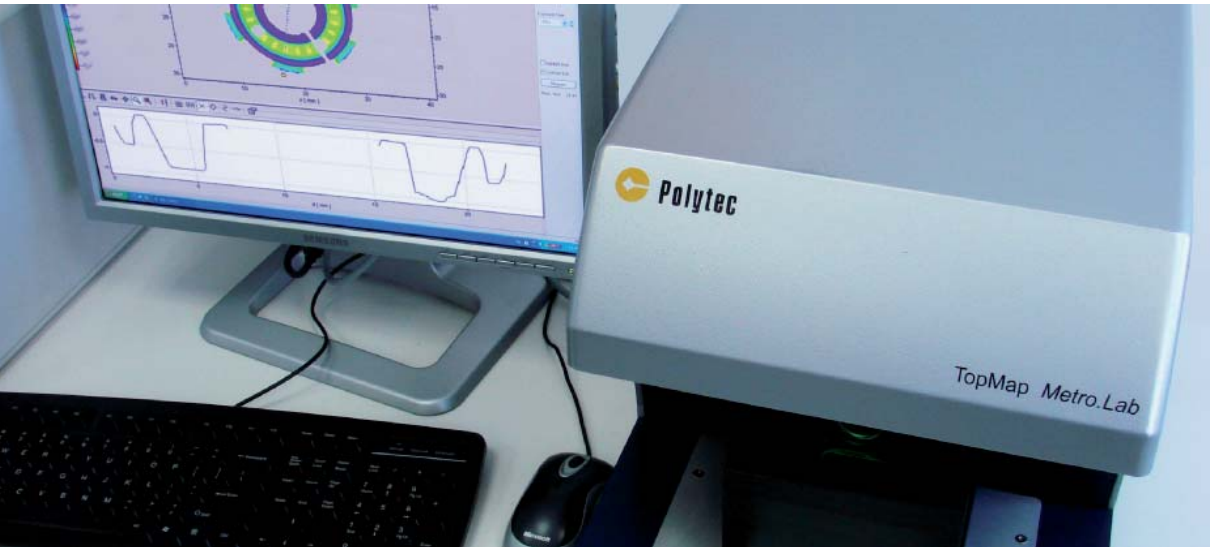
3-D Measurements on Shock Absorber Pistons



Field of Application

VIB Vibration measurement using laser-Doppler vibrometry

LSV Velocity and length measurements using laser surface velocimetry

TOP Measurement of surface topography using white-light interferometry

ST Measurement of spectral material properties using NIR spectrometry

When manufacturing working pistons for automobile shock absorbers, very tight tolerances must be adhered to regarding shape and surface parameters, and this despite high throughput. It is difficult for tactile measurement systems to attain the necessary reproducibility because of the discontinuous shape of the workpiece and the low position of the surface to be measured. White-light interferometry as an optical measurement technology in contrast provides the topography of all the surfaces within seconds with a high level of repeatability.

Requirements of Shock Absorber Pistons

Shock absorbers absorb vibrations or dampen movement. Their widespread use in industry and in the automobile sector have given rise to numerous technical solutions for various problems. In a motor vehicle for example, shock absorbers are safety-relevant components and are also material to ride comfort.

Conventional car shock absorbers convert the kinetic energy into heat. This is done through resistance that a working piston (Figure 1) has to overcome in a tube filled with oil. Shape and parameters of the piston are optimized for the special damping properties of the respective task. The working piston has orifices to allow flow through.

Figure 1: Piston of a shock absorber.

Polytec GmbH

Optical Measurement Systems

Application Note

TOP-04

August 2008

The shape of particular surfaces impacts on the flow characteristics. The workpiece may also have to be manufactured to fit additional components precisely, such as valves. This means that tight tolerances need to be complied with, even when producing larger numbers of pieces. White-light interferometry over large surface areas is very appropriate for quality control of the components. So far, topographic profile measurements have predominantly been carried out using tactile methods. With this method however, taking measurements on flatness and waviness parameters and determining height differences, flatness or parallelisms is difficult and time-consuming. For tactile measurement systems, the uninterrupted shape of the workpiece and the deep position represent a great challenge when trying to attain the necessary reproducibility.

3-D Characterization of the Piston

White-light interferometry as an optical measurement technology in contrast provides the topography of all the surfaces within seconds, with a high level of repeatability. In Figure 2 you can see a 3-D profile of the faces in the piston interior and in Figure 3 the topography of the lateral face and two deeper interior faces.

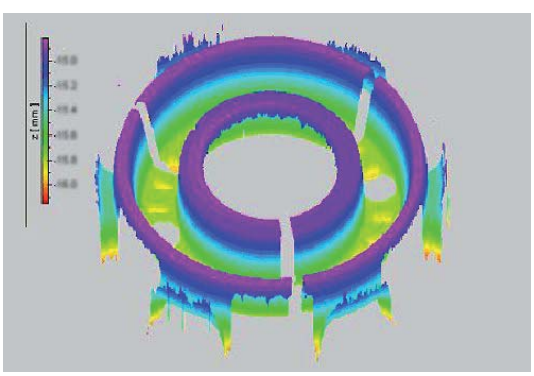


Figure 2: 3-D Profile of faces inside the piston.

