Journal of Manufacturing Systems 33 (2014) 76–83

Contents lists available at ScienceDirect

Journal of Manufacturing Systems

journal homepage: www.elsevier.com/locate/jmansys

Model testing of fixture–workpiece interface compliance in dynamic conditions

Branko Tadic[a], Djordje Vukelic[b,*], Dragomir Miljanic[c], Bojan Bogdanovic[a], Ivan Macuzic[a], Igor Budak[b], Petar Todorovic[a]

[a] University of Kragujevac, Faculty of Engineering, Department for Production Engineering, 34000 Kragujevac, Serbia
[b] University of Novi Sad, Faculty of Technical Sciences, Department for Production Engineering, 21000 Novi Sad, Serbia
[c] Metalik DOO, Trebjeska 6, 81400 Niksic, Montenegro

ARTICLE INFO

Article history:
Received 1 November 2012
Received in revised form 21 January 2013
Accepted 20 May 2013
Available online 15 June 2013

Keywords:
Fixture
Machining
Clamping
Locating
Compliance

ABSTRACT

This paper is focused on the problem of compliance of interface between clamping/locating fixture elements and workpiece, under dynamic loads during machining. In contrast to previous investigations, the authors have developed a special device dedicated to testing of physical models which represent clamping/locating elements and workpiece. This device allows optimization of a large number of input parameters which are critical to interface compliance. It was used in experimental investigations to establish the impact that the radius of the spherical tip of a clamping/locating element has on the interface compliance and load capacity. The results of experimental investigation show that, under certain conditions, the clamping/locating elements with larger-radius spherical tips provide significantly lower interface compliance. Future investigations should be aimed at finding optimum macro- and micro-geometries of contact interface, as well as the selection of materials for clamping/locating elements.

1. Introduction

The main objective of machining fixture is to establish and secure the desired position and orientation of the workpiece during machining on machine tool. Fixtures have a direct impact upon product quality, productivity and cost. The costs associated with fixture planing, design and manufacture can account for 10–20% of the total cost of a manufacturing system [1]. On the other hand, approximately 40% of rejected parts are due to dimensioning errors that are attributed to poor fixturing design [2].

Many researchers have focused on the investigation of the influence of fixture–workpiece system on the aggregate accuracy of machining. As regards the fixture layout optimization, the research has been mostly focused on: kinematic analysis, force analysis, contact analysis, finite-element analysis (FEA), etc. Numerous methodologies have been proposed to allow fixture layout optimization.

Meyer and Liou [3] presented a methodology to generate fixture layout under dynamic machining forces. Linear programming was used to determine optimal positions of locating elements and clamping forces. Nee et al. [4] reported a sensor-assisted fixture that was capable of delivering varying clamping loads, calculated from a quasi-static model, to minimize workpiece distortion. Li and Melkote [5] presented an optimal synthesis approach for the fixture layout and clamping force that considers workpiece dynamics during machining and determines the optimal clamping force for a multiple clamp fixture subjected to a quasi-static machining force. Hurtado and Melkote [6] formulated a multi-objective optimization model that defines minimum clamping loads to achieve workpiece shape conformability and fixture stiffness goals for a workpiece subjected to quasi-static machining forces. Kulankara et al. [7] presented an iterative algorithm that minimized the workpiece elastic deformation for the entire cutting process by alternatively varying the fixture layout and clamping force. Vallapuzha et al. [8] investigated the use of spatial coordinates to represent locations of fixture elements in their fixture layout optimization model solved by genetic algorithms (GA). Xiong et al. [9] formulated the clamping optimization problem as a constrained nonlinear programming problem based on the concept of passive force closure. Kaya and Ozturk [10] simulated the machining operations by using a finite element model. The machining forces are considered as area force and applied over the tool workpiece contact area. Liao [11] used the GA to find the optimal numbers of locators and clamps as well as their optimal positions in sheet metal assembly such that the workpiece deformation and variation are minimized. Amaral et al. [12] employed 3-2-1 locating method and developed an algorithm to automatically optimize fixture support, clamp locations, and clamping forces, to minimize workpiece deformation, subsequently increasing machining accuracy. Deiab and Elbestawi [13] presented the results of a full factorial experimental investigation of

* Corresponding author. Tel.: +381 21 485 23 26; fax: +381 21 454 495.
E-mail address: vukelic@uns.ac.rs (D. Vukelic).

0278-6125/$ – see front matter © 2013 The Society of Manufacturing Engineers. Published by Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.jmsy.2013.05.004