

Manufacturing Technology Materials and Introduction to Manufacturing

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Metals

M4X01163

Level 4 20 credits

JACS CODE J511

Aims

- ▶ To develop a knowledge base and understanding of the structure, properties and basic selection of all classes and materials
- ▶ To develop a knowledge and appreciation of the processes used in the manufacture of components with a view to providing basic process selection parameters using a broad range of industrial applications to illustrate this.

Learning outcomes

- ▶ Upon successful completion of this module, the student should be able to demonstrate:
- ▶ An understanding of the structure and properties of metallic, polymers and ceramics
- ▶ Knowledge of the applications, advantages and limitations of different manufacturing processes and
- ▶ Knowledge and understanding of engineering materials and manufacturing process selection

Metals

- ▶ What is a metal?
- ▶ Example of a metal?
- ▶ What do we know about metals?

Metals

IIA (2)															
3 Li Lithium 6.939	4 Be Beryllium 9.0122														
11 Na Sodium 22.9898	12 Mg Magnesium 24.312														
		VIII B													
		IIIB (3)	IVB (4)	VB (5)	VIB (6)	VII B (7)	(8)	(9)	(10)	IB (11)	IIB (12)	13 Al Aluminum 26.9815			
19 K Potassium 39.102	20 Ca Calcium 40.08	21 Sc Scandium 44.956	22 Ti Titanium 47.90	23 V Vanadium 50.942	24 Cr Chromium 51.996	25 Mn Manganese 54.9380	26 Fe Iron 55.847	27 Co Cobalt 58.9332	28 Ni Nickel 58.71	29 Cu Copper 63.546	30 Zn Zinc 65.37	31 Ga Gallium 69.72			
37 Rb Rubidium 85.47	38 Sr Strontium 87.62	39 Y Yttrium 88.905	40 Zr Zirconium 91.22	41 Nb Niobium 92.906	42 Mo Molybdenum 95.94	43 Tc Technetium (99)	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.905	46 Pd Palladium 106.4	47 Ag Silver 107.868	48 Cd Cadmium 112.40	49 In Indium 114.82	50 Sn Tin 118.69		
55 Cs Cesium 132.905	56 Ba Barium 137.34	57 La Lanthanum 138.91	72 Hf Hafnium 179.49	73 Ta Tantalum 180.948	74 W Tungsten 183.85	75 Re Rhenium 186.2	76 Os Osmium 190.2	77 Ir Iridium 192.2	78 Pt Platinum 195.09	79 Au Gold 196.967	80 Hg Mercury 200.59	81 Tl Thallium 204.37	82 Pb Lead 207.19	83 Bi Bismuth 208.980	84 Po Polonium (210)
87 Fr Francium (223)	88 Ra Radium (226)	89 Ac Actinium (227)	104 Rf Rutherfordium (261)	105 Db Dubnium (262)	106 Sg Seaborgium (266)	107 Bh Bohrium (264)	108 Hs Hassium (269)	109 Mt Meitnerium (268)	110 Uun Ununium (269)	111 Uuu Ununium (272)	112 Uub Ununium (277)				

58 Ce Cerium 140.12	59 Pr Praseodymium 140.907	60 Nd Neodymium 144.24	61 Pm Promethium (145)	62 Sm Samarium 150.35	63 Eu Europium 151.96	64 Gd Gadolinium 157.25	65 Tb Terbium 158.924	66 Dy Dysprosium 162.50	67 Ho Holmium 164.930	68 Er Erbium 167.26	69 Tm Thulium 168.934	70 Yb Ytterbium 173.04	71 Lu Lutetium 174.97
90 Th Thorium 232.038	91 Pa Protactinium (231)	92 U Uranium 238.03	93 Np Neptunium (237)	94 Pu Plutonium (242)	95 Am Americium (243)	96 Cm Curium (247)	97 Bk Berkelium (247)	98 Cf Californium (251)	99 Es Einsteinium (254)	100 Fm Fermium (257)	101 Md Mendelevium (258)	102 No Nobelium (259)	103 Lr Lawrencium (260)

Metal Properties Worksheet

Property	Metals	Non-metals
Appearance		
State at room temperature		
Density		
Strength		
Malleable or brittle		
Conduction of heat		
Conduction of electricity		
Magnetic material		
Sound when hit		

Metal Properties Worksheet Answer

Property	Metals	Non-metals
Appearance	Shiny	Dull
State at room temperature	Solid (except mercury, which is a liquid)	About half are solids, about half are gases, and one (bromine) is a liquid
Density	High (they feel heavy for their size)	Low (they feel light for their size)
Strength	Strong	Weak
Malleable or brittle	Malleable (they bend without breaking)	Brittle (they break or shatter when hammered)
Conduction of heat	Good	Poor (they are insulators)
Conduction of electricity	Good	Poor (they are insulators, apart from graphite)
Magnetic material	Only iron, cobalt and nickel	None
Sound when hit	They make a ringing sound (they are sonorous)	They make a dull sound

Metals-Properties

All metals are:

- ▶ Solid
- ▶ Shiny
- ▶ Ductile
- ▶ Malleable
- ▶ Good conductors
- ▶ Lose electrons easily

Most metals:

- ▶ Are solid at room temperature
- ▶ Are hard and strong
- ▶ Have a high density
- ▶ Are sonorous

- ▶ Three metals are magnetic

Metals-Properties

All metals are:

