CONNECTICUT STATE DEPARTMENT OF EDUCATION

Division of Instruction

Hartford

SHOP THEORY FOR THE MACHINE TRADES

SUBJECT: Metallurgy of Iron and Steel

SESSION 11.

OBJECTIVE: Quenching and Timing

METHOD: Lecture, reading, and test

REFERENCES: Johnson, Metallurgy
Machinery's Hand Book

I. Quenching and Timing the Quench are the more technical points in the heat treatment of steel (Johnson, pp.232-9)

1. Water or brine quenching. Very fast
   a. Used with steels having a very fast gate speed, i.e. plain carbon steels

   b. Defects and limitations: shallow penetration and tendency to crack, check, or warp

2. Oil quenching. Slower than brine and water
   a. Used with steels having a slower gate speed, i.e. most alloy steels

   b. Advantages: deeper penetration and less tendency to crack or warp

3. Air quenching. Very slow
   a. Used with steels having an extremely slow gate speed, i.e. high speed steel

   b. Advantages: deep penetration and red-hardness

4. Quenching in molten salts or lead baths
   a. Used with all classes of steels for interrupted and isothermal quenching

   b. Advantages: permits a greater variety of procedures and very accurate control

5. Furnace cooling:
   a. Extremely slow, from hours to days

   b. Used in annealing and malleablizing

II. Basic S-Curve (Johnson, pp.239-40)
   1. Shows time required for austenite to transform into pearlite or martinsite when held at any under cooled temperature

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2. Each class of steel has its own S-curve

3. Points to be noted in the S-curve for .78% carbon steel:
   a. If cooled to 1300° and held, there is no transformation

   b. If cooled and held at 1000°, transformation starts in about 8 seconds

   c. This point of fastest transformation time is called the "knee" of the curve. Cooling of carbon steels must be very fast to get past this danger point

   d. If held at 1000° for longer than 8 seconds, a finer and harder pearlite is formed (Rc 41)

   e. If successfully quenched to 550° and held, transformation begins in two minutes (120 sec. on the curve) and is complete in one hour (3600 sec.). A very fine form of pearlite is formed (Rc 56)

   f. If successfully quenched to 200°, hard martensite is formed (Rc 65)

4. Effects of amount of carbon on shape or S-curve
   a. Less than .30% carbon, knee of curve is very close to the zero line (a small fraction of a second). Very difficult to harden.

   b. .30% to .85% carbon, range of full martinsitic transformation. Transformation time is slower.

   c. More than .85% carbon, rate of transformation is faster. More difficult to obtain full transformation to martinsitic condition but the excess of cementite adds to the hardness

III. Interrupted and Isothermal Quenching

1. Reasons for
   a. Gains deeper hardness penetration

   b. Prevents internal stresses which result in cracking, checking, or warping

   c. Can be worked so that a satisfactory hardness, coupled with greatly increased toughness, can be obtained.

2. Austempering (Johnson, p.255. H.B.,pp.1641-2)
   a. Heat to hardening temperature and quench in salt bath at 350° to 800°, according to the composition of the steel.

   b. Hold at this temperature 10 minutes to 60 minutes

   c. Finish cooling in air

   d. Results: a fairly hard form of refined pearlite called "bainite" (R-c 56) and much tougher. Very little warping.

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e. Limitations; limited to small or thin pieces

3. Martempering (Johnson, p.256. H.B., p.1642)
   a. Quench at hardening temperature to about 400° in a salt bath

   b. Hold briefly to insure uniform temperature

   c. Finish cooling in air

   d. Draw in the conventional manner

   e. Results: a hard martinsitic structure without danger of internal stresses

4. Isothermal quenching (H.B., p.1642)
   a. Same process as austempering until bainite is formed, then reheat to some higher temperature and hold a definite length of time

5. Spherodizing (Johnson, p.251. H.B., p.1642)
   a. Draw at high temperature, 1000° to 1200°, any martinsitic steel

   b. Results: fine rounded particles of carbide are present. Increases machinability

STUDENT ASSIGNMENT

I. Read references carefully and check outline

II. Answer questions

III. Check answers and grade papers

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Name of Student_____Date_____

Instructor_____Grade_____

Questions - Metallurgy of Iron and Steel
Session 11, Quenching and Timing

1. What class of steels is quenched in water and brine?

2. Give three bad results or defects of fast quenching.

3. What class of steels is frequently quenched in air?

4. What class of quenching media is used in interrupted quenching?

5. What will be the result if a steel is quenched more slowly than the critical quenching speed?

6. Give the main steps in austempering.

7. How is spherodizing done?

8. At what temperature does transformation from austenite to martinsite begin?

9. What is the lowest carbon content at which hardening of steel is practicable?

10. Why is it better, if possible, to quench in oil?