Cast Irons

Yildiz Technical University
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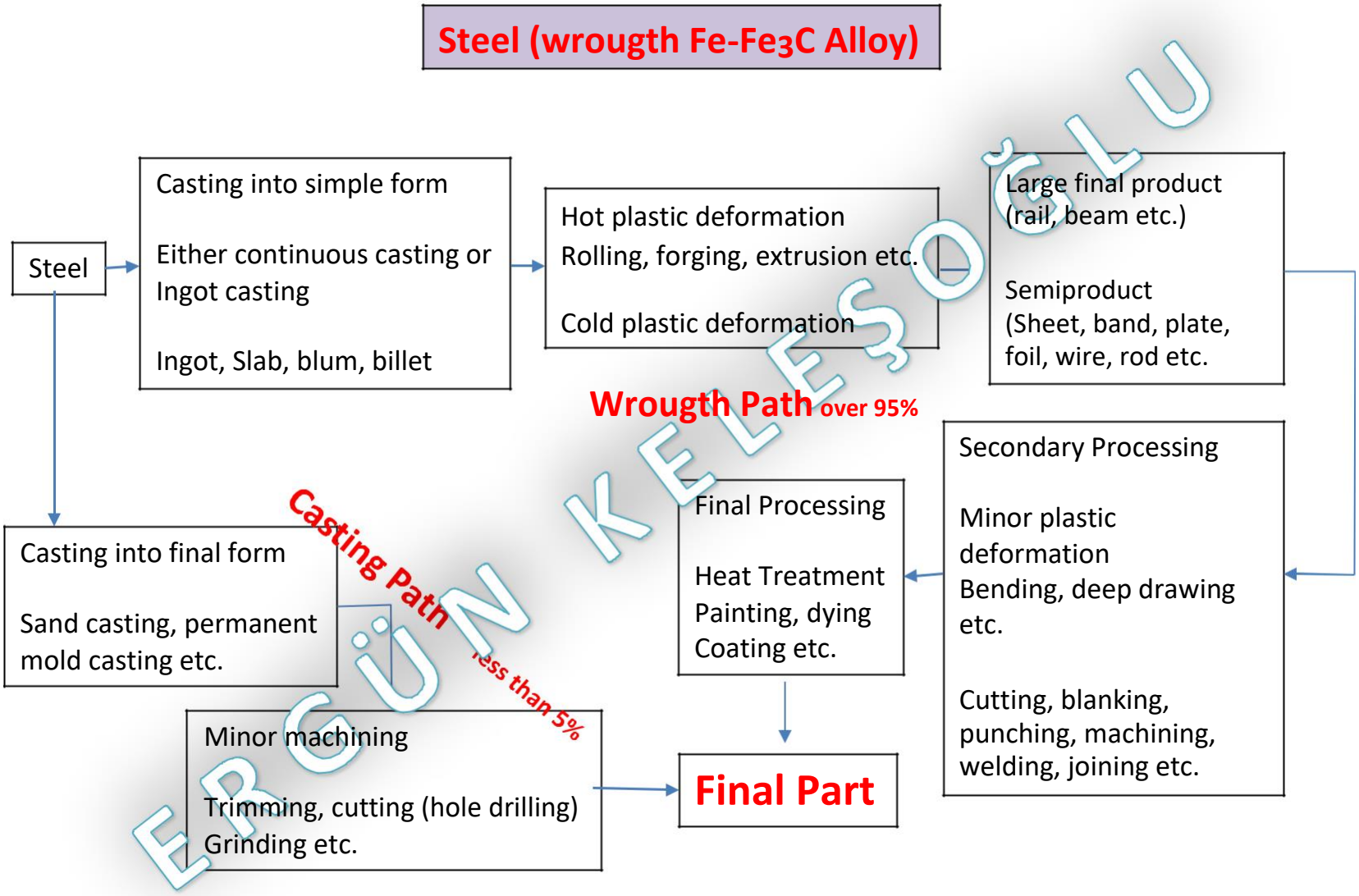
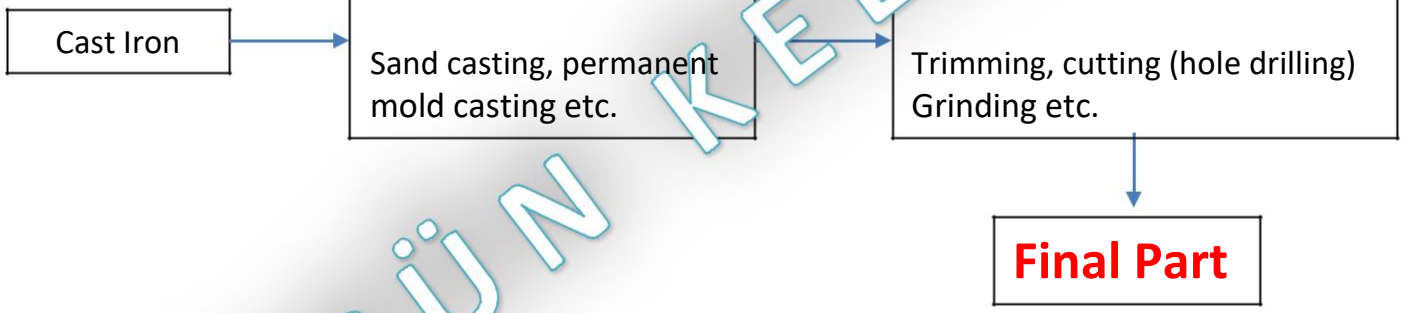

Steel (wrougth Fe-Fe3C Alloy)
Steel
Casting into simple form
Either continuous casting or Ingot casting
Ingot, Slab, blum, billet
Hot plastic deformation
Rolling, forging, extrusion etc.
Cold plastic deformation
Large final product (rail, beam etc.)
Semiproduct (Sheet, band, plate, foil, wire, rod etc.
Wrougth Path over 95%
Secondary Processing
Minor plastic deformation
Bending, deep drawing etc.
Cutting, blanking, punching, machining, welding, joining etc.
Final Processing
Heat Treatment
Painting, dying
Coating etc.
Casting into final form
Sand casting, permanent mold casting etc.
Casting Path
less than 5%
Minor machining
Trimming, cutting (hole drilling)
Grinding etc.
Final Part
ERGÜN KELEŞOĞLU

Cast Iron (cast Fe-Fe_3C/Graphite Alloy)

Casting Path almost 100%



Fe – C Diagrams

When C content is lower than 2% (Steel range)
Only iron-cementite phase diagram is favour.

