UNIT III

HEAT TREATMENT

Engineering Materials and Metallurgy

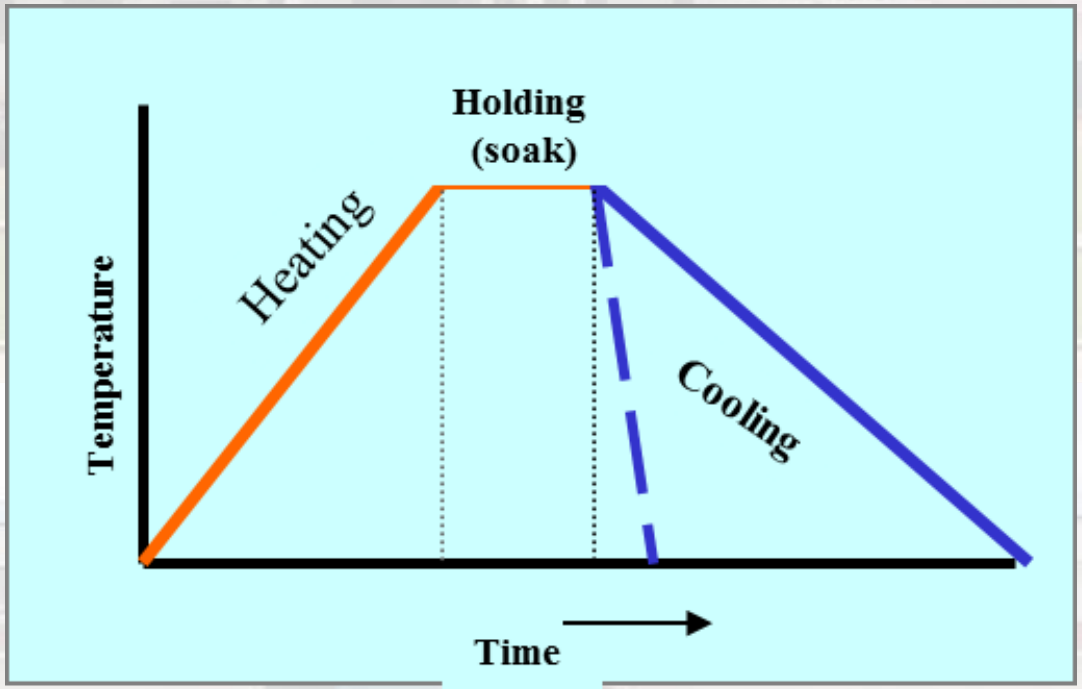
KARTHICK B

ASSISTANT PROFESSOR / MECHANICAL ENGG

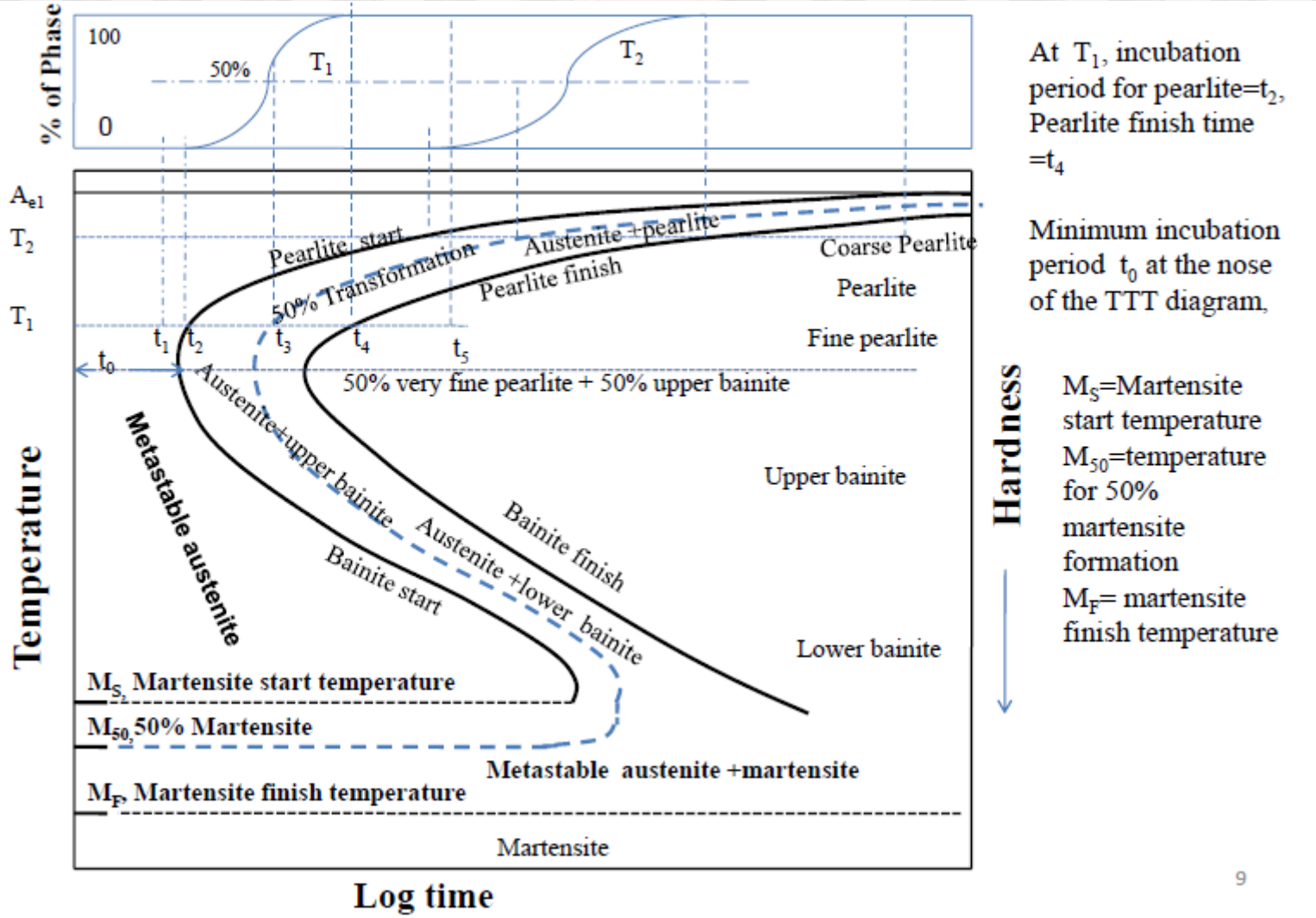
Heat Treatment

Heat Treatment

Defined as the controlled heating and cooling of metals for the primary purpose of altering their properties (strength, ductility, hardness, toughness, machinability).



