5th Research/Expert Conference with International Participations
"QUALITY 2007", Neum, B&H, June 06-09, 2007.

THE EXPERIMENTAL STUDY OF MATERIAL SEPARATION IN PERSONAL TYRES

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ABSTRACT

In the paper we deal with evaluation of experimental contactless detection of separations in personal tyres. The systematic experimental study of the problem discovers the separation creation in personal tyres under different load and manner of exploitation. The results of separation detection obtained by contactless method are compared with those of optical microscopy. An excellent coincidence of both methods was obtained.

Non-destructive experimental methods used for controlling of new and retreaded tyres and rubber products that allow us to discover defects and flaws occurring at production, resp. as the result of strain during application, can be divided into following groups:

- *Ultrasonic flaw detection*
- *X-ray analysis*
- *Computed tomography (X-ray+ PC) – higher stage of x-ray analysis*
- *Microscopic methods (raster tunnel microscopes)*
- *Laser holography*
- *Laser interferometry (shearography) – higher stage of holography*

This method can be used to discover separations of tested tyres in the sphere of laboratory and vehicle tyre examination, as well as in production launching and quality control of current production. Advantage of this method is that no other special preparation of tyres is necessary and no damage occurs during their analysis. That is why test equipment ITT-1 for non-destructive analysis by SDS Systemtechnik GmbH was used during examination of separation distribution in tyres.

1. EXPERIMENTAL APPARATUS

New method of non-destructive analysis of tyres based on laser holography and named „laser shearography" was patented in 1987 by Laser Technology, Inc. Special camera composed of special optic member, lens and CCD camcorder visualizes structural defects manifested by submicroscopic surface separations in the whole tyre profile from bead to bead. This method is suitable for quality control of all tyre types in the process of production and tyre retreading [1]. Shearography, newly developing in last decade, also known as Speckle Pattern Shearing Interferometry (SPSI), is coherent-optic measuring method similar to holography. Its simple arrangement and relative resistance against external vibrations are preferences contributing to the usage of this method in industry. Shearography in contrast to holography measures not deformation but deformation gradient (output plane of derivation shift) [2].

Non-destructive analyzer used in examination of separation distribution, works also on the principle of TV – shearography.

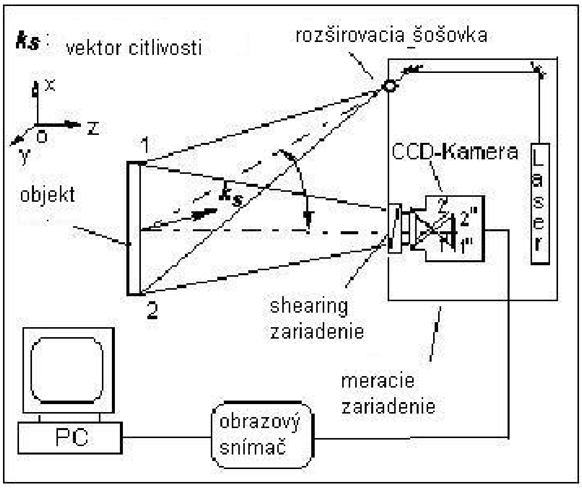

Figure 1. Principle of speckle shearing interferometry (shearography)

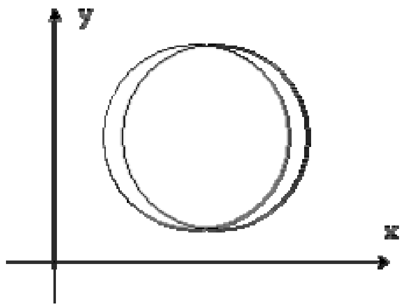

Figure 2. Two minor dislocated images of the object in the image plane for shearing function