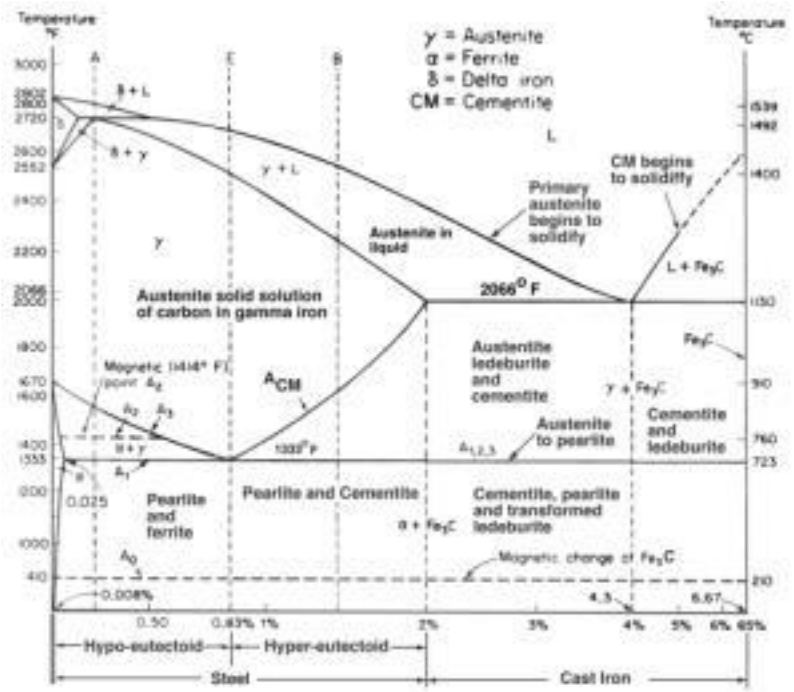
When C content is higer than 2% (Cast iron range)
Both systems are possible.

