FURNACES

Reference: 4. Furnaces (Bureau of Energy Efficiency)

Syllabus

Furnaces: Classification, General fuel economy measures in furnaces, Excess air, Heat distribution, Temperature control, Draft control, Waste heat recovery.

Definitions:—	
■	A furnace is a device used for heating. The name derives from Latin Fornax; oven.
■	The Oxford English Dictionary defines a furnace as 'an enclosed structure for intense heating by fire, esp. of metals, whereas a kiln is described as 'as furnace or oven for burning, baking or drying, esp. for calcining lime or firing ceramics'.
■	A furnace is an equipment to melt metals for casting or heat materials for change of shape (rolling, forging etc.) or change of properties (heat treatment).

Usage of furnaces		
■	A blast furnace performs basic melting (of iron ore) operation to get pig iron, cupola furnace is used for getting cast iron and an electric arc furnace is used for re-melting steel	
■	Different furnaces are employed for melting and re-melting ferrous and nonferrous materials.	
■	A furnace contains a high temperature zone or region surrounded by a refractory wall structure which withstands high temperatures and being insulating minimizes heat losses to the surroundings.	
■	Since flue gases from the fuel come in direct contact with the materials, the type of fuel chosen is important. For example, some materials will not tolerate Sulphur in the fuel. Solid fuels generate particulate matter, which will interfere the materials placed inside the furnace. For this reason : —	
	●	Most furnaces use liquid fuel, gaseous fuel or electricity as energy input.
	●	Induction and arc furnaces use electricity to melt steel and cast iron.
	●	Melting furnaces for nonferrous materials use fuel oil.
	●	Oil-fired furnaces mostly use furnace oil, especially for reheating and heat treatment of materials.
	●	Light diesel oil (LDO) is used in furnaces where sculpture is undesirable.

1.1 Classification of Different Furnaces

Based on: —

1-	**Heat generation**					
	Based on the method of generating heat, furnaces are broadly classified into two types namely:—					
	(i)	Combustion type (using fuels) and			(ii)	Electric type.
2-	**Kind of fuel**					
	In case of combustion type furnace, depending upon the kind of combustion it can be broadly classified as:—					
	(i)	oil fired,	(ii)	coal fired or	(iii)	gas fired
3-	**Mode of charging**					
	Based on the mode of charging of material furnaces can be classified as					
	(i)	Intermittent or Batch type furnace or Periodical furnace and				
	(ii)	Continuous furnace.				
4-	**Heat recovery**					
	Based on mode of waste heat recovery as recuperative and regenerative furnaces.					
5-	**Mode of Heat transfer**					
	Another type of furnace classification is made based on mode of heat transfer, mode of charging and mode of heat recovery as shown in the Figure 4.1 below					

Table 2. Classification of furnaces

No.	Types and examples		Classification method		
1-	Methods of Heat generation	(i)	Combustion (using Different fuels)	(i)	Oil-fired
				(ii)	Gas-fired
				(iii)	Coal-fired
		(ii)	Electricity type.	(i)	Electric Resistance Furnace
				(ii)	Plasma Melting Furnace
				(iii)	Induction Furnace
2-	Mode of charging materials	(i)	Intermittent Or Batch Or Periodical	(i)	Forging
				(ii)	Re-rolling (batch/pusher)
				(iii)	Pot
		(ii)	Continuous	(i)	Pusher
				(ii)	Walking beam
				(iii)	Walking hearth
				(iv)	Continuous recirculating bogie furnaces
				(v)	Rotary hearth furnaces
3-	Mode of heat transfer	(i)	Radiation (open fire place)		
		(ii)	Convection (heated through medium)		
4-	Mode of waste heat recovery	(i)	Recuperative		
		(ii)	Regenerative		