Fig. 1 shows the principle of shearography functionality. Extended laser beam illuminates tested object. Laser beam reflected of the object surface is focused in the image plane of CCD camera. Peculiarity of this camera lies in the fact that e.g. wedge prism, bi-prism or Michelson's interferometric arrangement, used in non-destructive analyzer, is integrated in the front of camera lens of shearing apparatus. Shearing elements cause two minor dislocated images of the object in the image plane (see fig. 2). Finally, interferometric intersection of both minor dislocated images gives us the interferogram that means creation of so-called speckle interferogram. That is why this technique is referred to as shearography. Mentioned settings make it obvious that shearography does not need additional reference beam for the production of interferogram in contrast to holography and speckle pattern interferometry, but it needs so-called self-reference light beam because of the shearing effect. Shearography thus uses its own optical system reference.

Analogous to holographic interferometry, there are also two speckle interferograms stored at shearographic examination induced via two deformation states: first non-deformed, the second at load. Visible strip pattern occurs also with the contribution of the intensity distribution intersection of double speckle interferograms, simple digital subtraction of intensity distribution of two speckle interferograms and with the help of signal sensors of the microcomputer. This visible strip pattern is shearogram, that is, in comparison to hologram, not interpreted as contour line of deformation but it is marked by deformation gradient in the direction of dislocation [3].

Shearography allows discovering defective places as holography does, but it is not so sensitive to shock. The last development stage of this method is exclusion of film usage and full implementation of electronic features what allows real time evaluation. History of method development, its basic theoretical principles, instrumentation and applications for evaluation of tyres can be found in [4].

Laser holography, shearography and digital shearography along with X-ray technology are powerful tools for evaluation of tyre endurance. Today, digital shearography presents the most effective tool regarding simplicity and costs of laser technology [5].

