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NOVEL WORKPIECE CLAMPING METHOD FOR INCREASED MACHINING PERFORMANCE

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Fixtures which balance cutting forces and torques by the friction forces generated on contact surfaces of locating, clamping elements and workpiece surfaces are widespread in industrial practice. Among other things, these friction contacts are characterized by a certain amount of interface compliance which is a complex function of macro- and microgeometry of contact pairs in the workpiece-fixture system, as well as the clamping and cutting forces. Workpiece machining errors are mostly the consequence of that interface compliance. This paper investigates workpiece-fixture interface compliance in cases where clamping is performed using a standard, and specially designed clamping element. Theoretical considerations are presented, followed by results of experimental investigation. Considerable advantages of the specially designed clamping element compared to its standard counterpart are demonstrated by experiments. The results are a good starting point for a research into optimization of special fixture clamping elements and their wider industrial application.

Keywords: *fixture, clamping force, compliance, indenting*

Povećanje učinkovitosti strojne obrade novom metodom stezanja izradaka

Izvorni znanstveni članak

Naprave kod kojih se sile i momenti nastali u procesu rezanja uravnotežuju silama trenja, nastalim na kontaktima elemenata za baziranje i stezanje s izratkom, su vrlo zastupljene u industriji. Spomenute kontakte, pored ostalog, karakterizira određena popustljivost veza koja je složena funkcija makro i mikrogeometrije kontaktnih parova u sustavu izradak-naprava, sila stezanja i sila rezanja. Pogreške obrade uvelike su posljedica upravo popustljivosti spomenutih veza. U radu se razmatra popustljivost veza između elemenata za stezanje i izratka u slučajevima stezanja uređajem za stezanje s ravnim čelom i specijalno dizajniranog elementa za stezanje. Nakon teorijskih razmatranja izloženi su rezultati eksperimentalnih istraživanja. Rezultati ukazuju na značajne prednosti specijalno dizajniranog elementa za stezanje u odnosu na standardni oblik elementa za stezanje s ravnim čelom. Dobiveni rezultati otvaraju prostor za istraživanja u smislu optimizacije elemenata naprava za stezanje i mogućnosti njihove industrijske primjene.

Keywords: *naprava, sila stezanja, popustljivost, utiskivanje*

1 Introduction

Application of new scientific approaches to improve the level of knowledge and organization in production preparation sectors not only has a considerable impact upon the final product characteristics but also indirectly affect production costs and times of delivery. Manufacturing companies which primarily focus on technological and operational preparation of production, i.e. those that keep up to date with the technological parameters and the results of technological processes, stand the best chances of improving the activities in the observed sectors [1]. One of essential characteristics of modern production systems is the ability to manufacture a variety of high-quality products in the shortest possible time. Short time-to-market is a key instrument in providing market domination and higher profit margins. Job and small-batch production often take priority as dictated by the market demand for a variety of products. All this demands development of a flexible, agile, manufacturing system which is capable of meeting new production programs [2].

Owing to stringent market demands and intensive development of science, equipment, and novel technologies, the level and trend of further development of machining processes in the metal cutting industry depend on numerous factors. The factors which most influence the quality of machining process are: type of blank, machining technology, operations, sub-operations, machine tools, cutting tools, fixtures, measuring devices, etc. [3, 4, 5, 6, 7]. In order to bring the machining process to a higher level, all these elements must be optimized. Within a number of factors which influence output effects of manufacturing process, machining fixtures play a prominent role [8].

Fixture design optimization has been focused on by numerous investigations in previous years.

DeMeter [9] used a rigid body fixture-workpiece model and the min-max load criterion for synthesis of optimal fixture layout and minimum clamp actuation intensity. Nonlinear optimization methods were used while neglecting the elastic deformation of workpiece. Jeng et al. [10] presented a search algorithm for the instant center of motion, based on the correlation between the cutting forces and clamping moments. Based on the property of instant center of motion, minimum clamping force was estimated. Wu and Chan [11] used genetic algorithm (GA) to determine the most statically stable fixture layout. They used a rigid body fixture-workpiece model and ignored elastic deformation of the workpiece due to clamping and machining forces. Meyer and Liou [12] presented a methodology to generate the configuration of a fixture, which was under dynamic machining forces. Linear programming was used to determine optimal locator positions and clamping forces. Wang et al. [13] developed an intelligent fixturing system to adjust the clamping forces adaptively to achieve minimum deformation of the workpiece according to cutting forces. Linear static finite element analysis (FEA) was used to find the workpiece deformation. Krishnakumar and Melkote [14] presented a GA-based discrete fixture layout optimization method to minimize the deformation of the workpiece under static conditions.