TTT of a Eutectoid Steel



At T_1, incubation period for pearlite=t_2, Pearlite finish time =t_4

Minimum incubation period t_0 at the nose of the TTT diagram.

M_S=Martensite start temperature
M_{50}=temperature for 50% martensite formation
M_F= martensite finish temperature

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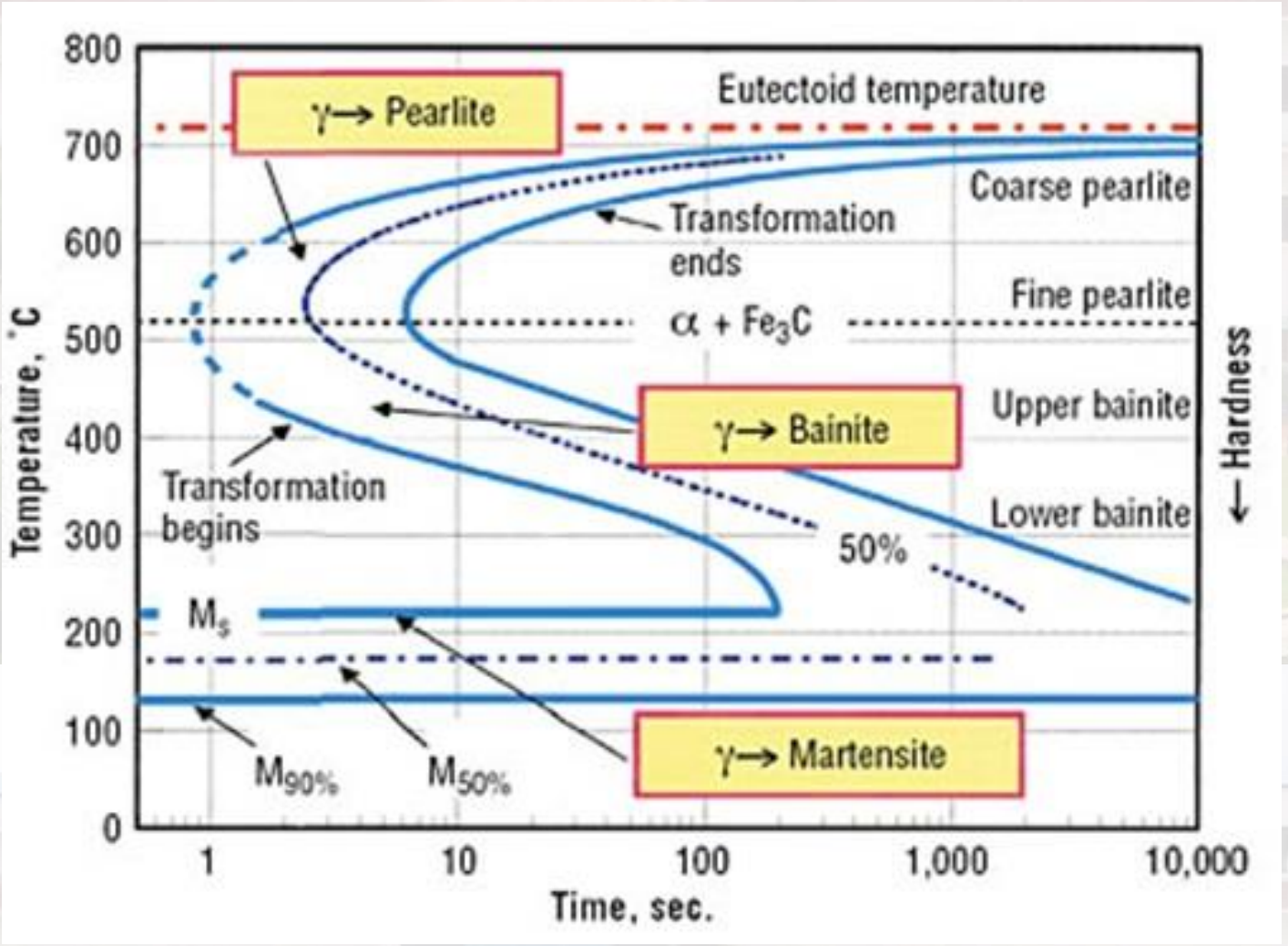
Time Temperature Transformation



TTT

- Time temp transformation (or) **isothermal transformation (or) S curve (or) C curve (or) Bain's Curve.**

- It is created three process:

✓ Austenitizing

✓ Isothermal Heat treatment

✓ Quenching

❖ **Isothermal transformation**

TTT

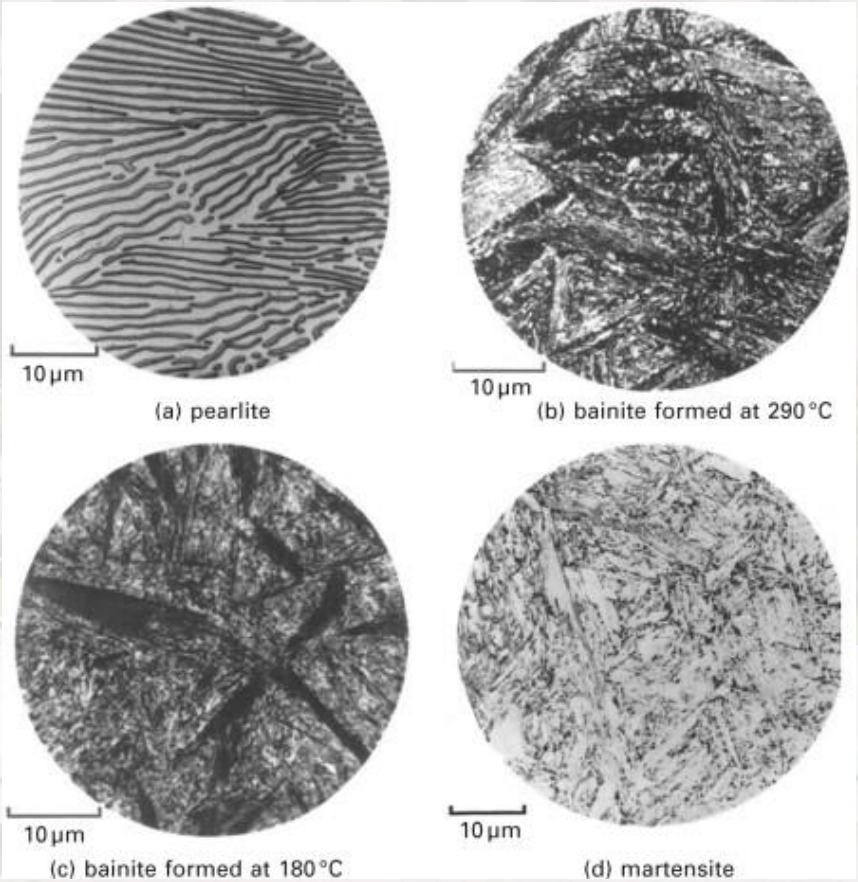
- 723˚-550˚C→ Pearlite is formed.
- Transformation temp decreases pearlite change from coarse to fine.
- On rapid quenching Martensite is formed.
- 550˚C- 250˚C → Bainite is formed.
- Bainite → Non-lamellar eutectoid structure.

