HKPC 生產力局
Dual Laser Metal Polishing

HKPC TechDive
Background

• Metal product surface finishing is important
  • Mechanical properties
  • Optical properties
  • Corrosion resistance
  • Visual impression

• Mechanical polishing process takes up 30% to 50% of the production cycle time

• A need of high precision micro-polishing due to the demand on minimization and complex parts to consumer product

• Particularly for the mould and die industry, high value-added product
Limitations of Conventional Polishing

- Mechanical polishing process is labour-intensive and time-consuming
- Lack of skillful technicians, poor repeatability & reproducibility
- Challenging to polish micro-sized feature, even with robotic arm and CNC machine integration
- Even tiny error or defect can make irreversible damage
- Suspended particulate generated in the process leading to health issue
What is Laser Polishing

- Automated laser process, operator independent
- Non-contact polishing with employed two types of laser, CW and pulsed
- High reproducibility, high process speeds, especially when compared to manual polishing
- No grinding and polishing particulate generated

Selectively polished surface
# 2-step Laser Polishing Process

<table>
<thead>
<tr>
<th></th>
<th>Macro-polishing</th>
<th>Micro-polishing</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Laser radiation</strong></td>
<td>Continuous Wave Laser</td>
<td>Pulse Laser</td>
</tr>
<tr>
<td><strong>Remelting depth</strong></td>
<td>20 - 100 µm</td>
<td>&lt; 5 µm</td>
</tr>
<tr>
<td><strong>Process time</strong></td>
<td>7 - 60 s/cm²</td>
<td>1 - 10 s/cm²</td>
</tr>
<tr>
<td><strong>Initial roughness</strong></td>
<td>milled, turned, EDM</td>
<td>ground, fine milled</td>
</tr>
<tr>
<td></td>
<td>Ra = 0.4 - 10 µm</td>
<td>Ra = 0.2 - 0.8 µm</td>
</tr>
<tr>
<td></td>
<td>Adjust glossy</td>
<td>Adjust glossy</td>
</tr>
<tr>
<td><strong>Achievable roughness</strong></td>
<td>Depending on material, material quality and initial roughness</td>
<td>Ra = 0.1 - 0.50 µm</td>
</tr>
</tbody>
</table>
Laser Polishing Process

Process video on tool (24s)
Laser Polishing System

- CW + pulsed fiber laser source
- 3-axis galvo scanner and 5-axis portal machine with XYZ-AC kinematics
- Designed for parts with up to 100 kg
- Protective gas process chamber
Innovative Polishing Process

- HKPC developed patented laser polishing process
- Optimal processing parameter on materials:
  - Tooling steel
  - Stainless steel
  - Titanium & Ti alloy
Comparison of Polishing Surface Microstructure

<table>
<thead>
<tr>
<th>Conventional Polishing</th>
<th>CW Laser</th>
<th>Pulsed Laser</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Steel</td>
<td>TiAl6V4</td>
</tr>
<tr>
<td>Sharp-edged scratches</td>
<td>No sharp-edged scratches</td>
<td>No sharp-edged scratches</td>
</tr>
<tr>
<td>Flat surface</td>
<td>Nearly no change in dimensional accuracy</td>
<td>Nearly no change in dimensional accuracy</td>
</tr>
<tr>
<td>Risk of losing dimensional accuracy</td>
<td>Slightly wavy surface</td>
<td>Finer surface</td>
</tr>
<tr>
<td>Correction of errors</td>
<td>No error-correction</td>
<td>No error-correction</td>
</tr>
</tbody>
</table>

- Steel
- TiAl6V4
Solution and Technical Advantages
Materials Study

- Sample materials: 1.2343 Tool steel (H11)
- Initial turned surface $Ra \approx 1.5 \mu m$
- A: Laser structured surface, micro-laser polished
- B: Macro-laser polished $Ra \approx 0.12 \mu m$
- C: Macro- and micro-laser polished $Ra \approx 0.09 \mu m$
- The optimal surface $Ra \approx 0.1 \mu m$ will be possible with laser polishing

Remarks: Laser polishing parameter database developed
Materials Database

Remarks: Study of materials capability with laser polishing
Solution and Technical Advantages
Tool of Patterned Lens

- Materials: 1.2083 Stainless steel
- Reduction of 50% manual polishing processing time
- Initial surface roughness: $Ra \approx 0.7\mu m$
- Polished cavity surface roughness $Ra: \approx 0.15 \mu m$ (B1)
Solution and Technical Advantages
Tool of Textured Phone Cover

- Materials: 1.2344 Tool steel
- Chemical etched pattern with high initial surface roughness
- Processing time: 15 minutes (selectively polished area)
- Glossy surface is formed by laser polishing on etched pattern surface
Solution and Technical Advantages

Tool of Glass Bottle

- Materials: GGG40
- Ductile iron is difficult to polish due to carbon nodular
- State of the art for manual polishing with a roughness $Ra \approx 0.4 \mu m$
- Initial roughness (as milled): $Ra \approx 1-2 \mu m$
- Laser polished roughness: $Ra \approx 0.35-0.40 \mu m$
- Homogeneous roughness over the complete surface achieved

Polished region

Size: 75 x 100 mm²
Solution and Technical Advantages
Medical device (VAD) parts

• Materials: Titanium grade 5
• Processing time:
  • Manual polishing: 3 hours
  • Laser polishing: approx. 5 minutes
• No chemical contamination by polishing process
• Less sharp-edged scratches
• Precision dimensional control
• No correction of errors from previous manufacturing steps
Summary

- Innovative
  - Feasible for 3D geometries
  - Automated laser process
  - Fast speed (5-12x)
  - Excellent dimensional accuracy

- Challenging issue
  - Complicated geometries, sharp ends
  - Fine texture patterned & selective polishing region
  - Chemical-free polished surface
  - Improve tool lifetime
Q&A
HKPC 生產力局

Dual Laser Metal Polishing

任駿宇
助理顧問
智能製造部
香港生產力促進局
電話: 2788 5736
電郵: cosmoyum@hkpc.org