CONNECTICUT STATE DEPARTMENT OF EDUCATION

Division of Instruction

Hartford

SHOP THEORY FOR THE MACHINE TRADES

SUBJECT: Metallurgy of Iron and Steel

SESSION 8.

OBJECTIVE: The Personality of Steel

METHOD: Reading Lesson, Test and Discussion

REFERENCES: Palmer, Tool Steel Simplified

I. Chemical Analysis

1. Objectives of different alloys (Palmer, pp.57-8)
   a. Greater wear resistance
   b. Greater toughness or strength
   c. Hardenability
   d. Red hardness
   e. Machinability

2. Effects of different alloys
   a. Carbon promotes hardness
   b. Manganese (Palmer,p.284) increases hardness penetration
   c. Silicon (Palmer,p.284) in combination with manganese, moleybdnum, or chromium, adds strength and toughness
   d. Phosphorous or Sulphur, generally regarded as harmful impurities, are sometimes added to steel to improve machinability
   e. Chromium increases toughness and hardening penetration
   f. Nickel, when used with chromiu, increases wear resistance and toughness
   g. Tungsten, up to 1.5%, adds hardness. 12% to 20%, with 4% chromium, produces red-hardness
   h. Vanadium and Molybdnum increase hardenability, wear resistance, and red-hardness
   i. Cobalt is used sometimes to increase temperature of red-hardness
   j. Columbium, a new element, seems to promote wear resistance and decrease tendency for decarburization in hardening. Its properties are not yet fully explored

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II. Machinability (Palmer, p.284)

1. Relative hardness

2. Character of chip

3. Grain structure

4. Soft spots and hard spots

III. Hardenability (Palmer, pp.60-66) depends upon chemical analysis

1. Depth of penetration (Palmer, pp.42-3)
   a. 1/8" is about the limit for carbon steels

   b. Alloy steels harden more deeply

   c. High speed steel is deep hardening; 1" penetration is possible

2. Gage speeds in quenching
   a. Critical quenching speed is the maximum time that can be consumed in cooling past the lower critical point and still allow maximum hardness. The time varies from less than one second to many minutes. It is very fast for low carbon steels and very long for high speed steels. It is expressed in degrees per second.

   b. The quenching speed must be faster than the gate speed if any hardening is to result.

   c. Water and brine are fast quenching, oil is medium fast, and air is very slow

IV. Timbre (Palmer, pp.66-72)

1. Timbre does not depend upon chemical analysis but upon the grain size. The term is applied to .90% to 1.5% carbon steels

2. Causes of variation in timbre are not fully understood-apparently, timbre is "just born in".

3. A certain heat of steel will be uniform in timbre, no matter what may happen to it later in the nature of mill operations or heat treating.

4. Kinds of timbre
   a. Tough timbre, small and uniform grain size.

   b. Brittle timbre, large and non-uniform grain size

5. Tests for timbre
   a. Heat to 100° above normal hardening temperature, quench in brine, then break and examine broken cross section. Fine grain indicates tough timbre, coarse grain shows brittle timbre.

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6. Effects of timbre on toughness (Palmer, pp.72-3)
   a. Toughness varies directly with the timbre

7. Effects of timbre on cracking in hardening (Palmer, p.74)
   a. Rough timbre is less liable to crack when hardened

8. Effects of timbre on grinding checks (Palmer, pp.75-6)
   a. Brittle timbre increases checks

9. Effects of hardness penetration on size changing (Palmer, p.77)
   a. The deeper the penetration, the more tendency there is to increase in size when hardened

