HOEGANAES

Ancorsteel® FD-4600A / FD-4800A

Ancorsteel steel powders were developed to extend the capability of P/M parts to satisfy the needs of today's technology where higher strength and toughness are required.

Typical Analysis and Properties

Chemistry (weight %) (w/o)

	Ni	Mo	Cu	C	Oxygen
Ancorsteel FD-4600A	1.75	0.50	1.50	<0.01	0.13
Ancorsteel FD-4800A	4.00	0.50	1.50	<0.01	0.13

Apparent Density, g/cm³

Ancorsteel FD-4600A	3.0
Ancorsteel FD-4800A	3.0

Flow Rate, s/50g

Ancorsteel FD-4600A	27
Ancorsteel FD-4800A	25

Sieve Analysis, (U.S. Standard) (w/o)

Micrometers	+250	-250 / +150	-150 / +45	-45
U.S. Standard Mesh	(+60)	(-60 / +100)	(-100 / +325)	(-325)
Ancorsteel FD-4600A	Trace	6	71	23
Ancorsteel FD-4800A	Trace	6	71	23

Description

The alloy content is composed of nickel, molybdenum, and copper, and conforms to MPIF Material Standard 35, Material Designations FD-02XX and FD-04XX. Conventional sintering practice is adequate for meeting high performance requirements. The additives are diffusion alloyed to maintain compressibility of the base atomized iron. The recommended density range is 6.8 g/cm³ and above.

The composition is balanced to give excellent properties along with close dimensional control.

Application

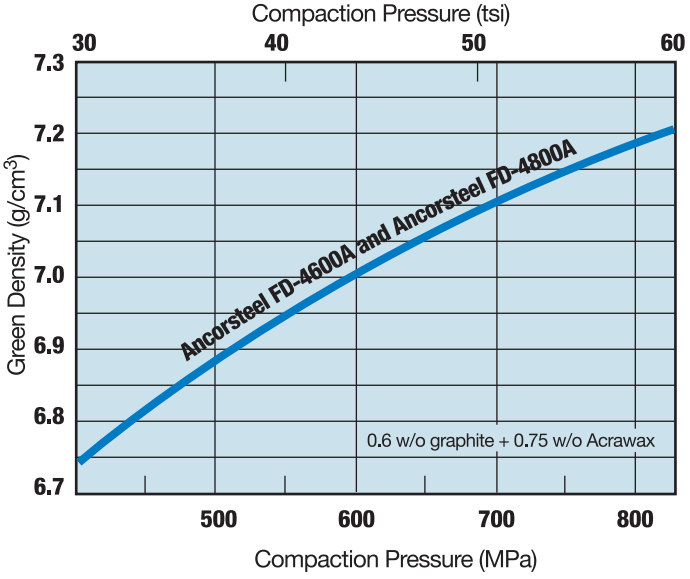
- *Parts requiring greater toughness than attainable with conventional P/M materials. Ancorsteel FD-4800A is recommended for more severe conditions.*
- *Parts subjected to "brinelling" type of loading.*
- *Parts subjected to dynamic loading.*
- *Parts with close dimensional tolerances.*

Compressibility and Green Strength

The diffusion-alloying technique used in making the Ancorsteels retains the high compressibility of the base atomized iron. Both powders have good green strength in the design density range.