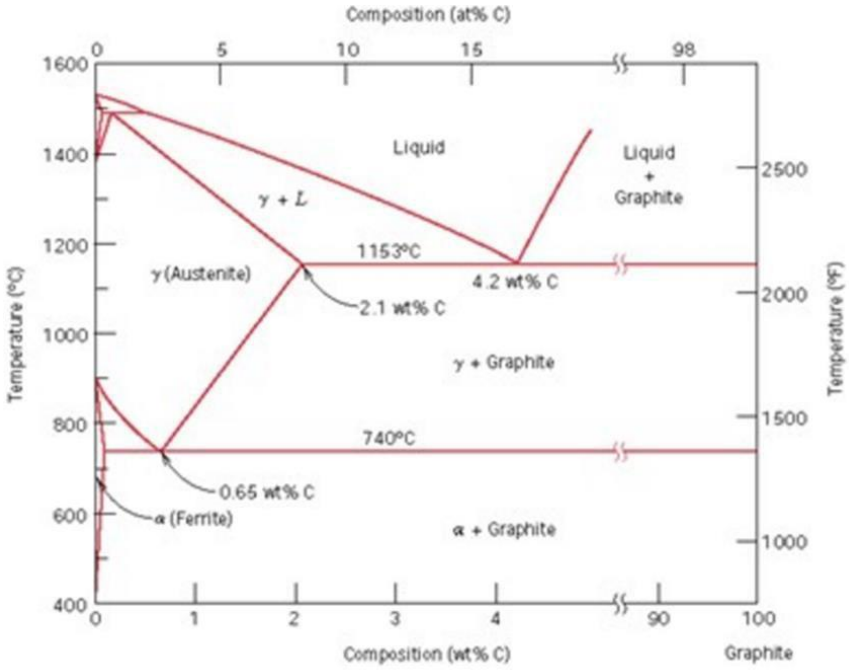
White

Gray

Fe-Cementite Phase Diagram

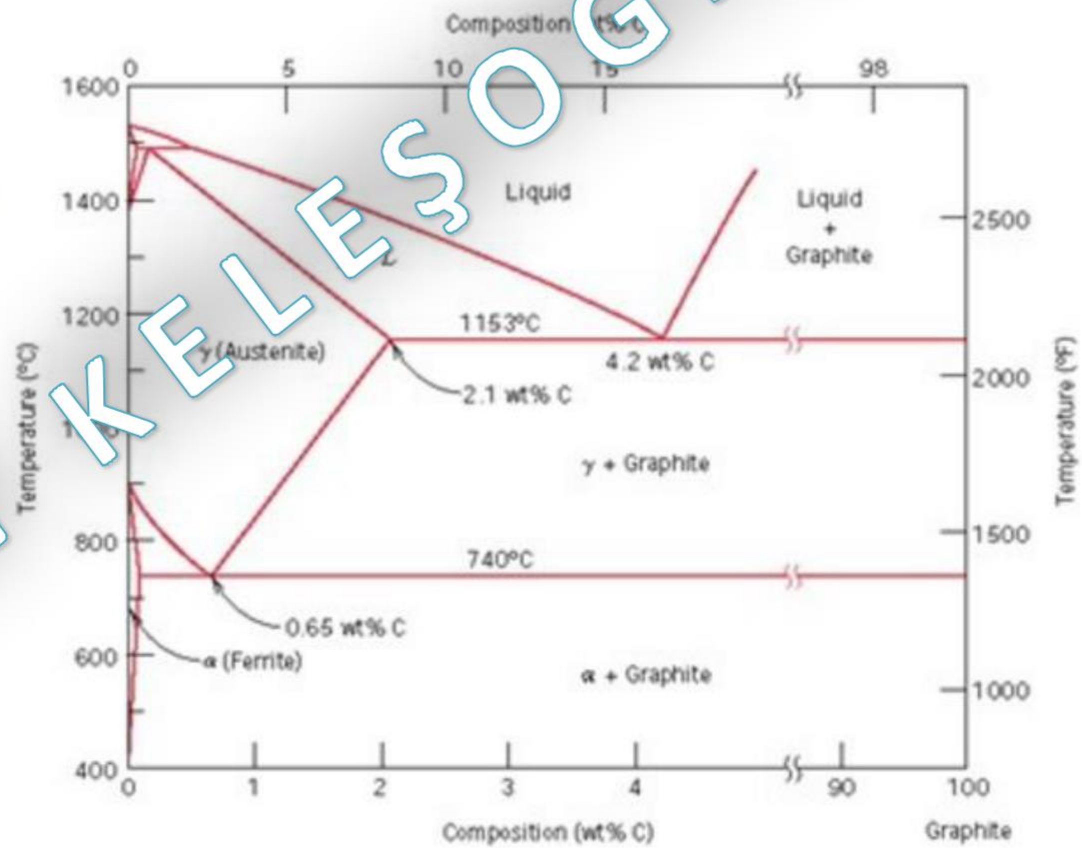
Fe-Graphite Phase Diagram





Cast Iron

- Fe-C alloys with 2-4%C
- 1-3% Si is added to improve castability
- Phase diagram shows graphite rather than Fe_3C since C may be present in the form of both graphite and cementite
- Temperatures and compositions are different from the Fe-Fe_3C diagram
- Features:
  - Low melting temperature (1153ºC to 1400ºC)
  - Low shrinkage
  - Easily machinable
  - Low impact resistance
  - Low ductility



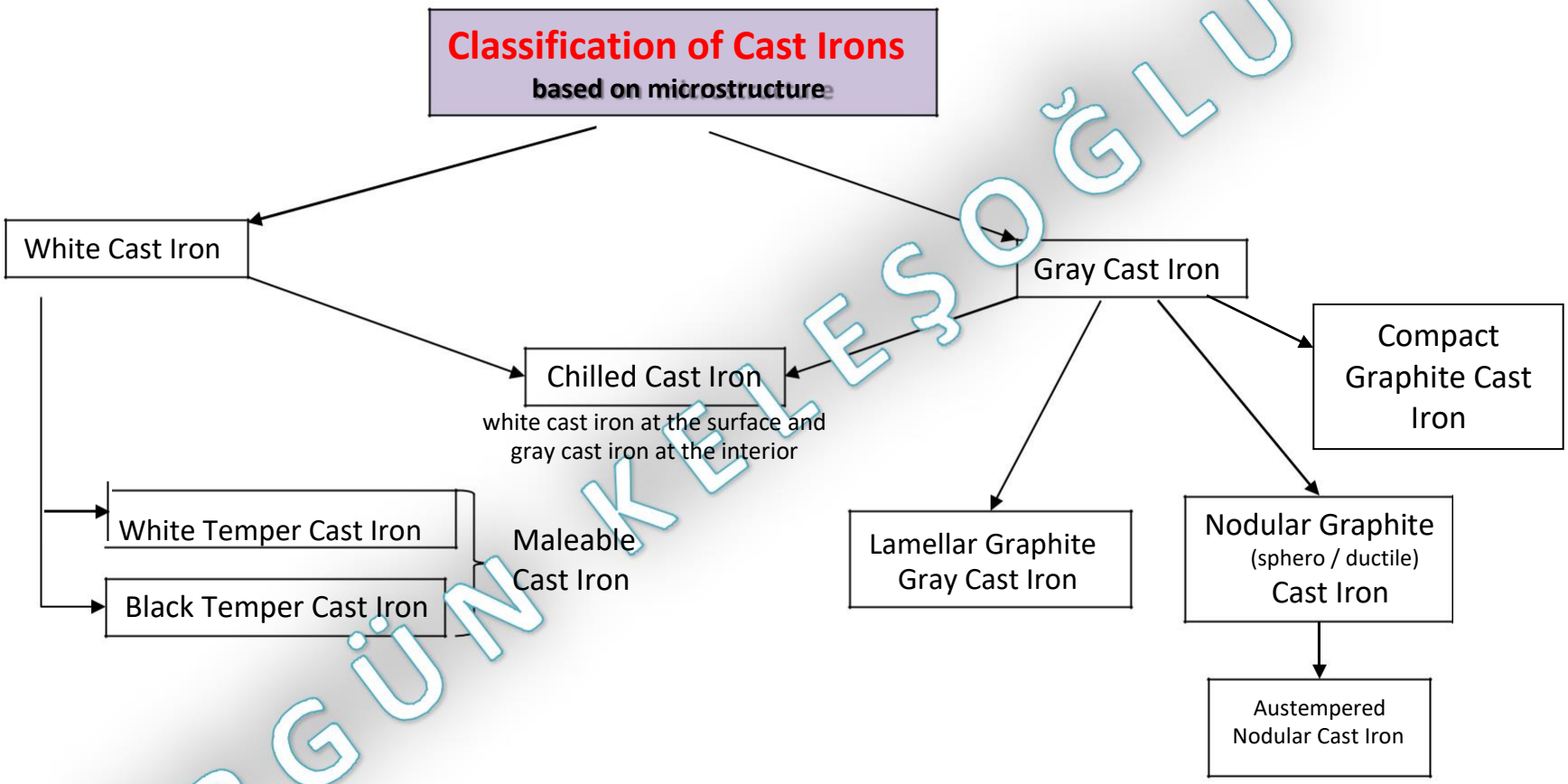
- Carbon can occur in C.I's as:

  combined carbon (Fe_3C) or free carbon (graphite)

