**AISI S7**

**General Purpose and Shock Resisting Tool Steel**

**Typical Analysis**

Carbon 0.50; Manganese 0.70; Silicon 0.25; Chromium 3.25; Molybdenum 1.40

**Advantages**

Excellent combination of high strength and toughness

Useful in moderate hot work as well as cold work tooling

Added size stability when air hardened

**Applications**

AISI S7 is a general purpose air hardening tool steel well suited for many tools requiring exceptional toughness, good wear resistance and added dimensional stability. Its air hardening capacity extends through 2 ½” thick sections with larger sizes requiring flash oil quenching. Applications of AISI S7 include hot working tools operating in the lower hot work temperature ranges, i.e. below 1000⁰F.

Typical applications include blanking and forming dies, bending dies, punches, master hubs and plastic molding dies.

**Thermal Treatment Summary**

**Critical Points**

Heating (Ac) - 100⁰F/Hr. – begins 1440⁰F, ends 1508⁰F

Cooling (Ar) - 50⁰F/Hr. – begins 1346⁰F, ends 1270⁰F

**Forging** – 1950 to 2050⁰F, stop at 1700⁰F, cool slowly

**Annealin**g – 1500 to 1550⁰F, furnace cool to 1000⁰F, air cool, BHN 223 max

**Preheating** – 1200 to 1300⁰F prior to hardening

**Hardening** – 1700 - 1725⁰F (see more detailed hardening instructions)

**Tempering** – 400 to 500⁰F Rc 55-58 (for most requirements)

**FABRICATION**

**Forging**

Heat slowly to about 1300⁰F and then more rapidly to the forging temperature range of 1950-2050⁰F. Do not hot work below 1700⁰F. After forging, allow to cool slowly, preferably buried in vermiculite, lime or other insulating material. It is desirable to anneal soon after forging.

**Annealing**

Heat to 1500-1550⁰F, hold until uniformly heated and cool slowly to below 1000⁰F. To reduce scaling and decarburization, box annealing in a neutral medium is suggested. Hold at temperature for about 1 hour for each inch of the smallest dimension of the container. Annealed hardness range is 187-223 Brinell.

**Machinability**

AISI S7 is readily machinable in the annealed condition. Its machinability rating is about 85% of a 1% carbon tool steel.

**HEAT TREATMENT**

**Hardening**

Preheat to 1200-1300⁰F and then heat to 1700-1750⁰F, the normal hardening temperature range. Time at the hardening temperature should be relatively long, approximately ½ hour per inch of greatest section thickness. Use of protective atmosphere, salt bath, pack hardening, protective paint or tool wrap is desirable to control decarburization during hardening. Sections no greater than 2 1/2 “ in thickness will harden through in still air. Sections of greater thickness require cooling in air blast, salt quenching to 1000⁰F, or flash oil quenching to 1000⁰F followed by air cooling. Very heavy sections (over 6” thickness) should be oil quenched to approximately 125⁰F. Temper as quickly as possible after the hardening operation, preferably when the tool has cooled to approximately 125⁰F.

**Tempering**

For cold work applications, AISI S7 is normally tempered in the range 400-500⁰F. When used for hot working tools, tempering at 900-1000⁰F is usually desirable. The steel should be held for at least 2 hours at the tempering temperature before air cooling. Increased tempering time is desirable for large tools.

**Hardening and Tempering Series**

Samples 1 inch round by 2 inches long were hardened by air and oil quenching from 1725⁰F and tempered at the indicated temperatures. Resulting hardness is shown in the following chart:

|  |  |  |
| --- | --- | --- |
| **Tempering Temperature ⁰F** | **1725⁰F Air Cooled Rockwell C** | **1725⁰F Oil Quenched Rockwell C** |
| As Quenched | 60.0 | 61.0 |
| 300 | 58.5 | 60.0 |
| 400 | 57.0 | 58.5 |
| 500 | 55.5 | 56.5 |
| 600 | 54.0 | 54.0 |
| 700 | 53.5 | 53.5 |
| 800 | 52.5 | 52.5 |
| 900 | 51.5 | 52.0 |
| 1000 | 49.5 | 51.5 |
| 1100 | 48.0 | 48.5 |
| 1200 | 37.5 | 37.5 |

**Effect of Mass on Hardening Response**

To determine the effect of increasing mass on hardening response, hardness tests were performed on cross sectional discs prepared from mid-length on several section sizes using accelerated quenching rates with increasing section size. Hardness test results from surface and center areas for the various sizes are listed below:

|  |  |  |  |
| --- | --- | --- | --- |
| **Section Size** | **Heat Treatment** | **Rc Hardness** | |
| **Surface** | **Center** |
| 2 ½” sq. x 5” long | Preheat 1300⁰F  High heat 1725⁰F  Air Cool to 150⁰F  Temper at 400⁰F | 61  58 | 60  58 |
| 4 1/2” sq x 9” long | Preheat 1300⁰F  High Heat 1725⁰F  Flash Oil Quench to 1000⁰F  Air Cool to 150⁰F  Double Temper at 400⁰F | 61  58 | 59  56 |
| 6” sq. x 12” long | Preheat 1300⁰F  High Heat 1725⁰F  Flash Oil Quench to 1000⁰F  Air Cool to 150⁰F  Double Temper at 400⁰F | 59  56 | 54  54 |
| 9” sq. x 18” long | Preheat 1300⁰F  High Heat 1725⁰F  Oil Quench to 150⁰F  Double Temper at 150⁰F | 61  56 | 56  54 |

**Size Stability**

When hardened at 1725⁰F, still air cooled to 150⁰F and then tempered at 400⁰F, AISI S7 normally will show growth at a rate not exceeding .001” per inch.

**C-Notch Charpy Impact Tests**

C-notch Charpy impact samples 2.165 inches long by .394 inches square were prepared from 8 ¾ inch by 7 inch bar with the length of the impact sample parallel to the short transverse direction of the bar. A ½ inch radius C-notch was ground to a depth of .079 inch. All samples were hardened at 1725⁰F in a controlled atmosphere furnace for 15 minutes at temperature and air cooled. Samples were tempered for 2 hours at the indicated temperatures. Finish grinding was completed after heat treating. Testing was done on a 240 foot pound capacity testing machine. Each value is the average of 3 tests.

|  |  |  |
| --- | --- | --- |
| **Tempering Temperature ⁰F** | **Energy Absorbed ft lbs** | **Hardness Rockwell C** |
| None | 15.5 | 61.0 |
| 300 | 24.0 | 60.0 |
| 400 | 52.2 | 57.5 |
| 500 | 40.3 | 55.5 |
| 700 | 46.3 | 54.0 |
| 800 | 40.0 | 54.0 |
| 900 | 46.3 | 53.5 |
| 1000 | 47.0 | 52.5 |
| 1100 | 91.7 | 45.5 |
| 1200 | 117.5 | 36.5 |