

Uddeholm Formvar®

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This information is based on our present state of knowledge and is intended to provide general notes on our products and their uses. It should not therefore be construed as a warranty of specific properties of the products described or a warranty for fitness for a particular purpose.

Classified according to EU Directive 1999/45/EC
For further information see our "Material Safety Data Sheets".

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GENERAL

Uddeholm Formvar is a high performance hot work tool steel which offers a very good resistance to hot wear and plastic deformation. Uddeholm Formvar is characterized by:

- Good temper resistance
- Good high-temperature strength
- Excellent hardenability
- Good dimensional stability throughout heat treatment and coating operations

Typical analysis %	C	Si	Mn	Cr	Mo	V
	0.35	0.2	0.5	5.0	2.3	0.6
Delivery condition	Soft annealed < 229 HB					
Colour code	Violet/yellowgreen					

HOT WORK APPLICATIONS

TOOLS FOR EXTRUSION

Part	Copper, copper alloys HRC	Aluminium, magnesium alloys HRC
Dies	-	46-52
Liners, dummy blocks, stems	46-52	44-52

TOOLS FOR HOT FORGING

Part	Steel, Aluminium, HRC
Inserts	44-52

PROPERTIES

PHYSICAL PROPERTIES

Data at room and elevated temperatures.

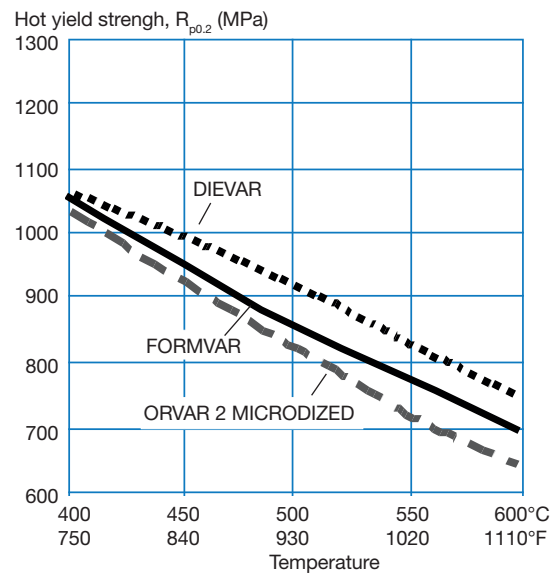
Temperature	20°C (68°F)	400°C (750°F)	600°C (1110°F)
Thermal conductivity W/m °C	-	31	32
Btu in/(ft²h°F)	-	216	223

MECHANICAL PROPERTIES

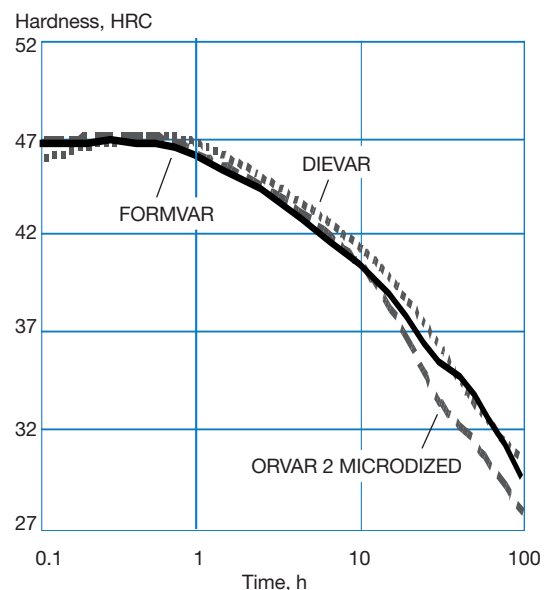
Tensile properties at room temperature, short transverse direction.