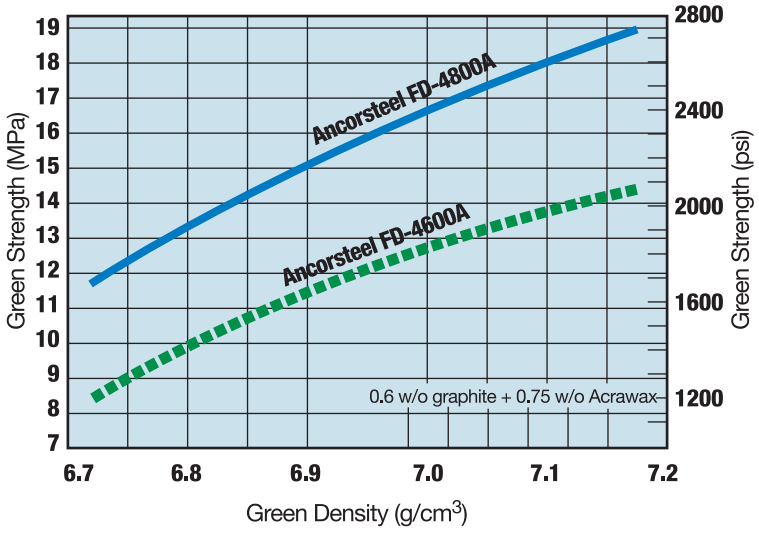
The Effects of Compaction Pressure on Green Density

Ancorsteel FD-4600A and Ancorsteel FD-4800A



The Effects of Green Density on Green Strength

Ancorsteel FD-4600A and Ancorsteel FD-4800A



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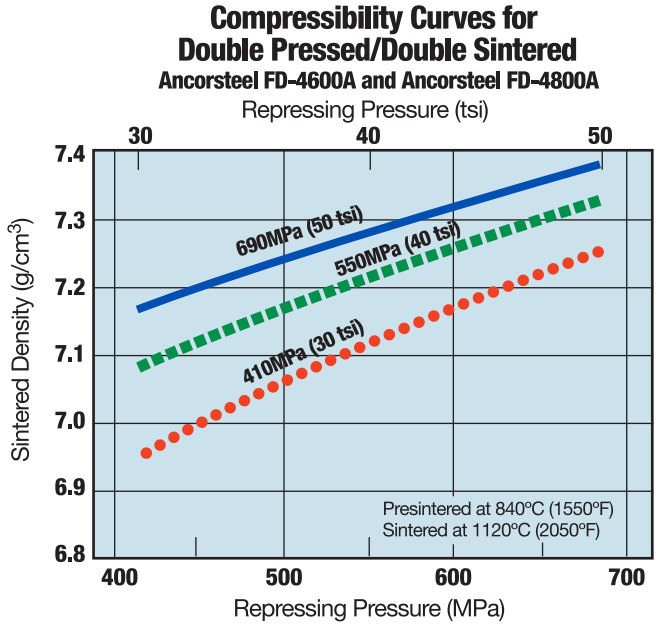