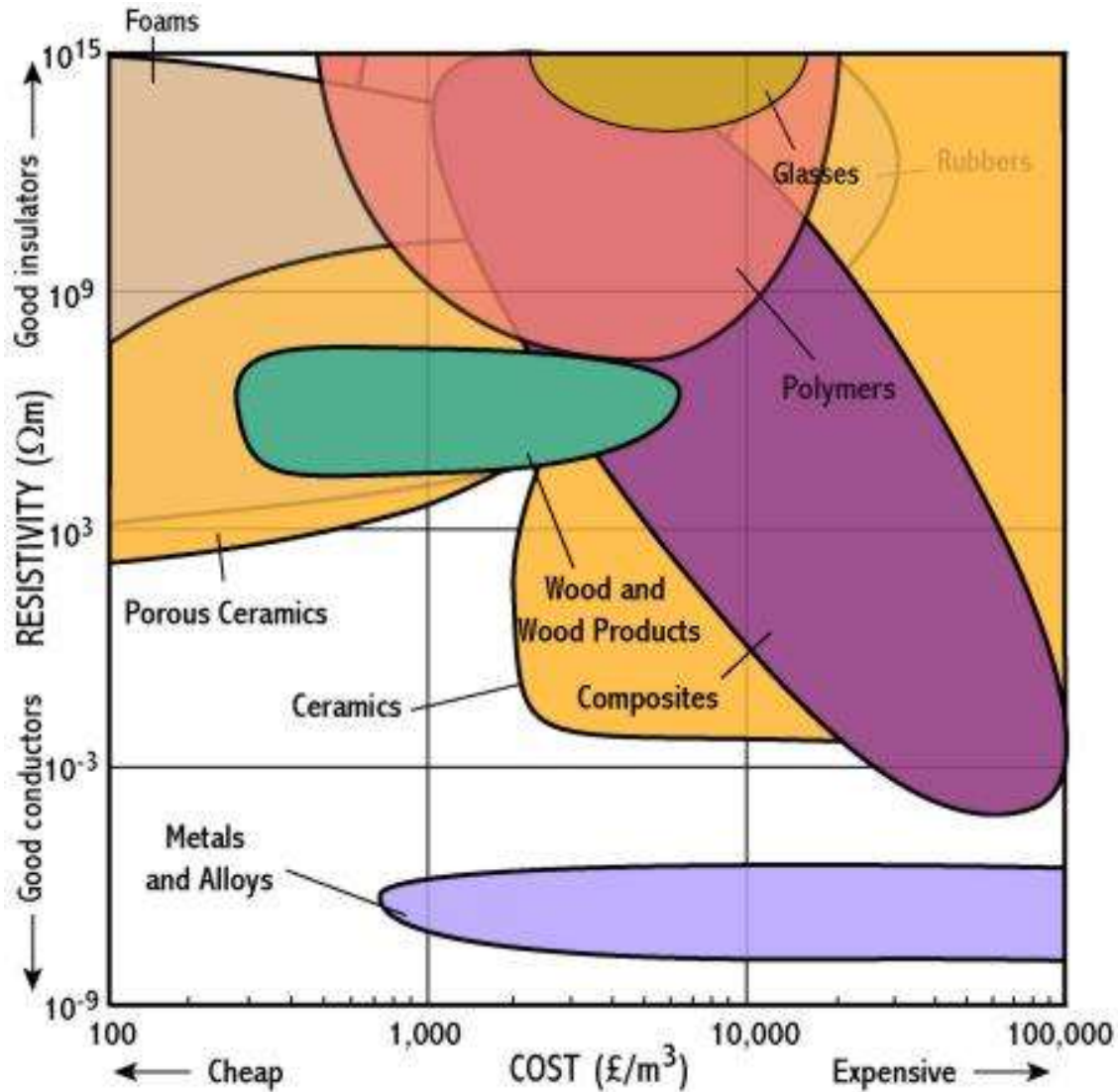
- ▶ Solid
- ▶ Shiny
- ▶ Ductile
- ▶ Malleable
- ▶ Good conductors
- ▶ Lose electrons easily

Most metals:

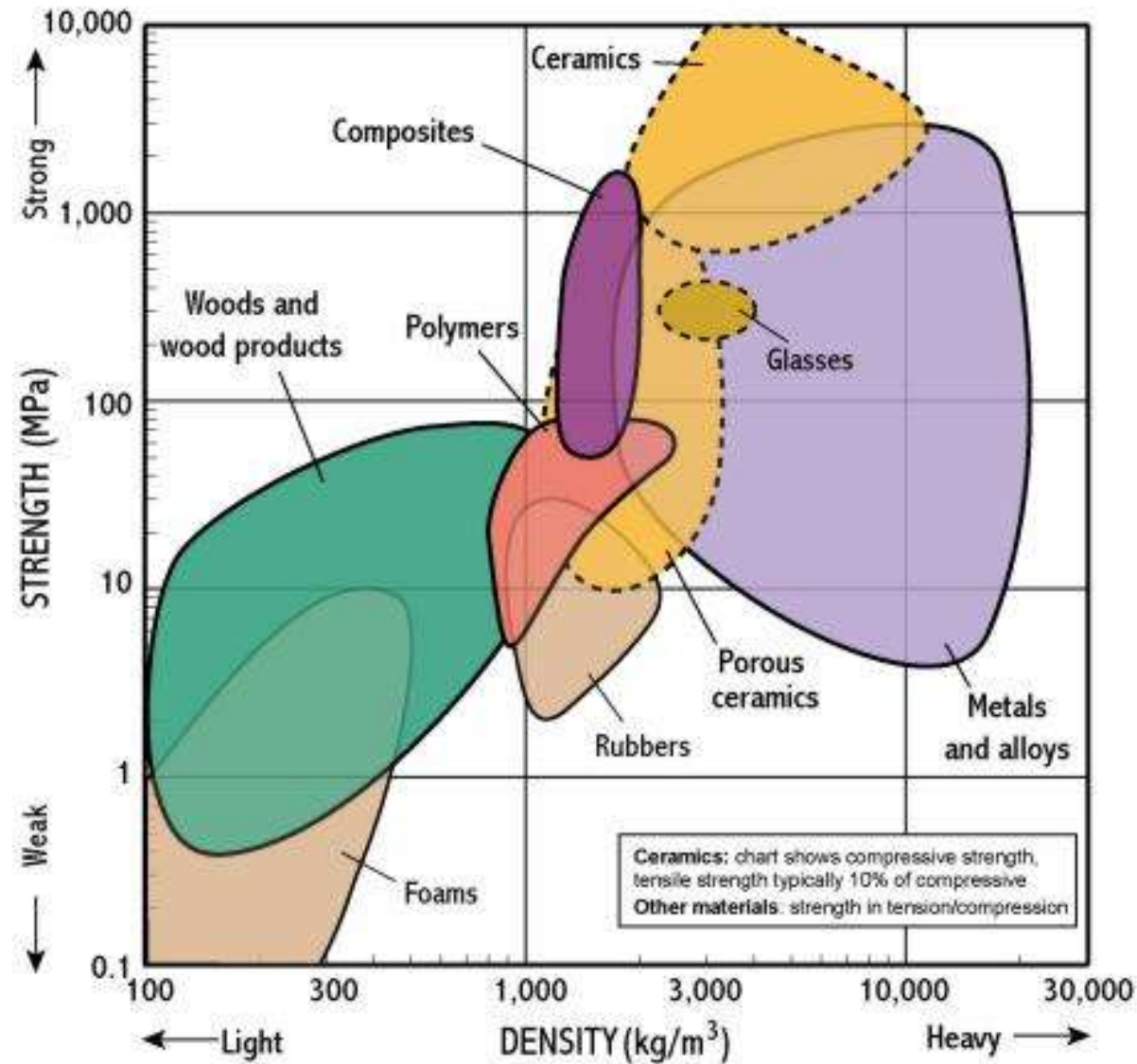
- ▶ Are solid at room temperature
- ▶ Are hard and strong
- ▶ Have a high density
- ▶ Are sonorous

