PROCESSES & TOOLS FOR HIGH PERFORMANCE GRINDING

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GRINDING CONFERENCE

Level 1

ABRASIVES

SAINT-GOBAIN

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Saint-Gobain

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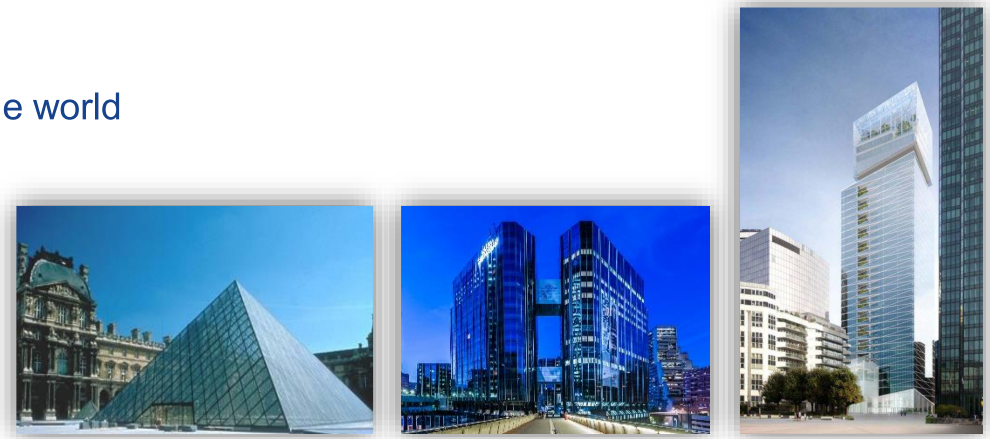
SAINT-GOBAIN

… one of the 100 industrial companies in the world



- **More than 170000 employees**
- **Manufacturing facilities in 65 countries**
- **Turnover > 38 Mrd €**

