CUTTING SHAPING DATA
SOFT MAGNETIC ALLOYS

INTRODUCTION

This brochure gives an overview of the data on lathing/cutting, drilling, milling and grinding for our soft magnetic alloys. It covers our materials MUMETALL, PERMENORM 5000 V5 / 5000 H2, VACOFLUX 17 and hot worked VACOFLUX 50. All these nickel-iron and cobalt-iron alloys, except VACOFLUX 50, are very tough in the soft, hot rolled state. Thus we recommend semi-finished products are purchased in the hard state whenever possible and machined in this state. However, in this case, owing to the size of the parts, the hot rolled state was selected.The tools and the machine settings used have been compiled in the following tables. If very heavy machinery is available the cutting rates can be increased substantially, in particular when rough turning. In contrast, the cutting performance when finishing is largely governed by the specified tolerances and end-surface requirements. The aim of this leaflet is to provide users with the relevant data on the most important soft magnetic alloys as a guideline for cutting-shaping processes. The tables should be of practical use to those working on site as they not only include nominal values but recommendations on tooling.

CUTTING SHAPING DATA

LATHING

Reversible carbide tips, quality P10 - P30 were used for the tests. A low cutting speed and high feed rate were selected for rough turning. In contrast, for finishing the cutting rates are heavily dependent on the specified tolerances and the surface quality required. As a result, low feed and high cutting speed are implemented (see table for details on feed and cutting speed). Rings and discs are to be machined from the outside inwards – especially, when working with VACOFLUX 50, or, prior to this, the edges are to be chamfered at 45° to avoid damage. The geometry of the reversible carbide tip to be used is also governed by the machining requirements (rough machining or finishing, surface quality, shape etc).

DRILLING

The cutting-shaping data with hand feed are based on a normal standard drill of the commonly used HSS quality. When drilling with automatic feed, HSS drills with TiN coating were implemented. With VACOFLUX 50, a slight chipping of the edges may occur when the drill emerges through the material, we recommend drilling from both sides.

MILLING

When milling the material was pre-worked with a cutter head of 100 mm Ø at relatively high cutting speed. Then using the VHM milling head, Ø 16 mm (TiAIN) milling was completed with an appropriately low cutting speed. Again, VACOFLUX is prone to edge cracking and should be chamfered or machined towards the center.

FLAT GRINDING

When selecting a grinding disc for soft magnetic alloys, a comparison with hardened tool steel is possible and corresponding discs can be used. Due to extreme heat development, good cooling is crucial for the grinding discs. VACOFLUX 50 may split at the edges and should be chamfered or machined from the outside inwards.

COOLING

Special attention must be paid to cooling and lubrication. Drilling oil emulsions are generally preferred; as a rule in accordance with DIN 6558 emulsions with 5 - 10 % coolant oil are used. In the tests conducted, a 5 % cutting oil emulsion was used for cooling in all work steps.

SPECIAL REMARKS

Whenever possible a cooling phase is to be introduced between pre and final machining steps to allow for (to neutralize) any expansion which might occur. Occasionally, pre-machining may affect the dimensional accuracy of the finished part. In special cases involving difficult, complex or thin walled work pieces or tight tolerances, the material can be run through a suitable intermediate annealing step, so-called stress relief heat treatment.

HEAT TREATMENT

After machining, the parts must be cleaned thoroughly to remove impurities caused by lubrication. The magnetic materials are then subjected to a final heat treatment to set the optimum magnetic properties. This final magnetic heat treatment step takes place after finalshaping.

Alloy	High Temperature Annealing
MUMETALL	5 h 1,050 °C, cool in furnace to < 300 °C H_2 atmosphere
VACOPERM 100	5 h 1,150 °C, cool in furnace to < 300 °C H_2 atmosphere
PERMENORM 5000 V5 / 5000 H2	5 h 1,150 °C, cool in furnace to < 300 °C H_2 atmosphere
TRAFOPERM	5 h 1,150 °C, cool in furnace to < 300 °C H_2 atmosphere
VACOFLUX 50	10 h 820 °C, cool in furnace to < 200 °C H_2 atmosphere
VACOFLUX 17	10 h 850 °C, cool in furnace to < 200 °C H_2 atmosphere

The data for PERMENORM can be used as a basis for VAC Expansion and Glass-to-Metal Sealing Alloys VACON 11/70, VACOVIT and VACODIL.

