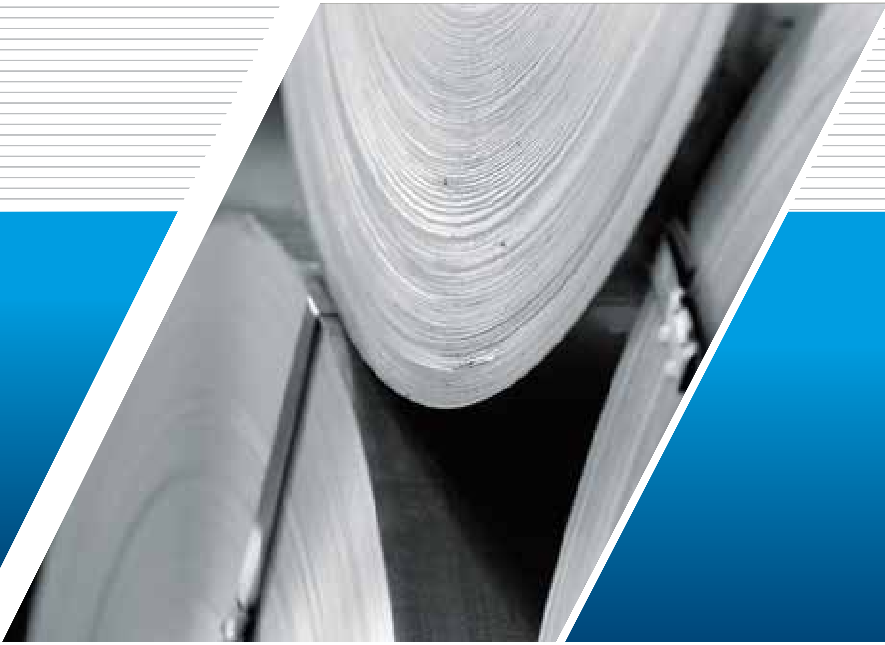
Reshaping your world™

TECHNICAL SOLUTIONS FOR

CUTTING & GRINDING FOR PRIMARY STEEL MARKET



NORTON®
SAINT-GOBAIN

TECHNICAL SOLUTIONS FOR PRIMARY STEEL MARKET

From initial steel conditioning to grinding, finishing and polishing of sheets, bars or tubes, whether cutting slabs, billets and bars or re-grinding rolls to the highest surface quality, Saint-Gobain provides the optimum abrasive solution for every application.

NORTON®
SAINT-GOBAIN

CONTENTS

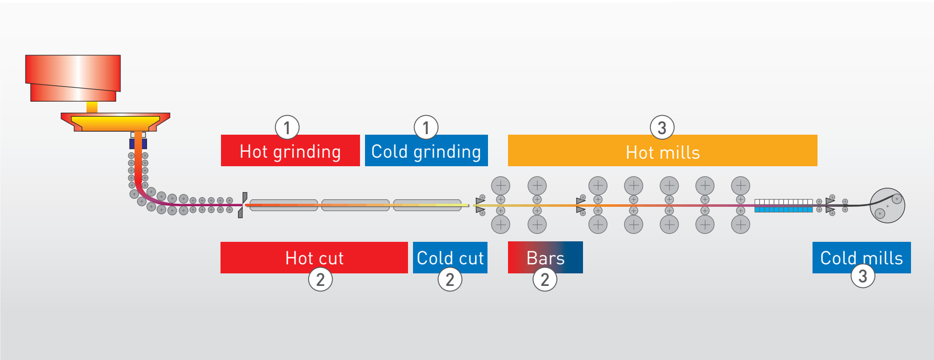
STEEL MANUFACTURING

It is a major component in the manufacturing of buildings and infrastructures, machines, tools and transportation. Modern steel is identified by grades. Its processing from ore to semi-finished materials such as slabs, ingots and plates undergoes the same steps.

INTRODUCTION

To become steel, iron is melted and re-processed to reduce the carbon content and add other chemicals. This liquid is then continuously cast into long slabs or ingots. The ingots are heated in a soaking pit and hot rolled into slabs.

The diagram below shows the grinding and cutting application stages involved in steel production:



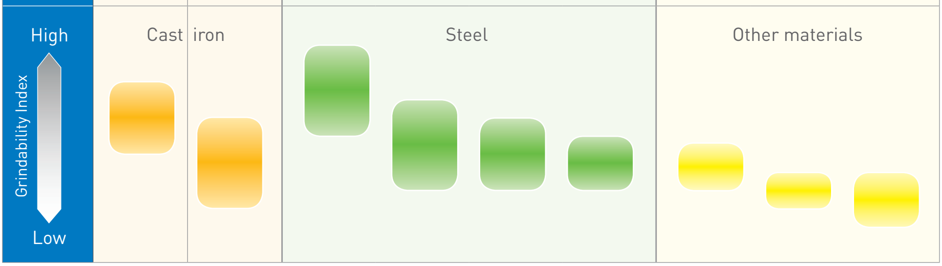
1. Steel Conditioning

2. Large Diameter Cut-Off

3. Roll Grinding

MATERIAL CLASSIFICATION

	CAST IRON		STEEL				OTHER MATERIALS		
Material family	Cast iron grey (2.5-4% C)	Ductile/ nodular cast iron	Carbon steel soft (<1.3% Carbon)	Carbon steel hard (<3.4% Carbon)	Stainless & alloy steel	Tool steel	Nickel alloy	Titanium	Aluminium
Density range	7.1-7.3	6.6-7.2	7.7-8.1	7.8-8.3	7.7-9	6.5-8.2	8.2-8.9	4.5	2.7
Hardness	180-300 HB	130-220 HB	86-580 HB	170-600 HB	80-600 HB	140-750 HB	140-513 HV	70 HB-60HV	15 HV
Application	Engine gears	Gears, camshafts, crankshaft	Various general engineering				Aerospace, sport, military, automotive.		



The graph above shows the grindability index for each material family. The grindability index is defined as the measure of how easy or hard a material is to grind under specified conditions. It is expressed in volume of material removed per unit volume of wheel wear.

OUR COMMITMENT: SAFETY, QUALITY AND ENVIRONMENT PRESERVATION

SAFETY

The personal safety of workers using abrasive cutting and grinding wheels is our primary concern. All Norton abrasive wheels are developed, manufactured and safety tested in accordance with the European standard EN12413, safety requirements for bonded abrasive products. In addition, all Norton products meet stringent requirements of the Organization for the Safety of Abrasives (oSa). Saint-Gobain Abrasives is a founding member of the oSa organisation.

www.fepa-abrasives.org

www.osa-abrasives.org

QUALITY

Saint-Gobain Abrasives is fully ISO accredited:

ISO 9001:	certifies Quality Management system is in accordance with requirements of quality standards.
ISO 14001:	certifies Environmental Management system is in accordance with requirements of environmental standards.
OHSAS 18001:	health and safety at work certification.

ENVIRONMENTAL PRESERVATION

Environmental Protection

Waste management is undertaken to optimise recycling activities and zero pollution of air, water and land is defined as a major objective.

Reduction of Natural Resource Consumption

New production processes and procedures are regularly implemented to help minimise the amount of waste created during the manufacturing process.

STEEL CONDITIONING (BZZ)

In steel conditioning processes, hot pressed, very hard wheels without porosity, are commonly used to eliminate defects (cracks, impurities and straws) from slabs, blooms, billets and ingots.

INTRODUCTION

Before further processing semi-finished steel products, the workpiece should be free from scale and flaws. High-pressure grinding is the optimal process for removing scale, cracks and other surface defects. Grinding large-scale rounded parts however, requires specific grinding facilities. Machines generally have extremely high driving power, between 50 and 630 kW. The grinding speed is generally 80 m/s.

Grinding processes can be optimized, enhancing quality and reducing costs by:

- Removing defects and cracks at lower cost
- Ensuring the best surface quality for downstream processes
- Minimizing metal waste at the conditioning stage

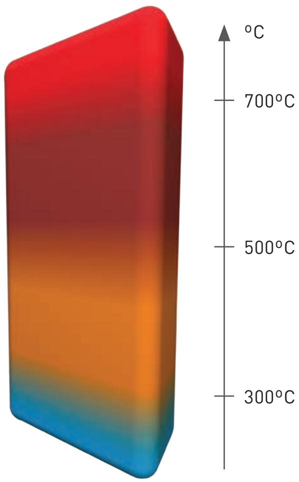
Three key process characteristics will dictate the choice of wheel specification:

- Temperature of the material to be ground
- Material characteristics
- Features of the machine or pressure applied during grinding

WORKPIECE TEMPERATURE

After casting, the steel is cut into slabs, billets or blooms. Steel conditioning with hot-pressed wheels is carried out with cold, warm or hot workpiece temperature to remove scale, eliminate defects, and achieve the required surface finish.

WORKPIECE TEMPERATURE	
Red hot grinding	Above 700°C
Hot grinding	500-700°C
Warm grinding	300-500°C
Cold grinding	Up to 300°C



MATERIAL CHARACTERISTICS

The characteristics and shape of the material dictate the choice of grinding wheel specification.

Steel mills:

- Carbon steel - used for springs and bearings
- Low, medium and high alloyed steels
- Stainless steel - austenitic, ferritic martensitic and duplex
- Refractory steels - titanium, zirconium and nickel
- Slabs, billets, ingots, blooms, rounds

Foundries (roll manufacturers):

- Roughing rolls - work and back up
- Spin cast high chrome, high speed steel

MACHINE CHARACTERISTICS

Typical machine features:

- Power ranges from 50 to 630 kW
- Medium to high stiffness

Typical metal removal:

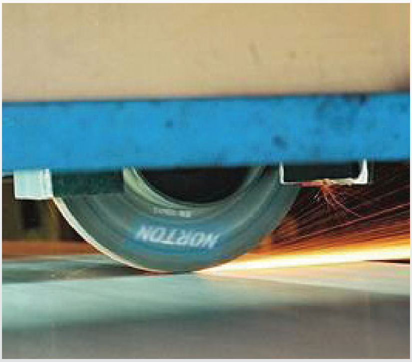
- 3 to 15 kg/s/mm
- 2 to 7 kg/kWh (on stainless steel)