- **3 Pillars**

Innovative Materials

23,5%

Construction-products

27,5%

Distribution

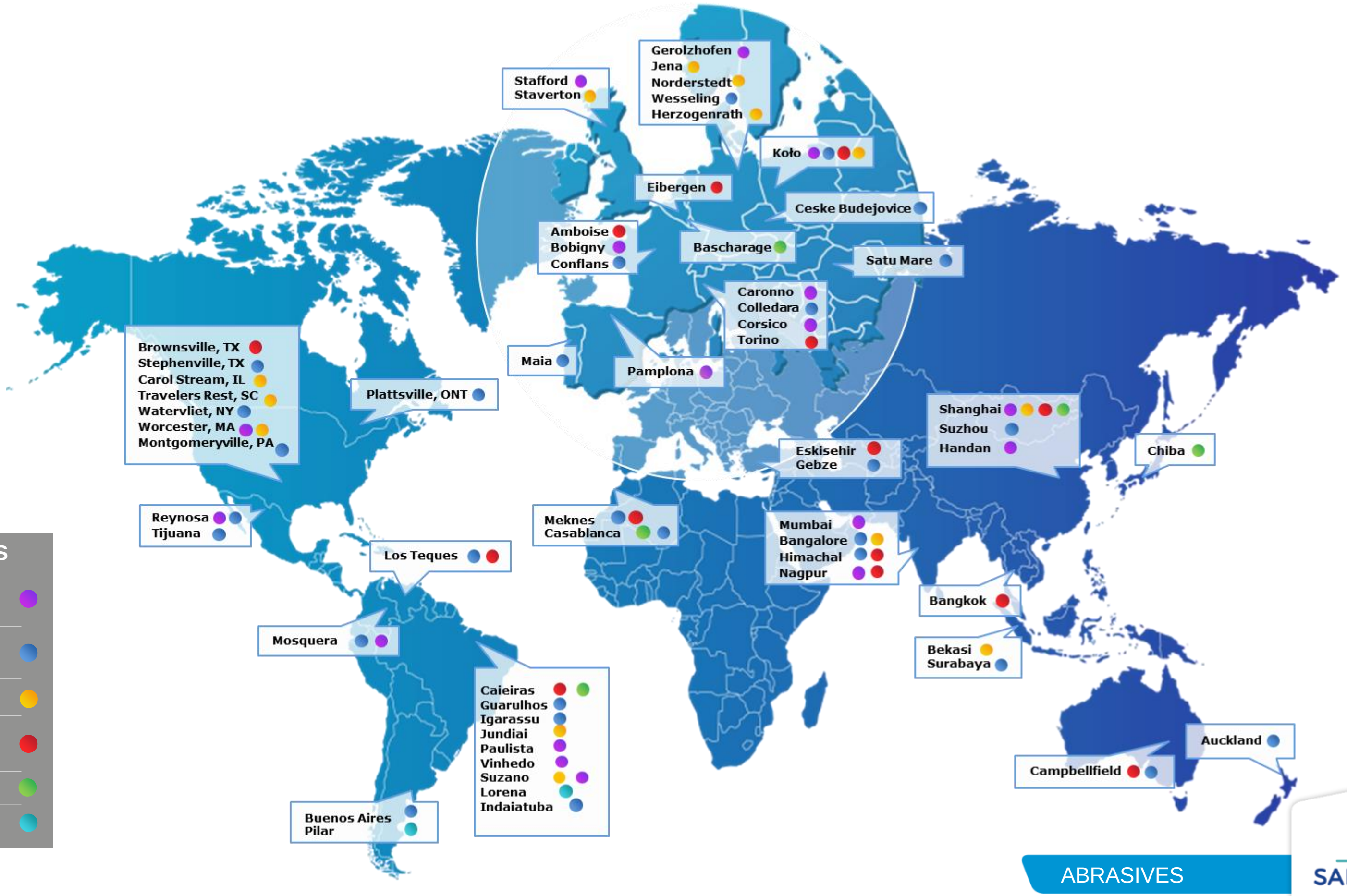
49%

SAINT-GOBAIN ABRASIVES

- **Supplier for all product groups**
  - Bonded Abrasives
  - Coated Abrasives
  - Superabrasives
  - Thin- and Cut-off Wheel
  - Construction Products
- **~ 11000 Employees**
- **61 plants in 27 countries**
- **~ 1,5 Mrd € turnover**
- **Major brands:**

NORTON SAINT-GOBAIN WINTER flexovit

SAINT-GOBAIN ABRASIVES



PRODUCTGROUPS	
BONDED ABRASIVES	🟣
COATED ABRASIVES	🔵
SUPERABRASIVES	🟡
THIN & CUT-OFF WHEELS	🔴
CONSTRUCTION	🟢
OTHERS	◉

Grinding Basics

MOTIVATION

- The efficiency of the grinding processes is constantly being increased with regard to material removal, grinding times, surface quality and the complexity of the process sequences.
- Amongst other aspects this is necessary for the processing of new materials and also helps reduce grinding costs.
- But how is this achieved?
  - On the one hand, with modern grinding machines that allow for fast and optimum processes.
  - On the other hand, through the development of innovative grinding tools that make optimum process parameters possible in the first place. The individual combination of the right abrasive grain and the suitable bond leads to a specification that ensures the highest performance for the respective application.

FROM THE GLOBAL DEMANDS TO THE DETAILED SOLUTION

Market Demand
- Increase in efficiency
- Noise reduction
- Robustness
- Life time
- Cost reduction
- Environment protection

