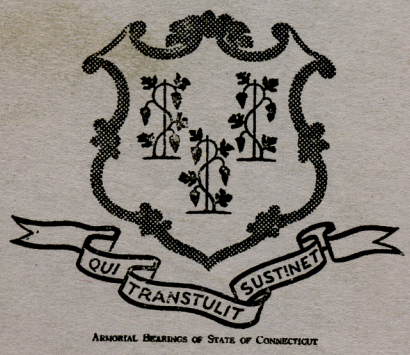
STATE OF CONNECTICUT
DEPARTMENT OF EDUCATION
DIVISION OF VOCATIONAL EDUCATION
HARTFORD, CONNECTICUT

VT-218-T-6

SHOP THEORY FOR MACHINE TRADES

METALLURGY OF IRON AND STEEL



ARMORIAL BEARINGS OF STATE OF CONNECTICUT

SESSIONS 1-12

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METALLURGY OF IRON AND STEEL

SESSION 1

Object: Chemistry of Iron and Steel.
Method: Lecture, test, and discussion.
References: Johnson, Metallurgy.
Palmer, Tool Steel Simplified.
Machinery's Handbook

I. Iron Ore (Johnson, pp 64, Palmer pp 13)

(1) Consists of oxides of iron and impurities.

(2) Types of iron ore.

(a) Hematite = Fe_2O_3 =70% iron.
Found in Lake Superior region - surface mined on huge scale with modern machines - very low cost - transported by ore boats to Lake Erie ports and reshipped to steel mills - 80% of all iron made in U.S. comes from hematite.

(b) Magnetite = Fe_3O_4 = 72.4% iron.
A magnetic iron ore used when hematite is not available.

(c) Impurities found in natural iron ore are silicon (sand), phosphorous, and sulphur.

II. What is an Oxide?

(1) An oxide is any chemical combination of oxygen (from the air mostly) with a metal.

(2) Oxidation = adding oxygen.

(a) Combustion = fast oxidation
ex. burning of any substance

(b) Corrosion = slow oxidation
ex. making iron from iron ore.

III. Blast Furnace (Johnson, pp 66,67 - Palmer pp 14)

(1) Takes oxygen and some impurities away from iron ore.

(2) Adds carbon and other ingredients (sulphur, silicon, phosphorous, and manganese).

SHOP THEORY FOR MACHINE TRADES, Session 1 - (Continued)

IV. Pig Iron (Johnson, pp. 69,70. Palmer, pp. 14, 15)

1. Product of the blast furnace

2. Comes molten from the furnace and is cast into 100 lb. "pigs", or goes, still molten, to another furnace or converter.

3. Iron pigs or molten blast furnace iron is the first step in iron and steel making.

4. Pig iron is 3.5% to 4% carbon, 4% to 3.5% impurities and 92% to 93% iron.

V. Wrought Iron (Johnson, pp. 79, 80. Palmer, pp. 15, 16)

1. Carbon and most of the impurities in pig iron are oxidized away (pig iron is reduced) and slag added in a puddling furnace

VI. Carbon Steels

1. Pig iron or a mixture of pig iron and steel scrap are reduced in a furnace and required amounts of carbon and other ingredients added
   a. The Bessemer converter (Johnson, pp. 70, 71. Palmer, p.20) burns out carbon and some impurities by blowing air through molten pig iron to make Bessemer steel

   b. The open hearth furnace (Johnson, pp. 73-6. Palmer, pp.18,19) mixes and reduces a mixture of pig iron and scrap to make open hearth steel

   c. The graphite crucible furnace (Johnson, p. 76. Palmer, pp.20) is principally a mixing process. It is nearly obsolete

   d. The electric furnace (Johnson, pp. 76-7. Palmer, p.20) is a mixing furnace. It supplants the crucible process, and is very much used for fine steel making

   e. Cementation process, obsolete, of hostorical interest only

VII. Grades of Iron and Steel

1. W.I. Wrought Iron = pure iron plus slag
   a. Can be forged and welded

   b. Tough

   c. Resists corrosion

2. C.I. Cast Iron = iron plus 3.5% to 4% carbon plus impurities and extra ingredients
   a. Easy to machine

   b. Brittle

SHOP THEORY FOR MACHINE TRADES, Session 1 - (Continued)

