The future of the surface
Optimum tribosystems through functionally optimized surfaces

Gehring

Honing technology from the industry leader

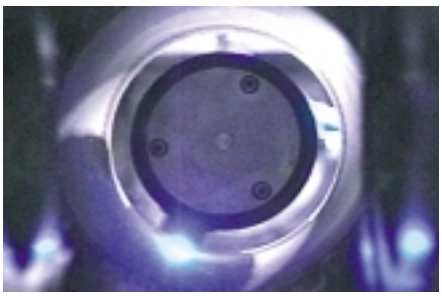
The Gehring name has stood for progress in honing technology for over 75 years. The company has evolved into the globally operating Gehring group, and is now represented in all the relevant markets throughout the world.

As a system supplier for the entire sphere of honing technology, Gehring solves all kinds of tasks in virtually unlimited areas of operation, in particular, engines, injection pumps and hydraulic and compressor components.

Socio-political parameters increasingly define the direction of technological innovation. A reduction in oil and fuel consumption and emissions as well as an increase in the service life and load capacity of components are elements, towards which modern technology has to be directed. The Gehring Group has received and understood this message and is putting it into practice.

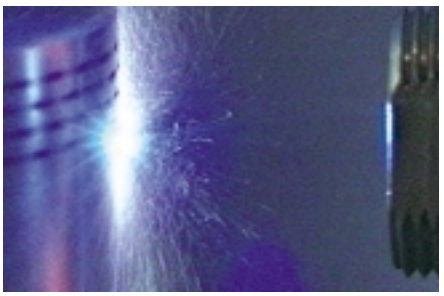
Laser technology is the latest example of innovative, future orientated technology which has made Gehring a focal supplier in this industry. The developments in this area are described as follows. The aim is: Optimum tribosystems through functionally optimized surface structures. Gehring will tell you how this goal can be reached.

Laser beam sources of a laser structuring machine



Laser optical head located coaxially in the cylinder bore

Laser structuring of a cylinder wall

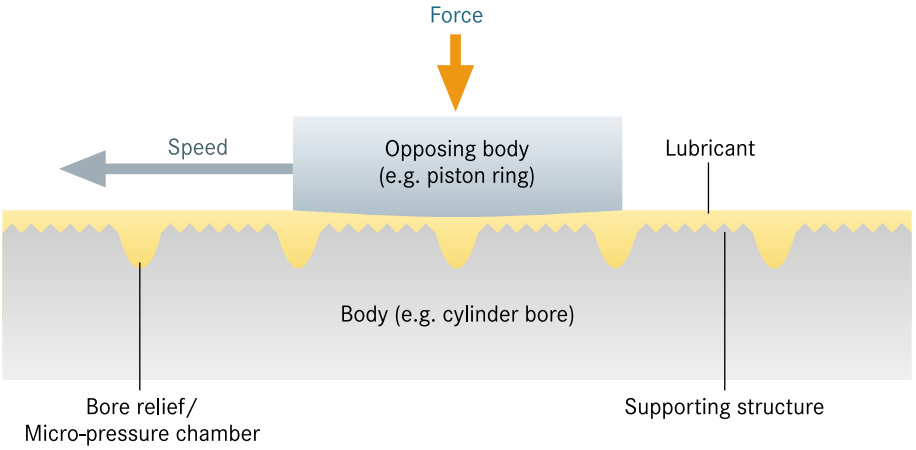


External structuring of a pin


Gehring

Optimizing tribological systems

The piston ring and the cylinder wall are a typical example of a tribological system. This consists of a body, opposing body and intermediate material. The lubricant, i.e. the oil, is the intermediate element between the body and the opposing body in the tribological system of an internal combustion engine. Its task is to reduce the frictional forces.

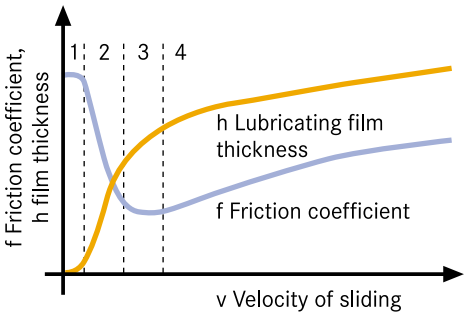


Tribological system: The lubricating film should be thicker than the roughness of the sliding surfaces.

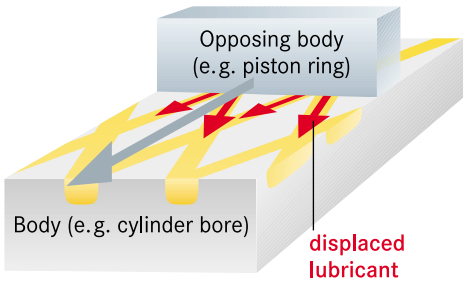
Various frictional conditions occur during operation:
fluid friction, mixed friction and boundary friction. The proportion of mixed friction should be reduced in favor of fluid friction.

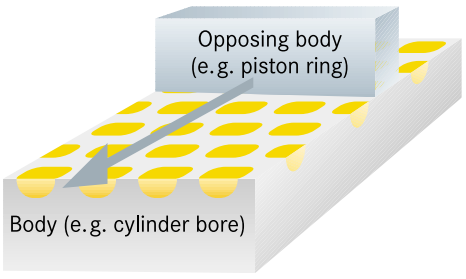
The following are required to obtain a full fluid-film lubrication condition:
a narrowing gap, a relative tangential movement of the sliding surfaces to each other and an adequate quantity of lubricant. Adhesion and abrasion, i.e. friction and wear of the contact surfaces, occur without full fluid-film lubrication.