- Shape and distribution of free carbon also important

Parameters that influence are:

- Carbon content,
- Alloy and impurity content,
- Cooling rate during and after freezing,
- Heat treatment after casting



Check of Cast Structure

Gray Cast Iron

Chille zone
White Cast Iron

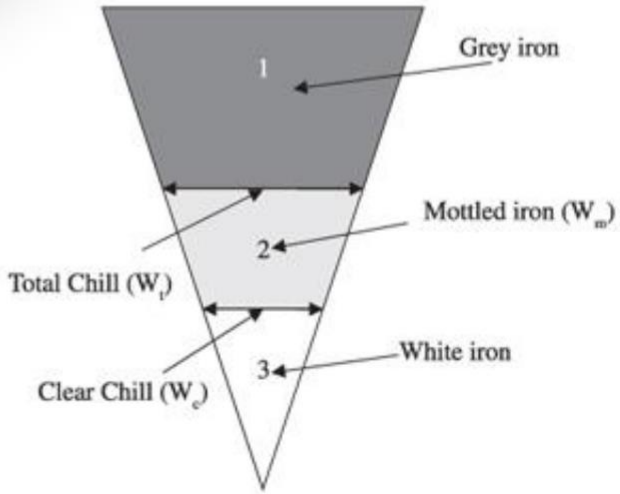


Figure 1. White, mottled and gray iron zones (1, 2 and 3) of the wedge sample, and the dimensions representing W_t and Wc chill criteria.

Classification of cast iron

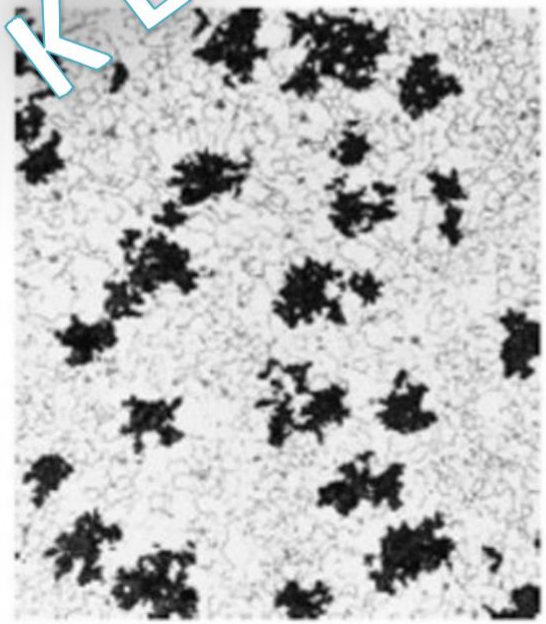
	Type of cast iron	Graphite	Ductility	
•	White	No	No	ast cooling rates
•	Gray	Flake	No	Slow cooling rates
•	Malleable	**Anneal: flake to nodule**	Yes	white iron + annealing heat treatment
•	Nodular	Nodular	Yes	additions made so that nodules of graphite form instead of flakes
•	Compact	Worm like	Yes	additions made so that worm like graphite form instead of flakes

Cast Irons

- Types
  - White cast iron
    - Carbon in the form of cementite
  - Malleable cast iron
    - Carbon in the form of irregular graphite nodules
    - Obtained by heat treating white cast iron

White cast iron

- Fe_3C + pearlite
- Hard, brittle
- Shows a "white" crystalline fractured surface
- Excellent wear resistance
- High compressive stress



Malleable cast iron

- White cast iron + annealing treatment **(900-950°C for many days/cooling slowly)**
- During annealing treatment graphite nucleates and grows from the Fe_3C to form nodules

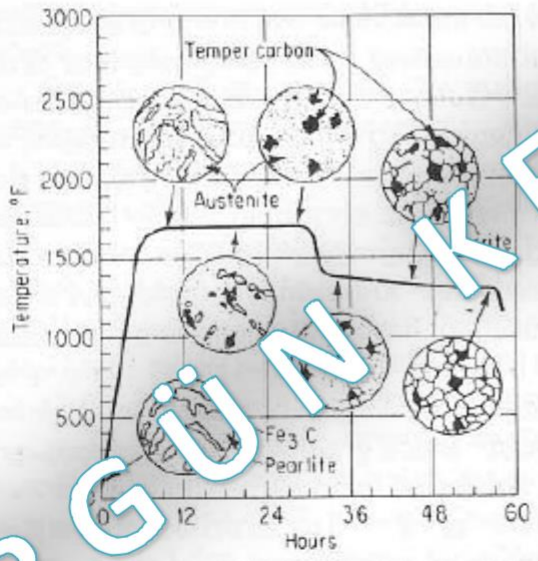
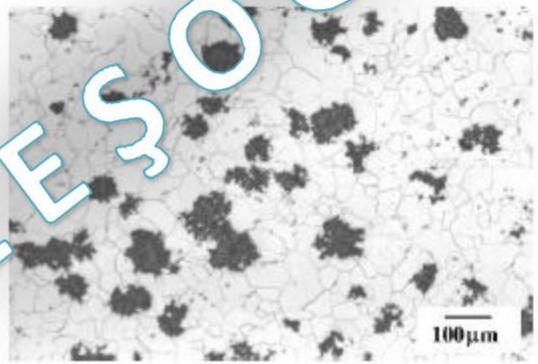
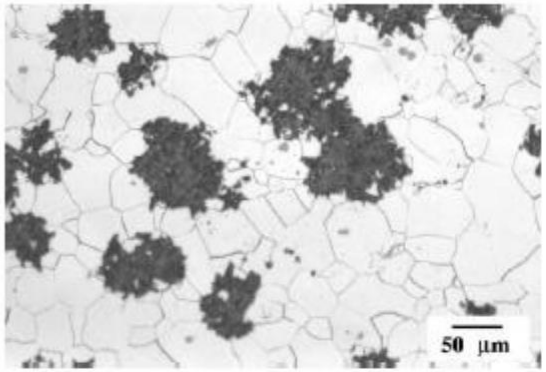


