Life Cycle Management of Abrasive Tools and its Effect on Sustainable Grinding

LMAS

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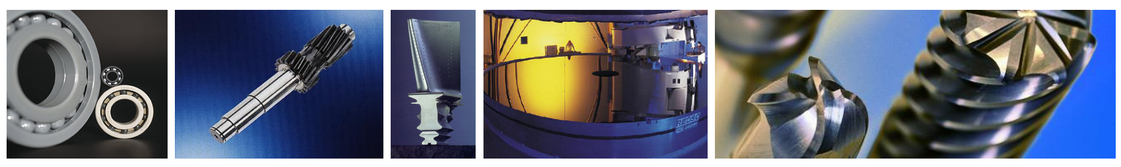
Motivation

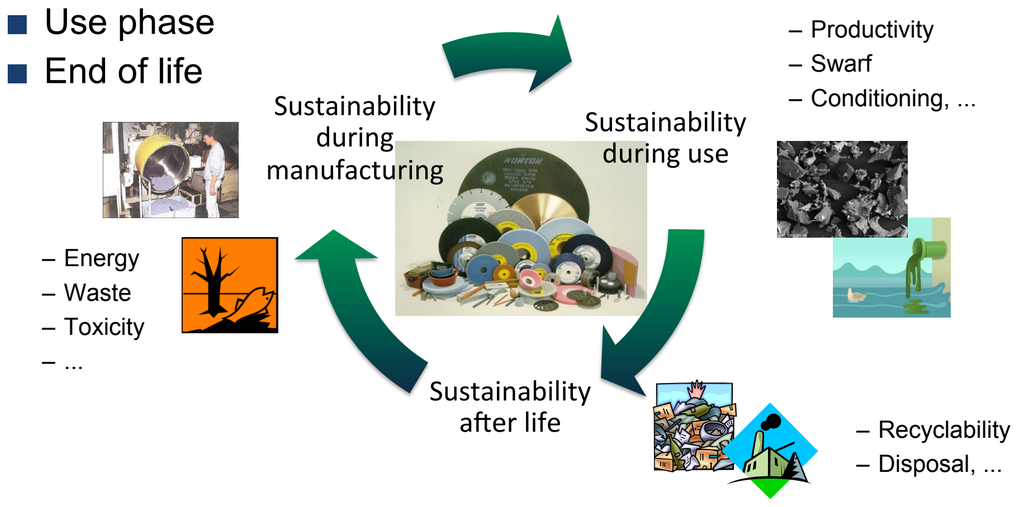
- Machining with geometrically undefined cutting edges represents a key technology capable of
  - High process performance
  - High process stability
  - High quality tolerances
- However, sustainability is a growing concern.
- Abrasive tools are main enablers for capable processes and are the focus of the following analyses.



Source: MTU, Junker, Franke, Cerobear, Walther Trowal, Siemens, Schott Glas

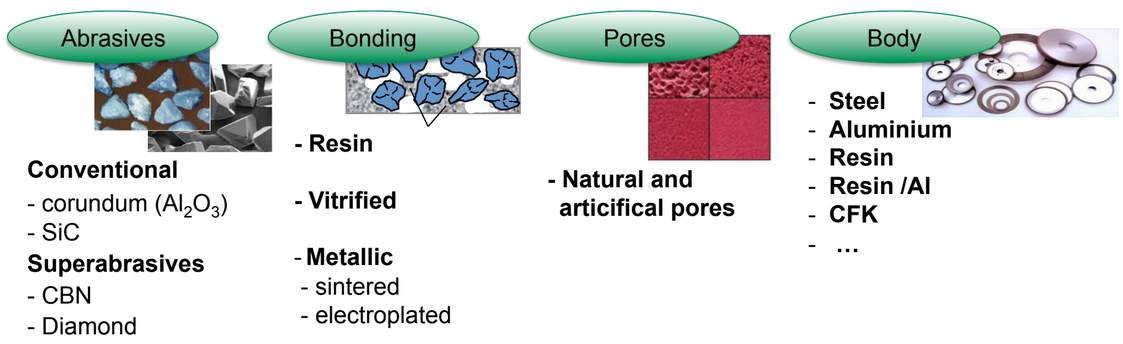
Objectives

- Develop holistic view of the life cycle of abrasive that considers energy, resource efficiency, and sustainability during
  - Manufacturing phase
  - Use phase
  - End of life