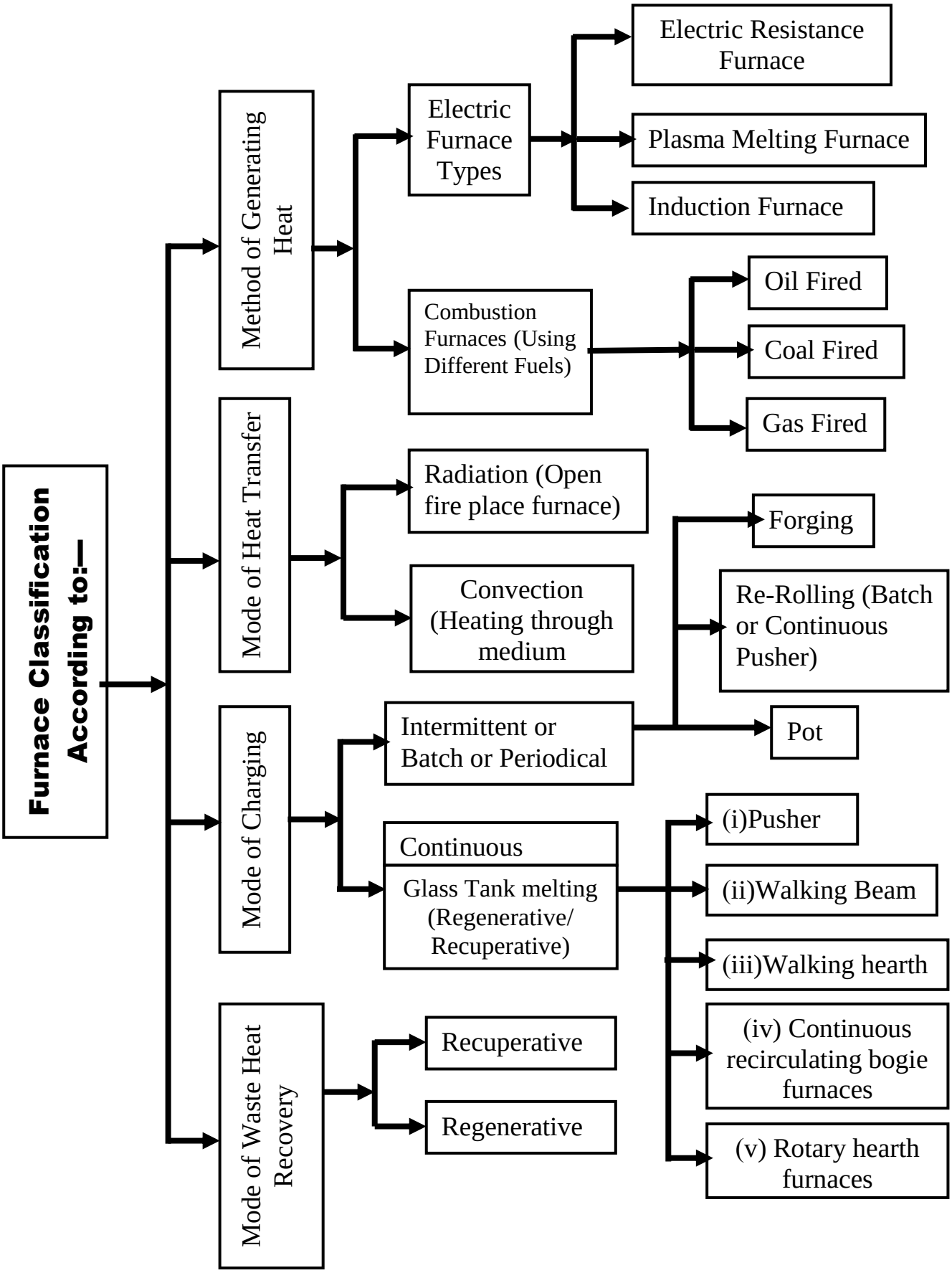

Fig. 1.1: Furnace Classification

1.2 Types of Different Furnaces

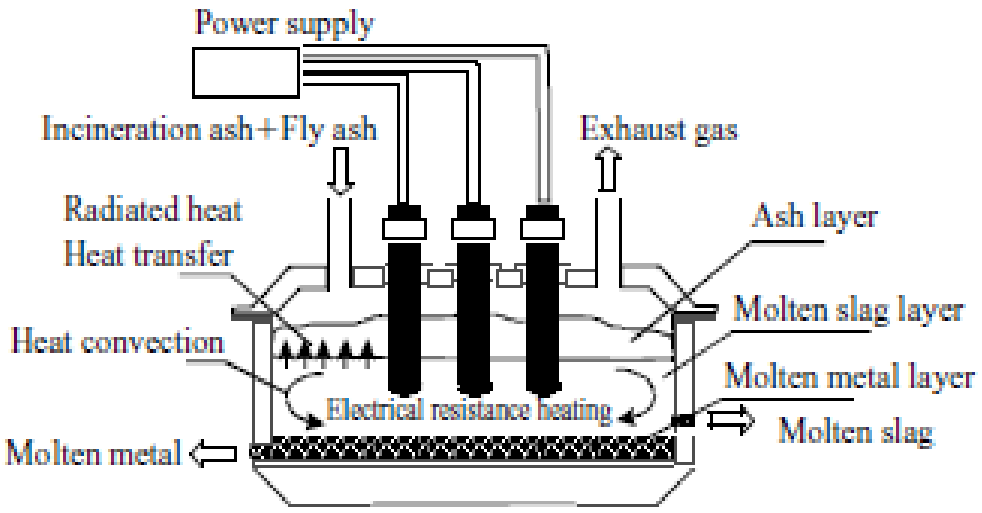

Fig.1 JFE electric-resistance furnace

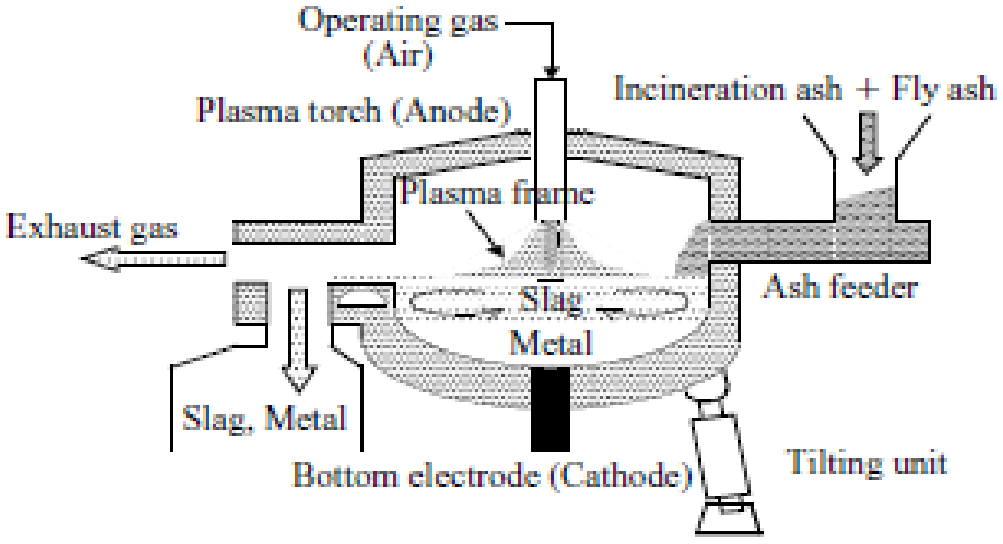

Fig.2 JFE plasma melting furnace

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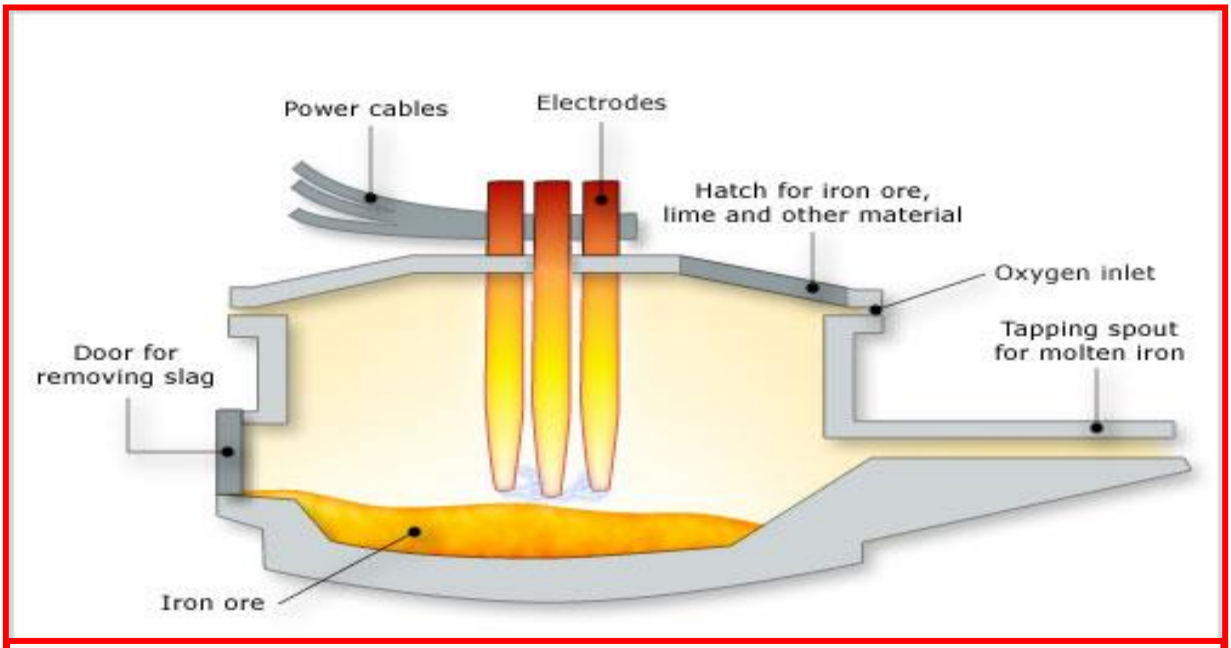


Fig. 3: Electric arc furnace

The electric arc furnace is used to reduce iron from iron ore. Heat is generated from an electric arc between electrodes. Oxygen is blown into the furnace, and lime and other materials are added to combine with the impurities and form slag. Molten iron is extracted and poured out via a tapping spout. It is then processed again in an electric arc furnace to make steel – particularly special quality steel