- ▶ Three metals are magnetic
–Iron, Cobalt, Nickel

Electrical resistivity against cost



Strength against Density

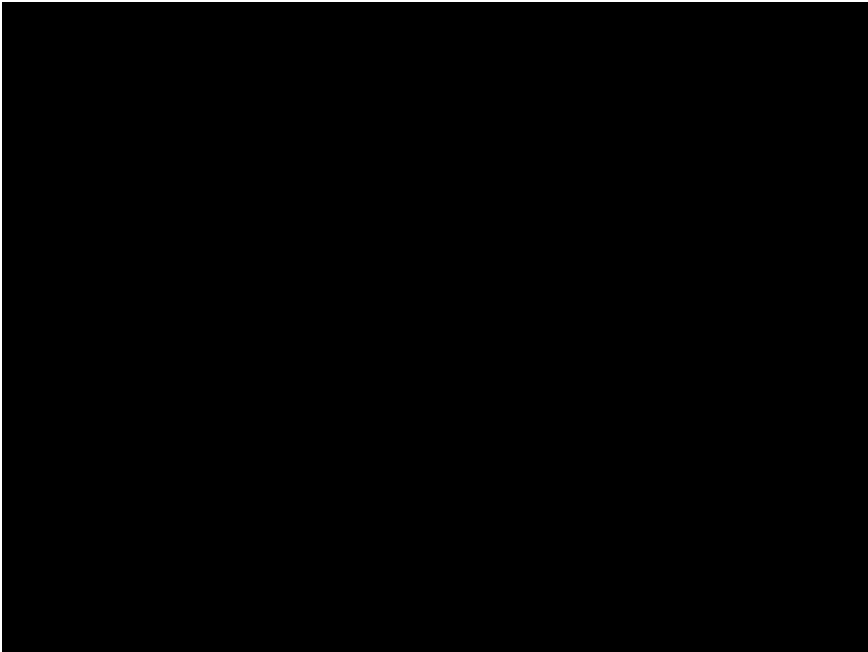


Structure and Properties -Metals

Introduction to Steel

- ▶ Metals and Alloys have many useful engineering properties and so have widespread applications in Engineering Designs
- ▶ Iron and its alloys (principally steel) account for about 90% of the world's production of metals mainly because of their combination of good strength, toughness and ductility at relatively low cost
- ▶ Alloys based on iron are called ferrous alloys, while those based on other metals are called non-ferrous alloys

Steel - the video



Rolling



By rolling, cast ingots, strands and slabs are reduced in size and converted into basic forms such as sheets, rods and plates.

Rolling operations reduce the thickness or change the cross-section of a material through compressive forces exerted by rolls.

These forms can then undergo further deformation to produce a large variety of finished products formed by processes such as forging, extrusion, sheet metal forming etc.

From a tonnage viewpoint, rolling is clearly predominant among all manufacturing processes, with approximately 90% of all metal products experiencing at least one rolling operation.

The Rolling Process

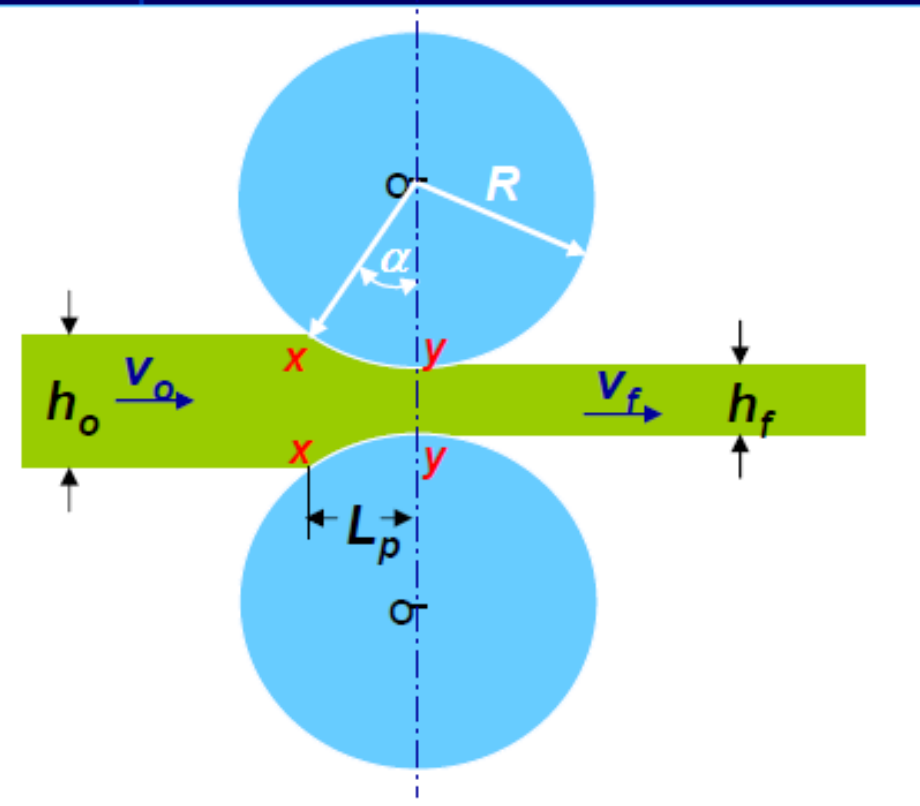
In the basic rolling process metal is passed between two rolls that rotate in opposite directions, the gap between the rolls being somewhat less than the thickness of the material.

Because the rolls rotate faster than the speed of the incoming metal, friction along the contact interface acts to propel the metal forward.

