Technical Datasheet

CarTech® Micro-Melt® 20-4 Alloy

Type Analysis

Single figures are nominal except where noted.

Carbon	1.90 %	**Manganese**	0.35 %
Silicon	0.60 %	**Chromium**	20.00 %
Molybdenum	1.00 %	**Vanadium**	4.00 %
Tungsten	0.65 %	**Iron**	Balance

General Information

Description

CarTech Micro-Melt 20-4 alloy is a highly wear and corrosion resistant, air hardening martensitic cold-work stainless die steel produced using Carpenter's powder metallurgy (P/M) process. The excellent wear resistance of the alloy is provided by a significant volume fraction of hard vanadium-rich carbides, while the alloy's outstanding corrosion resistance is obtained as a result of the chromium-rich matrix. The application of Carpenter's P/M processing creates a segregation-free and homogeneously fine carbide and grain size distribution, and when coupled with the use of molten metal filtration, results in improved cleanliness and toughness compared to conventionally cast and wrought processed material. CarTech Micro-Melt 20-4 alloy's uniform microstructure, fine carbide distribution, cleanliness and high chromium content, is responsible for the material's excellent combination of wear resistance, toughness, polishability and corrosion resistance.

Applications

The unique combination of wear resistance, toughness, polishability and corrosion resistance makes CarTech Micro-Melt 20-4 alloy an excellent candidate material for plastic compounding and injection feed screws and screw segments, barrel liners, screw tips, backflow check valves and mold cavities, particularly when processing plastics resins that contain abrasive and/or corrosive fillers and particulates. Other potential applications include pelletizer, granulator and high-performance industrial and custom knives as well as food processing equipment. In severe applications requiring toughness and good wear and corrosion resistance, CarTech Micro-Melt 20-4 alloy can reduce tooling requirements by as much as 75% compared to conventional tooling.

Properties

Physical Properties

Specific Gravity	7.61	
Density	0.2750	lb/in^3
Mean CTE		
68 to 212°F	6.06	x 10^{-6} in/in/°F
68 to 392°F	6.23	x 10^{-6} in/in/°F
68 to 572°F	6.56	x 10^{-6} in/in/°F
68 to 752°F	6.73	x 10^{-6} in/in/°F
68 to 932°F	6.84	x 10^{-6} in/in/°F

Mean Coefficient of Thermal Expansion

Temperature		Coefficient	
68°F to	20°C to	10^{-6}/ °F	10^{-6}/°C
212	100	6.06	10.9
392	200	6.23	11.2
572	300	6.56	11.8
752	400	6.73	12.1
932	500	6.84	12.3

Thermal Conductivity	97.07	BTU-in/hr/ft^2/°F
Modulus of Elasticity (E)	31.0	x 10^3 ksi

Heat Treatment

Decarburization

Micro-Melt 20-4 alloy, like all carbon-bearing steels, is subject to decarburization during thermal processing; however, the taking of proper precautions should insure that there is no decarburization during heat treatment. Salt bath, controlled atmosphere, or vacuum furnaces are acceptable for heat treating this alloy.

Normalizing

Normalizing is not recommended for this alloy.

Annealing

Suitable precautions should be taken to prevent excessive decarburization or carburization. Heat slowly at a rate not exceeding 400°F/hr. (222°C/hr.) to 1860/1900°F (1016/1038°C) and hold at temperature for the longer of 4 hrs. minimum or 1 hr./in. of maximum thickness. Following soaking, cool slowly in the furnace at a rate not to exceed 30°F/hr. (15C/hr.) to 1000°F (538°C), after which the part may be air-cooled to room temperature. The resulting annealed hardness should be a maximum of 280 BHN (~30 HRC).

Hardening

As mentioned above, Micro-Melt 20-4 alloy can be heat treated in salt, vacuum, or controlled atmosphere furnaces, with precautions being taken to avoid decarburization during the heat treatment operation. Preheat to 1400/1450°F (760/788°C) and equalize. After preheating, rapidly heat to 1950/2100°F (1066/1149°C) when using salt or atmosphere controlled furnaces and 2050/2150°F (1121/1177°C) when using vacuum furnaces. Austenitizing at the low end of this temperature range will maximize toughness at the expense of wear resistance, while the reverse will occur when austenitizing at the high end of this range. Soak at the austenitizing temperature for 30 minutes and then quench.

