DURACON® 45M

a New CoFeNi Alloy for Mould and Die Production

DURACON® 45M is a special CoNiFe alloy which combines mechanical hardness and strength with a very high thermal conductivity. It is therefore ideally suited for advanced mould and die tools for high productivity and/or excellent moulding impressions.

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Special features

+ high thermal conductivity
+ high mechanical hardness
+ high tensile strength
+ free of beryllium

Compared to classic tool alloys

+ four times higher thermal conductivity
  ⇒ reduction of cycle time
+ higher surface quality, better size and dimensional accuracy
+ very good corrosion resistance

Compared to Cu and CuBe alloys

+ higher hardness and tensile strength
+ similar thermal expansion to tool alloys
+ no beryllium

Compared to other special alloys

+ higher thermal conductivity
+ high corrosion resistance
+ extremely simple and reliable thermal hardening

DURACON® 45M has been designed to combine the best of two worlds. Compared to classic tool alloys, DURACON® 45M features a thermal conductivity up to four times higher. Compared to copper beryllium alloys, DURACON® 45M offers a higher strength and therefore a higher tool life. The production of filled materials (glass fibers, rock flour) is therefore possible.

Higher tool temperatures are possible with the same cooling times which is of advantage for the reproduction of sophisticated structures and which can improve the strength of joint lines. The high thermal conductivity avoids excessive heat or hot spots in regions which are difficult to cool. Tempering units can react faster in case of disturbances thanks to smaller temperature differences in the tool.

The features of DURACON® 45M are especially advantageous in case of variothermal tempering, independent from the heating method. Besides traditional heating with e. g. water as medium, the ferromagnetic properties allow inductive heating systems with fast reaction times and a high efficiency.

DURACON® 45M is a special alloy developed and produced by Vacuumschmelze GmbH & Co. KG (VAC), Germany. SEKELS GmbH, Germany, is an official distributor of VAC and offers DURACON® 45M ex stock.

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DURACON® 45M – typical properties

Property			Unit	Base condition (martensitic)	Hardened (500°C/2h)
Composition			Co 45 % + Ni 15 % + Fe 40 %		
Tensile strength	R_m	25 °C	MPa [=N/mm²]	950	1300*
Yield strength	$R_{p0.2}$	25 °C	MPa [=N/mm²]	700	1300*
Young's modulus	E	25 °C	GPa [=kN/mm²]	170	180
Hardness	HV	25 °C		280	480
Hardness	HRC	25 °C		28	48
		200 °C			44
		300 °C			42
		400 °C			40
Toughness (DIN EN ISO 148-1, Charpy-V)		RT	J	> 50	2,5
Maximum application temperature			°C		ca. 350**
Density	ρ		g/cm³	8,3	8,3
Thermal expansion coefficient	α	20-100 °C	10^{-6} 1/K	11,1	10,6
		20-400 °C	10^{-6} 1/K	12,1	11,3
Elektrical conductivity	σ	25 °C	mΩmm²	10	12
Thermal conductivity	λ	25 °C	W/mK	72	82
		200 °C		64	72
		400 °C		58	60
Spezific heat capacity	c_p	25 °C	J/(g K)	0,43	0,43
Ferromagnetism				Yes	Yes

DURACON® 45M in comparison to

Property	Unit	Tool alloys	1.2343	DURACON® 45M	Cu alloys	$CuBe_2$
Thermal conductivity	W/m•K	10 - 35	23	**95**	60 – 320	130
Hardness	HRC	40 – 66	~ 52	**48**	20 – 42	40
Tensile strength	MPa	900 – 2500	~ 1500	**1300***	650 - 1200	1170
Toughness	J	5 – 42	5 – 10	**< 5***	3 - 7	7
Thermal expansion	1/K	10 - 12 •10^6	11,0 •10^6	**11,2 •10^6**	16 - 18 •10^6	17,5 •10^6
Application temperature	°C	Very high	Very high	**Ca. 350****	Up to 300	Up to 300
Corrosion resistance		Poor to very good	Poor	**Good**	Good	Good
Spezific heat capacity	J/g•K	0,43 - 0,48	0,45	**0,43**	0,38 - 0,44	0,44

*In the age hardened condition the material is brittle. Due to the very low ultimate strain, the tensile strength and the yield strength cannot be determined reproducibly.