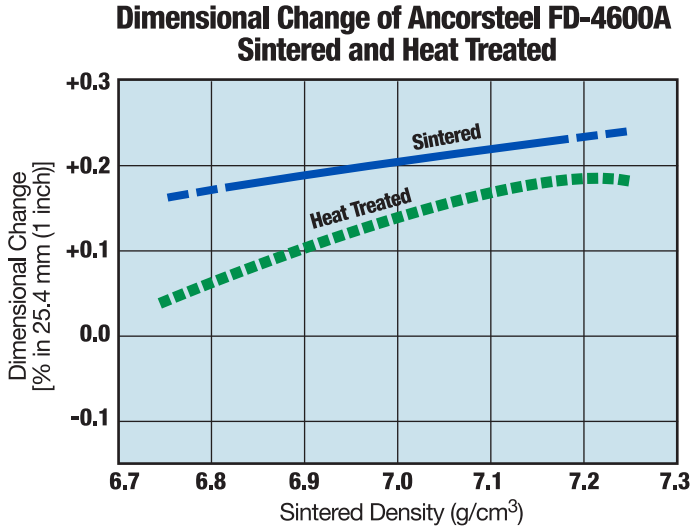

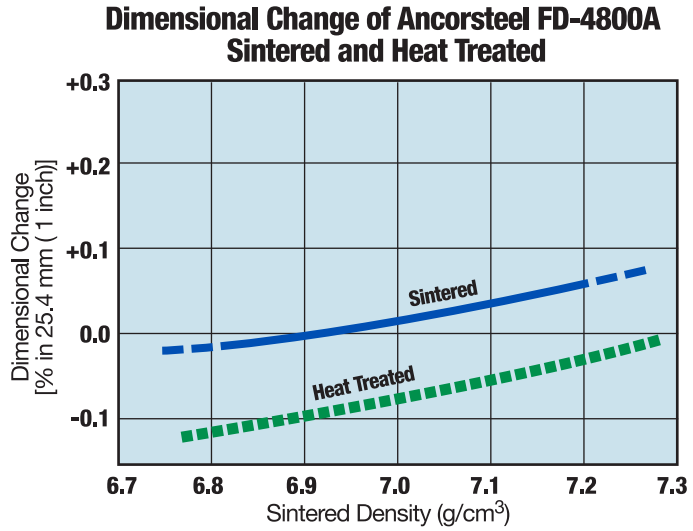

Double Pressing-Double Sintering *To achieve strength, hardness, and toughness higher than attainable at 7.1g/cm^3, the double press-double sinter approach is used.*

Sintered and Heat Treated Properties

The static and dynamic mechanical properties are shown for the Ancorsteels premixed with 0.6 w/o graphite and 0.75 w/o Acrawax C. Tensile test specimens were prepared and tested in accordance with MPIF Standard 10 (ASTM E 8). The "dog bone" specimen geometry was used to determine the sintered tensile properties and the machined round specimen was used to determine the tensile properties in the heat treated condition. Elongation was measured from a 25.4mm (one inch) gauge length and yield strength was measured at 0.2% offset. Unnotched Charpy impact specimens were prepared and tested in accordance with MPIF Standard 40 (ASTM E 23). Rotating bending fatigue (RBF) specimens were machined from sintered, rectangular compacts to the dimensions outlined in MPIF Standard 56.

The test specimens described above were pressed to various density levels, sintered in dissociated ammonia (D.A.) at 1120ºC (2050ºF) for 30 minutes at temperature and cooled in a water jacketed cooling chamber. The dimensional change values are measured from die size (carbide die) as a function of sintered density. Heat treatment was performed at 840ºC (1550ºF) for 15 minutes at temperature followed by quenching in oil at 50ºC (120ºF). The atmosphere was dissociated ammonia with methane additions. The quenched parts were stress relieved for one hour at 175ºC (350ºF) in air. Higher temperature 260ºC (500ºF) stress relieving will result in higher toughness but generally at the expense of hardness. Good heat treated properties can only be obtained if parts are well-sintered. The hardenability of the Ancorsteels is adequate for most P/M parts. The higher alloyed Ancorsteel FD-4800A is prefered for parts with thicker ruling sections.