Hardness	44 HRC	48 HRC	52 HRC
Tensile strength R_m	1480 MPa 96 tsi 214 000 psi	1640 MPa 106 tsi 237 000 psi	1900 MPa 123 tsi 275 000 psi
Yield strength $R_{p0.2}$	1210 MPa 78 tsi 175 000 psi	1380 MPa 89 tsi 200 000 psi	1560 MPa 101 tsi 226 000 psi

RESISTANCE TO PLASTIC DEFORMATION AT ELEVATED TEMPERATURE



TEMPERING RESISTANCE AT 600°C (1110°F)



HEAT TREATMENT GENERAL RECOMMENDATIONS

SOFT ANNEALING

Protect the steel and heat through to 850°C (1560°F). Then cool in furnace at 10°C (20°F) per hour to 600°C (1110°F), then freely in air.

STRESS RELIEVING

After rough machining the tool should be heated through to 650°C (1200°F), holding time 2 hours. Cool slowly to 500°C (930°F), then freely in air.

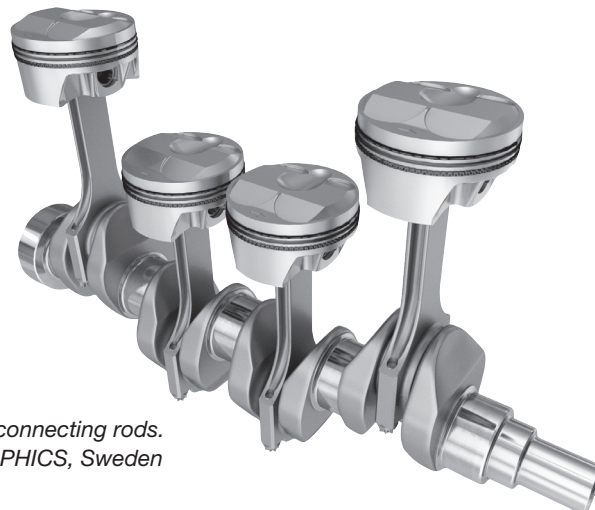
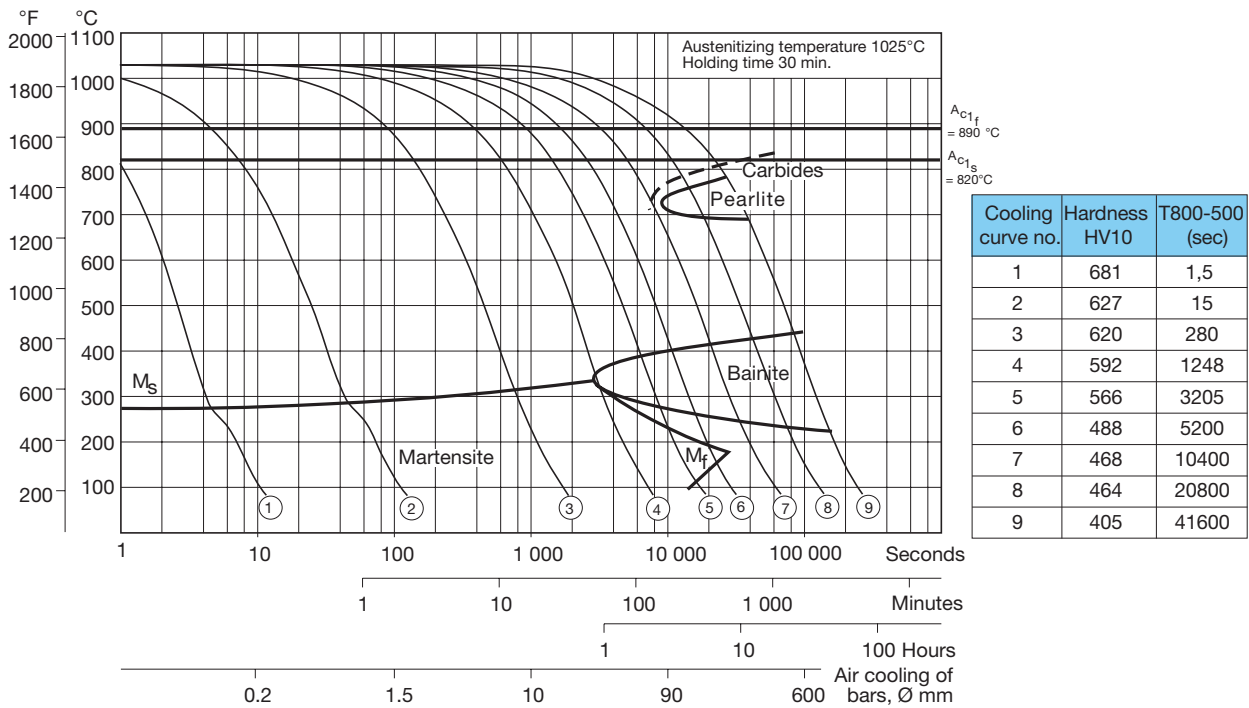
HARDENING