**Extrapolated from measurements at 400, 450 and 500 °C up to 1000 hours.

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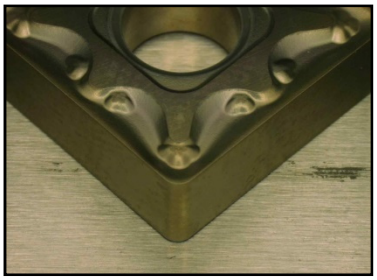
DURACON® 45M – machining

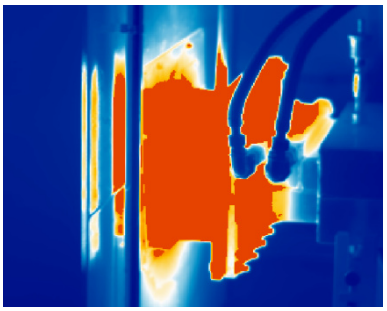
In the delivery condition (not hardened) DURACON® 45M can be machined with most machining meth- might be higher. Tests with wire eroding showed a reduced surface roughness compared with classic tool alloys. After hardening, polishing of DURACON® 45M shows very good results.

- Hardness (not hardened) 28 – 33 HRC
- Turning (coated hard metal tools)
  - higher tool wear
  - tendency to very long chips
- Good machine milling
- Threading
  - tools with TiN coating
- Very good wire and die sinking
- Good polishing
- Machining with diamond tools
  - possible w/o problems
  - free of carbon (< 0,01 %)



DURACON® 45M – hardening

Hardening of DURACON® 45M is a relatively simple process. In case of rework of the tool after hardening by means of grinding and/or polishing, the hardening process is possible even w/o protective atmosphere. However protective atmosphere avoids the building of a (thin) oxide layer.



- 500 °C, 2 hours, protective atmosphere recommended (not mandatory)
  - place material into hot furnace at 500 °C (for quick heat up)
  - 2 hours holding time after the material is fully and homogeneously heated up
  - take material out of the furnace to cool material below 200 °C in less than 2 hours
  - no enforced cooling required (but possible)
- Annealing under normal atmosphere creates a thin oxide layer (~ 1 µm)
- Slight positive change of shape (similar to typical tool steels). Measurement at hot rolled rods:
  - longitudinal growth of length: ~ 0,01 %
  - radial growth of length: ~ 0,04 %