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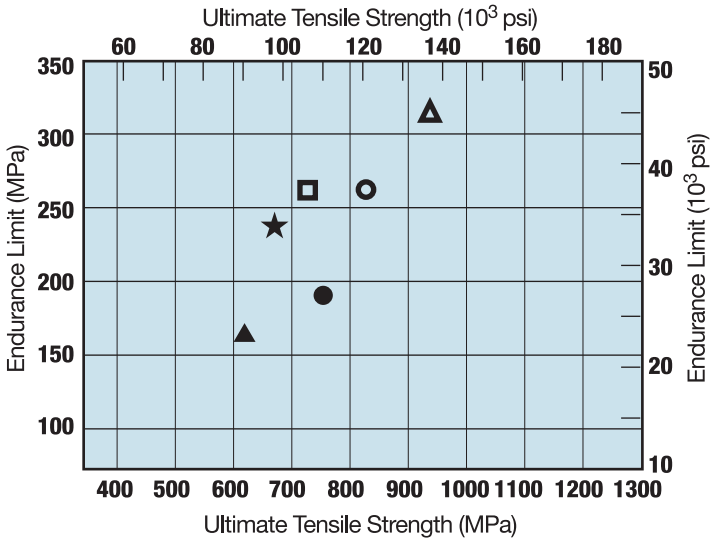
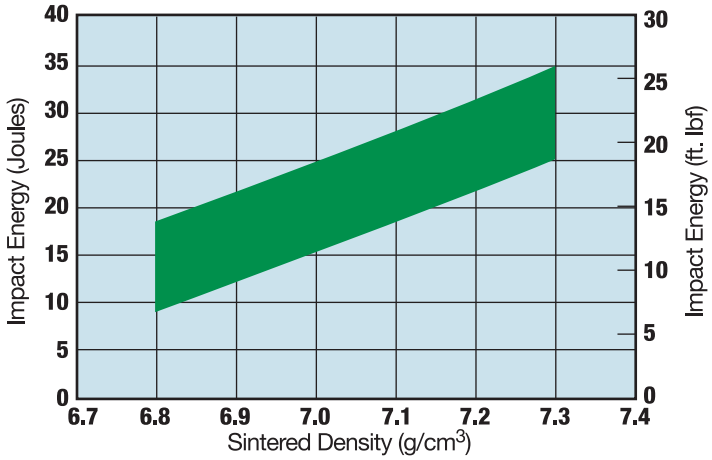
Fatigue Endurance Limit vs Tensile Strength for Ancorsteel FD-4600A and Ancorsteel FD-4800A Processed Under Various Conditions



Material	Compaction Pressure MPa (tsi)	Graphite Addition (w/o)	Sintering Temperature °C (°F)
Ancorsteel FD-4600A	440 ▲ (34)	0.6	1120 (2050)
	680 ● (45)	0.6	1260 (2300)
	680 ★ (45)	0.6	1120 (2050)
Ancorsteel FD-4800A	690 □ (50)	0.4	1120 (2050)
	690 ○ (50)	0.4	1260 (2300)
	690 △ (50*)	0.6	1120 (2050)

*Repressed at 690 MPa (50tsi)

Effect of Sintered Density on the Room Temperature Impact Energy of Ancorsteel FD-4600A and Ancorsteel FD-4800A



Material	Graphite Addition (w/o)	Sintered Impact Joules (ft. lbf)	Austenitizing Temperature °C (°F)	Tempering Temperature °C (°F)	Heat Treated Impact Energy Joules (ft. lbf)
Ancorsteel FD-4600A	0.4	22 (16)	840 (1550)	175 (350)	11 (8)
	0.6	15 (11)	815 (1500)	180 (375)	12 (9)
	0.8	14 (10)	800 (1475)	230 (450)	11 (8)
	0.8*	14 (10)			
Ancorsteel FD-4800A	0.4	22 (16)	840 (1550)	175 (350)	10 (7)
	0.6	20 (15)	815 (1500)	190 (375)	12 (9)
	0.8	18 (13)	800 (1475)	230 (450)	12 (9)
	0.8*	19 (14)			

*Repressed at 690 MPa (50 tsi)

Specimens were compacted to a density of 7.0 g/cm^3

Sintering was performed at 1120°C (2050°F) for 30 minutes at temperature in dissociated ammonia.

*Sintered and then stress relieved at 175°C (350°F) for 60 minutes in air.

*Heat treatment consisted of austenitizing in dissociated ammonia for 15 minutes at temperature then quenching in oil at 65°C (150°F) and tempering for 60 minutes in air.

