

NORTON

SAINT-GOBAIN

Transforming
surfaces
...and beyond



TECHNICAL SOLUTIONS FOR GRINDING

GEAR MARKET

TECHNICAL GUIDE




SAINT-GOBAIN





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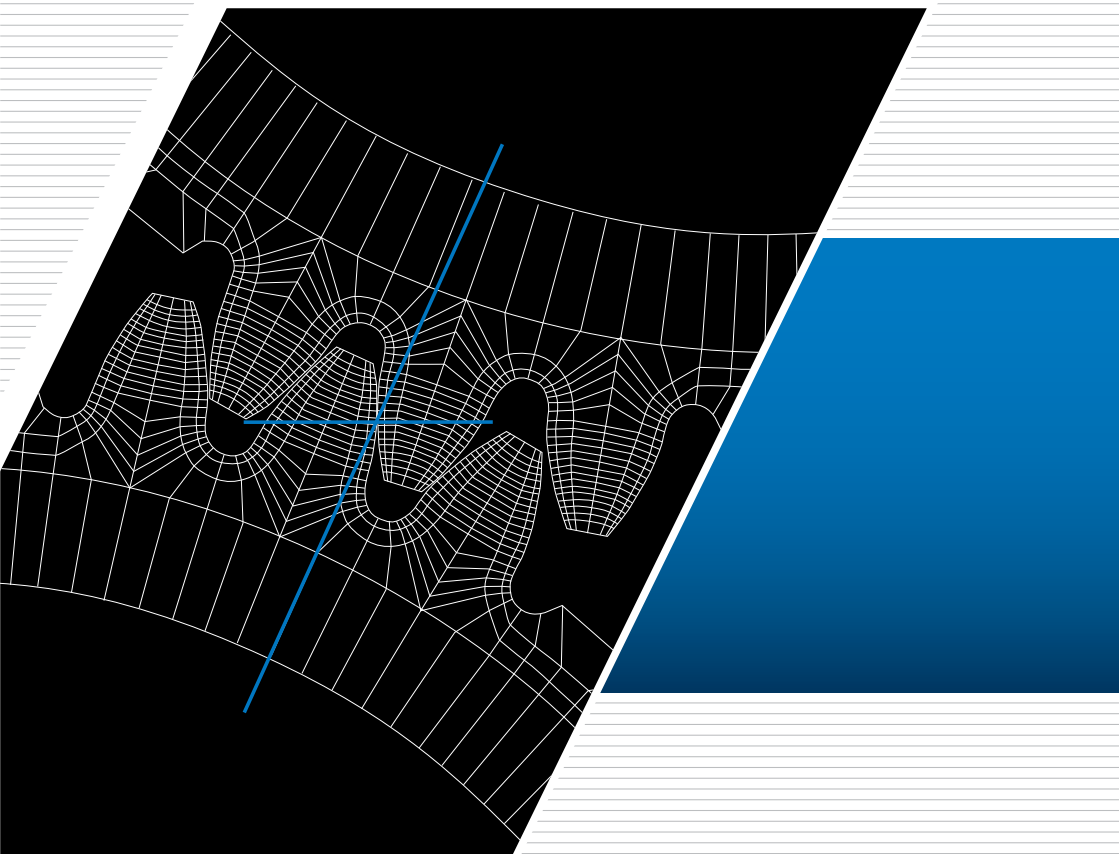
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INTRODUCTION



Increasingly stringent requirements for gears result in tighter tolerances, higher profile accuracy and improved surface finish. The choice of abrasive is key in the production of high quality gears. In order to select the right abrasive, it is important to understand the terminology and technical criteria. Saint-Gobain Abrasives offers a range of gear grinding wheels engineered to deliver a complete technical solution.

GEAR CHARACTERISTICS

DEFINITIONS:

Line of action: line along which the force between two meshing gear teeth is directed.

Pitch point: the point where the line of action crosses a line joining the two gear centres.

Pitch circle: the circle centred on the gear axis and passing through the pitch point.

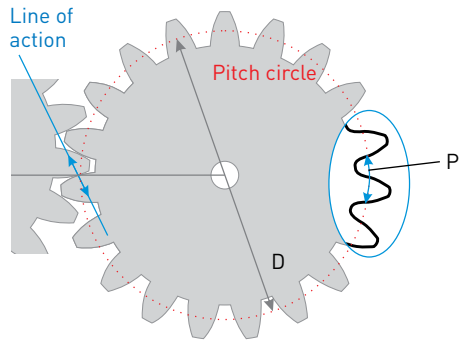
Circular pitch (P): the distance from one face of a tooth to the corresponding face of an adjacent tooth on the same gear, measured along the pitch circle.

Pitch diameter or reference diameter (D): diameter of a pitch circle.

Modulus or "size coefficient" (M): the module of a gear is equal to the pitch diameter divided by the number of teeth Z.

Pressure angle (α): the angle at a pitch point between the line of action which is normal to the tooth surface, and the plane tangent to the pitch surface.