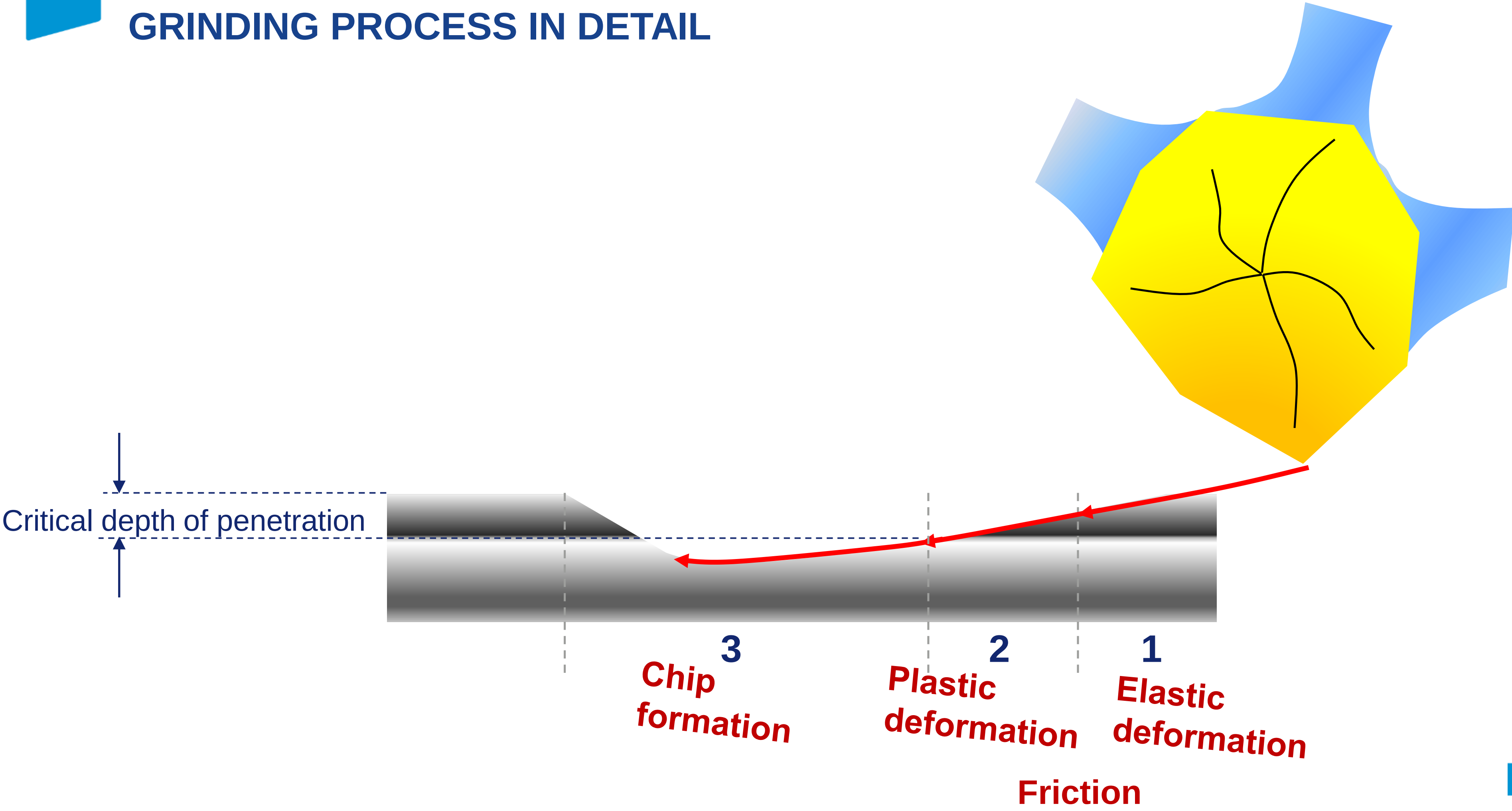
Industry Demand
- Tighter tolerances
- Higher profile accuracy
- Improved surface finishes
- New materials (hard/tough/light/...)
- Cost reduction
- Lean manufacturing

System Approach
- Analyze and evaluate the total system

Knowledge of the Criteria
- Workpiece properties
- Technical details and workpiece requirements
- Commercial objectives
- Machine equipment and capacity

Technical & Commercial Grinding Solution
- Comparison of possible processes
- Superabrasive or bonded?
- Grinding:
  - Selection of the grinding tool (grit quality and bond system)
  - Definition of the specification
  - Determination of process parameters