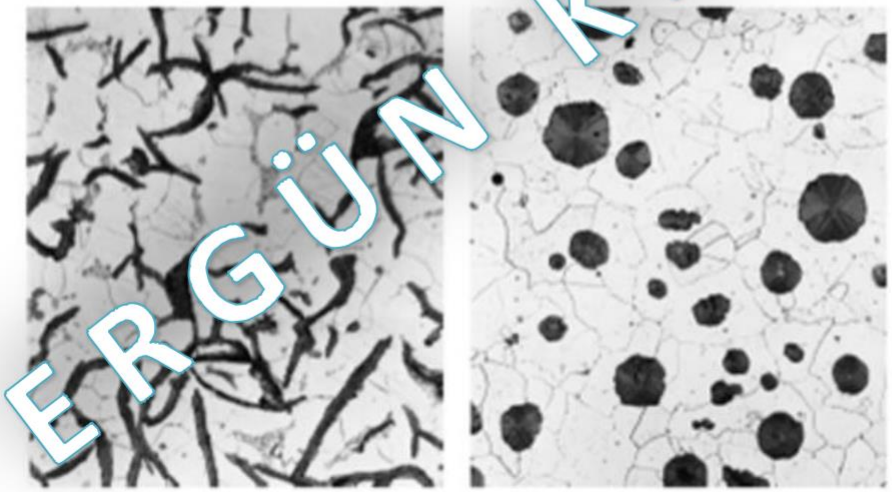
Fig. 1 ... changes in microstructure as a function of ... malleablerizing cycle resulting in temper carbon in a ... ite matrix. (From "Malleable Iron Castings," Malleable ... ders Society, Cleveland, Ohio, 1960.)