Preheating temperature: 600–900°C (1110–1650°F). Normally a minimum of two preheats, the first in the 600–650°C (1110–1200°F) range, and the second in the 820–850°C (1510–1560°F) range. When three preheats are used the second is carried out at 820°C (1510°F) and the third at 900°C (1650°F).

Austenitizing temperature: 1000–1030°C (1830–1890°F).

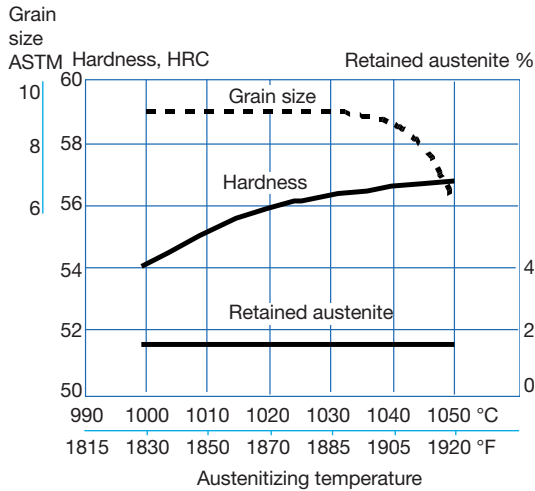
CCT GRAPH

Austenitizing temperature 1025°C (1875°F). Holding time 30 minutes.



Crankshaft and connecting rods.
Illustration: GRAPHICS, Sweden

HARDNESS, GRAIN SIZE AND RETAINED AUSTENITE AS FUNCTIONS OF AUSTENITIZING TEMPERATURE



QUENCHING

RECOMMENDED QUENCHING MEDIA

- High speed gas/circulating atmosphere
- Vacuum (high speed gas with sufficient positive pressure). An interrupted quench at 320–450°C (610–840°F) is recommended where distortion control and quench cracking are a concern
- Martempering bath, salt bath or fluidized bed at 450–550°C (840–1020°F)
- Martempering bath, salt bath or fluidized bed at 180–200°C (360–390°F)
- Warm oil, approx. 80°C (180°F)

Note: Temper the tool as soon as its temperature reaches 50–70°C (120–160°F).

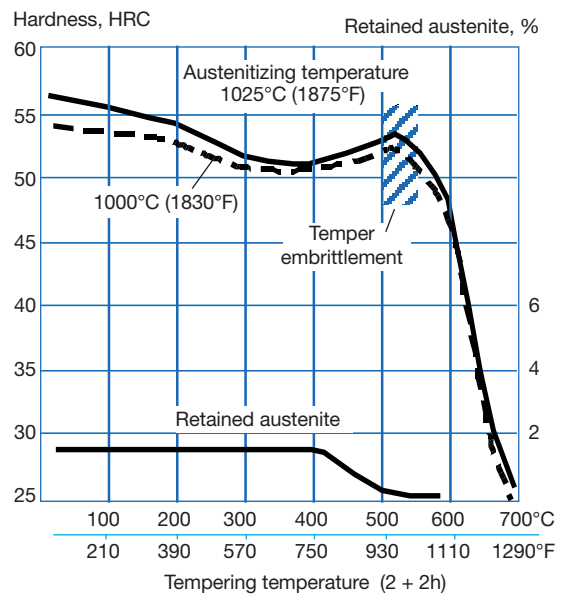


TEMPERING

Choose the tempering temperature according to the hardness required by reference to the tempering graph below. Temper minimum twice for forging and extrusion tools with intermediate cooling to room temperature. Holding time at temperature minimum 2 hours.