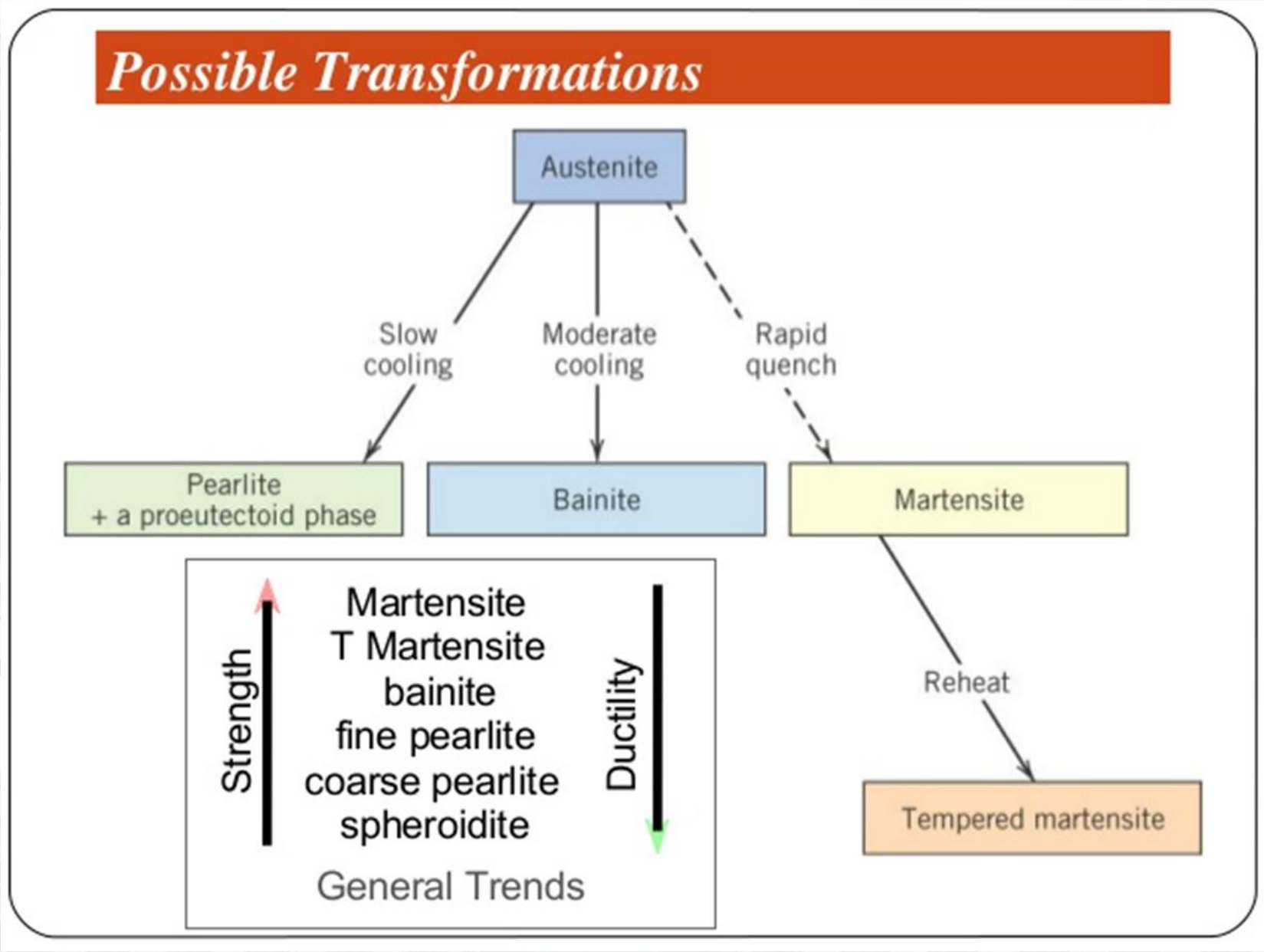
TTT

- **Bainite**

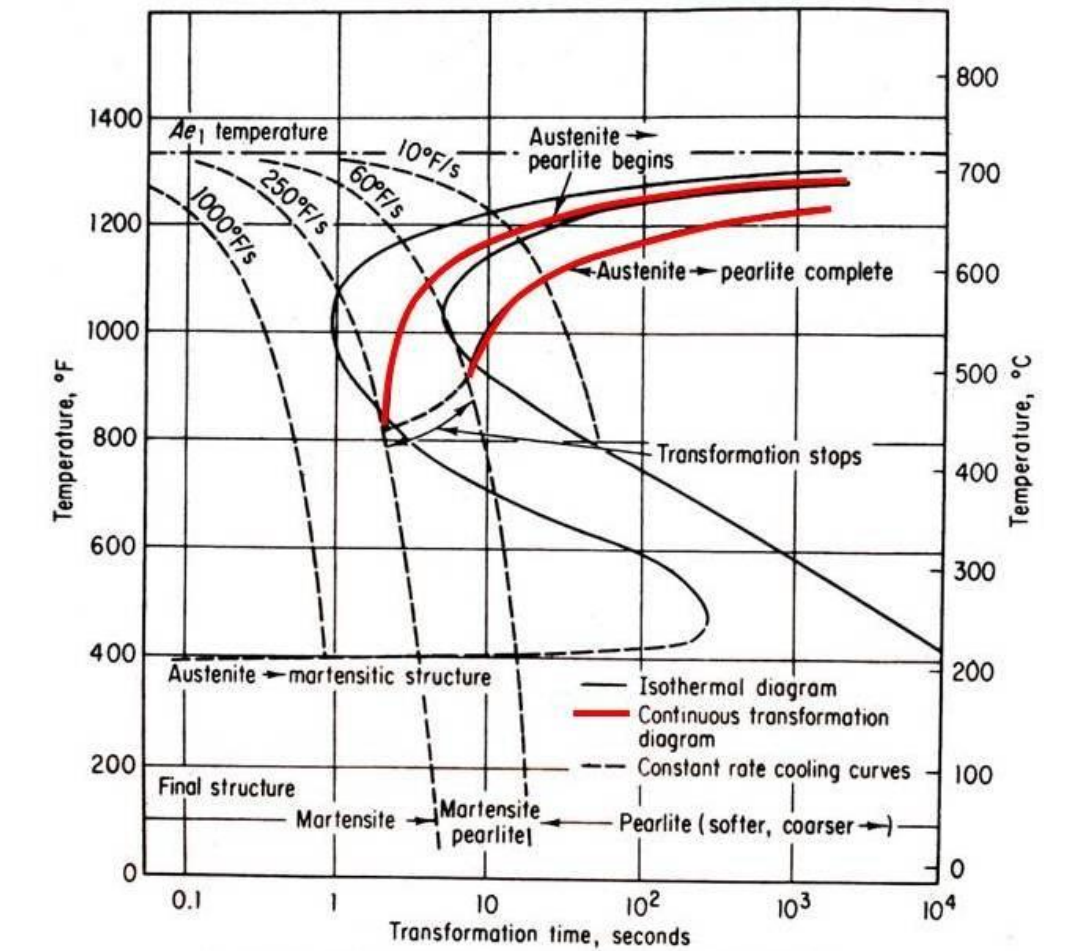
❖Upper Bainite→ 550˚- 350˚C → has large rod like cementite regions

❖Lower Bainite→ 350˚ - 250˚C → has much finer cementite particles.




Possible Transformations
Austenite
Slow cooling
Moderate cooling
Rapid quench
Pearlite + a proeutectoid phase
Bainite
Martensite
Reheat
Tempered martensite
Strength
Ductility
Martensite
T Martensite
bainite
fine pearlite
coarse pearlite
spheroidite
General Trends

