Aleris
Europe

Aluminium for mould and tool construction

Machinability of GIANTAL, WELDURAL and HOKOTOL

Aleris Rolled & Extruded Products - Europe, a division of Aleris International, Inc. (based in Beachwood, Ohio (U.S.A.)), is one of the world's leading suppliers of high quality aluminium products.

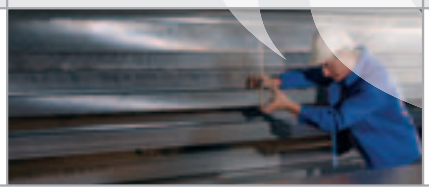
Annually more than 500,000 tons of semi-finished highly specialized and customized products for a wide variety of end users are manufactured and supplied worldwide using plants located in Koblenz, Bonn, Vogt and Bitterfeld (Germany), Duffel (Belgium) and Tianjin (China).

The prerequisites are state-of-the-art production plants, process- and product-oriented research and development, a comprehensive quality management system, sound marketing and distribution structures as well as healthy, safe and environmentally-friendly working conditions; success, however, is primarily based on highly skilled and motivated employees.

As a result of both experience and know-how, which have been gained by being the principal supplier to many industries, and continuous investment in the prerequisites, products have been improved continually to satisfy fully the requirements of the tool- and mould-making industry.

Photo on the title page with friendly permission of Handtmann, Germany.

Machinability of GIANTAL, WELDURAL und HOKOTOL



The term machinability refers to the general suitability of a material for machining, e. g. drilling, turning or milling. It describes the way in which a material can be cut, taking all properties into account – i. e. its resistance to machining and how it influences the quality of the finished part.

Machinability should always be considered in conjunction with the machining processes used, and thus also the tool and the cutting conditions. In terms of design and manufacture, machinability is extremely important for the selection of the material and manufacturing process.

A material with good machining properties is distinguished by the following:

a. after machining, the surface of the workpiece is smooth and

b. the chips produced during machining are short-brittle and therefore can be easily transported, so that they do not interfere with processing (= short-brittle spiral and helical chips).

Disregarding the large number of different machining processes, there are a few assessment criteria which can be employed to differing extents in order to document and check general machinability:

- cutting force
- tool life
  (or tool life travel, tool life quantity)
- surface quality of the workpiece
- chip shape

These assessment criteria, in turn, are influenced to varying degrees by the following factors:

- material (type, structure)
- tool (cutting material, geometry level of wear)
- cutting conditions (feed motion, depth of cut, cutting speed, cutting edge angle, cooling, lubrication)

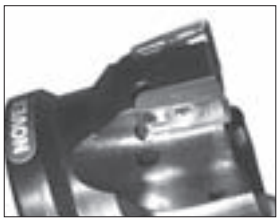
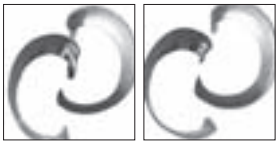
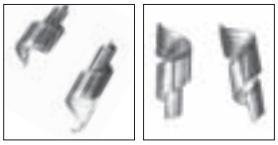
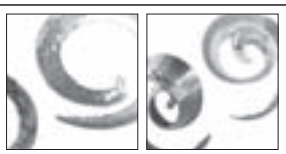
Together with the laboratory Corus Research, Development and Technology (CRD&T) in IJmuiden (The Netherlands) and Prof. Dr. Kaufeld from the Ulm University of Applied Sciences (Germany), selected machining processes have been used to examine the machinability of the aluminium wrought alloys, GIANTAL, WELDURAL and HOKOTOL, which have been specially developed for mould and tool construction.

The results – which are illustrated on the following pages of the brochure “Aluminium for mould and tool construction: Machinability of GIANTAL, WELDURAL and HOKOTOL” – show that, in the case of all the machining processes used, the selection of a suitable commercially available tool and use of the correct cutting conditions make it possible to influence the machinability of the alloys GIANTAL, WELDURAL and HOKOTOL to such an extent that, following processing, the workpiece has a smooth surface (measured as arithmetical mean roughness value (R_a)*1 and mean roughness depth (peak to valley) (R_z)*2) and the chips produced during cutting can be categorized as short-brittle spiral and helical chips.

