Machining Strenx and Hardox

Drilling, countersinking, tapping, turning and milling

SSAB

Strenx high strength steel and Hardox wear plate are steel grades that can be machined with high speed steel (HSS) or cemented carbide (CC) tools. This brochure includes our suggestions for cutting data (feeds and speeds) and the selection of tools. Other factors that should be taken into account in machining operations are also discussed. The proposals have been drawn up following our own tests on tools of various makes and in consultation with leading tool manufacturers.

TYPICAL PROPERTIES OF STRENX AND HARDOX

	Strenx 700	Strenx 900/960	Strenx 1100	Hardox HiTuf	Hardox 400	Hardox 450	Hardox 500
Tensile strength, R_m [N/mm²]	~860	~1040	~1350	~940	~1250	~1400	~1550
Hardness [HBW]	~260	~320	~430	~350	~400	~450	~500

Drilling

Either high speed steel or cemented carbide drills can be used for drilling. The machine available and its stability determine the type of drill that should be employed. But whatever the machine type, it is vital to minimize vibrations.

Radial or column drilling machines

Recommendations for reducing vibrations and increasing the useful life of the drill:

- Minimize the distance from the drill to the column.
- Avoid wooden spacer blocks.
- Clamp the workpiece securely, and drill as close as possible to the spacer blocks.
- Minimize the distance between the drill tip and arm by using a short spindle and short drill.
- Just before the drill breaks through, disengage the feed for about a second. Play and elasticity in the machine could otherwise snap the drill tip. Reengage the drill feed when the play/elasticity have ceased.
- Provide an abundant supply of coolant.

HSS
HSS-E
HSS-Co

Individual holes can be drilled with an ordinary HSS drill. For rational production, either a micro-alloyed (HSS-E) drill or a cobalt-alloyed (HSS-Co) drill is recommended.

HSS-Co

Use an HSS-Co drill (8 % Co) with a small helix angle and a robust core that can withstand high torques.

	Strenx 700	Strenx 900/960	Strenx 1100	Hardox HiTuf	Hardox 400	Hardox 450	Hardox 500
v_c[m/min]	~18	~15	~7	~12	~9	~7	~5
D [mm]	**Feed rate, f [mm/rev] / Speed, n [rpm]**						
5	0.10/1150	0.10/950	0.05/445	0.07/760	0.05/570	0.05/445	0.05/320
10	0.10/575	0.10/475	0.09/220	0.10/380	0.10/290	0.09/220	0.08/130
15	0.16/400	0.16/325	0.15/150	0.16/250	0.16/190	0.15/150	0.13/85
20	0.23/300	0.23/235	0.20/110	0.23/190	0.23/150	0.20/110	0.18/65
25	0.30/240	0.30/195	0.25/90	0.30/150	0.30/110	0.25/90	0.22/50
30	0.35/200	0.35/165	0.30/75	0.35/130	0.35/90	0.30/75	0.25/45

More stable machine tools, such as boring mills and bedtype milling machines

For improved productivity, the benefits of cemented carbide drills should be put to usein modern and stable machines.
The choice is available between three main types of drills with cemented carbide cutting edges. The choice of drill type is dependent on the stability of the machine, the clamping of the workpiece, the hole diameter and the required tolerance. Always use the shortest possible drill.

Coolant

- Use the type of coolant intended for drilling.
- Rule of thumb for drilling with internal coolant passages: Coolant flow [l/min] Drill diameter [mm].

Solid cemented carbide drill

- Diameters from approx. 3 mm
- Close tolerances (high precision)
- Can be reground
- Sensitive to vibrations

Brazed cemented carbide drill

- Diameters from approx. 10 mm
- Close tolerances (high precision)
- Can be reground
- Less sensitive to vibrations than solid carbide.