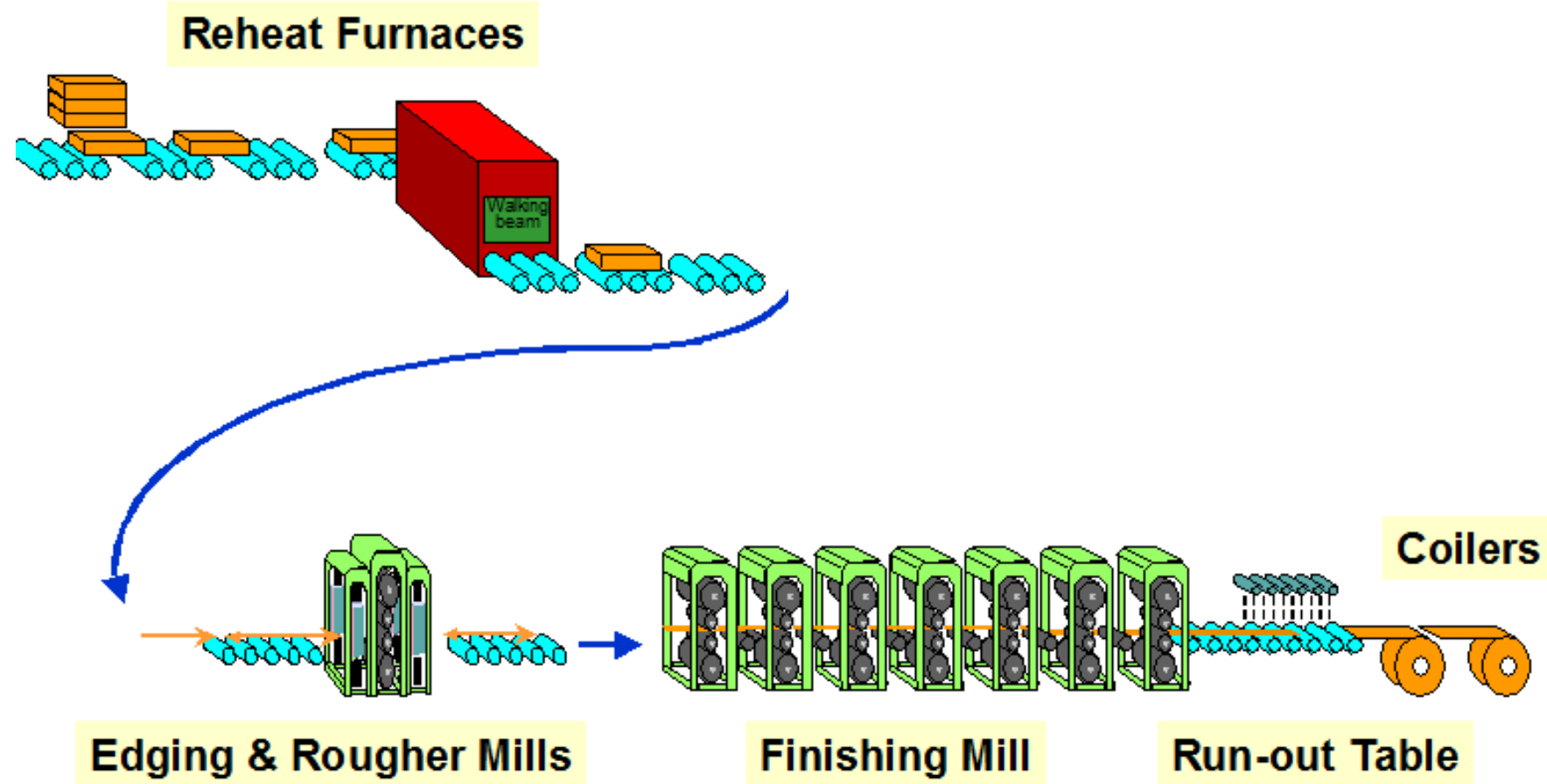
The metal is then squeezed and elongates to compensate for the decrease in thickness.

The amount of deformation that can be achieved in a single pass between one pair of rolls depends on the friction conditions.

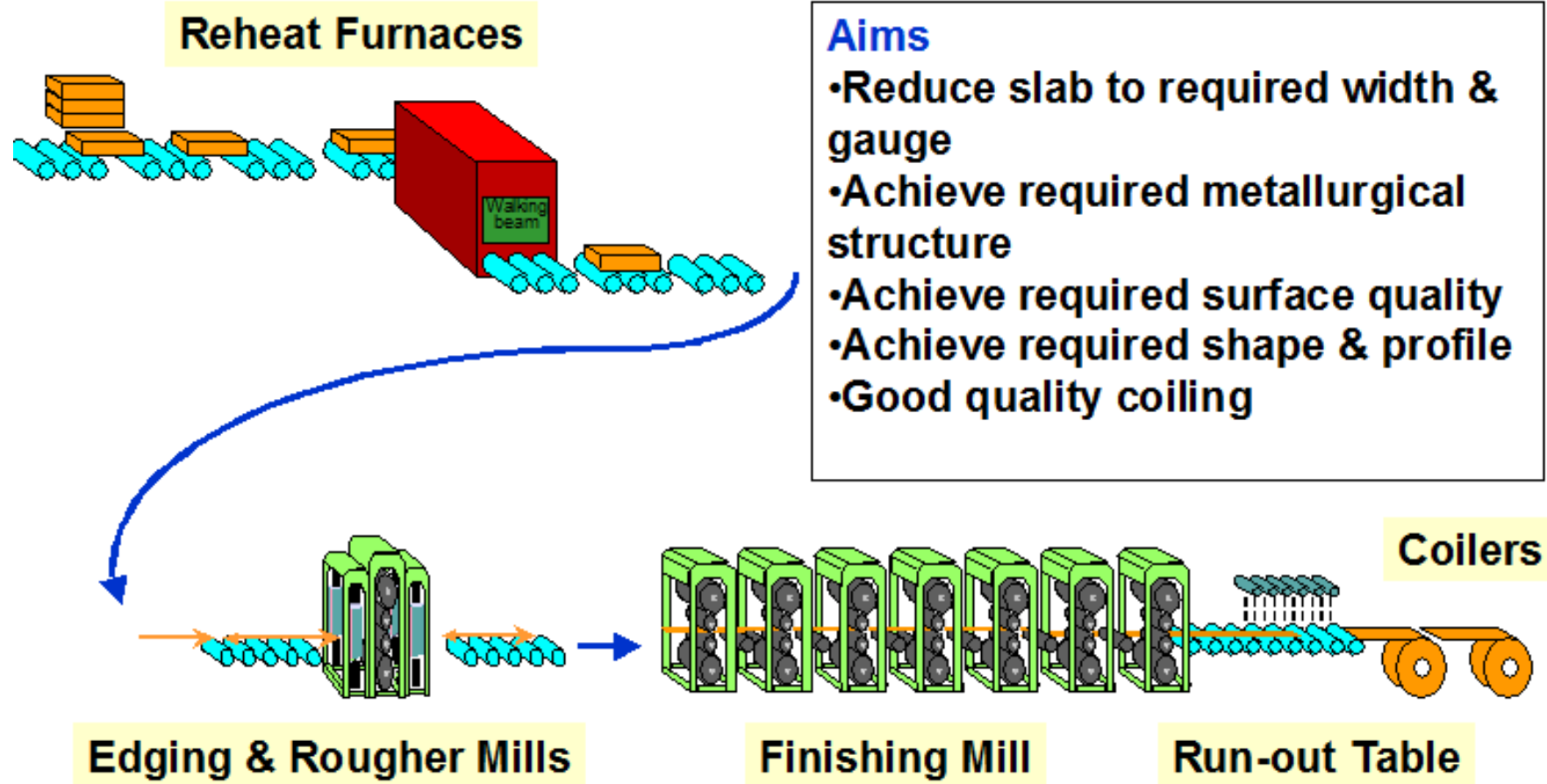
- If too much thickness reduction is demanded the rolls cannot advance the material, and simply skid over its surface.
- If too little deformation is given, the operation will be successful, but more passes will be needed to produce a given part which will increase the cost of production.