Profile angle (V): the angle at a specified pitch point between a line tangent to a tooth surface and the line normal to the pitch surface (which is a radial line of a pitch circle).



$\pi \cdot D = \text{Gear perimeter} = P \cdot Z$
Module "M" is defined as

$$M = \frac{P}{\pi} \Rightarrow M = \frac{D}{Z}$$

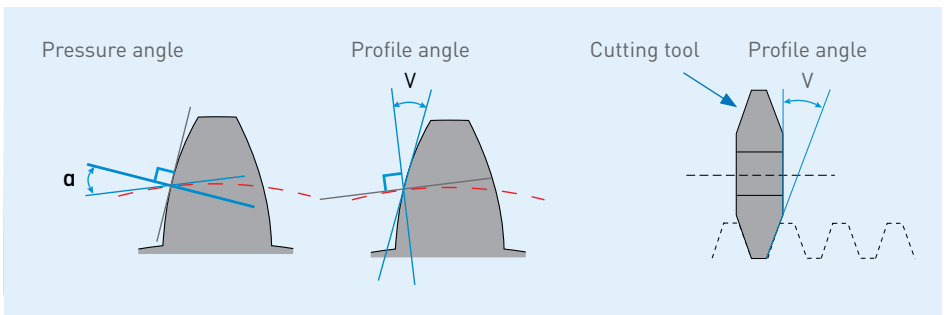
KEY:

D = Pitch diameter

P = Circular pitch

M = Module

Z = Number of teeth



Number of entries (E): the number of threads of a worm wheel. As a general rule, E should:

- not be a multiple of the number of teeth (Z)
- be as high as possible (maximum 7)

Direction: rotational orientation (left or right) of the threads

UNDERSTANDING THE PARAMETERS

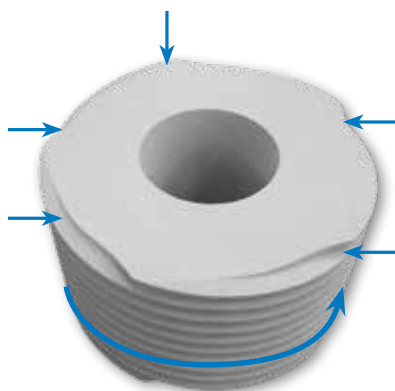
Use the information below as a guide to calculating the wheel parameters.

Part speed: PS (RPM) or (m/s)

Wheel speed: WS (RPM) or (m/s)

Number of entries: E

Number of teeth: Z



Worm wheel with E=5

Direction: left
(seen from top)



$$(1) P_S = \frac{W_S \times E}{Z}$$

Choice of E (depends on Z, see example below)

Example calculation:

- gear with Z = 30
- max PS = 600 RPM
- max WS = 4000 RPM

$$\text{Based on (1)} \quad E = \frac{P_S \times Z}{W_S} \Leftrightarrow E = \frac{600 \times 30}{4000} = 4.5$$

In this example, the general rule suggests 5 should be selected as the number of entries. However, 5 is a multiple of 30 so 4 should be chosen to optimize wheel speed.

The part speed is calculated by:

$$P_S = \frac{W_S \times E}{Z} \Leftrightarrow P_S = \frac{4000 \times 4}{30} = 533 \text{ RPM}$$

GEAR CHARACTERISTICS

GEAR MANUFACTURING

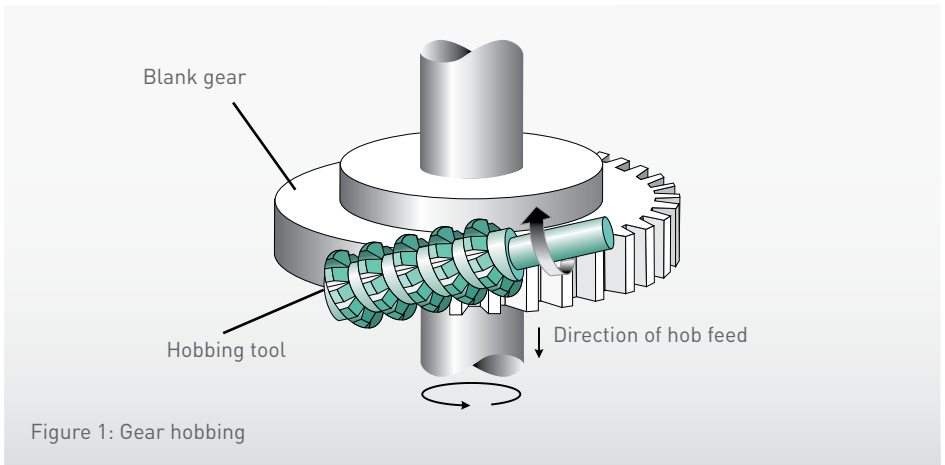
Prior to grinding, a number of stages are involved in gear manufacturing:

Hobbing is a roughing operation which produces smooth and accurate gear teeth (see figure 1).

precision tools to remove small amounts of material to correct profile errors.