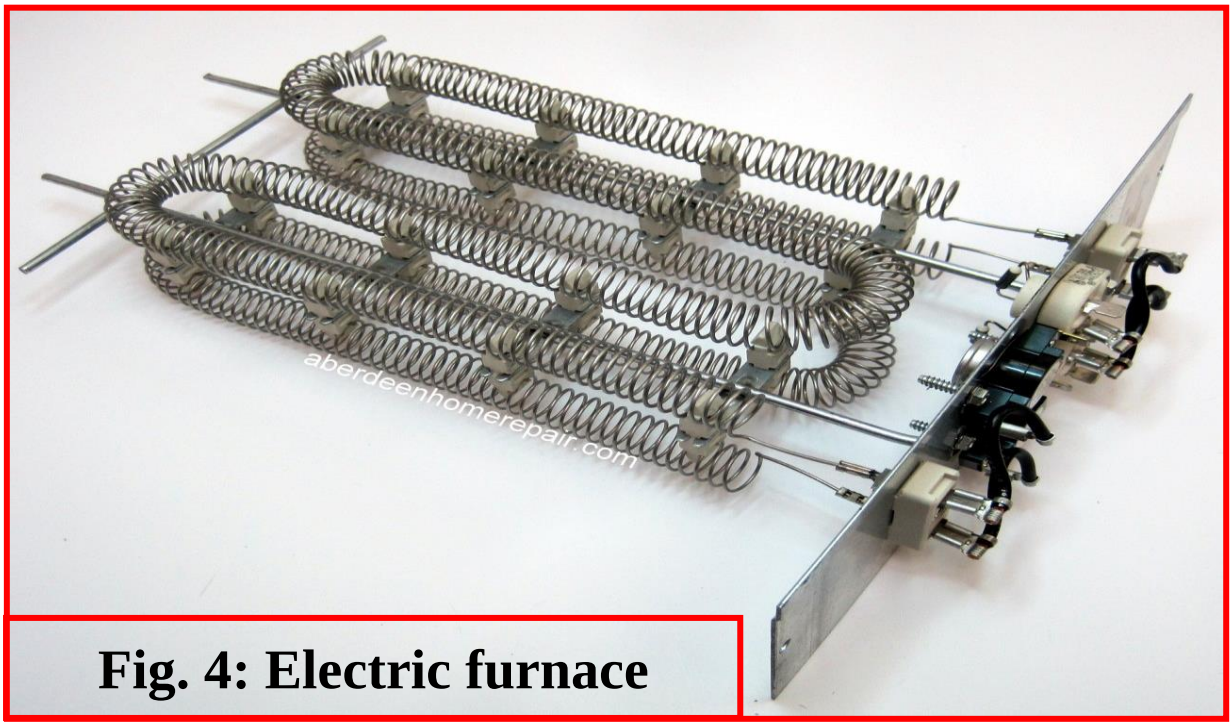


Fig. 4: Electric furnace

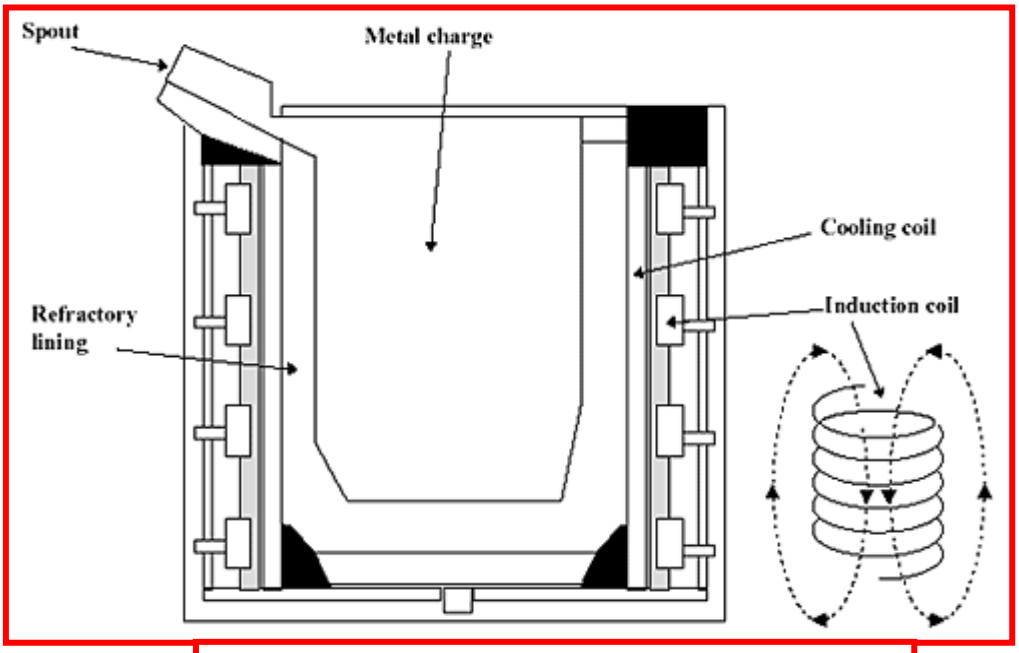


Fig. 4: Induction Furnaces

An induction furnace is an electrical furnace in which the heat is applied by induction heating of metal. The advantage of the induction furnace is a clean, energy-efficient and well-controllable melting process compared to most other means of metal melting. (فرن الحث الكهربائى)

Electric induction furnaces are the highly used furnaces for melting iron and non ferrous alloys. As compared to other cupola furnaces, these furnaces are pollution free and have outstanding metallurgical control.

Cyclone furnace

A water-cooled horizontal cylinder in which fuel (coal, gas, or oil) is fired and heat is released at extremely high rates. When firing coal, the crushed coal is introduced tangentially into the burner at the front end of the cyclone (see illustration). About 15% of the combustion air is used as primary and tertiary air to impart a whirling motion to the particles of coal. The whirling, or centrifugal, action on the fuel is further increased by the tangential admission of high-velocity secondary air into the cyclone.