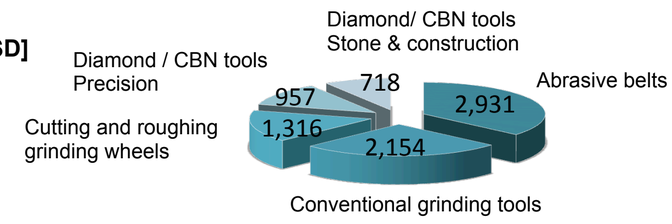
Source: Rappold Winterthur, Saint-Gobain Abrasives

Grinding Tool Composition



Abrasives world market 2004 [Mio. USD]

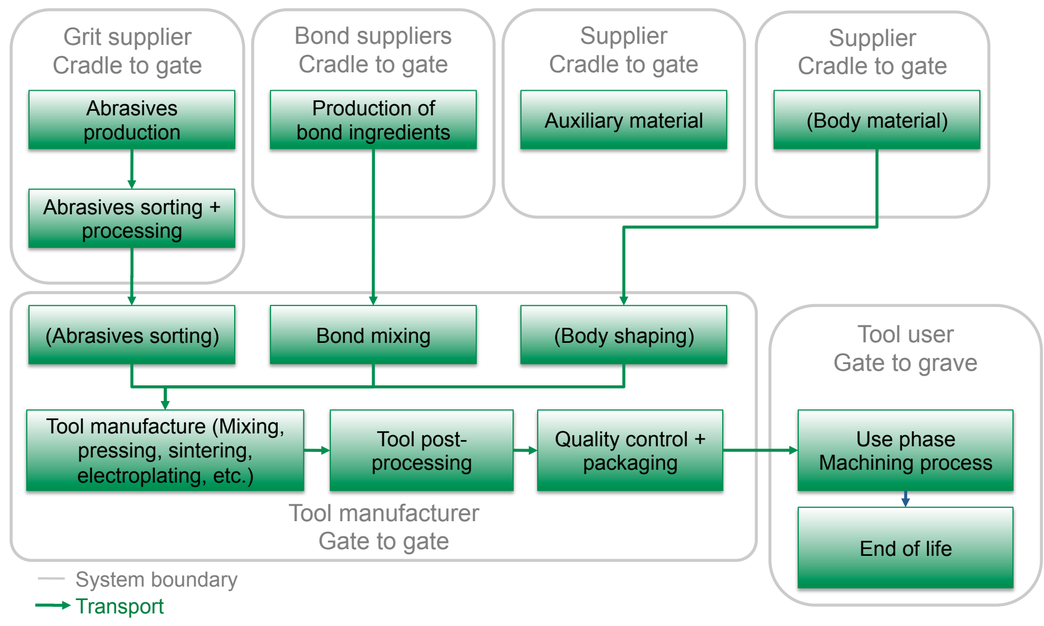
Market volume of around $8bn



Source: Elbe Schleiftechnik, Tyrolit, Semung Diamond Tools

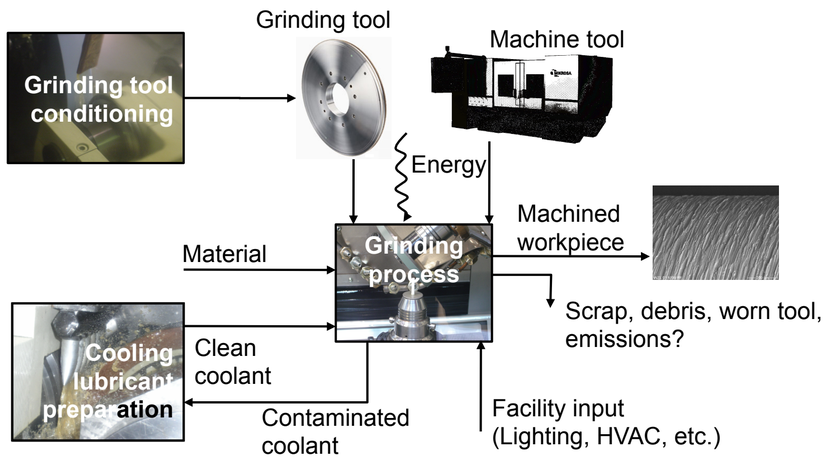
Source: Werner, VDS, 2004

Grinding Tool Production

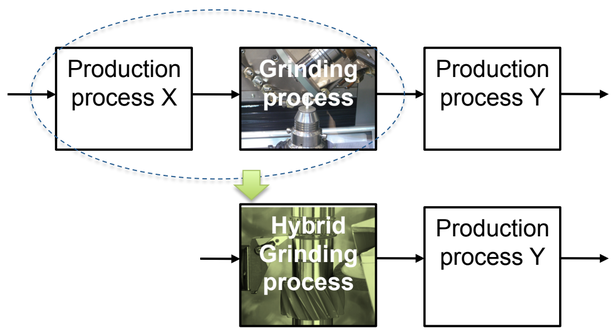


Use Phase: Grinding Process, Process Chain, Leveraging

- Enhance the grinding process
  - Coolant reduction
  - Reduced energy consumption
  - Higher productivity



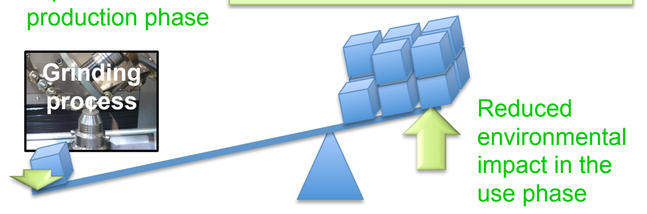
- Shorten the process chain
  - Avoid tool change and add value by combination of hard cutting, grinding and hard roller burnishing
  - Avoid the hardening process by grind-hardening



- Leverage grinding for enhanced product life cycle
  - Speed stroke grinding to induce compressive stress
  - Decreased product wear by tribo-layers
  - Shorter wear-intensive run/-in phases of seal systems

Possibly higher environmental impact in the production phase

