

THE MINISTRY OF HIGHER AND SECONDARY SPECIALIZED  
EDUCATION OF THE REPUBLIC OF UZBEKISTAN  
ANDIJAN MACHINE – BUILDING INSTITUTE

FACULTY ”AUTOMATICS AND ELECTROTECHNOLOGY ”

CHAIR “MATERIAL - SCIENSE AND NEW MATERIALS TECHNOLOGIE”

## **THE EXPLANATION LETTER OF DIPLOMA PROJECT**

**The theme of diploma project:** Iron-Carbon (Fe-C) phase diagram of electron projects stand.

**Graduate 057-12 student’s group**

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**The head of chair:**

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**Advisors:**

**The safety activity of the life:**

**N. Qobulova**

**Economic part**

**I.Qayumov**

**ANDIJAN - 2016**

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(name of higher educational institute)

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(name of the faculty)

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Chair

**TASK**  
ON ACCOMPLISHING  
DIPLOMA PROJECT

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(student name and surname)

1. Theme of the diploma project \_\_\_\_\_

2. Verified according to the institution's decree N \_\_\_\_ on \_\_\_\_ 20\_\_ year.

Information on the accomplishment of the diploma project: \_\_\_\_\_

3. Information included in the explanatory letter (texts in hand-written (70-80 pages) or electronic format (40-50 pages)):

a) On existing technological process \_\_\_\_\_

b) On calculation section of automatic setting system \_\_\_\_\_

c) On construction automated guided system of technological processes :

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d) On technology labor safety sections: \_\_\_\_\_

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e) The list of Used literature: \_\_\_\_\_

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4. The list of draft the diploma project: \_\_\_\_\_

a) The draft of structural diagram the automated system: \_\_\_\_\_

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b) The draft of functional diagram the technological process: \_\_\_\_\_

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c) The draft of principal the technological process: \_\_\_\_\_

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d) General appearance of main panel: \_\_\_\_\_

5. Calendar plan on the diploma project sections.

№	Diploma project sections	Start date	End date	Signature (supervisor)	Supervisor name
1	Conclusion	28.01.2016	1.02.2016		B.Tojiboyev
2	Importance of the theme	03.02.2016	06.02.2016		B.Tojiboyev
3	Commentary of the literatures	07.02.2016	15.02.2016		B.Tojiboyev
4	Main part	16.02.2016	05.03.2016		B.Tojiboyev
5	Technologic part	08.03.2016	31.03.2016		B.Tojiboyev
6	Economic part	01.04.2016	28.04.2016		I.Qayumov
7	The safety activity of the life	29.04.2016	14.05.2016		N.Qobulova
8	Conclusion and offers	14.05.2016	17.05.2016		B.Tojiboyev
9	The list of the used literatures	17.05.2016	18.05.2016		B.Tojiboyev
10	Attachment	19.05.2016	24.05.2016		B.Tojiboyev

6. Date of assigning a task 27.12.2015 yil

7. Date of submitting diploma project: \_\_\_\_\_

Head of faculty:

R.Zulunov

Supervisor:

B.Tojiboyev

Task has been accepted for accomplishment:

A.Numonov

Head of the chair:

Q.Xalmerzayev

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## **Introduction.**

Today, the automotive industry of Uzbekistan can be regarded as the locomotive of the entire domestic industry, for giving new impetus to the development of related industries and sustainable scale-up of employment. The branch is represented by a range of enterprises and organizations, which employ more than 27,000 people. It ranks not just among major suppliers of finished products for export, but also leads in the development of new technologies and bringing modern products to the markets. The new mixer truck ranks among the innovations and meets international standards.

*President of the Republic of Uzbekistan dated 15.07.2008. PP-916 to stimulate the implementation of innovative projects and technologies in the production of additional measures. Scientific and practical research and development of innovative products and production modernization, technical and technological renewal of execution promoting the creation of new mechanisms, and in 2008 from innovative ideas, technologies and projects of the fair every year. The set of measures to strengthen and develop the material-technical base of higher educational institutions for the period 2011-2016 years, according to the, The complex of measures on optimization of areas and specialties for training of highly qualified personnel, the further improvement of the state educational standards in accordance with.*

Originally the name steel was applied to various combinations of iron and carbon, there being present, together with these, as impurities, small proportions of silicon and manganese. At the present time, however, the use of the name is extended to cover combinations of iron with tungsten, vanadium, nickel, chromium, molybdenum, titanium and some of the rarer elements. These latter combinations are quite generally known as the alloy steels to distinguish them from the carbon steels, in which latter the characteristic properties are dependent upon the presence of carbon alone. The alloy steels are divided into high-speed

steels and low-carbon alloy steels. The specific properties that distinguish these different steels are due in part to their respective compositions, that is, to the particular elements they contain, and, in part, to their subsequent working and heat-treatment.

The Iron Age began about 3000 years ago and continues today. Use of iron and steel, a stronger and cheaper material changed drastically daily life of a common person. Age of Advanced materials: throughout the Iron Age many new types of materials have been introduced (ceramic, semiconductors, polymers, composites...). Understanding of the relationship among structure, properties, processing, and performance of materials. Intelligent design of new materials. Numerous investigations and discussions on phase diagrams are devoted to the plotting of the equilibrium phase diagram of the iron-carbon system and the obtaining of more precise information on it. Theoretical and experimental investigations, which were begun by D.K. Chernov in 1868, continued by F. Osmond, A. Sauveur, W.C. Roberts – Austen, A. Martens, A. Ledebur, Le Chatelier H., Roozeboom B.W.H. and many other scientists, have been in progress up to our time. It should be noted that practically every handbook, textbook and current publication contains superposed stable and metastable phase diagrams of the iron-graphite and iron-cementite systems. Such superposition allows rather easily to envisage the presence of graphite or cementite in the microstructure of iron-carbon alloys at the room temperature when using samples after various isothermal exposures and cooling rates. The purpose of the present study is to obtain more accurate knowledge of the equilibrium phase diagram of the iron-carbon system on the basis of literary data. For that it is necessary first of all to specify phase constituents of the iron-carbon system, which include:

- homogeneous liquid solution of iron and carbon atoms ( $L$ );
- ferrite ( $Fer$ ) – solid solution of carbon atoms in the bcc – lattice of iron (in this paper we do not differentiate between high temperature and low temperature ( $a$ ) phases);
- austenite ( $A$ ) – solid solution of carbon atoms in the fcc – lattice of iron;

- graphite (*Gr*) – solid solution of iron atoms in the hexagonal lattice of carbon;
- cementite – crystal structure formed by iron and carbon atoms, close to the stoichiometric relationship  $Fe_3C$ ;
- martensite (*M*) – solid solution of carbon atoms in the tetragonal lattice of iron.

Phases *L*, *Fer*, *A*, *Gr* are considered to be equilibrium and phases *Cem* and *M* - non-equilibrium. Ledeburite, perlite, sorbite, bainite, troostite contain several both equilibrium and non-equilibrium phases. These terms are used to characterize microstructure in samples, ingots, castings. In an equilibrium phase diagram there must be only names of equilibrium phases. It seems incorrect to use the same term to designate structural constituents composed of two or more equilibrium or non-equilibrium phases in the equilibrium phase diagram. In one of the recent papers the author substantiated the necessity to consider *Cem* in iron-carbon alloys the equilibrium phase at temperatures below 727 °C and suggested a new version of the equilibrium phase diagram Fe – 6.67 % C (Fig. 1). We can agree with many author's conclusions and first of all with that *Cem* is an equilibrium phase below 727 °C. However, the phase diagram of the system Fe – 6.67 % C in fig. 1 has essential inaccuracies and contradicts the classic law of heterogeneous equilibrium – Gibbs's phase rule. Thus, in the region *S* – *E* – *C* – *F* in the temperature range 1147 – 727 °C three phase constituents *A*, *Gr* and *cl.C* (carbon clusters) are shown, and in the region *Q* – *P* – *S* (below 727 °C) – three phase constituents *Fer*, *Cem* and *Gr*, which is inadmissible according to Gibbs's phase rule, because in the temperature – concentration region at constant pressure in a binary system in the equilibrium state there can be only two phases and the three-phase equilibrium is possible only at one temperature. It must be noted that already in 1900 B.W.H. Roozeboom suggested to consider *Cem* a stable phase at temperatures below 1000 °C and gave the appropriate diagram. However that diagram was not accepted completely for the reason that *Cem* decomposes at temperatures above 738 °C.

Iron-Carbon phase diagram Source: William D. Callister Jr., (1994)

When ferrite is at room temperature, it has a BCC structure, which can only

absorb a low amount of carbon. Because ferrite can only absorb a very low amount of carbon at room temperature, the un-absorbed carbon separates out of BCC structure to form carbides which join together to create small pockets of an extremely hard crystal structure within the ferrite which is cementite. However, when ferrite is heated to a temperature above the transformation line ( $723^{\circ}\text{C}$ ), the BCC structure changes to FCC structure known as austenite which is allowing the absorption of the carbon into the crystal structure (Parrish, 1999). Once the steel enters the austenitic phase, all of the cementite dissolves into austenite. If the steel is allowed to cool slowly, the carbon will separate out of the ferrite as the cubic-structure reverts from face-centered back to body-centered. The islands of cementite will reform within the ferrite, and the steel will have the same properties that it did before it was heated. However, when the steel is rapidly cooled, or quenched, in a quenching medium such as oil, water, or air room temperature, the carbon does not have time to exit the cubic structure of the ferrite and it becomes trapped within it. This leads to the formation of martensite which is the microstructure that produces the most sought after mechanical properties in steel fasteners (Parrish, 1999). During quenching, it is impossible to cool the specimen at a uniform rate throughout. The surface will always cool more rapidly than the interior of the specimen. Therefore, the austenite will transform over a range of temperatures, yielding a possible variation of microstructure and properties depending on the position within the material. The successful heat treatment of steels to produce a predominantly martensitic microstructure throughout the cross section depends mainly on three factors (Prabudev, 1988):

- (i). The composition of the alloy
- (ii). The type and character of the quenching medium
- (iii). The size and shape of the specimen

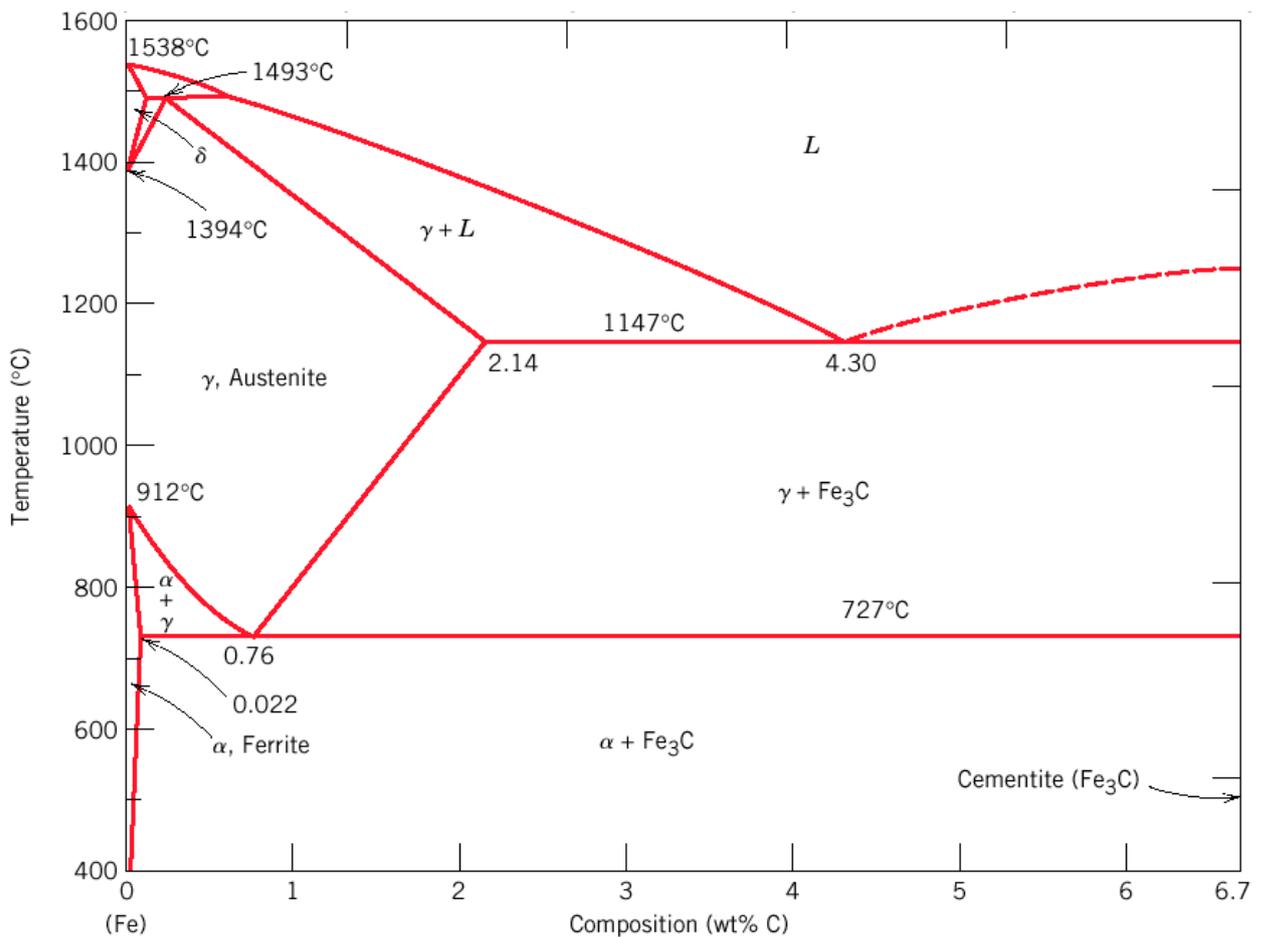
Hardenability is the ability of steel to transform into martensite with a particular quenching treatment. This is directly affected by the alloy composition of the steel. For every different steel alloy there is a specific relationship between its mechanical properties and its cooling rate. Hardenability is not “hardness” which is

a resistance to indentation but hardness measurements are utilized to determine the extent of a martensitic transformation in the interior of the material. A steel alloy that has a high hardenability is one that hardens, or forms martensite, not only at the surface but also to a large degree throughout the entire interior. In other words, hardenability is a measure of the degree to which a specific alloy may be hardened (Askeland, 1984). The newly formed martensite is considered as a grain structure but not a phase and it is very hard and brittle. Due to the brittleness inherent in martensite, steel that has been quenched from austenitizing temperatures will require tempering before it can be placed into service. Tempering involves heating the steel to a specific temperature below that of the transformation line and allowing it to cool slowly. This causes the crystal structure to relax, thereby increasing the ductility and decreasing the hardness to specified levels. The specific tempering temperature will vary based on the desired results for the steel (Parrish, 1999). The following example will demonstrate the effectiveness of tempering: ASTM A193 Grade B7, SAE J429 Grade 8 and ASTM A574 Socket Head Cap Screws are all made from alloy steels. In fact some alloy steel grades can be used to manufacture any of the three final products such as 4140 and 4142 alloy steel. The final mechanical properties appear in the table. The initial heat treating process is relatively the same for all three products. The parts are heated until fully austenitized and then are quenched in oil and tempered (Chokshi, 2005). This tempering temperature dictates the final mechanical properties. The following are the minimum tempering temperatures and its specification.

## IMPORTANCE OF THE THEME.

### The Iron–Iron Carbide (Fe–Fe<sub>3</sub>C) Phase Diagram

In their simplest form, steels are alloys of Iron (Fe) and Carbon (C). The Fe–C phase diagram is a fairly complex one, but we will only consider the steel part of the diagram, up to around 7% Carbon.



### Phases in Fe–Fe<sub>3</sub>C Phase Diagram

α-ferrite - solid solution of C in BCC Fe

- Stable form of iron at room temperature.
- The maximum solubility of C is 0.022 wt%

- Transforms to FCC  $\gamma$ -austenite at 912 °C
- $\gamma$ -austenite - solid solution of C in FCC Fe
- The maximum solubility of C is 2.14 wt %.
  - Transforms to BCC  $\delta$ -ferrite at 1395 °C
  - Is not stable below the eutectic temperature (727 °C) unless cooled rapidly
- $\delta$ -ferrite solid solution of C in BCC Fe
- The same structure as  $\alpha$ -ferrite
  - Stable only at high T, above 1394 °C
  - Melts at 1538 °C
- Fe<sub>3</sub>C (iron carbide or cementite)
- This intermetallic compound is metastable, it remains as a compound indefinitely at room T, but decomposes (very slowly, within several years) into  $\alpha$ -Fe and C (graphite) at 650 - 700 °C Fe-C liquid solution.

#### **A few comments on Fe–Fe<sub>3</sub>C system**

C is an interstitial impurity in Fe. It forms a solid solution with  $\alpha$ ,  $\gamma$ ,  $\delta$  phases of iron. Maximum solubility in BCC  $\alpha$ -ferrite is limited (max. 0.022 wt% at 727 °C) - BCC has relatively small interstitial positions. Maximum solubility in FCC austenite is 2.14 wt% at 1147 °C - FCC has larger interstitial positions.

**Mechanical properties:** Cementite is very hard and brittle can strengthen steels. Mechanical properties also depend on the microstructure, that is, how ferrite and cementite are mixed.

**Magnetic properties:**  $\alpha$  -ferrite is magnetic below 768 °C, austenite is non-magnetic. Classification. Three types of ferrous alloys:

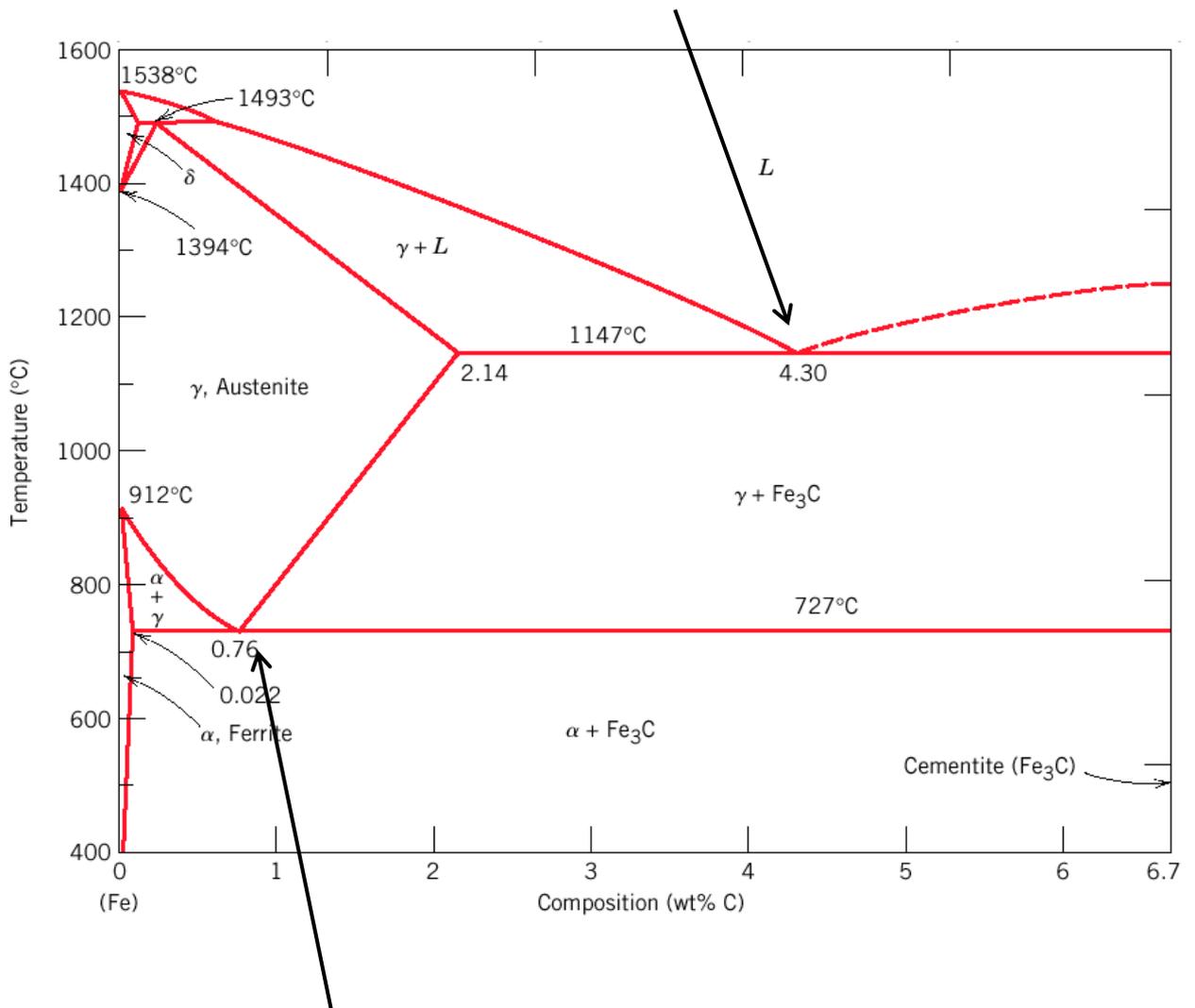
- **Iron:** less than 0.008 wt % C in  $\alpha$ -ferrite at room T
- **Steels:** 0.008 - 2.14 wt % C (usually < 1 wt % )  
 $\alpha$ -ferrite + Fe<sub>3</sub>C at room T (Chapter 12)
- **Cast iron:** 2.14 - 6.7 wt % (usually < 4.5 wt %)