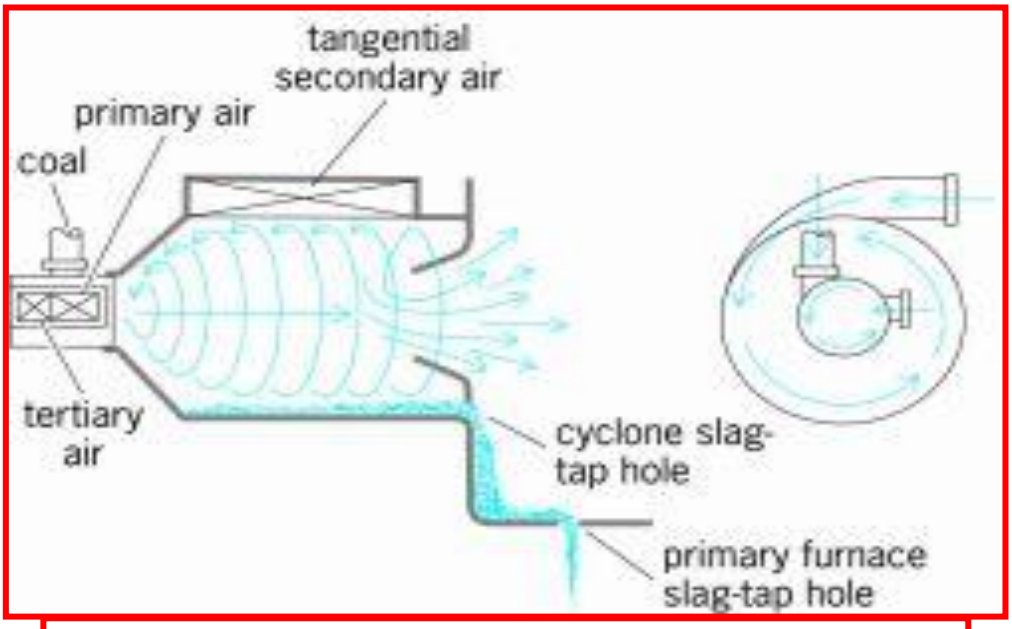
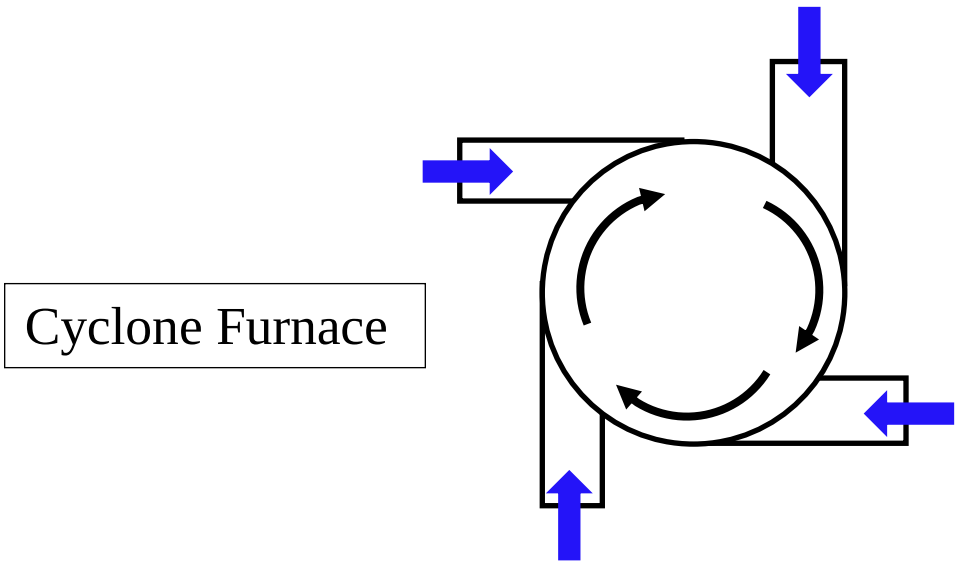


Fig.5 : Schematic diagram of cyclone furnace



The products of combustion are discharged through a water-cooled re-entrant throat at the rear of the cyclone into the boiler furnace. Essentially, the fundamental difference between cyclone furnaces and pulverized coal-fired furnaces is the manner in which combustion takes place. In pulverized coal–fired furnaces, particles of coal

move along with the gas stream; consequently, relatively large furnaces are required to complete the combustion of the suspended fuel. With cyclonic firing, the coal is held in the cyclone and the air is passed over the fuel. Thus, large quantities of fuel can be fired and combustion completed in a relatively small volume, and the boiler furnace is used to cool the products of combustion

