Photonics in Manufacturing and “3-D-Printing”

IWF / INSPIRE
Konrad Wegener
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Contents

- Additive Manufacturing
- IWF-inspire activities
Trend (google – Abfrage)

«Rapid Prototyping»

«3D Printing»

«Additive Manufacturing»

Institut für Werkzeugmaschinen und Fertigung
Institute of Machine Tools and Manufacturing

Inspire

ETH
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich
Classification of AM-processes: metals

Source: ISO17296-1
Classification of AM-processes: polymers

3D printing, noun
fabrication of objects through the deposition of a material using a print head, nozzle, or another printer technology
Complexity for free

- Nearly unlimited freedom of design \(\Rightarrow\) exploitation
- \(\Rightarrow\) Permitted design opportunities (and not restrictions of freedom)
- Process optimization, Increase in reliability, Standardization

Kosten für Kleinserien 1 - 3000

conventional manufacturing

Additive Manufacturing

Cost cutting, Increase in productivity

traditional design design for conventional manufacturing

Design for ADDITIVE MANUFACTURING Functionally optimized design
Ishikawa – diagram SLS

Influence parameter on AM-Processes (Additive Manufacturing) © 2010 Inspire

Tracking system along the process chain to guarantee the traceability of the production of any part
Benchmark piece, test piece, VDI 3404

- Dependency on build place within working envelope
- Similar to casting: delivery of test piece with the part

Testpiece irpd1
Focus visual

Testpiece irpd2
Focus: quantitativ
Overview  inspire: iwf, irpd

Key areas of research and transfer
- Grinding, honing, lapping
- Optimization of machine tools
- Additive manufacturing
- High-energy beam manufact.: laser
- EDM
- Factory planning and virtual reality

Emerging fields
- Micro manufacturing
- Chip removal with geom. defined cutting edges
- Electro mobility
Research – Laser Ablation

- Laser processing of diamond and CBN cutting tools
- Laser touch dressing of dressing wheels
- Conditioning of cubic boron nitride (CBN) grinding wheels
- Laser shaping of bulk metallic glass
Laser profiling & grinding tests

- Wear test: force monitoring and wear measurement
- Stable grinding conditions after run in with higher forces
- Dense surfaces from tangential tangential laser truing
- Run in characterized by self sharpening, partly pull out
- Damage to grains from laser treatment negligible (not analyzed)
Laser Touch Dressing

- dressing times reduced by factor 2
- no graphitization
- removal of bad (negative) flanks
- lower forces
- lower energy load on workpiece
Cutting edge wear at processing of CFRP

- Cutting edge radii vs. fiber orientation angle (FA), relative to cutting direction
  - new G, L \( r_K = 4.3 \) to 6.5 \( \mu m \)
  - at removed volume \( V'_w = 31 \) cm\(^2\)/mm
    - 150° FA \( r_K = 8.6 \) \( \mu m \)
    - 90° FA \( r_K = 30.6 / 35.9 \) \( \mu m \)
    - 30° FA \( r_K = 36.4 / 32.0 \) \( \mu m \)

- Similar wear on both (L,G) cutting tools
- Striations for FA=30°, especially for G
- Grain pullout for G
**DIPLAT – Applications & Tool Characteristics**

**APPROACH I TOOLS**

- CVD/PCD/PCBN ultra-hard bulk material on a substrate

- Ablation of defined patterns (rake angle, cutting edge etc.) for enhanced functionality of the ultra-hard surface

- Creation of cutting tool edges with superior quality

- Diamond coated microdrill

- CVD diamond micro array

- Laser patterned CVD diamond

**APPROACH II TOOLS**

- Ultra-hard grain/grit layer & bond material

- Structuring of the grit layer (chip flow paths, rake angles) for enhanced tool performance

- Truing / Profiling of complex surface-set 3D freeform tools

- Diamond grinding wheel

- Diamond grain grit rows

**Applications**

- Mills, Drills and Cutting Tools
- Micro grinding tools
- Fine grinding/dressing pads
- Honing & Lapping tools

- Dressers & Truing Tools
- Grinding Tools
- Gear Grinding
- Broaching Tools

**Partly laser trued diamond dressing wheel**
CTI-project Advanced Laser Cladding
- Thin layers < 200 µm with minimum dilution
- Dense and crack-free structures without delamination
- Exotic layer-substrate material combinations
- Laser cladding combination with thermal spraying
Additive Manufacturing (AM)

Scientific goals:
- additive processes for manufacturing SLM, SLS, DMD
- Prozess simulation, predictability of results
- Optimization of surfaces and material properties
- development of materials, process windows
- machines, test bench for AM
- medical manufacturing
- Process design and QM for AM
Research – Additive Manufacturing

- Selective Laser Melting

- Selective Laser Sintering

- Direct Metal Deposition
Thank-you for your attention

wegener@iwf.mavt.ethz.ch