FORMVAR

UDDEHOLM FORMVAR

ASSAB	UDDEHOLM a voestalpine company	REFERENCE STANDARD		
		AISI	WNr.	JIS
ASSAB DF-3	ARNE	O1	1.2510	SKS 3
ASSAB XW-10	RIGOR	A2	1.2363	SKD 12
ASSAB XW-42	SVERKER 21	D2	1.2379	(SKD 11)
CALMAX / CARMO	CALMAX / CARMO		1.2358	
VIKING	VIKING / CHIPPER		(1.2631)	
CALDIE	CALDIE			
ASSAB 88	SLEIPNER			
ASSAB PM 23 SUPERCLEAN	VANADIS 23 SUPERCLEAN	(M3:2)	1.3395	(SKH 53)
ASSAB PM 30 SUPERCLEAN	VANADIS 30 SUPERCLEAN	(M3:2 + Co)	1.3294	SKH 40
ASSAB PM 60 SUPERCLEAN	VANADIS 60 SUPERCLEAN		(1.3292)	
VANADIS 4 EXTRA SUPERCLEAN	VANADIS 4 EXTRA SUPERCLEAN			
VANADIS 8 SUPERCLEAN	VANADIS 8 SUPERCLEAN			
VANCRON SUPERCLEAN	VANCRON SUPERCLEAN			
ELMAX SUPERCLEAN	ELMAX SUPERCLEAN			
VANAX SUPERCLEAN	VANAX SUPERCLEAN			
ASSAB 518		P20	1.2311	
ASSAB 618 T		(P20)	(1.2738)	
ASSAB 618 / 618 HH		(P20)	1.2738	
ASSAB 718 SUPREME / 718 HH	IMPAX SUPREME / IMPAX HH	(P20)	1.2738	
NIMAX / NIMAX ESR	NIMAX / NIMAX ESR			
VIDAR 1 ESR	VIDAR 1 ESR	H11	1.2343	SKD 6
UNIMAX	UNIMAX			
CORRAX	CORRAX			
ASSAB 2083		420	1.2083	SUS 420J2
STAVAX ESR	STAVAX ESR	(420)	(1.2083)	(SUS 420J2)
MIRRAX ESR	MIRRAX ESR	(420)		
MIRRAX 40	MIRRAX 40	(420)		
TYRAX ESR	TYRAX ESR			
POLMAX	POLMAX	(420)	(1.2083)	(SUS 420J2)
ROYALLOY	ROYALLOY	(420 F)		
COOLMOULD	COOLMOULD			
ASSAB 2714			1.2714	SKT 4
ASSAB 2344		H13	1.2344	SKD 61
ASSAB 8407 2M	ORVAR 2M	H13	1.2344	SKD 61
ASSAB 8407 SUPREME	ORVAR SUPREME	H13 Premium	1.2344	SKD 61
DIEVAR	DIEVAR			
QRO 90 SUPREME	QRO 90 SUPREME			
FORMVAR	FORMVAR			

( ) - modified grade

Edition 20200413

20190618

GENERAL

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

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

Typical analysis %	C 0.35	Si 0.2	Mn 0.5	Cr 5.0	Mo 2.3	V 0.6
Standard specification	None					
Delivery condition	Soft annealed to approx < 229HB.					

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
Inserts	44 – 52

PROPERTIES

PHYSICAL PROPERTIES

Data at room and elevated temperatures.

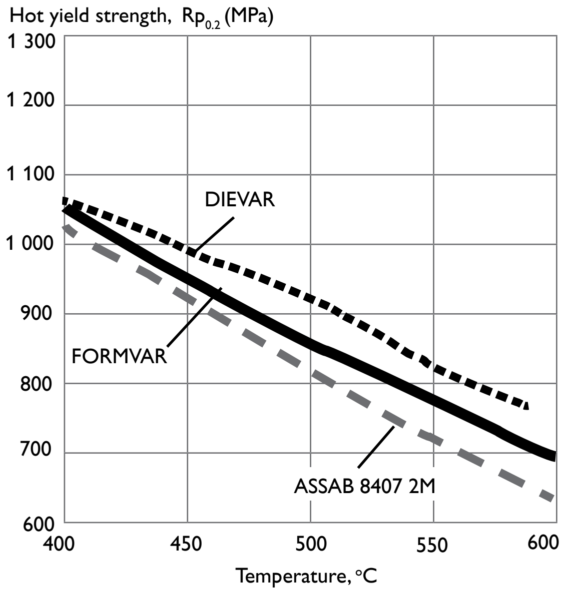
Temperature	20 °C	400 °C	600 °C
Thermal conductivity* W/m °C	-	31	32

