CONNECTICUT STATE DEPARTMENT OF EDUCATION

Division of Instruction

Hartford

SHOP THEORY FOR THE MACHINE TRADES

SUBJECT: Metallurgy of Iron and Steel

SESSION 10.

OBJECTIVE: The Theory of Iron and Carbon Alloys

METHOD: Lecture and discussion

REFERENCES: Johnson, Metallurgy
Machinery's Hand Book

I. Types of Alloys

1. An alloy is any mixture of two or more metals
   a. Type I alloy (Johnson, p.103). A mixture of two metals that goes into a liquid solution when hot and forms a solid solution when cold
      ex. copper and nickel

   b. Type II alloy (Johnson, p.105). A liquid solution when hot, insoluble when cold
      ex. silver and lead

   c. Type III alloy (Johnson, p.118). A liquid solution when hot, a mixed solution when cold
      ex. iron and carbon

   d. Type IV alloy (Johnson, p.112). Completely unmixable when either hot or cold
      ex. lead and copper

   e. Type V alloy (Johnson, p.113). A chemical compound is formed
      ex. $CuAl_2$, WC, Fe_3C.

II. Carbon Steel Terms (H.B., p.1632)

1. Carbon and iron form a <u>Class III</u> alloy

2. <u>Ferrite</u>. Free, almost pure, iron that exists in fully annealed low carbon steel when cold

3. <u>Cementite</u>. (Iron carbind, Fe_3C). The condition of the carbon in fully annealed, cold steel

4. <u>Pearlite</u>. A laminated mechanical mixture of ferrite and cementite, 99.15% iron and .85% carbon
   a. Fully annealed carbon steel with less than .85% carbon, will, therefore, contain ferrite and pearlite (an excess of iron).

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b. Fully annealed steel with more than .85% carbon will consist of pearlite and cementite (an excess of carbon)

c. Fully annealed steel with exactly .85% carbon will be pure pearlite (an excess of neither iron nor carbon). This .85% carbon steel is called eutectoid steel

5. Austenite. The solid solution of iron and carbon that exists at a temperature that is above the upper critical point
   a. Pearlite begins to dissolve into austenite at the lower critical and is complete at the upper critical

6. Martinsite. A hardened condition of the pearlite when austenite is cooled rapidly through the critical range

7. Bainite, Troostite, Spherodite are special conditions of the iron carbon solution obtained by interrupted quenching, re-heating, or overheating (will be considered in the lesson that follows this one).

III. The Iron Carbon Diagram (see attached separate sheet)

1. Shows graphically the changes that appear in the structure of any carbon steel, lower than 1.7% carbon, when heated through a temperature range of 1000° to 2000°.

STUDENT ASSIGNMENT

I. Answer the following questions by direct application of the diagram.

II. Grade papers

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Name of Student_____Date_____

Instructor_____Grade_____

Questions - Metallurgy of Iron and Steel
Session 10, The Theory of Iron and Carbon Alloys

1. To what extent is the lower critical temperature nearly constant for all percentages of carbon?

2. How does the upper critical temperature change as more carbon enters into the composition of the steel?

3. At what percentage of carbon does the steel, at normal temperature, consist of 100% pearlite?

4. Determine the following temperature points for S.A.E. 1043 steel:
   a. lower critical
   b. upper critical
   c. full annealing range
   d. hardening temperature range
   e. normalizing temperature range
   f. range that permits a mixture of austenite and ferrite
   g. temperature at which transformation to austenite is complete

5. From the chart, Johnson, p.241, determine the maximum Rc hardness of .85% carbon steel.

6. At what carbon percentage does the ferrite disappear from cold annealed steel and the cementite begin?

7. At what percentage of carbon does ferrite absolutely disappear from the diagram?

8. If the carbon content is in excess of .85%, how could you determine the percentage of carbon present as free cementite?

9. How much does the range of hardening temperature vary for steels in excess of .85% carbon?

10. At what percentage of carbon does the diagram end?

11. What is the mixture of carbon and iron, beyond the scope of this diagram, called?

12. What does this diagram tell you definitely about how to cool down or quench the steel that is receiving hardening treatment?

13. How does the time element, in a general, enter into the technique of quenching?

14. What is the lowest possible carbon content that will permit the forming of austenite?

15. What should be the approximate temperature for normalizing 1.4% steel?