GRINDING PROCESS IN DETAIL



Critical depth of penetration

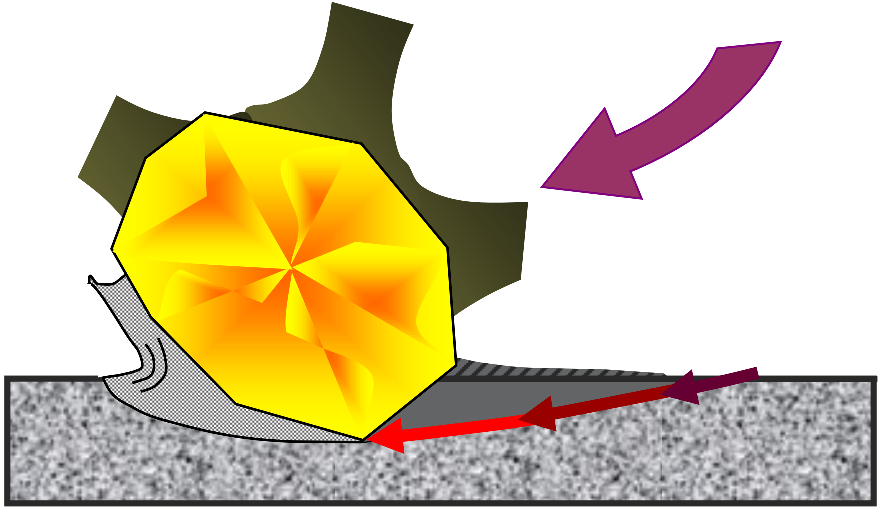
3 **Chip formation**

2 **Plastic deformation**

1 **Elastic deformation**

Friction

GRINDING PROCESS … INTERACTIONS



Chip formation

Deformation
elastic / plastic

Friction / interaction
grit / workpiece / chip und chip / bond / workpiece

An efficient grinding process means:

- High material removal
- Low spindle power
- Cool grind
- No damaging interactions
- Long wheel life
- High form stability

High Performance Grinding

Abrasive Grain and Specification

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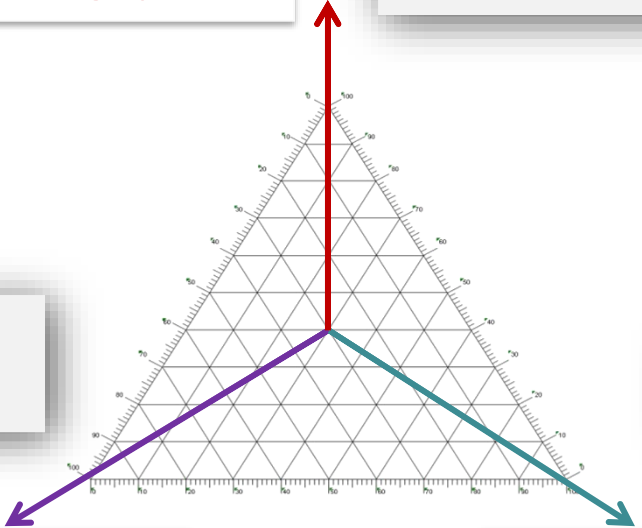
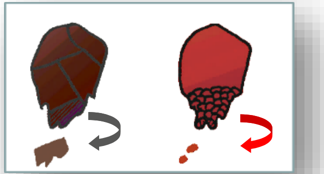
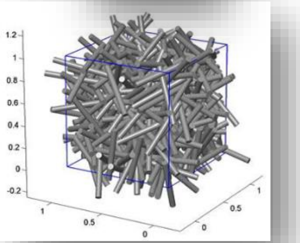
THREE BASIC COMPONENTS FOR OPTIMAL SOLUTIONS



Grain

Fused alumina (white, rose, monocrystalline)
Seeded gels (SG, XG, NQ, …)
Extruded alumina (TG, TGX, …)
Diamond / cBN



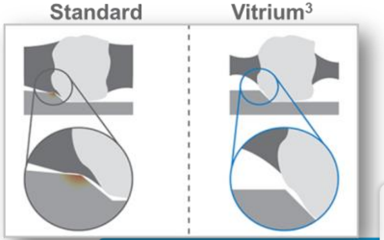


The porosity is formed by a specific matrix technology or by artificial pore inducers