Tempering in the range of 500–550°C (930–1020°F) for the intended final hardness will result in a lower toughness.

TEMPERING GRAPH



Above tempering curves are obtained after heat treatment of samples with a size of 15 x 15 x 40 mm, cooling in forced air. Lower hardness can be expected after heat treatment of tools and dies due to factors like actual tool size and heat treatment parameters.

NITRIDING AND NITROCARBURIZING

Nitriding and nitrocarburizing result in a hard surface layer which has the potential to improve resistance to wear and soldering, as well as resistance to premature heat checking.

Uddeholm Formvar can be nitrided and nitrocarburized via a plasma, gas, fluidized bed, or salt process. The temperature for the deposition process should be minimum 25–50°C (50–90°F) below the highest previous tempering temperature, depending upon the process time and temperature. Otherwise a permanent loss of core hardness, strength, and/or dimensional tolerances may be experienced.

During nitriding and nitrocarburizing, a brittle compound layer, known as the white layer, may be generated. The white layer is very brittle and may result in cracking or spalling when exposed to heavy mechanical or thermal loads. As a general rule the white layer formation must be avoided.

Nitriding in ammonia gas at 510°C (950°F) or plasma nitriding at 480°C (895°F) both result in a surface hardness of approx. 1100 HV_{0.2}.

In general, plasma nitriding is the preferred method because of better control over nitrogen potential. However, careful gas nitriding can give same results.

The surface hardness after nitrocarburizing in either gas or salt bath at 580°C (1075°F) is approx. 1100 HV_{0.2}.

DEPTH OF NITRIDING

Process	Time	Depth*	Hardness HV _{0.2}
Gas nitriding at 510°C (950°F)	10 h	0.16 mm 0.0063 inch	1100
	30 h	0.22 mm 0.0087 inch	1100
Plasma nitriding at 480°C (895°F)	10 h	0.15 mm 0.0059 inch	1100
Nitrocarburizing – in gas at 580°C (1075°F) – in salt bath at 580°C (1075°F)	2 h	0.13 mm 0.0051 inch	1100
	1 h	0.08 mm 0.0031 inch	1100

* Depth of case = distance from surface where hardness is 50 HV_{0.2} over base hardness



Tool for production of connecting rods.

CUTTING DATA RECOMMENDATIONS

The cutting data below are to be considered as guiding values which must be adapted to existing local condition.

The recommendations, in following tables, are valid for Uddeholm Formvar in soft annealed condition.

TURNING

Cutting data parameters	Turning with carbide		Turning with high speed steel Fine turning
	Rough turning	Fine turning	
Cutting speed (v_c) m/min f.p.m.	150–200 490–655	200–250 655–820	15–20 50–65
Feed (f) mm/rev. i.p.r.	0.2–0.4 0.008–0.016	0.05–0.2 0.002–0.008	0.05–0.3 0.002–0.012
Depth of cut (a_p) mm inch	2–4 0.08–0.16	0.5–2 0.02–0.08	0.5–2 0.02–0.08
Carbide designation ISO US	P20–P30 C6–C5 Coated carbide	P10 C7 Coated carbide or cermet	– –