MECHANICAL PROPERTIES

TENSILE PROPERTIES AT ROOM TEMPERATURE, SHORT TRANSVERSE DIRECTION

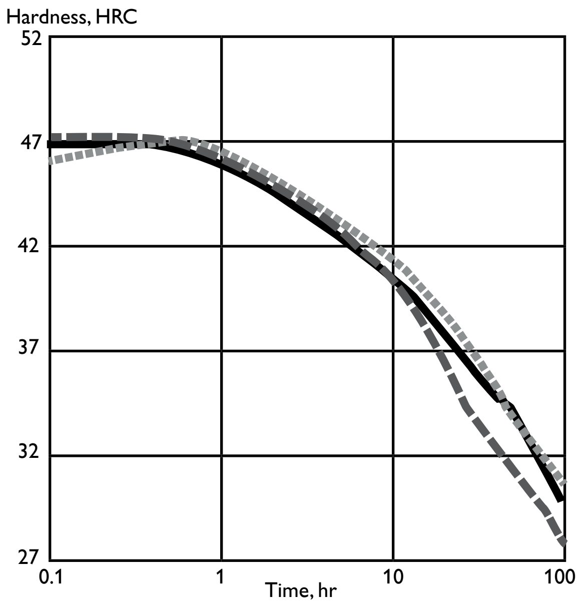
Hardness	44 HRC	48 HRC	52 HRC
Tensile strength, R_m MPa	1 480	1 640	1 900
Yield point Rp0.2 MPa	1 210	1 380	1 560

RESISTANCE TO PLASTIC DEFORMATION AT ELEVATED TEMPERATURE



TEMPERING RESISTANCE AT 600°C

Austenitising : 1020 °C/30 min
Tempering: 616 °C / 2 x 2h.



