The Precision Characterisation of 3D Form

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Two aspects of a surface are of interest: surface form and surface irregularity. The form is the geometry of an object. Superimposed on the form and usually of much finer detail is surface irregularity. The irregularity can be a combination of symmetrical and non-symmetrical deviations from nominal form and conclusions about the manufacturing process or the environmental and operating conditions under which a body has been used can be drawn from it. On curved surfaces there is a need to remove the form before analysis of the surface irregularity is enabled. In this research, methods and algorithms are developed for precision form characterisation of curved surfaces in three dimensions (3D).

Form characterisation of a surface is the definition of surface geometry from discrete data, e.g. obtained by surface measurement with a stylus instrument. In this research the emphasis is on form characterisation of spherical surfaces and rotationally symmetric, non-spherical surfaces of second or higher order. The algorithms are used in the development of a software package for computer aided surface assessment (CASA). A basic system has already been developed and the next step is the upgrade to an intelligent and standardised system for automated surface assessment.

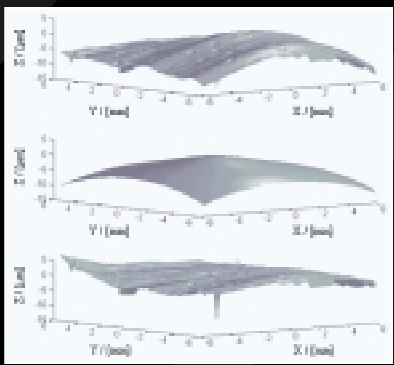

Figure 1: Classification of the total surface irregularity (top) of an aspheric lens into symmetrical (centre) and non-symmetrical (bottom) surface irregularity.

Following the analysis of some example surfaces. The surfaces are typical for the optical industry, i.e. camera or contact lens manufacture. Other examples include the analysis of worn switching contact surfaces and woven reinforcement fibre. Form and irregularity are measured simultaneously. The data in a Cartesian co-ordinate system is defined to a resolution of 10 nanometre in the vertical axis (z-axis) and is based on a uniform grid with spacings typically between 20 and 250 micrometres. A surface is described by up to 27,000 discrete points on an area usually not bigger than 1000 square millimetre.

Analysis of lens surfaces

In Figure 1 the surface irregularity of a diamond turned aspheric lens is shown. The irregularity has been obtained by removal of the best-fit form and is further decomposed. The symmetric irregularity often can be related to wrong tool settings and be useful for the calculation of a tool path correction. The non-symmetric irregularity on the other hand shows fine surface damage in form of scratches and craters.

The surfaces as shown in Figure 1 are defined on a grid of 64 by 88 points in the xy-plane. Grid spacing in x and y is 197 and 140 micrometre respectively. The asymmetric irregularity has a standard deviation of 1.35 micrometre.

Analysis of electrical switching contact surfaces

Arc erosion in electrical switching contacts affects the reliability of the contact interface and hence the reliability of the switch itself. The mass change together with a 3D profile of the surface irregularity can be used to describe the condition of a contact. On curved contact surfaces there is a requirement to remove the form in order to evaluate the mass change. Figure 2 shows the surface measurement of an electrical switching contact (cathode) after 4000 break only operations, switching a 14.7A current (240V, 50Hz). Opening velocity of the switch has been 0.1m/s and opening occurred at 1ms relative to the current zero. Also shown is the surface irregularity after removal of the best-fit sphere.

The surfaces as shown in Figure 2 are defined on a grid of 90 by 90 points in the xy-plane. Grid spacing in x and y is identical and 25 micrometre. Form characterisation by minimum zone sphere fitting evaluated a radius of R = 2.213mm to be used for form removal.

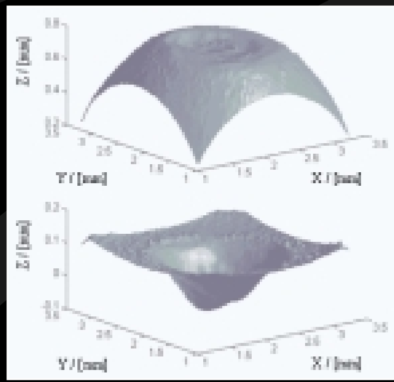

Figure 2: Measured surface of an eroded electrical switching contact (top). Form fitting followed by form removal enables analysis on the surface irregularity (bottom).

Analysis of woven reinforcement fibre

The spatial distribution of woven reinforcement fibres can be assessed without need for form characterisation. The spatial distribution, which is affected by the style of weave, is important in the manufacture of composite materials to estimate the resin flow rate and for the prediction of the mechanical properties of the cured composite material.

The surfaces in Figure 3 are defined on a grid of 164 by 164 points in the xy-plane. Grid spacing in x and y is identical and 125 micrometre.

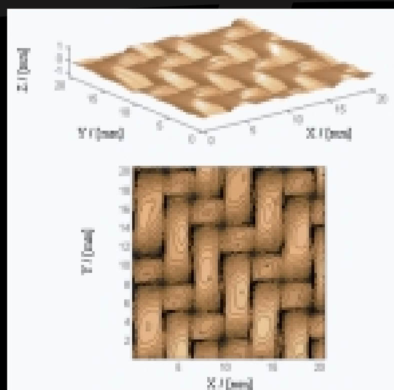

Figure 3: Surface measurement of a woven reinforcement fibre (top). Contour analysis of the surface (bottom) can be used to determine the proportion of resin or fibre at different levels along the vertical axis (z-axis).

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