MILLING

FACE- AND SQUARE SHOULDER MILLING

Cutting data parameters	Milling with carbide	
	Rough milling	Fine milling
Cutting speed (v_c) m/min f.p.m.	130–180 430–590	180–220 590–720
Feed (f_z) mm/tooth inch/tooth	0.2–0.4 0.008–0.016	0.1–0.2 0.004–0.008
Depth of cut (a_p) mm inch	2–4 0.08–0.16	–2 –0.08
Carbide designation ISO US	P20–P40 C6–C5 Coated carbide	P10 C7 Coated carbide or cermet

END MILLING

Cutting data parameters	Type of milling		
	Solid carbide	Carbide indexable insert	High speed steel
Cutting speed (v_c) m/min f.p.m.	130–170 425–560	120–160 390–520	25–30 ¹⁾ 80–100 ¹⁾
Feed (f_z) mm/tooth inch/tooth	0.03–0.20 ²⁾ 0.001–0.008 ²⁾	0.08–0.20 ²⁾ 0.003–0.008 ²⁾	0.05–0.35 ²⁾ 0.002–0.014 ²⁾
Carbide designation ISO US	–	P20–P30 C6–C5	– –

¹⁾ For coated HSS end mill $v_c = 45–50$ m/min. (150–160 f.p.m.)

²⁾ Depending on radial depth of cut and cutter diameter

DRILLING

HIGH SPEED STEEL TWIST DRILL

Drill diameter		Cutting speed (v_c)		Feed (f)	
mm	inch	m/min	f.p.m.	mm/rev.	i.p.r.
– 5	–3/16	15–20*	49–66*	0.05–0.15	0.002–0.006
5–10	3/16–3/8	15–20*	49–66*	0.15–0.20	0.006–0.008
10–15	3/8–5/8	15–20*	49–66*	0.20–0.25	0.008–0.010
15–20	5/8–3/4	15–20*	49–66*	0.25–0.35	0.010–0.014

* For coated HSS drill $v_c = 35–40$ m/min. (110–130 f.p.m.)

CARBIDE DRILL

Cutting data parameters	Type of drill		
	Indexable insert	Solid carbide	Carbide tip ¹⁾
Cutting speed (v_c) m/min f.p.m.	180–220 590–720	120–150 390–490	60–90 195–295
Feed (f) mm/rev. i.p.r.	0.05–0.25 ²⁾ 0.002–0.01 ²⁾	0.10–0.25 ³⁾ 0.004–0.01 ³⁾	0.15–0.25 ⁴⁾ 0.006–0.01 ⁴⁾

¹⁾ Drill with replaceable or brazed carbide tip

²⁾ Feed rate for drill diameter 20–40 mm (0.8”–1.6”)

³⁾ Feed rate for drill diameter 5–20 mm (0.2”–0.8”)

⁴⁾ Feed rate for drill diameter 10–20 mm (0.4”–0.8”)

CUTTING DATA RECOMMENDATIONS

The cutting data below should be considered as guidelines only. These guidelines must be adapted to local machining conditions.

The recommendations, in following tables, are valid for Uddeholm Formvar hardened and tempered to 44–46 HRC.

TURNING

Cutting data parameters	Turning with carbide	
	Rough turning	Fine turning
Cutting speed (v_c) m/min f.p.m.	40–60 130–195	70–90 230–295
Feed (f) mm/rev. i.p.r.	0.2–0.4 0.008–0.016	0.05–0.2 0.002–0.008
Depth of cut (a_p) mm inch	1–2 0.04–0.08	0.5–1 0.02–0.04
Carbide designation ISO US	P20–P30 C6–C5 Coated carbide	P10 C7 Coated carbide or mixed ceramic

DRILLING

HIGH SPEED STEEL TWIST DRILL (TiCN COATED)

Drill diameter		Cutting speed (v_c)		Feed (f)	
mm	inch	m/min	f.p.m.	mm/rev.	i.p.r.
– 5	–3/16	4–6	13–20	0.05–0.10	0.002–0.004
5–10	3/16–3/8	4–6	13–20	0.10–0.15	0.004–0.006
10–15	3/8–5/8	4–6	13–20	0.15–0.20	0.006–0.008
15–20	5/8–3/4	4–6	13–20	0.20–0.30	0.008–0.012