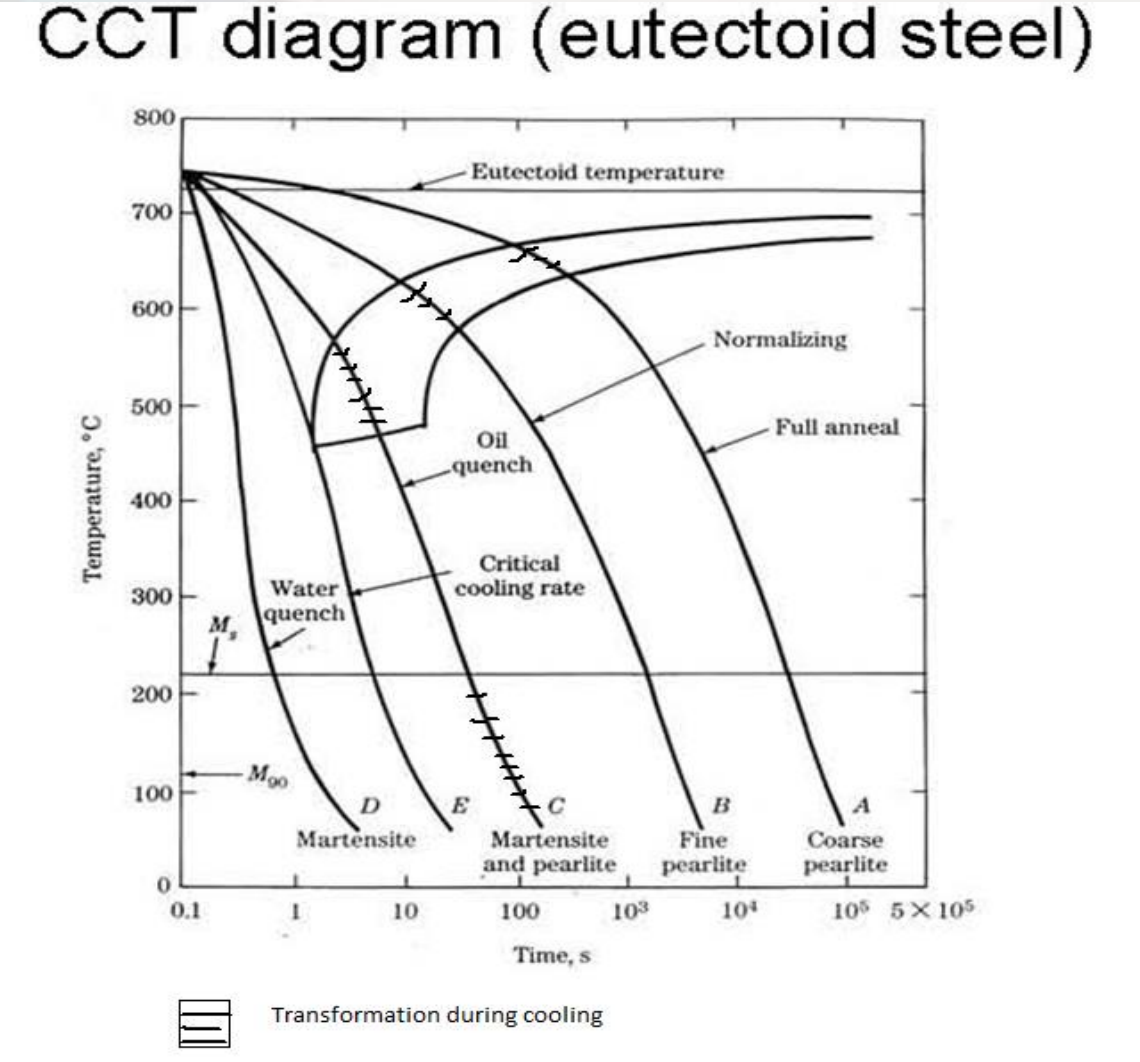
Continuous Cooling Transformation



Continuous Cooling-Transformation (C-T) Diagram
(Derived from the isothermal-transformation diagram for a plain-carbon eutectoid steel)

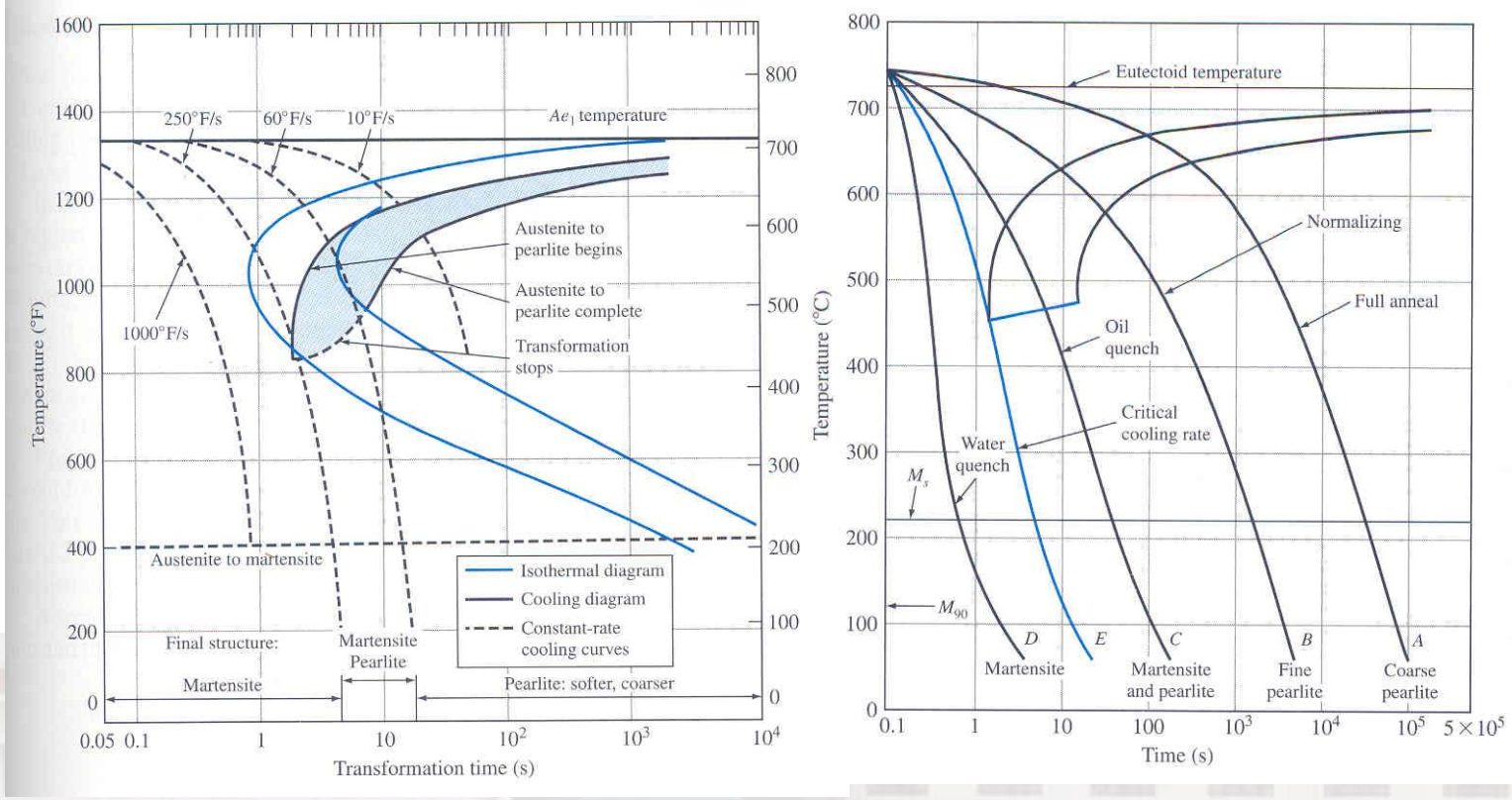
CCT

- The time required for a reaction to start and to end is delayed.
- The isothermal curves are shifted to longer times and lower temperatures.
- No transformation below 450˚C.