c. Low tensile strength

d. Grades
grey cast iron
white cast iron
malleable castings

3. M.S. Machine Steel (low carbon steel) = .10% to .35% carbon
a. Ductile

b. Easy to machine

c. Cannot be hardened and drawn like higher carbon steels

4. C.R.S. or C.D.S. Cold Rolled or Cold Drawn Steel. Same analysis as M.S. Is M.S. cold worked into rods or bars. Same qualities as M.S. except that cold working polishes the surface, makes the grain structure more fibrous, and toughens the product

5. T.S. Tool Steel (High carbon steel) = .35% to 1.75% carbon
a. Tough

b. Harder to machine

c. Higher tensile strength

d. Can be hardened and drawn

6. D.R. Drill Rod. Same analysis as T.S., cold rolled or drawn and often ground to exact size, plus or minus .0005 is possible accuracy

7. - - - Piano Wire = cold drawn, special analysis T.S., also specially heat treated
a. Extreme tensile strength

b. Practically unstretchable

c. Elastic

8. - - - Die Block Steel = very high carbon, some silicon, extremely hard and brittle but wear resisting

9. Spring Steel, practically the same as piano wire

10. H.S.S. High speed Steel = iron plus carbon plus tungsten plus chromium plus vanadium (many different specifications)
a. Many grades for many uses

b. High tensile strength

c. Easy to machine

d. Responds to various heat treatments

SHOP THEORY FOR MACHINE TRADES, Session 1 - (Continued)

11. C.S. Cast steel = any steel (.10% to 2.5% carbon) that is cast into molds
    a. Many grades for many uses
    b. High tensile strength
    c. Easy to machine
    d. Responds to various heat treatments

12. S.A.E. Society of Automotive Engineers Steel (called S.A.E. steel for short)
    a. Carefully compounded from many ingredients for many uses in accordance with very strict specifications
    b. A number code is used to indentify each steel (H.B. 1548)

13. A.I.S.I. American Iron and Steel Institute Steels (H.B. 1548)
    A new numbering code that follows S.A.E. numbers but adds a letter in front of the S.A.E. number to indicate the source or method of manufacture
    ex. C1008 = Basic low carbon open hearth.
    E3310 = Electric nickel-chromium

14. Alloy Steels
    a. H.S.S., S.A.E., and all other steels containing planned ingredients other than iron and carbon, as a class, are termed Alloy Steels
    b. Metals used in making alloy steels
    Iron---------Fe.
    Carbon-------C.
    Manganese----Mn.
    Silicon------Si.
    Phosphorous--P.
    Sulphur------S.
    Chromium-----Cr.
    Nickel-------Ni.
    Tungsten-----W (Wolfram)
    Vanadium-----V.
    Molybdnum----Mo.
    Cobalt-------Co.
    Columbium----Cb.

STUDENT ASSIGNMENT

I. Read over this outline carefully and all listed references

II. Write out brief answers to the questions for Session 1. You may refer to the outline and the texts in answering questions.

CONNECTICUT STATE DEPARTMENT OF EDUCATION

Division of Instruction

Hartford

Name of Student_____Date_____

Instructor_____Grade_____

Questions - Metallurgy of Iron and Steel
Session 1, Chemistry of Iron and Steel

1. Tell exactly what the chemical symbol Fe_2O_3 means.

2. Explain the terms "oxidation" and "reduction" as used in the iron and steel making industry.

3. Give an example of
   a. slow oxidation
   b. fast oxidation

4. What is the difference in composition, in general terms, between pig iron and cast iron?

5. Why are castings not made from W.I.?

6. Tell how slag enters into the making of W.I.

7. What <u>one</u> element, added to iron makes steel?

8. What are alloy steels?

9. Explain the meaning of "red-hardness".

10. What changes in machines and machining methods have been required in industry since the discovery of H.S.S.?