Application

- Cold grinding
- Warm grinding
- Hot grinding

Machine

- Low power (120 kW and below)
- Medium power (120 - 250 kW)
- High power (250 kW and above)



Material

- Stainless steel
- Carbon steel
- High alloy steel
- Titanium

Requirements

- Yield loss
- Surface finish
- Life

APPLICATION GUIDELINES

The following variables can influence the grinding application:

Machine:
- Machine type
- Power
- Operating speed
- Machine controls & condition
- Angle of tilt

Work piece:
- Part cross section
- Part conditions
- Grindability of material
- Desired finish
- Depth of defect
- Quality of casting/pouring

Grinding Wheel:
- Wheel size
- Hardness grade
- Type of abrasive
- Grit & size
- Structure & bond

Operating condition:
- Pressure
- Cross feed
- Rate of table travel
- Area of contact
- Power drawn

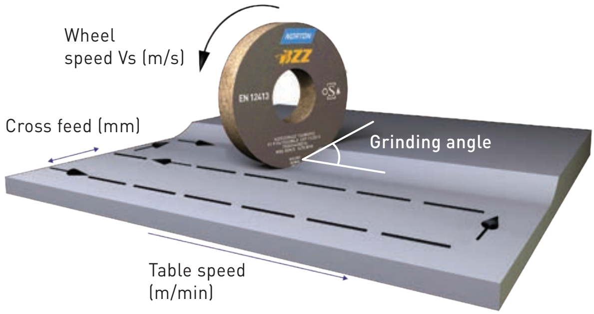
Material Removal Rate = material removed/grinding time [kg/h]

Wheel Wear Rate = wheel wear / grinding time [kg/h] or [dm³/h]

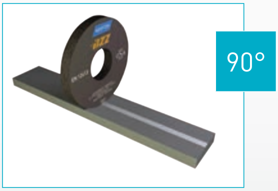
Grinding Ratio = material removed/wheel wear [kg/dm³]

Q-ratio = material removed/ wheel wear [kg/kg]

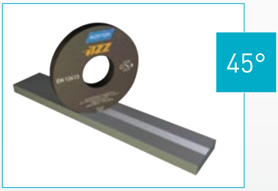
Yield loss = material removed of material weight in ‰



GRINDING ANGLE COMPARISON



- Minimum grinding wheel wear
- Good surface roughness
- Minimum corner breakdown



- Optimum Material Removal Rate (MMR)
- Increase grinding path width
- Reduce scallop effect (less over grinding)

TROUBLESHOOTING

EFFECT OF INCREASING PERIPHERAL WHEEL SPEED (V_S)

POSITIVE EFFECT	NEGATIVE EFFECTS
Reduced wheel wear	Increased grinding heat & energy consumption
Improved surface finish	Increased vibration
Increased MMR	Higher wheel stresses
Increase grinding ratio (MR/WW)	Increased machine stresses

TOP TIP

Usual, maximum and optimal wheel speed is 80 m/s. On constant RPM machines, the peripheral wheel speed decreases.

INCREASED FORCE	REDUCED FORCE
Increases wheel wear rate	Improves surface finish
Increases metal removal rate	Reduces depth of cut
Increases power required	Reduces yield loss

TOP TIP

Steel conditioning can be performed on constant load or constant power (following machine feature and/or programming). On constant power MRR is more controlled.

INFLUENCE OF THE TABLE SPEED

Typically, table speed is between 30 and 60 m/min.

INCREASE TRAVERSE RATE	DECREASE TRAVERSE RATE
Reduce grinding power	Increase depth of cut
Reduce wheel wear rate	Increase metal removal rate
Increase vibration/chatter	Increase heat generation
Better surface finish if no chatter	-
The wheel acts harder	The wheel acts softer

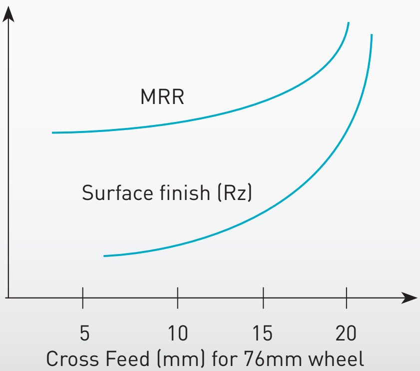
EFFECT OF THE WHEEL SIZE

LARGER DIAMETER	LARGER THICKNESS
Increased contact area	Increased contact area
Wider grinding path	Wider grinding path
Lower cost per dm^3 wheel	Higher wheel stresses
Increase surface area for energy absorption	Increased surface area for energy absorption
Increase wheel performance	Increase wheel performance

INFLUENCE OF CROSS-FEED

LARGE CROSS-FEED	SMALL CROSS-FEED
Increases MMR Increases over grind	Reduce peak-valley dimension

Influence of Cross Feed on
MRR & Surface Finish



Stainless steel slab conditioning

IMPROVING SURFACE QUALITY

Wheel bond grade	Holding abrasive in wheel longer than normal (stable grinding) produces better surface finish
Grinding force	Reducing grinding force improves surface finish
Wheel speed	Increasing wheel speed improves surface finish
Table speed	Increasing table speed improves surface finish
Metal quality	Grinding low tensile materials gives poor finish
Grinding temperature	Reduction of the temperature decreases surface finish

ON-SITE TESTING

Use the Test Request Form found at the back of this Guide or the System Documentation to collect test data.