Shaving and hardening are finishing operations carried out to improve dimensional accuracy, surface finish and hardness. Shaving uses high

Finally, the **grinding** operation produces a high surface finish, correcting any distortion following heat treatment.



The grinding method is determined by the shape and the module of the gear.



Power honing is a process where gears are finished directly after hobbing and heat-treating.



MAIN GEAR GRINDING METHODS



Continuous gear generation

Profiles an exact gear form into the workpiece. With multiple passes, the wheel grinds the gear teeth to produce the desired gear geometry.

Image courtesy of Kapp O' Niles



Profile grinding

Profiles the exact shape of the gear tooth. The wheel runs between two opposing teeth to grind both surfaces at the same time. Mainly used for large gears.



Bevel grinding

Bevel gears are conically shaped gears often used in differentials. Grinding of spiral bevel gears is performed with cup wheels following a profile grinding process.



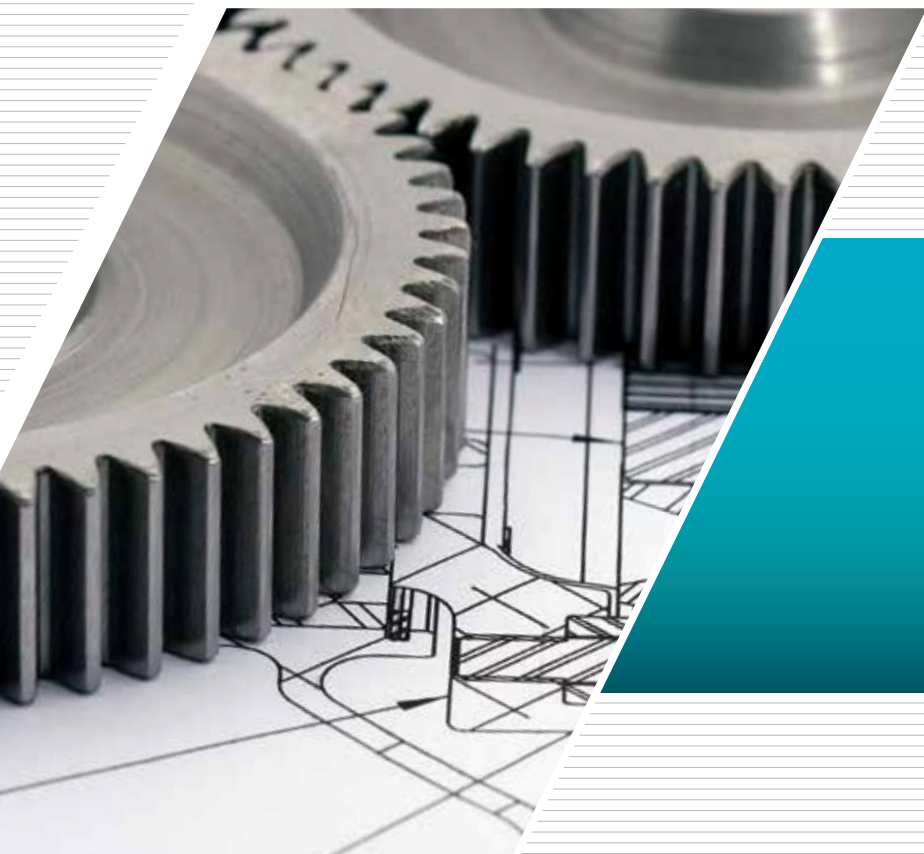
Power honing

Finishing is performed after hobbing and heat-treating. Gear flanks are ground in the internal diameter of a honing ring generating a typical surface structure improving the noise level of transmission boxes.

NOTES

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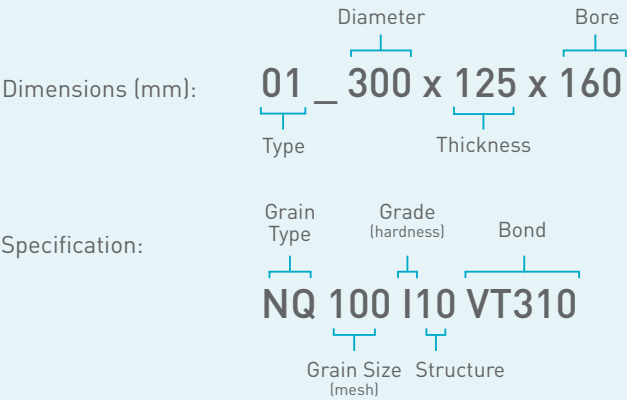
WHEEL SELECTION GUIDE



WHEEL SELECTION GUIDE

PRODUCT DESCRIPTION

Use the following example as a guide when selecting wheel shape, profile and grit quality.



GRIT SIZE SELECTION

The larger the gear module, the coarser the grit.