Quenching

Quenching can entail the use of pressurized gas in a vacuum furnace, warm oil or neutral salt. When treating in a vacuum furnace, the inert pressurized gas should be a minimum of 4 bars. A quench rate of approximately 400°F/min. (222°C/min.) to a temperature <1000°F (538°C) is necessary to insure the attainment of optimum properties. When quenching using warm oil, quench until the part is black, about 900°F (482°C), then continue cooling in still air to room temperature. When quenching using neutral salt, quench the tool into a salt bath maintained at 1000°F (538°C), equalize the part, then continue cooling in still air to room temperature. When quenching using inert pressurized gas in a vacuum furnace, the time in the gas-quenching medium will depend on the size of the relevant work piece and furnace parameters.

Large complex parts should be preheated using a multi-step process that would entail equalizing just below the AC1, heating slowly [25°F/hr. (14°C/hr.)] through the AC1 – AC3 range, equalizing just above the AC3 and then rapidly heating to the austenitizing temperature. A knowledgeable heat-treat shop should be contacted for specific details on this procedure.

Cold Treatment

When austenitizing at temperatures >2100°F (1149°F), a cryogenic or refrigeration treatment is suggested after quenching to reduce the presence of retained austenite. After quenching from the austenitizing temperature to 125/150°F (51/66°C) cool the part to -100°F (-73°C) and hold at this temperature for 1 hour. Remove the part from the cooling medium and allow it to warm to room temperature in still air.

Stress Relieving

To relieve the stresses of machining, heat slowly to 1200/1300°F (649/704°C), hold for a minimum of 2 hours at temperature, cool slowly and uniformly to about 800°F (427°C), then cool in still air.

Tempering

Tools should be tempered immediately after completion of quenching or after completion of quenching and the cryogenic treatment. The typical tempering range for this alloy is 400 to 750°F (204 to 399°C). Tools should be soaked at temperature for the greater of 1 hour per inch (25.4 mm) of thickness or 2 hours minimum, and then cooled to room temperature in still air. The typical working hardness for the alloy is 57/59 HRC; however, a higher working hardness of 62/63 HRC can be used to enhance the material's wear resistance at the expense of corrosion resistance and toughness.

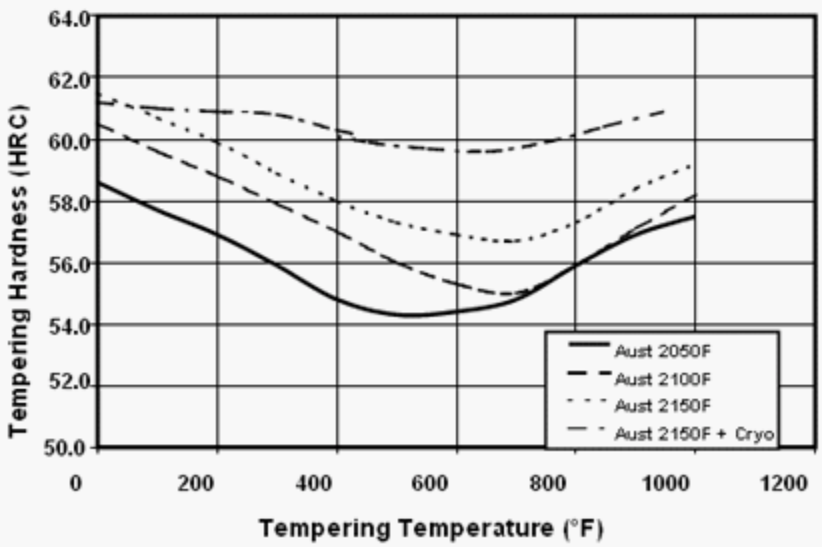
Parts should never be tempered between 800 and 1100°F (427/583°C) since both the corrosion resistance and toughness will be severely degraded due to excessive carbide precipitation.