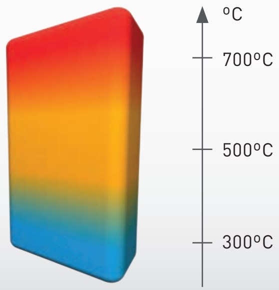
LARGE DIAMETER CUT-OFF (LDCO) WHEELS

Steel cutting requires high performance reinforced wheels to provide a good quality, clean cut and efficient cut rate. Saint-Gobain Abrasives offers a wide range of optimized cutting wheels to meet all requirements, temperatures of cut and material characteristics. Large Diameter Cut-Off wheels (LDCO) are larger than 900mm in diameter and are widely used in the steel market.

INTRODUCTION

The choice of cut-off wheel depends on process variables including the temperature of the material to be cut, material characteristics (type, shape and dimensions) and cut-off machine (power availability and type).

WORKPIECE TEMPERATURE		APPLICATION
Hot cutting	700-1000°C	Steel mills
Warm cutting	300-700°C	Steel mills
Cold cutting	Up to 300°C	Steel mills and finishing shops



MATERIAL CHARACTERISTICS

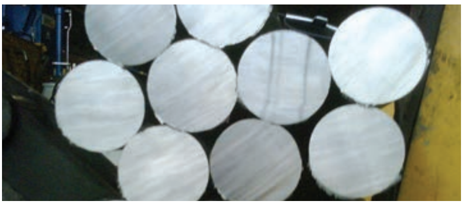
Material type and characteristics influence the choice of wheel specification.
The following material types are commonly found in LDCO applications:

- High alloyed carbon steel (construction steel, bearing steel)
- Low alloyed carbon steel
- Super-alloys Ni-Cr based
- Stainless steel
- Titanium

CUT REQUIREMENTS

Quality: White cut, cut straightness (within tight tolerance).
G-ratio: Life time of the cutting-wheel, dark cut permitted.

Cut requirements can vary depending on the application. Quality of cut is often important when a white cut is required.



White cut (no burns, cut straightness)

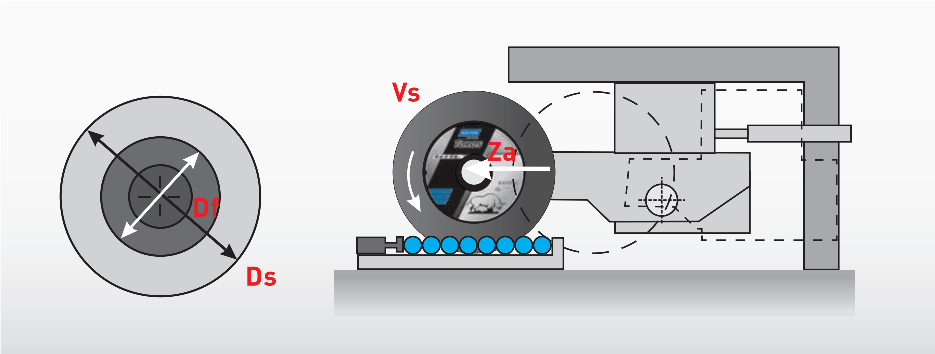
Dark cut (burns, blueing is visible)

TOP TIP

The shape (round, square) and dimensions of the bars to be cut can impact wheel performance and specification. The key parameter is the contact surface (cross section) during cutting.

APPLICATION GUIDELINES

The diagram below shows an example of a traverse cutting-off application with main operating parameters highlighted.



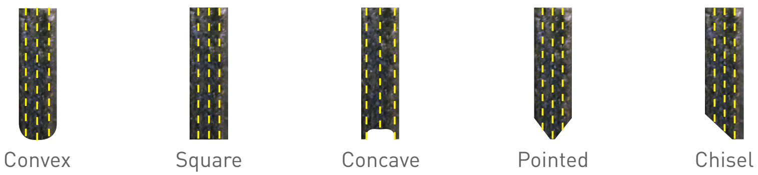
The table below shows the common range values for these operating parameters.

Peripherical speed **(Vs)**	63 to 100 m/s
Flange Diameter **(Df)**	1/3 wheel LDCO diameter (Ds)
Infeed **(Za)**	12-30 cm^2/s for hot cutting
	8-25 cm^2/s for warm cutting
	5-15 cm^2/s for cold cutting

PROFILE CHARACTERISTICS

Wheel profile is influenced by internal fiberglass, layer & working par.

- Square/Light Convex: most common for correct application
- Concave: most common when mild specifications are used with light pressure on the workpiece. Helps to maintain straight cutting.
- Pointed: wheel is too hard cutting or feed rate is too slow
- Chisel: results from incorrect machine torque or from incorrect layer distribution inside the wheel.