Indexable insert drill

- Diameters from approx. 12 mm
- Offers high productivity
- Wider tolerance than the others (lower precision)
- Good economy

		Strenx 700	Strenx 900/960	Strenx 1100	Hardox HiTuf	Hardox 400	Hardox 450	Hardox 500
		Cutting speed, vc [m/min] and Feed rate, f [mm/rev]						
Solid cemented carbide	v_c	70-100	50-80	30-50	45-80	40-70	35-65	30-60
	f	0.10-0.25	0.10-0.20	0.08-0.18	0.10-0.30	0.10-0.25	0.08-0.18	0.08-0.15
Brazed cemented carbide	v_c	40-60	40-50	30-40	40-50	35-45	30-40	20-30
	f	0.12-0.18	0.12-0.18	0.10-0.15	0.10-0.15	0.10-0.15	0.10-0.15	0.08-0.12
Indexable inserts	v_c	75-140	70-130	60-100	70-130	60-120	60-100	50-70
	f	0.08-0.18	0.08-0.18	0.06-0.14	0.04-0.16	0.04-0.16	0.04-0.16	0.04-0.14

Cutting data for drilling in Hardox 550 and 600 are available in TechSupport no 40 and 23.
For more info please contact your Technical Manager.

If the drill diameter is small, select a lower feed rate within the specified range.

To calculate the speed of rotation from the recommended cutting speed :

Example for drill diameter D = 15 mm and cutting speed v_c = 80 m/min.

Speed, $n = \frac{v_c \times 1000}{\pi \times D} = \frac{80\ 1000}{3.14 \times 15} = 1698$ approx. 1700 rpm.

Formulas:

$v_c = \frac{\pi \times D \times n}{1000}$

$n = \frac{v_c \times 1000}{\pi \times D}$

$v_f = f \times n$

v_c = cutting speed [m/min]
D = drill diameter [mm]
n = speed [rpm]
π = 3.14
v_f = feed rate [mm/min]
f = feed rate [mm/rev]

Drilling (contd.)

If problems should arise ...

If problems should arise ...	Action and solutions
HSS drill tip deformed	Adjust the drill setting.
CC drill tip deformed	Increase the coolant flow rate, clean the filter and the coolant holes of the drill.
Wear on the outside of the drill	Choose a tougher grade ~ see the figure on page 8.
Holes oversize/undersize	Reduce the feed rate.
Chip build-up in the drill flutes	Increase the feed rate.
Vibrations	Improve the stability by more secure workpiece clamping and reduced drill overhang.
Small damage to the cut. edges (edge chipping)	Check the guideline values of cutting data.
Asymmetrical holes	Check that the right HSS or CC grade is used.
Short useful life of HSS tool	Increase the cutting speed.
Short useful life of CC tool	Reduce the cutting speed.

Counterboring and countersinking

Spot-facing and countersinking are best done by means of countersinking tools which have replaceable cemented carbideinserts and a rotating pilot. Use coolant.

Counterbore with replaceable inserts and revolving pilot.

Conical countersink with replaceable inserts and revolving pilot.

NOTE

1. Reduce the cutting data by about 30 % in countersinking.
2. Always use a revolving pilot.

	Strenx 700	Strenx 900/960	Strenx 1100	Hardox HiTuf	Hardox 400	Hardox 450	Hardox 500
v_c [m/min]	70-100[2]	40-80[2]	20-50[2]	30-80[2]	25-70[2]	20-50[2]	17-50[2]
Feed rate, f [mm/rev]	0.10-0.20	0.10-0.20	0.10-0.20	0.10-0.20	0.10-0.20	0.10-0.20	0.10-0.20
D [mm]	**Speed. n [rpm]**						
19	1175-1675	670-1340	335-840	500-1340	420-1175	335-840	285-840
24	930-1325	530-1060	265-665	400-1060	330-930	265-665	225-665
34	655-935	375-750	185-470	280-750	235-655	185-470	160-470
42	530-760	300-600	150-380	230-600	190-530	150-380	130-380
57	390-560	225-440	110-280	170-440	140-390	110-280	95-280

1) If chipbreaking problems should arise, feed in steps of 2 mm at a time.
2) If the machine power is low, select a cutting speed towards the lower end of the range.

Cutting data for countersinking/counterboring in Hardox 550 and 600 are available in TechSupport no 40 and 23.
For more info please contact your Technical Manager.

HSS countersinking cutters with three cutting edges and equipped with a pilot can be used in the Strenx steels tabulated below. An abundant flowof coolant is necessary.