Typical Rockwell C Hardness Values Using a Vacuum Furnace Followed by Tempering

Tempering Temperature 2 hours	Austenitizing Temperature			
	2050°F (1121°C)	2100°F (1149°C)	2150°F (1177°C)	2150°F + Cryo (1177°C)
As-Quenched	58.5	60.5	61.5	61.0
200°F (93°C)	57.0	59.0	60.0	61.0
400°F (204°C)	55.0	57.0	58.0	60.5
600°F (316°C)	54.5	55.5	57.0	59.5
800°F (427°C)*	56.0	56.0	57.5	60.0
1000°F (538°C)*	57.5	58.0	59.0	61.0

* Parts should not be tempered at these temperatures since both toughness and corrosion resistance will be severely degraded due to excessive carbide precipitation.

Hardness (HRC) Versus Tempering Temperature
Micro-Melt® 20-4 Alloy (Austenitized in a Vacuum Furnace)



All samples were preheated to 1450°F (788°C), equalized, then austenitized at the indicated temperature for 30 minutes, quenched to room temperature using 4 bars of inert N_2, and then tempered at the indicated temperature for 2 hours. Material identified by "Cryo" received a -100°F (-77°C) cryogenic treatment for 1 hour prior to tempering. The hardness values in the table are representative of those attainable with austenitizing temperatures ranging from 2050°F to 2150°F (1121/1177°C). The data show that vacuum hardening necessitates slightly higher austenitizing temperature in order to obtain a hardening response that is comparable to that obtained when using neutral salt or atmosphere controlled furnaces.

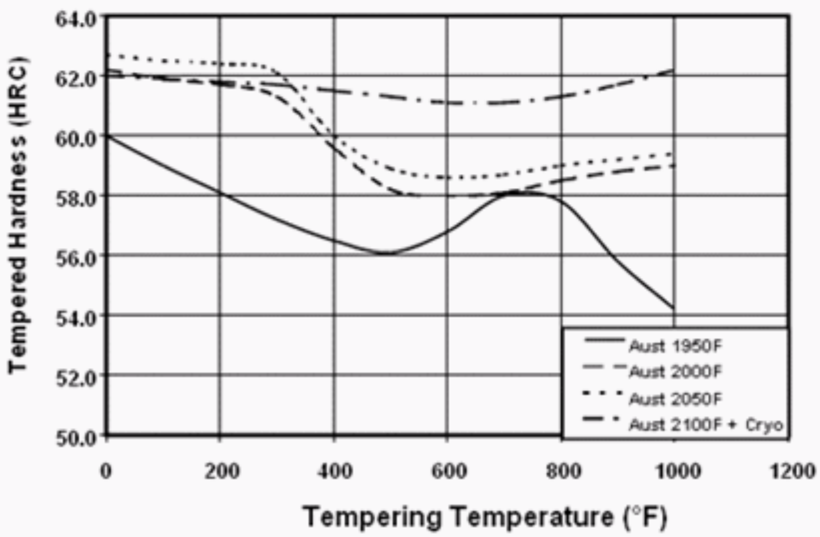
Typical Rockwell C Hardness Values Using Salt or Atmosphere Furnaces Followed by Tempering

Tempering Temperature 2 hours	Austenitizing Temperature			
	1950°F (1066°C)	2000°F (1093°C)	2050°F (1121°C)	2100°F + Cryo (1149°C)
As-Quenched	60.0	62.0	62.5	62.0
200°F (93°C)	58.0	61.5	62.5	62.0
400°F (204°C)	56.5	59.5	60.0	61.5
600°F (316°C)	57.0	58.0	58.5	61.0
800°F (427°C)*	58.0	58.5	59.0	61.5
1000°F (538°C)*	54.0	59.0	59.5	62.0

* Parts should not be tempered at these temperatures since both toughness and corrosion resistance will be severely degraded due to excessive carbide precipitation.

