EN 410
Energy Management

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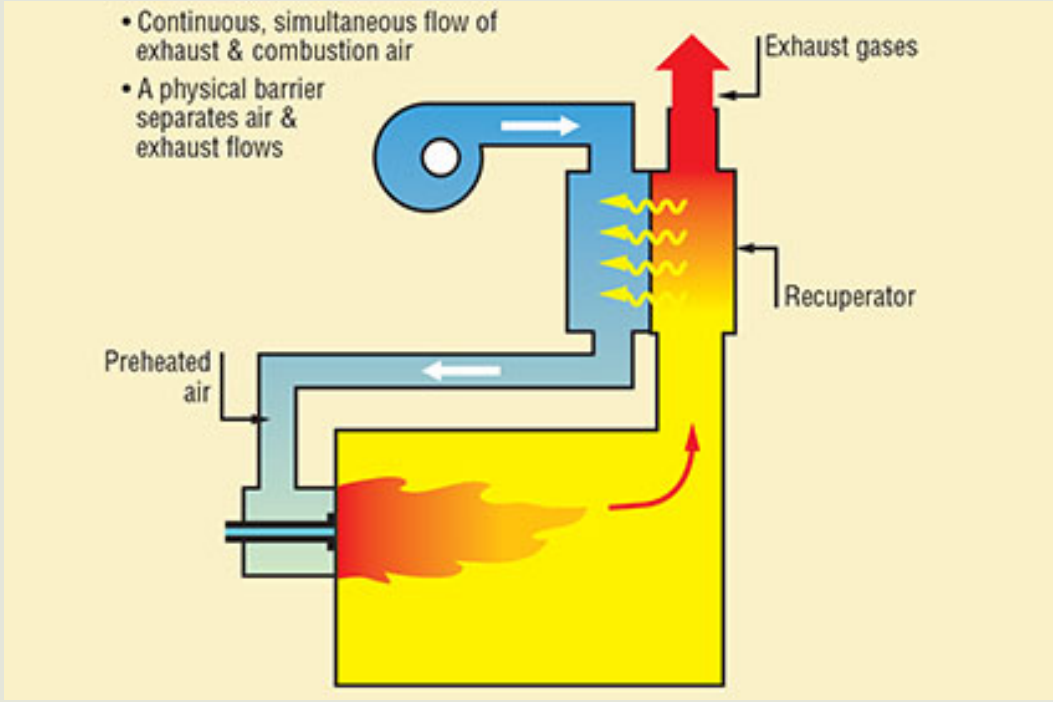
Furnace

