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COMPARATIVE MODEL ANALYSIS OF TWO TYPES OF CLAMPING ELEMENTS IN DYNAMIC CONDITIONS

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This paper studies the compliance of the fixture-workpiece system. Workpiece clamping case with two types of clamping elements is considered. The first type of clamping element is standard, with flat top, while the second one is specially designed, with round cutting insert. Analyzed was the case of workpiece clamping using small forces, whereby the deformations in the workpiece/clamping element interface are predominantly on the order of magnitude of roughness height. A comparative analysis of dynamic behaviour of both types of clamping elements is also presented. In comparison with its standard counterpart, the specially designed clamping element with round cutting insert has superior clamping performance regarding both tangential load capacity and compliance.

Keywords: *clamping, compliance, fixture, roughness*

Usporedna analiza modela dva tipa elemenata za stezanje u dinamičkim uvjetima

Izvorni znanstveni članak

U radu se razmatra popustljivost sustava naprava-izradak. Razmatra se slučaj stezanja izratka s dva tipa elemenata za stezanje. Prvi tip elementa za stezanje je sa standardnim ravnim čelom. Drugi tip elementa za stezanje je specijalne izvedbe s čelom u obliku kružnog klina. Analiziran je slučaj stezanja malim vrijednostima sila stezanja pri čemu se deformacije u zonama kontakta između elemenata za stezanje i izratka pretežno odvijaju u zonama visine neravnina. Također je prikazana komparativna analiza, predhodno spomenuta, dva načina stezanja izradaka u uvjetima dinamičkih opterećenja. Specijalno dizajnirani element za stezanje s čelom oblika kružnog klina u odnosu na standardni element za stezanje s ravnim čelom ima izrazito veću steznu učinkovitost po pitanju tangencijalne nosivosti i popustljivosti.

Ključne riječi: *hrapavost, naprava, popustljivost, stezanje*

1 Introduction

Key aspects of product development are conceptual and detailed design stages in which new ideas emerge and are being evaluated. This can be a long, complex and often iterative process, which encompasses following stages: identification of the need for some product, creation of initial ideas for the design, evaluation and improvement of such ideas, detailed design, testing of the solution for further improvements, generation of complete documentation for the adopted solution, such as the engineering drawings, bills of materials, etc. [1, 2]. All this implies that it is not only necessary to design a product, but also to select the most adequate manufacturing equipment [3]. Locating and clamping of workpiece and cutting tools in their working position is performed using special equipment, generally termed fixtures. Fixtures significantly influence the output effects of manufacturing process. For that reason fixture design is very important and demands great attention since it directly influences the total cost of manufacture, productivity, machining quality, etc. [4, 5].

In order to reduce the costs of fixture design and optimization, and increase the efficiency of machining system, and accuracy, precision and quality of machining, over the years a number of methodologies which aide fixture designers have been proposed.

Choudhuri and De Meter [6] presented a methodology for analyzing the impact of a locator tolerance scheme on the geometric errors of a workpiece. Wang et al. [7] focused on the fixture performance of the workpiece locating accuracy and developed different algorithms for force closure fixturing with the D-optimality criterion to minimize the workpiece positioning errors. Estrems et al. [8] determined the uncertainty in a cutter hole within a rotational workpiece. The workpiece was located by means of two V-blocks to determine the uncertainty when the dimensional values are influenced by the accuracy of the fixtures. Xiong et al. [9] introduced a geometric constraint into the elastic contact model to calculate the passive force of a fixture-workpiece system. Qin et al. [10] formulated an elastic contact model to optimize the fixture layout. Zhu and Ding [11] transformed the form-closure fixture layout design into a linear program and solved it using the simplex method in discrete domain. Asante [12] predicted the contact load and pressure distribution at the contact points in a workpiece-fixture system by combining contact elasticity and FEM. Wang et al. [13] proposed a systematic method to identify the surface errors, location error and machining error through FEA and coordinate measurement machine measurements, respectively. The evaluation of profile tolerance was done through the analysis of error sources by assuming an absolute precise surface. Chaiprapat and Rujikietgumjorn [14] developed a mathematical model that is able to predict the geometric variation in a resultant-machined surface when the tolerance of a datum feature is given. Vukelic et al. [15] used a combination feature-based, knowledge-based and geometry-based methodology for development complex system for fixture selection, modification, and design. Zheng and Chew [16] presented a method to select optimal locations for 4/7 fixels automatically. They used Gilbert-Johnson-Keerthi distance algorithm and the Gram-Schmidt process to yield the fixel locations. Fan and Kumar [17] studied the fixture locating layout with