## Eutectic and eutectoid reactions in Fe-Fe<sub>3</sub>C

**Eutectoid:** 0.76 wt% C, 727 °C  $\gamma(0.76 \text{ wt\% C}) \leftrightarrow \alpha (0.022 \text{ wt\% C}) + \text{Fe}_3\text{C}$

**Eutectic:** 4.30 wt% C, 1147 °C

$L \leftrightarrow \gamma + \text{Fe}_3\text{C}$



**Eutectoid:** 0.76 wt% C, 727 °C

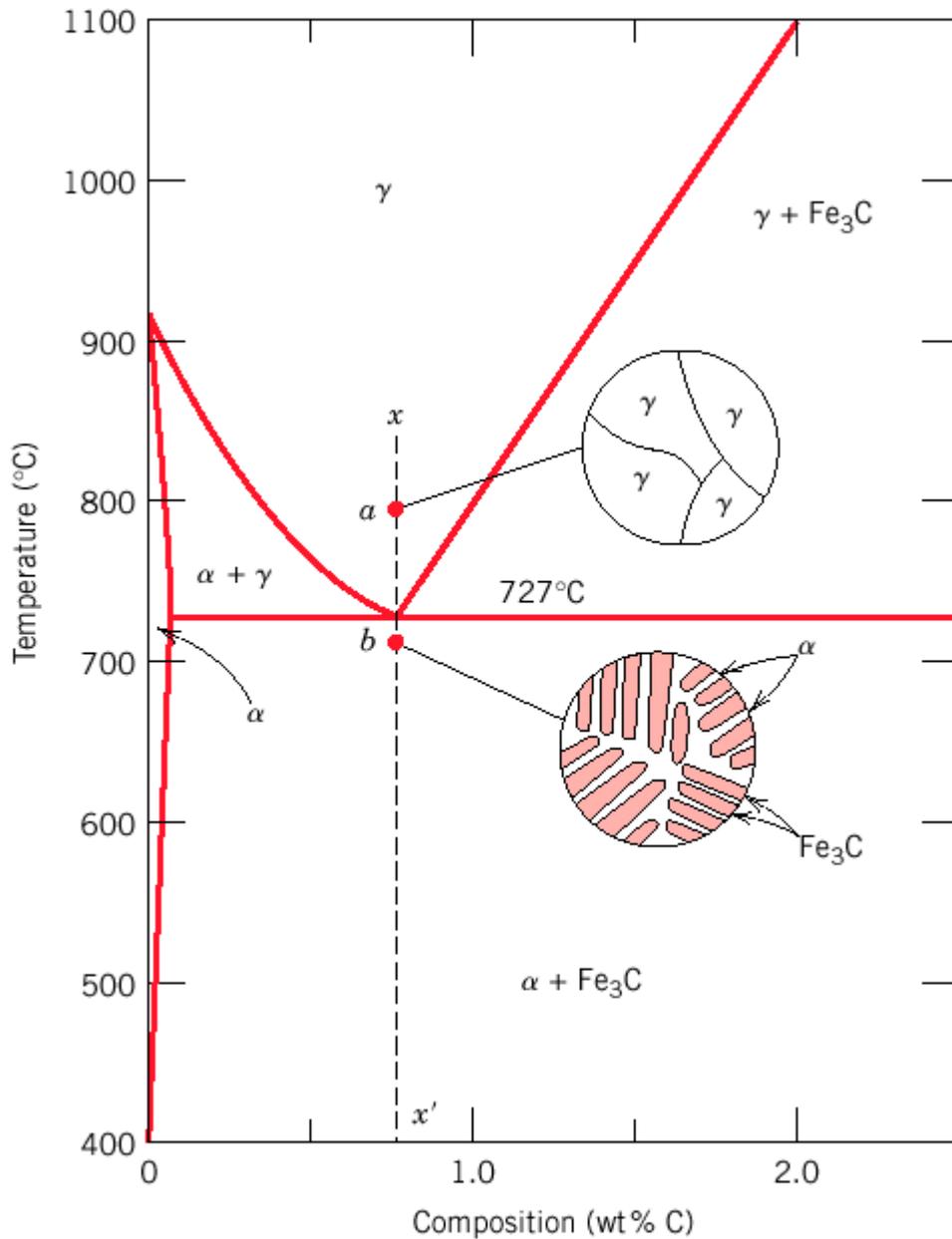
$\gamma(0.76 \text{ wt\% C}) \leftrightarrow \alpha (0.022 \text{ wt\% C}) + \text{Fe}_3\text{C}$

Eutectic and eutectoid reactions are very important in heat treatment of steels.

### Development of Microstructure in Iron - Carbon alloys

**Microstructure depends on composition (carbon content) and heat treatment.** In the discussion below we consider slow cooling in which equilibrium is maintained.

### Microstructure of eutectoid steel (I)

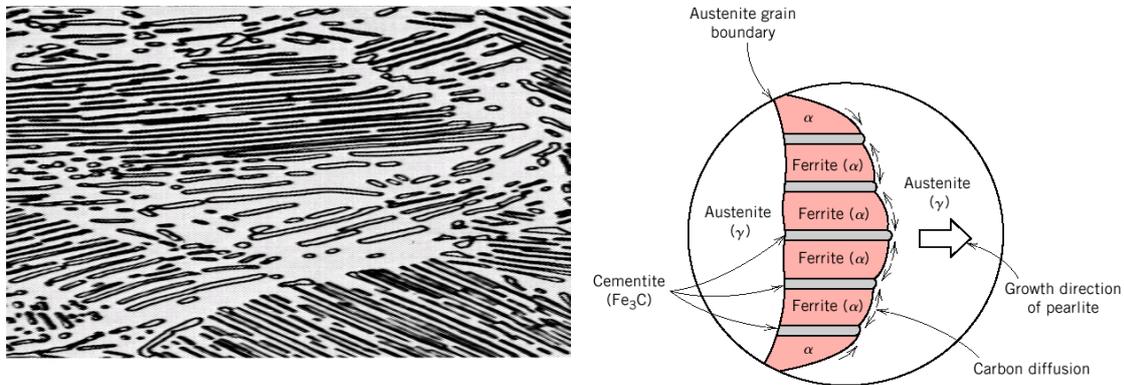


### Microstructure of eutectoid steel (II)

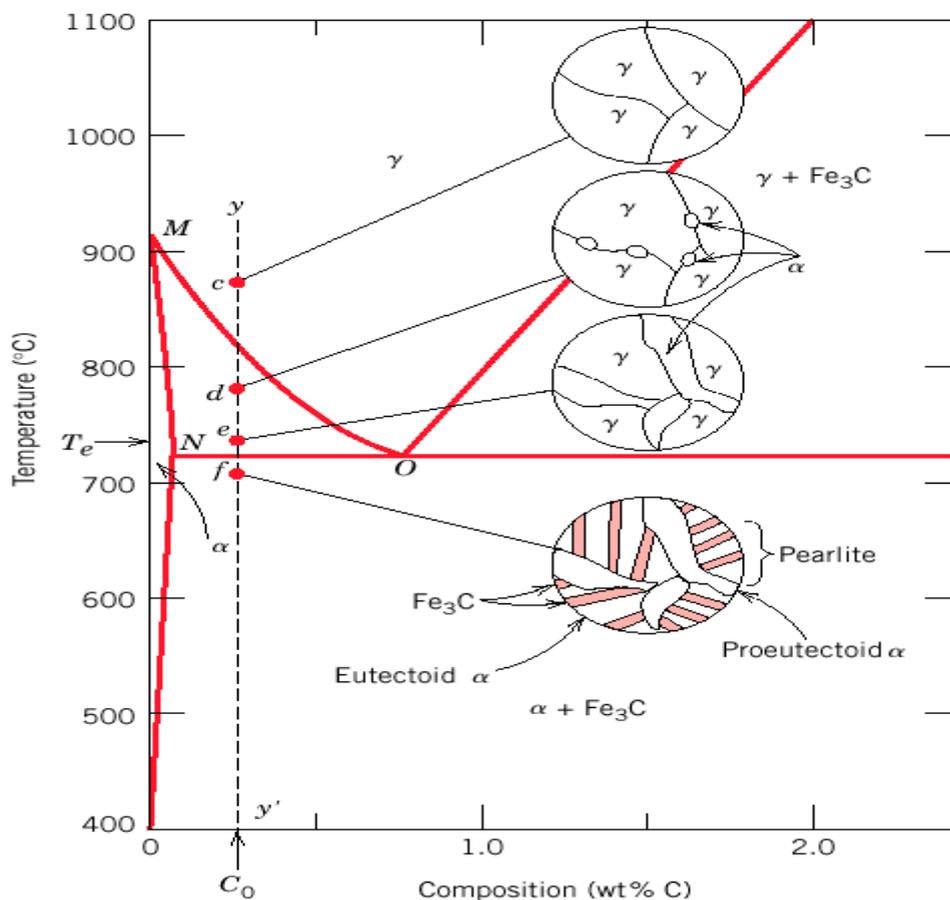
When alloy of eutectoid composition (0.76 wt % C) is cooled slowly it forms **pearlite**, a lamellar or layered structure of two phases:  $\alpha$ -ferrite and cementite

(Fe<sub>3</sub>C) The layers of alternating phases in pearlite are formed for the same reason as layered structure of eutectic structures: redistribution C atoms between ferrite (0.022 wt%) and cementite (6.7 wt%) by atomic diffusion. Mechanically, pearlite has properties intermediate to soft, ductile ferrite and hard, brittle cementite.

In the micrograph, the dark areas are Fe<sub>3</sub>C layers, the light phase is  $\alpha$ - ferrite

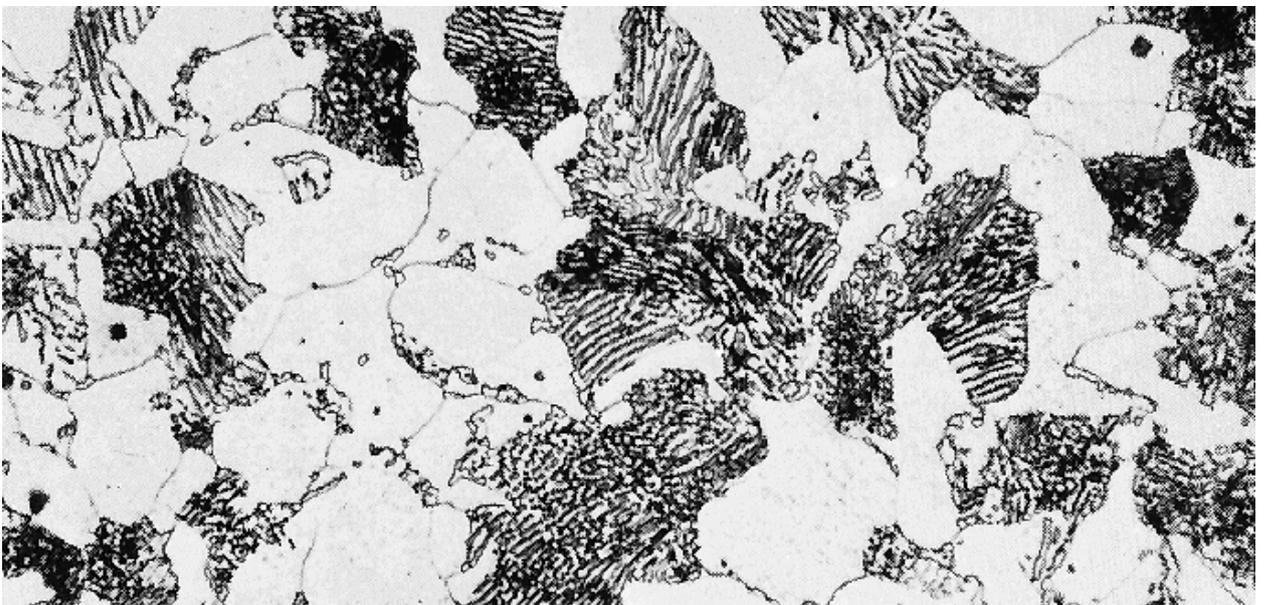
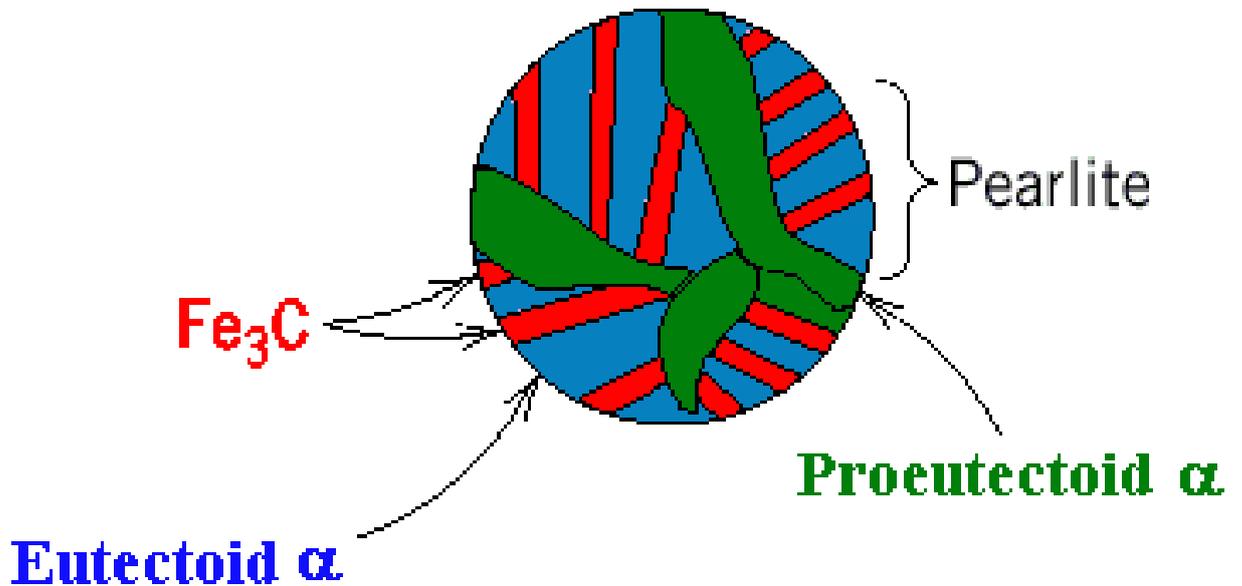


Compositions to the left of eutectoid (0.022 - 0.76 wt % C) **hypoeutectoid** (*less than eutectoid* -Greek) alloys.  $\gamma \rightarrow \alpha + \gamma \rightarrow \alpha + \text{Fe}_3\text{C}$



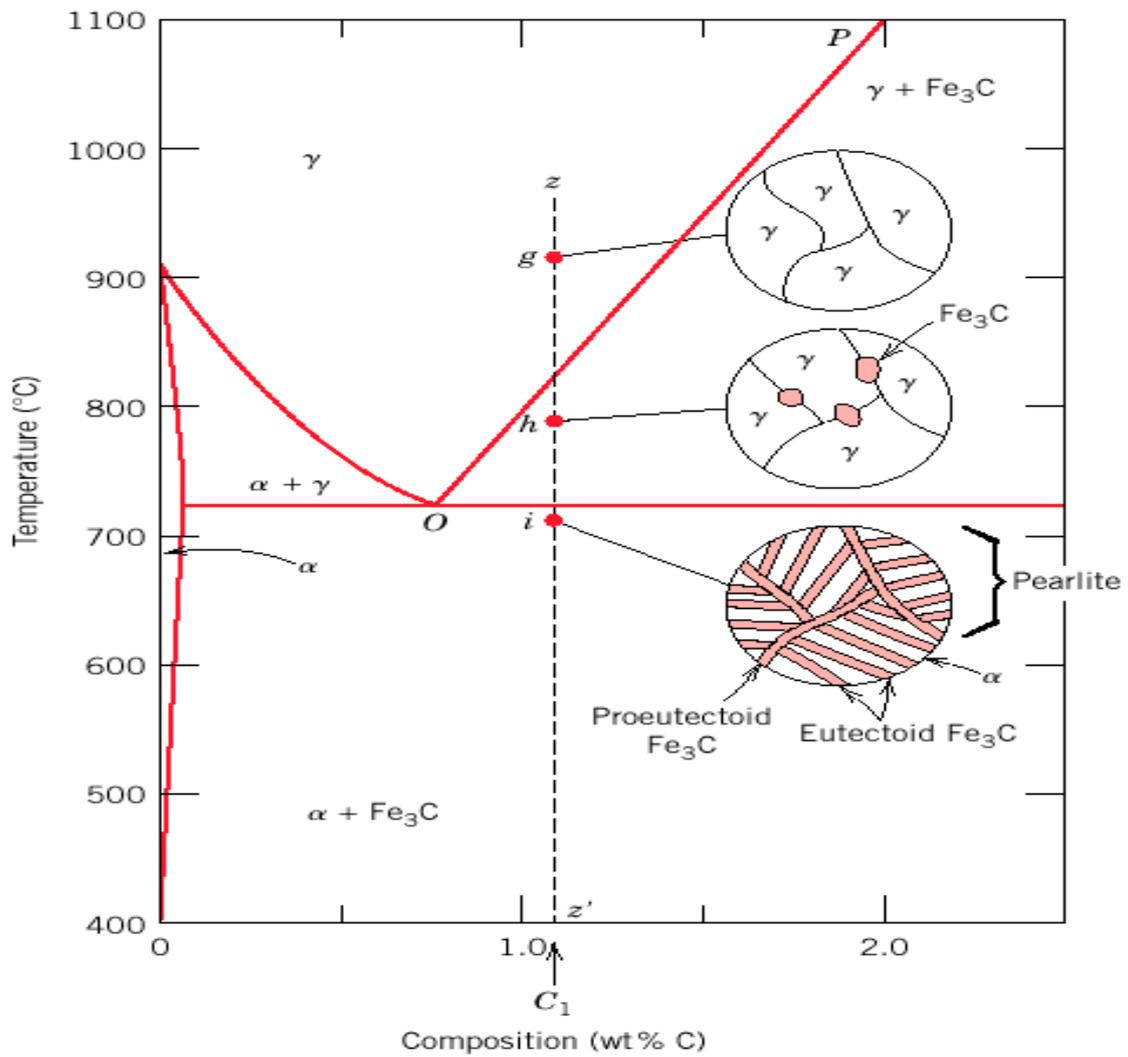
## Microstructure of hypoeutectoid steel (II)

Hypoeutectoid alloys contain proeutectoid ferrite (formed above the eutectoid temperature) plus the eutectoid perlite that contain eutectoid ferrite and cementite.