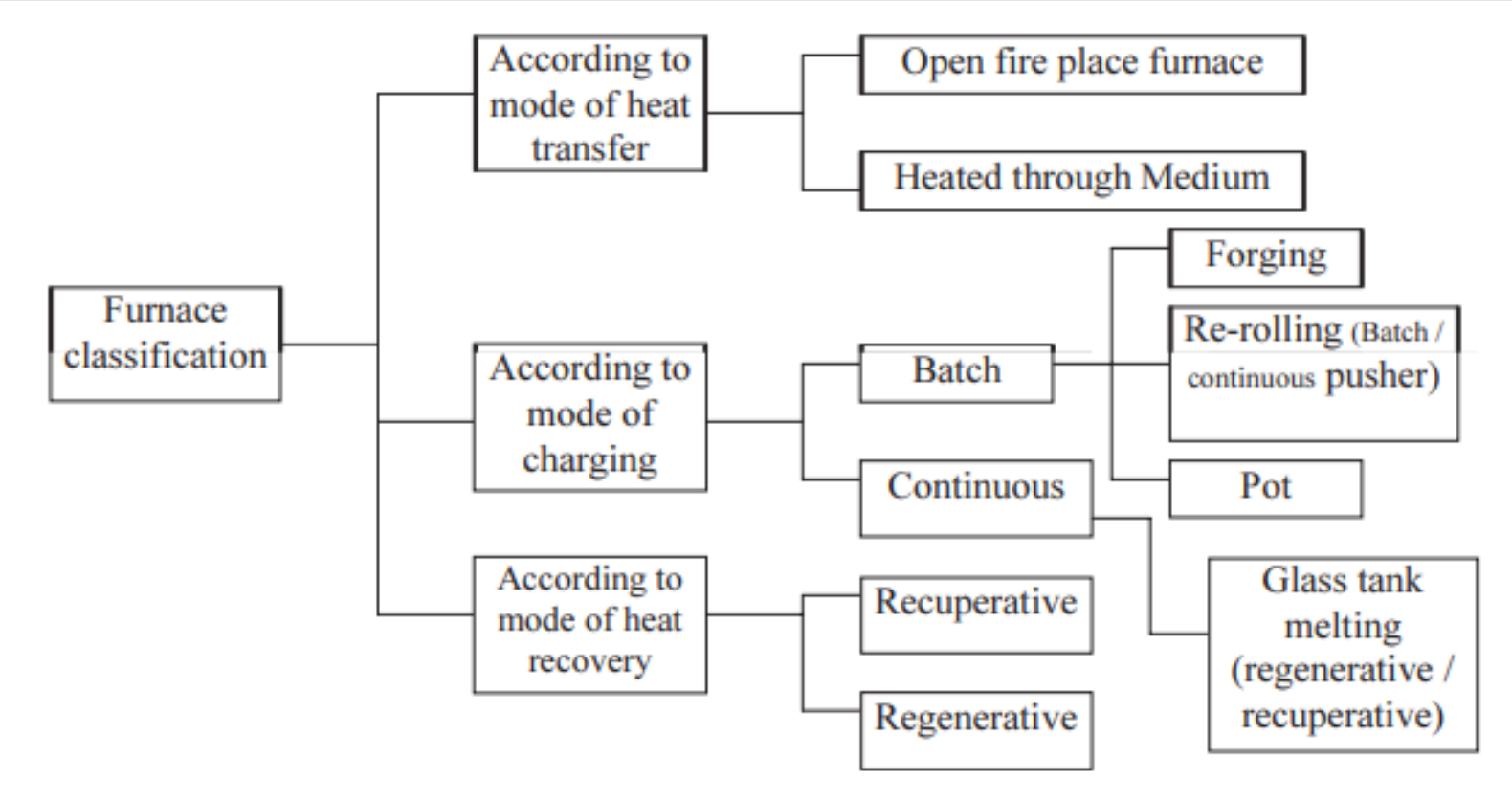
A furnace is an equipment

- to melt metals for casting
- heat materials for change of shape (rolling, forging etc)
- change of properties (heat treatment)

- Equalisation of the temperature within the stock
- Since the products of flue gases directly contact the stock, type of fuel chosen is of importance (e.g. tolerance to sulphur).
- Solid fuels generate particulate matter that interferes with the stock
- Liquid fuel, gaseous fuel or electricity