HEAT TREATMENT

SOFT ANNEALING

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

STRESS RELIEVING

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

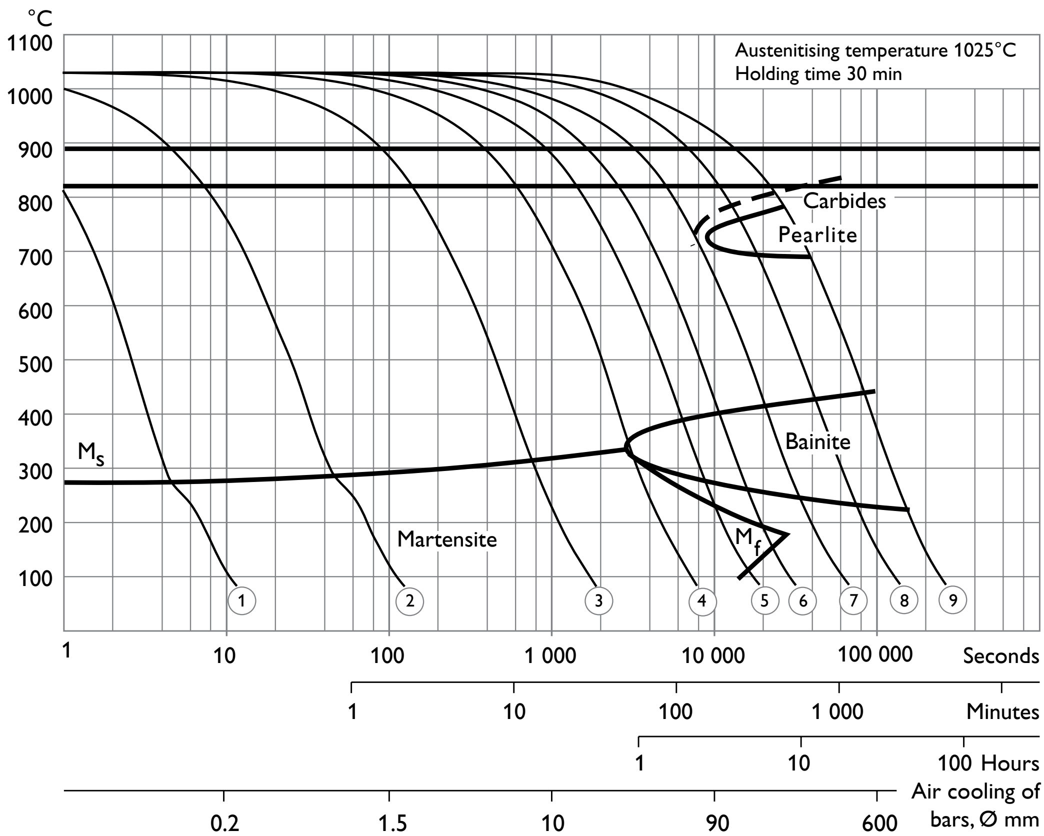
HARDENING

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

Austenitising temperature: 1000 – 1030°C.

CCT-GRAPH

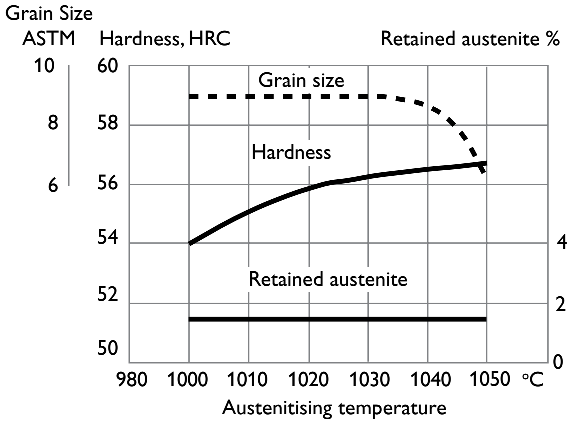
Austenitising temperature 1025 °C. Holding time 30 minutes.



Cooling Curve No.	Hardness HV 10	$T_{800-500}$ sec
1	681	1.5
2	627	15
3	620	280
4	592	1 248
5	566	3 205
6	488	5 200
7	468	10 400
8	464	20 800
9	405	41 600

Crankshaft and connecting rods.
Illustration, GRAPHICS, Sweden

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



QUENCHING

QUENCHING MEDIA

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

Note: Temper the tool as soon as its temperature reaches 50-70°C.

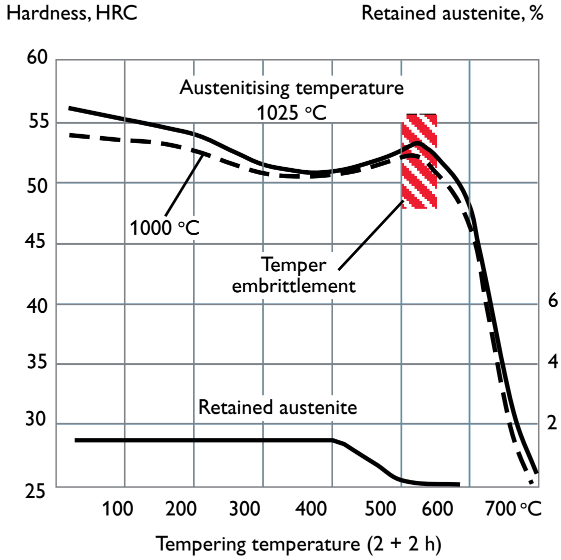
TEMPERING

Choose the tempering temperature according to the hardness required by reference to the tempering graph below. Temper minimum three times for die casting dies and 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 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 NITROCARBURISING

Nitriding and nitrocarburising 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.

Formvar can be nitrided and nitrocarburising via a plasma, gas, fluidised bed, or salt process. The temperature for the deposition process should be minimum 25 - 50 °C 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 nitrocarburising, 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 or plasma nitriding at 480 °C 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 nitrocarburising in either gas or salt bath at 580 °C is approx. 1100 $HV_{0.2}$.