CARBIDE DRILL

Cutting data parameters	Type of drill		
	Indexable insert	Solid carbide	Carbide tip ¹⁾
Cutting speed (v_c) m/min f.p.m.	60–80 195–260	60–80 195–260	40–50 130–160
Feed (f) mm/rev. i.p.r.	0.05–0.25 ²⁾ 0.002–0.01 ²⁾	0.10–0.25 ³⁾ 0.004–0.01 ³⁾	0.15–0.25 ⁴⁾ 0.006–0.01 ⁴⁾

¹⁾ Drill with replaceable or brazed carbide tip

²⁾ Feed rate for drill diameter 20–40 mm (0.8”–1.6”)

³⁾ Feed rate for drill diameter 5–20 mm (0.2”–0.8”)

⁴⁾ Feed rate for drill diameter 10–20 mm (0.4”–0.8”)

MILLING

FACE- AND SQUARE SHOULDER MILLING

Cutting data parameters	Milling with carbide	
	Rough milling	Fine milling
Cutting speed (v_c) m/min f.p.m.	50–90 160–295	90–130 295–425
Feed (f_z) mm/tooth inch/tooth	0.2–0.4 0.008–0.016	0.1–0.2 0.004–0.008
Depth of cut (a_p) mm inch	2–4 0.08–0.16	–2 –0.08
Carbide designation ISO US	P20–P40 C6–C5 Coated carbide	P10 C7 Coated carbide or cermet

END MILLING

Cutting data parameters	Type of milling		
	Solid carbide	Carbide indexable insert	High speed steel TiCN coated
Cutting speed (v_c) m/min f.p.m.	60–80 195–260	70–90 230–295	5–10 16–33
Feed (f_z) mm/tooth inch/tooth	0.03–0.20 ¹⁾ 0.001–0.008 ¹⁾	0.08–0.20 ¹⁾ 0.003–0.008 ¹⁾	0.05–0.35 ¹⁾ 0.002–0.014 ¹⁾
Carbide designation ISO US	–	P10–P20 C6–C5	– –