Hardness (HRC) Versus Tempering Temperature

Micro-Melt® 20-4 Alloy (Austenitized in Salt/Atmosphere Furnaces)



All samples were preheated to 1450°F (788°C), equalized, then austenitized at the indicated temperature for 30 minutes, quenched into warm oil to room temperature, and then tempered at the indicated temperature for 2 hours. Material identified by "Cryo" received a -100°F (-77°C) cryogenic treatment for 1 hour prior to tempering. The hardness values in the table are representative of those attainable with austenitizing temperatures ranging from 1950°F to 2100°F (1066/1149°C). Vacuum hardening may result in slightly lower hardness values.

Workability

Machinability

35 to 40% of a 1% C-bearing steel.

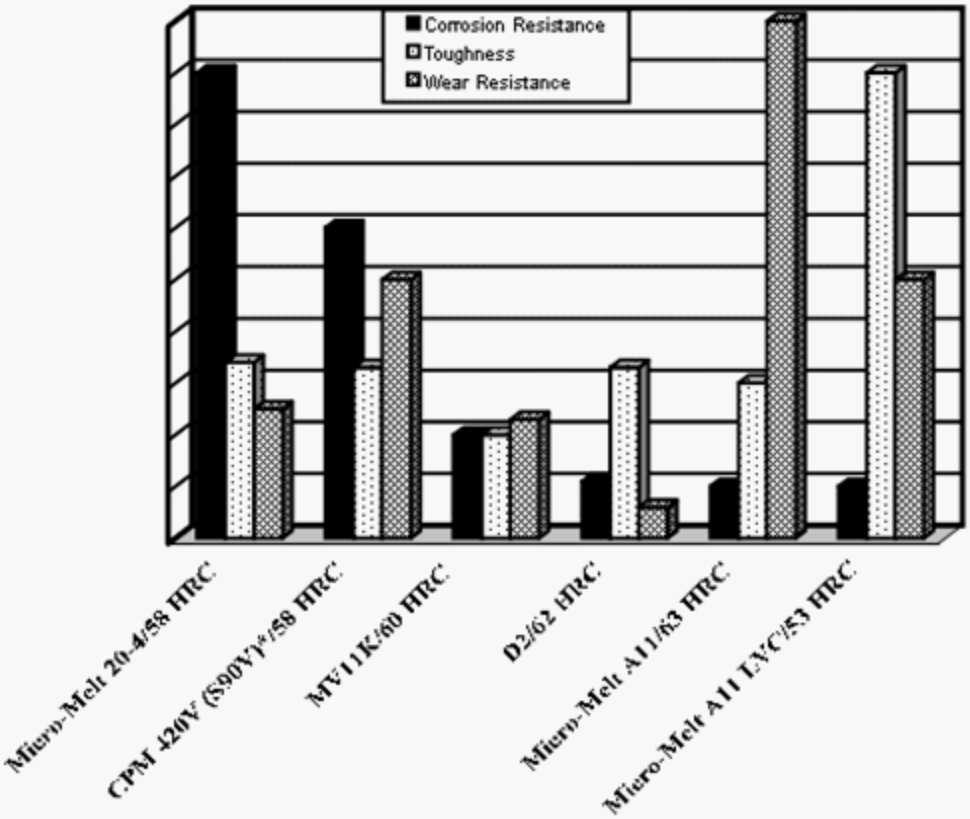
Other Information

Forms Manufactured

- Bar
- Bar-Rounds
- Billet
- Powder
- Bar-Flats
- Bar-Squares
- HIP'd Shapes
- Strip

Relative Properties of Plasticating Alloys

The relative toughness, wear resistance and corrosion resistance of Micro-Melt 20-4 alloy compared to other cold-work steels that have been used for plastic molding and extrusion applications are shown below. Corrosion testing was performed using dilute Aqua Regia. Toughness testing was performed using unnotched Izod impact specimens. Wear resistance was measured using the Dry Sand/Rubber Wheel wear test per ASTM G65. Results could vary under different test conditions.



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Edition Date: 8/1/12

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