Fraunhofer ILT - Short Profile

With about 370 employees and more than 11,000 m² of usable floorspace the Fraunhofer Institute for Laser Technology ILT is worldwide one of the most important development and contract research institutes of its specific field. The activities cover a wide range of areas such as the development of new laser beam sources and components, precise laser based metrology, testing technology and industrial laser processes. This includes laser cutting, caving, drilling, welding and soldering as well as surface treatment, micro processing and rapid manufacturing.

Furthermore, the Fraunhofer ILT is engaged in laser plant technology, process control, modeling as well as in the entire system technology. We offer feasibility studies, process qualification and laser integration in customer specific manufacturing lines. The Fraunhofer ILT is part of the Fraunhofer-Gesellschaft with more than 80 research units, 20,000 employees and an annual research budget of over 1.8 billion euros.
Laser Polishing of Metals

The Fraunhofer Institute for Laser Technology ILT has been developing a manufacturing process that utilizes laser radiation for the automated polishing of workpieces with complexly shaped 3D surfaces. This new process enables users to avoid time-consuming manual work and opens up advantages in terms of economic savings as well as time reduction.

The Process

Polishing with laser radiation is based on remelting a thin surface layer of the workpiece and the subsequent smoothing of the surface roughness due to surface tension. The innovation of laser polishing results from the fundamentally different active principle (remelting) compared to conventional grinding and polishing (abrasion). For metals diode-pumped solid-state lasers are normally used. Pulsed laser radiation with pulse durations of several 100 ns is used for metallic surfaces with a small initial surface roughness, e.g. after grinding. If the initial roughness is higher, e.g. after milling or EDM-processing, continuous laser radiation must be utilized. The remelting depth is in the range of several 100 nm for pulsed and up to 100 μm for continuous laser radiation.

Process Features and Advantages

- Automated processing of 3D surfaces
- Polishing results independent of laborer
- Short machining times, especially in comparison to manual polishing
- Selective polishing of limited areas
- Polishing of milled, turned, grinded or EDM-processed surfaces
- Force-free polishing due to non-contact process
- No pollutive impact from grinding and polishing wastes
- No contamination of the material with abrasives

Tool and Mould Making

Manual polishing represents the state-of-the-art in tool and mould making, but has processing times often above 10 min/cm². Therefore, there is a high demand for automated polishing techniques for complexly shaped 3D surfaces. The roughness required is usually in the range of Ra = 0.05 to 0.3 μm.

On tool steels 1.2343, 1.2344, 1.2379 and 1.3207 with milled or EDM-processed surfaces with an initial surface roughness of Ra = 1 - 4 μm, laser polishing can reduce the roughness down to Ra = 0.05 to 0.2 μm. The processing time is ≈ 1 min/cm². This process has been tested on injection molds and embossing dies. The laser polished surfaces from these tests exhibit comparable service life as those from manually polished surfaces.

Furthermore, the modulation of the process parameters allows the adjustment of the gloss level with a high spatial (150 μm) resolution. This enables the manufacturing of two and multi-gloss-level designs on tool surfaces. On conventionally photo-chemically etched leather textures, for example, only the lower parts of the leather texture in the tool are polished, the upper parts remain matt.

Deburring and Shaping by Melting

With laser remelting, burrs can be removed and edges rounded. The amount of rounding and the shape of the rounding is adjustable by changing the processing parameters. Depending on the requirements of different applications, slightly rounding up to spherical geometries is possible.

Medical Engineering

Pure titanium and titanium alloys are widely used in medical engineering. The polishing of these materials is a work-intensive process when conventional machining techniques are used, because the material tends to ‘smear’ under contact with mechanical tools. Remnants of the polishing agent, bacteria and other impurities can cling to ‘smear-over’ surface defects and cause serious problems. In contrast, during laser polishing the surface solidifies from the molten state. Sharp-edged scratches and ‘smear-over’ grinding ridges do not occur.

The roughness of diamond-milled titanium surfaces can be reduced from Ra = 0.3 μm down to Ra ≤ 0.1 μm with pulsed laser radiation. The processing time is 3 s/cm² and, thus, one to two magnitudes smaller than manual polishing.

Further Materials

In particular, laser polishing is appropriate for nickel, titanium and cobalt/chrome alloys. Even at initial roughnesses in the range of Ra = 1 - 4 μm, these materials can be polished down to a roughness of Ra < 0.2 μm within 5 - 20 s/cm². Furthermore, other steels and cast iron can also be polished. The quality of the polishing result depends, however, on the material and especially its homogeneity.

Machine Tool and CAM-NC Data Chain

Together with partners from industry, Fraunhofer ILT has developed a machine tool for laser polishing of metallic workpieces. The results and experience from the laboratory have been transferred to a robust machine tool suitable for industrial manufacturing. The basis of the machine is a five-axis portal machine for positioning the workpieces and performing slow feed motions. This axis system is combined with a high dynamic three-axis laser scanner to achieve the needed process speeds of up to 1 m/s.

Due to the machine kinematics with 5 + 3 axes, special demands are made upon the CAM-NC data chain. Fraunhofer ILT is developing a solution where the end user can use his known CAM system from milling for the tool path generation for laser polishing. With a subsequent Technology Processor comprising the functions of a post processor and technology specific functions the ‘milling paths’ are converted in »laser polishing paths«.

Machine tool and CAM-NC data chain are available for customers for application tests and specimen production at Fraunhofer ILT.

Contact

Dr. Edgar Willenborg, Phone +49 241 8906-213
edgar.wilenborg@ilt.fraunhofer.de

Dr. Konrad Wissenbach, Phone +49 241 8906-147
konrad.wissenbach@ilt.fraunhofer.de

1 Machine tool for laser polishing.
2 Two-gloss-level design through selective laser polishing.
3 Laser rounded wire end.
4 Laser polished mold to emboss claw poles.
5 Laser polished and unprocessed ball joint.