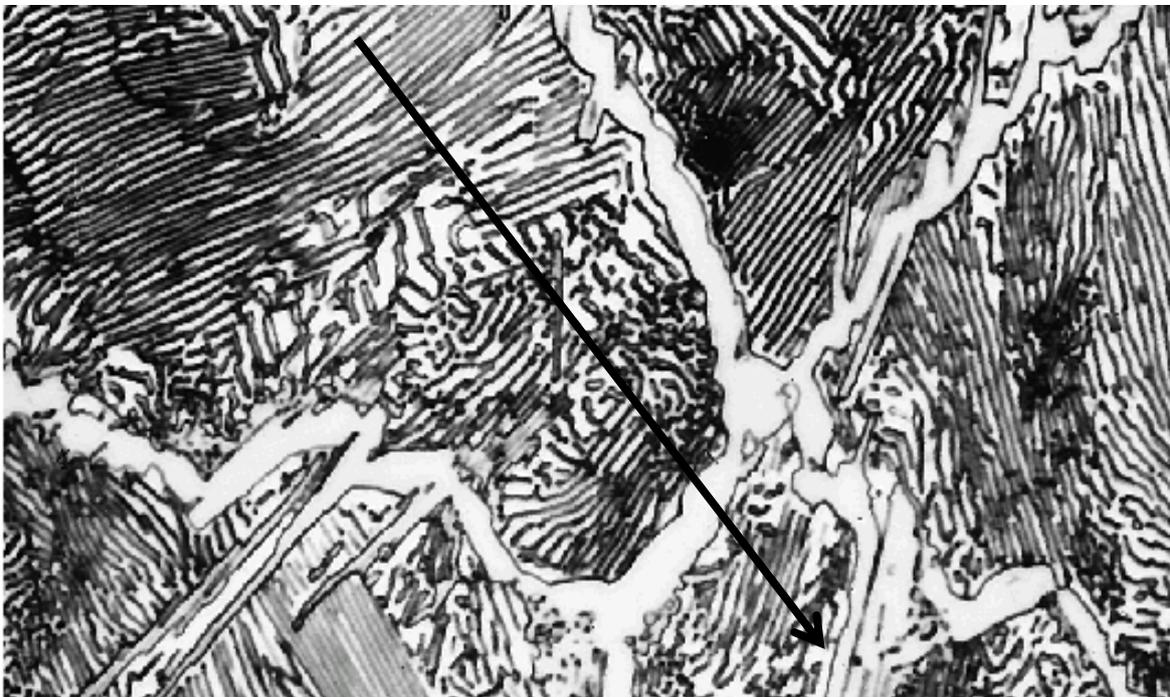
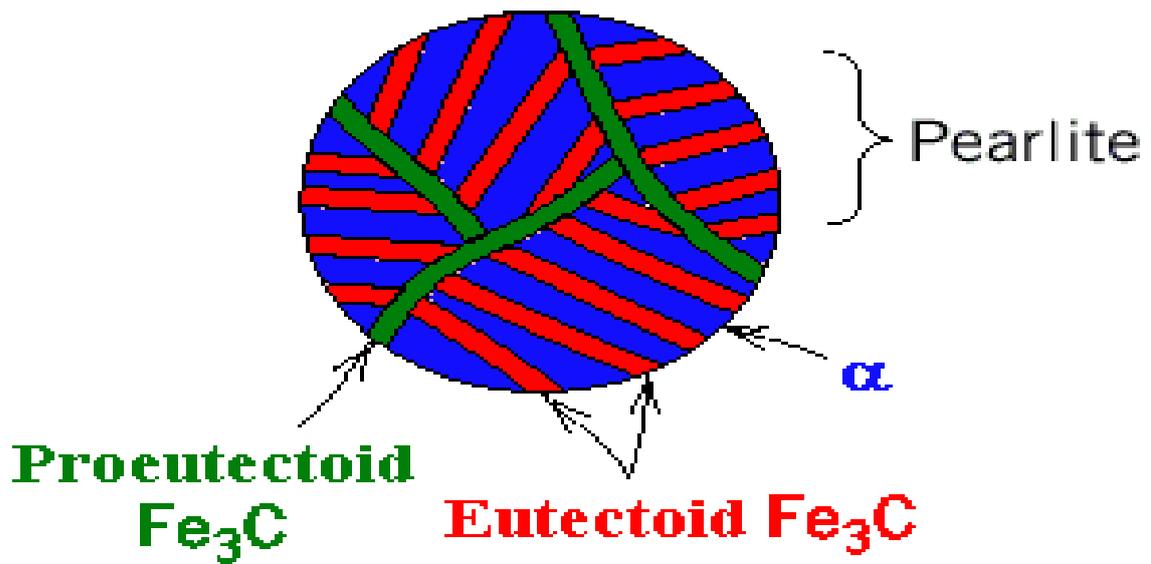
## Microstructure of hypereutectoid steel (I)

Compositions to the right of eutectoid (0.76 - 2.14 wt % C) **hypereutectoid** (*more than eutectoid* -Greek) alloys.  $\gamma \rightarrow \gamma + \text{Fe}_3\text{C} \rightarrow \alpha + \text{Fe}_3\text{C}$

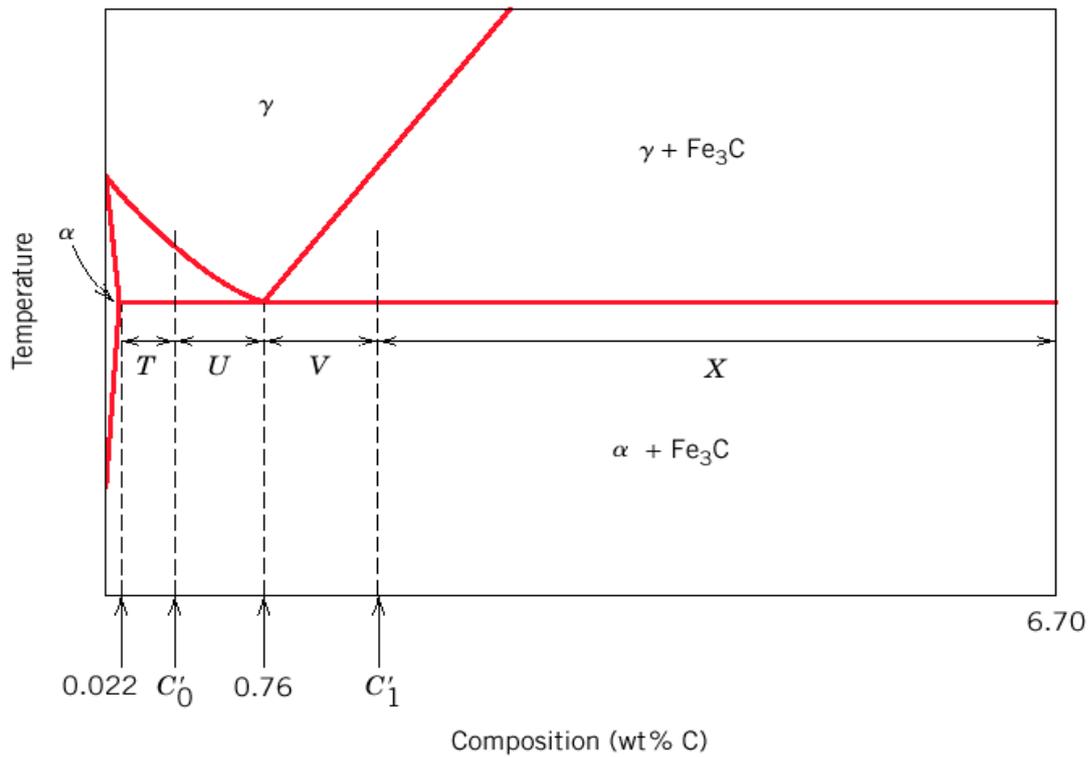


### Microstructure of hypereutectoid steel (II)

Hypereutectoid alloys contain proeutectoid cementite (formed above the eutectoid temperature) plus pearlite that contain eutectoid ferrite and cementite.



How to calculate the relative amounts of proeutectoid phase ( $\alpha$  or  $\text{Fe}_3\text{C}$ ) and pearlite? Application of the lever rule with tie line that extends from the eutectoid composition (0.76 wt% C) to  $\alpha - (\alpha + \text{Fe}_3\text{C})$  boundary (0.022 wt% C) for hypoeutectoid alloys and to  $(\alpha + \text{Fe}_3\text{C}) - \text{Fe}_3\text{C}$  boundary (6.7 wt% C) for hypereutectoid alloys.



Fraction of  $\alpha$  phase is determined by application of the lever rule across the entire ( $\alpha + \text{Fe}_3\text{C}$ ) phase field:

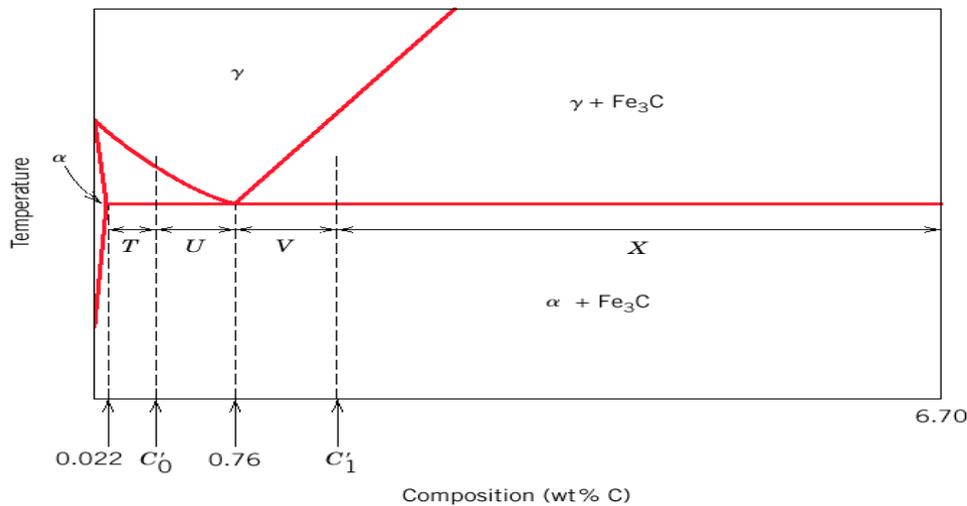
**Example for hypereutectoid alloy with composition  $C_1$**

Fraction of pearlite:

$$\text{WP} = X / (V+X) = (6.7 - C_1) / (6.7 - 0.76)$$

Fraction of proeutectoid cementite:

$$\text{WFe}_3\text{C} = V / (V+X) = (C_1 - 0.76) / (6.7 - 0.76)$$



### Phase Transformations of Fe-C Phase transformations. Kinetics.

**Phase transformations** (change of the microstructure) can be divided into three categories: Diffusion-dependent with no change in phase composition or number of phases present (e.g. melting, solidification of pure metal, allotropic transformations, recrystallization, etc.) Diffusion-dependent with changes in phase compositions and/or number of phases (e.g. eutectoid transformations)

**Diffusionless phase transformation** - produces a metastable phase by cooperative small displacements of all atoms in structure (e.g. martensitic transformation discussed in later in this chapter) Phase transformations do not occur instantaneously. Diffusion-dependent phase transformations can be rather slow and the final structure often depend on the rate of cooling/heating. We need to consider the time dependence or kinetics of the phase transformations.

#### Kinetics of phase transformations

Most phase transformations involve change in composition redistribution of atoms via diffusion is required. The process of phase transformation involves:

**Nucleation** of of the new phase - formation of stable small particles (nuclei) of the new phase. Nuclei are often formed at grain boundaries and other defects. **Growth** of new phase at the expense of the original phase.  $y = 1 - \exp(-ktn)$  **Avrami Equation.**

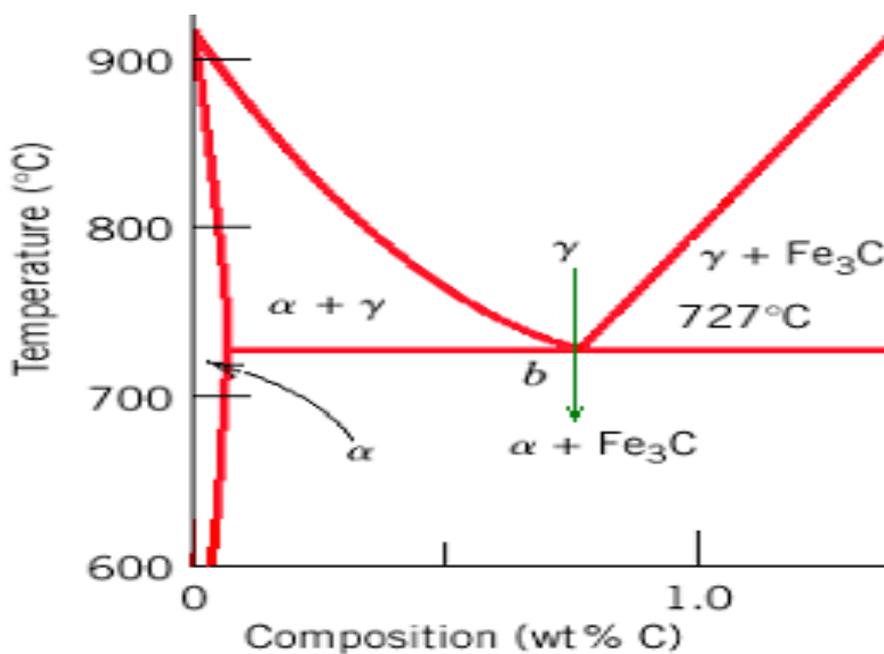
#### Superheating / supercooling

Upon crossing a phase boundary on the composition-temperature phase diagram phase transformation towards equilibrium state is induced. But the

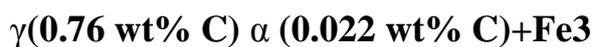
transition to the equilibrium structure takes time and transformation is delayed. During cooling, transformations occur at temperatures less than predicted by phase diagram: **supercooling**. During heating, transformations occur at temperatures greater than predicted by phase diagram: **superheating**. Degree of supercooling/superheating increases with rate of cooling/heating. Metastable states can be formed as a result of fast temperature change. Microstructure is strongly affected by the rate of cooling. Below we will consider the effect of time on phase transformations using iron-carbon alloy as an example.

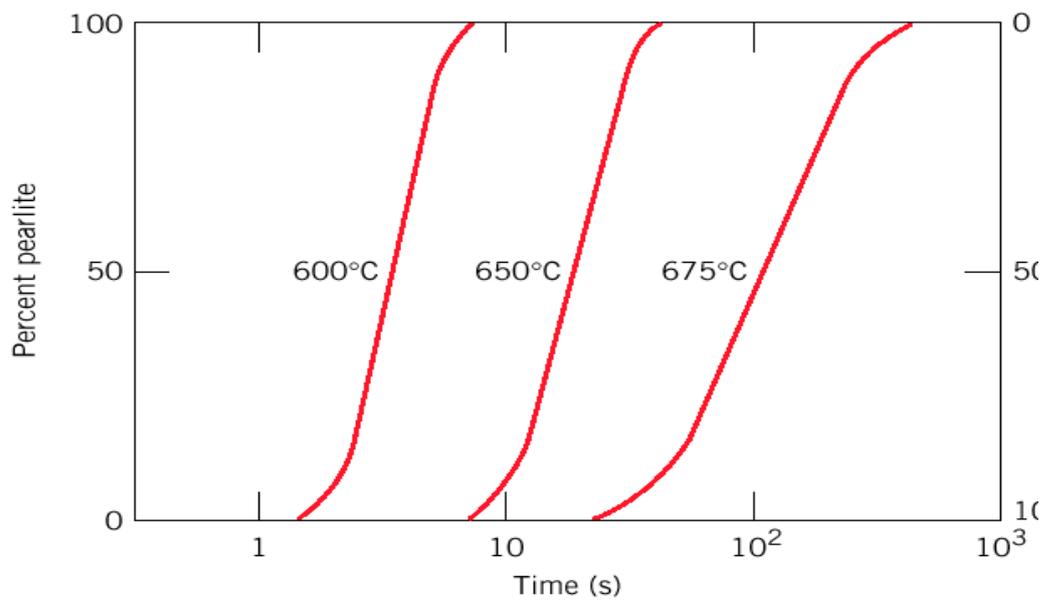
**Let us consider eutectoid reaction as an**

**Example;**

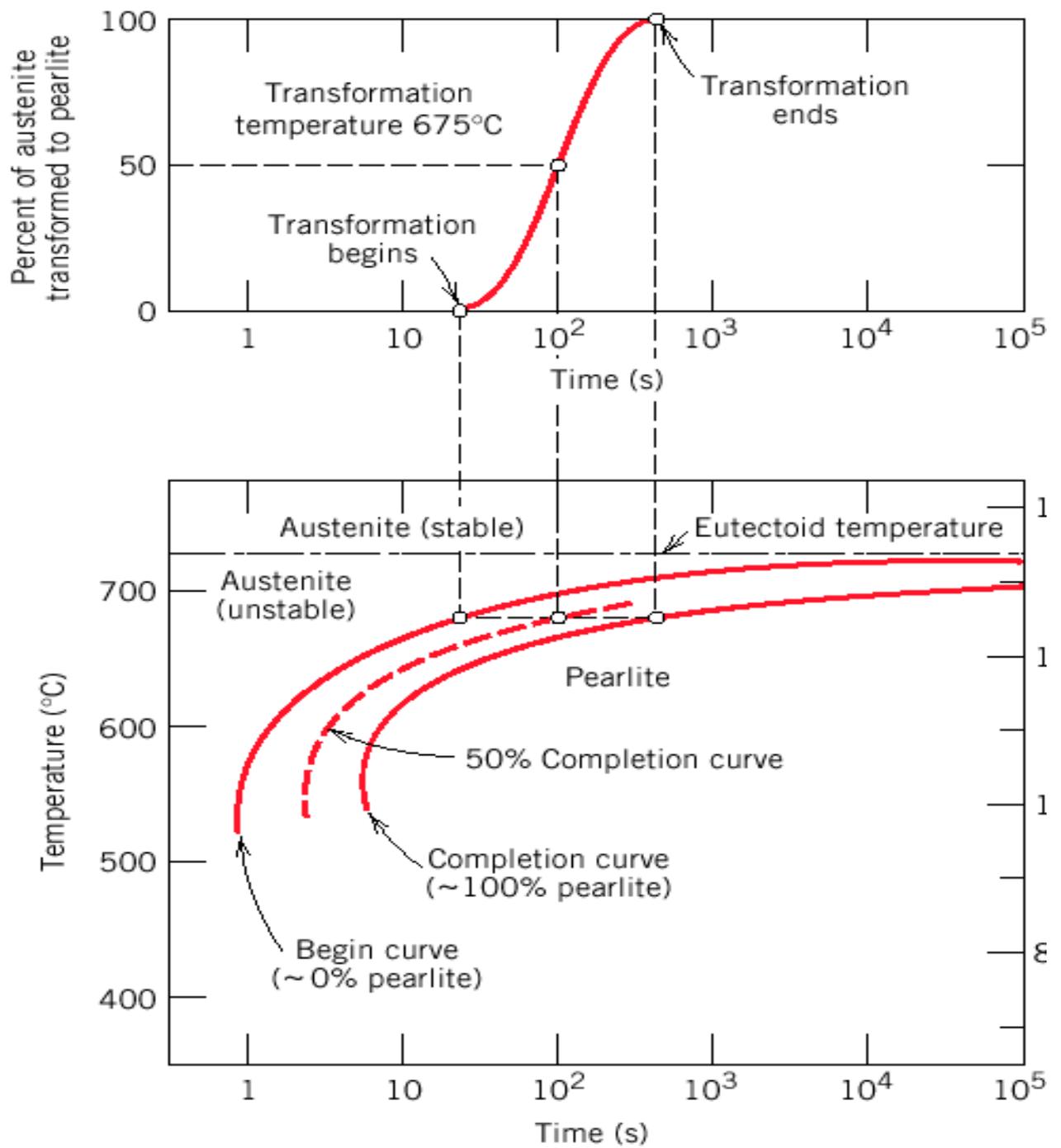


eutectoid reaction:

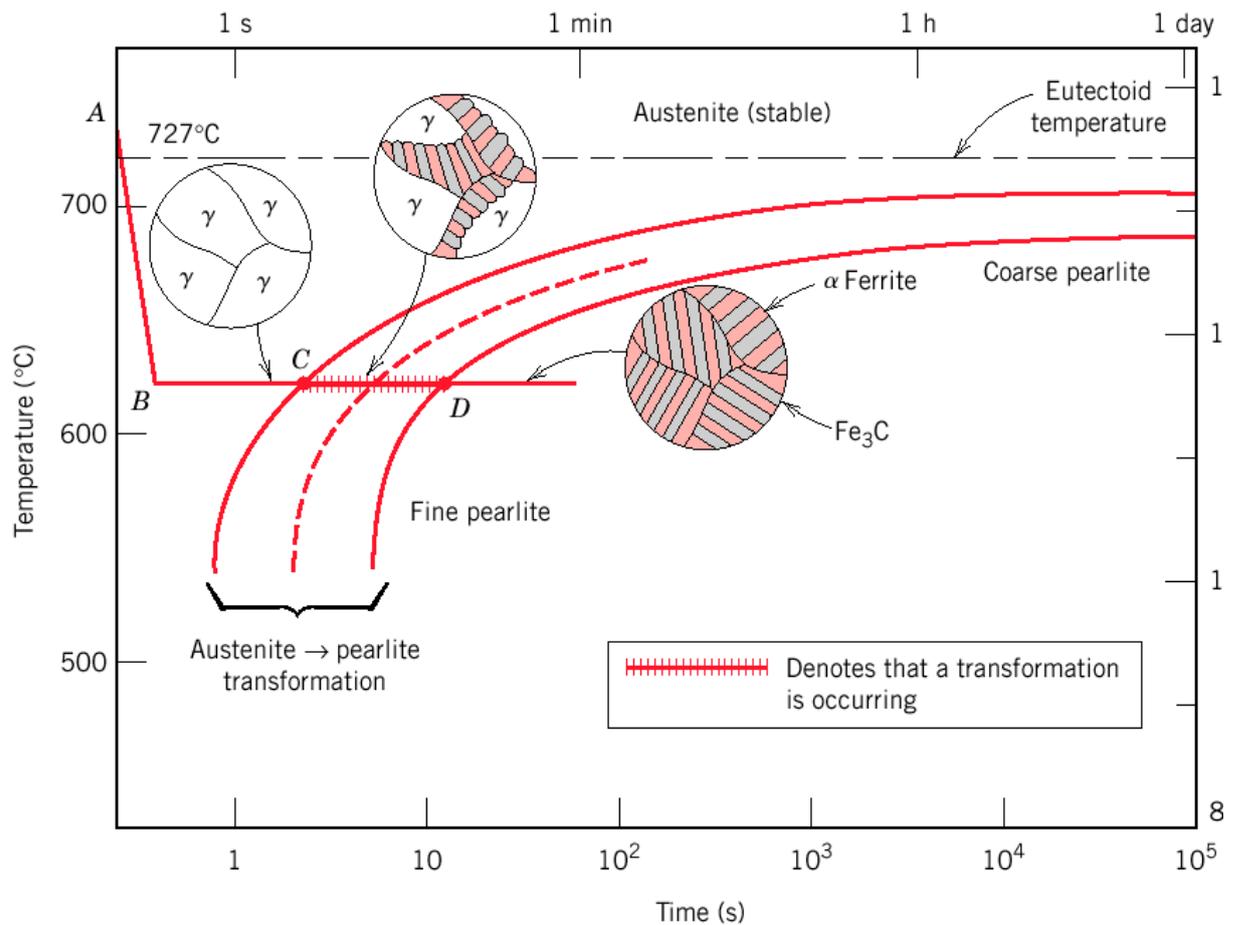




The S-shaped curves are shifted to longer times at higher T showing that the transformation is dominated by nucleation (nucleation rate increases with supercooling) and not by diffusion (which occurs faster at higher T). **Isothermal Transformation (or TTT) Diagrams (Temperature, Time, and % Transformation).**



**TTT Diagrams**



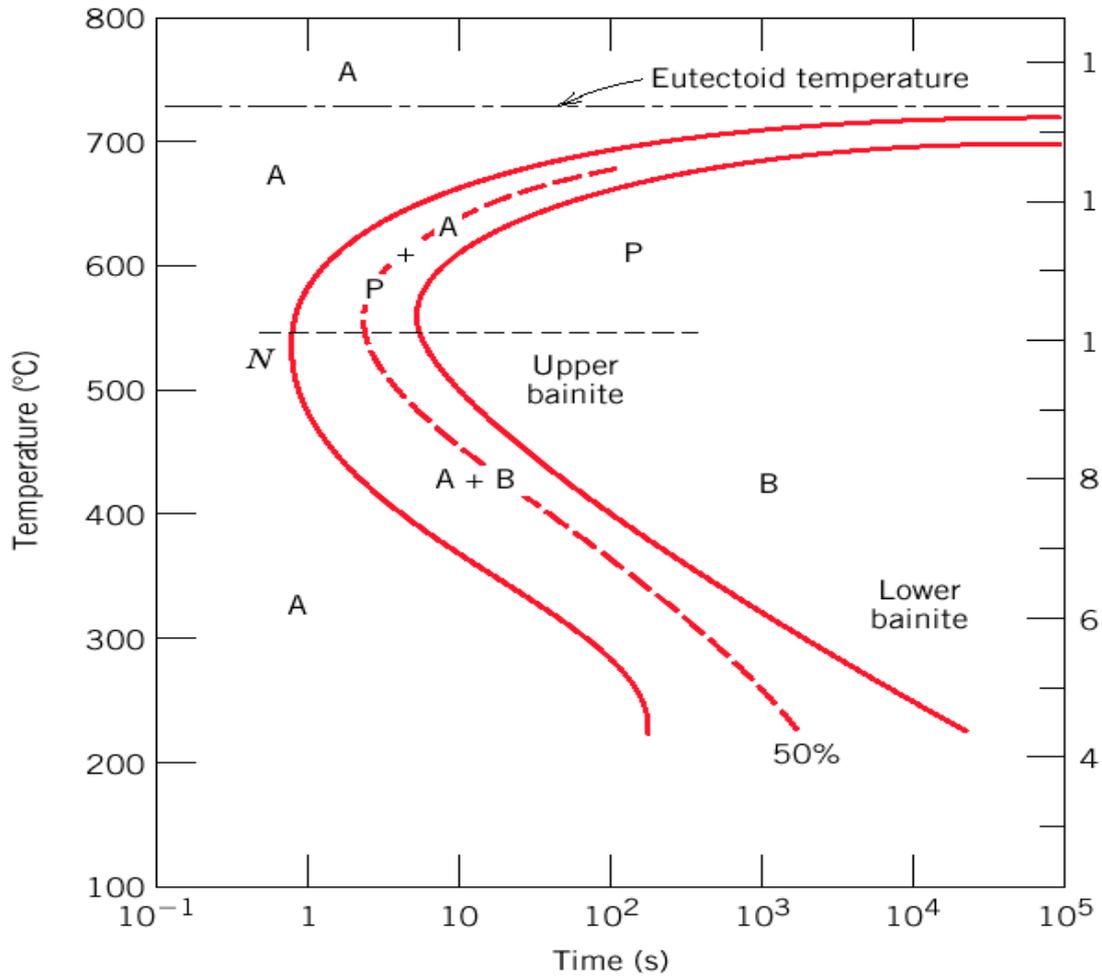
The thickness of the ferrite and cementite layers in pearlite is  $\sim 8:1$ . The absolute layer thickness depends on the temperature of the transformation. The higher the temperature, the thicker the layers.

### TTT Diagrams

The family of S-shaped curves at different  $T$  are used to construct the TTT diagrams. The TTT diagrams are for the **isothermal** (constant  $T$ ) transformations (material is cooled quickly to a given temperature before the transformation occurs, and then keep it at that temperature). At low temperatures, the transformation occurs sooner (it is controlled by the rate of nucleation) and grain growth (that is controlled by diffusion) is reduced. Slow diffusion at low temperatures leads to fine-grained microstructure with thin-layered structure of pearlite (**fine pearlite**). At higher temperatures, high diffusion rates allow for larger grain growth and formation of thick layered structure of pearlite (**coarse pearlite**). At compositions other than eutectoid, a proeutectoid phase (ferrite or

cementite) coexist with pearlite. Additional curves for proeutectoid transformation must be included on TTT diagrams.

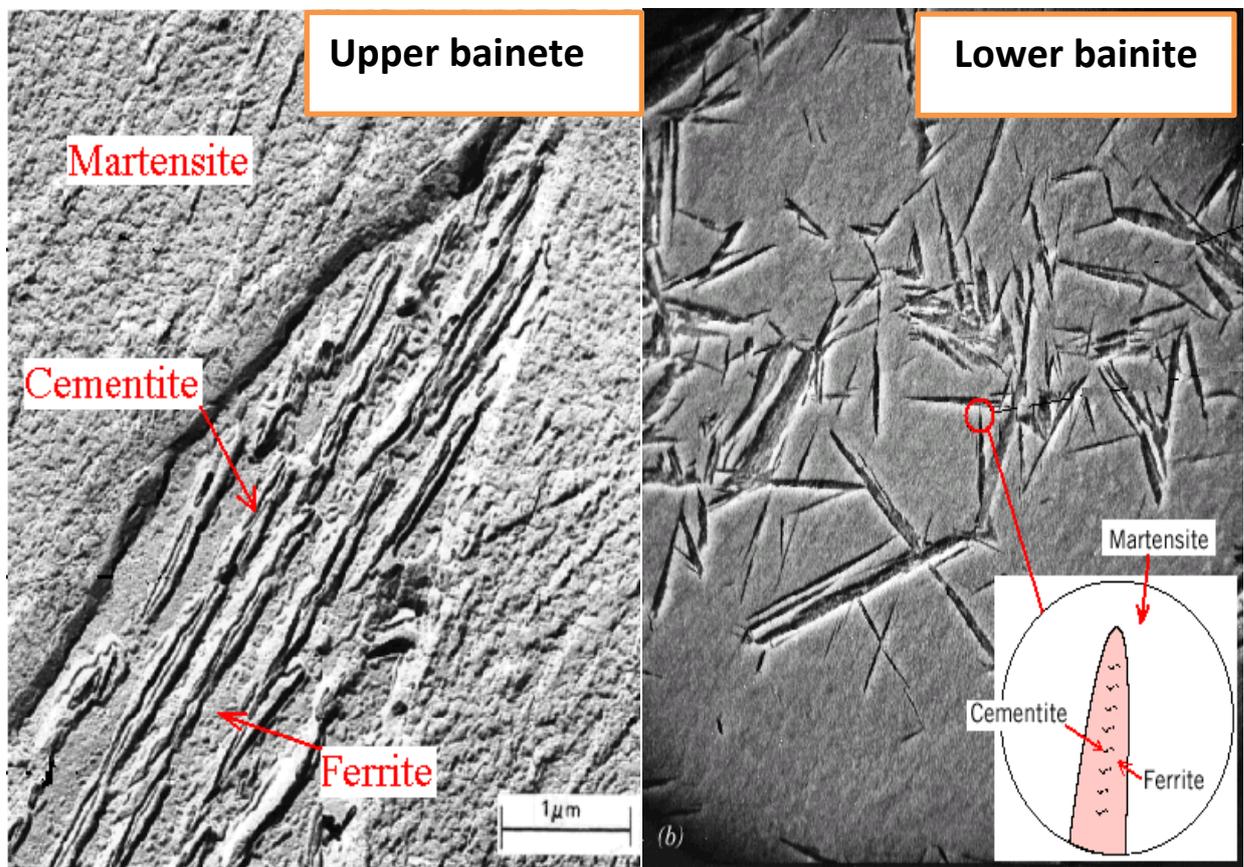
### Formation of Bainite Microstructure (I)



If transformation temperature is low enough (540°C) bainite rather than fine pearlite forms.

### Formation of Bainite Microstructure (II)

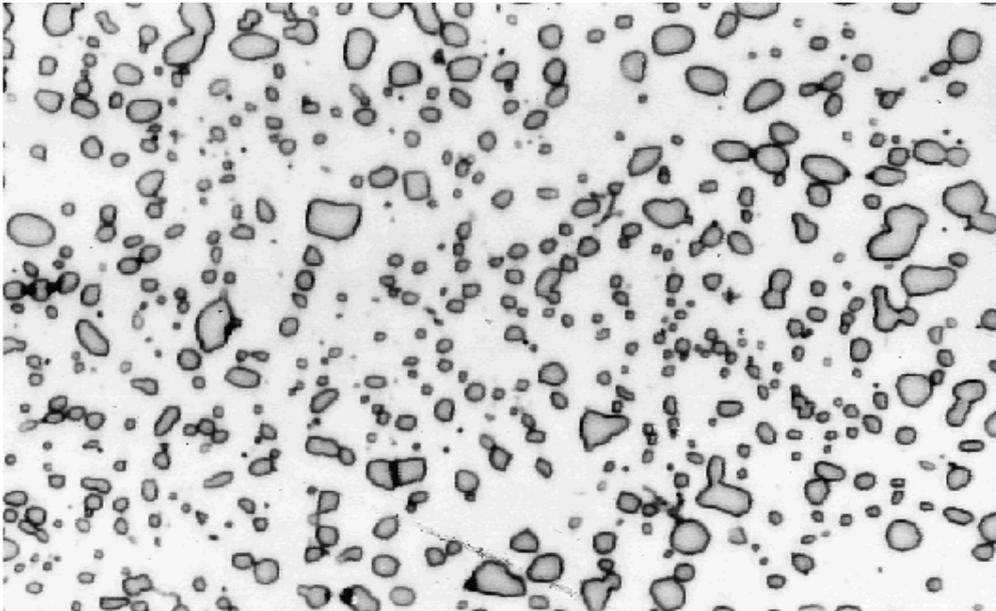
For  $T \sim 300-540^{\circ}\text{C}$ , **upper bainite** consists of needles of ferrite separated by long cementite particles. For  $T \sim 200-300^{\circ}\text{C}$ , **lower bainite** consists of thin plates of ferrite containing very fine rods or blades of cementite. In the bainite region, transformation rate is controlled by microstructure growth (diffusion) rather than nucleation. Since diffusion is slow at low temperatures, this phase has a very fine (microscopic) microstructure. Pearlite and bainite transformations are competitive; transformation between pearlite and bainite not possible without first reheating to form austenite.



### Spheroidite

- Annealing of pearlitic or bainitic microstructures at elevated temperatures just below eutectoid (e.g. 24 h at 700 C) leads to the formation of new microstructure – **spheroidite** - spheres of cementite in a ferrite matrix.

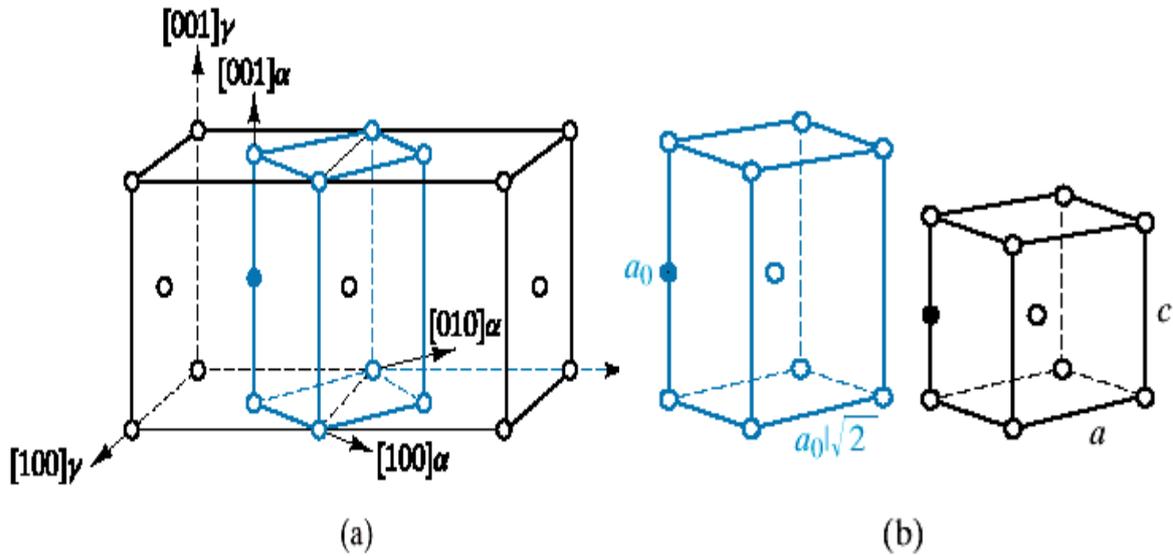
- Composition or relative amounts of ferrite and cementite are not changing in this transformation, **only shape of the cementite inclusions is changing.**
- Transformation proceeds by C diffusion – needs high T.
- Driving force for the transformation - reduction in total ferrite - cementite boundary area.



### **Martensite (I)**

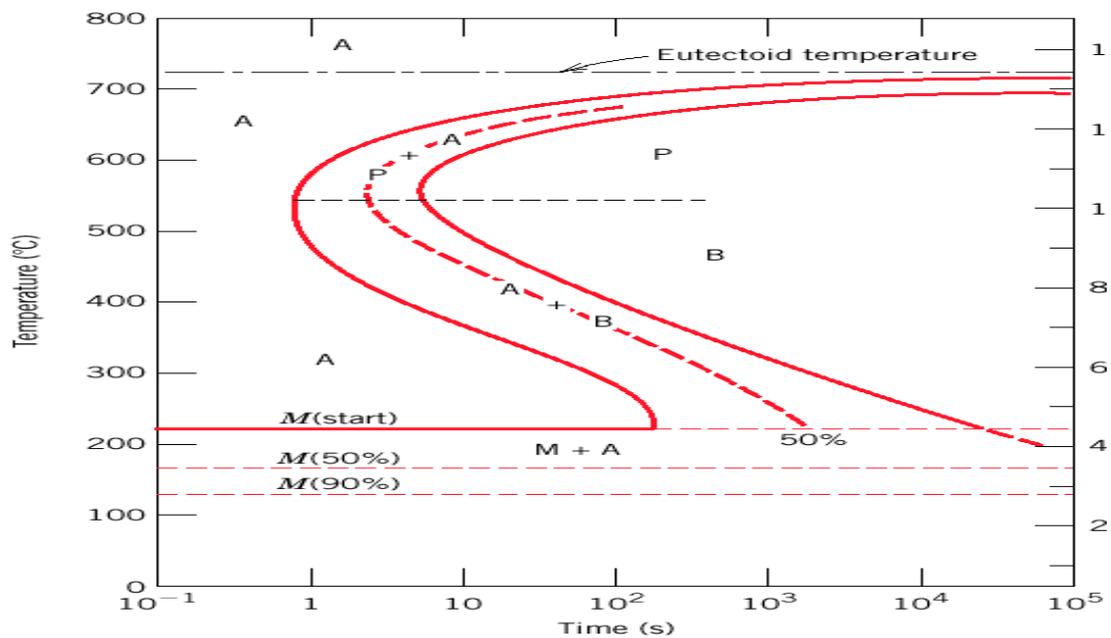
- Martensite forms when austenite is rapidly cooled (quenched) to room T.
- It forms nearly instantaneously when the required low temperature is reached. The austenite-martensite does not involve diffusion → no thermal activation is needed, this is called an **athermal transformation.**
- Each atom displaces a small (sub-atomic) distance to transform FCC  $\gamma$ -Fe (austenite) to martensite which has a Body Centered Tetragonal (BCT) unit cell (like BCC, but one unit cell axis is longer than the other two).
- Martensite is metastable - can persist indefinitely at room temperature, but will transform to equilibrium phases on annealing at an elevated temperature.

- Martensite can coexist with other phases and/or microstructures in Fe-C system•
- Since martensite is metastable non-equilibrium phase, it does not appear in phase Fe-C phase diagram.



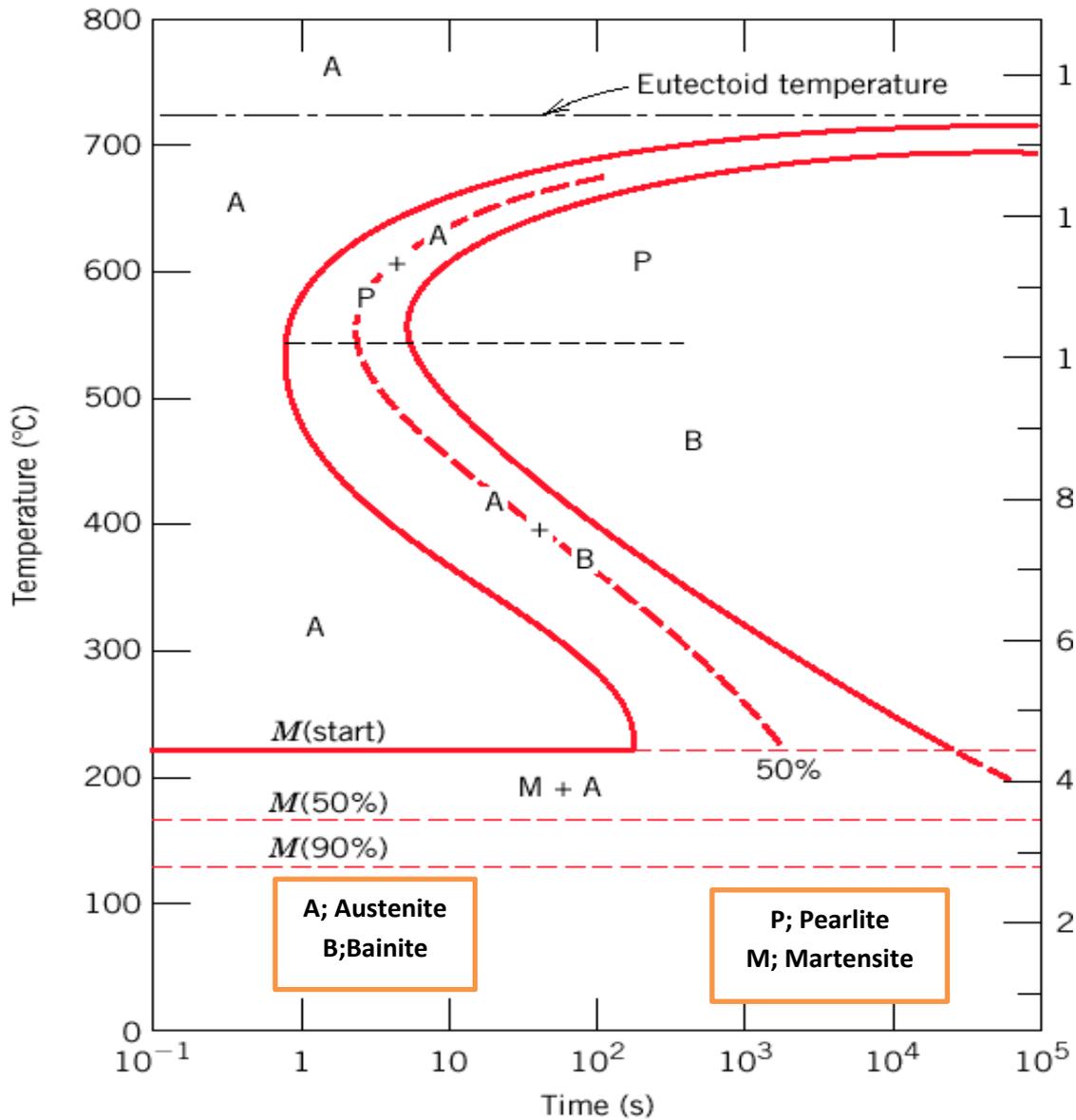
The martensitic transformation involves the sudden reorientation of C and Fe atoms from the FCC solid solution of  $\gamma$ -Fe (austenite) to a body-centered tetragonal (BCT) solid solution (martensite).