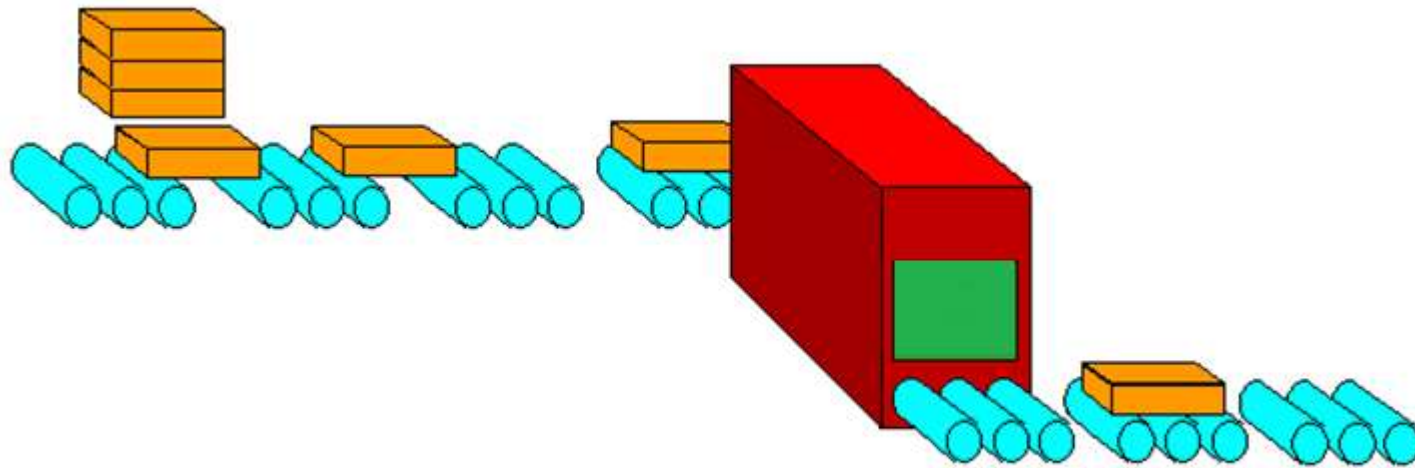
Hot Rolling



Hot Rolling



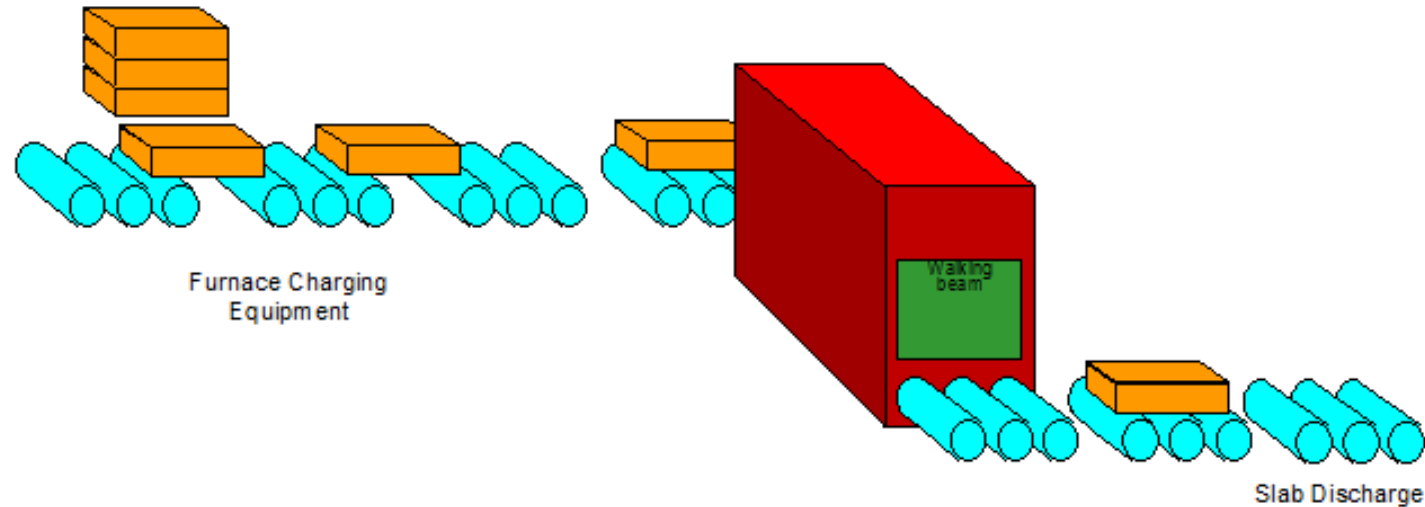
Reheat Furnace



Reheat Furnace

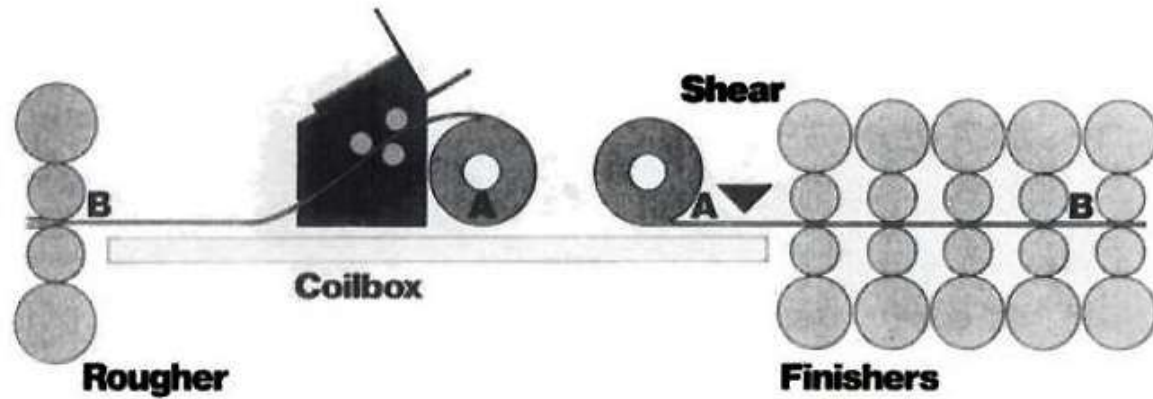
Aims

- Heat slab uniformly to required temperature (approx 1250degC)
- Minimise energy consumption
- Control oxidation/scale formation (gas + controlled O₂ level)



