CONNECTICUT STATE DEPARTMENT OF EDUCATION

Division of Instruction

Hartford

SHOP THEORY FOR THE MACHINE TRADES

SUBJECT: Metallurgy of Iron and Steel

SESSION 6.

OBJECT: Various Heat Treatments (preliminary outline)

METHOD: Lecture, reading lesson, and test

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

I. Surface Treatments

1. Applied surfaces (Johnson, pp.269-71)
   a. Plating - by electrolysis
   b. Galvanizing-dipped in melted zinc
   c. Sherardizing-zinc powder applied and heated to 575° to 850°
   d. Schoop metalizing-hot metal sprayed on
   e. Hard facing-hard metal surface applied to a tough base by means of a torch
   f. Oxidation-applying an oxide film by heating in a special salt bath

2. Flame hardening of surfaces (Johnson, pp.272-3, H.B., p.1650)
   a. Quick heat by a torch followed by quick quenching in water
   b. Applied to the surface of large iron or steel castings
   c. Steel castings should be .40% to .70% carbon for best results

3. Surface carburizing (Johnson, p.276. H.B., p.1648)
   a. Adding a certain amount of carbon to a thin surface layer of low carbon or low carbon alloy steel by heating in an atmosphere of burning carbon. Result is a tough low carbon center and a hard high carbon surface.
   b. Use of solid carburizers, such as charcoal (usually called pack hardening).
   c. Use of gas carburizers, such as carbon monoxide or illuminating gas (a mixture of CO and CH_4)

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d. Use of liquid carburizers, such as sodium or potassium cyanide (generally called case hardening). (Johnson, pp.286-7)

e. All classes of carburizing require a hardening operation after the carburizing operation is completed

f. Depth of penetration varies from a few thousandths of an inch for case or cyanide hardening to one sixteenth of an inch for pack hardening

4. Nitriding (Johnson, pp.288-92. H.B., p.1649)
   a. Applied to special alloy steels

   b. Heated in a muffle furnace to about 960° and for 18 to 90 hours in an atmosphere of active ammonia gas (NH_3)

   c. Hardness in excess of Rc 74 is obtainable

II. Deep Penetration Treatments

1. Normalizing (Johnson, pp.258-9. H.B., pp.1631,1647)
   a. Heat above critical point (about 1440) and cool in air

   b. Relieves internal stresses, refines grain, and promotes machinability).

   c. Usually applied before annealing

   d. Also applied to forgings and castings

2. Annealing (Johnson, pp.261-3. Palmer, p.211. H.B.p.1646)
   a. Heat slightly above critical point (about 1340°) and slow cool in an oven

   b. Softens steel, refines grain structure, reduces brittleness and hardness

   c. Is also applied to forgings and castings

3. Stress relieving (Johnson, pp.264-4. Palmer, p.211)
   a. Heat below critical point (900° to 1200°), furnace cool to 860° and finish cooling in air

   b. Use mostly on forgings, castings and welded structures to relieve internal stresses

4. Hardening
   a. Heat to above the critical temperature and quench quickly in water or brine or slowly in oil, melted salts, or air, according to kind of steel

   b. Applied after machining

   c. Increases hardness or brittleness but decreases toughness

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5. Tempering or Drawing (Johnson pp.248-9. Palmer p.214)
   a. Applied after hardening to remove brittleness
   b. Heat to much lower temperature than for hardenint (300° to 800°), soak for an hour or more and cool in air
   c. Makes the steel softer and tougher; softening increases as temperature used increases
   d. The correct temperature may be estimated by the color of the polished steel which changes with the heat, but the more accurate method is to use a pyrometer
6. Austempering, Martempering, and Spherodizing will be taken up later under the head of Interrupted Quenching
7. Deep freezing and Aging (Palmer, pp.215-6)
   a. Steel is not fully hardened when quenched
   b. Hardening is completed only after a long time at room temperature. This fact may be the reason for what is known as "change of size"
   c. Deep freezing or alternate boiling and freezing speeds up the aging process
8. Heat treatment of High Speed Steels
   a. High speed steels require special hardening and drawing techniques, which will be taken up later in this outline

III. Heat Treatment of Cast Iron (Johnson, pp.358-68)

1. Stress relief annealing
2. Full annealing
3. Hardening and Tempering
4. Nitriding
5. Effect of steel molds or chills on castings
6. Malleabilizing

STUDENT ASSIGNMENT

I. Read all references and check with outline

II. Answer the questions for Session 6. (You may use the outline).

III. Check answers and grade papers

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Name of Student_____Date_____