### TTT Diagram including Martensite



Austenite-to-martensite is diffusionless and very fast. The amount of martensite formed depends on temperature only.

### Time-temperature path – microstructure

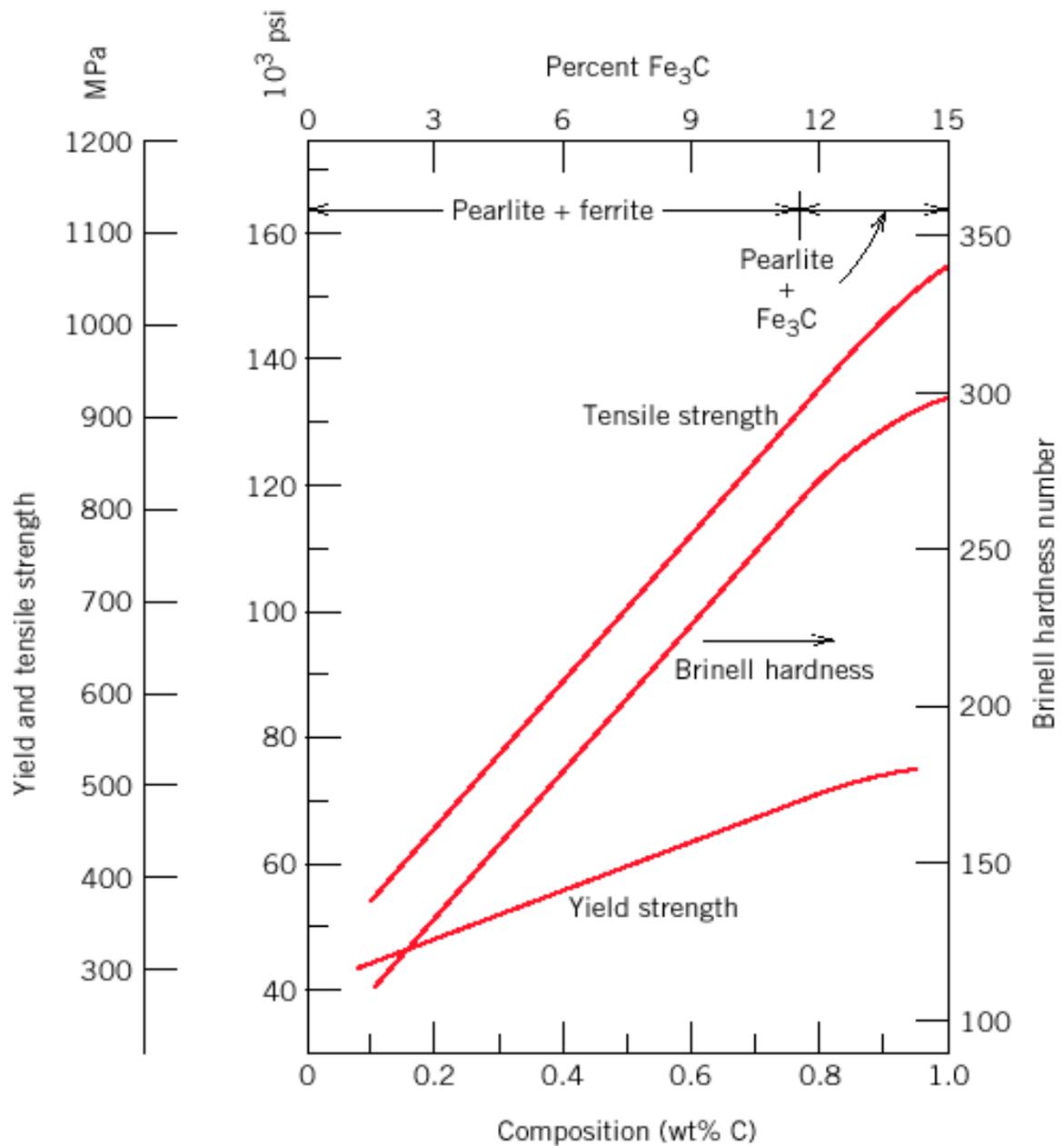


Austenite-to-martensite is diffusionless and very fast. The amount of martensite formed depends on temperature only.

## Time-temperature path – microstructure

### Mechanical Behavior of Fe-C Alloys (I)

Cementite is harder and more brittle than ferrite - increasing cementite fraction therefore makes harder, less ductile material.



## Mechanical Behavior of Fe-C Alloys (II)

The strength and hardness of the different microstructures is inversely related to the size of the microstructures (fine structures have more phase boundaries inhibiting dislocation motion).

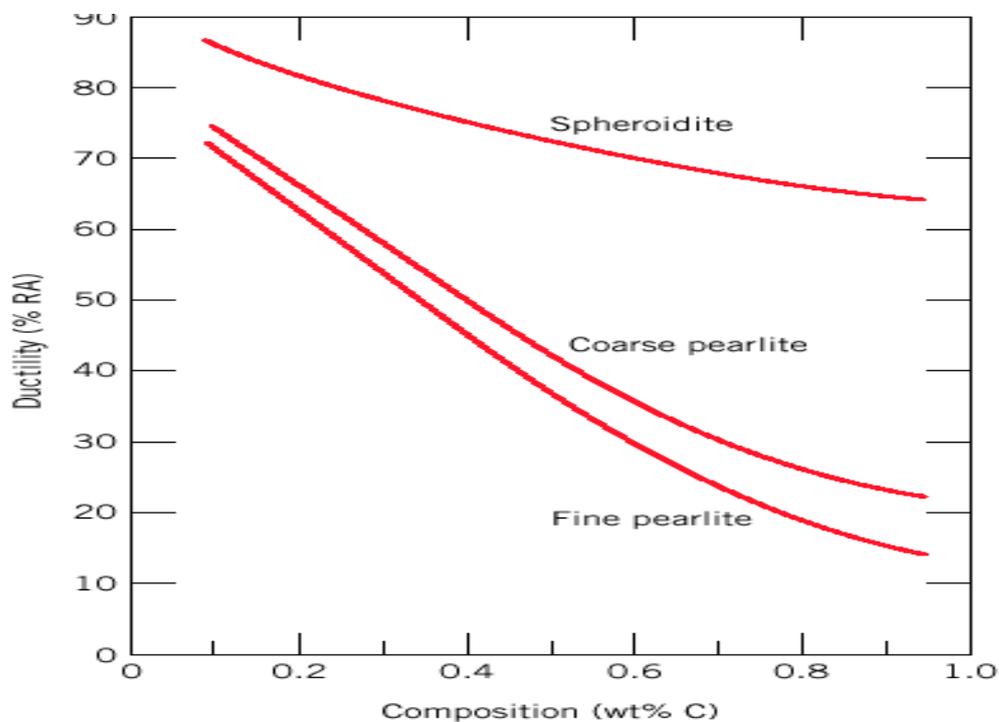
### Mechanical properties of bainite, pearlite, spheroidite.

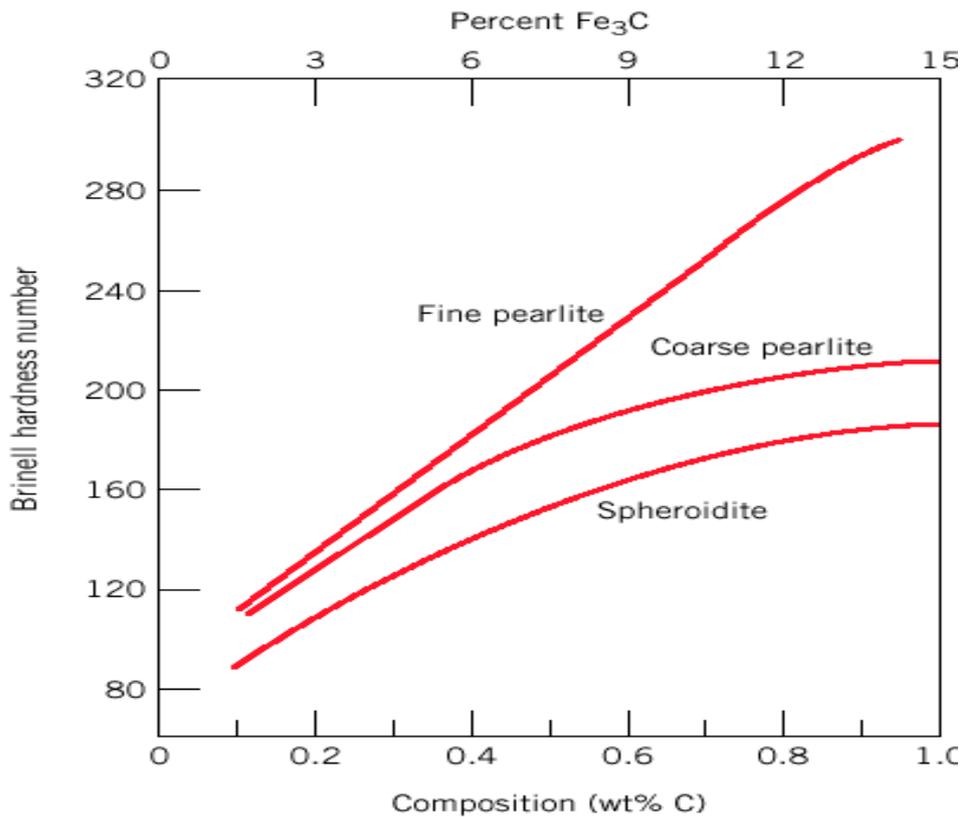
Considering microstructure we can predict that. Spheroidite is the softest. Fine pearlite is harder and stronger than coarse pearlite. Bainite is harder and stronger than pearlite.

### Mechanical properties of martensite

Of the various microstructures in steel alloys. Martensite is the hardest, strongest and the most brittle. The strength of martensite is not related to microstructure. Rather, it is related to the interstitial C atoms hindering dislocation motion (solid solution hardening,) and to the small number of slip systems.

## Mechanical Behavior of Fe-C Alloys (III)

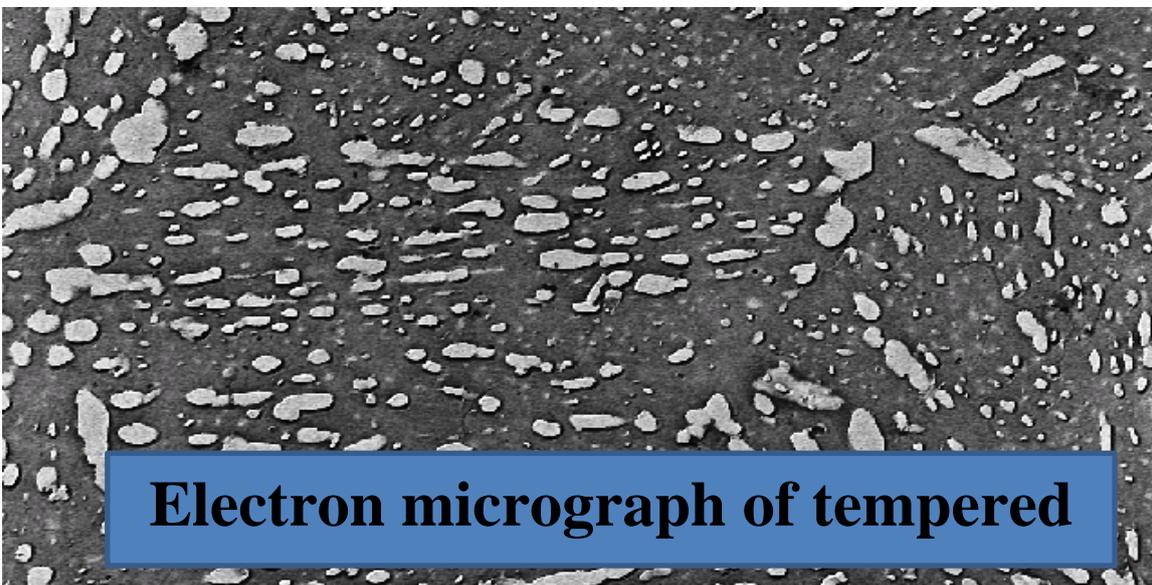
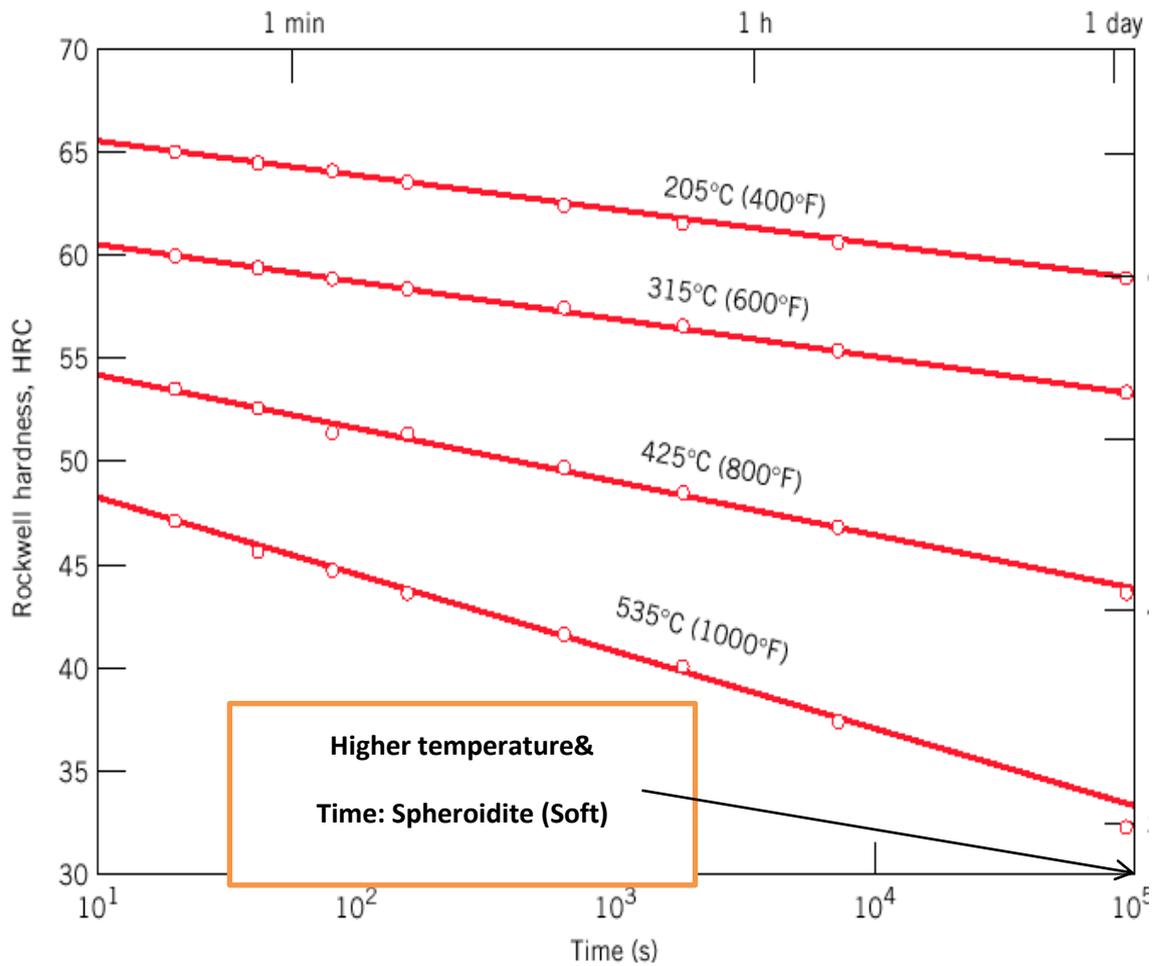




### Tempered Martensite (I)

Martensite is so brittle that it needs to be modified for practical applications. This is done by heating it to 250-650 oC for some time (tempering) which produces **tempered martensite**, an extremely fine-grained and well dispersed cementite grains in a ferrite matrix. Tempered martensite is less hard/strong as compared to regular martensite but has enhanced ductility (ferrite phase is ductile). Mechanical properties depend upon cementite particle size: fewer, larger particles means less boundary area and softer, more ductile material –eventual limit is spheroidite. Particle size increases with higher tempering temperature and/or longer time (more C diffusion) - therefore softer, more ductile material.

## Tempered Martensite (II)



## Commentary of the literatures

While doing this projects Iron-Carbon case diagram, I used from Uzbek scientists' scientific literatures and foreign nation scientists' books. actually. Prizident of Uzbekistan Islom Karimov's select works, Machine building magazines, hand books, a lot of technical books' and I have written to get order from the internet.

As we known Iron is very important thing to us and to our life, because become nowadays technology is more developing than that before in the world actually in Uzbekiston too. The more famous plant in Uzbekistan For example; There are „GM Uzbekistan” in andijon and Traktor plant in Toshkent, again Andijon MASH, Mexanic plant and lots of plants. Iron is so needed to every plants, That's why, it is so difficult imagine without iron at the our life.

***Our main goal, despite the difficulties, to go forward decidedly, consistently continuing ongoing reforms, structural transformations in economy, creating even more opportunities for development of private property, entrepreneurship and small business.***

*Dear participants of the meeting!*

The agenda of today's enlarged meeting of the Cabinet of Ministers includes the results of economic and social development of the country for the past 2015 and approval of the most important priorities of country's economic development in 2016. Analyzing progressive advancement of the country on path of democratic reforms and sustainable development, we have all grounds to state that in the past year we have taken decisive steps in implementation of fundamentally important reforms aimed at achieving our main goal - to reach the level of developed democratic countries in the world with a strong social oriented economy, providing a decent standards and quality of life of our people.

JSC "GM Uzbekistan" in Khorezm region has launched serial production of mini-truck "Chevrolet Labo", overall cost of project totals approximately 6 million US dollars, and annual capacity is 5000 machines necessary for farmers and

entrepreneurs. It should be noted that this is the third model produced at the new plant "Khorezm Auto", which has already launched production of cars "Damas" and "Orlando". In the Pap district of Namangan region a solar photovoltaic power plant of 130 kW has been put into operation. So far this project is in test regime, but by 2020 the country plans to put into operation three more solar power plants of 100 MW each.

High-speed passenger trains on railway lines to Samarkand and Karshi are opened, allowing to organize the running of high-speed trains "Afrosiyob" from Tashkent to Karshi. As a result the carriage of passengers from the capital to Kashkadarya and back reduced twice. The profound structural changes are taking place **in agriculture**. Through hard work and skills of farmers despite the difficult weather conditions in the country grown and harvested a rich crop of agricultural products - produced more than 7.5 million tons of grain, more than 3.35 million tons of cotton. It should be noted that high yields are provided mainly due to intensification of agricultural production, improvement of selection and implementation of recognized varieties of cotton and grain crops, the development of modern agricultural technologies. The average yield of wheat in country reached 55 quintals per hectare, and in some areas reached 60-77 quintals per hectare, which is a great achievement of our farmers.