Furnace can be walking beam (PT) or pusher design (LL)

Use of coil box



Coilbox

Reduced length of delay table

Peak power requirement reduced by 13%

Energy saving by 6%

Drive power in finishing train reduced as much as 40%

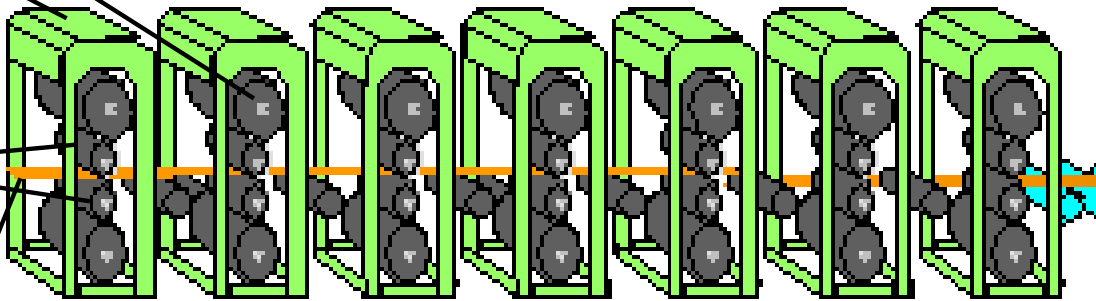
Rolling Worksheet

1) Fill in the blanks:

A Is the part of the hot rolling mill called the _____

B contains the rolls and is called the _____ or the _____

C is the large roll on the top called the _____



D At this stage the steel going through the mill is called the _____

F The rolls in the middle are called the _____

F The roll in between the stands is called the _____ or _____

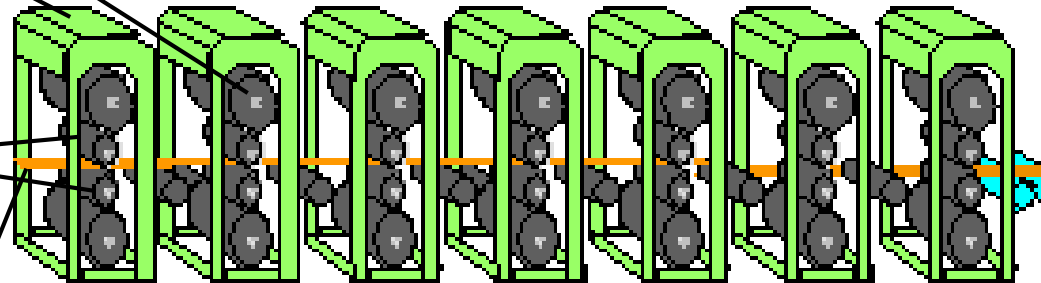
Rolling Worksheet

1) Fill in the blanks:

A Is the part of the hot rolling mill called the Finishing Mill

B contains the rolls and is called the stand or the mill housing

C is the large roll on the top called the Back up Roll



D At this stage the steel going through the mill is called the strip

E The rolls in the middle are called the work rolls

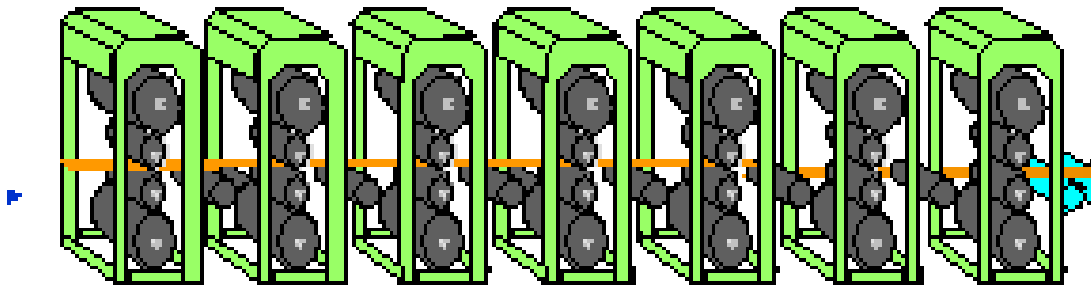
F The roll in between the stands is called the looper roll or tension roll

Finishing Mill

Aims

- Reduce strip to final thickness~3mm
- control width

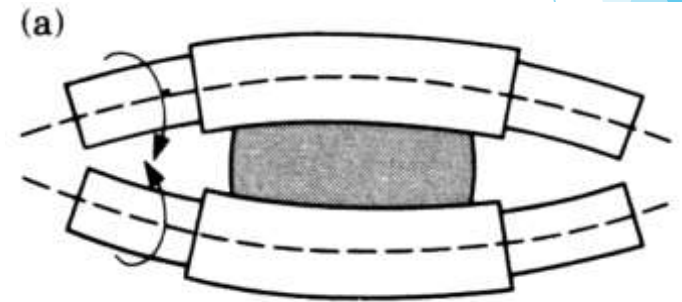
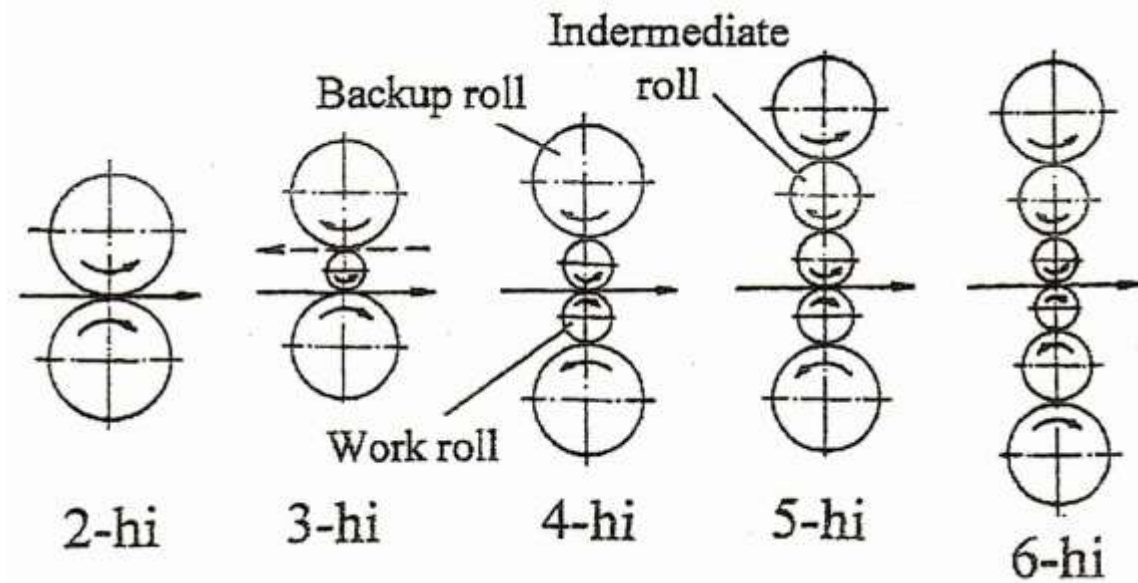
Temperature reduces to ~900°C



