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Abstract

Precise evaluation of form error is important for quality control in the manufacture of camshafts. For circular arc cams, a conventional method is to fit each arc segment of the cam individually. In such a case, at the connecting points of two fitted segments, there may be discontinuity or non-smoothness. In this paper, a global cam fitting algorithm based on the nonlinear least squares method is proposed. A circular arc cam is represented by the mathematic function in terms of form, rotation and position parameters. By imposing parameter constraints, a closed and smooth profile can be obtained as the result of fitting. In order to evaluate the performance of the proposed algorithm, the uncertainties of the fitted parameters are estimated by the GUM uncertainty framework and Monte Carlo simulations. Compared to the conventional cam fit, the uncertainties obtained by the proposed algorithm are lower. Additionally, the factors which significantly affect the fitting results are specified.

Keywords: cam evaluation, least squares fit, uncertainty evaluation, GUM uncertainty framework, Monte Carlo method

1 Introduction

Camshafts are one of the most important components of internal combustion engines. Their manufacturing precision has significant influence on the performance of engines [1-3]. In high-speed machinery, poor manufacturing techniques seriously impede the functional ability of the mechanism, especially for automotive valve gear system cams [4]. A deviation of cam form of as little as some hundredths of a millimeter may triple the resulting permissible forces [5]. Therefore, the dimensional deviation and form deviation of cams should be exactly examined in the quality control of camshaft manufacturing.

In form measurement, a manufactured workpiece is commonly assessed and verified by comparing it with its design specification. This design specification (i.e. nominal profile) should be firstly parameterized in terms of position, orientation, shape and size with respect to an ideal geometry. The measured data points obtained by a measuring machine are fitted to detect the deviation from the parameterized nominal profile of the part.

In the evaluation of complex cams (e.g. plate cam), some of them have their design functions of the profiles or follower displacement curves. Normally, the complex nominal profile is approximated by some simple geometric elements or combinations of them.