CCT

- In continuous cooling transformation from martensite to pearlite takes place at a range of temperature.
- Start and finish lines shifted to longer time.
- No transformation below 450^0C.



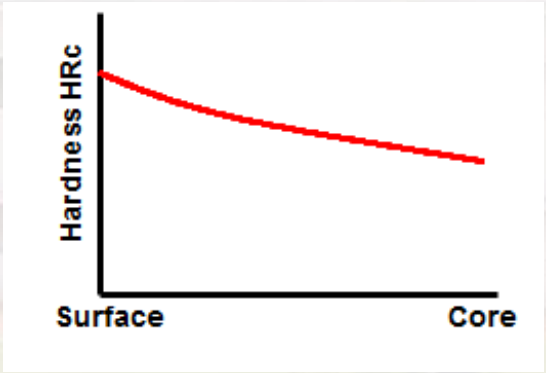
CCT

- A→ Coarse pearlite
- B→ Fine Pearlite
- C→ Martensite and Pearlite → Split Transformation
- D→ Martensite
- E→ Tangent to Nose of CCT→ critical cooling rate→ 100% Martensite.

Hardenability

Hardenability

In a ferrous alloy, the property that determines the depth and distribution of hardness induced by quenching from elevated temperatures

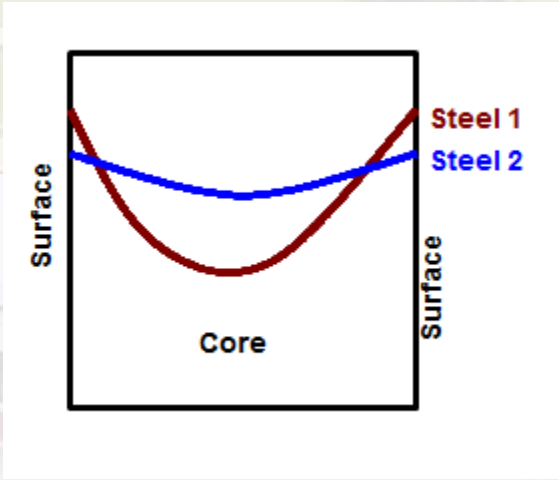


Hardenability Vs Hardness:-

Hardness : Function of only carbon content

Hardenability : C & Alloy content, grain size, Component size,

Quenchant etc



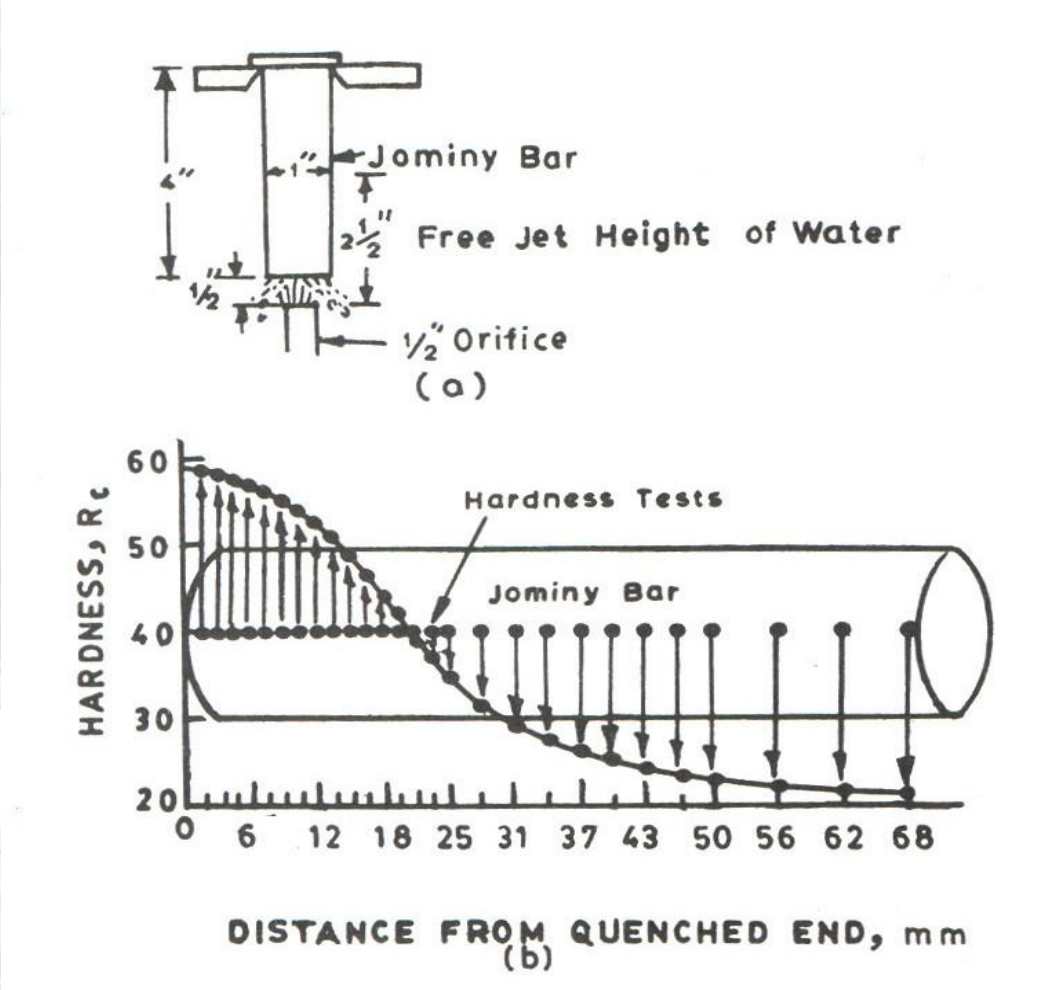
Jominy Hardenability (Quench) test

- Steel Sample: 25mm dia and 100mm long
- Heating the test piece to an austenitising temperature and quenching from one end with a controlled and standardized jet of water
- Take a sample from the furnace and place it on the Jominy test fixtures and observe the cooling pattern
- The cooling rate along the Jominy test specimen varies from about 225 °C s^{-1} (at bottom) to 2 °C s^{-1}
- After quenching the hardness profile is measured at (0.16 mm) intervals from the quenched end after the surface has been ground back to remove any effects of decarburisation (0.38mm is removed from the surface)