V. Internal Soundness of Steel (Palmer, pp.82-9)

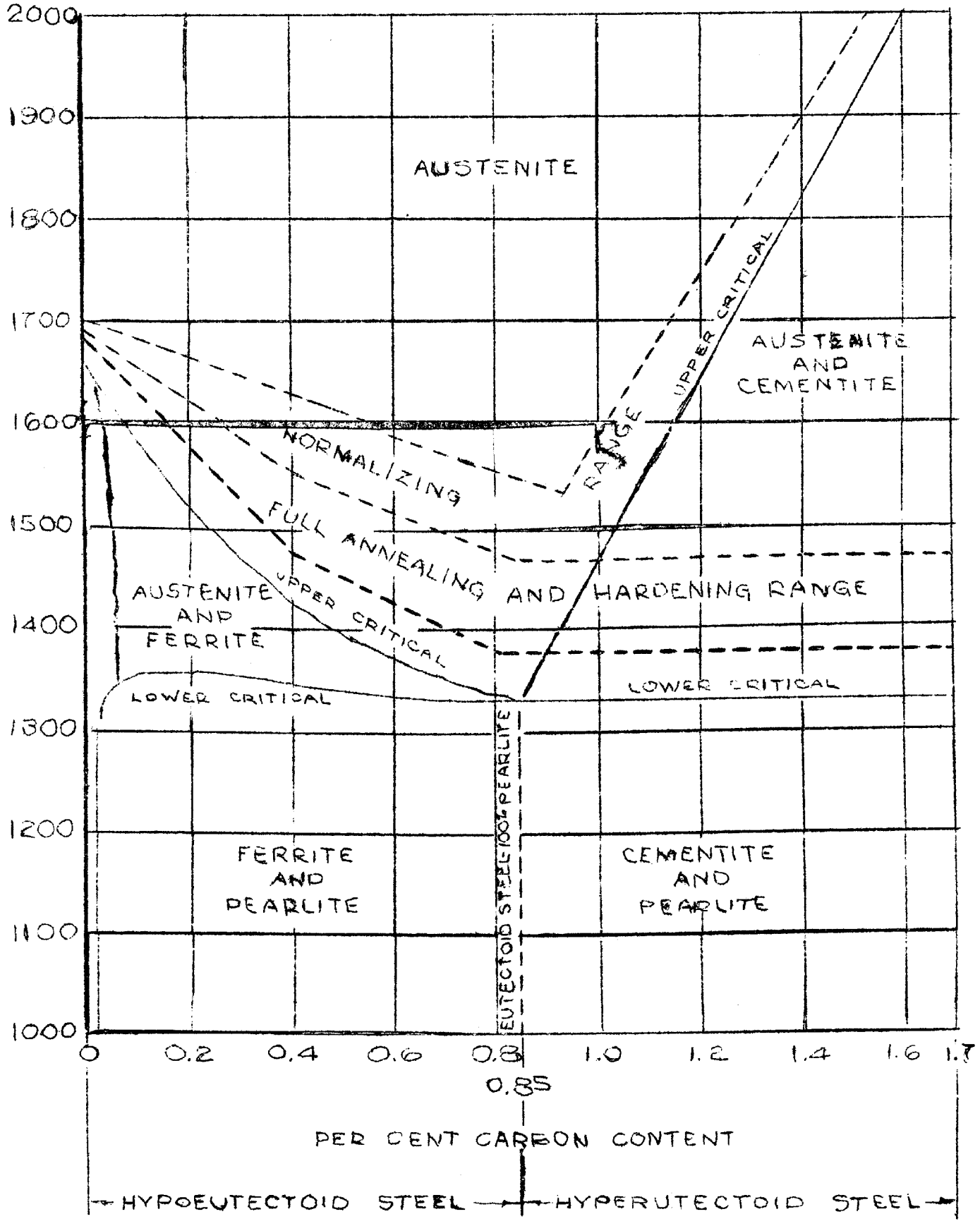
1. The hot acid test
   a. A cross section from the end of the steel billet is made and boiled in acid and then examined for internal defects (pipes, blowhole, etc.)

STUDENT ASSIGNMENT

I. Read text references and outline and work out the answers to the questions

II. Discussion and grading of papers

IRON & CARBON DIAGRAM



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Name of Student_____ Date_____

Instructor_____ Grade_____

Questions - Metallurgy of Iron and Steel
Session 8, The Personality of Steel

1. Name the five characteristics of steel that may be controlled by adding different combinations of alloying metals.

2. What is the principal advantage gained by adding carbon to steel?

3. What is the essential element that promotes red-hardness?

4. What new alloying element has recently been discovered?

5. What is the relation between depth of penetration and amount of size changing that might be expected?

6. Can the timbre of a certain heat of tool steel be changed by subsequent rolling processes?

7. Name the two kinds of timbre and give their relation to grain size.

8. Which timbre quality is likely to show grinding checks?

9. What is the relation between aging and size changing?

10. Name the necessary steps in the hot acid test.