Classification of furnace

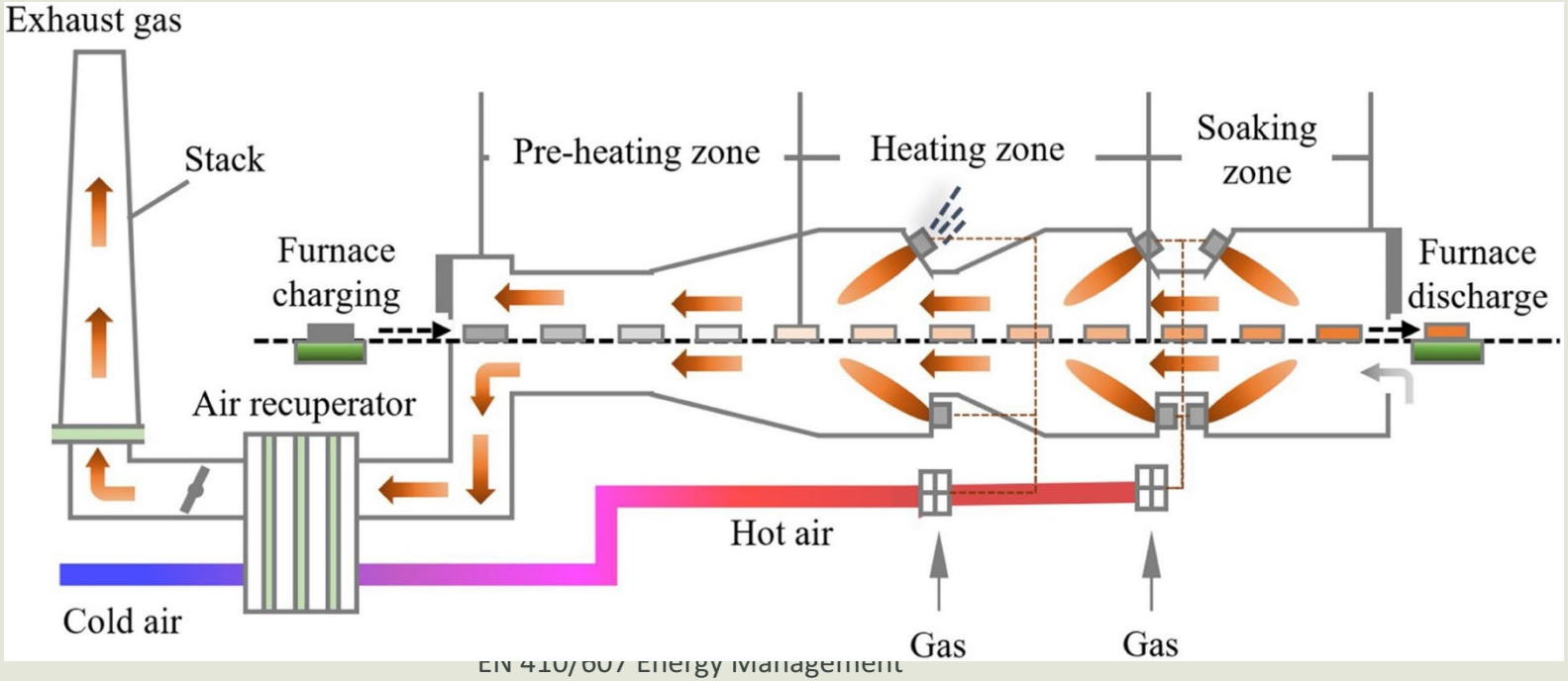


Forging furnace

- 1200-1250℃
- Heat up time ➡ Soaking time ➡ Forging time
- Soaked for 4-6 hrs for uniform temperature
- Mostly manual

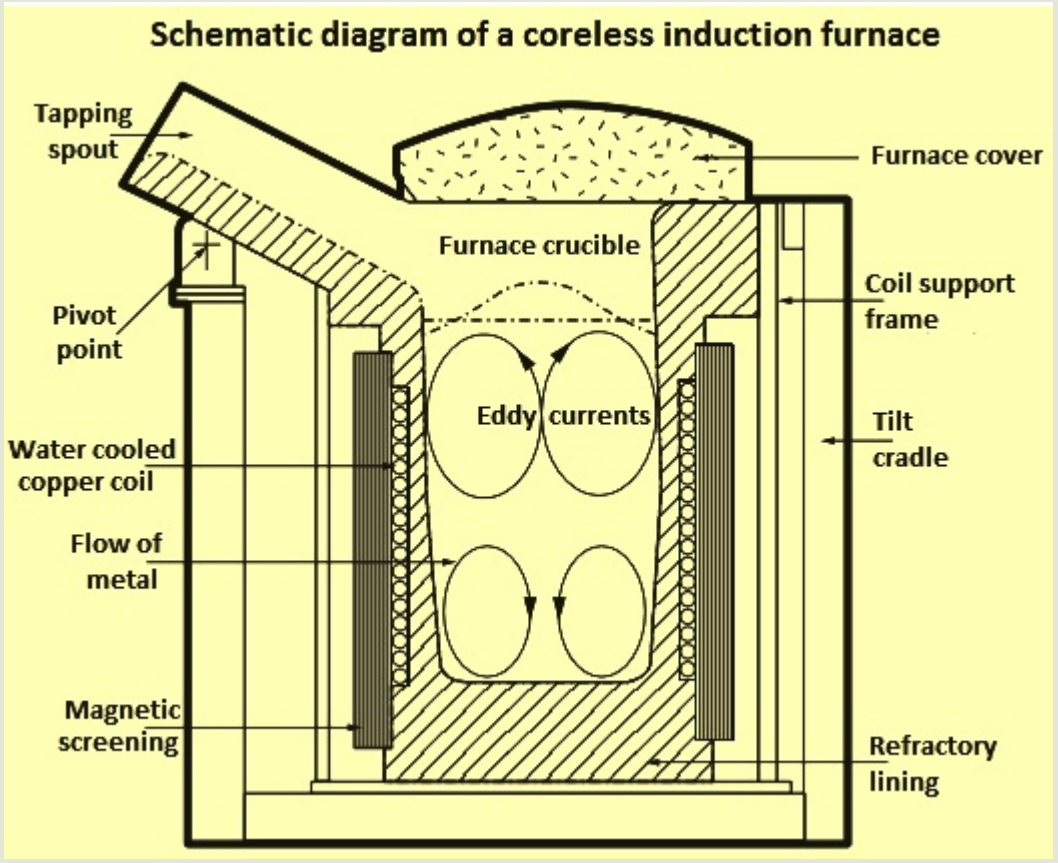
Continuous reheating furnace

- Steel Industry
- 900-1250°C
- Radiation and convection from the gases of the burner and the furnace walls