Jominy Hardenability (Quench) test

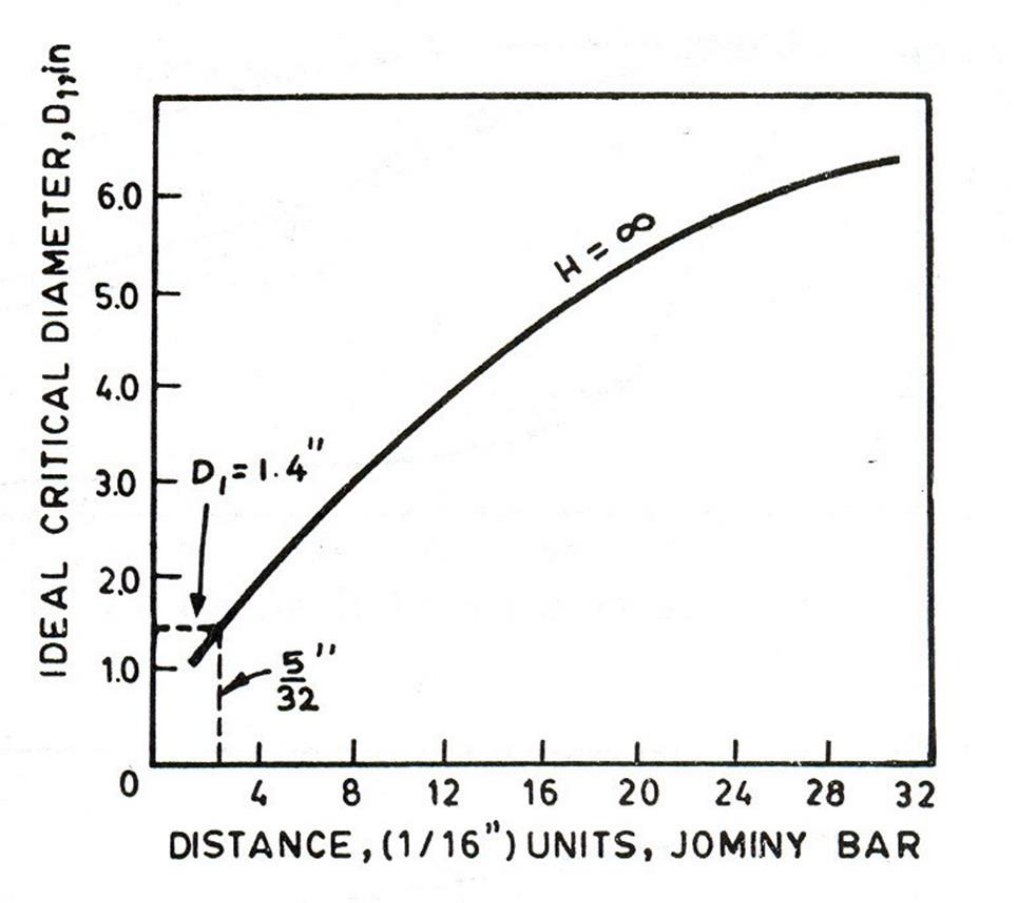
- The hardness variation along the test surface is a result of microstructural variation which arises since the cooling rate decreases with distance from the quenched end
- Measure the distance from the quench end at where the hardness is equal to 54 HRc in the units of 0.16mm