In addition, the rapidly developing sectors of agriculture such as horticulture, horticulture, viticulture and cattle breeding. Last year, 12.592 million tons of vegetables, including potatoes, 1.85 million tonnes of melons, 1.556 million tons of grapes, 2.731 million tons of fruits has been harvested. We attach exceptional importance to deepening of industrial processing of agricultural raw materials, the development of storage infrastructure grown produce. In the past year created and upgraded 230 enterprises in the industrial processing of agricultural products, developed and modernized 114 new cold stores with a capacity of 77.8 thousand tons. The total storage capacity of fruits and vegetables in the country increased to 832 thousand tons, which allows in the course of year without interruption and

without sharp seasonal price spikes to provide country's population with main types of agricultural products, to expand its exports, to maintain price stability.

All of this is the result of selfless labor of our farmers and all rural workers. It gives me great pleasure to express our sincere gratitude.

In the past year, we continued systematic work to achieve dynamic **development of the sphere of services** as one of the most important factors and directions to deepen structural reforms and diversify economy, increasing employment, income and quality of life.

In short, you need to provide whole cycle forecasting organization of production - from raw materials to finished products with a substantiation of expediency and cost recovery. Calculations show that as a result of the release of products with high value-added petrochemical products production volumes can be increased with development of its new species in 2030 by 3.2 times, products from ferrous metals - by 2.2 times, of iron or steel - 2 3 times, chemical products, including fertilizers - 3.2 times.

Deep processing of cotton fiber, fruits and vegetables using modern technologies will increase in 2030 production volumes demand on domestic and foreign markets environmentally friendly finished products textile and light industry by 5.6 times, fruits and vegetables - by 5.7 times.

This list can be continued.

Along with this increase in the production of modern finished products with high added value, demand in foreign markets, will be basis of sustained high growth rate of its exports.

I must say that this work has already begun in the country. However, it requires a radically new software integrated approach with a view to the perspective view of each raw material and semi-finished products with high potential, have a specific program of deep processing, calculated for 2020, 2025, 2030.

We now have good reason, based on deep analysis of trends in global economy and realistic assessment of our resources and capabilities, **to set a target - not less than 2-fold increase in 2030 GDP of our country.** Due to drastic structural reforms - to achieve accelerated growth of industry and bring its share in GDP to 40% against 33.5% in 2015, while share of agriculture has fallen from 16.6% to

10.8%, to reduce energy intensity of GDP is about 2 times as a result of the widespread introduction of energy saving technologies.

The reality of the task can be judged based on the following calculations. In order to achieve the growth of GDP for the years 2016-2030 2 times, enough to provide average annual growth rate of 4.8%, while over the past 11 years the average GDP growth rate in the country amounted to level no less than 8%.

*Dear compatriots!*

**The most important priority envisaged for 2016 economic program should be unconditional continued initiated system of democratic reforms and modernization of the country, deep structural changes in the economy, especially in industry and agriculture, advanced development and protection of private property, entrepreneurship and small business, ensuring macroeconomic balance.**

We have set ourselves the task to ensure this year's GDP growth at 7.8%, the volume of industrial production - 8.2%, agriculture - 6.1, retail trade - 14 and services - 17.4%, maintain inflation in the range of 5.5-6.5%, ensure the growth of real incomes by 9.5%, the average wages, pensions, scholarships and grants, taking into account the tax benefits provided by the - by 15%. A crucial role in the realization of these objectives belongs to investment program for 2016 as an essential instrument of structural transformation of industry and economy as a whole. We should take urgent measures to ensure the unconditional entry within the terms provided for 2016, 164 major investment projects worth more than 5 billion US dollars.

First of all, completion of high-speed train "Afrosiyob" to Bukhara, two steam and gas turbines of 450 MW each at Talimarjan TPP, power unit of 150 MW at the Angren TPP, three blocks of desulfurization capacity of 6 billion cubic meters of gas at the Mubarek Gas Processing Plant, a new smelter capacity of 70 thousand tons of copper at the Almalyk MMC, capacity expand of cement plant in Jizzakh region to 1 million tons of Portland cement, development of production of new models of cars, "Aveo" (T-250) at JSC "GM Uzbekistan". In 2016, its planned

to build in rural areas 13 thousand houses with a total area of more than 1 million 800 thousand square meters, as well as to pave 900 kilometers of water networks, gas and electricity, 325 kilometers of access roads. In general, in 2016 its planned to direct investments for development, modernization and structural adjustment in the equivalent 17.3 billion US dollars with a growth rate of 109.3%, of which more than 4 billion US dollars contain foreign investment with an increase against 2015 by 20.8%. I would like to emphasize especially the need to improve the accountability of officials, regardless of their affiliation with the delivery and installation of machinery and equipment that meets all modern requirements. To this end, last year the Cabinet of Ministers of the Republic of Uzbekistan Agency on expert assessment of feasibility studies of projects newly constructed and reconstructed production facilities, equipment and technology was established. It is the organization, first of all, that will be strictly responsible for the unconditional fulfillment of all requirements by customers. A recent study by a special commission of the Cabinet of Ministers to study the state of problem at enterprises of light and textile industry revealed a number of serious flaws in this case. Such inspections should be continued. Along with this specific articles to strengthen the responsibility of the customer for the delivery and commissioning of outdated equipment must be added to the Administrative Responsibility Code and the Criminal Code.

**An important task is to continue in 2016 started work on unconditional implementation of major provisions of Program of development and modernization of engineering and communication and road infrastructure in 2015-2019.**

The focus should be laid on issues to complete modernization of Uzbek national highway, about 513 kilometers of roads of which this year to be constructed and reconstructed. In the area of rail transport a key focus will be the further development of the railway network, providing electrification of railways section Samarkand-Bukhara and continued work on electrification of Karshi-Termez section. An important event of the year will be the completion of the 19-kilometer

rail tunnel through on pass Kamchik and opening of railway traffic on Angren-Pap section, which will provide cargo transportation by rail between Ferghana Valley and other regions of the country. Once again I want to emphasize that it is vital for us, this promising project, which has not only a strategic and economic importance, but also characterized by an increased level of progress we have made in the field of communications and transport.

*Dear participants of the meeting!*

**Fundamentally important priorities of economic program for 2016 and near future is the further deepening of reforms and structural changes in agriculture, efficient use of land and water resources.** I must say that transition to a system of farm management the issue of optimization of land areas size, which provides each farmer enterprise the right for rental property, remains relevant. This is primarily due to the fact that in conditions of irrigated agriculture, water scarcity and high salinity of almost all arable territory of the Republic of Karakalpakstan, regions and rural areas, there is a great variety of land fertility and yield class. It took hard systemic work to reach rational and optimal provision of land areas, taking into account experience of development, efficiency and profitability of farms established in various regions. At the same time an effective factor in avoiding and preventing subjective approach in determining size of areas is that all of this extremely important work was entrusted to deputy corps, advising farmers and rural community. As a result of further optimization of land created over 17.5 thousand farms and more than 250 thousand new jobs. The largest number of farms established in Tashkent, Jizzakh, Namangan, Samarkand, Kashkadarya, Ferghana, Andijan regions and Karakalpakstan. A new mechanism for granting and withdrawal of land for farms, when the decision is made not by hokim of district, but the district Council of deputies on conclusion of territorial councils and commissions of farmers to address issues of land areas provision. Especially I would like to dwell on the issue of fundamental importance to quality of structural changes in agriculture and development of economy as a whole. We are talking about a phased reduction of the volume of production and state purchases of cotton

from 3.35 million tons to 3 million tons up to 2020. Calculations show that the volume of produced cotton will allow, on the one hand, to fully meet the needs of, first of all, textile and light industry, raw material, given its deep processing, and on the other hand - to keep a strong position of our country as a supplier of cotton fiber and its derivatives to world markets. I must say that by reducing the production of raw cotton by 350 thousand tons released about 170.5 thousand hectares of irrigated land. Thus, as a rule, released land with low yield class where cotton yield do not exceed 12-15 quintals per hectare - with the average achieved in the country yields 26.1 centners per hectare. Released mainly saline land and land in the foothill areas unsuitable for growing cotton. The fact that in recent years has been a sharp fall in prices and demand for cotton in world market is equally important. The cultivation area, exempt from cotton in turn to be sown with vegetables, including potatoes, fodder, oilseeds, established orchards and vineyards. As a result of optimization of crop areas and introduction of modern agricultural technologies by 2020 its provided for to bring production volumes of cereal crops up to 8.5 million tons with an increase of 16.4%, increase of potato production by 35%, other vegetables - 30%, fruit and grapes - 21.5%, meat - by 26.2%, milk - by 47.3%, eggs - by 74.5%, fish - by 2.5 times. We should take into account that exports of these types of food will be substantially increased. **As before, our focus remains on issues related to development of social sector, further improvement of level and quality of life.** The social sector in 2016 will be allocated 59.1% of total expenditure from State budget, that surpasses last year's indicator, including on education - 33.7%, on healthcare - 14%. At the same time costs for maintenance and development of education will increase against the previous year by 16.3%, healthcare - 16%. I would especially like to note the growing volume of funds allocated for development of material-technical base of higher educational institutions (HEIs) of our country. It is envisaged to allocate 355 billion soums to construction and reconstruction of 13 HEIs, including Karakalpakstan, Bukhara and Samarkand State University, Fergana Polytechnic Institute. Also a complex of buildings of the Tashkent State Institute of Dentistry,

new academic buildings branches Inha University and Singapore Institute of Management Development will be built. The most important task for us is to ensure employment of the population - in 2016 provides for the creation of about 990 thousand new jobs, including by accelerating the development of small business and private entrepreneurship, services will be organized more than 660 thousand jobs. In 2016, we will ensure employment of more than 510 thousand graduates of universities, high schools and colleges. Once again I would like to remind the heads of district, city and regional administrations about their personal responsibility for this area of work, bearing in mind that the solution to problem of employment of young people, our children, especially in rural areas, continues to be for us one of most urgent tasks. It is extremely important in shaping annual plan of admission to professional colleges and academic lyceums mainstream, what new facilities will be commissioned in 3-4 years in the district, city, area, some footage of how they need to function, and on this basis make appropriate adjustments to reception. In the context of increasingly tough competition in world markets becomes **fundamental priority improving competitiveness of our economy, increasing support for export enterprises, promotion of full participation in export of farms, small businesses and private entrepreneurship.** In these areas there is a huge, yet untapped potential. It should be borne in mind that, unlike the industrial exporting enterprises, small businesses and farmers are exempt from the mandatory sale of banks to 50% of foreign exchange earnings from the export of their products themselves should be interested in promoting their products for export First of all, we should critically review the system of benefits provided to exporters to take additional measures to further simplify customs procedures, reduce time of implementation and tariffs on carrying out foreign trade operations. Its essential to broader introduce the electronic form of registration of all documents and licensing procedures, export-related products. Serious responsibility for resolution of all these issues rests with structure of transformed Ministry of Foreign Economic Relations, Investments and Trade. Today they are fully responsible for coordination of export and involvement of new members in

export activities, expanding supply of our products for export, development of new markets. The most serious attention should be paid to experience of Fund for export support for small business and private enterprises, established in 2013 under the National Bank for Foreign Economic Activities. This is a unique structure that is intended to provide legal, financial and organizational services to businesses to promote their products and services to foreign markets. In this connection, I consider it necessary to consolidate financial capacity of this Fund due to an increase in current year of the size of its share capital at least twice, as well as to expand its powers, functions, and a list provided them with financial services, to consider the establishment in the regions of its business units.

**In modern conditions, in the era of the Internet and electronic wide introduction of modern information and communication technologies in the fields of economy, a radical acceleration of the creation of the "Electronic Government" is of priority importance.**

The whole world experience shows that in current global economy the role and importance of information and communication technologies is increasing, including manufacturing of computer and telecommunications technology, software development and provision of on their basis a wide range of interactive services. We should not forget that the development of ICT has a direct impact on level of competitiveness of country, allows to collect and summarize vast amounts of information, offers great opportunities for management at strategic level. I must say that today ICT accounts for about 5.5% of world GDP, and according to authoritative international experts estimates by 2020 this figure will exceed 9%.

For example, in Republic of Korea share of the ICT sector in the country's GDP totals more than 11.8%, in Sweden - 7%, in United States of America - 6.8%.

Despite the fact that in recent years, this sector of our economy developing rapidly, we must recognize that we are only at the initial stage - the share of ICT accounts for only about 2% of GDP. At the same time, we have all the necessary resources and opportunities for more rapid development of the sector, with a view to growing

up professional staff in the country where those active in Tashkent foreign universities South Korean Inha and universities of our country prepare such a staff. On the eve of the new year we all decided to name 2016 as the Year of Healthy Mother and Child. In accordance with the centuries-old traditions of our people, we firmly believe that a healthy mother and healthy child are the key to keep a happy family, in turn, happy family is the basis of a prosperous society. We have a huge large-scale work on implementation of program, in which special attention is paid to such issues as further strengthening of protection of family, motherhood and childhood, formation and consolidation of material and technical base, personnel potential perinatal and screening centers, nursing services , increase level and quality of care for young mothers and children, creation of healthy spiritual environment in families, formation of girls' physical health and intellectual development of compulsory education in academic lyceums and professional colleges, their regular exercise. At the same time we must bear in mind that further strengthening of physical and moral health of our children, mothers, all our people undoubtedly depends on our constant attention to these problems.

*Dear compatriots!*

Today we have every reason to be proud of what has been done and executed by us in past 2015. We have entered into an anniversary for our country - the year of 25th anniversary of Uzbekistan's independence. I will not be mistaken if I say that for every citizen of Uzbekistan, a matter of honor - to make a significant contribution to the fact that 2016 has become for us worthy of this great date.

Of course, the coming year will not be easy, but I am convinced that all the parameters and indicators will surpass last 2015's ones. There is no doubt. I wish you all good luck and success in achieving these noble objectives.

## Main part

There are two iron-carbon equilibrium diagrams:

- stable iron-graphite Fe-Gr
- metastable iron-cementite Fe-Fe<sub>3</sub>C

The stable condition usually takes a very long time to develop. The metastable diagram is of more interest. Fe<sub>3</sub>C iron carbide called cementite because it is hard.

Following phases exist on Fe-Fe<sub>3</sub>C diagram:

- liquid solution of iron and carbon (L)
- ferrite ( $\alpha$ ) – an interstitial solid solution of carbon in Fe <sub>$\alpha$</sub>  (bcc). At room temperature ferrite is ductile but not very strong.
- austenite - an interstitial solid solution of carbon in Fe <sub>$\gamma$</sub>  (fcc).
- cementite (Fe<sub>3</sub>C) hard and brittle compound with chemical formula Fe<sub>3</sub>C. It has metallic properties.

On a base of Fe-Fe<sub>3</sub>C diagram we can divide iron-carbon alloys into:

- steels,
- cast steels,
- cast irons.

Steel is an alloy of carbon and iron and other alloying elements (e.g. Mn, Si) with carbon content up to 2% intended for wrought products or semi products.

Cast iron is an alloy of carbon and iron and other alloying elements (e.g. Mn, Si) with carbon content over 2% intended for castings. Now, we consider only a part of Fe-Fe<sub>3</sub>C diagram referring to steel.

Perlite is a structure (i.e. consists of two phases) consists of alternate layers of ferrite and cementite in the proportion 87:13 by weight. Pearlite is formed from austenite at eutectoid temperature ( $A_1$ ) 727°C upon slow cooling.

There are three groups of steels according to carbon content:

- hypoeutectoid steels containing less than 0.76% C

- eutectoid steel with carbon content about 0.76%
- hypereutectoid steels contain more than 0.76% C (up to 2% C)

Hardenability is the ability of steel to transform into martensite with a particular quenching treatment. This is directly affected by the alloy composition of the steel. For every different steel alloy there is a specific relationship between its mechanical properties and its cooling rate. Hardenability is not “hardness” which is a resistance to indentation but hardness measurements are utilized to determine the extent of a martensitic transformation in the interior of the material.

## Technical unit

### Phase transformation in steels

In general, steel refers to an iron-carbon alloy, which may contain up to 2 wt.% C. Although carbon is the most common element, a group of alloying elements such as Mn, Si, Cr, Mo and Ni may also be added to steels to obtain desired properties. Obviously, these elements need to be added to the iron base in molten state, generally at temperature above 1600 C. When cooling from liquid state, different phase transformations can take place, as shown in Fig.4. The first phase transformation is from liquid  $\rightarrow$   $\delta$ -ferrite, which has a bcc (body centered cubic) structure. With decreasing temperature,  $\delta$ -ferrite transforms to  $\gamma$ -austenite, fcc (face centered cubic) form of iron which can take up to 2.1 wt.% carbon.

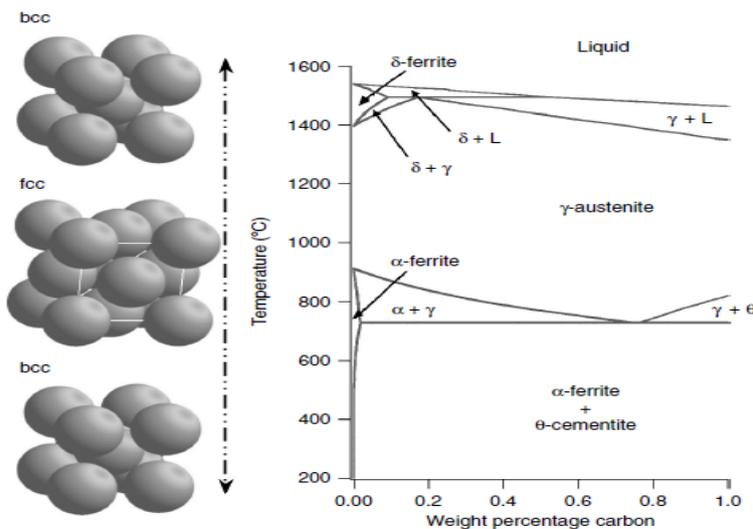


Fig.: Fe-C phase diagram showing allotropic forms of Iron

At lower temperatures,  $\alpha$ -ferrite, another allotropic form of iron becomes stable, which has a bcc structure and can dissolve a small amount of carbon, up to a maximum of 0.02 wt% at 723°C. This large difference in carbon solubility of austenite and  $\alpha$ -ferrite implies that steels are heat treatable. When cooling from austenitic temperature, austenite may decompose to different microstructures as

ferrite, pearlite, bainite and martensite, making it possible to obtain a wide variety of mechanical properties by controlling the process variables. To have a better understanding of steels in general, these microstructure evolutions need to be studied in detail. However, more focus is put on the martensitic and bainitic transformations due to their dominance in sinter-hardening process.

### **Ferritic and pearlitic transformations:**

The product of the eutectoid transformation in steels is called pearlite, which is in fact a lamellar mixture of ferrite and cementite developed alternately during slow cooling of austenite. Considering the Fe-C phase diagram shown in Fig. the eutectoid transformation at 723°C may be written as;



Application of lever rule at this temperature gives the amount of cementite within the pearlite colonies;

$$0.77 - 0.02 / 6.67 - 0.02 \times 100 = 11 \text{ wt\%}$$

and therefore, the weight percent of ferrite is 89%. This simple calculation shows that the pearlite basically contains 89% ferrite, and consequently similar thermal properties can be used for these phases in numerical modeling.

Pearlite and ferrite transformations are good examples of the diffusional process. The term diffusional implies that this transformation is controlled by diffusion process and is a function of both time and temperature. Thus, the kinetics of transformations can be simulated by application of the volume extended concept introduced by Johnson, Mehl, Avrami and Kolmogorov .

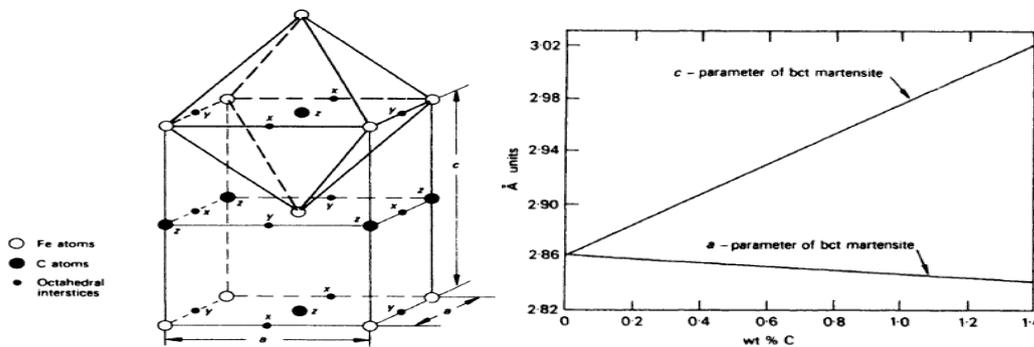
### **Martensitic transformation:**

Rapid cooling of steels from austenitic region may lead to formation of martensite. Unlike austenite to ferrite and pearlite transformations, formation of martensite is diffusionless. This implies that the elements in solid solution in the former austenite, remains in solution in the martensite. Therefore, martensite can be considered as a supersaturated solid solution of carbon in ferrite. This transformation is accompanied by a large shear deformation and a volume

expansion, since the carbon atoms order within interstitial sites, in such a way that the bcc structure of ferrite changes to the body-centered tetragonal (bct) structure, shown in Fig.5a. The degree of tetragonality can be evaluated by measuring the ratio between the axes,  $c/a$ ;

$$c/a = 1 + 0.045 \text{ wt\% C}$$

The effect of carbon content on lattice parameters,  $c$  and  $a$ , are shown in Fig.5b, showing that tetragonality increases dramatically with higher carbon dissolution.



a) bct structure of martensite b) effect of carbon on lattice parameters,  $a$  and  $c$

Martensitic transformation is commonly considered as athermal, since the transformation starts at a well-defined temperature,  $M_s$  (i.e. martensite start temperature), and continues until martensite finish temperature,  $M_f$ , is reached. However, isothermal martensitic transformation may also occur at constant temperatures.