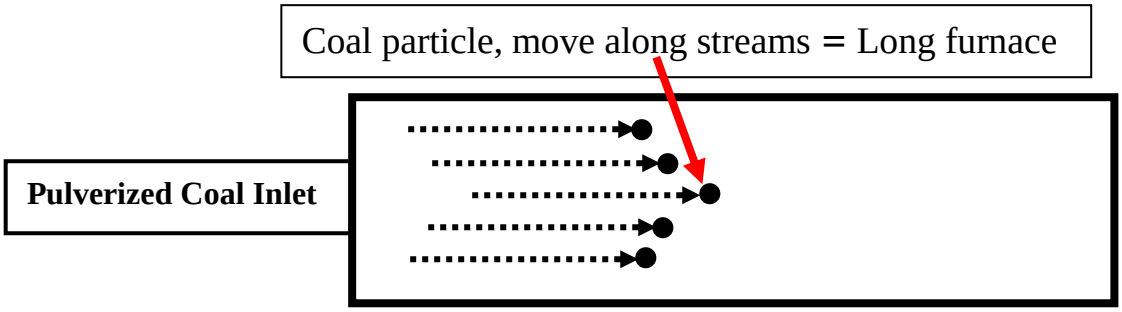


Fig. 5-A: Pulverized coal–fired furnace

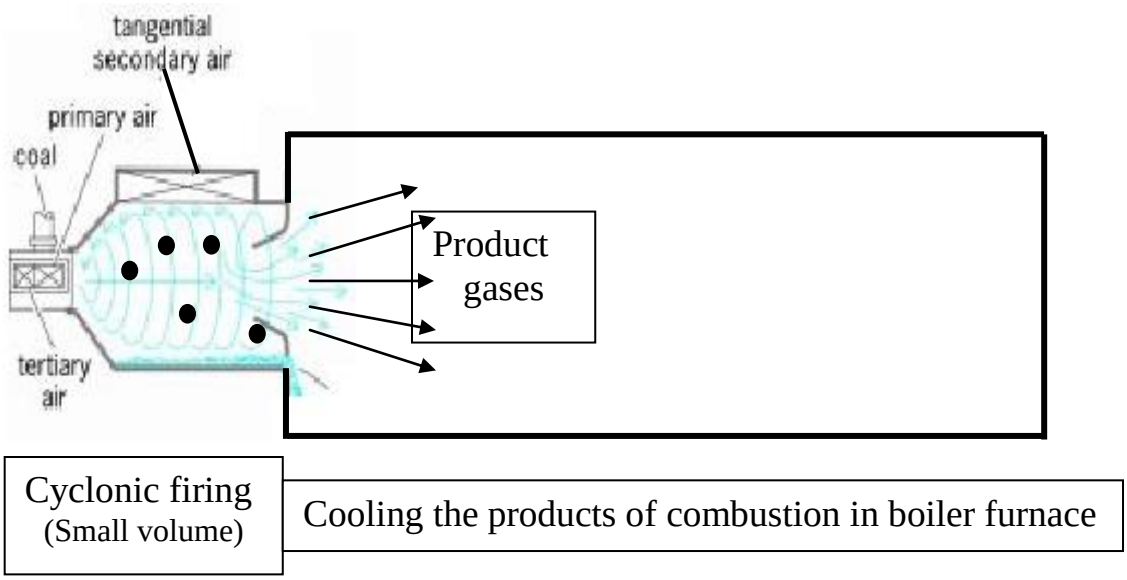


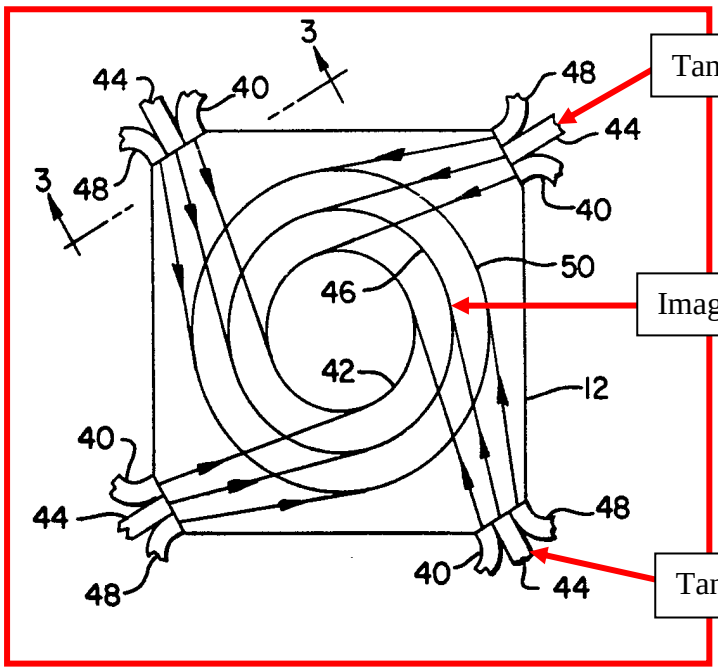
Fig. 5-B: Cyclonic-firing of pulverized coal

Fig. 5: Difference between cyclone furnaces and pulverized coal-fired furnaces

Tangential furnace

Furnace with sets of nozzles for tangential introduction of pulverized coal, air and recirculated gases.

A furnace in which fuel, such as pulverized coal, is burned, with the fuel and air being introduced into the furnace through tangential burners located in each of the four corners thereof and being directed tangentially to an imaginary circle in the center of the furnace. The invention will be described with pulverized coal, but is not limited to coal. Combustion gases from downstream of the furnace are recirculated back to the furnace, and are also introduced into the furnace from the four corners, in a tangential manner. The coal is introduced along with primary air to be directed at the smallest of a series of concentric imaginary circles; the recirculated gases are directed tangentially at a somewhat larger imaginary circle; and the secondary air is directed tangentially at a still larger imaginary circle.



Burners are directed tangentially to an imaginary circle in the center of the furnace

An Alstom advanced low NO_x tangential firing systems.
Photo courtesy Alstom.

Cyclone Furnaces

Design features:

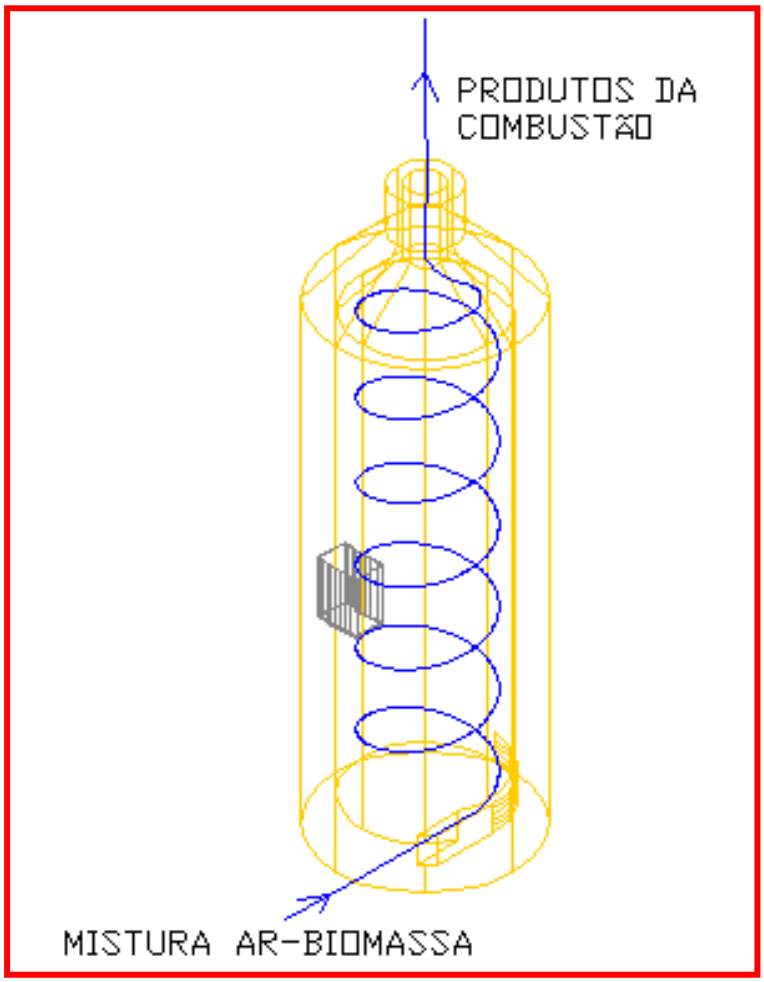
Commercially-built in sizes from (1.8 to 3 m) in diameter; water-cooled tangent tube, seal welded construction; three general boiler arrangements - single wall firing with screen tubes, open furnace single wall firing with close-coupled target wall, and open furnace opposed wall firing. Various burner types are available. Cyclone-equipped units include Universal Pressure (UP), Radiant Boilers (RB), and Stirling boilers.

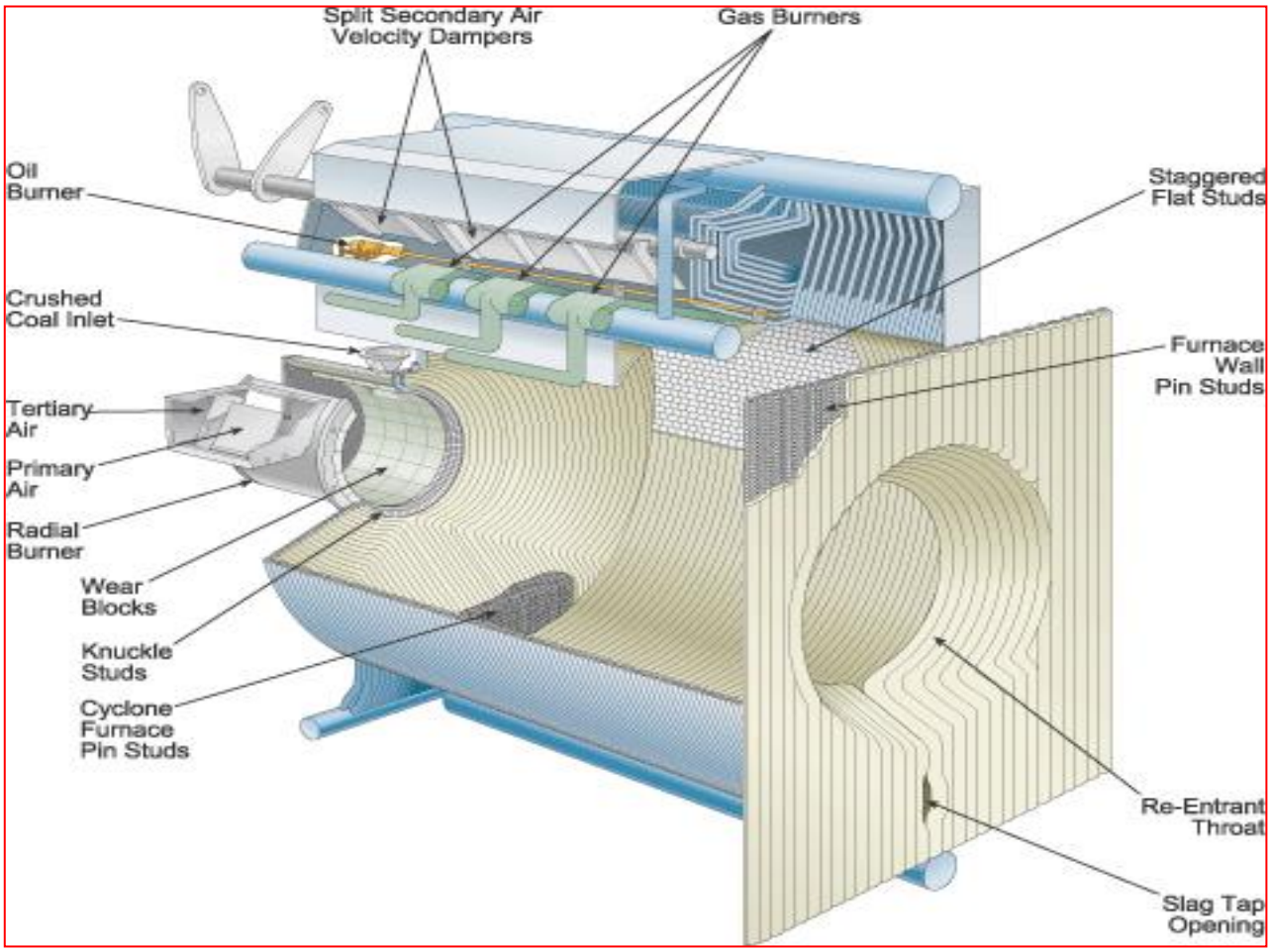
Standard maximum heat input range:

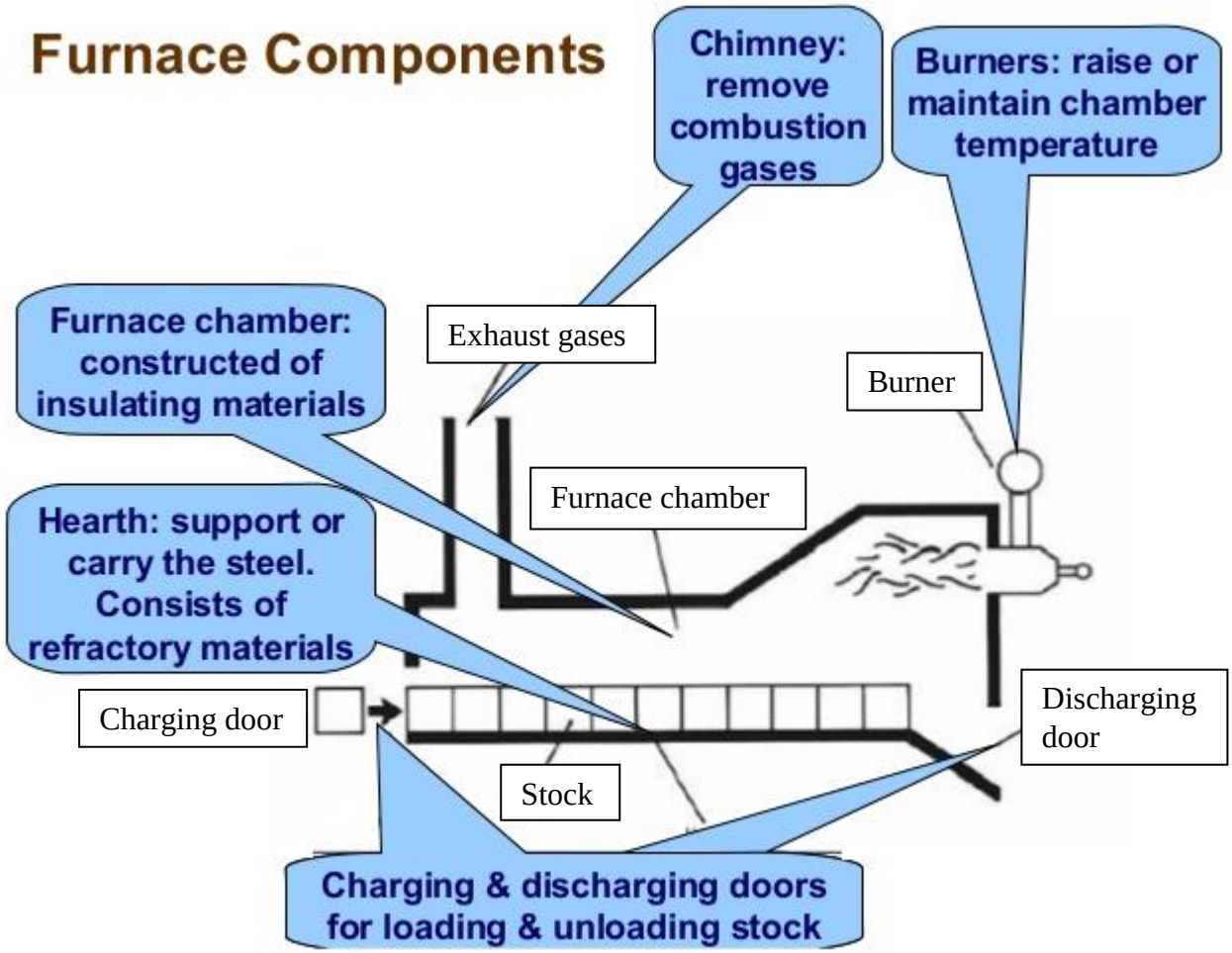
150 to 425+ X 106 Btu/h (44 to 124.6+ MWt).

Fuel:

Burns bituminous, subbituminous and lignite coal grades suitable for cyclone operation, fuel oil and natural gas; co-firing experience includes utilizing tire derived fuel (TDF), refuse derived fuel (RDF), paper mill sludge, wood, petroleum coke, and coke oven gas.




Split Secondary Air Velocity Dampers
Gas Burners
Oil Burner
Staggered Flat Studs
Crushed Coal Inlet
Furnace Wall Pin Studs
Tertiary Air
Primary Air
Radial Burner
Wear Blocks
Knuckle Studs
Cyclone Furnace Pin Studs
Re-Entrant Throat
Slag Tap Opening


Furnace Components
Chimney: remove combustion gases
Burners: raise or maintain chamber temperature
Furnace chamber: constructed of insulating materials
Exhaust gases
Burner
Furnace chamber
Hearth: support or carry the steel. Consists of refractory materials
Charging door
Discharging door
Stock
Charging & discharging doors for loading & unloading stock