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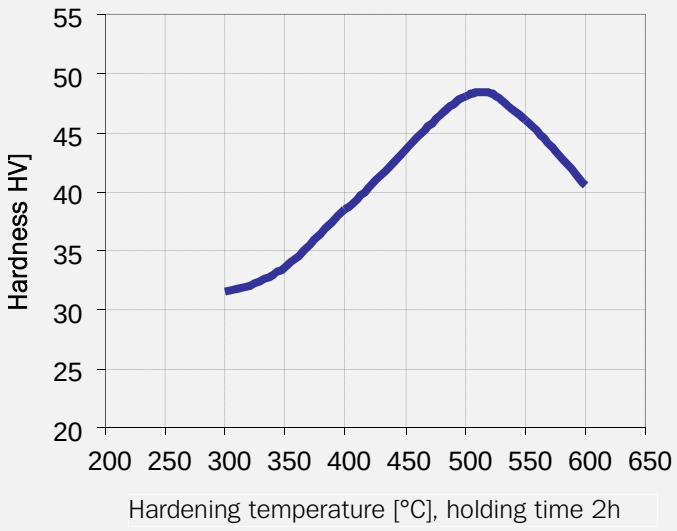
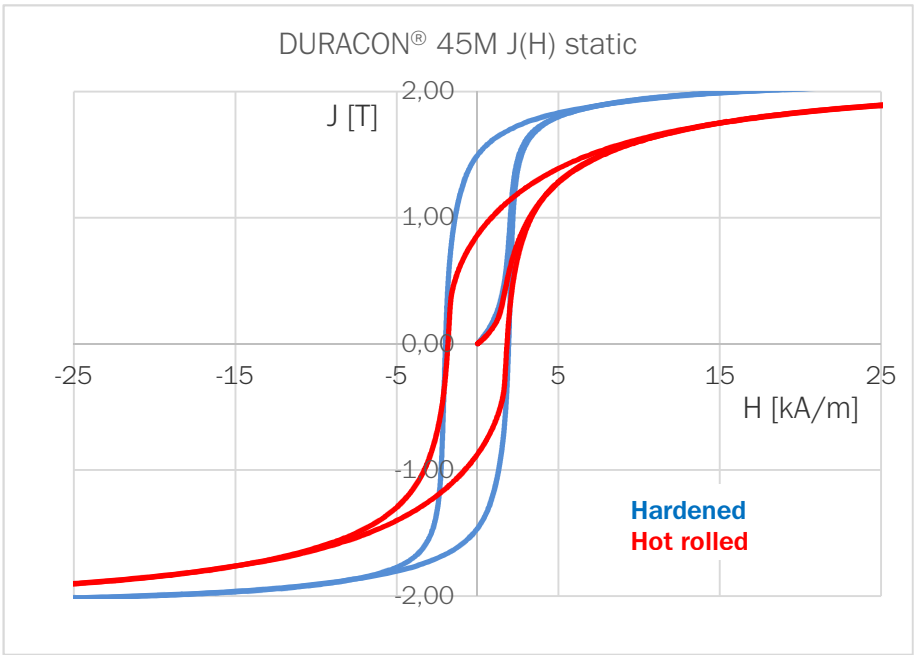
DURACON® 45M – hardening

+ martensitic microstructure from RT to more than 450 °C
+ excellent homogeneity
+ homogeneous hardness (very good through hardening)
+ high tensile strength
+ high stability up to more than 300 °C
+ thermal expansion similar to standard tool alloys
+ no degasing as DURACON® 45M is melted under vacuum
- brittle and therefore less suitable for thin and elongated parts with high shearing strainst



DURACON® 45M – magnetic properties



DURACON® 45M is ferromagnetic and combines a high saturation flux density and a moderate coercivity with excellent mechanical toughness. Besides the already mentioned option of inductive heating, this special combination, together with the good corrosion resistivity, could be of interest for some special applications. The diagram shows an example of static J(H) loops bevor and after hardening, measured at a rod of 10 mm diameter and a length of 90 mm.

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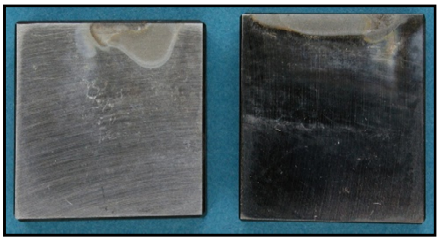
DURACON® 45M – corrosion resistance

Medium (temperature)	1.2343	DURACON® 45M
Formaldehyde 10 % (RT)	2	2
Hydrofluoric 10 % (RT)	2900	66
Sodium chloride solution 10 % (RT)	3	1
Sodium chloride solution 10 % (80°C)	2	2
Lactic acid 10 % (RT)	20	3
Lactic acid 10 % (80°C)	350	22
Nitric acid 10 % (RT)	17500	17550
Nitric acid 10 % (80°C)	70500	50700
Hydrochloric 10 % (RT)	57	7
Hydrochloric 10 % (80°C)	3900	1700

Corrosion tests in cooling water circuit, 180 °C, 24 hours:



› DURACON® 45M

› 1.2343

› Fe95Mo3W2

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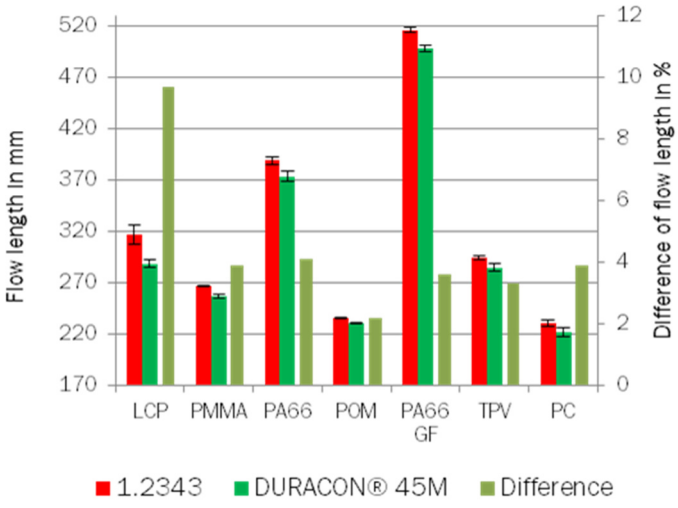
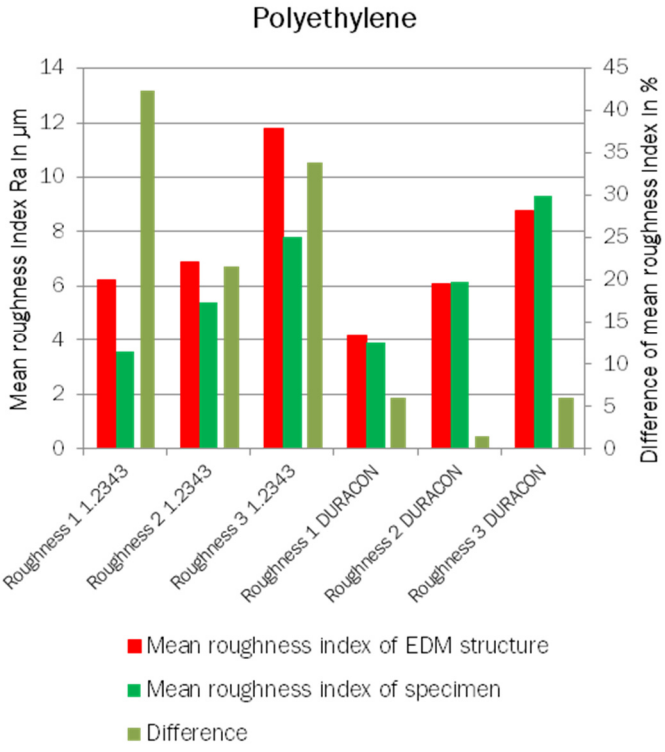
DURACON® 45M – flow length and moulding impressions

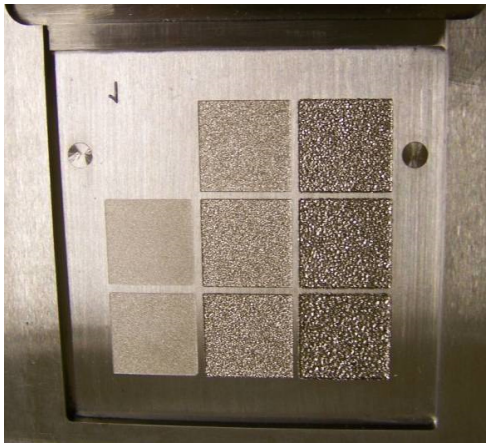
A higher thermal conductivity shortens the cycle time and increases the output. The quality of the parts is improved by more homogeneous wall temperatures. The design of the tools is simplified as a higher distance of the cooling channels to the tool wall is possible as well as lower wall thicknesses.

To demonstrate the difference the flow length of different plastic materials in a spiral has been investigated. These differences might be more pronounced under real conditions (Study of Fachhochschule Schmalkalden, see diagram on the right).



Investigations of the Fachhochschule Schmalkalden are showing that DURACON® 45M can improve the accurate reproduction of surface details depending however on the alloy and the process.





Comparison of reproduction of surface details between 1.2343 tool alloy and DURACON® 45M (Study of Fachhochschule Schmalkalden, picture left and diagram on the right).