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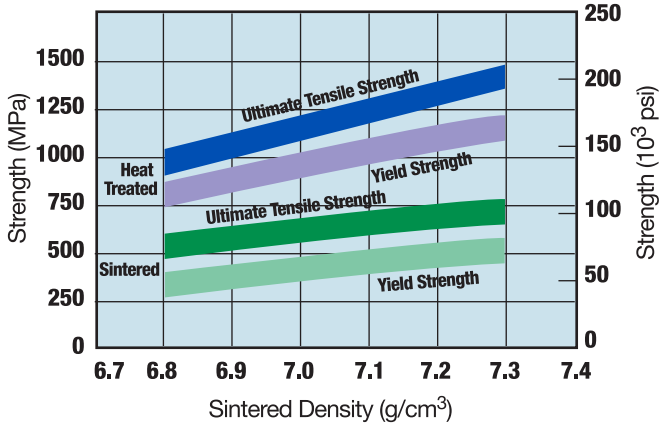
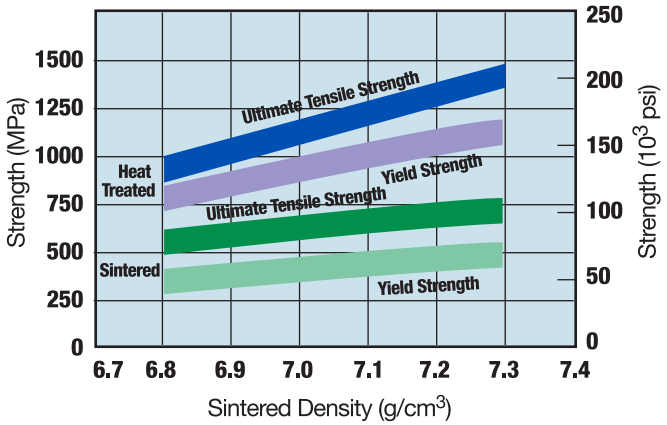
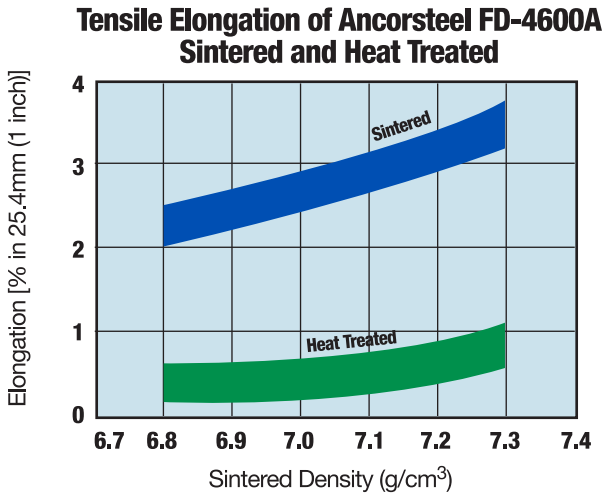
Tensile Properties of Ancorsteel FD-4600A Sintered and Heat Treated



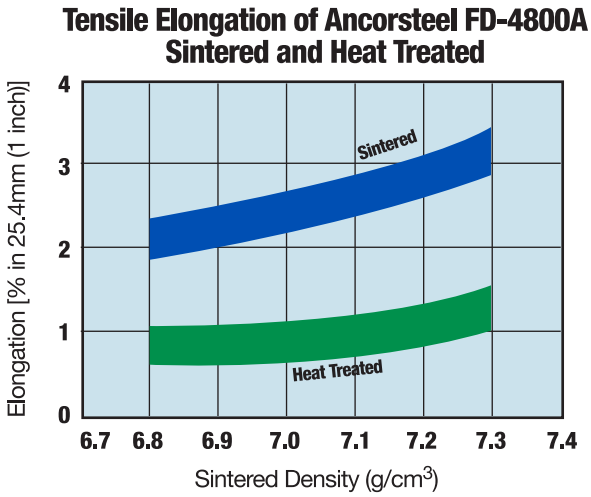
Tensile Properties of Ancorsteel FD-4800A Sintered and Heat Treated