Induction furnaces

- Crucible is cover with coper coil which carries powerful alternate current
- Created magnetic field penetrates the melt and induces the eddy current by electromagnetic induction (production of an electromotive force (emf) across an electrical conductor in a changing magnetic field)
- Eddy currents heat the meatal by Joule heating (passage of an electric current through a conductor produces heat)



Performance Evaluation

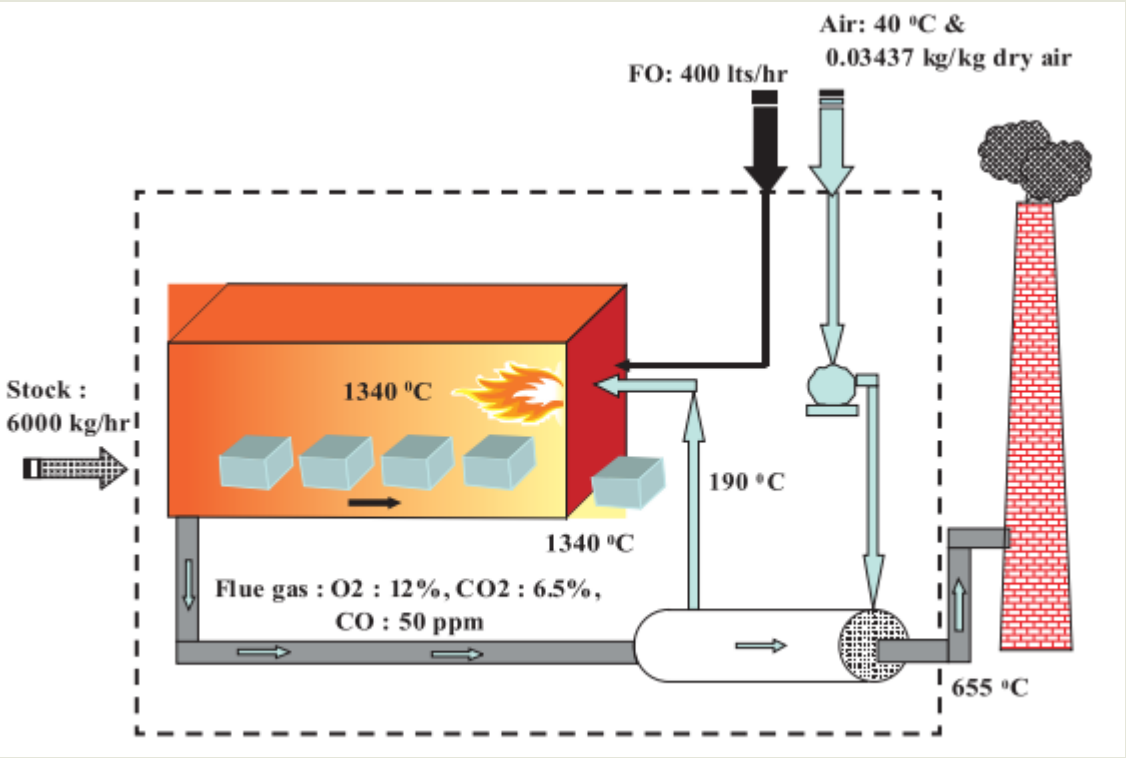
- **The Direct Method:** Energy gain of the stock is compared with the energy content of the fuel

- **The Indirect Method:** Efficiency is calculated based on losses and energy input