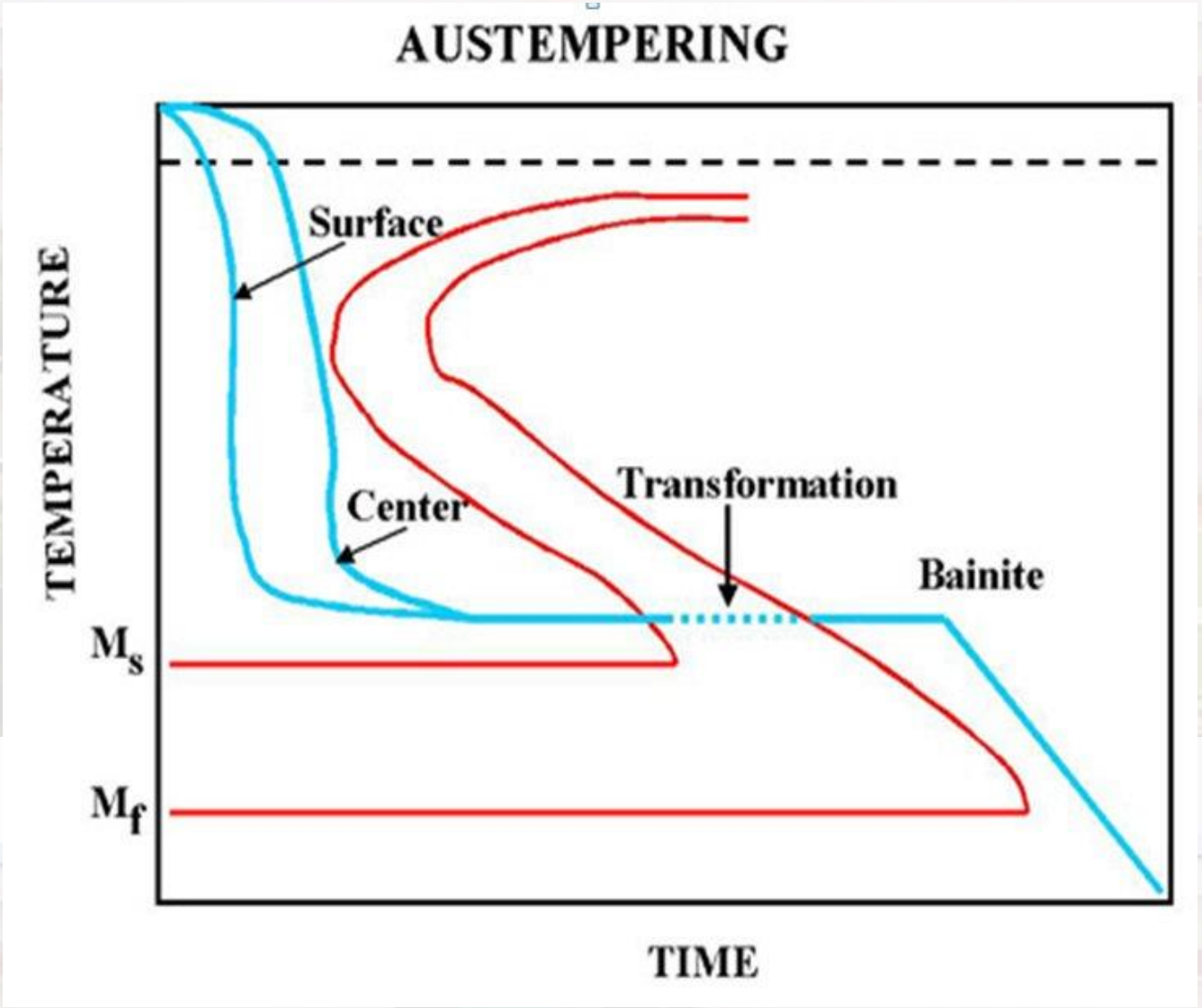
Jominy Hardenability (Quench) test



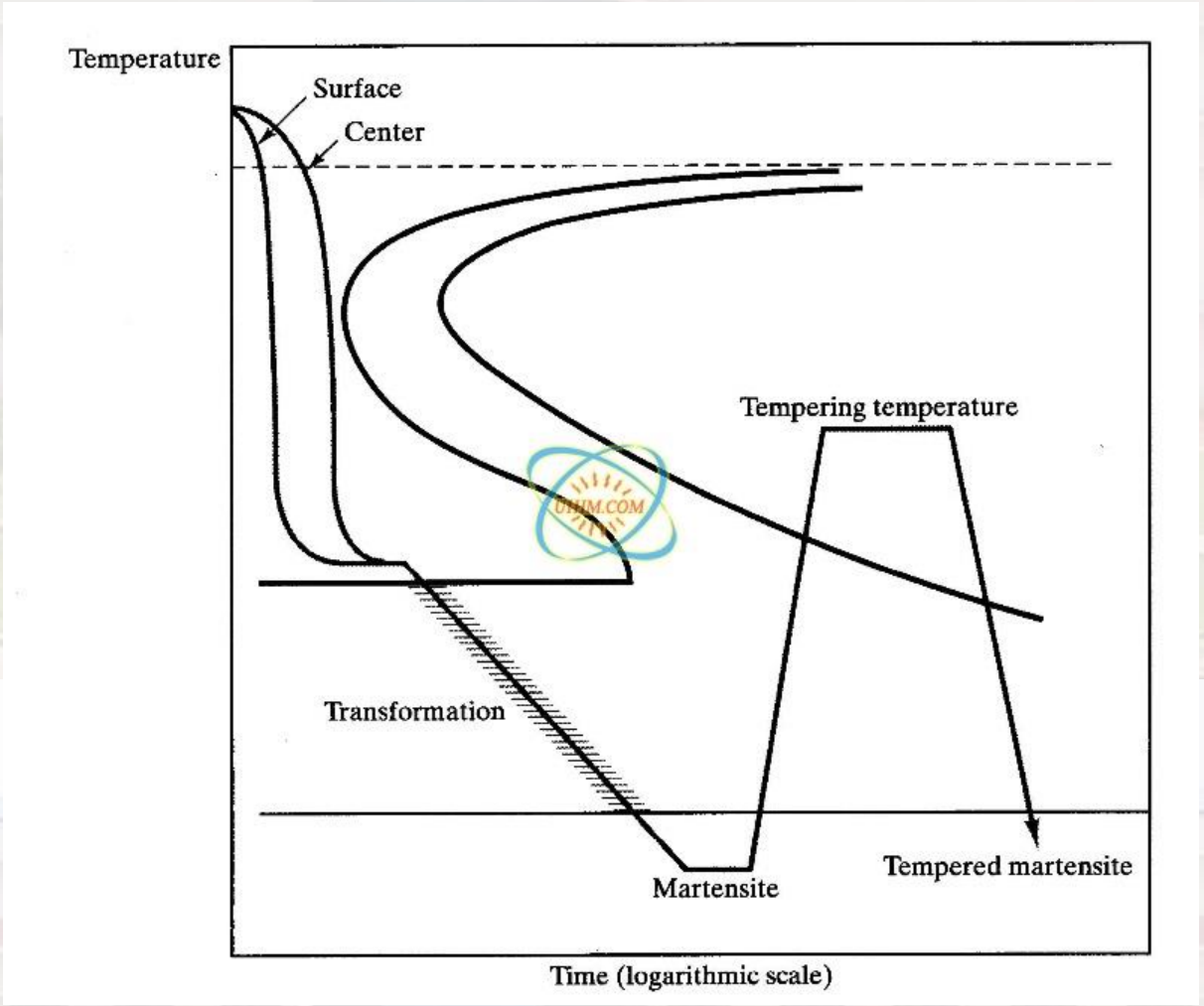
Jominy Hardenability (Quench) test

Relationship between the Jominy distance and critical diameters for an ideal quench medium




AUSTEMPERING
TEMPERATURE
Surface
Center
Transformation
Bainite
M_s
M_f
TIME

Martempering



THANK YOU

Assessment

https://docs.google.com/document/d/1FEgM2mJBH4Zz4TiptKQHpX5hyvGNuc8C/edit