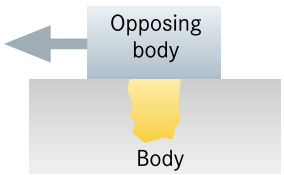
Surface topographies which ensure an adequate supply of oil and facilitate transition to the full fluid-film lubrication condition must be created to counter this negative effect. Contrary to popular opinion, this concerns the creation of a micro-structured surface and not just an absolutely smooth surface. An application area for laser honing or laser structuring.



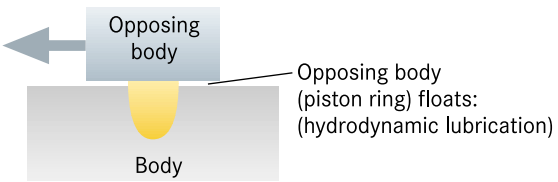
Stribeck curve:
1 Boundary friction
2 Mixed friction
3 Elastohydrodynamic lubrication
4 Hydrodynamic full fluid-film lubrication





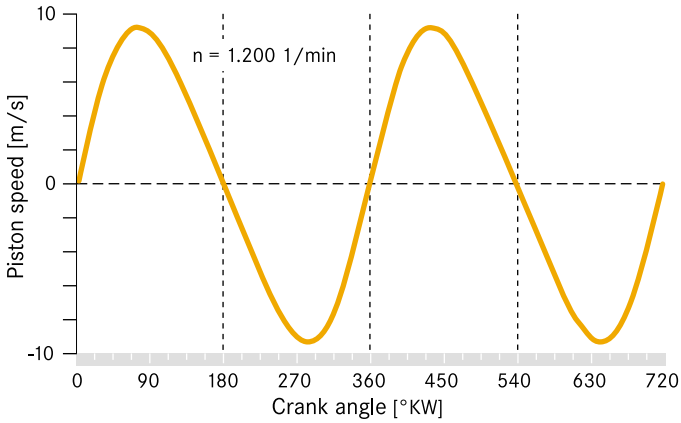


Communicating system (cross-hatch structure)

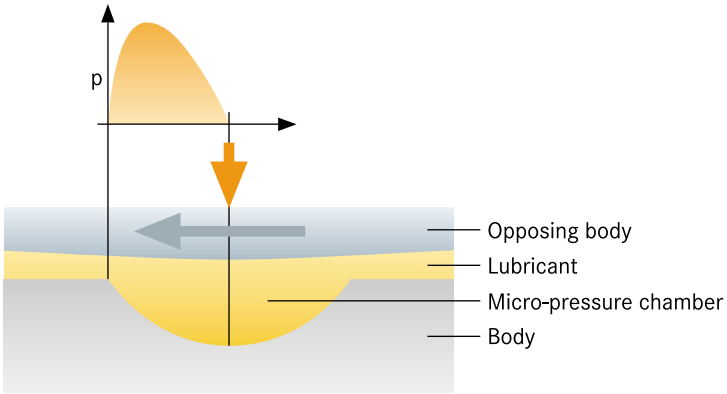


Micro-pressure chamber system (pocket structure)

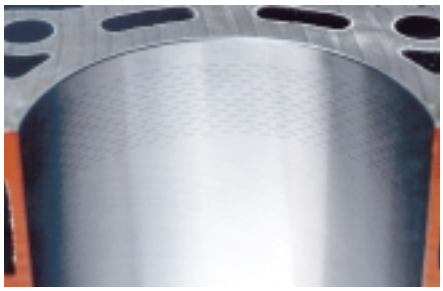
Resolving an apparent contradiction



Piston speeds of a four-stroke engine: Maximum loads through ignition at the top dead center



Build-up of the hydrodynamic pressure



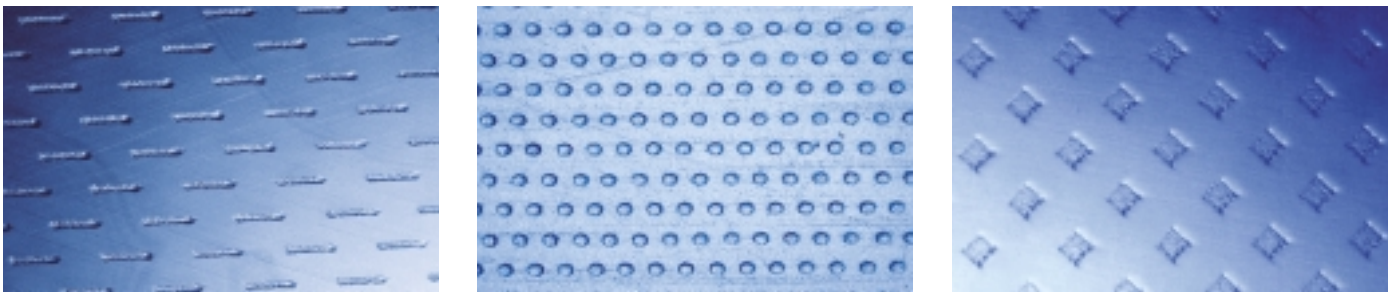
Cylinder wall after machining: Optimum lubrication conditions are obtained in the area of maximum loading through the application of surface reliefs.

