AISI A2

Air Hardening Die Steel

Typical Analysis
Carbon 1.00; Manganese 0.70; Chromium 5.00; Molybdenum 1.10; Vanadium 0.25

Advantages
Outstanding combination of abrasion resistance and toughness
Good size stability in heat treatment
Not difficult to fabricate
Good hardenability

Applications
Use for wide variety of cold work requirements where a compromise between wear resistance and toughness is needed and safety in hardening is essential. Typical uses involve blanking and forming dies and punches, bending dies, trim dies, forming rolls and plastic molds.

Thermal Treatment Summary
Critical Points
Heating (Ac) - 100ºF/Hr. – begins 1427ºF, ends 1481ºF
Cooling (Ar) - 50ºF/Hr. – begins 1373ºF, ends 1328ºF
Forging – 1800-2000ºF, stop at 1650ºF, cool slowly
Annealing – 1500 to 1600ºF, furnace cool, BHN 235 max
Stress Relieving – 1100 to 1200ºF, air cool
Preheating – 1200 to 1250ºF, prior to hardening
Hardening – 1725 to 1775ºF, air quench to 150ºF
Tempering – 350 to 400ºF Rc 60-61
900 to 1000ºF Rc 55-57

FABRICATION

Forging
Heat slowly to 1800-2000ºF, allowing sufficient time for the steel to heat through before forging. Do not hot work AISI A2 below 1500ºF. After forging, allow the steel to cool very slowly, preferably buried in ashes, lime, expanded mica, or similar materials. Anneal as soon as possible.

Annealing
Heat slowly to 1500-1600ºF and furnace cool, allowing the temperature to drop no faster than 50º per hour while in the range between 1450 and 1300ºF. For surface protection, parts should be annealed in controlled atmosphere or vacuum furnaces or packed in tubes or other containers in such materials as cinders, spent carburizing compound, or other slightly carbonaceous substance. The usual annealed hardness is 202-248 Brinell.

Machinability
AISI A2 can be machined readily in the fully annealed condition. Its machinability is about 65% of annealed 1% carbon tool steel.

Grindability
AISI A2 is moderately easy to grind and has a grindability index of 20.0* when hardened and tempered to full working hardness.

* courtesy of Norton Company

HEAT TREATMENT

Hardening

Preheat slowly to 1300-1400ºF and then more rapidly to the hardening range of 1725-1775ºF. Hold the steel at the hardening temperature until the heat has completely penetrated the work piece, using working times almost as long as those used with high carbon-high chromium steels. For adequate surface protection, controlled atmosphere or vacuum furnaces or salt baths are recommended. When such furnaces are not available, wrapping the tool in stainless steel foil provides some surface protection during hardening.

Cool to room temperature in still air or in a dry, mild air blast. As-quenched hardness should be about Rockwell C 63-65.

Tempering

Normal tempering temperatures vary from 350 to 500ºF for tools intended for working on medium to light gage material. When a tougher material is to be worked and when the tool or die is subject to shock, a double tempering treatment at 900-1000ºF is recommended. Refer to the Tempering Series data for the approximate hardness to be expected. To estimate tempering time, allow 1 hour per inch of thickness but not less than 1 hour even for very thin sections.

Hardening Series

Samples 2 inches long by 1 inch round were preheated at 1200ºF, heated to the indicated hardening temperature and held for 30 minutes in an atmosphere of about 10 percent CO, then cooled in still air. After being fractured, the samples were tested for hardness. Full hardness is developed in sections as large as 4 inch cubes by cooling in still air from 1750ºF.

Hardening Temperature ºF	Hardness Rockwell C	Shepherd Fracture Rating
1600	46-47	8
1650	54-55	9 ½
1700	60	10
1750	64	9 ¾
1800	63	9 ½
1850	62	9 ½
1900	59-60	9

Single Tempered	Air Cooled		Single Tempered	Air Cooled	
	1750ºF	1775ºF		1750ºF	1775ºF
None	64.0	64.5	800	56.5	57.0
300	63.0	63.5	900	56.0	57.0
400	61.0	61.5	1000	55.0	56.5
500	59.0	60.0	1100	53.0	53.0
600	58.0	59.0	1200	47.0	47.0
700	57.0	58.0			