DEPTH OF NITRIDING

Process	Time	Hardness Depth*	$HV_{0.2}$
Gas nitriding at 510 °C	10 h	0.16 mm	1 100
	30 h	0.22 mm	1 100
Plasma nitriding at 480 °C	10 h	0.15 mm	1 100
Nitrocarburising - in gas at 580 °C	2 h	0.13 mm	1 100
- in salt bath at 580 °C	1 h	0.08 mm	1 100

* 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 should be considered as guidelines values which must be adapted to existing local condition.

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

TURNING

Cutting data parameters	Turning with carbide		Turning with High speed steel
	Rough turning	Fine turning	Fine turning
Cutting speed (v_C), m/min	150 – 200	200 – 250	15 - 20
Feed (f) mm/rev	0.2 – 0.4	0.05 – 0.2	0.05 -0.3
Depth of cut (a_p) mm	2 – 4	0.5 – 2	0.5 - 2
Carbide designation ISO	P20 - P30 Coated carbide	P10 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	130 – 180	180 – 220
Feed (f_z) mm/tooth	0.2 – 0.4	0.1 – 0.2
Depth of cut (a_p) mm	2 – 4	< 2
Carbide designation ISO	P20 – P40 Coated carbide	P10 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	130 – 170	120 – 160	25 – 30 [1)]
Feed (f_z) mm/tooth	0.03 – 0.20 [2)]	0.08 – 0.20 [2)]	0.05 – 0.35 [2)]
Carbide designation ISO	–	P20 – P30	–

[1)] For coated HSS end mill, vc ~ 45 – 50 m/min
[2)] Depending on radial depth of cut and cutter diameter

DRILLING

HIGH SPEED STEEL TWIST DRILL

Drill diameter mm	Cutting speed (v_C) m/min	Feed (f) mm/r
≤ 5	15 – 20 *	0.05 – 0.15
5 – 10	15 – 20 *	0.15 – 0.20
10 – 15	15 – 20 *	0.20 – 0.25
15 – 20	15 – 20 *	0.25 – 0.35

* For coated HSS drill v_c = 35 - 40 m/min.

CARBIDE DRILL

Cutting data parameters	Type of drill		
	Indexable insert	Solid carbide	Carbide tip [1)]
Cutting speed (v_C), m/min	180 – 220	120 – 150	60 – 90
Feed (f) mm/r	0.05 – 0.25 [2)]	0.10 – 0.25 [3)]	0.15 – 0.25 [4)]

[1)] Drill with replaceable or brazed carbide tip
[2)] Feed rate for drill diameter 20 – 40 mm
[3)] Feed rate for drill diameter 5 – 20 mm
[4)] Feed rate for drill diameter 10 – 20 mm

GRINDING

WHEEL RECOMMENDATION

Type of grinding	Soft annealed	Hardened
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

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 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	40 – 60	70 – 90
Feed (f) mm/rev	0.2 – 0.4	0.05 – 0.2
Depth of cut (a_p) mm	1 – 2	0.5 – 1
Carbide designation ISO	P20 - P30 Coated carbide	P10 Coated carbide or cermet

DRILLING

HIGH SPEED STEEL TWIST DRILL (TiCn COATED)

Drill diameter mm	Cutting speed (v_C) m/min	Feed (f) mm/r
≤ 5	13 – 20	0.05 – 0.10
5 – 10	13 – 20	0.10 – 0.15
10 – 15	13 – 20	0.15 – 0.20
15 – 20	13 – 20	0.20 – 0.30

CARBIDE DRILL

Cutting data parameters	Type of drill		
	Indexable insert	Solid carbide	Carbide tip [1]
Cutting speed (v_C), m/min	60 – 80	60 – 80	40 – 50
Feed (f) mm/r	0.05 – 0.25 [2]	0.10 – 0.25 [3]	0.15 – 0.25 [4]

[1] Drill with replaceable or brazed carbide tip
[2] Feed rate for drill diameter 20 – 40 mm
[3] Feed rate for drill diameter 5 – 20 mm
[4] Feed rate for drill diameter 10 – 20 mm