*1 R_a = arithmetical mean roughness value
The arithmetical mean roughness value R_a, signifying the roughness parameter, is a value that is recognized and used internationally. It denotes the arithmetical mean value of the absolute values of the profile deviations within the sample area. The numerical value of R_a is always smaller than the R_z reading derived from the same sample.

*2 R_z = mean roughness depth (peak to valley)
The mean roughness depth (peak to valley) R_z denotes the mean roughness depth, i. e. the arithmetical mean of the highest single measurements of several single adjacent tracing sections.

Face milling – Roughing

Tool parameter			
Tool type	Milling tool with renewable cutters	Milling tool with renewable cutters	Milling tool with renewable cutters
Tool producer / type of tool	Walter, F3040.B.063.Z04.20 R4	Walter, F3042.B.050.Z05.15	Walter, F3040-100026
Diameter	63 mm (2.48 ins)	50 mm (1.97 ins)	40 mm (1.57 ins)
Number of cutters	4	5	3
Material of cutters	ZDGT200540R-K85 WMG 40	APHT 15T3 PDR-K88 WK 10	ZDGT200540R-K85 WMG 40
Corner radius of cutter	4 mm (0.1575 ins)	0.8 mm (0.0315 ins)	4 mm (0.1575 ins)
Tool design			
			
Milling parameter			
Cutting speed (v_c)	942 m/min (3,090 ft/min)	942 m/min (3,090 ft/min)	1,885 m/min (6,184 ft/min)
Spindle speed (n)	4,760 rev/min	6,000 rev/min	15,000 rev/min
Feed per tooth (f_z)	0.15 mm (0.0059 ins)	0.15 mm (0.0059 ins)	0.3 mm (0.0118 ins)
Axial infeed rate (a_p)	4 mm (0.1575 ins)	4 mm (0.1575 ins)	4 mm (0.1575 ins)
Radial infeed rate (a_e)	58 mm (2.28 ins)	45 mm (1.77 ins)	32 mm (1.26 ins)
Cooling lubricant	Emulsion (5%) Spray cooling (FD 1-30)	Emulsion (5%) Spray cooling (FD 1-30)	Dry Spray cooling (FD 1-30)
GIANTAL: Roughness at the milled surface			
R_a (µm)	0.6-0.7 (Emulsion [5%])	0.2-0.3 (Emulsion [5%])	0.5-0.7 (Dry)
R_z (µm)	3.2-3.4 (Emulsion [5%])	1.4-1.6 (Emulsion [5%])	3.2-3.4 (Dry)
R_a (µm)	0.4-0.5 (Spray Cooling [FD 1-30])	0.1-0.3 (Spray Cooling [FD 1-30])	0.4-0.6 (Spray Cooling [FD 1-30])
R_z (µm)	2.3-2.5 (Spray Cooling [FD 1-30])	1.2-1.4 (Spray Cooling [FD 1-30])	2.8-3.0 (Spray Cooling [FD 1-30])
Chip shape	Emulsion Spray Cooling	Emulsion Spray Cooling	Dry Spray Cooling
			
WELDURAL: Roughness at the milled surface			
R_a (µm)	0.2-0.4 (Emulsion [5%])	0.2-0.4 (Emulsion [5%])	0.6-0.8 (Dry)
R_z (µm)	2.4-2.6 (Emulsion [5%])	1.6-1.8 (Emulsion [5%])	4.1-4.3 (Dry)
R_a (µm)	0.3-0.5 (Spray Cooling [FD 1-30])	0.2-0.4 (Spray Cooling [FD 1-30])	0.6-0.8 (Spray Cooling [FD 1-30])
R_z (µm)	2.8-3.0 (Spray Cooling [FD 1-30])	1.7-1.9 (Spray Cooling [FD 1-30])	4.4-4.6 (Spray Cooling [FD 1-30])
Chip shape	Emulsion Spray Cooling	Emulsion Spray Cooling	Dry Spray Cooling
			