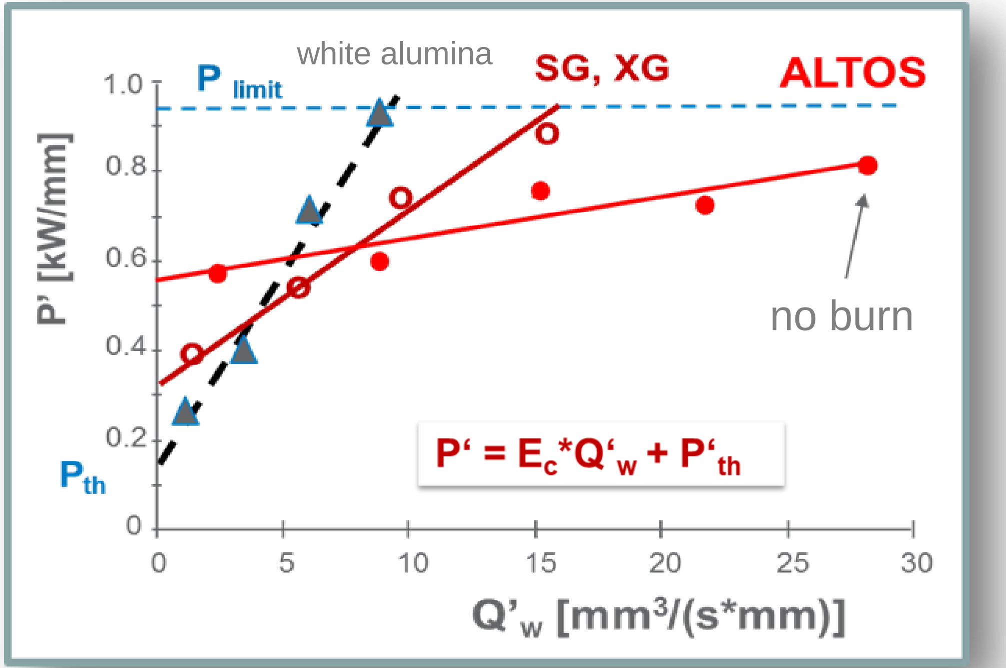
Porosity

Bond

Bonds show different hardness, wear resistance, grit retention capacity



THE VARIETY LEADS TO THE OPTIMUM



Why not only one single specification?

- Each abrasive grain/bond/porosity shows its strengths in certain areas
- The following points are influenced by specification:
  - Specific grinding energy E_c
  - Threshold power P_{th}
  - Aggressiveness / chip thickness
  - Surface roughness
  - Maximum metal removal rate Q
  - Wheel wear
  - Self-sharpening effect
  - Wheel life
- The grinding behavior can also be optimized by an adapted dressing strategy.

Creepfeed or Surface Grinding

CREEPFEED OR SURFACE GRINDING

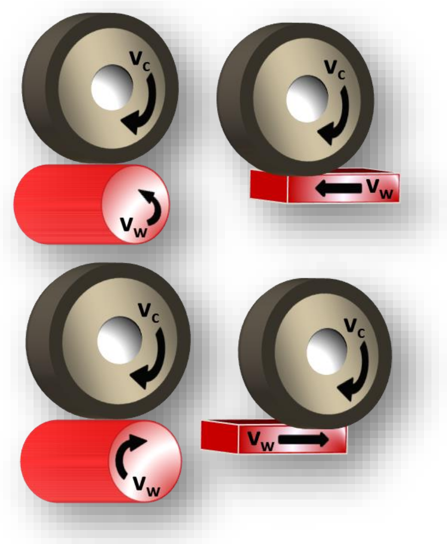
- Definition:

SURFACE	small infeed & high feed rate
CREEPFEED	large infeed & small feedrate

- A determining factor is the speed ratio q_s:

$$q_s = \frac{v_c}{v_w}$$

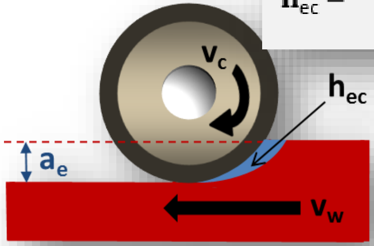
$10 < q_s < 50$	Risk of chatter & surface issues
$50 < q_s < 100$	Typical surface grinding with small infeed
$100 < q_s < 1000$	Risk of burn & very fine surface
$1000 < q_s$	Typical creepfeed condition with high infeed



SOME MORE THEORY: EQUIVALENT CHIP THICKNESS

This value can easily be used to configure grinding parameters:

$$h_{ec} = \frac{Q'_w}{v_c}$$



$$h_{ec} = \frac{v_w \cdot a_e}{v_c}$$

- Typical values:
  - Polishing and finishing: $h_{ec} = 0{,}01 – 0{,}1\ \mu m$
  - Precision grinding: $h_{ec} = 0{,}1 – 0{,}7\ \mu m$
  - Rough and high performance grinding: $h_{ec} = 0{,}7 – 3{,}5\ \mu m$