MILLING

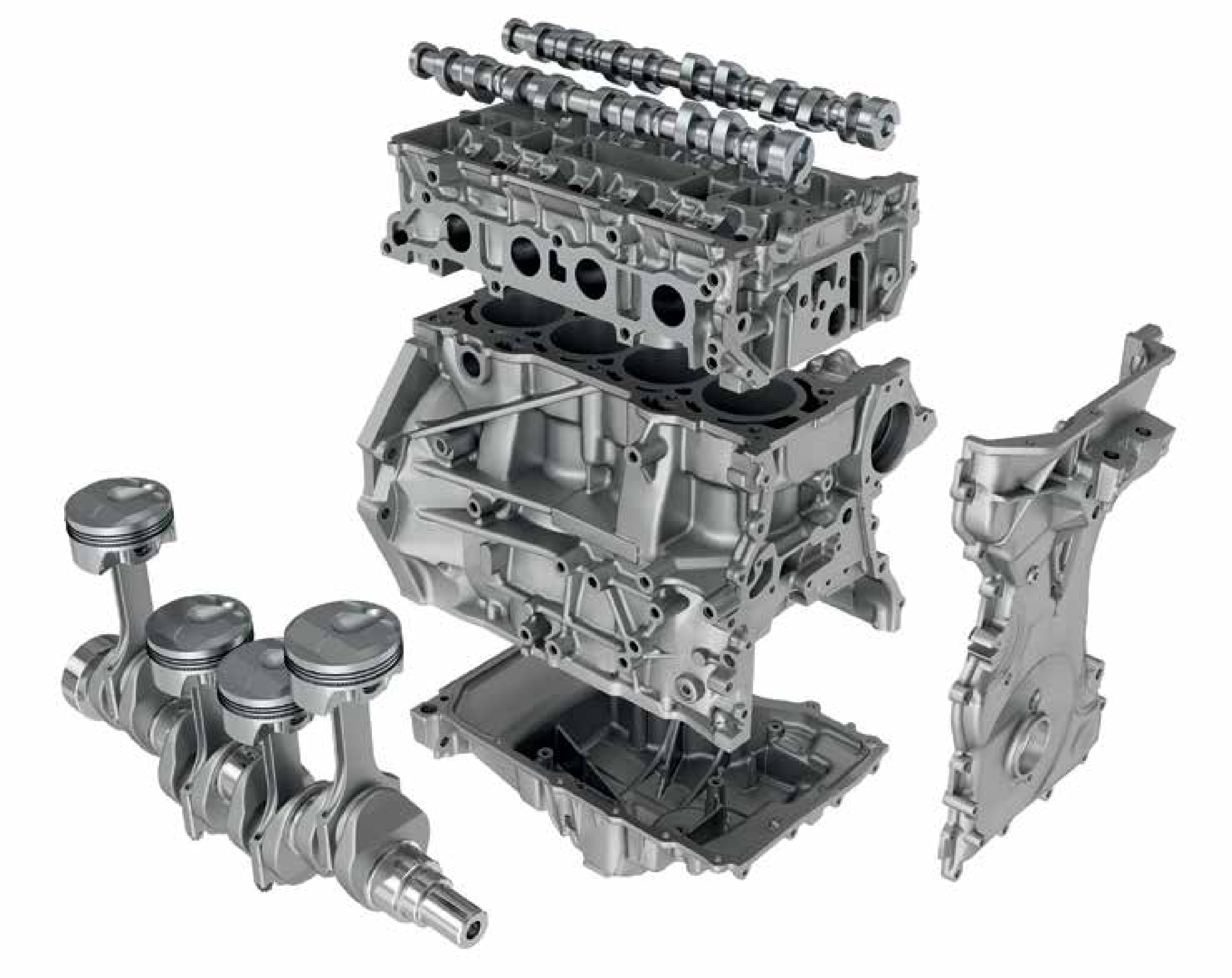
FACE AND SQUARE SHOULDER MILLING

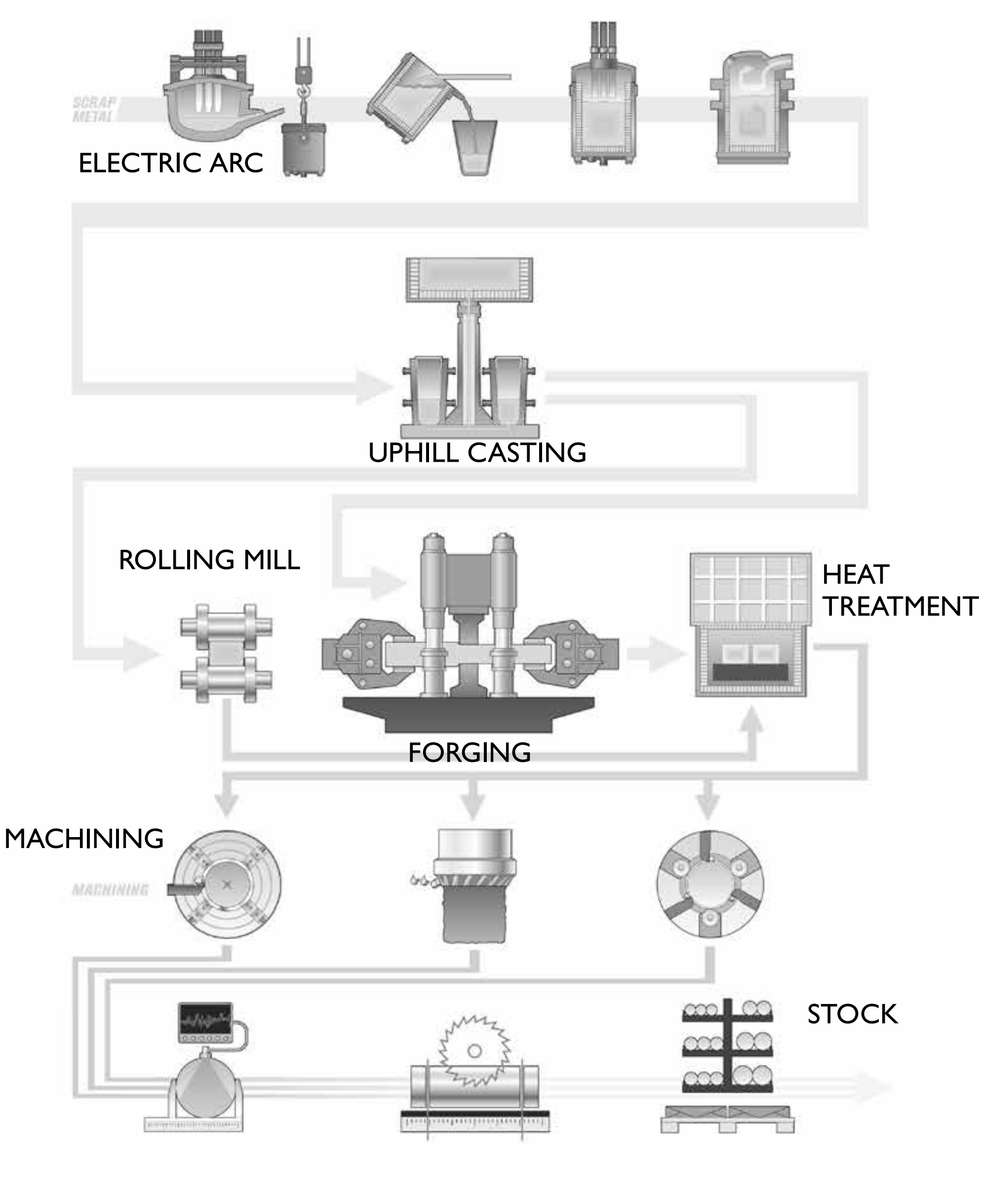
Cutting data parameters	Milling with carbide	
	Rough milling	Fine milling
Cutting speed (v_C) m/min	50 – 90	90 – 130
Feed (f_z) mm/tooth	0.2 – 0.4	0.1 – 0.2
Depth of cut (a_p) mm	2 – 4	< 2
Carbide designation ISO	P20 - P40 Coated carbide	P10 Coated carbide or cermet

END MILLING

Cutting data parameters	Type of milling		
	Solid carbide	Carbide indexable insert	High speed steel
Cutting speed (v_C), m/min	60 – 80	70 – 90	5 – 10
Feed (f_z) mm/tooth	0.03 – 0.20 [1]	0.08 – 0.20 [1]	0.05 – 0.35 [1]
Carbide designation ISO	–	P10 – P20	–

[1] Depending on radial depth of cut and cutter diameter





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.