		Strenx 700	Strenx 900/960
v_c [m/min]		~8	~7
D [mm]	Feed rate, f [mm/rev]	Speed, n [rpm]	
15	0.05-0.20	170	150
19	0.05-0.20	130	120
24	0.07-0.30	100	90
34	0.07-0.30	70	70
42	0.07-0.30	60	50
57	0.07-0.30	40	40

Tapping

If the correct type of tap is used, holes can be tapped in all Hardox and Strenx steels. We recommend fourflute taps which can withstand the high torques necessary for tapping holes in hard materials. When Hardox and Strenx materials are tapped, thread oil or thread paste is recommended as lubricant.

In applications in which thread strength is not critical, a somewhat larger than standard hole diameter can be drilled (about 3 % larger), in order to reduce the tap stresses during tapping. This will increase the useful life of the tap, above all when tapping holes in Hardox and Strenx 1100.

NOTE

1. If uncoated taps are used, the cutting data should be lowered by 30 %.
2. If tapping is carried out in NCmachines, thread milling can be employed.

Tap for blind holes. Strenx 700, Strenx 900/960.

Tap for through holes.

	HSS-Co (HSS-E) TiN or TiCN coated						
	Strenx 700	Strenx 900/960	Strenx 1100	Hardox HiTuf	Hardox 400	Hardox 450	Hardox 500
v_C[m/min]	10	8	3	6	5	3	2.5
Size	Speed, n [rpm]						
M10	320	255	95	190	160	95	80
M12	265	210	80	160	130	80	65
M16	200	160	60	120	100	60	50
M20	160	125	45	90	80	45	40
M24	130	105	40	80	65	40	30
M30	105	85	32	60	50	32	25

Cutting data for thread milling in Hardox 550 and 600 are available in TechSupport no 40 and 23.
For more info please contact your Technical Manager.

Milling

SELECTION OF MILLING METHOD AND CUTTERS

To ensure rational production, milling cutters with cemented carbide inserts are recommended.

FACE MILLING

Roughing

Select a cutter with round inserts, particularly for machining Hardox

Finishing

Select a cutter with 45° setting angle

SQUARE SHOULDER MILLING

Select amilling cutter with 90° setting angle

END MILLING

Unstable machine

Select a coated HSS-Co end mill*

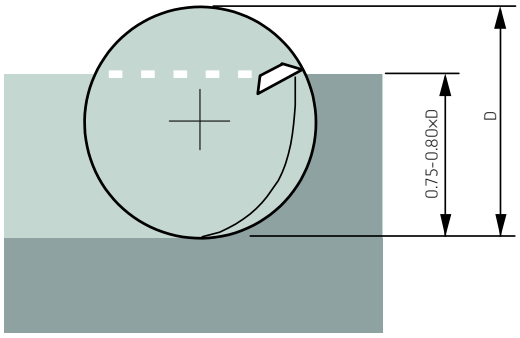
*) Avoid using an HSS endmill when machining a gas-cut edge.

Stable machine

Select a CC end mill – solid or with indexable inserts

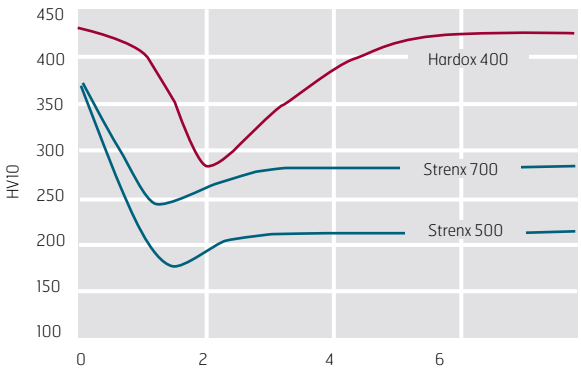
The following factors should be borne in mind when milling:

- Make certain that the workpiece is securely clamped.
- If the machine power is low, use a coarse-pitch cutter.
- If possible, avoid a universal head, since this weakens the tool mounting and power transmission.
- The width of cut in face milling should be about 75–80 % of the cutter diameter (see figure to the right).
- When milling surfaces which are narrower than the diameter of the milling head, the milling cutter should be located eccentrically, so that as many teeth as possible will be in engagement.
- When milling a gas-cut edge, the depth of cut should be at least 2 mm, in order to avoid the hard surface layer of the cut edge (see graph).