MODULE	GRIT SIZE				
	80	90	100	120	150
> 3.5					
1.5 - 3.5					
< 1.5					

The grit sizes highlighted with are recommended

TOP TIP

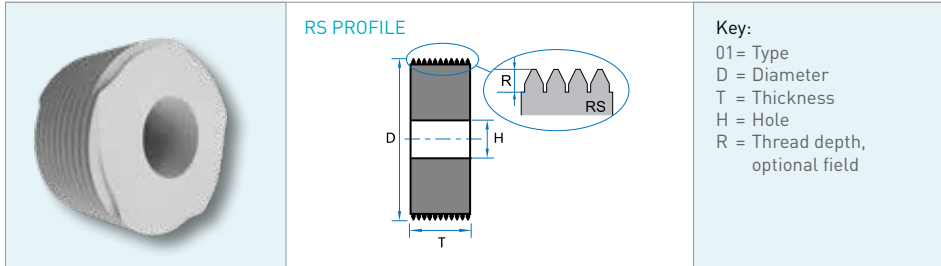
Be sure to check the wheel construction parameters: module, pitch, number of entries, pressure angle and thread direction.

Gear example:

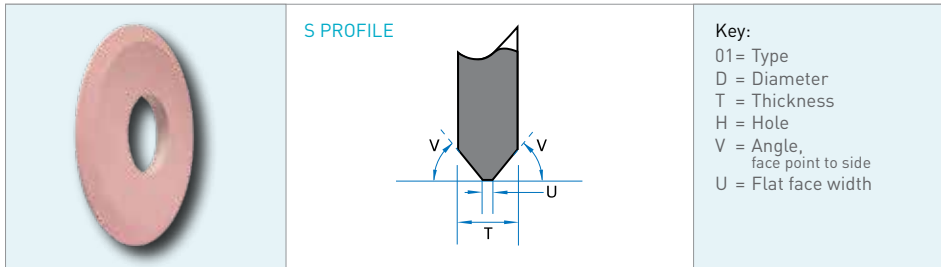
120mm diameter,
36 teeth,
pressure angle 20°,
module "M" = 3mm



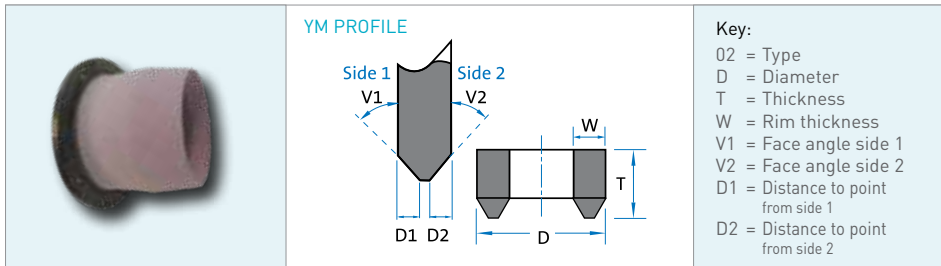
WORM WHEEL FOR CONTINUOUS GEAR GENERATION



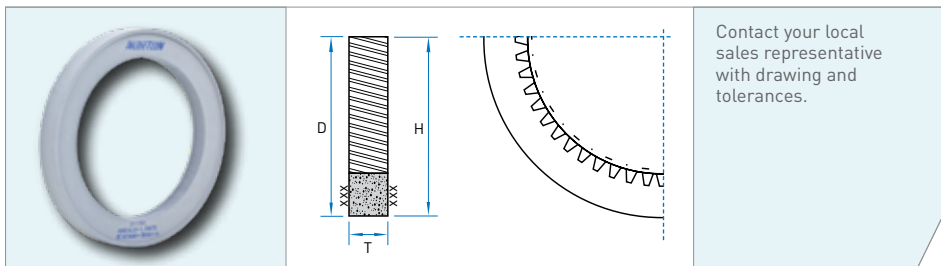
STRAIGHT WHEEL FOR PROFILE GRINDING



CUP WHEEL FOR BEVEL GRINDING



HONING RINGS FOR POWER HONING



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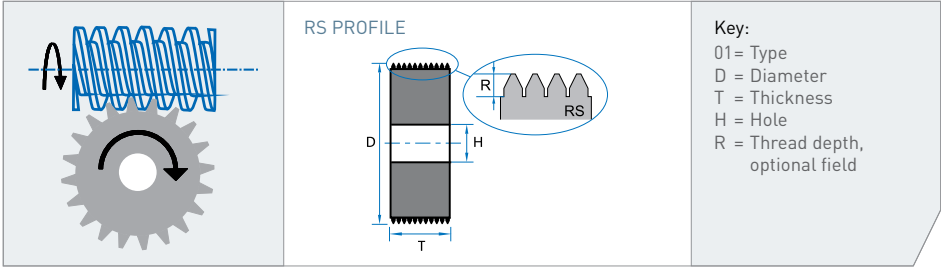
CONTINUOUS GEAR GENERATION



Continuous gear generation profiles an exact gear form into the workpiece. With multiple passes, the wheel then works on the gear teeth to produce the desired gear geometry. This is known as continuous grinding and is mainly used on small contact areas, but can also be used on large contact areas.

