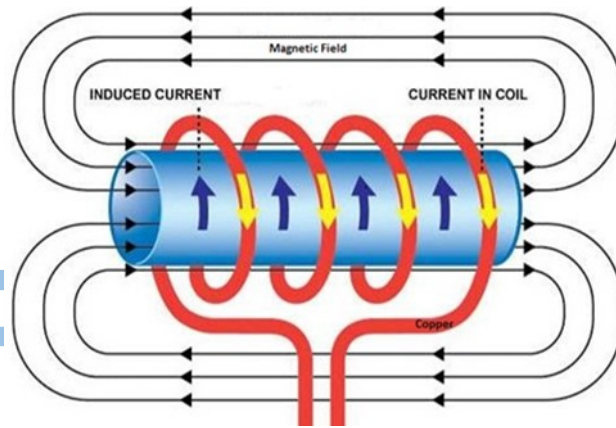
Working Principle:

Large AC current are sent through the copper coil. The large current in the coil generate strong magnetic fields. These magnetic field lines causes cause **EDDY currents** (electrons to flow internally within the piece of metal).

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Frequency of the magnetic field lines is tuned based on the object size and material composition. Properly tuning the pulse frequency causes stronger eddy currents. The natural electrical resistance of the metal and the strong eddy currents eventually make the metal hot enough to melt.

Internally what happens in Induction Heating??



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Induction Heating



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Applications:

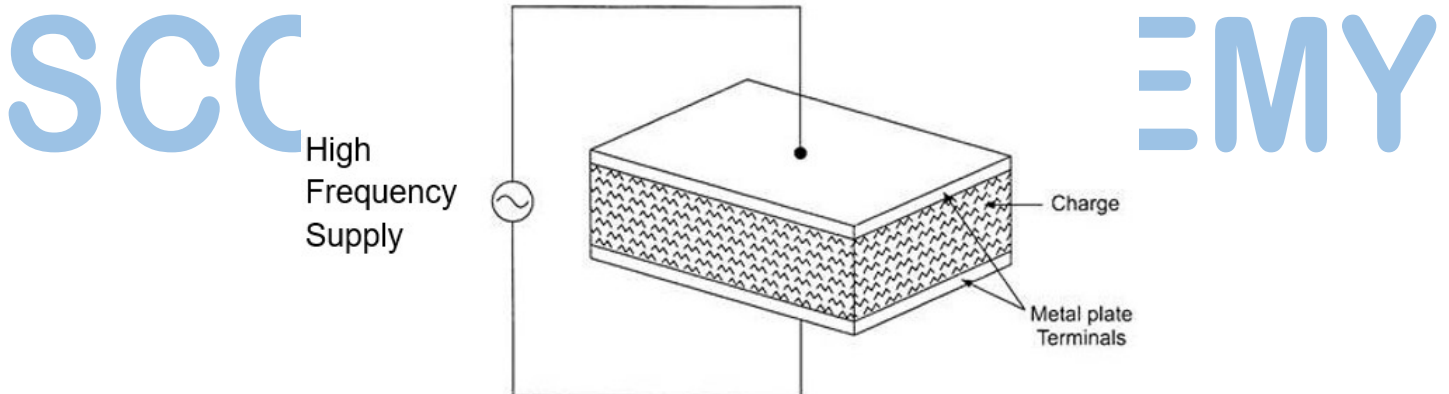
1. Heat treatment in metallurgy
2. **Zone refining** used in the semiconductor industry
3. To melt refractory metals that require very high temperatures.
4. It is also used in induction cook-tops for heating containers of food; this is called **induction cooking**.
5. **Plastic processing**: Induction heating is used in plastic injection moulding machines

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2. Dielectric Heating (or Electronic Heating or Radio Frequency Heating)

Dielectric heating is the process in which a radio frequency (RF) alternating electric field, or radio wave or microwave electromagnetic radiation heats a dielectric material. At higher frequencies, this heating is caused by molecular dipole rotation **within the dielectric**.

Dielectric Heating



In dielectric heating, it is **desirable** to use **HIGH FREQUENCY** than high voltage

Dielectric heating involves the heating of electrically insulating materials by dielectric loss. Frequencies in the range of **10–100 MHz** are necessary to cause dielectric heating.

In dielectric heating the heat is produced within the material itself. Because heat generation is uniform, the dielectric material is heated uniformly. This is the important property of dielectric heating.