ON-SITE TESTING

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TROUBLESHOOTING

PROBLEM	POSSIBLE CAUSE	SUGGESTED CORRECTION
Poor wheel life (Gratio)	Specification too soft	Harder bond/grade
	Grit too fine	Coarser grit
	Wheel too thin	Increase wheel thickness
	Grain too friable	Use more durable abrasive blend
Poor cut rate (MRR)	Insufficient power	Use harder grain and/or finer grit
	Specification too hard	Add a semi-friable diluent
	Abrasive too durable	Use softer or thinner wheel
	Abrasive too coarse	Use finer grit
Poor cut quality: not square cut	Wheel too hard	Use softer wheel
	Work piece not clamped properly	Check clamping sytem
	Miss-aligned spindle bearings	Check machine
	Insufficient feed rate	Increase feed rate
Poor cut quality: workpiece burn	Wheel too hard	Use softer grade wheel
	Grit too coarse	Use finer grit spec
	Wheel speed too high	Decrease rotational speed
Poor cut quality: workpiece burrs	Grit too coarse	Use finer grit
	Specification too hard	Go to a softer spec

NOTES

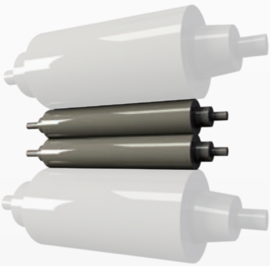
ROLL GRINDING

Grinding wheels are used in the regrinding and production of rolls in the steel, aluminium, brass, copper, paper and textile industries. The main consumption of rolls is in the primary steel industry where the rolling process is most commonly used to produce coils and plates to the required thickness and surface finish, starting from slabs. The material type and dimensions of rolls differ depending on the rolling application. Saint-Gobain Abrasives offers a wide product portfolio, providing cost benefits for grinding all roll materials (including HSS) in different applications.

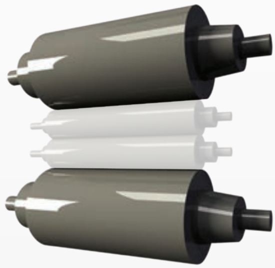
INTRODUCTION

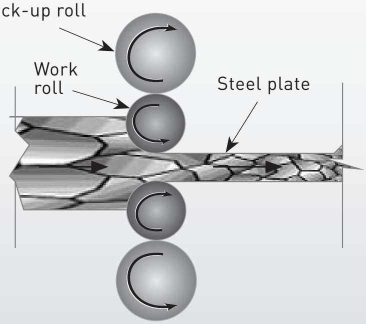
Steel slabs are rolled in Hot Rolling Mills (HRM) or Cold Rolling Mills (CRM) to achieve the desired finish and dimension. For both hot and cold applications, rolls can be divided into two different families: Work rolls and Back-Up rolls.

Work rolls are used for rolling the steel, designed to sustain the high pressure and temperature (especially on HRM) and to impart the required surface finish.

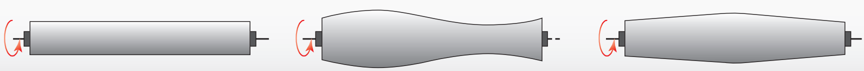


Back-up rolls support the tremendous pressure exerted on the work rolls. They are not in direct contact with the steel plate.

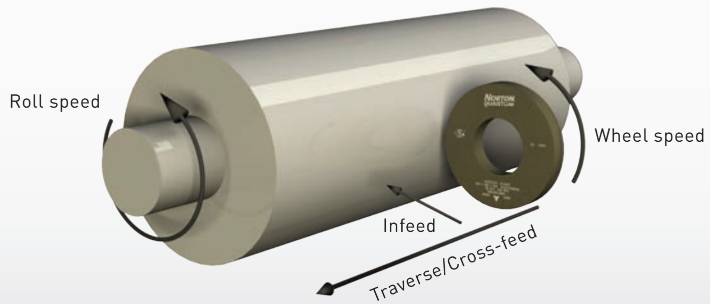




Rolls have different dimension, material and application requirements. Depending on the stage of the laminating process, a specific type of surface finish and roll shape is required:



Rolls degrade during the rolling process and can become scratched, cracked, lose their shape or even melt the steel. They are regenerated by a cylindrical, high precision grinding process (roll grinding).



Most roll grinding wheels are large in diameter (700-1080mm) and thickness (50-150mm). Roll grinding wheels are available in the following shape types (ISO standard 525):

- Type 01 = straight wheel
- Type 05 = single recess wheel
- Type 07 = double recess wheel
- Type 21 = wheel relieved on both sides

Roll grinding wheels are made from Aluminum Oxide and Silicon Carbide abrasive, including ceramic grain, combined with a resinoid bond. Grit size ranges from 24 to 220 with grades F to L most common.

The application is always carried out wet, using mostly emulsion with 3-5% water soluble oils (WSO).