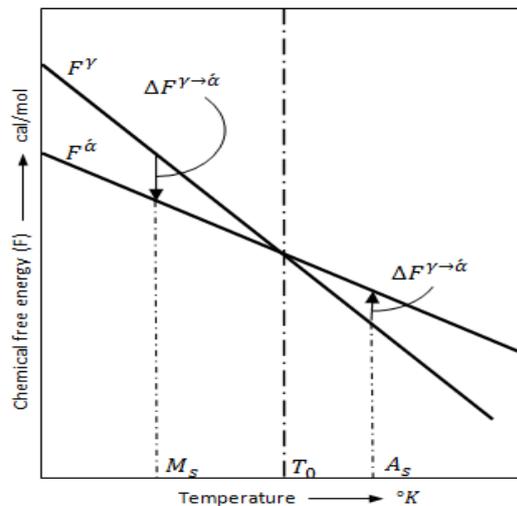
### *Thermodynamics aspects of martensitic transformation in steels*

Diffusionless nature of martensitic transformation implies that no chemical decomposition occurs during transformation; and therefore the chemical free

energies of the martensite and the parent phase depend only on temperature. There may exist a specific temperature ( $T_0$ ), at which these two free energies become equal. The difference between free chemical energy of austenite and martensite, at temperatures other than  $T_0$  can be given as;

$$F_{\gamma \rightarrow \alpha} = F_{\alpha} - F_{\gamma}$$

Where,  $F_{\gamma}$  and  $F_{\alpha}$  are chemical free energies of austenite and martensite, respectively. It has to be noted that, difference between chemical energies,  $F_{\gamma \rightarrow \alpha}$ , is positive when austenite is more stable than martensite. Fig. shows the variation of free energy with temperature for these phases. As can be seen, martensitic transformation does not take place until a certain supercooling is provided ( $M_s$  lies below  $T_0$ ), due to the presence of nonchemical free energies such as interfacial and strain energies. In practice, the supercooling ( $T_0 - M_s$ ) may exceed to a value as large as  $200^{\circ}\text{C}$ .



**Fig.:** Variation of chemical free energy for austenite and martensite with temperature after Kaufman and Cohen [8] with some modification)

One may express the overall free energy as;

$$W_{\gamma \rightarrow \alpha} = \Delta F_{\gamma \rightarrow \alpha} + \Delta G_{\gamma \rightarrow \alpha}$$

where,  $G_{\gamma \rightarrow \alpha'}$  represents the fraction of nonchemical free energies. The necessary condition for commencement of martensitic transformation is that the overall free energy becomes negative, or  $F_{\gamma \rightarrow \alpha'} < \Delta G_{\alpha' \rightarrow \gamma}$ . In other words, not only is it necessary that the chemical free energy is negative, but it also needs to be less than a certain quantity,  $G_{\alpha' \rightarrow \gamma}$ .

The classical theory of homogenous nucleation can be applied to study the martensitic transformation. In general, creation of new interfaces during solid state transformations will increase the free energy by an amount that depends on coherency of the parent phase (austenite) and the martensite. For a lenticular plate, with thickness of  $2c$  and radius of  $r \gg c$ , the interfacial free energy may be given as;

$$\Delta G_{s\gamma \rightarrow \alpha'} = 2\pi r^2 \sigma \text{ cal/particle}$$

where,  $\sigma$  represents the free energy of  $\alpha'/\gamma$  interface per unit area, or specific interfacial free energy. Fisher et al. assumed a coherent interface between the martensite and the parent phase, and calculated a value of  $5.7 \times 10^{-7} \text{ cal/cm}^2$  for  $\sigma$ . On the other hand, it can be shown that if the interface between them is considered semi-coherent, higher values for the specific interfacial free energy can be obtained ( $1.2 - 2.4 \times 10^{-5} \text{ cal/cm}^2$ ).

Mechanical free energy is also an important factor, since the martensitic transformation is accompanied by large shear deformations. As a result, elastic strains are developed and stored, both inside and around the martensite plates. The elastic free energy of a lenticular martensite plate may be expressed as;

$$G_{e\gamma \rightarrow \alpha'} = \pi c r^2 (A \epsilon) \text{ cal/particle}$$

where two terms  $\pi c r^2$  and  $A \epsilon$  refer to the approximated volume of martensite plate and the strain free energy of a unit volume of martensite, respectively, and  $A$  is the strain energy factor. Fisher et al. showed that elastic free energy can take values as large as 480 to 1140  $\text{cal/cm}^3$ . Within and around martensite plates, some extent of plastic deformation can also take place, to relax the developed shear strains. However, the energy needed for such deformations to occur is considerably large, and therefore its effect is generally regarded negligible. After inserting Eq.5 and Eq.6 into Eq.4; the overall free energy may take the form;

$$W_{\gamma \rightarrow \alpha} = \pi r^2 c f_{\gamma \rightarrow \alpha} + 2\pi r^2 \sigma + \pi c r^2 (Acr)$$

where,  $f_{\gamma \rightarrow \alpha}$  is the chemical free energy change per unit volume. Differentiating Eq. with respect to  $r$  and  $c$  determines the value of critical nucleus size, and finally the free energy barrier can be given as;

$$W = 8192 \pi \theta^2 \sigma^3 (27f^4) / \text{cal/particle}$$

where,  $\theta$  is a strain factor that depends on the elastic constant of the parent phase and shear angle of martensite plate. It should be mentioned that, although Eq.5 to Eq.8 give some indications regarding the effects of nonchemical energies on the transformation mechanism, the energy barrier calculated by Eq.8, is large by several orders of magnitude, leading to dramatic deviation from experimental observations. This confirms that martensite nucleation occurs on pre-existing embryos, and therefore, the whole mechanism is heterogeneous.

### *Effects of alloying elements*

The overall free energy of the martensitic transformation includes two separate terms, one is concerning the nonchemical free energies, discussed in previous section, and the other pertains to the chemical free energy, which will be studied here. In general, the alloying elements can influence both the chemical and nonchemical energies.

Since no chemical decomposition takes place during martensitic transformation, the chemical free energy of a binary  $Fe-X$  alloy system can be expressed formally by adding three following terms;

$$\Delta F_{Fe-X} \gamma \rightarrow \alpha = (1-x) \Delta F_{Fe} \gamma \rightarrow \alpha + x \Delta F_X \gamma \rightarrow \alpha + \Delta F_M \gamma \rightarrow \alpha$$

where  $x$  is the concentration of alloying element  $X$  in atom fraction. In above relation,  $\Delta F_M \gamma \rightarrow \alpha$  represents the difference in the free energy of mixing.

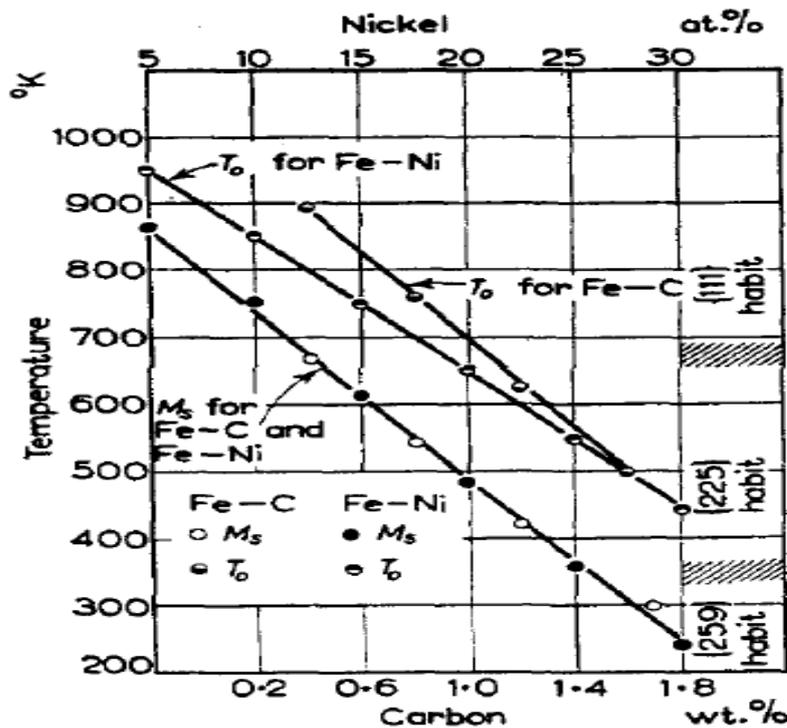
According to the basic rules of thermodynamics,  $\Delta F_X \gamma \rightarrow \alpha$  can be written as;

$$\Delta F_X \gamma \rightarrow \alpha = \Delta H_X \gamma \rightarrow \alpha - T \Delta S_X \gamma \rightarrow \alpha$$

where  $\Delta H_X \gamma \rightarrow \alpha$  and  $\Delta S_X \gamma \rightarrow \alpha$  are the enthalpy and entropy changes between  $\gamma$  and  $\alpha$  for the element  $X$ , respectively. Zener assumed that the solid solutions are ideal, which implies  $\Delta F_M \gamma \rightarrow \alpha = 0$  [8]. He further assumed that  $\Delta S_X \gamma \rightarrow \alpha$  is zero, and therefore Eq.9 can be simplified as;

$$\Delta F_{Fe-X\gamma \rightarrow \alpha} = (1-x)\Delta F_{Fe\gamma \rightarrow \alpha} + x\Delta H_{X\gamma \rightarrow \alpha}$$

The values of  $\Delta H_{X\gamma \rightarrow \alpha}$  for different alloying system can be found in Ref.10. By setting  $\Delta F_{Fe-X\gamma \rightarrow \alpha}$  equal to zero, the value of  $T_0$  can be obtained. In general, those elements that expand the  $\gamma$  loop, i.e.  $\gamma$  stabilizers, make the value of  $\Delta H_{X\gamma \rightarrow \alpha}$  positive and lower  $T_0$ . Fig.7 shows the  $M_s$  and  $T_0$  for iron-carbon and iron-nickel .



As can be seen,  $M_s$  and  $T_0$  behave similarly, i.e. they both decrease as the alloying content increases. However, for the case of Fe-Ni, the difference between them,  $T_0 - M_s$ , increases with nickel content. This indicates that, the alloying elements may also take part in nonchemical free energies. Electron microscopy observations confirm that the martensitic transformation involves a large amount of slip or twinning. Thus, anything that can restrain the glide of dislocations may retard the transformation temperature. Ghosh and Olson suggested that the fraction of alloying elements in solid solution in austenite can be used to estimate the driving force necessary for martensitic transformation. Their hypothesis was based on the effects of solid solution strengthening mechanism on glide of dislocations. They

showed that the critical driving force can be expressed in term of interfacial frictional work;

$$-\Delta G_{crit} \rightarrow \dot{\alpha} = K(1 + K\mu_i, X_i)$$

### **Johnson–Mehl–Avrami–Kolmogorov (JMAK) model**

Johnson, Mehl, Avrami and Kolmogorov developed a model to determine the extent of the diffusive transformations under isothermal conditions . Their model is based on the following assumptions;

1. The nucleation process is random
2. The nucleation and growth rates are constant with respect to time
3. The nuclei have spherical shape

Under these assumptions, they showed that the volume fraction of the transformed phase  $X$ , at any given time  $t$ , can be obtained by;

$$X = 1 - \exp(-\pi^3 N G^3 t^4)$$

where  $N$  is the nucleation rates and  $G$  is the growth rate of the spherical nuclei. However, in actual practice, this simple model cannot cover all the possibilities during nucleation and growth process. For instance, grain boundaries act as the preferential sites for nucleation process and can enhance the rate of nucleation markedly. Therefore, one may express the JMAK model in a general form;

$$X = 1 - \exp(-k(T) t^n(T))$$

where  $k$  and  $n$  are the model's parameters and depend on the nucleation and growth mechanism. When the isothermal transformation diagram is available, these parameters can be obtained by means of the following relations;

$$n = \ln(\ln(1 - X_s) / \ln(1 - X_f)) / \ln(t_s t_f)$$

$$b = -\ln(1 - X_s) / t_s^n$$

where  $X_s$  and  $X_f$  are the starting and finishing volume fractions, usually taken as  $X_s = 0.01$  and  $X_f = 0.99$  and,  $t_s$  and  $t_f$  are respectively the start and finish transformation times at a constant temperature. Time derivative of Eq.21 takes the form of the following equation;

$$\dot{X} = b n (n - 1) (1 - X)^{-(n-1)}$$

If  $n$  in Eq.21 remains constant during transformation (i.e.  $n$  stays independent of temperature), and  $k$  is only a function of temperature, the rate equation Eq.24, can be expressed as  $(X)(T)$ , and the transformation is called isokinetic. It will be discussed later that, in such circumstances, *Scheil's principle* can be used to extend the JMAK model for anisothermal condition.

It takes an enormous effort to produce a TTT diagram. Generally, for a given steels composition, only one TTT diagram is available, which is provided for a specific austenite grain size and austenitizing temperature. In order to consider the difference between the austenite grain sizes reported in TTT diagrams ( $d\gamma_{TTT}$ ) and its size within the samples ( $d\gamma$ ), one may use the modified JMAK model [27] ;

$$X=1-\exp(-k(T)(d\gamma_{TTT}d\gamma)^{qn})$$

where  $q$  is to be taken 1 for ferrite and 2 for pearlite transformations.

#### **Austin and Rickett (AR) model**

Several author used the Austin-Rickett (AR) equation to describe the kinetics of diffusional transformations with time;

$$\log \frac{X_1 - X}{X_1 - X_0} = m \log(t) + c$$

where  $m$  and  $c$  are the model's parameters, which can be obtained using TTT digarams. Starink showed that this model can predict the kinetics of diffusion controlled transformations more precisely than the JMAK model. The rate of transformation can be obtained by differentiating with respect to time;

$$\frac{dX}{dt} = \frac{m}{10} \frac{c - m \log(X_1 - X)}{X_1 - X} (X_1 - X)^{1-m}$$

The volume fraction of the transformed phase can be calculated by integration of Eq.27 with respect to time. However, the initial value  $X=0$  at the beginning of the transformation results in zero transformation rates. Tehler suggested the following modification to tackle this problem;

$$X = \begin{cases} X & X > 0.0001 \\ 0.0001 & X < 0.0001 \end{cases}$$

## Kirkaldy equations

Kirkaldy and Venugopalan proposed a series of rate equations for diffusive transformations in steels, in a general form of,

$$\frac{dX}{dt} = (T)^n \exp\left[-\frac{Q}{RT}\right] F(C, Mn, Si, Ni, Cr, Mo, G) X^2 (1-X)^3 (1-X)^2 X^3$$

where  $F$  is a function of alloying elements in wt%,  $G$  is the prior austenite grain size (ASTM number),  $T$  is the undercooling, and  $Q$  is the activation energy of the diffusional reaction. The exponent of undercooling  $n$  is a constant concerning the diffusion mechanism ( $n = 2$  for volume diffusion in case of bainitic transformation and  $n = 3$  for boundary diffusion in case of ferrite/pearlite transformations). Application of Scheil's additivity rule together with time integration over time-temperature profile gives the volume fraction of transformed phase under any arbitrary cooling condition;  $T\Delta$

$$X = \int_{X_0}^X \frac{dX}{dt} dt = \int_{T_0}^T (\Delta T)^n \exp\left[-\frac{Q}{RT}\right] F(C, Mn, Si, Ni, Cr, Mo, G) X^2 (1-X)^3 (1-X)^2 X^3 dt$$

In general, the function  $F$ , the exponent  $n$  and the activation energy vary for ferrite, bainite and pearlite transformations.  $T\Delta$  is the difference between the equilibrium temperatures,  $A_1$ ,  $A_3$  and  $B_s$ , and the instantaneous temperature during cooling.  $T\Delta$

## Scheil's principle

The models defined in sections give a mathematical description of the transformation kinetics under isothermal condition. In common heat treating processes, except for some special cases in thermomechanical treatments, anisothermal condition (also referred to continuous cooling condition) is more frequent. However, in such circumstances, the aforementioned models are of no practical use. To tackle this limitation, Scheil proposed a hypothesis to calculate the incubation time under anisothermal condition from isothermal data, which is widely known as *Scheil's principle* or *Scheil additivity rule*. According to this

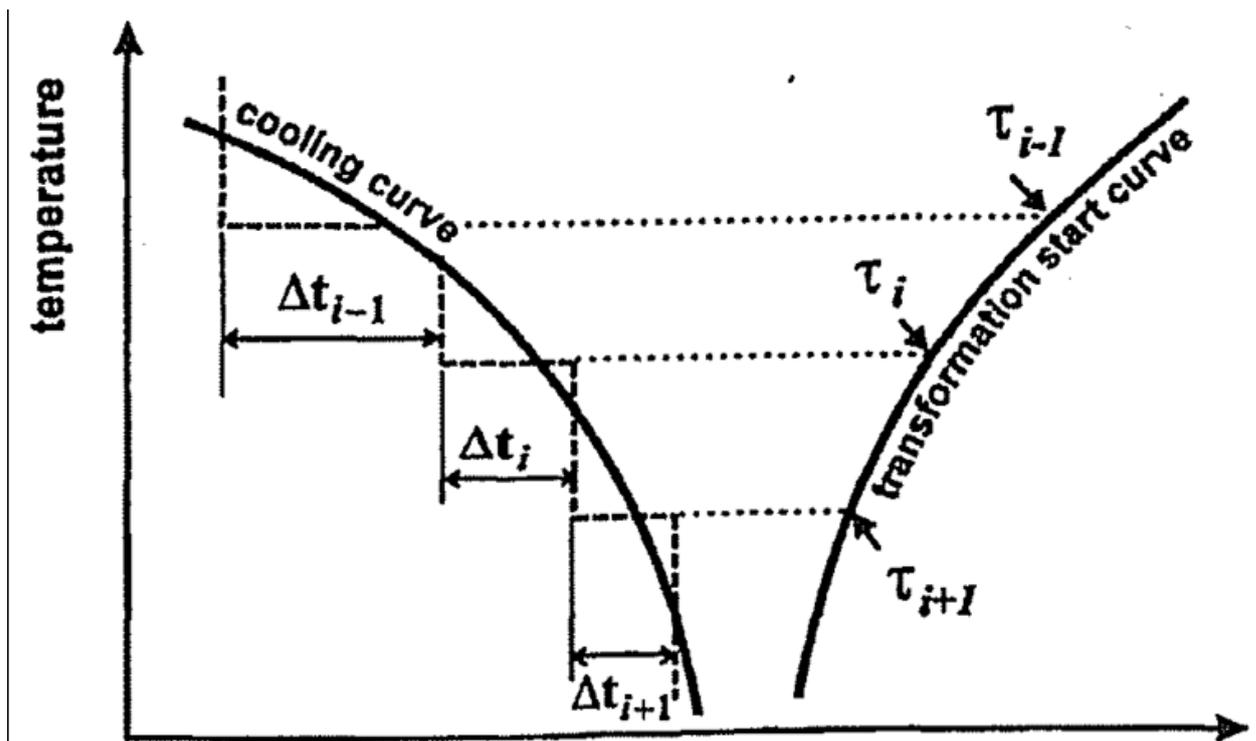
hypothesis, the time needed to reach a specific amount of transformed phase,  $X$ , under anisothermal conditions can be obtained, when the following relation is satisfied;

$$\int (T(\xi), X(t)) t_0 = 1$$

where  $\tilde{\tau}(T, X)$  is the time needed to reach the same fraction of  $X$  in isothermal condition. The incubation time of the transformation can be calculated applying similar hypothesis;

$$\int (T(\xi)) t_0 = 1$$

where  $\tau_s(T)$  is the isothermal incubation time corresponding to  $X=1\%$  at a given temperature, which is simply available in TTT diagrams. shows the schematic representation of the Scheil additivity rule.