$$h_{ec} = \frac{\pi \cdot d_w \cdot v_{fr}}{v_c}$$

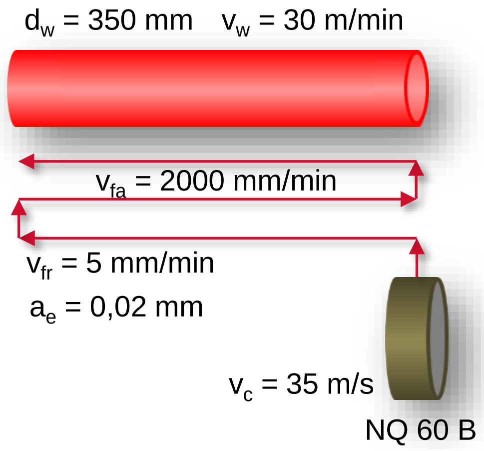
Practical impact of chip thickness:

- h_{ec} too small: burn, surface too fine … „wheel acts hard“
- h_{ec} too high: rough surface, noise, high wheel wear …. „wheel acts soft“

CASE STUDY FOR ROLL GRINDING

Problem: work too rough at both roll tails

- R_a in center 0,4 µm, at tails R_a = 1,7 µm ☹



- Traverse cut $h_{ec} = \frac{v_w \cdot a_e}{v_c}$ h_{ec} = 0,29 µm
- Plunge cut $h_{ec} = \frac{\pi \cdot d_w \cdot v_{fr}}{v_c}$ h_{ec} = 2,6 µm (at v_{fr} = 5 mm/min)
- Equivalent chip thickness is much too large during plunge cut!!!

Solution: Reduce v_{fr} = 0,5 mm/min h_{ec} = 0,26 µm ➡ R_a = 0,4 µm ☺

Cutting Speed v_c

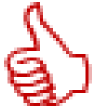
CUTTING SPEED

Does an increase of the cutting speeds v_c result in an increased material removal rate?

$$h_{ec} = \frac{Q'_w}{v_c}$$

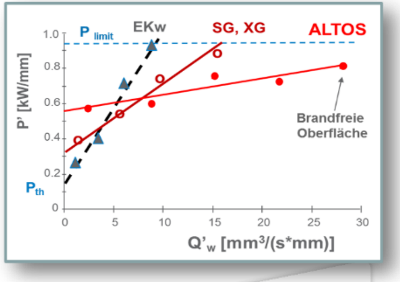
- Firstly, let's look at the equivalent chip thickness h_{ec}:
- Thus, if we strive to keep the chip formation mechanism constant …. same h_{ec} :

➡ $\boxed{\text{higher } v_c = \text{higher } Q'_w}$

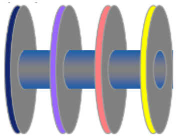


But please note:

- More heat ….. Thus, optimized coolant needed!!!
- Higher load on grain ….. Thus, need to select suitable specification!!!



CASE STUDY FOR PLUNGE GRINDING



Plunge grinding, Studer, 100 Cr6, Emulsion

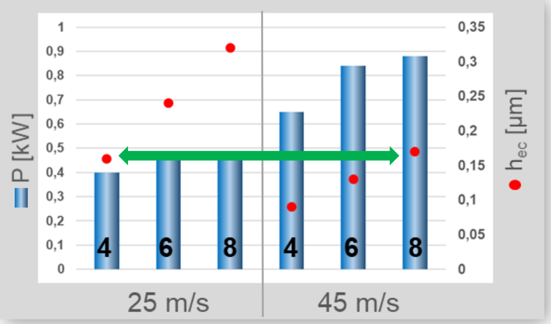
v_c = 25 und 45 m/s, Q'_w = 4, 6, und 8 mm³/mm s, d_w = 160 mm

Quantum NQ 80

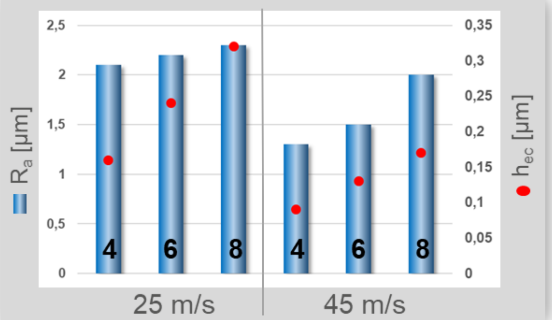
Result:

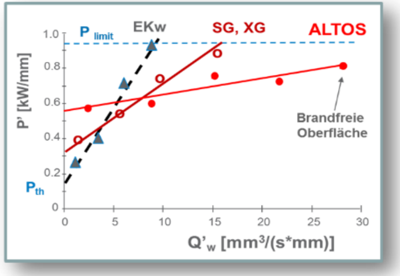
- Higher cutting speeds v_c result in higher material removal rate Q'_w at same chip thickness h_{ec}.
- However, it required a higher power draw P.
- Higher chip thicknesses h_{ec} lead to an higher roughness R_a.
- We have to use grit qualities with can resist to these demands.