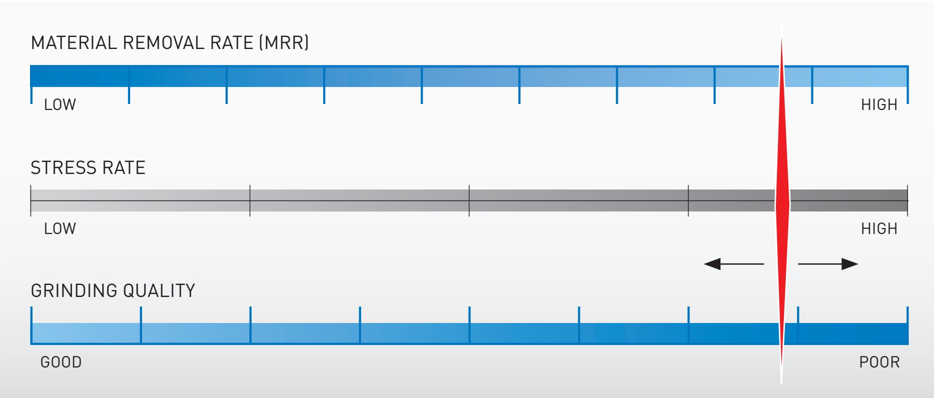
TOP TIP

Norton Vortex and Norton Quantum wheels provide very high performance (high MRR and wheel life) in steel mill grinding operations.

APPLICATION GUIDELINES

In roll grinding applications, the roll diameter is larger than the wheel diameter. The grinding result mainly depends on the stress between the wheel and roll at the point of contact.

Grinding parameters influence MRR, WWR (wheel wear rate), power absorbed (P) and surface quality (Ra).



- Roll surface quality, roughness and tight geometrical tolerances
- Any increase in stress between the wheel and the roll increases MRR
- Any reduction in stress between the roll and the wheel improves grinding quality

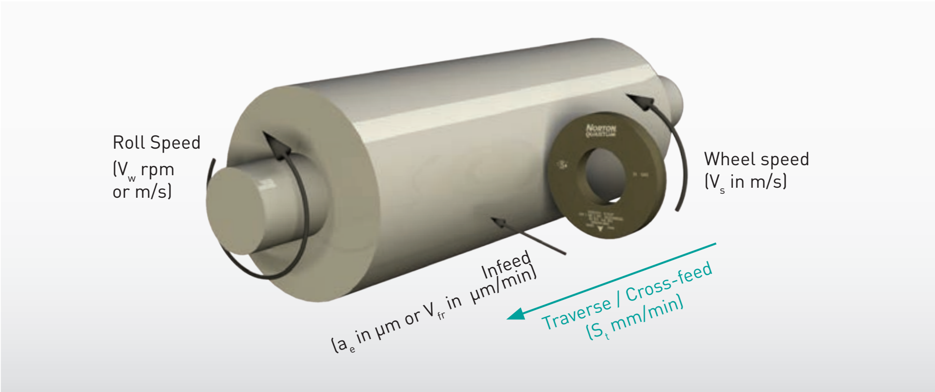
OPERATIONAL FACTORS EFFECTING GRINDING

The stress in the grinding zone depends on:

- Wheel speed (V_s measured in m/s)
- Roll speed (V_w measured in rpm or m/s)
- Cross-feed or traverse rate (S_t measured in mm/min),
- Sequential Infeed rate (a_e µm) or continuous infeed rate (V_{fr} µm/min)
- Coolant application, type and flow.

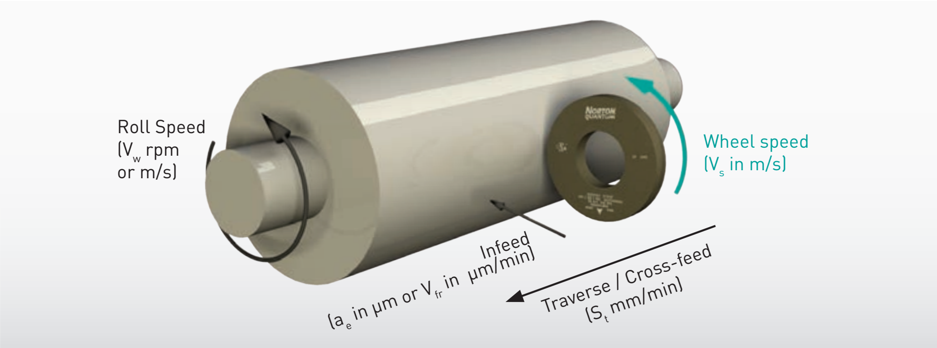
Changing the parameters affects the grinding quality, productivity and the total grinding cost.

TRAVERSE RATE



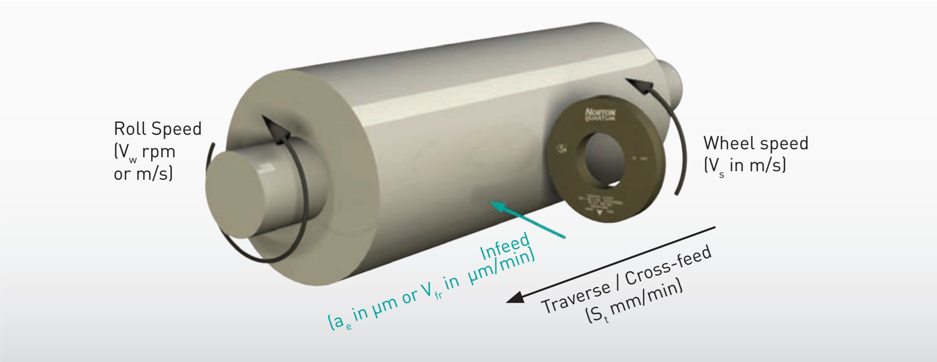
SLOW (< 1 000 mm/min)	FAST (> 1 000 mm/min)
Decreased wheel wear	Increased MRR
Lower amps / power	Shorter wheel life
Improved finish	Increased productivity
Better roll surface quality	Higher productivity