HOKOTOL: Roughness at the milled surface			
R_a (µm)	0.3-0.5 (Emulsion [5%])	0.2-0.3 (Emulsion [5%])	0.6-0.8 (Dry)
R_z (µm)	2.3-2.5 (Emulsion [5%])	1.6-1.8 (Emulsion [5%])	4.4-4.6 (Dry)
R_a (µm)	0.3-0.5 (Spray Cooling [FD 1-30])	0.2-0.4 (Spray Cooling [FD 1-30])	0.6-0.8 (Spray Cooling [FD 1-30])
R_z (µm)	2.5-2.7 (Spray Cooling [FD 1-30])	1.8-2.0 (Spray Cooling [FD 1-30])	4.4-4.6 (Spray Cooling [FD 1-30])
Chip shape	Emulsion Spray Cooling	Emulsion Spray Cooling	Dry Spray Cooling
			

Groove milling – Roughing

Tool parameter			
Tool type	Milling tool with renewable cutters	Shank end milling tool	Shank end milling tool
Tool producer / type of tool	Walter, F3040.H63A.025.Z02.15 R4	25x25/R4 61-3385 DK460F	Jabro SMG Diam. 10x14, JH 40
Diameter	25 mm (0.98 ins)	25 mm (0.98 ins)	10 mm (0.39 ins)
Number of cutters	2	3	2
Material of cutters	ZDGT150440R-K85 WMG 40	HM	HM
Corner radius of cutter	2 mm (0.0787 ins)	4 mm (1.575 ins)	0.1 mm (0.0039 ins)
Tool design			
			
Milling parameter			
Cutting speed (v_c)	1,021 m/min (3,350 ft/min)	1,021 m/min (3,350 ft/min)	471 m/min (1,545 ft/min)
Spindle speed (n)	13,000 rev/min	13,000 rev/min	15,000 rev/min
Feed per tooth (f_z)	0.2 mm (0.0079 ins)	0.2 mm (0.0079 ins)	0.15 mm (0.0059 ins)
Axial infeed rate (a_p)	5 mm (0.1969 ins)	5 mm (0.1969 ins)	5 mm (0.1969 ins)
Radial infeed rate (a_e)	25 mm (0.98 ins)	25 mm (0.98 ins)	10 mm (0.39 ins)
Cooling lubricant	Spray cooling (FD 1-30)	Spray cooling (FD 1-30)	Spray cooling (FD 1-30)
Ship volume over time (Q)	650 cm3/min (39.67 ins^3/min)	975 cm3/min (59.50 ins^3/min)	–
GIANTAL: Roughness at the milled surface			
R_a (µm)	0.5-0.7	1.4-1.6	2.6-2.8
R_z (µm)	2.9-3.1	7.3-7.5	11.2-11.4
Chip shape			
			
WELDURAL: Roughness at the milled surface			
R_a (µm)	0.8-1.0	1.0-1.2	2.8-3.0
R_z (µm)	3.6-3.8	5.9-6.1	12.8-13.0
Chip shape			
			
HOKOTOL: Roughness at the milled surface			
R_a (µm)	0.5-0.7	0.9-1.1	3.5-3.7
R_z (µm)	3.3-3.5	5.9-6.1	13.5-13.7
Chip shape			
			

Finishing (with shank end milling tool)

Tool parameter			
Tool type	Shank end milling tool		
Tool producer / type of tool	Jabro SMG Diameter 10x14, JH 40		
Diameter	10 mm (0.39 ins)		
Number of cutters	2		
Material of cutters	HM		
Corner radius of cutter	0.1 mm (0.0039 ins)		
Tool design			
			