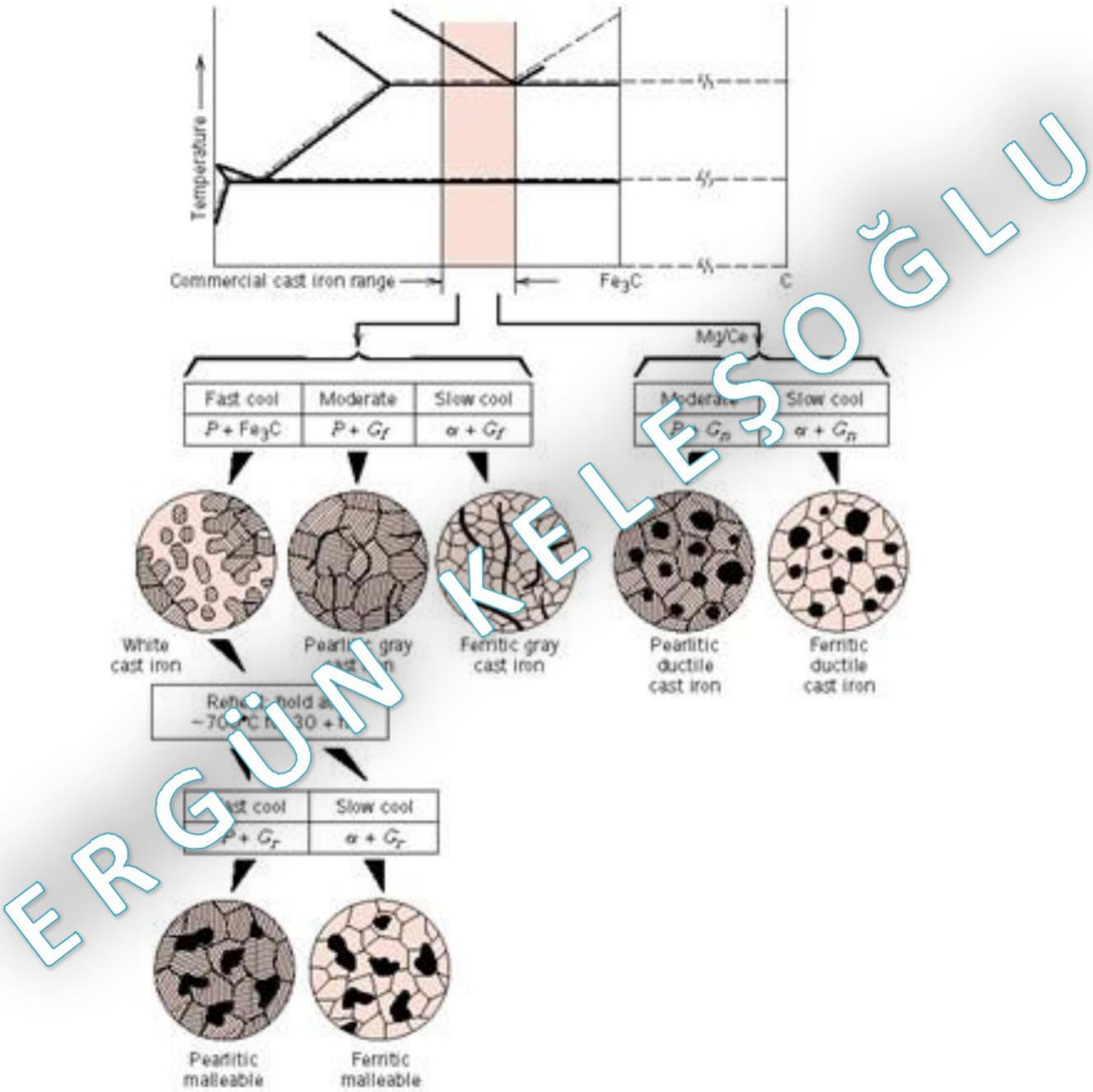


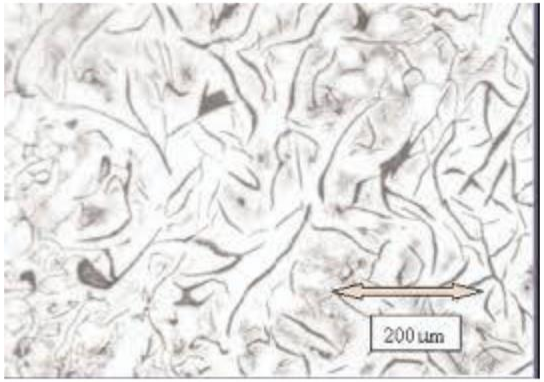


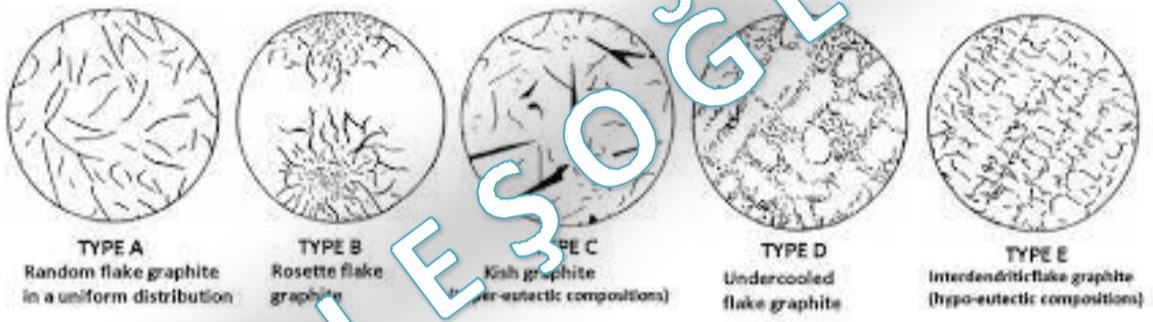
Cast Irons

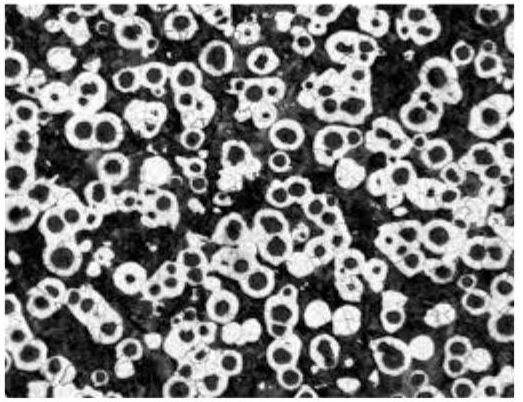
- Types
  - Gray cast iron
    - Carbon in the form of graphite flakes
    - 2.5 – 4% C and 1 – 3% Si (Promotes formation of graphite)
  - Nodular cast iron
    - Carbon in the form of spherical graphite nodules
    - 3-4% C and 1.8 – 2.8 % Si + Mg or Ce, and low impurities









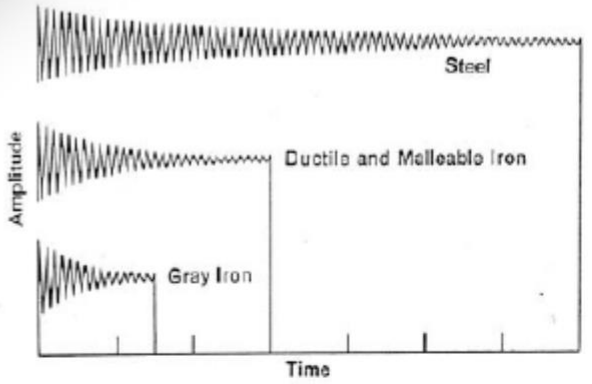


General characteristics/advantages of gray cast iron

- Cheap
- Low melting point
- Fluid – easy to cast, especially advantageous into large complex shapes
- Excellent machinability
- Excellent bearing properties
- Excellent damping properties
- Excellent wear resistance (hi C)
- Can be heat treated (surface hardened
- Can be alloyed etc.

Compressive strength >> tensile strength

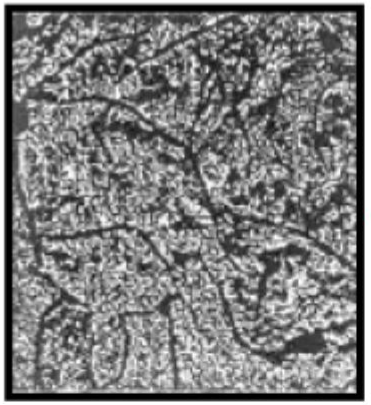
Great at dampening!



Relative ability of ferrous metals to dampen vibrations. The energy absorbed per cycle, or specific damping capacity of these can differ by more than 10 times.