WHEEL SPEED



SLOW (20 – 35 m/s)	FAST (36 - 48 m/s)
Lower amps/power	Increased MMR
Less chatter	Decreased wheel wear
	Higher Gratio / wheel life
Better roll surface quality	Higher productivity & lower abrasive cost

INFEED/INFEED RATE



LOW (<25µm)	HIGH (>50µm)
Improved surface finish	Increased MMR
Decreased wheel wear	Wheel acts softer
Lower amps / power	Higher productivity
Better roll surface quality	Higher productivity

CUT RATIO

Cut Ratio (CR) is the wheel speed (Vs) in m/s divided by the roll speed (Vw) in m/s (CR = Vs/Vw). Increasing wheel speed (Vs) and/or decreasing roll speed will increase the cut ratio.

CR between 45 and 60 is ideal for high MRR. Reduce CR less than 40 for better surface finish and below 30 to eliminate chatter.

CUT WIDTH

Cut width or overlap (Wc) is the amount of wheel overlap that takes place in one revolution of the roll.

Wc (mm/rev) = T Traverse rate (mm/min)/roll speed (rpm).

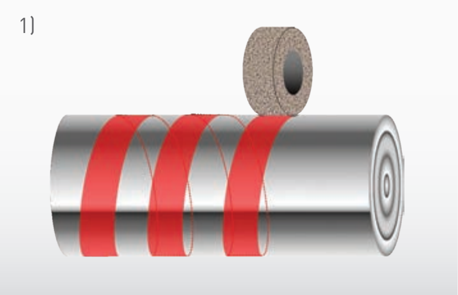
The smaller the Wc the better the finish, but the lower the MRR.

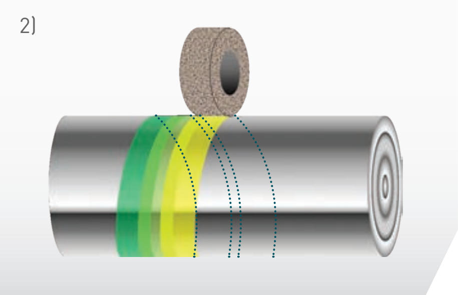
Having a Wc close to 67% of the wheel thickness is ideal for roughing.
Never exceed 75% of the wheel width (tolerances won't be kept and rough finish).

The diagrams below show two examples of overlap conditions.

1) Wc'<0% / no overlapping: some parts of the roll will not see the wheel during the pass.
This happens when the roll turns too slowly in comparison with traverse speed.

2) Wc'~33% partial overlapping: 1/3 of the surface of the roll sees the wheel twice during 1 pass.
The roll turns once turn while the wheel moves 2/3 of its width.





GRINDING FLUID (COOLANT AND LUBRICANT)

Main purposes of the grinding fluid are:

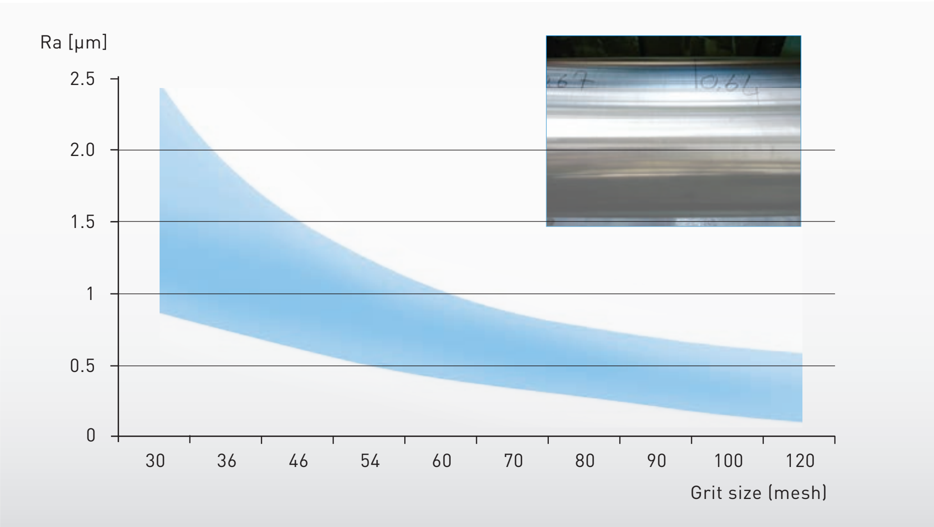
- Lubrication: helps to remove chips, reduces friction and grinding machine degradation.
- Coolant effect: keeps the work temperature low, preventing heat dissipation through the part (cracks) and in the wheel (bond degradation).