Milling parameter			
Cutting speed (v_c)	283 m/min (928 ft/min)	565 m/min (1,854 ft/min)	565 m/min (1,854 ft/min)
Spindle speed (n)	9,000 rev/min	18,000 rev/min	18,000 rev/min
Feed per tooth (f_z)	0.1 mm (0.0039 ins)	0.1 mm (0.0039 ins)	0.005 mm (0.0002 ins)
Axial infeed rate (a_p)	0.18 mm (0.0071 ins)	0.18 mm (0.0071 ins)	0.18 mm (0.0071 ins)
Radial infeed rate (a_e)	9.6 mm (0.3780 ins)	9.6 mm (0.3780 ins)	9.6 mm (0.3780 ins)
Cooling lubricant	Dry	Dry	Dry
GIANTAL: Roughness at the milled surface			
R_a (µm)	0.5-0.7	0.8-1.0	0.1-0.3
R_z (µm)	4.1-4.3	4.3-4.5	1.6-1.8
Chip shape			
			
WELDURAL: Roughness at the milled surface			
R_a (µm)	1.4-1.6	1.7-1.9	0.1-0.3
R_z (µm)	6.2-6.4	7.0-7.2	1.2-1.4
Chip shape			
			
HOKOTOL: Roughness at the milled surface			
R_a (µm)	1.5-1.7	1.7-1.9	0.3-0.5
R_z (µm)	7.1-7.3	7.8-8.0	2.9-3.1
Chip shape			
			

Finishing (with spherical cutter)

Tool parameter				
Tool type	Spherical cutter		Spherical cutter	
Tool producer / type of tool	Jabro SMG Diam. 10x8.5, JH 450		Jabro MG Diam. 2x4, HSC	
Diameter	10 mm (0.39 ins)		2 mm (0.0787 ins)	
Number of cutters	2		2	
Material of cutters	HM		HM	
Corner radius of cutter	5 mm (0.1969 ins)		1 mm (0.0394 ins)	
Tool design				
				
Milling parameter				
Spindle speed (n)	8,000 rev/min (26,246 ft/min)	16,000 rev/min (52,493 ft/min)	8,000 rev/min (26,246 ft/min)	16,000 rev/min (52,493 ft/min)
Feed per tooth (f_z)	0.08 mm (0.0031 ins)	0.08 mm (0.0031 ins)	0.04 mm (0.0016 ins)	0.04 mm (0.0016 ins)
Axial infeed rate (a_p)	0.09 mm (0.0035 ins)	0.18 mm (0.0071 ins)	0.03 mm (0.0012 ins)	0.06 mm (0.0024 ins)
Radial infeed rate (a_e)	0.04 mm (0.0016 ins)	0.08 mm (0.0031 ins)	0.02 mm (0.0008 ins)	0.04 mm (0.0016 ins)
Working angle	60°	60°	60°	60°
Cooling lubricant	Dry	Dry	Dry	Dry
	Spray cooling (FD 1-30)	Spray cooling (FD 1-30)	–	–
GIANTAL: Roughness at the milled surface				
R_a (µm)	0.1-0.3 (Dry)	0.2-0.4 (Dry)	0.2-0.4 (Dry)	0.4-0.6 (Dry)
R_z (µm)	1.2-1.4 (Dry)	1.6-1.8 (Dry)	2.1-2.3 (Dry)	2.6-2.8 (Dry)
R_a (µm)	0.1-0.3 (Spray Cool. [FD 1-30])	0.2-0.4 (Spray Cool. [FD 1-30])	–	–
R_z (µm)	1.2-1.4 (Spray Cool. [FD 1-30])	1.4-1.6 (Spray Cool. [FD 1-30])	–	–
WELDURAL: Roughness at the milled surface				
R_a (µm)	0.1-0.3 (Dry)	0.1-0.3 (Dry)	0.1-0.3 (Dry)	0.4-0.6 (Dry)
R_z (µm)	1.1-1.3 (Dry)	1.2-1.4 (Dry)	1.3-1.5 (Dry)	3.3-3.5 (Dry)
R_a (µm)	0.1-0.3 (Spray Cool. [FD 1-30])	0.1-0.3 (Spray Cool. [FD 1-30])	–	–
R_z (µm)	1.0-1.2 (Spray Cool. [FD 1-30])	1.3-1.5 (Spray Cool. [FD 1-30])	–	–
HOKOTOL: Roughness at the milled surface				
R_a (µm)	0.1-0.3 (Dry)	0.1-0.3 (Dry)	0.1-0.3 (Dry)	0.4-0.6 (Dry)
R_z (µm)	1.1-1.3 (Dry)	1.3-1.5 (Dry)	1.1-1.3 (Dry)	2.5-2.7 (Dry)
R_a (µm)	0.1-0.3 (Spray Cool. [FD 1-30])	0.1-0.3 (Spray Cool. [FD 1-30])	–	–
R_z (µm)	1.0-1.2 (Spray Cool. [FD 1-30])	1.3-1.5 (Spray Cool. [FD 1-30])	–	–