Honing is a manufacturing process for the machine finishing of cylinder walls, which is used throughout the world. However, a contradiction must be resolved, in order to meet the above described requirements.

In general, a high load capacity and thereby a good sliding property of the component through a high percentage contact area of the material should be obtained at a low depth of cut. That is to say: low roughness. On the other hand, an open structure is required, in order to ensure adhesion of the lubricant. This means in turn: roughness of the surface.

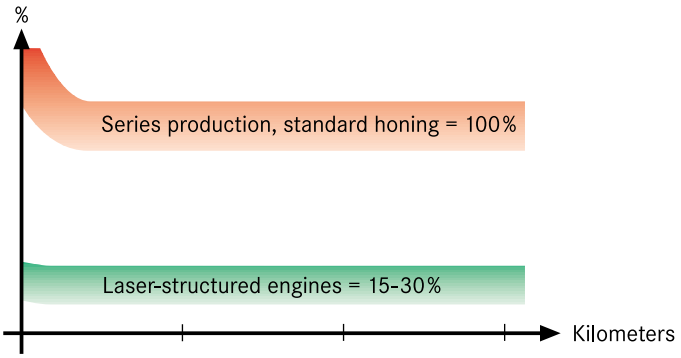
This apparent contradiction is resolved by placing defined oil retention pockets on a surface with low roughness.

Surface reliefs which meet the functional requirements with high flexibility in the various fields of application thereby arise for a great variety of motorizations.

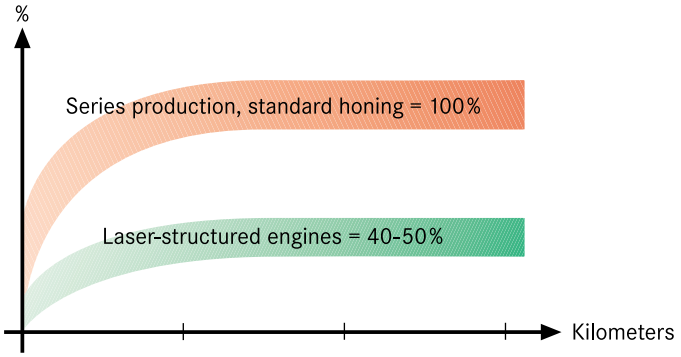


Pocket and cup structures

Long live maximum performance!



Oil consumption over 160,000 km

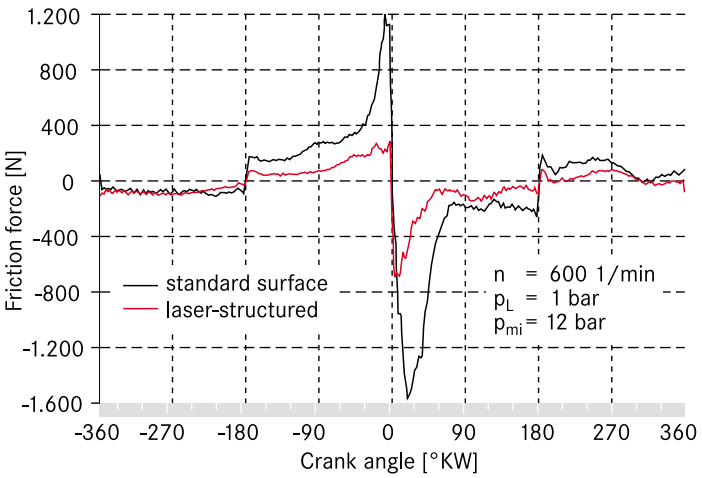


Wear

As always, the laws of physics set limits on this ideal of the engine builder. However, there are other facts apart from the scientific ones which have a bearing on the performance and running life of an internal combustion engine. The international requirements for drastic reductions in emissions of harmful substances and consumption values of fossil resources – e.g. pursuant to EURO 4 and 5 – pose new problems for engine developers.

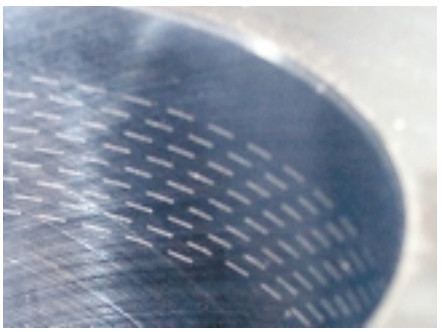
Gehring accepts this challenge and offers specific approaches to enable a solution.
The solutions concern the surface structure of high load components which slide against each other: i.e. the tribological system. In this regard, optimization of fuel combustion can produce good results, while the potential for reduction in the area of oil consumption has not yet been exhausted. The tribological focus is on the system of the piston ring and the cylinder wall.

Optimum lubrication must cope with extreme conditions here. In particular, extreme loads are caused by the maximum temperatures and pressures at the upper reversal point. Only a cylinder wall surface which has been prepared and formed for each case can guarantee its function in every situation.