Grinding fluid requirements:

- Flow rate is recommended at ~4 litres/min/kW with laminar flow
- Coolant speed from nozzle = wheel surface speed
- Pressure should be between 5 and 9 bars
- Nozzle dimensions cover complete wheel face (w = width of wheel)
- pH of grinding fluid should be less than 10, above pH10 organic bonds are degraded.

GRIT SIZE

- Coarser grits yield longer wheel life and increase MRR (productivity).
- Finer grit sizes improve surface finish and are also required to grind hard and tough materials like HSS.
- Abrasive type and bond type also influence surface finish.

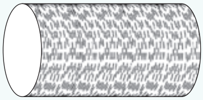
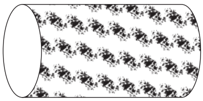
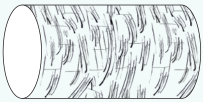
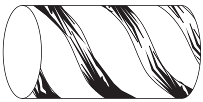


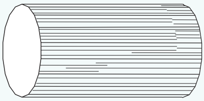
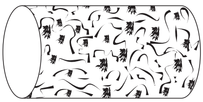
SUMMARY

TECHNICAL OUTPUT	WHEEL SPEED		ROLL SPEED		CROSS-FEED		INFEED	
	Slow	Fast	Slow	Fast	Slow	Fast	Slow	Fast
MRR	↓ (red)	↑ (green)	↑ (green)	↓ (red)	↓ (red)	↑ (green)	↓ (red)	↑ (green)
WWR	↑ (red)	↓ (green)	↓ (green)	↑ (red)	↓ (green)	↑ (red)	↓ (green)	↑ (red)
Power	↓ (grey)	↑ (grey)	↑ (grey)	↓ (grey)	↓ (grey)	↑ (grey)	↓ (grey)	↑ (grey)
Chatter	↓ (green)	↑ (red)	O	O	↓ (green)	↑ (red)	↓ (green)	↑ (red)
Surface Finish (Ra)	O	O	↑ (red)	↓ (green)	↓ (green)	↑ (red)	↓ (green)	↑ (red)

KEY: ↑ (red) Negative effect ↑ (green) Positive effect ↑ (grey) Power increase or decrease O No effect

TROUBLESHOOTING

PROBLEM	DIAGRAM	POSSIBLE CAUSE	SUGGESTED CORRECTION
Poor quality finish		Contaminated coolant	Filter coolant and clear regularly
		Grit collection in guard	Clean and flush inside guard periodically
		Traverse too fast	Reduce traverse rate
		Poor wheel dressing	Dress correctly before finish operations - use plenty of coolant while dress
		Wrong cut ratio	Reduce cut ratio
		Infeed too high	Reduce infeed for last passes
Longitudinal scratches		Spindle bearing failure	Check bearing for quality and aligment
		Grinding wheel surface not regular	Check wheel surface and set a dressing phase
V shapes defect		Dirty coolant	Clean coolant frequently
			Use an effective filter
		Dresser not properly fixed	Fix dresser properly
		Wheel too soft	Change specification or increase wheel speed
Feed lines		Not dressing properly	Check dressing parameters
		Wheel edges too sharp	Break/chamfer the edges
		Wheel not in axis with its centre	Check the axis passing between the centering points
		Incorrect overlap ratio	Decrease wheel speed &/or slow down traverse rate on finishing passes. Reduce overlap ratio (<75%)

PROBLEM	DIAGRAM	POSSIBLE CAUSE	SUGGESTED CORRECTION
Chattering		Spindle bearing failure	Check bearing for quality and aligment
		Vibrations from machine system	Maintenance
		Umbalanced wheel/flange coupling	Check the imbalance
		Roll speed too fast	Reduce roll speed until vibration stops
		Inadequate lubrication of rolls neck	Maintenance
		Wheel too hard	Reduce wheel speed; use softer grade
Burn & cracks		Roll speed too slow	Increase roll RPM
		Wheel speed too high	Decrease wheel speed
		Contact time too long	Increase traverse feed
		Stress on the contact area too high	Decrease wheel infeed and traverse speed
		Wheel too hard	Reduce wheel speed; use softer grade
		Wheel needs dressing	Dress wheel open with plenty of coolant
		Coolant not properly oriented	Direct better the coolant flow
		Not enough coolant flow	Increase coolant flow
		Poor wheel dressing	Dress wheel open with of coolant

ON-SITE TESTING

Use the Test Request Form found at the back of this Guide or the System Documentation to collect test data.

NOTES

NOTES

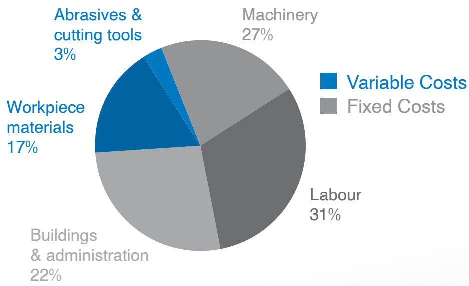
PSP

process solutions program

Typical cost reductions

On average abrasives and cutting tools only account for about 3% of total manufacturing budgets. Norton Quantum, Toros and BZZ 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%.

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