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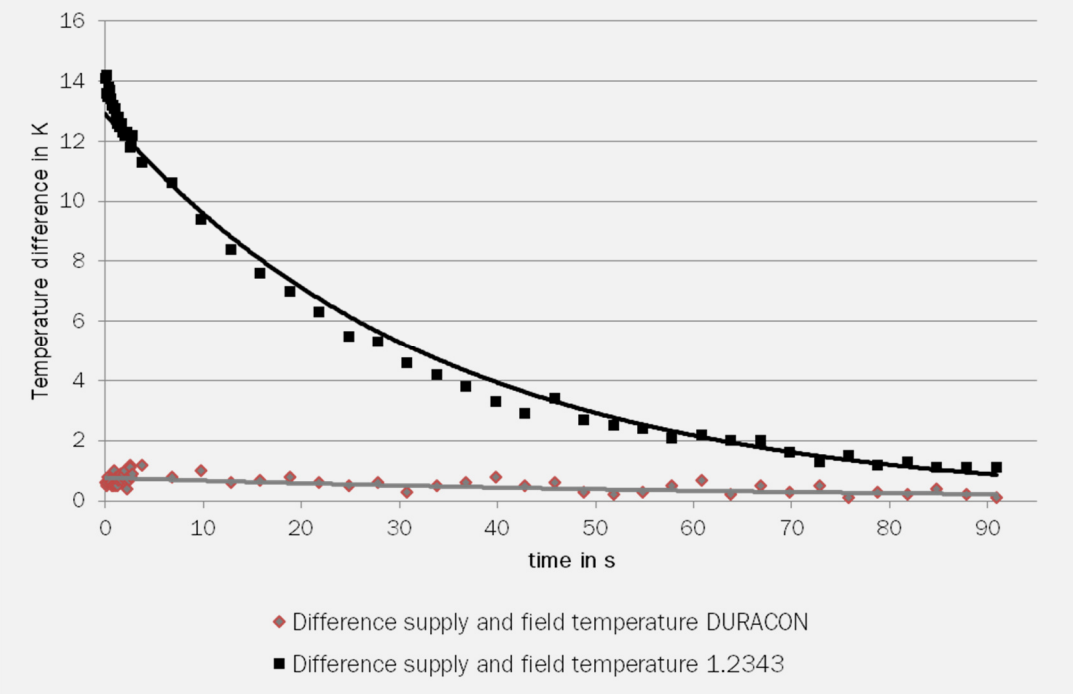
DURACON® 45M – residual cooling time and tempering behaviour

The cooling time of the tool is the dominating factor for the cycle time and cost effectiveness of an injection moulding process. When comparing DURACON® 45M with classic tool alloys and $CuBe_2$ under lab conditions, DURACON® 45M performs even better than $CuBe_2$. The reason for comparable cooling time savings is the lower heat capacity of DURACON® 45M.

In case of core parts which cannot actively be cooled, or unavoidable hot spots even higher advantages of DURACON® 45M can be expected than the results of the simple test configuration. (Study of Fachhochschule Schmalkalden).

Alloy	Plastic	Residual cooling time (s)	Saving (%)
1.2343	POM	5,62	-
DURACON® 45M	POM	5,20	7,75
$CuBe_2$	POM	5,25	6,65
1.2343	PC	2,46	-
DURACON® 45M	PC	2,21	10,07
$CuBe_2$	PC	2,24	8,87

The wall temperature of the moulding tools is controlled by the cooling media and tempering devices. Compared with classic tool alloys, DURACON® 45M reaches the required temperature level and a homogeneous temperature distribution faster. The diagram shows a comparison of the temperature difference between the supply temperature and the field temperature when heating with a steel plate (Study of Fachhochschule Schmalkalden).



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DURACON® 45M – forms of delivery

DURACON® 45M is melted in a special vacuum furnace and further processed by hot rolling and forging, followed by a homogenization annealing.

DURACON® 45M – contact address and partner

FORMS OF DELIVERY ARE

- hot rolled rods with diameters up to about 65 mm
- forged rods with diameters up to about 150 mm
- hot rolled slabs with thicknesses up to about 130 mm and widths up to about 320 – 370 mm

The rods have a length of about 3 m, the slabs of about 2 m. We cut rods and slabs to the required length and offer further mechanical machining, including the hardening process. The surface of slabs is fairly rough with width and thickness tolerances of up to ±5 mm. Please also mind edge radii of abt. 10 to 15 mm (depending on the thickness of the slab).

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