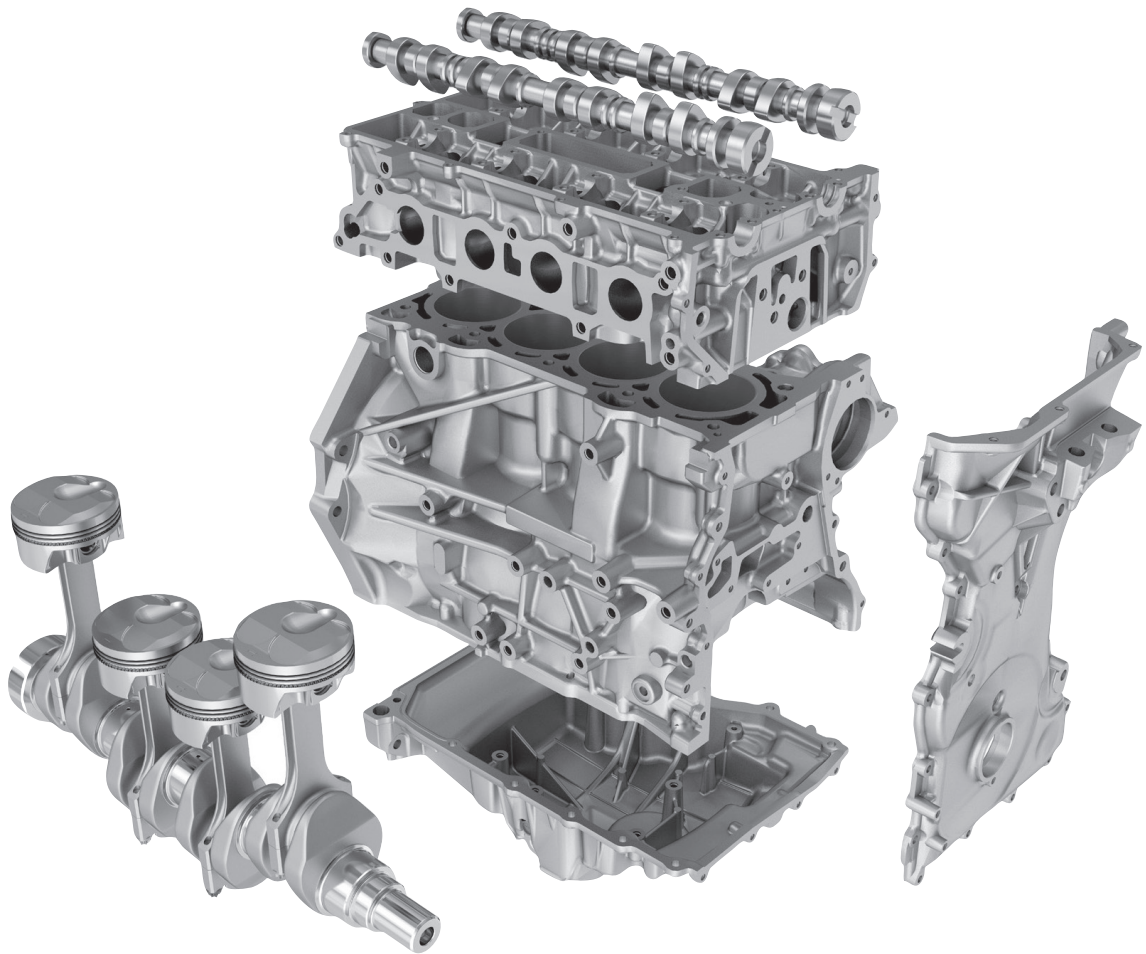
¹⁾ Depending on radial depth of cut and cutter diameter

GRINDING

A general grinding wheel recommendation is given below. More information can be found in the Uddeholm publication “Grinding of Tool Steel”.

WHEEL RECOMMENDATION

Type of grinding	Soft annealed condition	Hardened condition
Face grinding straight wheel	A 46 HV	A 46 HV
Face grinding segments	A 24 GV	A 36 GV
Cylindrical grinding	A 46 LV	A 60 KV
Internal grinding	A 46 JV	A 60 IV
Profile grinding	A 100 LV	A 120 JV



*Engine parts.
Illustration: GRAPHICS, Sweden*

THE CONVENTIONAL TOOL STEEL PROCESS

The starting material for our tool steel is carefully selected from high quality recyclable steel. Together with ferroalloys and slag formers, the recyclable steel is melted in an electric arc furnace. The molten steel is then tapped into a ladle.

The de-slagging unit removes oxygen-rich slag and after the de-oxidation, alloying and heating of the steel bath are carried out in the ladle furnace. Vacuum degassing removes elements such as hydrogen, nitrogen and sulphur.

In uphill casting the prepared moulds are filled with a controlled flow of molten steel from the ladle. From this, the steel goes directly to our rolling mill or to the forging press to be formed into round or flat bars.