WORM GRINDING WHEEL

WHEEL SELECTION GUIDE



WHEEL SELECTION GUIDE

Worm grinding wheels are available for the following machines:

MACHINE BRAND	MACHINE TYPE	WHEEL DIMENSIONS (mm)		
		Diameter	Thickness	Hole diameter
GLEASON	160TWG	240	125	120
	300TWG	220	180	76.2
	ZWS 380	350	84, 104	160
KAPP	KX150	180	125	100
	KX300	280	160	115
KLINGELNBERG	VIPER 500W	350	150	160
LIEBHERR	LCS200	195	200	90
	LCS300	220	230	110
	LCS380	240	230	110
NILES	ZX 630 - 800 - 1000	320	160	115
REISHAUER	RZ150, RZ60, RZ160, RZ260, RZ360	275	125, 160	160
	RZ400, RZ303C, RZ630, RZ800, RZ1000	300	125, 145	160
	RZ301S, RZ362A, RZ300E, AZA	350	62, 84, 104	160
	RZ701, RZ820	400	84, 104	160

TOP TIP

The number of teeth (Z) and number of entries (E) must not be multiples of one another. This avoids repetition and accumulation of defaults from threads on the same teeth.



THE XTRIMIUM COLLECTION

WORM GRINDING

An engineered micro-structured ceramic grain provides excellent free cutting action and durability to maximize performance and quality.

- Perfect homogeneity throughout wheel thickness
- Increased form holding
- Friction free

TARGET	MODULE	SPECIFICATION
High productivity	All	Xtrimium - Fast
High quality	Small	Xtrimium - Quality
Universal	MTO*	Xtrimium - Dynamic



DUAL WORM GRINDING

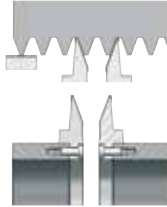
The dual wheel combines a vitrified section to grind, and a fine grit section to polish the gear teeth.

- High surface quality providing $R_z=1,0\mu\text{m}$ $R_{pk}=0,05\mu\text{m}$
- Wheels can be adapted to existing machines



DRESSING TOOLS FOR CONTINUOUS GEAR GENERATION GRINDING WHEELS

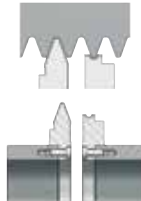
SINGLE-TAPER DRESSING DISCS



- Highly flexible tool concept for different module ranges
- Discs are mounted on separate spindles

Highly flexible solution

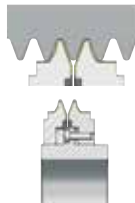
DOUBLE-TAPER DRESSING DISCS



- Very good when tooth root machining is required
- Tool design is dependent on the work piece

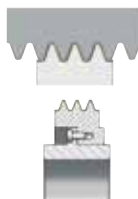
Module	Tool design
Small ≤ 1.5	Reverse electroplated
Large > 1.5	Positive electroplated

ROLLER DRESSER SETS FOR SINGLE-PASS DRESSING



- High pitch adjustment
- Very good when tooth root grinding is required
- Tool design is dependent on the workpiece