Losses in Furnaces

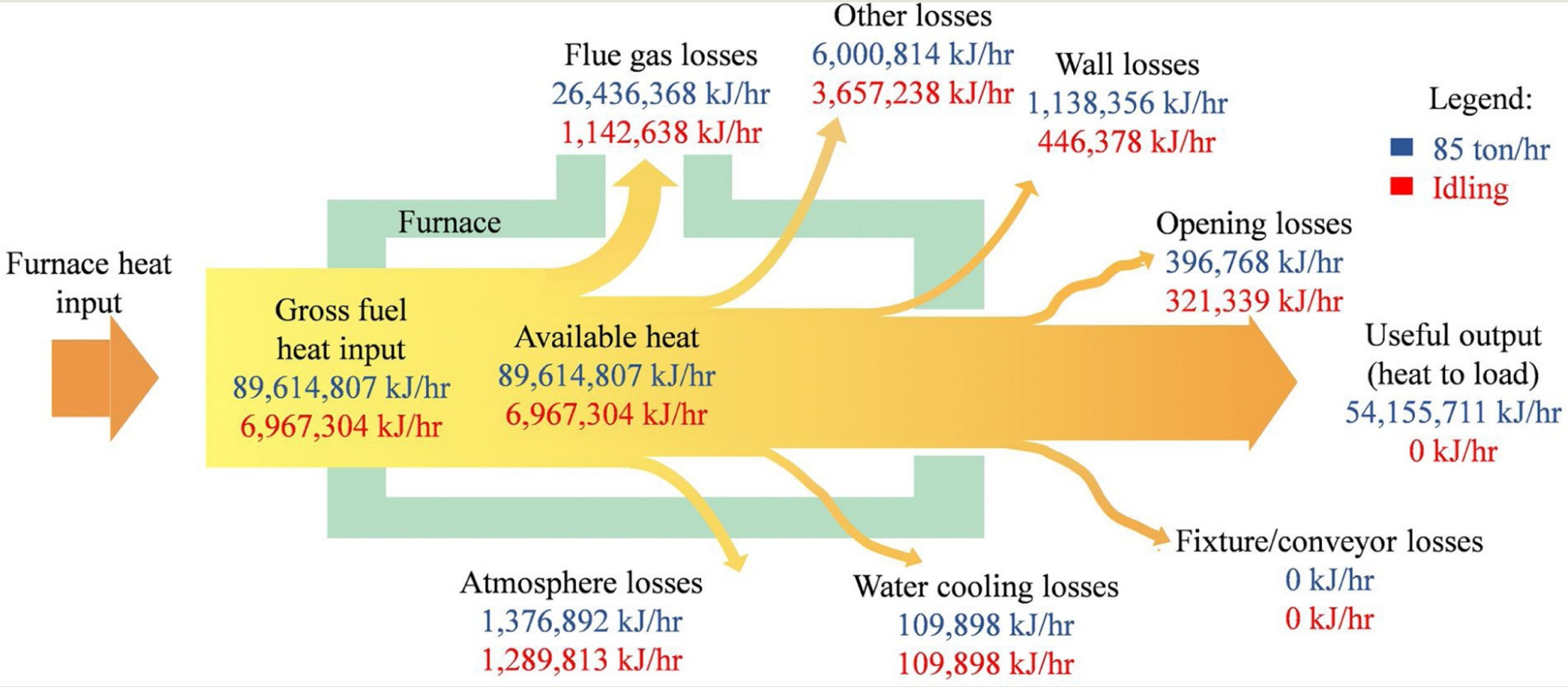
- **Flue gas loss**
- **Stored heat loss**: Energy stored in the furnace and insulation for uniform temperature during the start of cycle from cold to hot state (limited time of metal in the continuous furnace)
- **Insulation loss**: Losses from the furnace outside walls or structure
- **Cooling water loss :** Water is cicurated to maintain the temperature of rolls, bearings and doors
- **Material handling loss**: Heat transported out of the furnace by the load conveyors, fixtures, trays, etc.
- **Opening loss**: Radiation losses from openings, hot exposed parts, etc.
- Heat carried by the **cold air infiltration** into the furnace due to the draft of flue gas, openings, etc.,
- Heat carried by the **excess air** used in the burners.

Furnace heat losses



Heat Input			Heat output		
Item	**kcal/t**	**%**	**Item**	**kcal/t**	**%**
Combustion heat of fuel (Q_1)	6,13,300	99.70	Heat carried away by 1 tonne of billet (Q_3)	1,56,000	25.4
Sensible heat of fuel (Q_2)	1,840	0.30	Heat loss in dry flue gas per tonne of billet (Q_4)	3,22,247	52.4
			Heat loss due to formation of water vapour from fuel per tonne of billet (Q_5)	58,042	9.4
			Heat loss due to moisture in combustion air (Q_6)	20,070	3.3
			% Heat loss due to partial conversion of C to CO (Q_7)	229	0.04
			Amount of heat loss from the furnace body and other sections (Q_8)	6,122	1.0
			Radiation heat loss through furnace openings (Q_9)	38,485	6.2
			Unaccounted losses (Q_{10})	13,945	2.3
Total	**6,15,140**	**100**		**6,15,140**	**100**