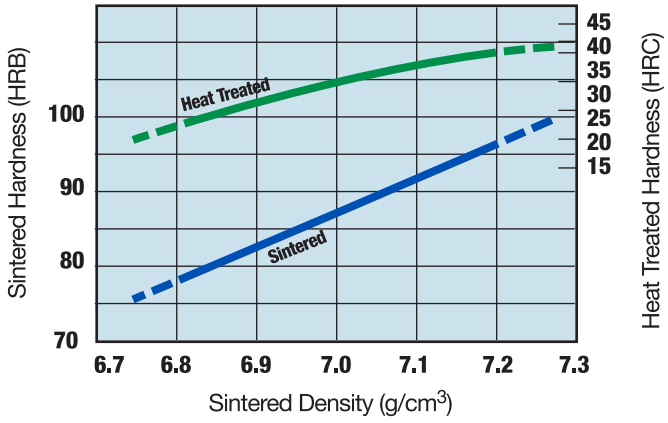
Tensile Elongation of Ancorsteel FD-4600A Sintered and Heat Treated



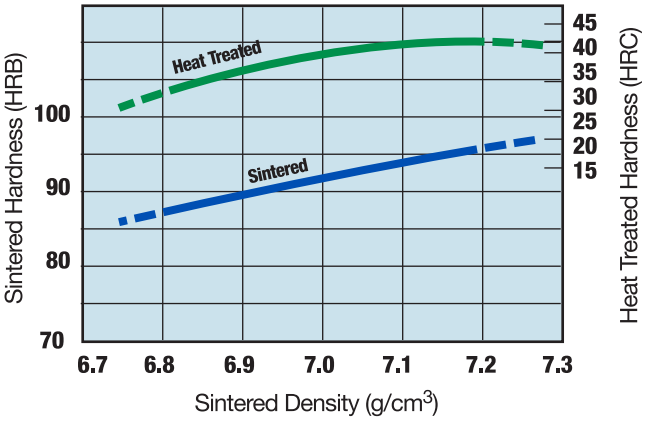
Tensile Elongation of Ancorsteel FD-4800A Sintered and Heat Treated



Apparent Hardness of Ancorsteel FD-4600A Sintered and Heat Treated



Apparent Hardness of Ancorsteel FD-4800A Sintered and Heat Treated



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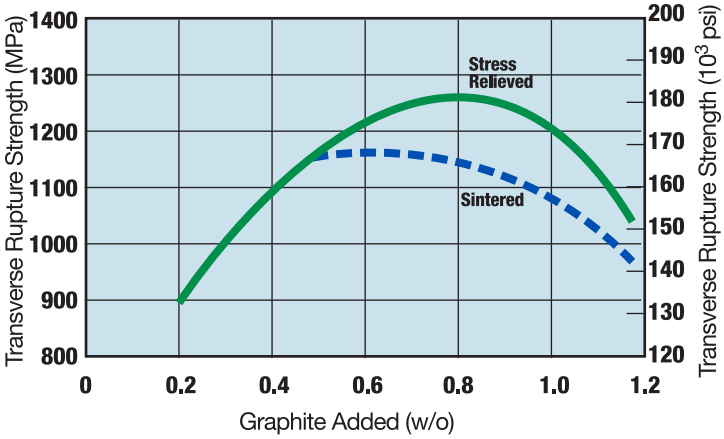
Effect of Graphite Additions *To determine the effect of varying graphite additions, MPIF Standard 41 (ASTM B-528) transverse rupture bars were prepared with graphite additions of 0.2 w/o to 1.1 w/o and were pressed to 7.0 g/cm^3. The bars were sintered at 1120ºC (2050ºF) for 30 minutes at temperature in dissociated ammonia. The transverse rupture strength, apparent hardness, and dimensional change are shown.*

The graphs show that the strength of both Ancorsteels reaches a maximum and then decreases when 0.6 w/o graphite is exceeded. This is caused by the formation of areas of untempered martensite.