Gray cast iron

- During slow solidification carbon in Fe separates or graphitizes to form separate graphite flakes



Cast iron: factors affecting graphitization

Cast iron Carbon Equivalent

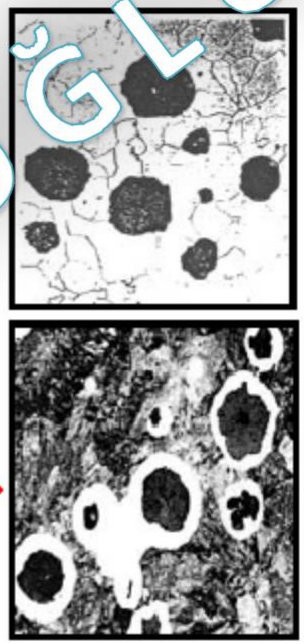
$$CE(\text{wt\%}) = C + \frac{Si + P}{3}$$

A high cooling rate and a low carbon equivalent favours the formation of white cast iron

A low cooling rate or a high carbon equivalent promotes grey cast iron

Ductile/nodular cast iron

- Gray iron composition for C and Si
- Impurity level control important as it will affect nodule formation
- Have nodule instead of flake if we add ~0.05% Mg and/or Ce
- As cast structure: graphite forms as nodules instead of flakes

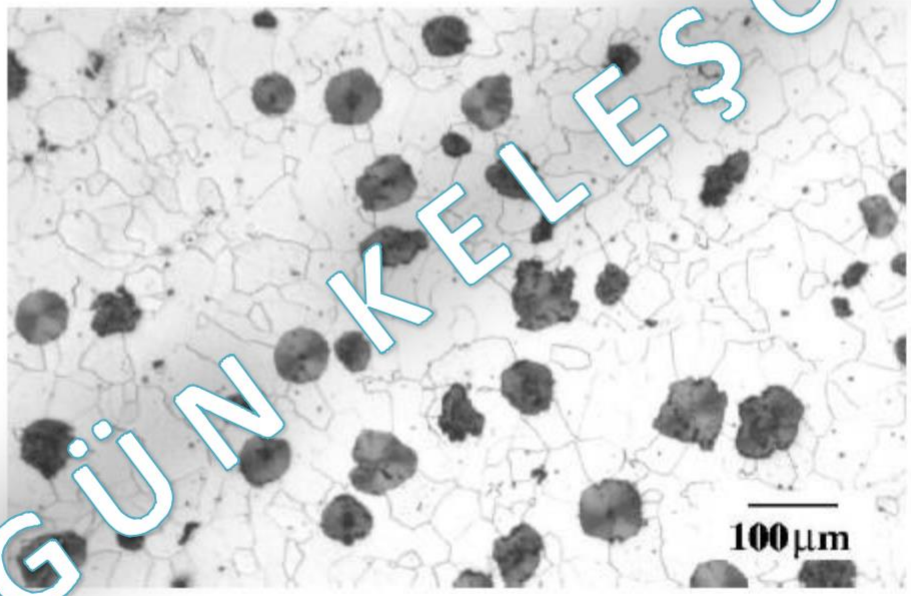


Additions of Ce / Mg poisons the easy growth direction and results change in graphite morphology from flakes to spheres which occurs due to isotropic growth

Spheroidal graphite cast iron usually has a pearlitic matrix.

Heat Treated Spheroidal Graphite Cast Iron

Annealing causes the carbon in the pearlite to precipitate on to the existing graphite or to form further small graphite particles, leaving behind a ferritic matrix.



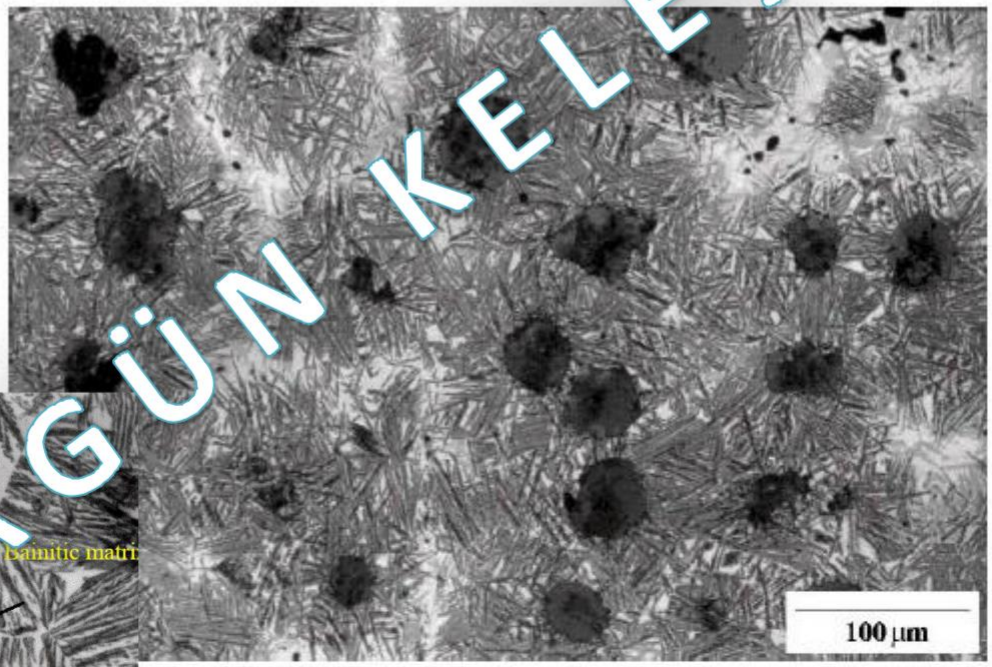
Applications: agricultural, automotive machinery