Friction force of the piston assembly: Comparison of a cylinder wall with a standard surface with a cylinder wall which has been laser-structured at the top dead center

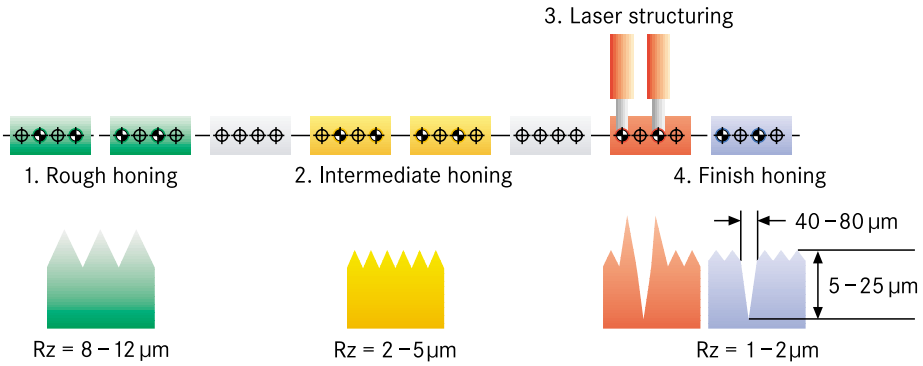
Source: ITV, University of Hanover



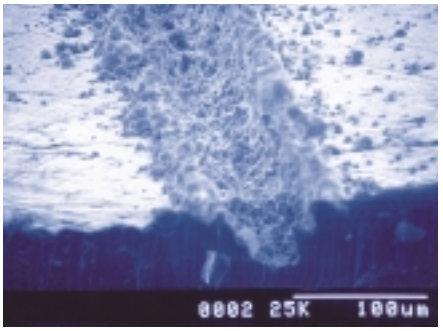
Cylinder wall after machining

Cylinder wall after 160,000 km

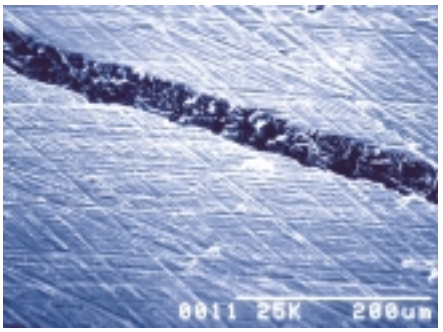
The model of sliding surfaces and run times