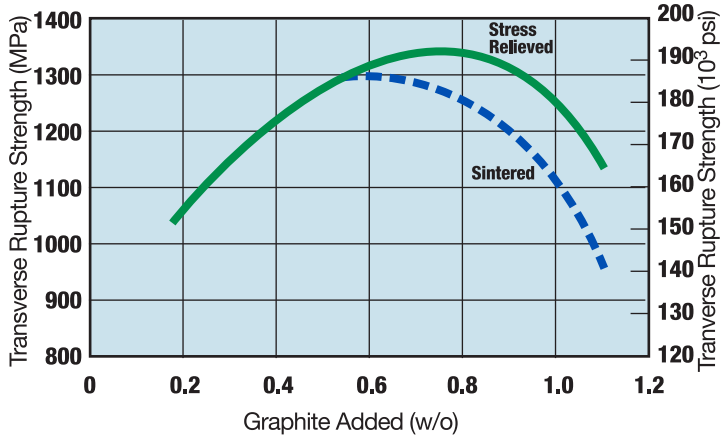
A stress relief anneal at 175ºC (350ºF) tempers the martensite formed by cooling from the sintering temperature and increases the strength appreciably, reaching a maximum at 0.8 w/o graphite. The stress relief anneal has no significant effect on the sintered hardness or dimensional change.

The formation of martensite must be considered if the parts require secondary machining.

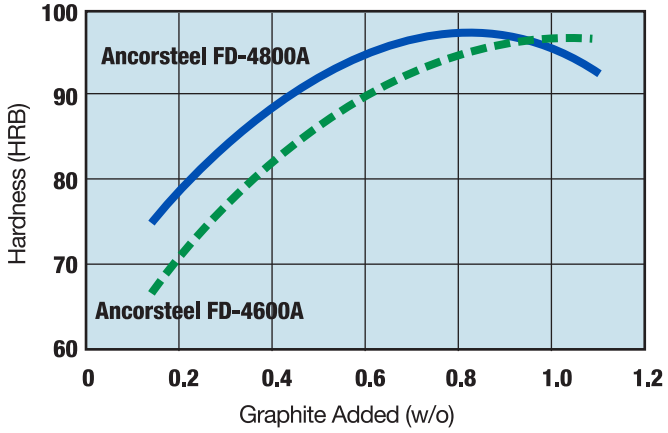
Effect of Graphite Additions and Stress Relief Annealing on Transverse Rupture Strength of Ancorsteel FD-4600A



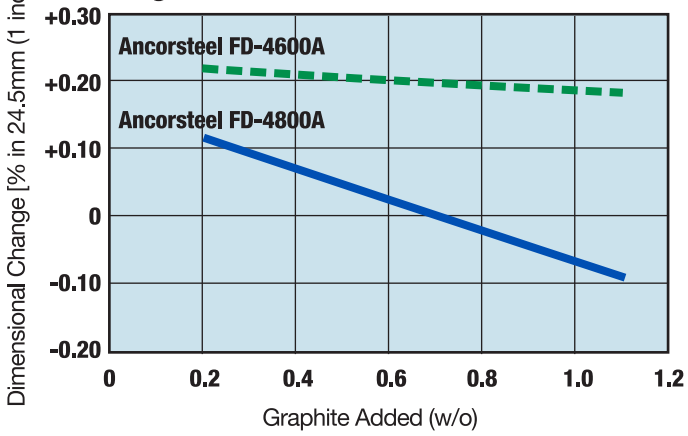
Effect of Graphite Additions and Stress Relief Annealing on Transverse Rupture Strength of Ancorsteel FD-4800A



Effect of Graphite Additions on the Sintered Hardness of Ancorsteel FD-4600A and FD-4800A



Effect of Graphite Additions on the Dimensional Change of Ancorsteel FD-4600A and FD-4800A



IMPORTANT NOTICE: *The data shown are based on laboratory processing standard test specimens. Results may vary from that obtained in production processing.*

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