Face milling (with an unsuitable tool design)

Tool parameter	
Tool type	Milling tool with renewable cutters
Tool producer / type of tool	Walter, F3042.B.050.Z05.15
Diameter	50 mm (1.97 ins)
Number of cutters	5
Material of cutters	APMT 15T3 PDR-DRR WAP 35
Corner radius of cutter	0.8 mm (0.0315 ins)

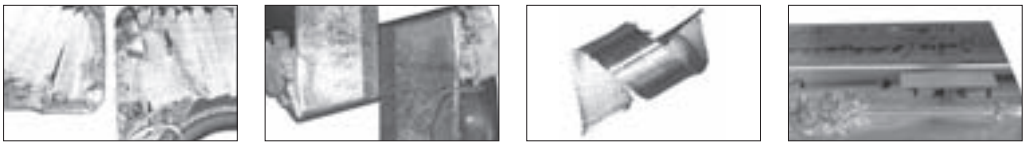
Tool design

Cutter plates before face milling

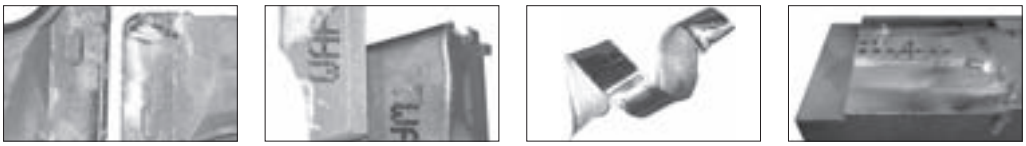
Milling parameter

Cutting speed (v_c)	628 m/min (3,090 ft/min)
Spindle speed (n)	4,000 rev/min
Feed per tooth (f_z)	0.1 mm (0.0039 ins)
Axial infeed rate (a_p)	4 mm (0.1575 ins)
Radial infeed rate (a_e)	45 mm (1.77 ins)
Cooling lubricant	Dry

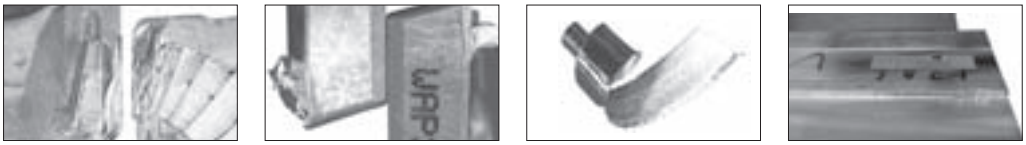
GIANTAL: Cutter plates, chip shape and workpiece surface after face milling with an unsuitable tool design



WELDURAL: Cutter plates, chip shape and workpiece surface after face milling with an unsuitable tool design