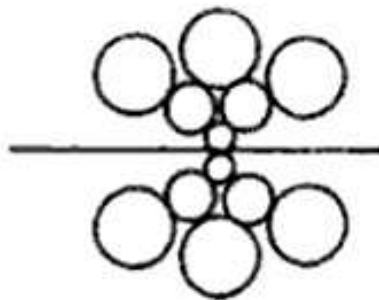
From five to seven stands containing work rolls and back up rolls.

Rolling Mills for Flat Products

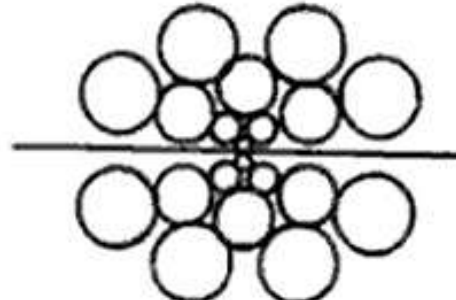
Types of mill stand by roll arrangement



Six-High



Twelve-High



Twenty-High

Types of mill stand by rolling direction

Non reversing

Rolling in forward direction only

Reversing

Rolling in forward & backward direction

Back-pass

Rolling in forward direction
Re-transfer in backward direction

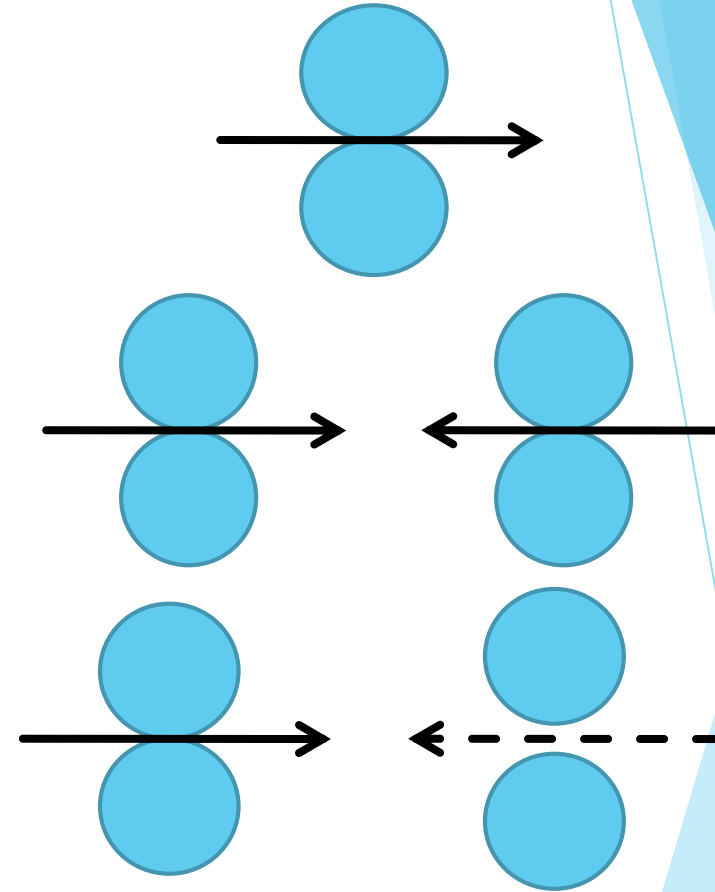
Drive train arrangement

Direct drive (same angular speed as motor)

Gear drive (angular speed adjustable)

Pinion drive (single motor drive of both rolls)

Independent drive (separate motors)



Mill stand arrangement

Open stand

Stand separation greater than rolled product length

Close coupled stand

Stand separation much less than rolled product length

Rolling temperature

Hot rolling

Above 900 (in the γ -region)

Warm rolling

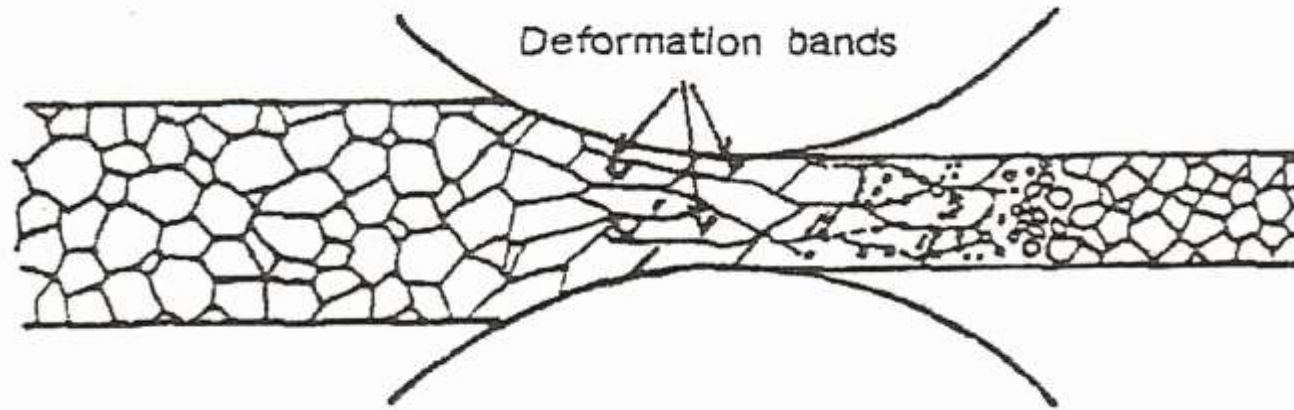
Above 720 (in the $\alpha + \gamma$ region)

