

## Technical information No. 8

### Austempered ductile iron (ADI)

#### Definition

Ausferritic ductile iron, also known as austempered ductile iron (ADI) or bainitic ductile iron is characterised by a favourable combination of high strength, high fatigue strength, good wear resistance and high values for the elongation to fracture.

For a given value of elongation at fracture ADI offers about twice the strength level of conventional grades of ductile iron (see Technical information No. 2). Therefore it is a competitive material for many cast and even forged steels. However the density of ADI is approximately 10 % less than that of steel and the material's damping capacity is clearly superior to steel. So noise emission can be reduced by the use of this material.

#### Relevant standards

Material designation and material properties: DIN EN 1564

General Tolerances and machining allowance: DIN ISO 8062 valid for all designs made since August 1998 (DIN 1685, valid for designs created before August 1998)

Metallic materials – Brinell hardness test: DIN EN ISO 6506

Metallic Material – Tensile testing at ambient temperature: DIN EN 10002-1; DIN 50125

Metallic Materials – Charpy Impact tests: DIN EN 10045-1

#### Material Properties

ADI is standardised in the USA (ASTM A897-90) as well as in Europe (DIN EN 1564) although the defined material grades slightly differ. DIN EN 1564 defines the material grades according to the properties of test bars taken from separately cast samples.

#### Heat treatment

Ausferritic cast iron is produced by a multi-step heat treatment consisting of heating the casting above the AC1 temperature to achieve a completely austenitic microstructure. In a second step the casting is cooled down at a rate sufficient to avoid the formation of pearlite. The subsequent isothermal transformation takes place at a temperature above the martensite start temperature. In general temperatures are between 250°C and 450°C depending on the respective material grade. This process results in a microstructure that consist predominantly of ferrite needles and austenite. This microstructure is called ausferrite.

Isothermal transformation in the upper temperature range for the isothermal transformation leads to lower values of strength but to higher values of elongation at fracture. Lower transformation temperatures result in high strength materials with high hardness and high wear resistance but limited ductility.

To allow hardenability of greater wall thickness additions of Cu, Ni and Mo are added.

#### Mechanical and physical properties of ADI

The property values for these materials apply to separately samples cast in sand moulds or moulds of comparable thermal behaviour, regardless of the method of producing ausferritic spheroidal graphite iron, its chemical composition and heat treatment.

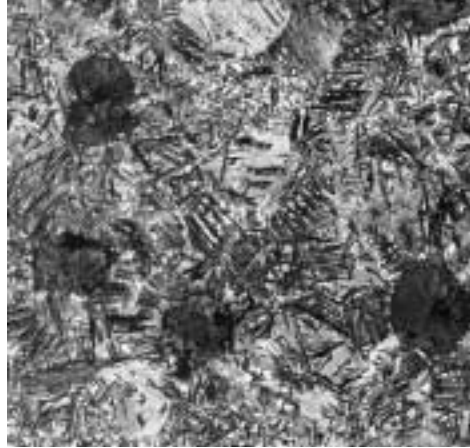
Material designation			EN-GJS-800-8	EN-GJS-1000-5	EN-GJS-1200-2	EN-GJS-1400-1
Material No.			EN-JS 1100	EN-JS 1110	EN-JS 1120	EN-JS 1130
Tensile strength	R <sub>m</sub>	N/mm <sup>2</sup>	800	1000	1200	1400
0.2 % proof stress <sup>1,1</sup>	R <sub>p0.2</sub>	N/mm <sup>2</sup>	500	700	850	1100
Elongation to fracture	A <sub>5</sub>	%	8	5	2	1
Brinell hardness	HB 30		260 - 320	300 - 360	340 - 440	380 - 480
Modulus of elasticity	E <sub>0</sub>	kN/mm <sup>2</sup>	170	168	167	165
Poisson ratio	γ		0,27	0,27	0,27	0,27
Shear modulus	G	KN/mm <sup>2</sup>	65	64	63	62
Fracture toughness	K <sub>Ic</sub>	MPa m <sup>1/2</sup>	62	58	54	50
Shear strength	T	N/mm <sup>2</sup>	720	890	1080	1260
Compression strength	R <sub>d</sub>	N/mm <sup>2</sup>	1300	1600	1900	2200
Density	ρ	Kg/dm <sup>3</sup>	7,1	7,1	7,1	7,1
Thermal conductivity	λ	W/(mK)	22,1	21,8	21,5	21,2
Coefficient of thermal expansion	α	10 <sup>-6</sup> m/(mK)	14,6	14,3	14,0	13,8

<sup>1,1</sup> Mandatory minimum values according to DIN EN 1564, Table 1

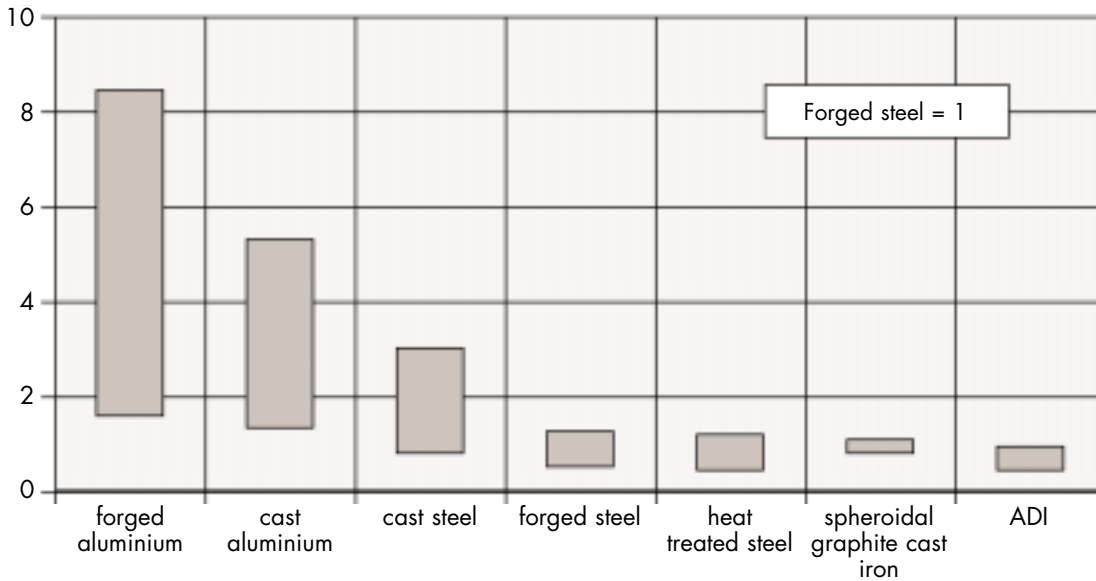
<sup>2</sup> Hardness values according to DIN EN 1564, Annex A.1

## Microstructure of EN-GJS-1000-5

The characteristic matrix microstructure of the various grades of ausferritic spheroidal graphite cast iron consists predominantly of ferrite and austenite – also known as ausferrite. Other matrix constituents (e.g. martensite, carbides) may be present at a level that will not affect the required mechanical properties. The ferrite has got a needle shape morphology and the austenite is stabilised by a high level of C. In contrast to bainitic structures of steel no carbides are present. When phase transformation during isothermal treatment starts, the solubility of C in the ferrite needles is much smaller than in the austenitic matrix. The excess C is pushed into the remaining austenite. Thereby the austenite gets more and more supersaturated. Thus the further phase transformation is hindered and the austenite is stabilised even at lower temperatures without transforming to martensite.



## Relative costs per unit of tensile strength for different construction materials



## Relative weight per unit of tensile strength for different construction materials