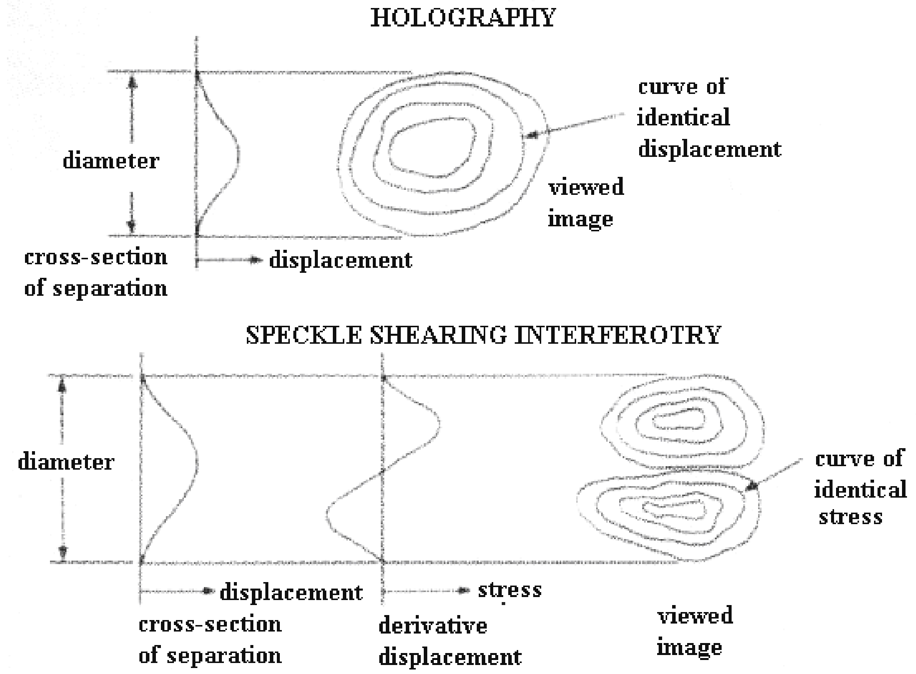

Figure 3. Comparison of holography and speckle shearing interferometry

Non-destructive analyzer used in our experiments allows quick and simple discovery of structure defects (closed separations) in tyres. Tyre test is performed by developing small external vacuum on tyre causing swelling of externally invisible separations. These structure defects are recorded by the way of interferometric measuring method, speckle shearing interferometry also called TV-shearography. The principle of measuring is based on electronic phase interferometry. Interferogram is directly measured by CCD camera, see fig. 4. Tyre surface is illuminated by coherent light – laser and concurrently observed with shifting setting. Two phases shift images – before and after decreasing of surrounding pressure – they are superposed and preprocessed. Interferential image of tyre surface at normal pressure is stored in computer memory to display characteristic separations. Second image, measured in deformed state at decreased pressure (vacuum creation) is subtracted from the first stored image. Difference between these two images is visualized on computer screen. Characteristic separations are shown as speckles on the computer screen, see fig. 5. Phase image and video image are available for each sector.

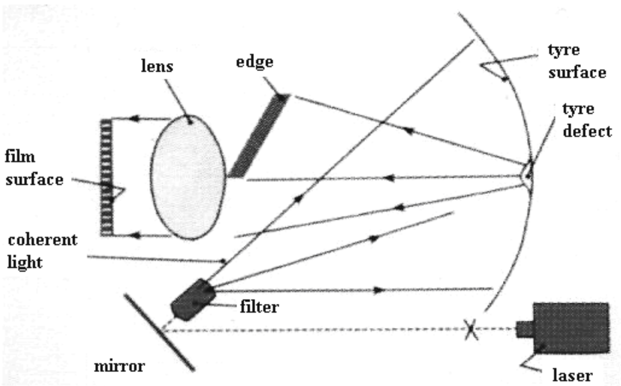

Figure 4. The principle of measuring on non-destructive analyzer

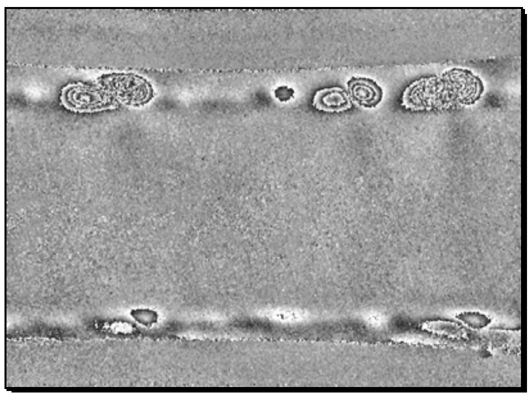

Figure 5. Displaying separations on the screen

System software provided with SDS tyre test sytem comprises of ITT Mes programme for management and recording of measured values [6] and also of the system for data browsing called ITTView allowing evaluation and archiving of measured results regardless on test development [7].

Measuring accuracy for this equipment is 10-4 mm from one end of the tyre casing to another. It is safe and non-radiative equipment (laser class 1) [8]. Camera test setting for tyre casing test on non-destructive equipment ITT-1 is set relatively into the casing from the internal (fig. 5) or external side. Tyre casing test is performed in circumferential sections. All settings are performed in the chamber area with vacuum. [9].

Similar equipment was also developed by Steinbichler Optotechnik GmbH [10].