: schematic representation of the Scheil additivity rule

It is shown that this additivity hypothesis is valid only if transformation is iso-kinetic. In this circumstance, the rate equation can be written as a separate function of  $X$  and  $T$  ;

$$X = f(X)g(T)$$

Referring back to, the necessary condition for JMAK and AR models to be written in the form of is that the exponents  $n$  and  $m$  are to be constant and  $b$  and  $c$  are only functions of temperature. However, in practice, this condition is rarely satisfied during phase transformation process. For instance, the values of  $n$  in JMAK model obtained from vary markedly with temperature, and can hardly be considered as a constant.

Hawbolt and his co-workers experimentally confirmed that the additivity rule does not hold for incubation period and when  $n$  varies markedly with temperature the application of the additivity rule leads to overestimation in calculation of the time needed for completion of pearlitic transformation. However, they found that if the incubation period is excluded from the whole transformation period, the exponent  $n$  is virtually constant, leading to an iso-kinetic transformation. It is worthy to note that in order to determine the parameters of the JMAK model; several researchers have directly used without taking into account the fraction of error introduced by inclusion of incubation period. However, recent study conducted by Zhu et al. showed that the fraction of error due to the inclusion of incubation time in calculations is small, despite the fact that according to Hawbolt et al. the additivity rule does not hold for incubation period.

### **Effects of porosity on the kinetics of transformations**

Porosity may affect the kinetics of transformation by several means. It is known that the most effective potential sites for nucleation of the diffusive products are the free surfaces and grain boundaries [24]. The porous nature of PM steels implies that this type of materials possess a larger amount of potential sites for nucleation process (due to the presence of free surfaces) compared to the conventional solid steels. Pores may also inhibit the grain growth at elevated temperatures due to the pinning effects [36, 37], leading to relatively smaller grain

sizes than it can be found in fully dense steels with similar chemical composition, heat treated under the same condition. Warke et al have conducted a detailed study on kinetics of diffusional transformation of a prealloyed PM steel. They found that the presence of porosity in PM steels decreases the austenite stability, and therefore, the incubation time reduces with increasing porosity content. The metallographic and dilatometric results provided in confirm that the presence of porosity can promote both the nucleation and growth mechanisms by increasing the amount of potential sites and the effective diffusion path in porous steels. Several authors reported a similar trend. In general, several factors may affect the kinetics of athermal (martensitic) transformation in steels. Different aspects of martensitic transformation were discussed in section . It is shown that  $M_s$  is highly sensitive to variation of interstitial alloying elements such as carbon and nitrogen. It is also shown that  $M_s$  reduces with decreasing the grain size, while the free surfaces can reduce the energy barrier for martensitic transformation, leading to an increase in . Hence, the porous nature of PM steels may affect the martensite start temperature by several means, in particular, the larger amount of free surfaces and likelihood of carbon fluctuation close to the pores may increase the  $M_s$  by several degrees compared to the wrought steels with similar chemical compositions. On the other hand, smaller austenite grain size in PM steels may lead to a decrease in martensite start temperature. However, as can be seen in Fig.8, the effect of austenite grain size on martensite start temperature is significant for grains smaller than  $10\ \mu m$ , which is not usually the case in PM steels, and therefore can be neglected. Several authors reported the same trend in dependence of  $M_s$  to the level of porosity. In a very recent study, Warke et al. experimentally confirmed that the martensite start temperature in PM steels increases with increasing the porosity content. Based on these experimental results, Semel and Lados suggested that the  $M_s$  in PM steels increases by  $2.3^\circ C$  per 1% porosity.

### **Constitutive equation and finite element formulation**

In order to study the cooling behavior of a material under a specific condition, it is necessary to solve the heat equation. However, except for some

simple cases, solving the heat equation requires complicated mathematical treatments, and often application of numerical methods such as Finite Difference Methods (FDM) and Finite Element Methods (FEM) is inevitable.

In this part, an attempt is made to provide a brief description of the general form of heat equation, including the latent heats of solid phase transformation. Then, the FE formulation of the axi-symmetric heat equation has been developed, and finally the procedure to couple the phase transformation terms has been described.

### Constitutive equation

Heat equation, in its general form, can describe the temperature distribution within any arbitrary region over the time. It can be derived using Fourier's law of heat conduction and the law of conservation of energy as where  $\rho$ ,  $k$ ,  $T$  and  $t$  are density, thermal conductivity, temperature and time, respectively.  $E$  is the specific internal energy. There may exist a differentiable function  $e$ , representing the specific internal energy within the material as;

$$E(x,t)=e(T,X_i) \quad (34)$$

where  $X_i=1,2,3,4$  correspond to volume fractions of ferrite, pearlite, bainite and martensite phases, respectively. Differentiating Eq.34 with respect to the internal variables gives;

$$\partial e / \partial T = c \text{ and } \partial e / \partial X_i = -q_i$$

where  $c$  is the specific heat and  $q_i$  represents the latent heats of  $i$ th solid transformation. Thus, the general form of heat equation in two dimensional Cartesian coordinate system may be written as;

$$\rho(T)c(T)\partial T / \partial t = \partial / \partial x [k(T)\partial T / \partial x] + \partial / \partial y [k(T)\partial T / \partial y] + \sum \rho_i(T)q_i(T)\partial X_i / \partial t \text{ in region } \Omega \quad (35)$$

As shown in Eq.35, in general, all the thermal properties can be temperature dependent. The boundary and initial conditions may be given as;

$$-k\partial T / \partial n = h(T)(T - T_\infty) + \sigma \epsilon(T)(T^4 - T_\infty^4) \text{ along } \Gamma \text{ for air cooling}$$

$$-k\partial T / \partial n = h(T)(T - T_\infty) \text{ along } \Gamma \text{ for water/oil quenching}$$

$$T_0 = T(x,y,0) \text{ at } t=0 \text{ in region } \Omega$$

where  $hc$  is the convective heat transfer coefficient,  $\sigma$  is the Stefan-Boltzmann constant (56.7 W/mm.K),  $\epsilon$  is the radiation emissivity of the surface

and  $T_\infty$  is the ambient temperature. Both  $hc$  and  $\varepsilon$  can be a function of temperature. The radiative part of can be written as;

$$\sigma \varepsilon(T)(T^4 - T_\infty^4) = \sigma \varepsilon(T)(T^2 + T_\infty^2)(T + T_\infty)(T - T_\infty) = hr(T)(T - T_\infty)$$

Therefore, Eq.36 may be expressed as;

$$-k \partial T / \partial n = h(T)(T - T_\infty) + hr(T)(T - T_\infty) = hrc(T)(T - T_\infty)$$

where,  $hrc$  is often called the combined heat transfer coefficient, including both the radiative and convective parts. In cylindrical coordinate system takes the following form;

$$\rho(T)c(T)\partial T / \partial t = k(T)(1/r \partial^2 r / \partial r^2 + \partial^2 T / \partial z^2) + \sum \rho_i(T)q_i(T)\partial X_i / \partial t$$

It is worthy to note that are both based on an assumption that the temperature gradient in the third direction is negligible. nonetheless, these equations have many practical uses. As an example, the temperature distribution of the cylindrical geometries such as rings can be estimated with a reasonable precision using shows 3D geometry which can be simplified to a 2D axi-symmetric domain, provided that the boundary conditions are also axi-symmetric.

## **Economic unit**

*President of the Republic of Uzbekistan dated 15.07.2008. PP-916 to stimulate the implementation of innovative projects and technologies in the production of additional measures.* 'Scientific and practical research and development of innovative products and production modernization, technical and technological renewal of execution promoting the creation of new mechanisms, and in 2008 from innovative ideas, technologies and projects of the fair every year.

*President of the Republic of Uzbekistan dated 02.11.2010 y. PP-1426 highly qualified scientific and scientific-pedagogical personnel on measures to further improve the system.* The decree on the basis of high qualified scientific and scientific-pedagogical personnel training system has been improved, in particular the intern researchers and senior research fellow and research institutions.

*President of the Republic of Uzbekistan dated 26.10.2011 y. PP-1631 in the city of Tashkent with the participation of the University of Cambridge in the UK to create a center of high technology.* According to the high-tech center in the city of Tashkent, the head of the president of the Academy of the honorary council was established and its Regulations.

*President of the Republic of Uzbekistan dated 28.02.2013 y. PR-1927 at the Tashkent State University of Economy "The scientific basis for the development of the economy and the problems" to create a center of scientific research.* In accordance with the decision of the Tashkent State University of Economy established a new research and educational institution, and goals and objectives. The resolution also outlined the structure and staff schedule of the center.

While doing diploma project, I found very easy way and economical, when I was build this project Iron-Carbon phase diagram.

Firstly, I draw Iron-Carbon phase diagram, with computer technology, so I spend 38,000 cum for being ready this sketch.

Secondly, I stucked this sketch to plastic. I bought plastic 80,000 cum. Then I installed to frame. I spend 45,000 cum for frame. Next I did main part, for this. I bought 125 electric bulb, every electric bulb 700 cum, all electric bulb 87,500 cum. And I bought 3 m cable 4,000 cum, and 10,000 cum for other smaller things, actually I spend 5 days for ready project. While build this project I spend all 264,000 cum.

## **The safety, activity of the life**

### Safety and labor safety

What is so important occupational health and safety regulation?

In the first place, because the highest value is always a man, his life and health. Neither wages nor the level of profitability of the enterprise, not the value of the manufactured product can not be a reason for neglecting the rules of safety and a justification of the existing threats to the life or health of workers. In addition, in this case it is also about values of a particular person as an employee with the knowledge inherent in it, skills and experience.

Second, properly organized work to ensure the safety of employees increases discipline, which in turn leads to increased productivity, reduction in the number of accidents, equipment breakdowns or other emergency situations, that is, increases the ultimate efficiency.

Thirdly, labor protection means not only ensuring the safety of workers during the performance of their duties. In fact, here also include a variety of activities: for example, the prevention of occupational diseases, the organization of proper rest and nutrition workers during work breaks, providing them with the necessary clothing and hygiene products, and even the implementation of social benefits and guarantees. The correct approach to the organization of labor protection at the enterprise, the clever use of a variety of ways to promote intangible employees give the latter the necessary sense of security, stability and governance in the interest of its employees. Thus, thanks to an established occupational safety and reduced employee turnover, which is also beneficial for the stability of the entire enterprise.

**Purpose:** Faulty technique is one of the chief causes of accidents and, because it involves the human element, is one of the most difficult to cope with. The purpose of this discussion is to help the student understand proper laboratory safety, to increase his awareness of the possible risks or hazards involved with laboratory work and to realize the laboratory is generally a safe place to work if safety guidelines are properly followed.

## CHEMISTRY LABORATORY RULES AND SAFETY PRECAUTIONS

1. Never work alone in the laboratory.
2. Smoking is not permitted in the building.
3. Unauthorized experiments are prohibited.
4. Know the location and use of the fire extinguisher, safety showers and first aid kit.
5. It is **required** that you wear prescription glasses or safety glasses at all times in the laboratory for your own protection. Contact lenses are particularly dangerous and they must not be worn in the laboratory.
6. Report all injuries to your instructor at once.
7. Never taste chemicals or solutions.
8. Use the fume hoods at the sides of the laboratory for all poisonous reactions or any reactions which produce noxious gases. **Note:** D770 Perchloric Acid hood is off limits to 2410 and should not be used.
9. When diluting concentrated acid or base always **add the concentrated acid or base to water** (never the reverse), while stirring the solution. Be very careful with sulfuric acid.
10. Keep an orderly, clean laboratory desk. Return glassware to the lab drawer when finished using it to keep the work area from becoming cluttered.
11. Place unneeded books, etc. on the shelves at the side of the laboratory.
12. Waste containers are provided for the disposal of all solid chemicals and paper, etc.
13. Stock reagent bottles are placed on the side bench or beside the balances; leave them at that position.
14. Always read the label **twice** before taking any chemical from a bottle. If you are not sure if you have the right chemical, **ask!**
15. When pouring reagents, hold the bottle so the label points upwards facing the palm of the hand. The accumulation of reagent on bottle lip may be removed by touching the bottle lip to the rim of the receiving vessel.

16. **Avoid** using an **excess** of reagent. If you happen to have measured out too much, see if someone else can use the excess.
17. Due to possible contamination of the contents of a whole stock bottle, never return unused chemical to the stock bottle.
18. Always check your glassware before you use it. If it is broken or cracked, exchange it for a new one.
19. There is one Container reserved for broken glass. All broken glassware should be placed in this crock and no other.
20. If corrosive chemicals or liquids come in contact with the skin or clothing, flood with copious amounts of water for an extended period of time.
21. Spilled chemicals should be wiped up immediately; spilled acid or base should be rinsed with plenty of water and wiped up with a sponge and the sponge rinsed after.
22. Inserting glass tubing or thermometers through a rubber stopper - first lubricate the tube and stopper with glycerol or water, then holding the tube near the end to be inserted insert slowly while rotating the tube. **BE VERY CAREFUL!**
24. When you are ready to leave the laboratory, your bench area should be rinsed off with a wet sponge and the water, gas, and air valves shut off.

### **Electrical Emergency Response**

Expedient, write about electric because there are electric bulbs at project of Iron-carbon phase diagram, that's why we have to know that how safety from electric. The following instructions provide guidelines for handling two types of electrical emergencies.

#### **Electric Shock:**

When someone suffers serious electrical shock, he or she may be knocked unconscious. If the victim is still in contact with the electrical current, immediately turn off the electrical power source. If you cannot disconnect the power source, push in the Emergency Power Off button.

**IMPORTANT:**

Do not touch a victim that is still in contact with a power source; you could electrocute yourself.

Have someone call for emergency medical assistance immediately. Administer first-aid, as appropriate.

#### Electrical Fire:

If an electrical fire occurs, try to disconnect the electrical power source, if possible. If the fire is small, you are not in immediate danger, and you have been trained in fighting fires, use any type of fire extinguisher except water to extinguish the fire. When in doubt, push in the Emergency Power Off button.

#### IMPORTANT:

Do not use water on an electrical fire.

## Conclusion and offers

While doing this projects Iron-Carbon case diagram, I used from Uzbek scientists' scientific literatures and foreign nation scientists' books. actually. Prizident of Uzbekistan Islom Karimov's select works, Machine building magazines, hand books, a lot of technical books' and I have written to get order from the internet.

A new version of the complete equilibrium phase diagram of the iron-carbon system has been proposed, in which it is assumed that non-alternative three-phase equilibrium  $Fer\ Gr - Cem$  at the temperature  $727\text{ }^{\circ}C$ , two-phase equilibrium  $Fer\ Gr$  in the temperature range  $738 - 727\text{ }^{\circ}C$  and two two-phase regions  $Fer\ Cem$  (up to 6.67 % C) and  $Cem\ Gr$  (over 6.67 % C) at the temperatures below  $727\text{ }^{\circ}C$  are present.

Today, the automative industry of Uzbekistan can be regarded as the locomotive of the entire domestic industry, for giving new impetus to the development of related industries and sustainable scale-up of employment. The branch is represented by a range of enterprises and organizations, which employ more than 27,000 people. It ranks not just among major suppliers of finished products for export, but also leads in the development of new technologies and bringing modern products to the markets. The new mixer truck ranks among the innovations and meets international standards.

There are two iron-carbon equilibrium diagrams:

- stable iron-graphite Fe-Gr
- metastable iron-cementite Fe- $Fe_3C$

The stable condition usually takes a very long time to develop. The metastable diagram is of more interest.  $Fe_3C$  iron carbide called cementite because it is hard.

Following phases exist on Fe- $Fe_3C$  diagram:

- liquid solution of iron and carbon (L)

- ferrite ( $\alpha$ ) – an interstitial solid solution of carbon in  $\text{Fe}_\alpha$  (bcc). At room temperature ferrite is ductile but not very strong.
- austenite - an interstitial solid solution of carbon in  $\text{Fe}_\gamma$  (fcc).
- cementite ( $\text{Fe}_3\text{C}$ ) hard and brittle compound with chemical formula  $\text{Fe}_3\text{C}$ . It has metallic properties.

On a base of Fe- $\text{Fe}_3\text{C}$  diagram we can divide iron-carbon alloys into:

- steels,
- cast steels,
- cast irons.

Steel is an alloy of carbon and iron and other alloying elements (e.g. Mn, Si) with carbon content up to 2% intended for wrought products or semi products.

Cast iron is an alloy of carbon and iron and other alloying elements (e.g. Mn, Si) with carbon content over 2% intended for castings. Now, we consider only a part of Fe- $\text{Fe}_3\text{C}$  diagram referring to steel.

Perlite is a structure (i.e. consists of two phases) consists of alternate layers of ferrite and cementite in the proportion 87:13 by weight. Perlite is formed from austenite at eutectoid temperature ( $A_1$ )  $727^\circ\text{C}$  upon slow cooling.

There are three groups of steels according to carbon content:

- hypoeutectoid steels containing less than 0.76% C
- eutectoid steel with carbon content about 0.76%
- hypereutectoid steels contain more than 0.76% C (up to 2% C)

As we known Iron is very important thing to us and to our life, because become nowadays technology is more developing than that before in the world actually in Uzbekiston too. The more famous plant in Uzbekistan For example; There are „GM Uzbekistant” in andijon and Traktor plant in Toshkent, again Andijon MASH, Mexanic plant and lots of plants. Iron is so needed to every plants, That's why, it is so difficult imegin without iron at the our life.

## The attachment

На сегодняшний день Самара является одним из городов с наиболее загрязнённым атмосферным воздухом. Загрязнение воздуха взвесными веществами над территорией города больше на 43%, чем в среднем по России, а концентрация других вредных превышает предельно допустимые нормы в десятки раз. В этом виноваты промышленные предприятия, многие из которых не имеют достаточно эффективных очистных сооружений, а также автотранспорт. Пыль, которой перенасыщен воздух города, забивается в лёгкие и может служить переносчиком различных вирусных инфекций. Основной источник пыли – плохие дороги и некоторые промышленные производства.



В Самаре находится 105 мощных промышленных предприятий, ежедневно выбрасывающих в воздух десятки тонн загрязняющих веществ, причём, многие из них располагаются вблизи жилых массивов. Атмосферный воздух города перенасыщен окисью углерода, диоксидом азота, сернистым ангидридом, ароматическими углеводородами, фенолом, формальдегидом, хлористым и фтористым водородом, бензапиреном, сажей, пылью. Все эти вещества оказывают неблагоприятное влияние на состояние здоровья горожан. Например, повышенная концентрация диоксида азота вызывает головные боли, кашель, одышку, страдает сердечно-сосудистая и кроветворная системы. Больше всего загрязняют воздух диоксидом азота

автомобили и различные теплоисточники. Формальдегид, основным источником которого является автотранспорт, плохо рассеивается и долго сохраняется в приземном слое. Это вещество не только вызывает аллергические заболевания, но и провоцирует рак, а взаимодействуя с углеводородами, формальдегид образует ещё более вредные вещества. Увеличение использования мазута как основного топлива крупнейших ТЭЦ города, приводит к росту концентрации в воздухе сернистого ангидрида. Самый неблагополучный район по состоянию окружающего воздуха – Кировский. Максимальное содержание в атмосфере хлористого водорода отмечается в Зубчаниновке. Это вещество отрицательно влияет на дыхательную систему. Основные загрязнители воздуха среди промышленных предприятий – это ОАО "КНПЗ", ОАО "ЗПОН", ОАО "Металлист-Самара".

Евросоюз ужесточает экологические стандарты для автомобилей. С 2012 года средний уровень выброса CO<sub>2</sub> одного автомобиля, продаваемого в Европе, не должен превышать 130 г/км. В случае несоблюдения этих требований штрафы могут быть наложены на самих производителей. Специалисты считают, что новые правила скажутся не только на автомобильных компаниях, но и на самих потребителях. Жесткие стандарты на загрязнения могут существенно повлиять на ценовую политику автокомпаний. К примеру, Daimler AG в 2010 году показал средний выброс CO<sub>2</sub> 160 г/км, что существенно выше требований ЕС. С учетом новых правил немецкому концерну пришлось бы заплатить десятки миллионов долларов штрафа, что конечно отразилось бы на ценах автомобилей, выпускаемых этой компанией.

Но именно жесткие экологические стандарты ЕС заставили обратить внимание многих на проблему загрязнения планеты. С момента появления этих требований автомобильная промышленность вступила на путь решения экологических проблем, в первую очередь за счет повышения эффективности двигателя внутреннего сгорания. На данном этапе Европа намерена удвоить

свои усилия в создании энергоэффективного пространства, в частности, путем развития гибридных и электрических транспортных средств.

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