FULL PROFILE ROLLER DRESSERS

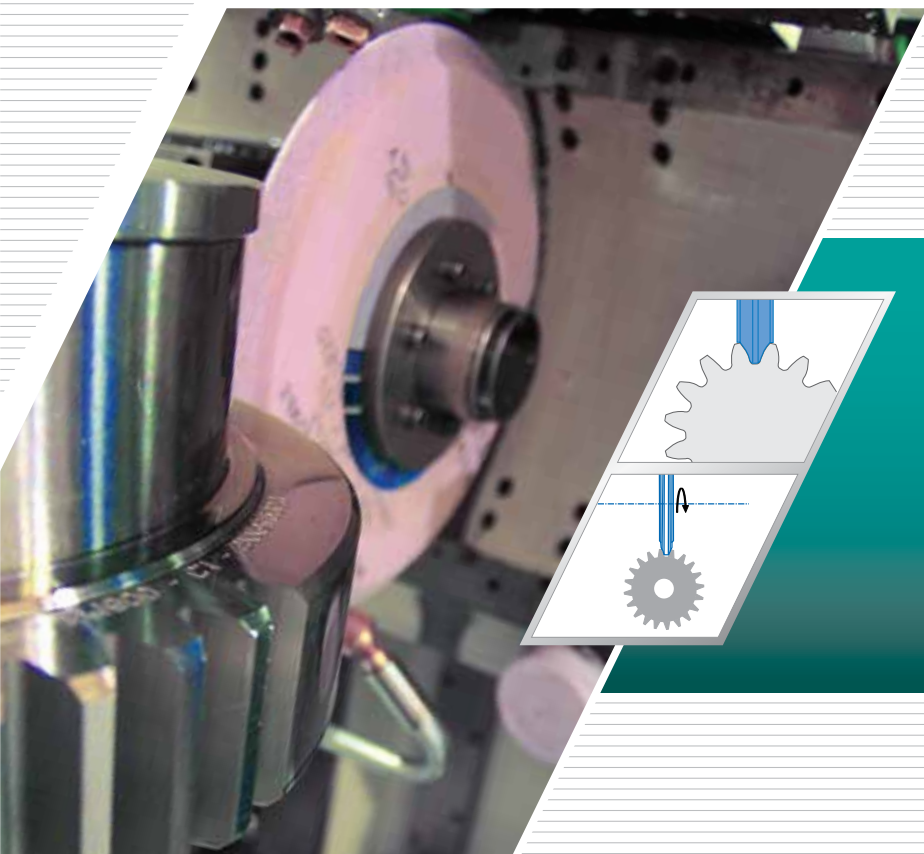


- Particularly suitable for modules ranges < 1.5
- Excellent tool design with low setup requirements
- Specific design to each workpiece

Highly productive solution

Contact: dresser@saint-gobain.com

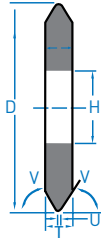
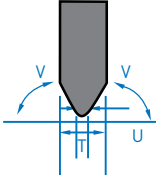
PROFILE GRINDING



Profile grinding forms the exact shape of the gear teeth. The wheel runs between two opposing teeth to grind both surfaces at the same time. This is known as discontinuous grinding and is used on large contact areas.

SINGLE PROFILE GRINDING WHEELS

WHEEL SELECTION GUIDE





Key:
 01 = Type
 D = Diameter
 T = Thickness
 H = Hole
 V = Angle, face point to side
 U = Flat face width

WHEEL SELECTION GUIDE

Wheels for grinding single profile gears are available for the following machines:

MACHINE BRAND	MACHINE TYPE	WHEEL DIMENSIONS (mm)		
		Diameter	Thickness	Hole diameter
GLEASON PFAUTER	P400G/ 600G/ 800G	350	30 to 60	127
	P1200G/ 1600G/ 2000G/ 2400G/ 2800G/ 3200G/ 4000G/ 5000G/ 6000G	450	30 to 80	127
	Opti-Grind	400	30 to 80	170
	Titan 1200, Titan 1500	450	40 to 80	127
HÖFLER	Promat 400, Helix 400 Rapid 650/800/1000/1250	400	20 to 100	127
	Rapid 1600/2000/2500/3000/ 4000/5000/6000/8000	450	40 to 100	127
	Rapid 2500I/ 3000I/ 4000I/ 6000I	470	80 to 130	127
KAPP	VAS P	200	20 to 50	76,2
KLINGELNBERG	VIPER 500W	350	10 to 60	160
NILES	ZP 08/10/12/16/20/24	450	40 to 130	127
	ZP 30/40/50/60	500	40 to 130	127
	ZE 400/630/800/1000/1200	350	63 to 80	127



DRESSING TOOLS

Winter rotary dressing discs provide excellent results on single profile wheels:

- Contour controlled CNC dressing
- Very flexible
- One tool for several profiles





PROFILE GRINDING

High porosity and permeability in this ceramic based wheel offering the fastest metal removal rate on the market.

- Unrivalled DIN quality
- Fast material removal

TARGET	PLATFORM	SPECIFICATION
High productivity	Altos	Xtrimium - Fast
High quality	Norton Quantum X	Xtrimium - Quality



NOTES

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SPIRAL BEVEL GEAR GRINDING WHEELS



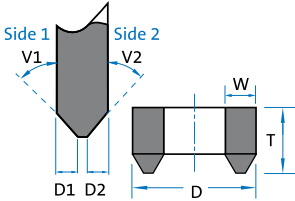
Bevel gears are conically shaped and used for differentials. Grinding of spiral bevel gears is performed with cup wheels in a specific profile grinding process.

SPIRAL BEVEL GEAR GRINDING WHEELS

WHEEL SELECTION GUIDE



YM PROFILE



Key:

- O2 = Shape code
- D = Diameter
- T = Thickness
- W = Rim thickness
- V1 = Face angle side 1
- V2 = Face angle side 2
- D1 = Distance to point from side 1
- D2 = Distance to point from side 2

WHEEL SELECTION GUIDE

Wheels for grinding single profile gears are available for the following machines:

MACHINE BRAND	MACHINE TYPE	WHEEL DIMENSIONS (mm)		
		Diameter	Thickness	Hole diameter
GLEASON	Phoenix 200HG	MTO*	MTO*	MTO*
	Phoenix II 275G/600G/800G			
KLINGELNBERG	G27			
	G50			
	G60			
	G100			

*Made to order



Bevel gear

TOP TIP

Wheels for spiral bevel grinding can be supplied directly glued on the metal plate upon customer demand.



SAINT-GOBAIN



BEVEL GRINDING

Altos is the 'must have' wheel, no other wheel for Bevel grinding compares.