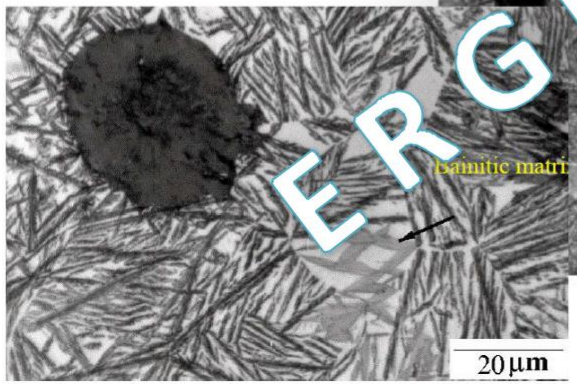
Austempered Ductile Cast Iron

The chemical composition of the cast iron is

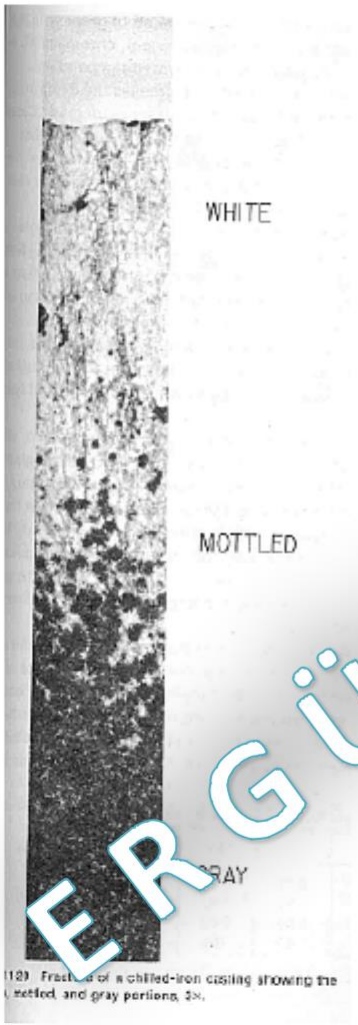
Fe-3.52C-2.51Si-0.49Mn-0.15Mo-0.31Cu wt%

Austenitised at 950°C, austempered at 350°C for 60 min.





Chilled Cast Iron



- Obtained by casting against a chiller
- Surface is White C.I. (faster cooling rates)
- Harder / wear resistant surface
- Depth depends on composition

  (C, Si decrease chill depth)

  Carbide forming elements like Cr, Mo increase chill depth

Applications:

Railway car wheels, crushing rolls, heavy machinery

Examples

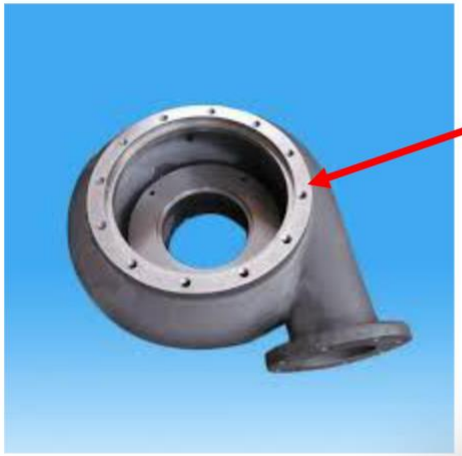
Manhole

Cast iron radiators

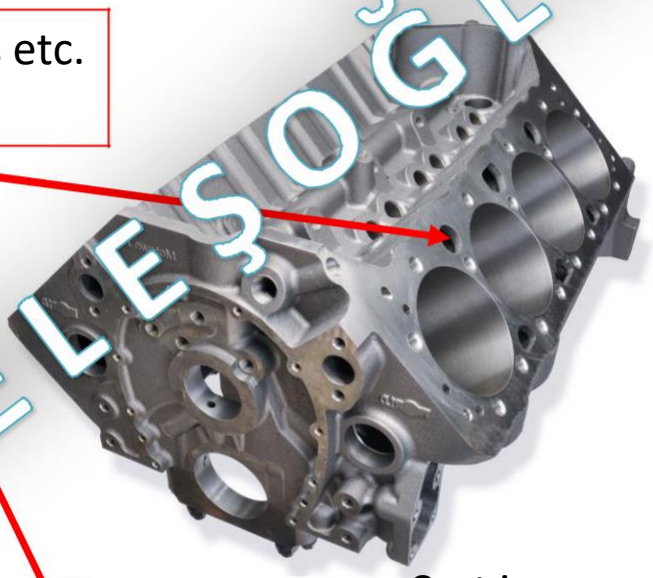
Cast iron valves

Examples

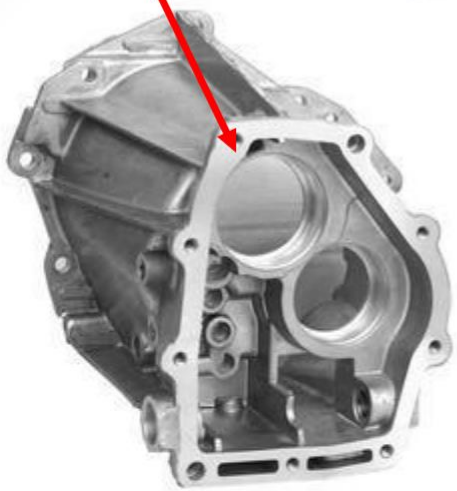
Surfaces / holes etc. to be machined



Centrifugal Cast Iron Pumps



Cast iron engine block



Gear Box

Examples

Fatih’s Cannon «Şahi»

Historical Buildings
Cast iron Gate of Dolmabahçe Palace

Designation of Cast Irons in European Standards

1	2	3	4	5	6
		Graphite Type	Matrix Type	Mechanical Property / Chemical Comp.	Additional Symbol (optional)
EN	GJ	L- Lamellar	A-Austenitic	-xxx min.Rm (N/mm^2)	-D Raw Cast
		S- Spheroidal	F- Ferritic	or	-H Heat Treated
		M- Temper	P- Pearlitic	-xx min. A	-W Suitable for Welding
		V- Vermicular	M- Martensitic	and	
		N- without Graphite, ledeburitic	L- Ledeburitik	S- Separate test sample	
		Y- Special Structure	Q- Quenched	U- Joined test sample	
			W- White Tempered	C- Sample from part	
			B- Black Tempered		

Example : EN GJL 350 EN GJS 700-2