Recommended cutting width in face milling

Hardness profile of gas-cut edge, cut in air



	FACE MILLING				END MILLING			
	Coated CC		Cermet	Coated CC	CC			HSS-Co
Grade	P40/CS	P25/C6	P20/C6-C7	K20/C2	K10/C3-uncoated	K10/C3-coated	P10/C7-indexable insert	TiCN-coated
Conditions	unstable	average	stable	stable	stable	stable	stable	unstable
Feed rate (f_z)	0.1-0.2-0.3	0.1-0.2-0.3	0.1-0.2	0.1-0.2	0.02-0.10	0.02-0.20	0.05-0.15	0.03-0.09
Plate grade	Cutting speed, v_c [m/min]							
Strenx 700	195-150-95	220-180-150	240-200	-	100	180	195-150	40
Strenx 900/960	95-75-50	200-160-130	220-170	-	90	130	140-120	18
Strenx 1100	-	150-120-110	150-120	-	90	100	110-90	-
Hardox HiTuf	-	170-150-140	170-150	-	90	100	110-90	-
Hardox 400	-	150-120-110	150-120	-	90	100	110-90	-
Hardox 450	-	150-120-110	150-120	-	90	100	110-90	-
Hardox 500	-	120-110	120-100	120-100	50	80	90-70	-

At higher feed rates, lower the cutting speed.
Cutting data for face milling in Hardox 550 and 600 are available in TechSupport no 40 and 23.
For more info please contact your Technical Manager.

Formulas:

$v_c = \frac{\pi \times D \times n}{1000}$

$n = \frac{v_c \times 1000}{\pi \times D}$

$f_z = \frac{v_f}{n \times z}$

$v_f = f_z \times n \times z$

v_c = cutting speed [m/min]
D = cutter diameter [mm]
n = speed [rpm]
π = 3.14
v_f = feed rate [mm/min]
f_z = feed rate per tooth [mm/tooth]
z = number of cutter teeth

If problems should arise ...

If problems should arise ...	Action and solutions
Land wear	Reduce the cutting speed
Notchwear	Increase the cutting speed
Cratering wear	Reduce the feed rate per tooth
Plastic deformation	Increase the feed rate per tooth
Cutting edge build-up	Use a more wear resistant CC grade (see page 8)
Comb cracks	Use a tougher CC grade (see page 8)
Small damage to the cutting edges (edge chipping)	Use a coarse-pitch cutter
Insert failure	Change the cutter position
Vibrations	Avoid using a coolant
Poor surface finish	Change over from HSS-Co to solid CC cutter
Short useful life of HSS-Co cutters	Check the cutter set-up

Turning

The cutting data recommendations below are applicable to tough cemented carbide grades. These are necessary for operations in which impact may occur, such as when turning plate with gas-cut edges.

Carbide grade	P25/C6	P35/C6-C7	K20/C2
Feed rate f_n [mm/rev]	0.1-0.4-0.8	0.1-0.4-0.8	0.1-0.3
	Cutting speed, v_c [m/min]		
Strenx 700	285-195-145	230-150-100	-
Strenx 900/960	130-90-70	105-65-45	-
Strenx 1100	130-90-70	105-65-45	-
Hardox HiTuf	130-90-70	105-65-45	-
Hardox HiTuf	130-90-70	105-65-45	-
Hardox 450	130-90-70	105-65-45	-
Hardox 500	-	-	100-80

At higher feed rates, lower the cutting speed.

Formulas:

$$v_c = \frac{\pi \times D \times n}{1000}$$

$$n = \frac{v_c \times 1000}{\pi \times D}$$

$$v_f = f_n \times n$$

v_c = cutting speed [m/min]
D = workpiece dia. [mm]
n = speed [rpm]
π = 3.14
v_f = feed rate [mm/min]
f_n = feed rate [mm/rev]

Tool materials / Cemented carbide grades

This brochure has been written in cooperation with Sandvik Coromant AB, DormerTools AB and Emuge Franken AB. Granlund Tools AB has contributed pictures and cutting data for the section dealing with countersinking.

For further information, please get in touch with our Technical Customer Service Department.

The Machining brochure is included in a series of publications that offer advice and instructions for working on Hardox and Strenx plate. The other two brochures in the series are Welding and Bending. Place your order for them with our Market Communication Department.

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