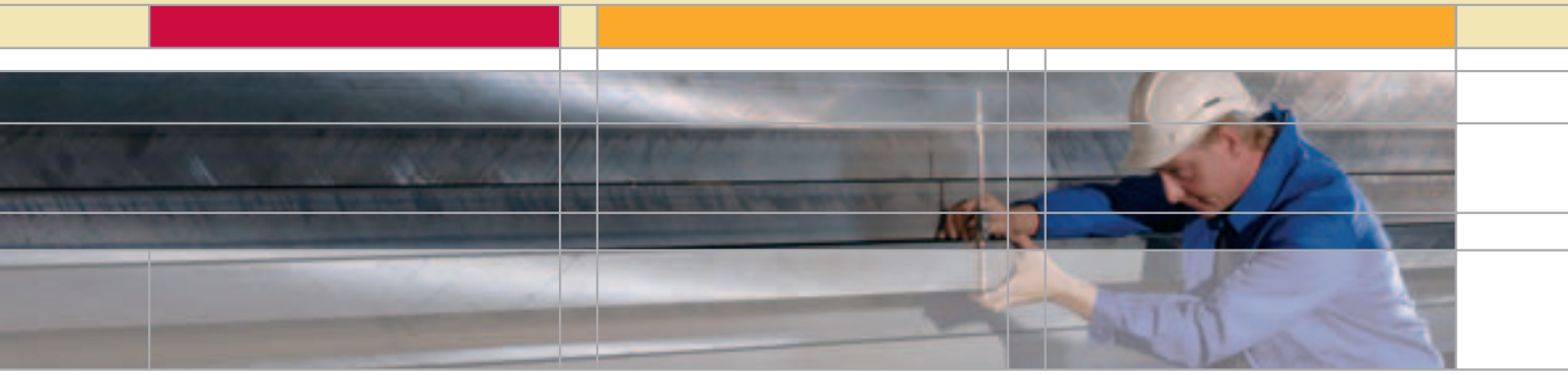
HOKOTOL: Cutter plates, chip shape and workpiece surface after face milling with an unsuitable tool design



Drilling

Tool parameter			
Tool type	Drilling tool with renewable cutters	Drilling tool	Drilling tool
Tool producer / type of tool	Walter, B3212.F.028Z01.056R	Dormer HSCO Jobber Drills	Klenk
Diameter	28 mm (1.10 ins)	13.5 mm (0.53 ins)	2.5 mm (0.10 ins)
Number of cutters	1	2	2
Material of cutters	PÜ28475-3 WXP 45	HM	HM
Tool design			
			
Drilling parameter			
Cutting speed (v_c)	528 m/min (1,732 ft/min)	254 m/min (833 ft/min)	47 m/min (154 ft/min)
Spindle speed (n)	6,000 rev/min	6,000 rev/min	6,000 rev/min
Feed per round (f_z)	0.3 mm (0.0118 ins)	0.2 mm (0.0078 ins)	0.15 mm (0.0059 ins)
Hole deepness	20 mm (0.79 ins)	20 mm (0.79 ins)	20 mm (0.79 ins)
Cooling lubricant	Spray cooling (FD 1-30)	Spray cooling (FD 1-30)	Spray cooling (FD 1-30)
GIANTAL: Chip shape			
			
WELDURAL: Chip shape			
			
HOKOTOL: Chip shape			
			

Drilling (with an unsuitable tool design)



Tool parameter	
Tool type	Drilling tool
Tool producer / type of tool	Klenk
Diameter	6.8 mm (0.2677 ins)
Number of cutters	2
Material of cutters	HM

Tool design

Drilling parameter	
Cutting speed (v_c)	85 m/min (279 ft/min)
Spindle speed (n)	4,000 rev/min
Feed per round (f_z)	0.08 mm (0.0315 ins)
Hole deepness	40 mm (1.57 ins)
Cooling lubricant	Dry

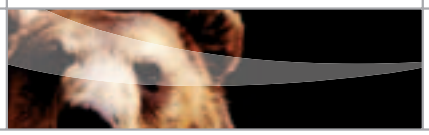
GIANTAL: Chip shape after drilling with an unsuitable tool design

WELDURAL: Chip shape after drilling with an unsuitable tool design

HOKOTOL: Chip shape after drilling with an unsuitable tool design

Properties and characteristics of GIANTAL, WELDURAL and HOKOTOL

We would be pleased to supply you with any further information about our activities.