Evaluating the data using the TMS software from Polytec allows you to hide surfaces by setting masks to enable you to examine individual surfaces in greater detail. Figure 4 shows the upper face with its lacerated inside edge. Figure 5 shows the profile of the two deeper inside ring faces. It is easy to see for example that the outer of the two rings is not parallel to the upper face (Figure 4), and the inner ring shows a slant.

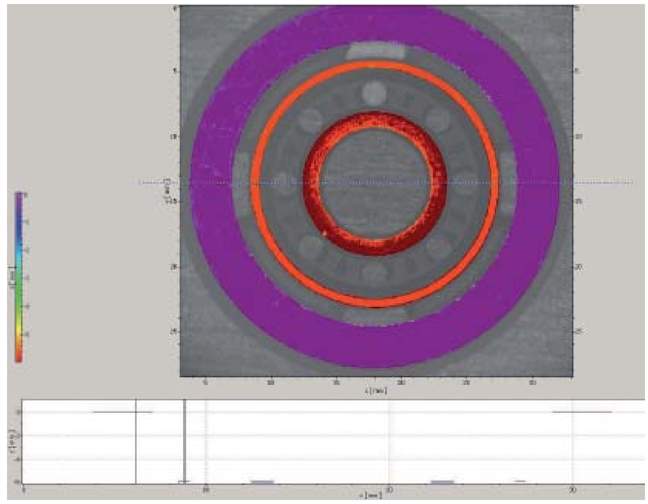


Figure 3: Topography of the lateral face and of two inner faces with line profile.

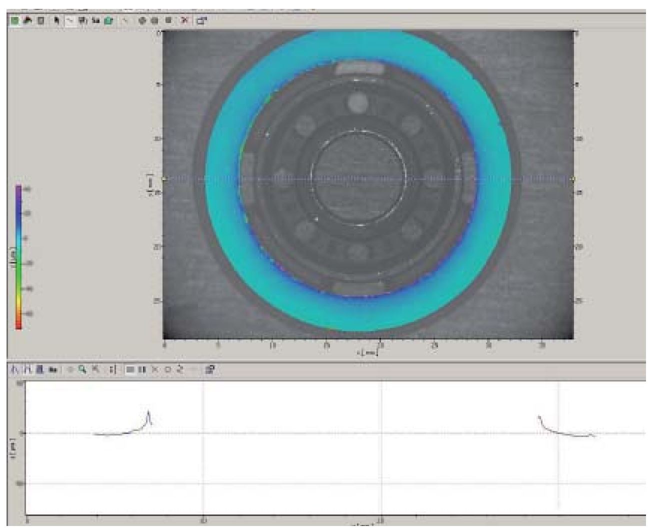


Figure 4: 3-D and line profile of only the upper face.

The geometric parameters, such as angles, slopes or height differences can easily be determined. Determining circular line profiles is also possible (Figure 6). In the example shown here, the outer surface is used as a reference. To obtain results that can be easily reproduced or to „only“ be able to compare different surfaces with each other, the line profiles always need to be selected at the same position for each measurement.

For rotationally symmetric surfaces, this is the center of the circle which can also be ascertained automatically with the aid of software. Starting which such an „Anchor point“, it is possible for example to evaluate a circular line profile with a constant position on the workpiece. In the example shown above, this therefore ensures that the angle does not make any height differences caused by components to have any impact; instead it ensures that only the ripple or lack of parallelism of a defined contour on the inner face comes into play. Figure 7 shows the results of repeat measurements of a faulty part with a scratch. You can see that the measured profiles (different lines) match up directly with each other. As white-light interferometry over large surface areas covers entire surfaces in one go, you can determine the values for parallelism and flatness very quickly. During the measurement however, the workpiece is not usually precisely vertically below the sensor head. Therefore it is necessary to ensure that visible side faces are not included in the evaluated face. This is also possible with the aid of the TMS software which ensures that the edge is always identified with all workpieces and that identical surfaces are measured.

White-light Interferometry in Manufacturing

Even though this method can be used for example to determine deviations in the complete topography of CAD data across a whole surface, in manufacturing often only a few parameters are relevant for quality control. In the above example, these were the height difference between the two ring surfaces and their flatness. Such measurements can be made automatically. Because of the software controlled, precisely defined position of the areas of evaluation or lines, high reproducibility and repeatability are given. The program can issue the measurement values with additional information, such as parts number, date and time, etc. Depending on the measurement task, the measurement may only take a few seconds.

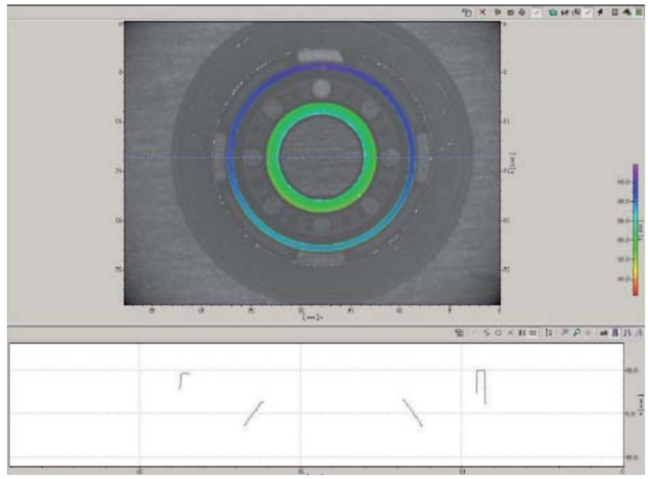


Figure 5: 3-D Profile of the deeper ring face.