- Burn free cutting
- Extremely fast grinding
- Reduces part rejection, overall lowering the cost per unit





DRESSING TOOLS

Winter offers a dressing solution for all spiral bevel gear grinding wheels:

- Contour controlled CNC dressing
- Very flexible
- One tool for several profiles

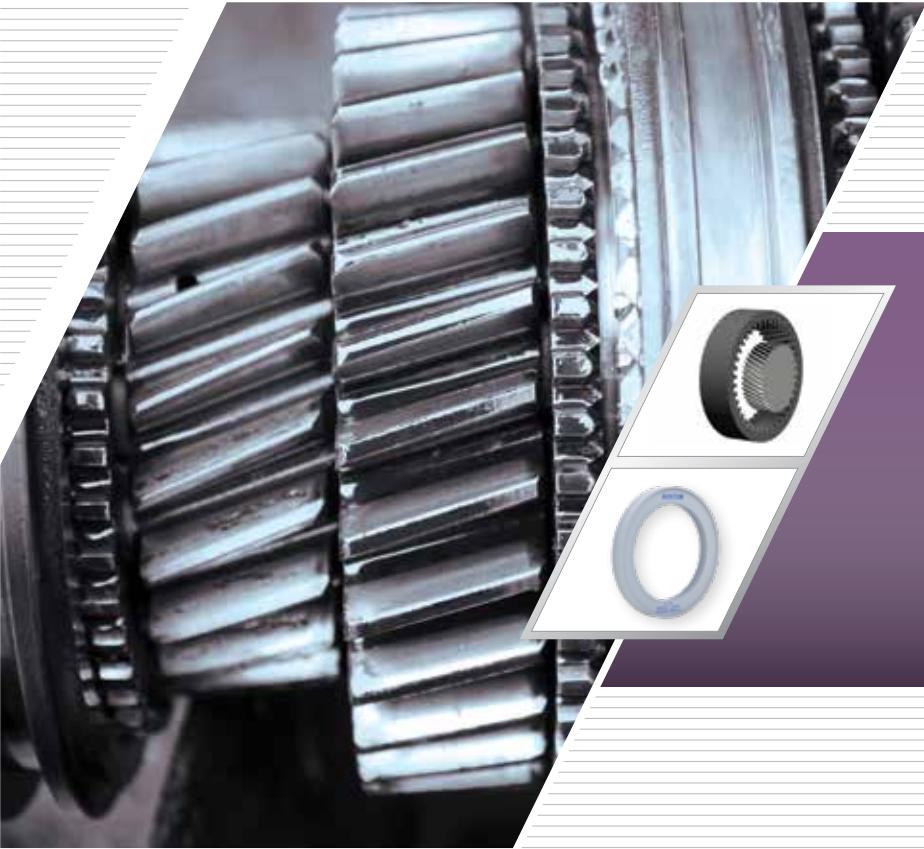


Source: Klingelberg

TOP TIP

Lubricant or cooling fluid filtration improves this complex grinding process. A defective filtration can lead to poor surface finish, heat generation, wheel loading and a shorter wheel life.

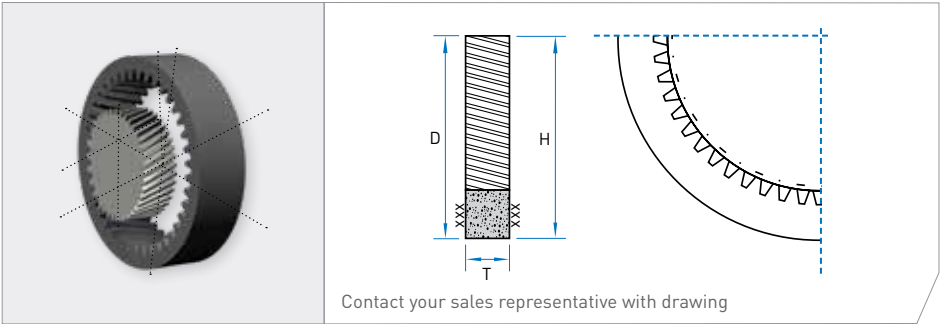
POWER HONING



Power-honing is an increasingly popular process in the production of gears and shafts for transmission boxes. Power honing is a final process where gears are finished after hobbing and heat-treating. Gear flanks are ground in the internal diameter of a honing ring, generating a typical surface structure, improving lubrication, and resulting in quieter gear transmission.

GRINDING POWER HONING RINGS

WHEEL SELECTION GUIDE



WHEEL SELECTION GUIDE

Honing rings are available for the following machines:


MACHINE BRAND	MACHINE TYPE	WHEEL DIMENSIONS (mm)		
		Diameter	Thickness	Hole diameter
FAESSLER	HMX 400	399.55	MTO*	MTO*
GLEASON	150SPH	300	MTO*	MTO*
	ZH250	400	MTO*	MTO*
PRÄWEMA	HFSL 203 / HS205 / HS205-D	269.95	MTO*	MTO*

*Made to order

For power honing grinding, Norton provides only the highest technology solution.

