촉침식 측정기의 비구면 측정용 알고리듬

Algorithm for stylus instrument to measure asphere

Byong Chon Park, Jin Seo, and Yoon Woo Lee, Kilsu Park* and Chang-Ock Lee*
Korea Reserach institute of Standards and Science
*Dept. of Mathematics, Korea Advanced Institute of Science and Technology
bcpark@kriss.re.kr

A reliable algorithm was developed for the analysis of the machined aspheric surfaces with the stylus instrument. The research was done prior to the evaluation of the uncertainties in the aspheric surfaces analysis, which essentially require the knowledge on the algorithm. The developed algorithm considered two important factors: pickup configuration(pivoted arm) and the stylus radius. It also compensates for the sample tilt and axis offset(the setup error) in the best-fit least-square process. The algorithm is coded by means of MATLAB. The algorithm was applied to the actual measurement of asphere, and compared with the results that the instrument produced. Our algorithm shows better performance over the commercial instrument in both of the instrument-calibration and analysis of aspheric surfaces. Based on the algorithm, the uncertainty analyses for several error sources have been done and is discussed.

1. Introduction

Stylus profilometry is a common approach for testing aspheric surfaces during the stage of generation and grinding in the manufacture of aspheric surfaces. It is simple, accurate and relatively low cost, although slow and low resolution compared with the interferometer.

The accuracy of the profilometry, however, is limited by many factors which include the transducer gain, depth of focus error, surface texture, surface slope, mechanical way bend, bow, or ripple of the stage guide, accumulated encoder/indexer errors, and so on.

The accuracy of the profilometry is important because the removal rates are much higher in the generation and grinding than in the polishing. Often it is the last evaluation of the manufactured asphere when the last process is diamond-turning or grinding. Therefore, it is worth evaluating the uncertainties of the asphere measurement with stylus instruments.

The code itself, due to the approximations or assumptions taken, contribute to the resultant uncertainties. Either the imperfection of the instrument function or incomplete knowledge about the metrological factors of the instrument, add to the

uncertainty budget, after the propagation through the execution of the algorithm.

Unfortunately, however, the algorithm is not available since it is a 'black-box' in the commercial instrument. The instrument manufacturer is not ready to help with working with their algorithm. Furthermore, the relevant references are so restricted as far as the authors can find.

As the first step for the uncertainty analysis, the research initiated with the focus on the development of algorithm that can be used in calibration and analysis instead of the 'black-box' in the instrument. Another objective is to modify the algorithm for the diverse application that the commercial instrument does not provide with the implemented code inside the commercial instrument.

The research includes the development of the algorithm, coding with visual C++ and MATLAB, evaluation of the code with the simulated profile, the demonstration of the actual measurement of an asphere sample, and the uncertainty estimation based on the developed algorithm.

2. Materials

Three standard spheres, with the nominal radii, 12, 22 and 80 mm, were used for the instrument calibration and the comparison of the two algorithms: commercial and the developed one.

An asphere sample is aluminium, and diamond-turned. The parameters for the manufacture are R=-800 mm, K=-0.843788, A_4= 0.483902E-09, A_6=-0.413819E-12, A_8=0.164575E-15, A_{10} = -0.234814E-19. Then it was coated with MaF_2 film for the protection of the fragile machined-aluminium surface. Form Talysurf Series 2(Taylor Hobson, UK) was used for the asphere measurement. It uses the laser pickup with pivoted stylus arm. The range/resolution is 6 mm/10 nm. The stylus arm is L-shape whose length are 12 mm from the pivot to the edged corner, and 5 mm from the corner to the tip. The radius of the stylus tip is 2 μm. These factors are used as a parameter or starting value for the calibration as well as the asphere measurement.

* Acknowledgement

This work was supported by the MOST-sponsored project "Development of technique to evaluate the precision optics" and KRISS-to-university joint-research program. The authors also acknowledge Geon-Hee Kim of Korea Basic Science Institute for manufacturing asphere sample.

* References

[1]Kilsu Park, Calibration Algorithms for Stylus Profilometer, Master's thesis, KAIST 2003.2.

[2]For example, David M. G. Stevens, "The application of optical techniques in aspheric surface assessment" Int. J. Mach. Tools Manufac. Vol. 32, No.1/2, pp 19-25(1992).