Instructor_____Grade_____

Questions - Metallurgy of Iron and Steel
Various Heat Treatments

1. What is the object of flame hardening?

2. Name five ways in which a metal may be applied to the surface of another metal.

3. Give two effects that the drawing operation has on hardened steel.

4. How can a precision gage fail, besides wearing out with use, after a long period of time?

5. How can colors be used in drawing steel that has been hardened?

6. Name eight different deep penetrating heat treatments for carbon and alloy steels.

7. How can the aging process be speeded up?

8. What is the ordinary range of temperature for drawing?

9. Compare the normalizing and full annealing temperatures.

10. What is meant by "draw for two hours at 400"?

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SHOP THEORY FOR THE MACHINE TRADES

Name of Student_____Date_____

Instructor_____Grade_____

T and F Test To Follow SESSION 6
(Semi-Final)

(This test is a review on the first six sessions, to be used at the option of the instructor for the purpose of checking grades already given)

INSTRUCTIONS TO STUDENT: If, in your opinion, the statement is true, mark a circle around the "T" at the right of the question. If the statement is not true, mark a circle around the "F".

1. Fe_2O_3 means two parts of iron by weight to three parts of oxygen by weight. T F

2. The rusting of an unpainted and exposed steel girder is classed as fast oxidation. T F

3. Iron ore is reduced to make pig iron. T F

4. Pig iron and cast iron have the same composition. T F

5. The blast furnace is used in the foundry to melt iron for casting. T F

6. The slag that is included in the make up of W.I. is the principal reason for its superior qualities of toughness and resistance to corrosion. T F

7. The cementation process of making steel is of great commercial importance at the present time. T F

8. Cast iron has less tensile strength than low carbon steel. T F

9. All S.A.E. steels are classed as alloy steels. T F

10. The chemical symbol for Tungsten is "T". T F

11. Good grades of pig iron are practically free from impurities. T F

12. The puddling furnace is kept hot by burning of its charge. T F

13. The foundry cupola is kept hot by the burning of its charge. T F

14. White cast iron has a greater carbon content than grey iron. T F

15. An electric furnace is impractical for melting pig iron in the foundry. T F

Semi-Final - (Continued)

16. A large percentage of the fine tool steel, used in the U.S. comes from the open hearth. T F

17. Basic Bessemer steel is commonly used for cheap screw machine stock. T F

18. Slag is removed from the bottom of the crucible used in the crucible process of making steel. T F

19. The cost per ton, in the Pittsburgh district, of iron ore mined in Minnesota is more than that of the ore that can be dug out of the local mines. T F

20. The blast furnace has a nearly uniform temperature throughout its length. T F

21. Slag is lighter than iron or steel. T F

22. Cold working improves the qulity of steel. T F

23. Castings are sometimes pickled in vinegar. T F

24. The burning off of a Bessemer converter lasts for hours. T F

25. Imperfections in steel ingots are not removed by subsequent regular mill operations. T F

26. Internal stresses cannot be removed from steel ingots. T F

27. Hot rolling develops a fibrous structure in the steel. T F

28. Hot forging of steel is sometimes done in an hydraulic press. T F

29. Spinning is not classed as a cold working process. T F

30. The welding process has become static in industry and the future will not see much increase in its use over the present time. T F

31. It is necessary to soak steel ingots at high temperature before starting them through the rolls. T F

32. Cold working produces considerable scale on the surface of the steel. T F

33. A large amount of steel is used in the construction of a modern sky-scraper. T F

34. Galvanizing of iron and steel is commonly doen by electrolvsis. T F

Semi-Final - (Continued)

35. Cyanide is used in case hardening of low, carbon steel. T F

36. Surface hardening treatments generally require a spearate hardening operation to follow the carburizing operation. T F

37. Case hardening is usually deeper than one fourth of an inch. T F

38. It is not practical to carburize deeper than one eighth inch. T F

39. Pack hardening is a surface hardening process. T F

40. Nitriding will produce a hardness in excess of Rockwell-c 74. T F

41. Normalizing temperatures run higher than full annealing temperatures. T F

42. Annealing is usually accomplished by heating to annealing temperature and cooling in air. T F

43. Heat treatment for stress relieving is commonly used on steel forgings and castings T F

44. Hardening of high carbon steel increases its toughness. T F

45. Drawing of carbon steel, that has been hardened, is usually done at a heat in excess of 800°. T F

46. Transformation from austenite to martinsite is a necessary factor in the hardening of carbon steels. T F

47. It takes months for a carbon steel to become fully hardened at room temperature. T F

48. It is impossible to speed up the aging process in finishing precision tools and gages. T F

49. H.S.S. must be hardened at a temperature in excess of 2000°. T F

50. Most of the standard heat treatments are also applied to iron castings. T F