Process sequence for the laser structuring of cylinder walls



Structure after laser processing

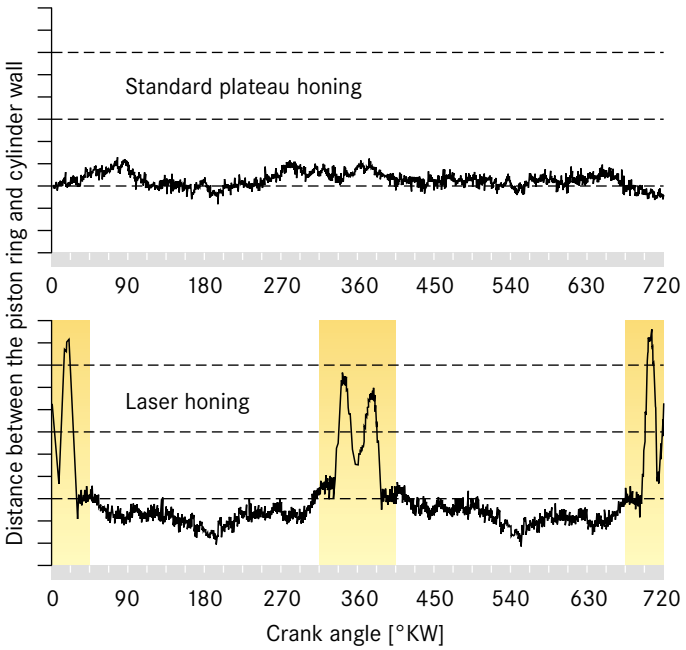


Structure after finish-machining

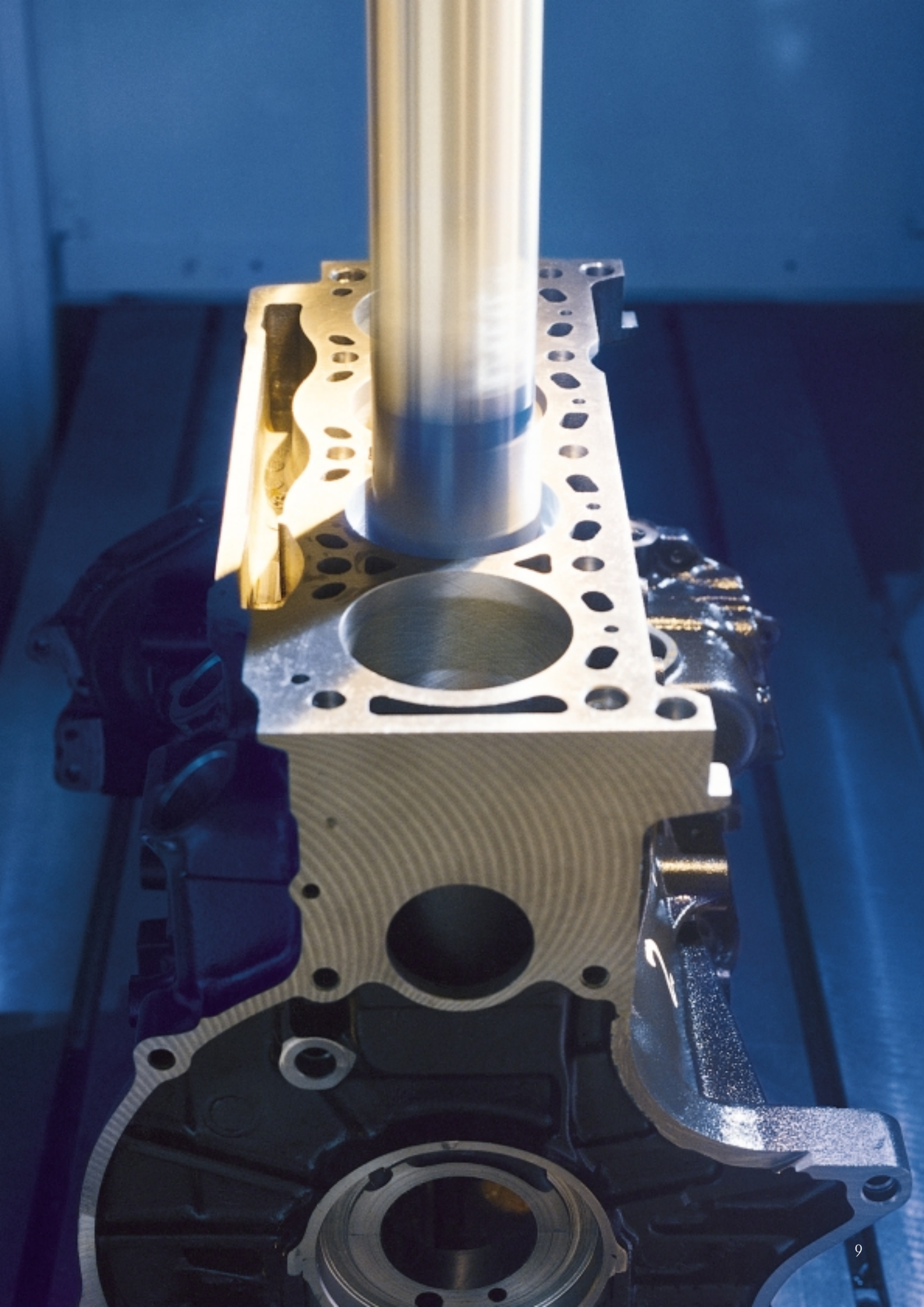
Laser honing – the combination of laser structuring and honing – is the magic word.
This process has already been tried and tested for a great many other ranges of application beyond engine manufacturing. And, as can be proved, the innovative Gehring technology also has the consequence of less wear and longer service lives here. The fact that Maschinenfabrik Gehring was awarded the Dr. Rudolf Eberle innovation prize of the Federal State of Baden-Württemberg in 2001 for its machine tool for the laser structuring of the sliding surfaces of pistons has had a particularly motivating effect on the development work.

Four operations define the process sequence in the prize-winning process.
Laser structuring follows conventional rough and intermediate honing, and the process is concluded by finish honing. The first two operations – rough and intermediate honing – improve the macro-form to almost the required final accuracy.

At the same time, the starting surface for the laser structuring of the bore is produced. Afterwards – during laser structuring – the defined laser structure for the specific engine is applied. Finally, finish honing is used to remove the ejected molten mass arising during the laser processing and to produce an extremely fine sliding surface. The tribological objective of a specific surface with a configurable relief is put into effect in this manner.

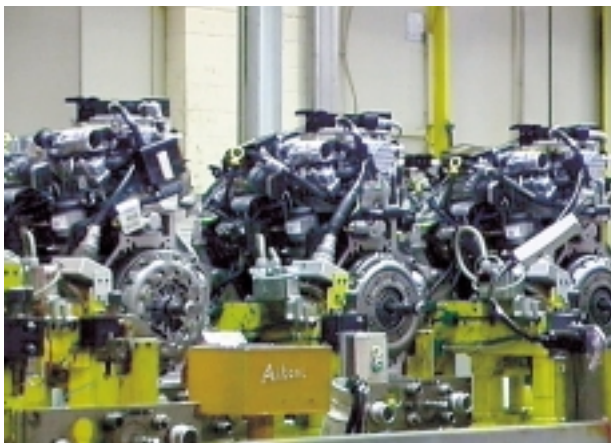


Average oil film thickness (distance) between the piston ring and cylinder wall of a laser-structured engine block: The oil film thickness markedly increases in the laser-structured (yellow) section.
Source: ITV, University of Hanover

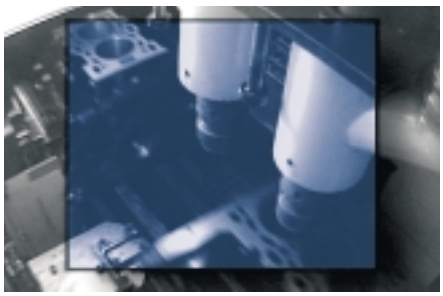


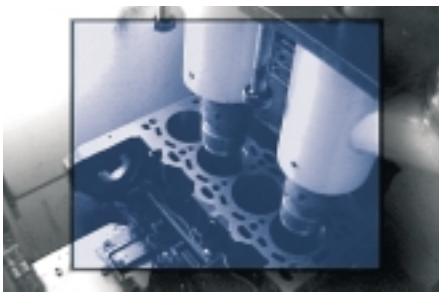
High-tech for advances in the macro-range

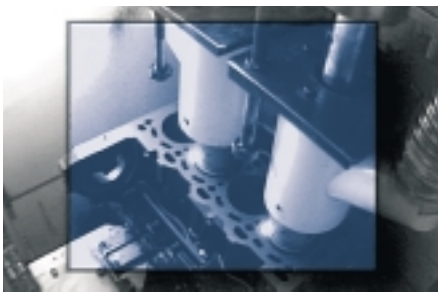
No matter whether it concerns racing engines or car and truck engines for road traffic, the laser honing process can be correspondingly diversified and optimized to produce a tribologically favorable structure. This process has proved to be a success in practice, e.g. at OPEL Powertrain GmbH, where it has been used in the series production of 4-cylinder diesel engines since January 2002.