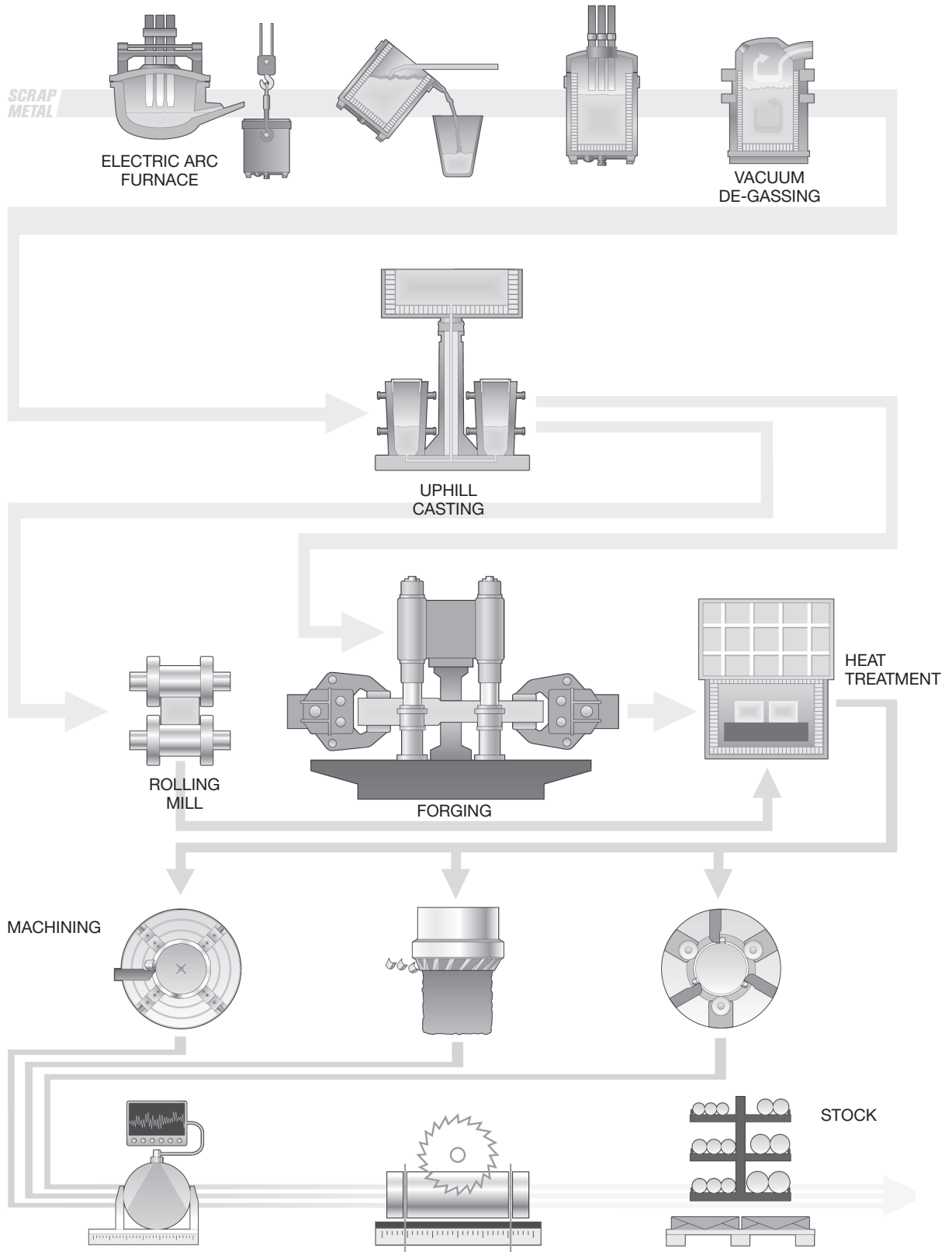
HEAT TREATMENT

Prior to delivery all of the different bar materials are subjected to a heat treatment operation, either as soft annealing or hardening and tempering. These operations provide the steel with the right balance between hardness and toughness.

MACHINING

Before the material is finished and put into stock, we also rough machine the bar profiles to required size and exact tolerances. In the lathe machining of large dimensions, the steel bar rotates against a stationary cutting tool. In peeling of smaller dimensions, the cutting tools revolve around the bar.

To safeguard our quality and guarantee the integrity of the tool steel we perform both surface- and ultrasonic inspections on all bars. We then remove the bar ends and any defects found during the inspection.



Manufacturing solutions for generations to come

SHAPING THE WORLD®

We are shaping the world together with the global manufacturing industry. Uddeholm manufactures steel that shapes products used in our every day life. We do it sustainably, fair to people and the environment. Enabling us to continue shaping the world – today and for generations to come.