CONNECTICUT STATE DEPARTMENT OF EDUCATION

Division of Instruction

Hartford

SHOP THEORY FOR THE MACHINE TRADES

SUBJECT: Metallurgy of Iron and Steel

SESSION 7.

OBJECT: Equipment Used in Heat Treating and Hardness Testing

METHOD: Reading Lesson, Test and Discussion

REFERENCES: Palmer, Tool Steel Simplified
Machinery's Hand Book

I. Factors in Heat Treating Steel

1. Composition of steels
   a. Heat treatments vary very greatly with the composition of the steels

   b. Each steel has its individual formula for heat treatment, usually furnished by the manufacturer

2. Temperature (Palmer, p.216)
   a. Preheating and heating for hardening, annealing, normalizing, etc., require definite temperatures for each class of steel. They should be kept within a range of 25° of correct theoretical temperature.

   b. The cooling or quenching operation requires still more accurate temperature control.

   c. The temperature of a piece of steel that is being heated, does not rise, for a short time, as it passes through the critical range. Also, on cooling back through this range, there is a short time during which the temperature of the steel does not drop. This is caused by changes in the internal physical structure or condition. Melting ice and freezing water show this same heat absorption and emission phenomenon. These points of interruption in the heat curve are called "recalescence" and"decalescence" points.

3. Timing (Palmer, pp.217-8)
   a. Accurate timing, both in heating and quenching, is very important

   b. Size and shape of the work is an important factor in timing.

   c. Method of heating (oven or bath) is important.

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4. Atmosphere (Palmer, p.237)
   a. Natural atmosphere

   b. Specialized or synthetic atmosphere

5. Special equipment is needed for heat treating
   a. For measuring and controlling temperatures

   b. For accurate timing

   c. For quenching work

   d. For testing hardness and toughness

II. Liquid Bath Furnaces (furnaces arranged to hold and heat up pots of lead or of various "salts").

1. Heating and preheating (Palmer, pp.242-6)
   a. Molten lead baths have a temperature range of 750° to 1600°

   b. Salt baths have a temperature range of 300° to 2500° and are classed as neutral or active.
      ex. - cyanide, as used in case hardening, is an active bath

2. Quenching baths (Palmer, pp.247-54)
   a. Water or brine, very fast, used for carbon steels

   b. Oil, slower than brine, used for most alloy steels

   c. Air, very slow, used for some high speed steels

   d. Salt and lead baths, used for interrupted quenching (see austempering and martempering in later lessons)

3. Drawing baths (Palmer, p.225)
   a. Oil for under 550°

   b. Salt baths for 450° to 1050°

   c. Molten lead baths for 750° to 1600°

   d. Electric ovens or furnaces are beginning to take the place of baths in various drawing operations

III. Oven Type Furnaces (Palmer, pp.234-41)

1. Types
   a. Muffle type, products of combustion are kept away from the work

   b. Semi-muffle type, products of combustion are allowed to circulate around the work but no direct contact with the fuel is permitted

   c. Open hearth type, work is in contact with the fuel and also exposed to the products of combustion

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2. Methods of firing
   a. Oil fired (Palmer, p.238)
   b. Gas fired (Palmer, p.239)
   c. Solid fuel fired
   d. Electric furnace (Palmer, p.239)

IV. Temperature Measurement (Palmer, pp.220-29)

1. Color charts and human eye
2. Thermocouple pyrometer (Palmer, pp.220-21)
   a. Indicating, shows temperature at time of observation
   b. Recording, keeps a written time and temperature record
   c. Controlling, shuts off and turns on fuel or current to maintain any desired temperature
3. Ceramic cones (H.B., p.1671)
4. Electrical resistance pyrometer (H.B., p.1670)
5. Radiation pyrometer (H.B., p.1670)
6. Optical pyrometer (H.B., p.1670)

V. Hardness Testing (Palmer, pp.260-68)

1. File test (Palmer, p.261), not accurate but useful in the hands of an experienced workman
2. Sceleroscope (Palmer, p.261), measures rebound height of a steel ball, easily carried about
3. Rockwell Hardness tester (Palmer, pp.262-3)
   a. Presses a penetrator (steel ball or diamond point) into the surface to be tested and measures the depth of penetration
   b. C-scale, diamond penetrator, 150 kilograms load
   c. B-scale, 1/16" steel ball, 100 k.g. load
   d. D-scale, diamond and 100 k.g. load
   e. F-scale, 1/16" steel ball, 60 k.g. load
   f. G-scale, 1/16" steel ball, 150 k.g. load
4. Brinell hardness tester (Palmer, p.264)
   a. Presses 10 millimeter diam. steel ball, 3000 k.g. load
   b. Measures diameter of depression
   c. Used mostly for softer materials

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5. Vickers hardness tester (Palmer, p.264)
   a. Same principle as Brinell

   b. Uses diamond point and same number scale as Brinell

6. Conversion tables (Palmer, p.551)

VI. Toughness Testing (Palmer, pp.268-82)

1. Charpy test for toughness (Palmer,p.270)
   a. Swinging pendulum breaks a prepared test piece and the resistance to breaking measured

   b. Izod test (Palmer,p.269), same principle as Charpy except that the test piece is broken at the end instead of in the middle

   c. The Capenter tortion test; breakage in tortion stress is measured. Said to be more reliable as it actually measures the important qualities of the steel

STUDENT ASSIGNMENT

I. Read outline and references in order listed.

II. Answer questions as you go along.

III. Discuasion and grading of papers.

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Name of Student_____Date_____

Instructor_____Grade_____

Questions - Metallurgy of Iron and Steel
Session 7, Equipment Used in Heat Treating and Hardness Testing

1. What are the two main advantages of using a bath for heating steel for hardening?

2. What two materials are commonly used in heating and preheating baths?

3. What is the difference in effect on the surface of the work between neutral and active salts?

4. Give two advantages of brine over fresh water in quenching.

5. What percentage of salt makes the best brine for quenching?

6. How do the quenching speeds of water, brine, oil, and air compare?

7. How do the maximum drawing temperatures compare with the hardening temperatures for any grade of steel?

8. What is meant by atmosphere control in a heating furnace?

9. Which hardness test are you the most familiar with?

10. Describe the Rockwell instrument as to general method used, type of penetrator, pressure, and scales commonly used.