Heat losses in the IRFs for the steel plant, Winnipeg, Canada



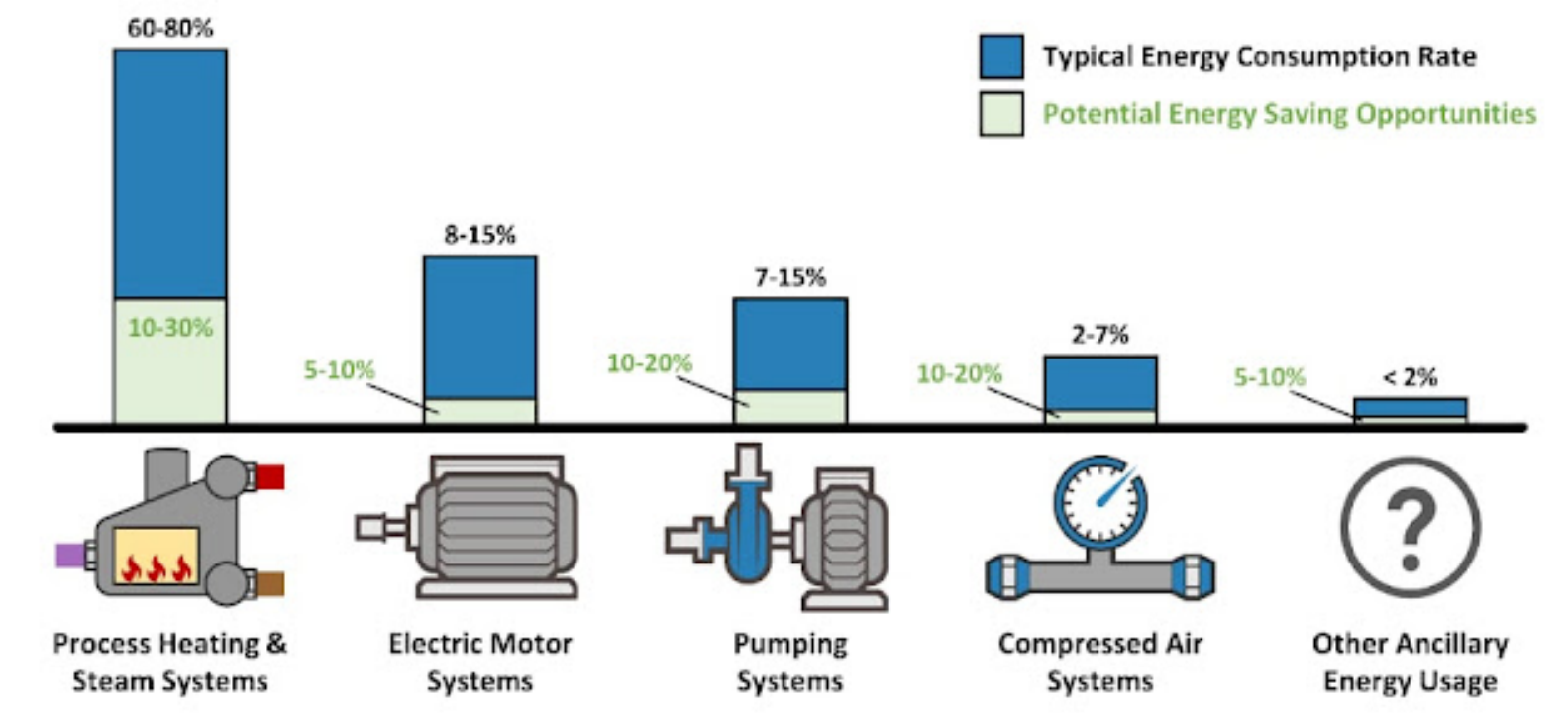
Thermal Efficiencies: Industrial Furnaces

Furnace Type	Typical thermal efficiencies (%)
1) Low Temperature furnaces	
a. 540–980 °C (Batch type)	20–30
b. 540–980 °C (Continous type)	15–25
c. Coil Anneal (Bell) radiant type	5–7
d. Strip Anneal Muffle	7–12
2) High temperature furnaces	
a. Pusher, Rotary	7–15
b. Batch forge	5–10
3) Continuous Kiln	
a. Hoffman	25–90
b. Tunnel	20–80
4) Ovens	
a. Indirect fired ovens (20°C–370°C)	35–40
b. Direct fired ovens (20°C–370°C)	35–40