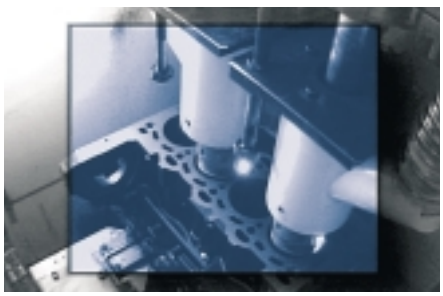
Laser-structured engines







Laser structuring with two spindles in series production

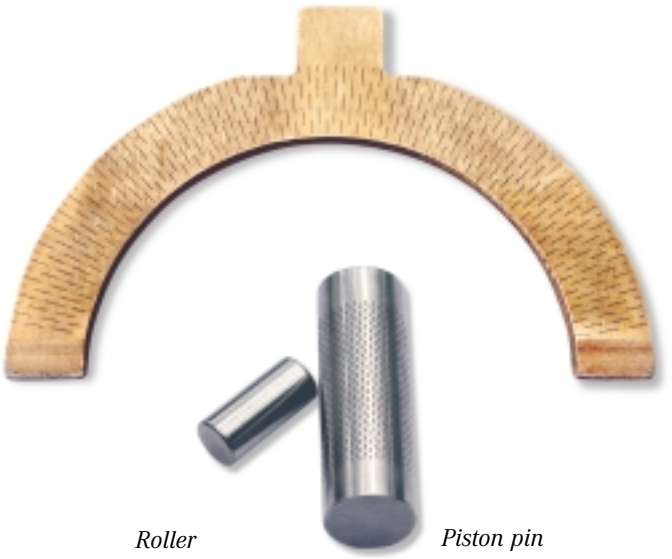


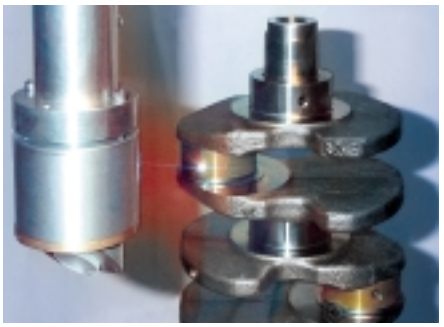
Finish-machining by honing after the laser structuring

Opel Vectra 2.0/2.2 DTI

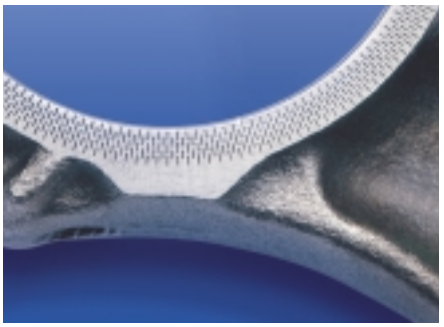
Technology from Gehring for structured movement!

Gehring has put the optimization of tribosystems at the top of its to do list.
It goes without saying that our developers have already taken a look at other fields, which could profit considerably from the use of laser honing. Incidentally, this does not just concern engine components such as crankshafts, the end face of the big connecting rod eye or thrust bearings. In the field of production engineering, upstream forming and punching tools as well as deep-drawing tools are also the subject of systematic optimization with regard to the advantages of honing technology for longer service lives and more efficient production. Gehring seeks out challenges and finds solutions. Our philosophy is as simple as that. Our success shows this to be the right approach.