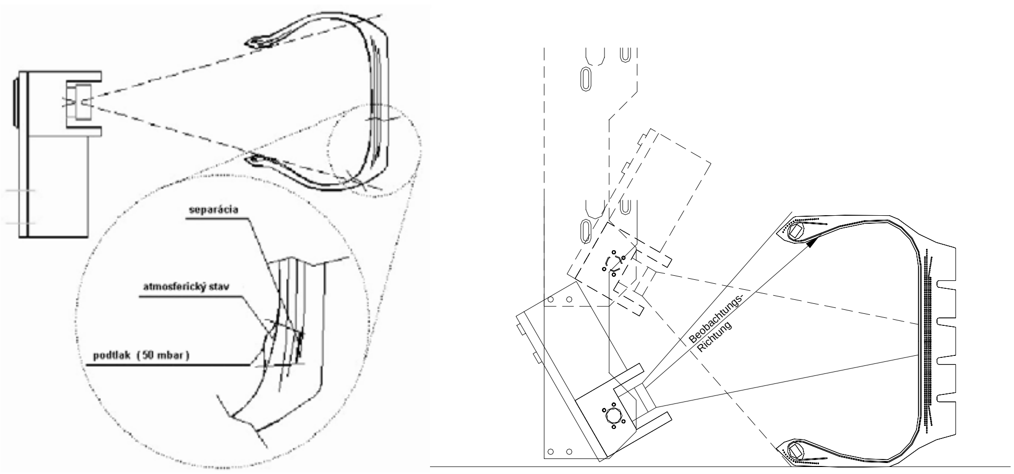

Figure 5. CCD camera setting of non-destructive analyzer at tyre casing test

2. RESULTS AND DISCUSSION

As we can see from the following figures, results obtained with the help of contact-less analyzer greatly correlate with real bare separations displayed at each shearogram. This method thus allows discovering of hidden defects occurring in tyres during their exploitation with high resolution.

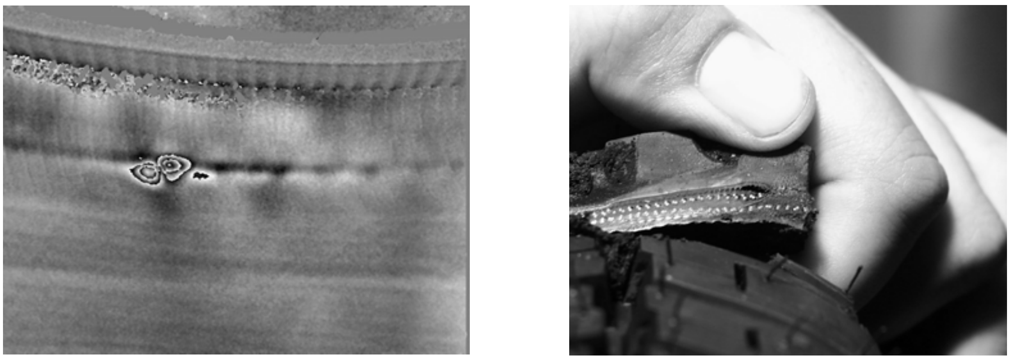

Figure 6. Local separation in the point of second bumper ending

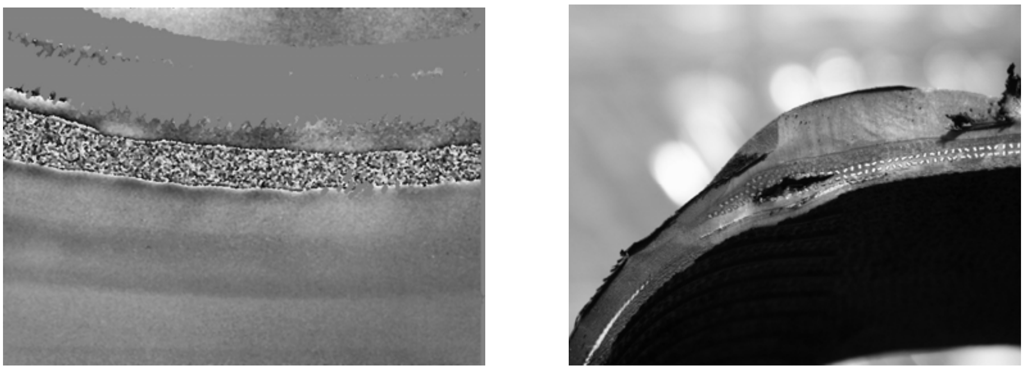

Figure 7. Longitudinal linear separation in the arm between first and second bumper

3. CONCLUSION

The presented method offer the contact less and sensitive testing of tyres quality in industrial frame. Comparison of measured defect with those appeared in the tyre shows an excellent coincidence.

4. REFERENCES

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