Alloy: MUMETALL (analysis: 76.6 % Ni / 4.5 % Cu / 3.3 % Mo / balance Fe)				
Shaping	**Cutting speed** V_c (m/min)	**Feed** f (mm/rev)	**Tool**	**Remarks**
Lathing[1]	50 - 150	0.15 - 0,50	Tooling head: reversible carbide tip Quality: P 10 - P 30	Cutting depth: a = 5 mm Coolant: 5 % cutting oil emulsion Clearance angle: 7°
Cutting[1]	50 - 150	0.05 - 0.20	Tool: Carbide cutting tip, coated (Zinner: ZG 30)[5]	Cutting depth: a = 4 mm Coolant: 5 % cutting oil emulsion
Drilling[4]	n = revs/min a) 60 - 450 b) 400 - 700	a) handfeed b) 0.05 - 0.15 (auto feed)	Tool: HSS drill a) standard drill b) standard drill with TiN coating	Coolant: 5 % cutting oil emulsion
Milling	a) 150 - 250 b) 40 - 80	fz = mm/cutting tooth a) 0.05 - 0.15 b) 0.02 - 0.10	a) cutter head: 100 mm Ø P 10 - P 30 (round reversible blades) b) VHM cutter: 16 mm Ø (TiAlN)	Coolant: 5 % cutting oil emulsion slight increase in tip wear
Flat Grinding	surface meters: 32 (m/sec)	–	Grinding disc: Type 40A80L6V13[6] Dimensions: 400 x 60 x 127 – DIN 69120 Keep disc well cooled to prevent overheating	Cutting depth: a = 0.005 mm Coolant: 5 % cutting oil emulsion good surface

Alloy: PERMENORM 5000 V5 / 5000 H2 (analysis: 47,5 % Ni / balance Fe)				
Shaping	**Cutting speed** V_c (m/min)	**Feed** f (mm/rev)	**Tool**	**Remarks**
Lathing[2]	20 - 60	0.10 - 0.50	Tooling head: reversible carbide tip Quality: P 10 - P 30	Cutting depth: a = 5 mm Coolant: 5 % cutting oil emulsion Clearance angle: 7° Poor chip breaking
Cutting[3]	50 - 150	0.10 - 0.20	Tool: Carbide cutting tip, coated (Zinner: ZG 30)[5]	Cutting depth: a = 4 mm Coolant: 5 % cutting oil emulsion
Drilling[4]	n = revs/min a) 220 - 650 b) 300 - 800	a) handfeed b) 0.05 - 0.25 (auto feed)	Tool: HSS drill a) standard drill b) standard drill with TiN coating	Coolant: 5 % cutting oil emulsion
Milling	a) 150 - 250 b) 50 - 100	fz = mm/cutting tooth a) 0.20 b) 0.02 - 0.10	a) cutter head: 100 mm Ø P 10 - P 30 (round reversible blades) b) VHM cutter: 16 mm Ø (TiAlN)	Coolant: 5 % cutting oil emulsion slight increase in tip wear a) Cutting depth: ap = 2 mm b) Cutting depth: ap = 10 mm
Flat Grinding	surface meters: 32 (m/sec)	–	Grinding disc: Type 40A80L6V13[6] Dimensions: 400 x 60 x 127 – DIN 69120 keep disc well cooled to prevent overheating	Cutting depth: a = 0.005 mm Coolant: 5 % cutting oil emulsion good surface