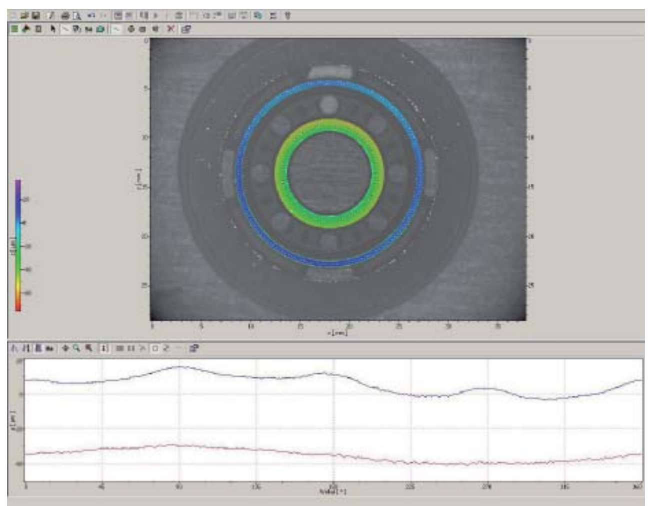


Figure 6: Ring profile.

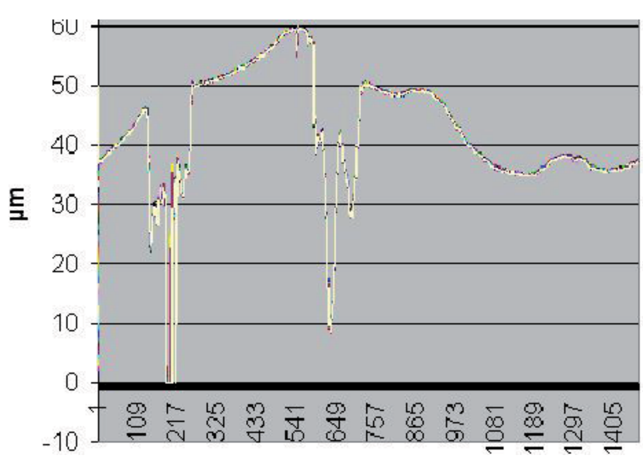
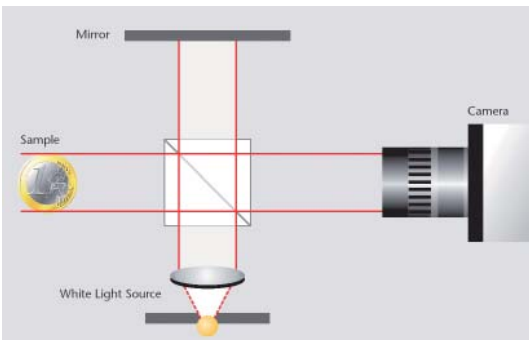


Figure 7: Repeat measurement (via measurement points).

How White-light Interferometry Works

The measurement procedure is based on the principle of the Michelson interferometer, whereby the optical configuration (Figure) includes a light source with a coherence length in the µm range. The collimated light beam is divided by a beam splitter into the object and reference beam. The object beam hits the object, the reference beam hits a mirror.



The light reflected back from the mirror and the object respectively is superimposed at the beam splitter again and is shown by a camera. Whenever the optical path for an object point in the measurement arm matches the optical path in the reference arm, there is constructive interference for all wavelengths in the spectrum of the light source, and the camera pixel of the respective object point has high intensity. For object points which do not fulfill this condition, the allocated camera pixel has a low intensity. Consequently, the camera registers all pixels which are at the same height. In the interferometer, either the reference arm or the object are now moved relative to the beam splitter. When traversing the evaluation length, you get interferences pixel by pixel and thus a height scan of the object. After the measurement run, the topographical structure of the sample has been digitized.

TopMap White-Light Interferometers by Polytec

The TMS-100 TopMap Metro.Lab is an affordable, good value laboratory device for random sampling applications. As an option, the workpieces can be positioned on pallets and be measured automatically. The TMS-300 TopMap In.Line is the ideal system

if you need to make precise measurements on surfaces, even in challenging environments, such as in production control. The compact instrument can often be mounted on the production line and measures given specifications (flatness, topography) within short cycle times. The measurement itself is quick and can be completely automated. The vertical resolution is a few nanometers and depending on the task, various areas of interest from 4.2 mm x 5.5 mm up to 19 mm diameter are available. The large stand-off distance allows extended measurement opportunities using a bending mirror.

You will find more information on TopMap White-Light Interferometers on the internet at www.topmap.info or contact your local Polytec sales/application engineer.

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