The classic alloy: GIANTAL

GIANTAL is a highly developed form of 5083-O which used to be the alloy used in fabricating the first generation of aluminium tools. GIANTAL is distinguished by significantly low internal stresses, the property which lends itself to excellent form stability during the process of milling the plate. The uniformity of its properties is remarkable, even when the plate is extremely thick. In addition, it exhibits good weldability and corrosion resistance.

For a non-heat treatable alloy it maintains a relatively good strength, even at elevated temperatures. It is important to take into account that for many applications, this alloy might not have sufficient strength. It must also be noted that its freecutting characteristics are not as good as hard (heat treatable) alloys and this must be taken into consideration for machining operations. The wear resistance of GIANTAL is in general better than 5083.

The universal alloy: WELDURAL

WELDURAL was introduced as a high quality material for the mould construction industry, designed for excellent weldability and high temperature resistance. Its strength is similar to that of medium to high strength aluminium alloys.
WELDURAL matches 2017A and 7075 alloys not only in machinability, wear resistance, and capability of being polished, but it also offers other advantages.

This alloy permanently maintains its relatively high strength at temperatures up to 250°C (482°F). The weldability of WELDURAL is as good as that of alloy 5083. In comparison to alloy 7075, that typically demonstrates a drop in strength and higher plate thickness, WELDURAL maintains a relatively high strength with no significant dependence on plate thickness. This characteristic property of WELDURAL along with its low internal stress level, ensures excellent machinability and high dimensional stability.

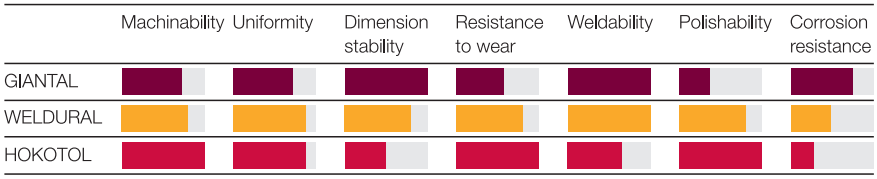
The high-strength alloy: HOKOTOL

Originally developed as a high-strength aluminium alloy for the aircraft industry, this alloy was further developed and optimized to satisfy the most demanding applications of the mould construction industry. The resulting mould construction alloy, HOKOTOL, exhibits very high strength and wear resistance as well as excellent uniformity of strength properties. These characteristics offer the mould builder an excellent machinability which remains constant across the entire thickness of the plate.

HOKOTOL plates are distinguished by their very high dimensional stability. Pertaining to surface porosity, they comply with the most demanding surface requirements.

High-strength aluminium alloys such as HOKOTOL are generally difficult to weld. However, repair welding is quite possible when an appropriate welding method such as MIG or TIG is used along with a suitable filler alloy.
Due to higher strength imparted to aluminium alloys, they are now used for applications which were until recently reserved for low to medium strength steels.

Characteristics of GIANTAL, WELDURAL and HOKOTOL



not suitable → very good suitable

www.aleris.com

Aleris Rolled & Extruded Products - Europe

“Marketing Communication”

Contact in Germany
Carl-Spaeter-Straße 10
56070 Koblenz · Germany
T +49 (0) 261 891 7329
F +49 (0) 261 891 9 7329
doreen.colausich@aleris.com
www.aleris.com

Contact in Belgium
A. Stocletlaan 87
2570 Duffel · Belgium
T +32 (0) 15 30 27 24
F +32 (0) 15 30 20 21
ann.van.dessel@aleris.com
www.aleris.com

Issue 3/08 · 2nd release