[1] Dimensions: 58 mm Ø

[2] Dimensions: 50 mm Ø

[3] Dimensions: 42 mm Ø

[4] Drill: 10.5 mm Ø

[5] Zinner GmbH, Karl-Martell-Str. 35, 90431 Nuremberg

[6] Krebs & Riedel, Bremer Str. 24, 34385 Bad Karlshafen

CUTTING SHAPING DATA

Alloy: VACOFLUX 17 (analysis: 17 % Co / 2,0 % Cr / balance Fe)

Shaping	Cutting speed V_c (m/min)	Feed f (mm/rev)	Tool	Remarks
Lathing[1]	50 - 150	0.15 - 0.50	Tooling head: reversible carbide tip Quality: P 10 - P 25	Cutting depth: a = 5 mm Coolant: 5 % cutting oil emulsion Clearance angle: 7° poor chip flow
Cutting[2]	50 - 150	0.05 - 0.20	Tool: Carbide cutting tip, coated (Zinner: ZG 30)[4]	Cutting depth: a = 4 mm Coolant: 5 % cutting oil emulsion
Drilling[3]	n = revs/min a) 350 b) 200 - 1000	a) handfeed b) 0.05 - 0.30 (auto feed)	Tool: HSS drill a) standard drill b) standard drill with TiN coating	Coolant: 5 % cutting oil emulsion
Milling	a) 80 - 160 b) 40 - 100	fz = mm/cutting tooth a) 0.05 - 0.20 b) 0.05 - 0.20	a) cutter head: 100 mm Ø P 10 - P 25 (round reversible blades) b) VHM cutter: 16 mm Ø (TiAlN)	Coolant: 5 % cutting oil emulsion edges crack easily
Flat Grinding	surface meters: 32 (m/sec)	–	Grinding disc: Type 40A80L6V13[5] Dimensions: 400 x 60 x 127 – DIN 69120 keep disc well cooled to prevent overheating	Cutting depth: a = 0.008 mm Coolant: 5 % cutting oil emulsion

Alloy: VACOFLUX 50 (analysis: 49 % Co / 1,9 % V / balance Fe)

Shaping	Cutting speed V_c (m/min)	Feed f (mm/rev)	Tool	Remarks
Lathing[1]	50 - 150	0.10 - 0.40	Tooling head: reversible carbide tip Quality: P 10 - P 25	Cutting depth: a = 5 mm Coolant: 5 % cutting oil emulsion Clearance angle: 7° Poor chip breaking
Cutting[2]	n = revs/min 50 - 150	0.05 - 0.15	Tool: Carbide cutting tip, coated (Zinner: ZG 30)[4]	Cutting depth: a = 4 mm Coolant: 5 % cutting oil emulsion Coolant heats up easily
Drilling[3]	n = revs/min a) 250 - 1,000 b) 100 - 1,250	a) handfeed b) 0.05 - 0.20 (auto feed)	Tool: HSS drill a) standard drill b) standard drill with TiN coating	Normal drills Coolant: 5 % cutting oil emulsion Slight fracturing of edges on drilling through.
Milling	a) 20 - 50 b) 20 - 50	fz = mm/cutting tooth a) 0.10 b) 0.02 - 0.08	a) cutter head: 100 mm Ø P 10 - P 25 (round reversible blades) b) VHM cutter: 16 mm Ø (TiAlN)	Coolant: 5 % cutting oil emulsion Edges crack, extreme wear of reversible cutting tip
Flat Grinding	surface meters: 32 (m/sec)	–	Grinding disc: Type 40A80L6V13[5] Dimensions: 400 x 60 x 127 – DIN 69120 keep disc well cooled to prevent overheating, long sparking-out period	Cutting depth: a = 0.003 mm per working step Coolant: 5 % cutting oil emulsion Edges crack

1 Dimensions: 50 mm Ø

2 Dimensions: 40 mm Ø

3 Drill: 10.5 mm Ø

4 Zinner GmbH, Karl-Martell-Str. 35, 90431 Nuremberg

5 Krebs & Riedel, Bremer Str. 24, 34385 Bad Karlshafen

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