Furnace Instrumentation

Sl. No.	Parameters to be measured	Location of Measurement	Instrument Required	Required Value
1.	Furnace soaking zone temperature (reheating furnaces)	Soaking zone side wall	Pt/Pt-Rh thermocouple with indicator and recorder	1200–1300°C
2.	Flue gas	Flue gas exit from furnace and entry to re-cuperator	Chromel Alummel Thermocouple with indicator	700°C max
3.	Flue gas	After recuperator	Hg in steel thermometer	300°C (max)
4.	Furnace hearth pressure in the heating zone	Near charging end side wall over hearth level	Low pressure ring gauge	+0.1 mm. of Wg
5.	Flue gas analyser	Near charging end side wall end side	Fuel efficiency monitor for oxygen & temperature	$0_2\% = 5$ t = 700°C (max)
6.	Billet temperature	Portable	Infrared Pyrometer or optical pyrometer	----

Energy Use

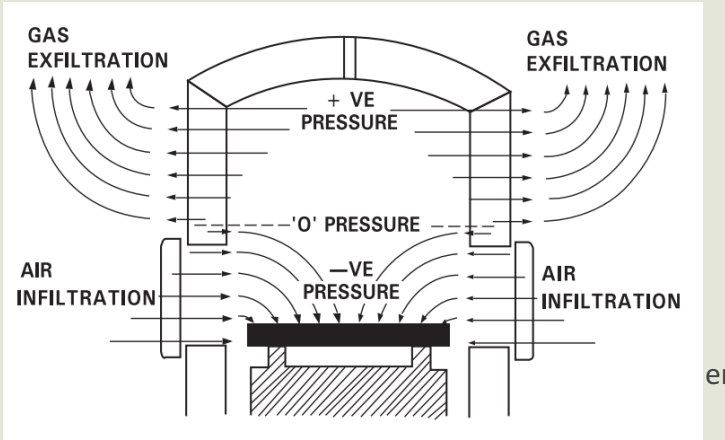

Typical Energy Consumption Rate
Potential Energy Saving Opportunities
60-80%
10-30%
8-15%
5-10%
7-15%
10-20%
2-7%
10-20%
< 2%
5-10%
Process Heating & Steam Systems
Electric Motor Systems
Pumping Systems
Compressed Air Systems
Other Ancillary Energy Usage

Energy Efficiency Measures

- Waste heat recovery (to charge/air) from the flue gases
- Proper heat distribution
- Operating at the desired temperature

Table 4.5 Operating Temperature of Various Furnaces	
Slab Reheating furnaces	1200 °C
Rolling Mill furnaces	1200 °C
Bar furnace for Sheet Mill	800 °C
Bogey type annealing furnaces	650 °C -750 °C

- Air Inflation (upto 40%) / Reducing heat losses from furnace openings



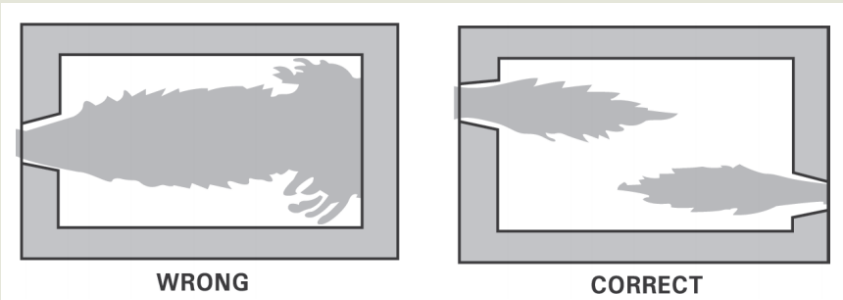
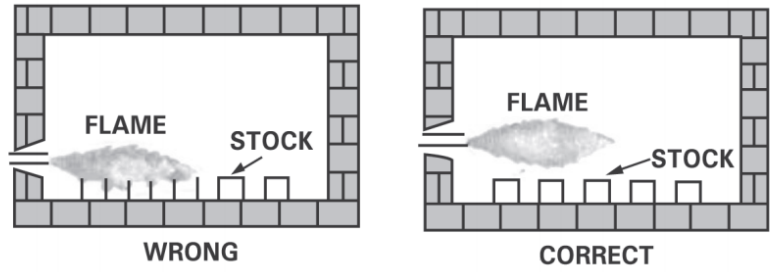