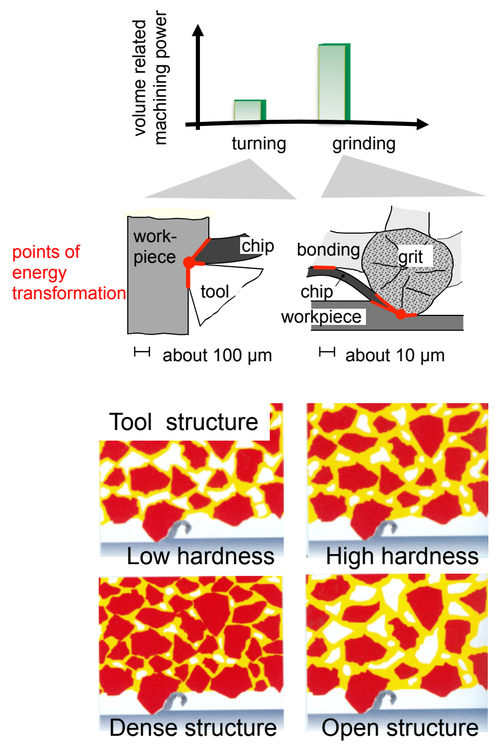
Product life cycle
- Shorter run-in phases of seal systems,
- Wear decreasing tribo layers,
- Reduced crack propagation, ...



Sources: after Dahmus, Gutowski, Helu, Dornfeld, Pictures from Tyrolit, Mikrosa, WZL RWTH Aachen

Use Phase: Tool Design

- Design parameters
  - Grit type
  - Grit size and size distribution
  - Bond type
  - Tool hardness
  - Pore volume and shape
- Design impacts
  - Process productivity
  - Process forces
  - Process heat generation and convection
  - Tool wear



Source: Tyrolit, Toenshoff

Future Work

- Evaluating abrasive tool production
  - Energy consumption in the production of abrasives related to tool productivity
  - Bonding, including pore builders
  - Body design (material and shape)
- Evaluating grinding process sustainability
  - Machine power measurements
  - Grinding swarf, emissions to air or cooling lubricant
  - Leveraging tool conditioning
- Generating a toolbox for the selection of abrasive grits
- Evaluating end of life
- Including supply chain and packaging aspects

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