Cold rolling

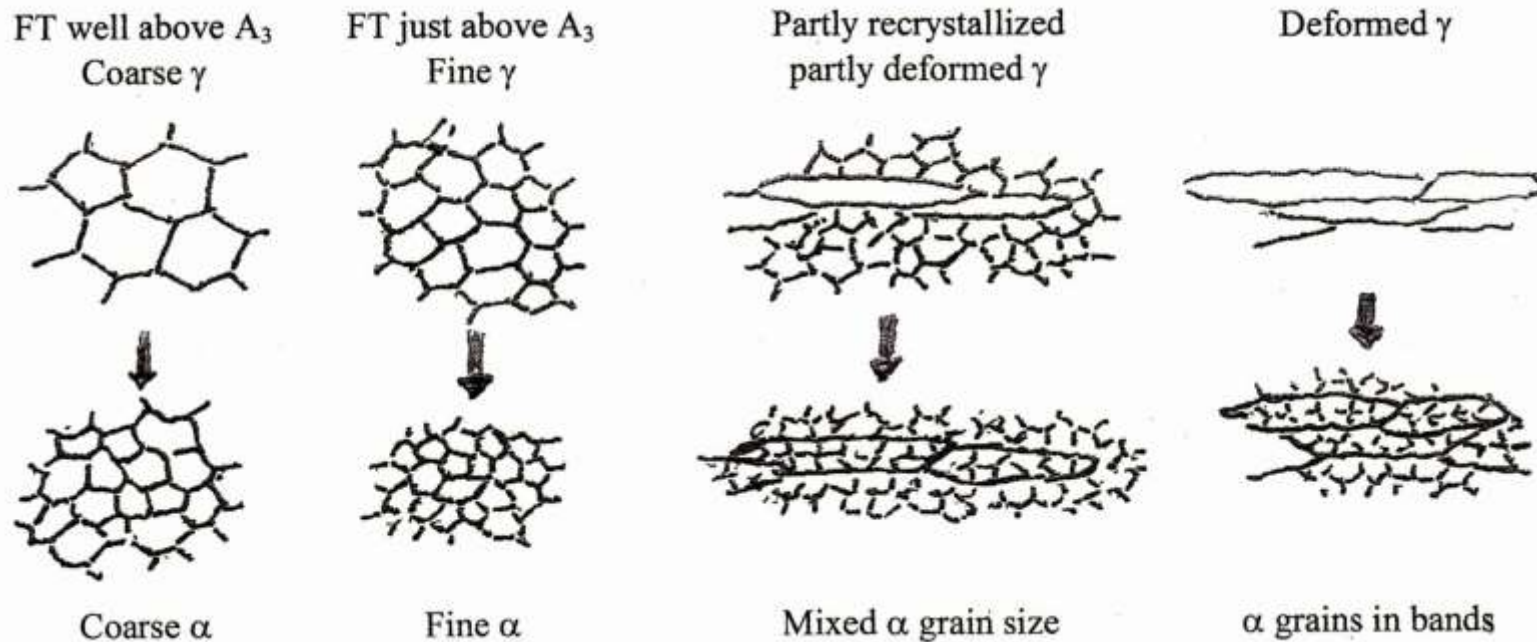
Room temperature

Conventional hot rolling of plain carbon steel

Finishing mill



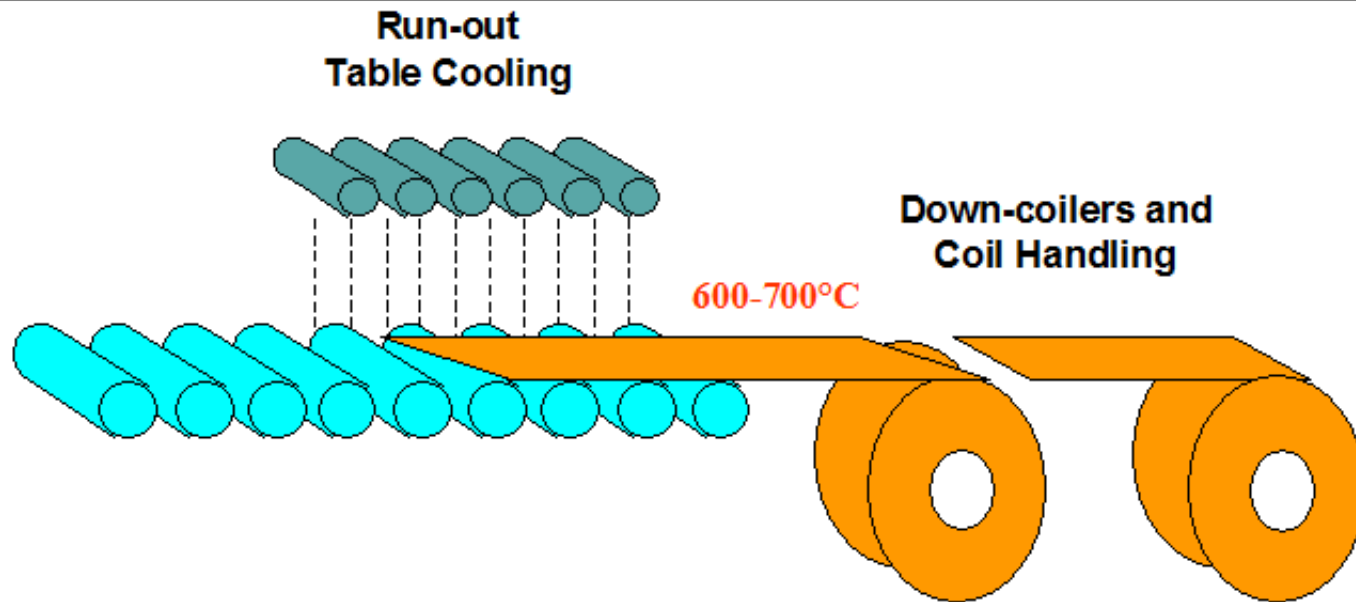
ROT and coiling



Run Out Table and Coiler

Aims

- Achieve required cooling regime/metallurgical structure
- Achieve required coiling temperature
- Produce high standard of coiling
- Uniquely identify coils



Hot Rolling

In hot rolling temperature control is required for success.

The starting material should be heated to a uniform elevated temperature, which is usually carried out in gas or oil-fired soaking pits or reheat furnaces. For plain carbon and low alloy steels, the soaking temperature is about 1200C.

Because of the oxidising atmosphere in the reheat furnaces, the slab surface becomes oxidised.

This surface scale must be removed before rolling.

This is achieved with high pressure water jets.

In most plants, the hot slab is then rolled through horizontal and vertical mill stands, known as 'scale breakers' which fracture and detach most of the oxide layer.

Hot Rolling

For any steel a wide range of microstructures and properties can be obtained by control of :

- The slab reheating temperature.
- The temperature of the steel during rough rolling.
- The finishing temperature(FT) of the steel exiting the final stand of the finishing mill.
- The coiling temperature(CT).
- The run out table(ROT) cooling schedule defining the patterns of cooling from FT to CT.

Run Out Table