Figure 4.18: Heat Distribution in Furnace

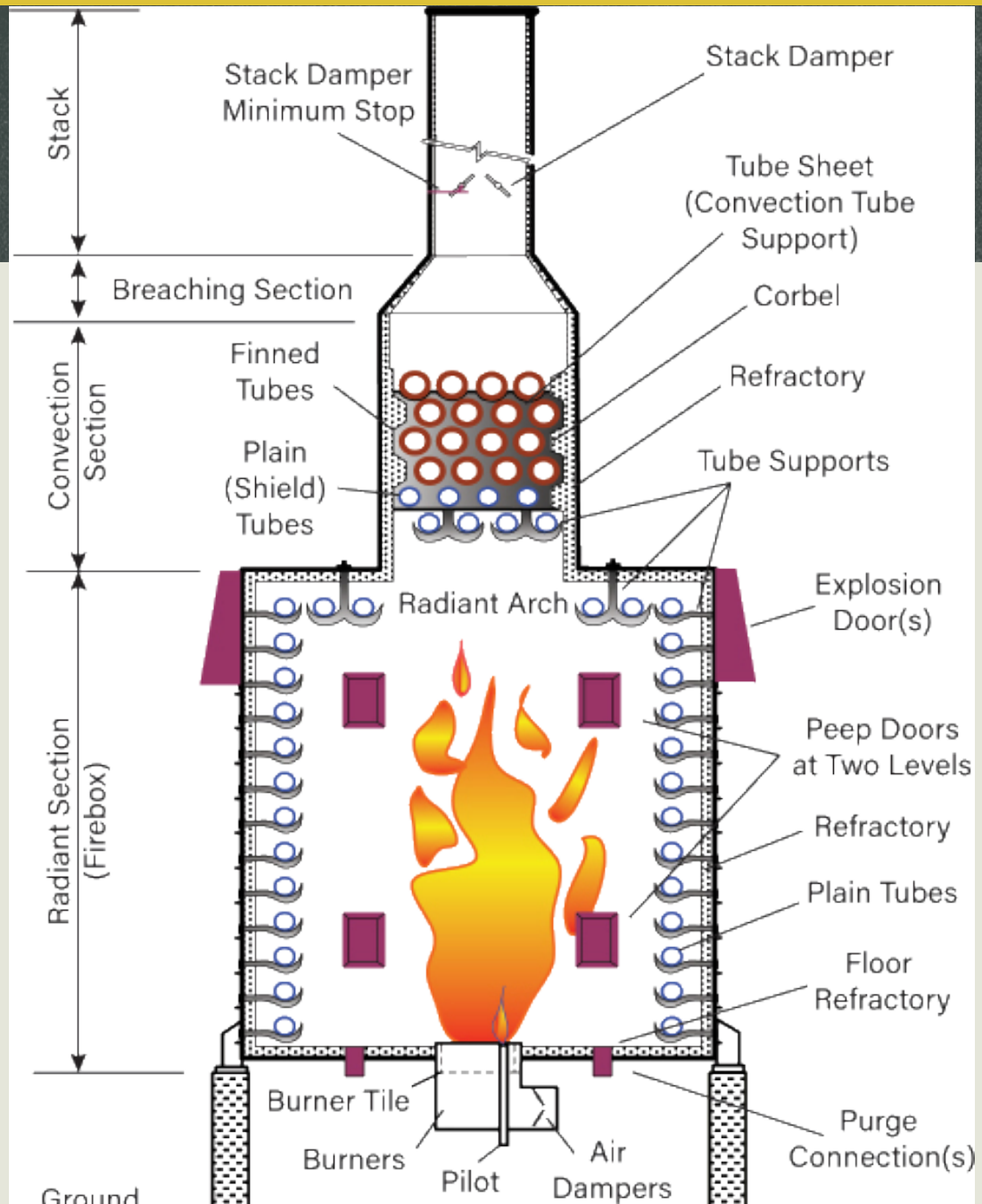


Energy Efficiency Measures

- Minimum wall losses by proper insulation
- Use of ceramic coatings in furnace chamber – Emissivity increases with increase in temperature Easy to apply, 8-20% savings,
- Complete combustion with minimum excess air
- Optimum capacity utilization – charge loading

Fired Heaters

- Energy and Cost intensive
- Design varied according to fan and pipe arrangements



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