P & h_{ec}



R_a & h_{ec}

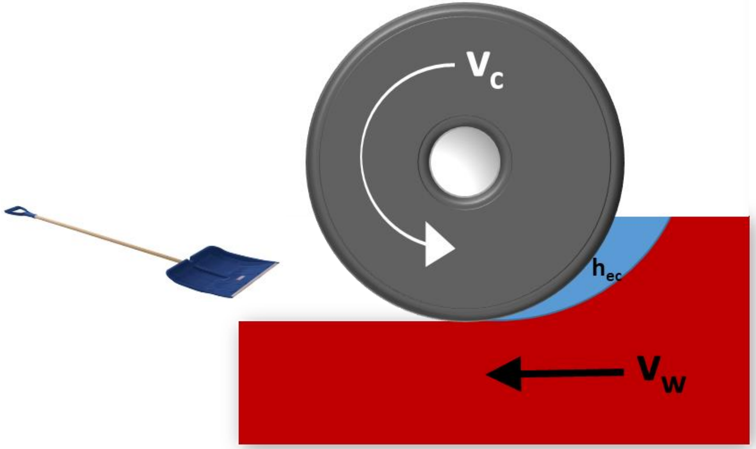




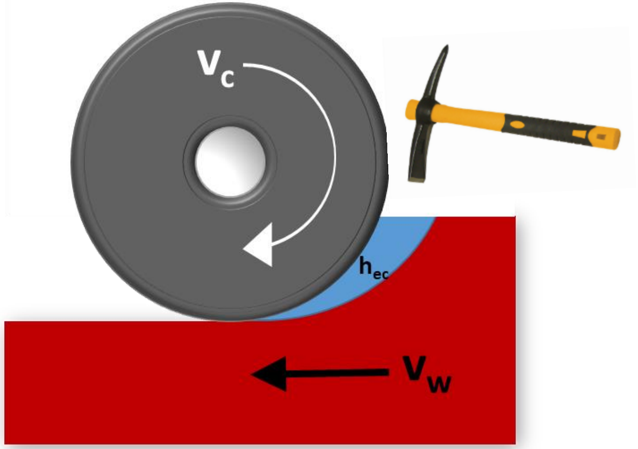
Grinding Direction

Counter or Uni Direction?
Up or Down Grinding?

GRINDING IN COUNTER OR UNI DIRECTION



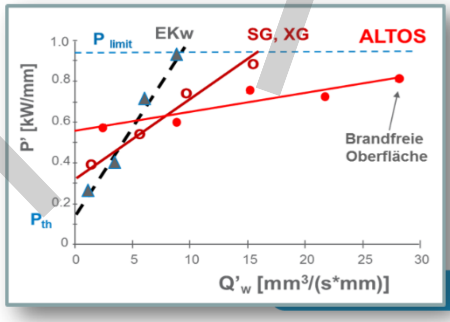
Counter direction



Uni direction

So what is the point here:

Counter directional	easy chip buiding
Uni-directional	grit toughness & resistance



CASE STUDY: OD PEEL GRINDING

Problem: Counter directional cut, HSS, Emulsion

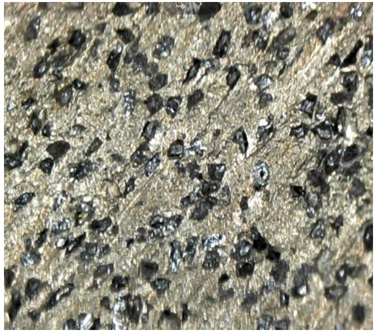
v_c = 30 m/s, v_w = 19 m/min, v_{fa} = 6 mm/min, a_e = 0,1 mm

➡ Noisy, wheel clogging, burn ➡ ☹

Solution: Change to uni directional cut

No other change in parameters! ➡

➡ Smooth, nicely cutting wheel, no burn, no chatter ☺



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Next step: The infeed could be increased by a factor of 3…. Higher performance!