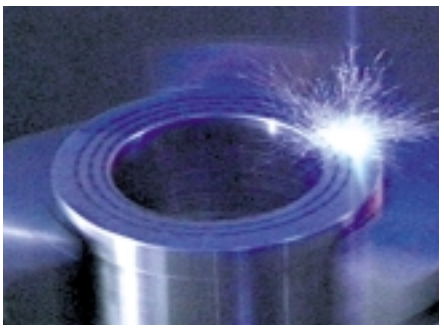




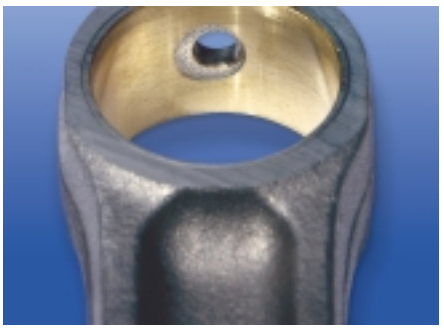
Laser structuring of a crankshaft



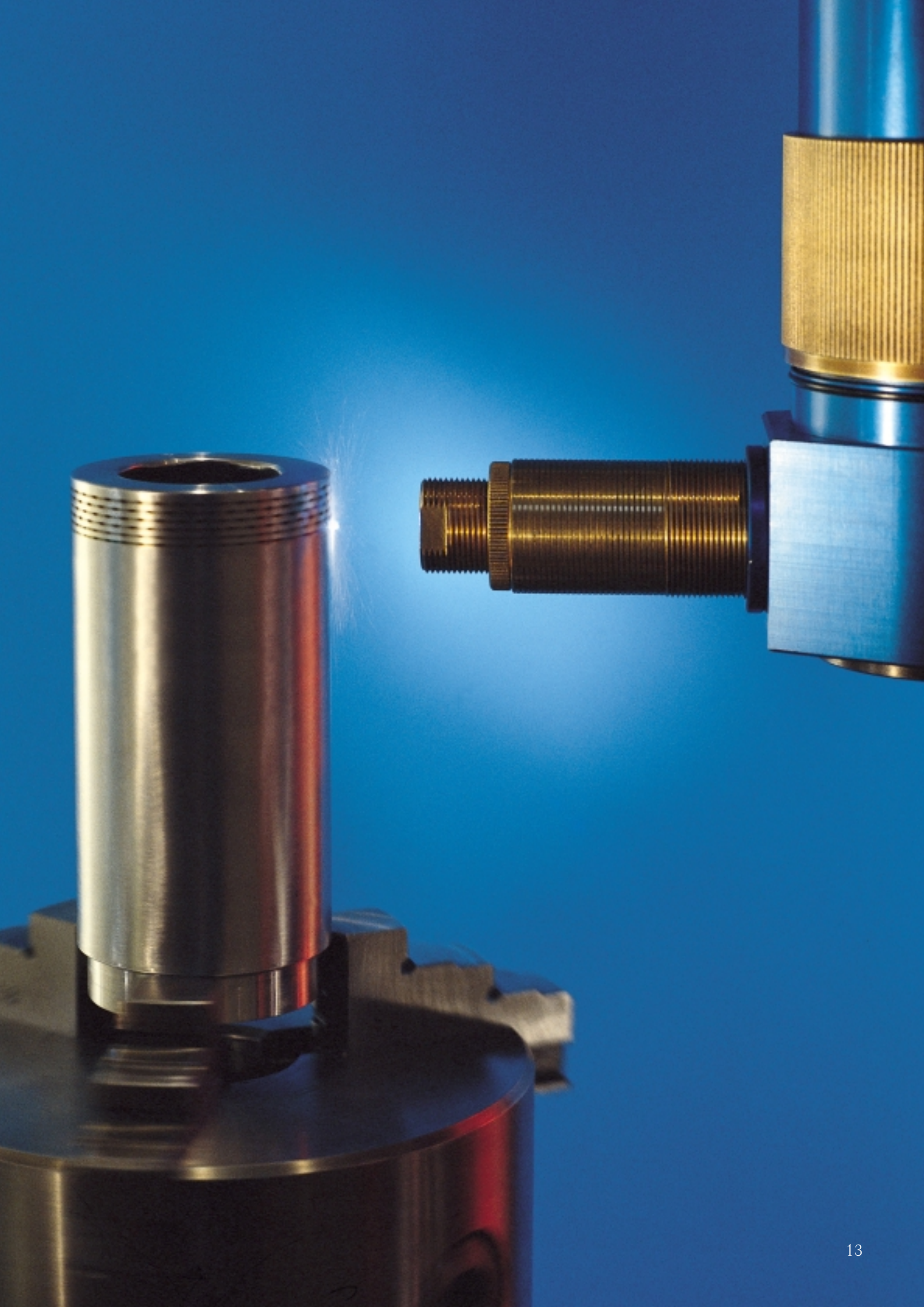
End face of the big connecting rod eye



Laser structuring of a plane surface



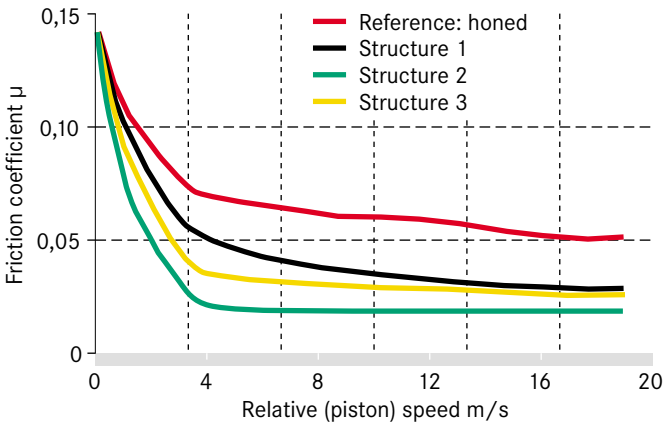
Small eye of the connecting rod



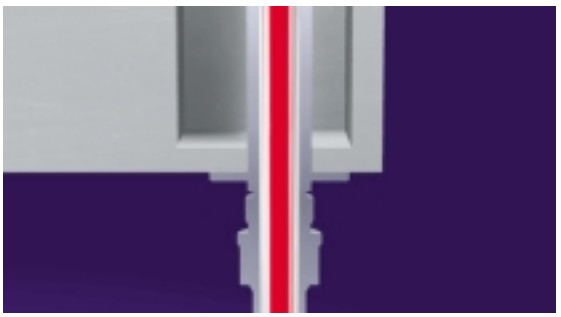
On a clear course – the vision of Gehring