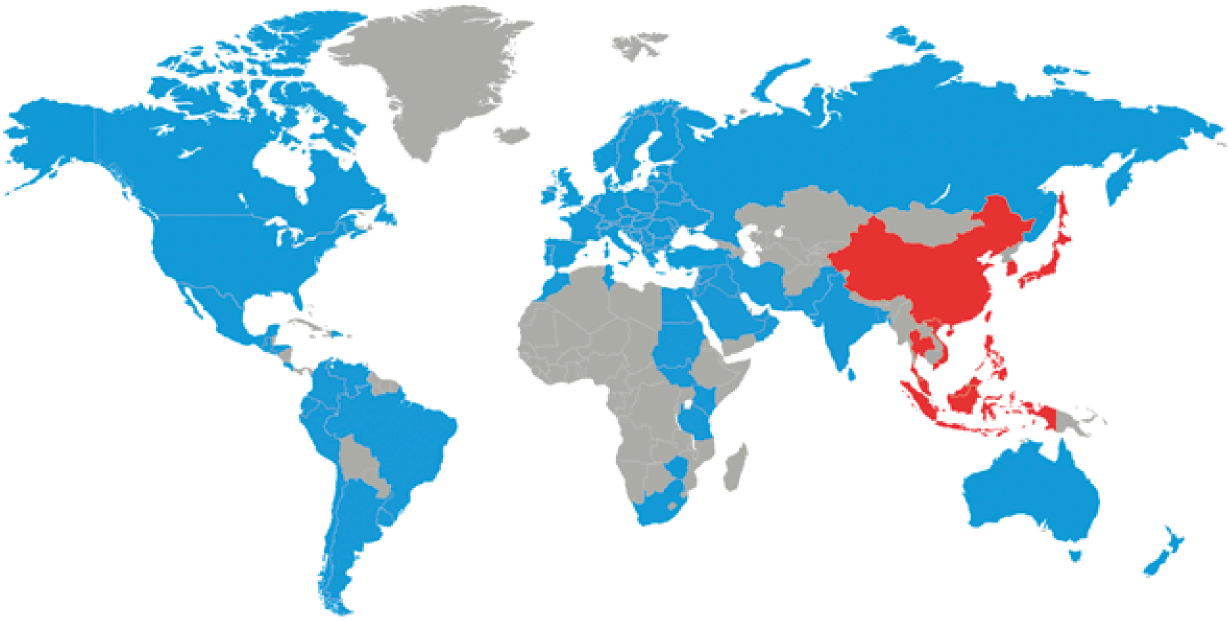
To safeguard our quality and guarantee the integrity of the tool steel we perform both surface - and ultrasonic inspections on all bars. We then remove the bar ends and any defects found during the inspection.

ASSAB

SUPERIOR TOOLING SOLUTIONS

A ONE-STOP SHOP

ASSAB is unmatched as a one-stop product and service provider that offers superior tooling solutions. In addition to the supply of tool steel and other special steel, our range of comprehensive value-added services, such as machining, heat treatment and coating services, span the entire supply chain to ensure convenience, accountability and optimal usage of steel for customers. We are committed to achieving solutions for our customers, with a constant eye on time-to-market and total tooling economy.



Choosing the right steel is of vital importance. ASSAB engineers and metallurgists are always ready to assist you in your choice of the optimum steel grade and the best treatment for each application. ASSAB not only supplies steel products with superior quality, we offer state-of-the-art machining, heat treatment and surface treatment services to enhance steel properties to meet your requirement in the shortest lead time. Using a holistic approach as a one-stop solution provider, we are more than just another tool steel supplier.

ASSAB and Uddeholm are present on every continent. This ensures you that high quality tool steel and local support are available wherever you are. Together we secure our position as the world's leading supplier of tooling materials.

For more information, please visit
www.assab.com

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