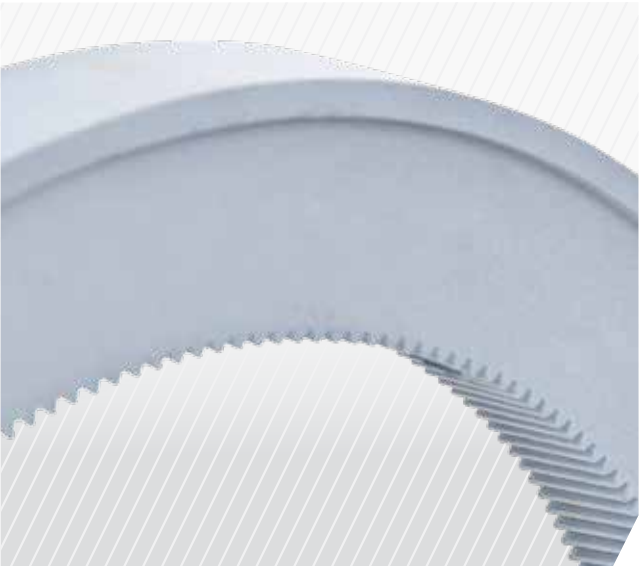


GRIT DESCRIPTION

TIER	GRIT TYPE	FEATURES	BENEFITS
BEST +++++	 <p>3NQW</p>	<ul style="list-style-type: none"> • Engineered microstructure ceramic grain • Latest grain technology • Engineered grain boundaries 	<ul style="list-style-type: none"> • Optimise cost savings and maximise performance • Free cutting action • Extremely durable • For low, medium and high force

BOND DESCRIPTION

TIER	BOND TYPE	FEATURES	BENEFITS
BEST +++++	VET	<ul style="list-style-type: none"> • Vitrified durable bond 	<ul style="list-style-type: none"> • Form holding • Reduce dressing needs



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SEMI FINISH STOCK SERVICE



Saint-Gobain Abrasives now offers a stock of semi-finished straight wheels, ready to be profiled on demand. This stock is designed to provide a fast track service and to increase flexibility.

SEMI FINISHED STOCK SERVICE

This document will help you to find the best solution for the most common machines on the market. Wheels can be ordered profiled or straight.

Contact your local sales representative for more information.



To increase the service efficiency, please detail all required profile information. If you have a drawing, don't hesitate to send it to your sales contact.

See below the two most common profiles to be machined from our semi-finished blank stock.

WORM WHEEL FOR CONTINUOUS GEAR GENERATION

	<p>RS PROFILE</p>	<p>Key: D = Diameter T = Thickness H = Hole M = Module Thread direction: left or right Number of entries/starts</p>
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STRAIGHT WHEEL FOR PROFILE GRINDING

	<p>S PROFILE</p>	<p>Key: D = Diameter T = Thickness H = Hole V = Angle, face point to side U = Flat width</p>
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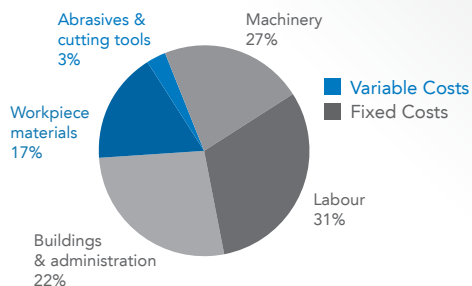
STOCK SIZES

WHEEL DIMENSIONS (mm)		
Diameter	Thickness	Hole diameter
240	230	110
350	104	160
300	125	160
320	230	110
250	180	125
275	125	160
350	150	160
280	160	115

Typical cost reductions

On average abrasives and cutting tools only account for about 3% of total manufacturing budgets. Norton Vitrium³, Altos and Vortex 2 products optimised with Norton's proprietary PSP (process solutions program) helps to optimise your total cost and improve your productivity.

For information on how to achieve the greatest overall cost savings, see the example below or go to www.saint-gobain-abrasives.com/psp-eu.aspx.



Decreasing the price of abrasives

A 30% price reduction will only reduce costs per part by 1%.

Increasing the life of abrasives

Even a 50% increase in product life will only reduce costs per part by 1%.

Increase overall productivity through PSP

With a 20% decrease in cycle time per part there will be a reduced total cost per part of more than 15%.



IMPROVING OUR CARBON FOOTPRINT

Increased productivity with existing customer machine capacity. Able to work with higher feed rates, speed and pressure, to significantly increase production while using fewer wheels. Reduced energy consumption with optimal firing temperatures during manufacturing of Norton Vitrium³, Altos and Vortex 2 wheels.

By choosing Norton Vitrium³, Altos and Vortex 2 technology for your grinding operation, you help to preserve the environment. In addition, Norton Vitrium³, Altos and Vortex 2 eliminate costly re-validation of processes associated with using chemical pore inducers such as naphthalene.



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