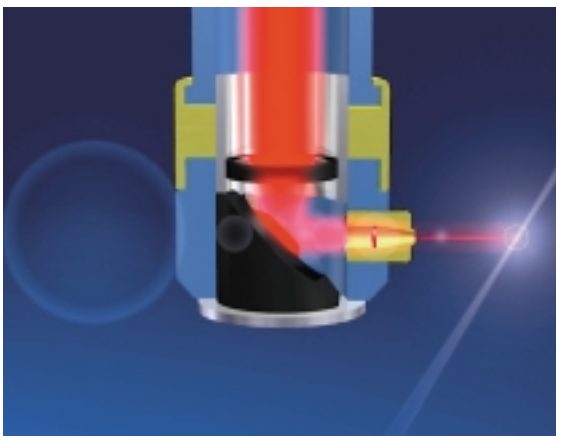
If a revolutionary technology provides optimum answers, it is time to ask questions, for example, about the limits of the operation, or whether, with suitable adjustments, it can operate in totally new areas. As an internationally recognized specialist in laser honing technology, Gehring opens itself for new challenges to a technology, in which we are more proficient than any other company and which we specifically make available to the customer in concrete terms.

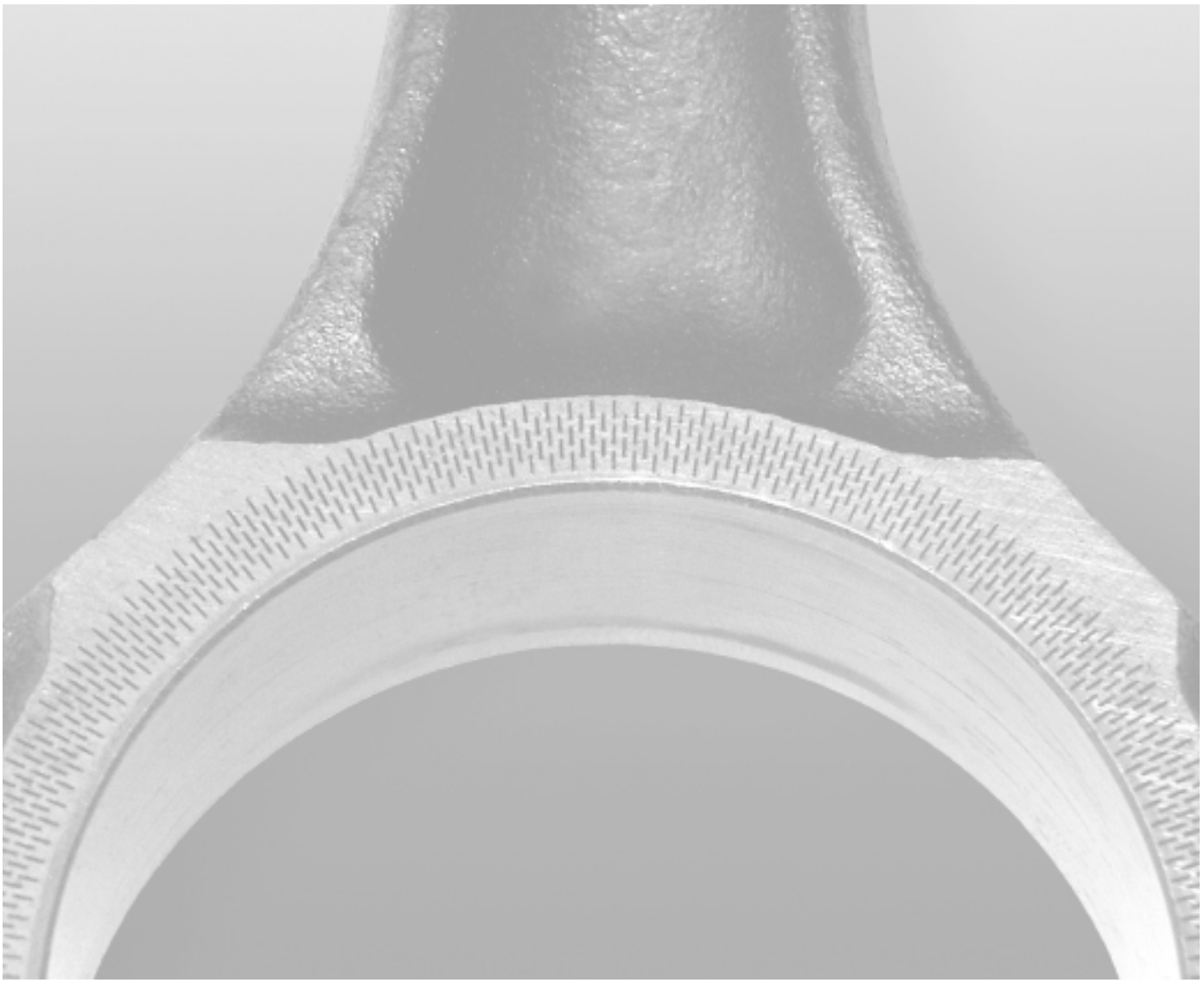
Laser technology from Gehring will also prove itself in new fields in the future.



Friction coefficient for various laser-structured surfaces compared with a honed surface.







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