New Developments of Grinding Tools

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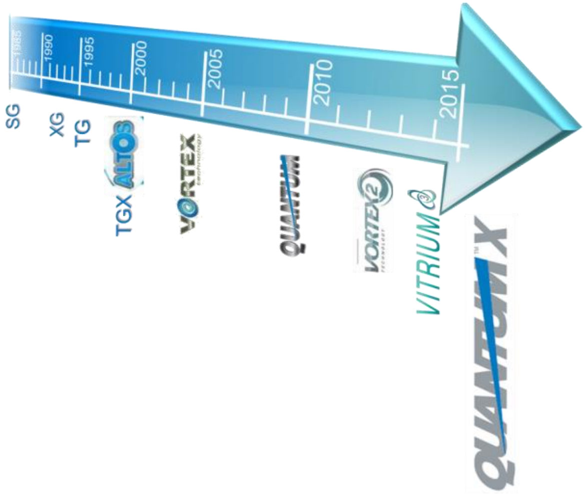
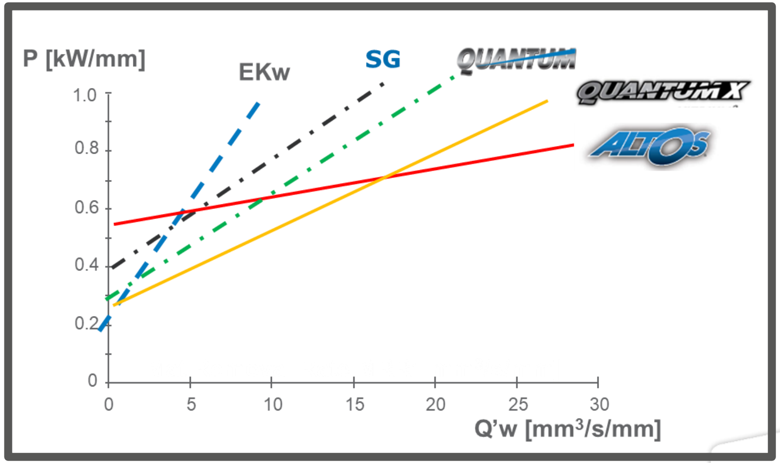
ABRASIVES

SAINT-GOBAIN

DEVELOPMENT OF NEW GRINDING SOLUTIONS

- Based on the understanding of the microscopic mechanisms a suitable tool can be specified.
- We consider and analyze the kinematics and individual loading of the abrasive grains and the entire system.
- Saint-Gobain regularly develops new abrasive grains and tools to meet the increasing demands of the market.





More to come in Level II presentation

Summary

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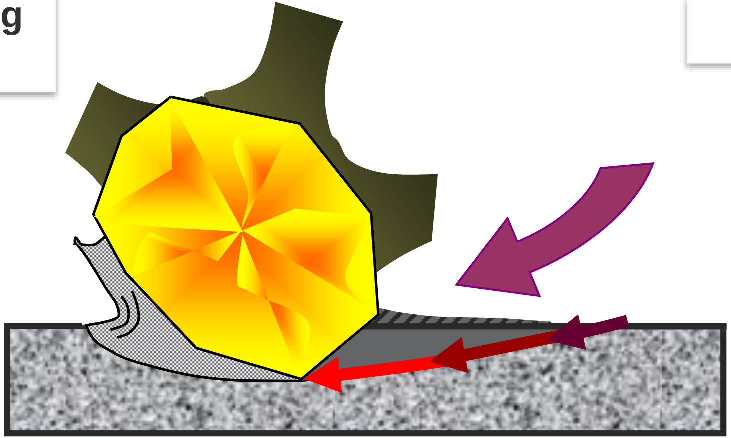
SUMMARY



Selection of grain type

Specification

Specific Grinding energy

Porosity

Cooling

Threshold power

Direction of Grinding

Chip thickness

Speed ratio

Chip formation

Deformation elastic / plastic

Knowing the microscopic processes

and

understanding the properties of grain, bond, machine, and workpiece

we are

capable to specify a grinding solution,

in order to

optimize the performance of the grinding process!

Thanks for your attention

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