Note: *The AC Bridge used to find the dielectric loss / dissipation factor??*



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Ans: **Schering's Bridge**

Applications: (Most number of applications)

1. Preheating of Plastic Preforms (moulds)
2. Gluing of Wood (plywood manufacturing), furniture industry
3. Baking of foundry cores (in casting & moulding industry)
4. Diathermy (Dielectric heating is also employed for heating tissues and bones of the body required for the treatment of certain types of pains and diseases.
5. In agriculture to kill pests
6. Sterilization: The dielectric heating is quite suitable for sterilization of bandages, absorbent cotton, sterile gauge, instruments
7. Textile Industry
8. **Food Processing:** The use of dielectric heating for food processing is one of the most modern methods. It has brought many advantages for the food processing industry

The dielectric heating can be appreciably employed for the following purposes:

- a. **Pasteurising of milk** and beer inside bottles.
- b. **Dehydrating of fruits, milk, cream, vegetables and eggs** etc.
- c. Cooking of foods without removing the outer shells.
- d. Defrosting of frozen foods such as meat and vegetables.
- e. **Germicidal heating**-In dielectric heating process the products do not lose flavour.

Disinfestation of cereals and grains-Dielectric heating may be used to destroy the eggs of insects and pests saving grains and cereals from damage and also to prevent these eggs, larva or moth etc. to pass on to cereal processing equipment and develop into dangerous worms later on under favourable conditions of temperature and humidity.

Note: The cost of the equipment required for dielectric heating is so high that it is employed where other methods are impracticable or too slow.

Microwave Heating: Above 100 MHz, Dielectric Heating is categorised as Microwave heating.

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Modern **microwave ovens** make use of electromagnetic waves with electric fields of much higher frequency and shorter wavelength than RF heaters.

Domestic microwave ovens operate at **2.45 GHz - 915 MHz range**. This provides for highly efficient, but less penetrative dielectric heating

Microwave volumetric heating is a commercially available method of heating liquids, suspensions, or solids in a continuous flow on an industrial scale.

Application for microwave volumetric heating:

- **Pasteurization**
- Microwave chemistry
- Sterilization
- Food preservation
- Biofuel production

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NOTE:

For **SSC JE / Sub Engineer level exams**, an overall idea of Electric Heating is sufficient (Please refer to course outline shared in class).

Points indicated in **RED** should be carefully studied.

Applications of each methods are asked frequently in SSC JE/ Sub-Engineer level exams

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Additional exam specific points are discussed in our class / Q&A Sessions. Please complete the same before final exams



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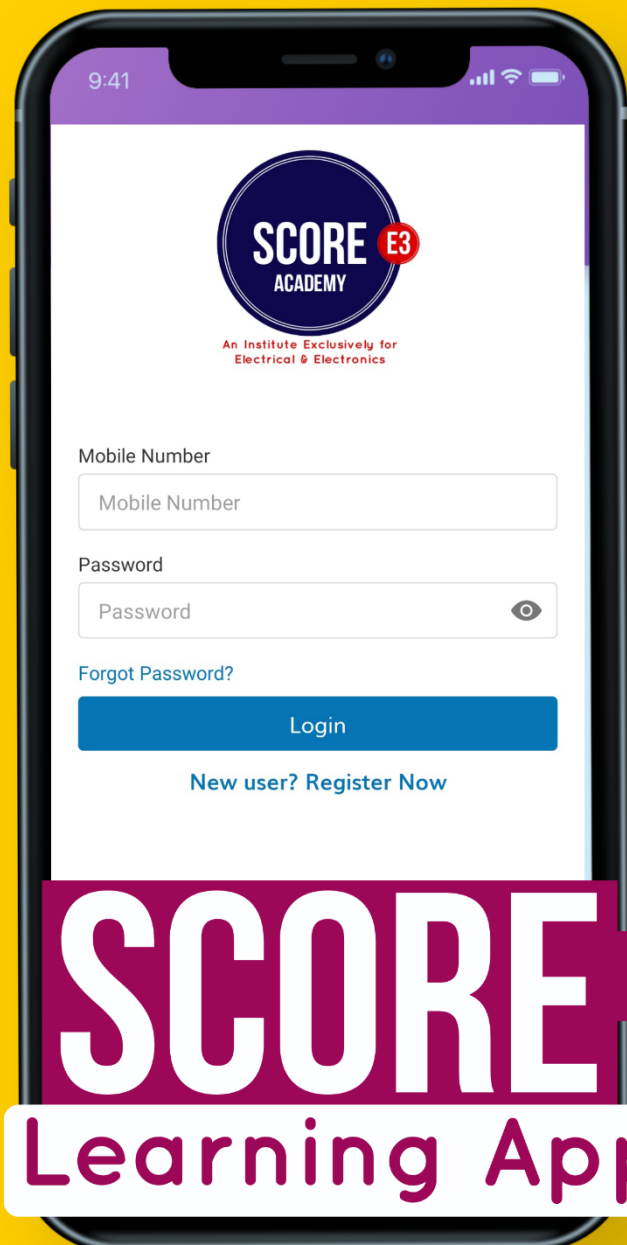
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