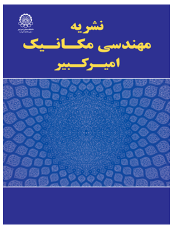

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An Experimental Approach for Determination of Locators Reaction Forces in Milling Fixtures

M. Sohrabifard, M. J. Nategh*

Advanced Technologies in Machine Tools Lab., Department of Mechanical Engineering, Tarbiat Modares University, Tehran, Iran

ABSTRACT: The contact stiffness between the workpiece and fixture locating system is one of the decisive factors for the maintenance of the stability of the workpiece during the machining process. In order to estimate the contact stiffness, it is needed to determine the locator reaction forces. These forces are created by the clamping forces, cutting forces, workpiece weight, and friction effects of the contact between the workpiece and fixture locating system. Some analytical approaches have already been presented for calculating the location reaction forces. However, there are six equations for a 3-2-1 locating system, but 18 unknown parameters. Therefore, an optimization solution is proposed in the literature to obtain the reaction forces which involves several simplifying assumptions which result in considerable errors in the solution. In this study, in addition to presenting the mathematical model of the total system, an experimental approach has been proposed in order to determine the locator reaction forces. This can provide a suitable means for evaluating the optimization solutions and analytical models for determining the locator reaction forces and contact stiffness and diminishing the errors.

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1- INTRODUCTION

When a workpiece is inserted in a fixture, the various parts of the fixture are subjected to external loads, which are transmitted through the workpiece. However, in a milling fixture with a 3-2-1 locating system, there are six locators restraining six degrees of freedom of the workpiece in three-dimensional space. Considering two components of tangential forces and one component of vertical force for each locator, there are a total of eighteen unknowns which cannot be calculated by the six equations of equilibrium of forces and torques applied to the workpiece. In order to eliminate the uncertainty of the system of equations, many principles and methods were used by some researchers [1-7]. However, except for the researches [8, 9], in which Fuji disposable paper was used to experimentally measure the reaction force of the base locators, in none of the mentioned studies was an experimental method for direct measurement of the reaction forces of the locators. In this research, a suitable and cost-effective solution is presented in which by using Force-Sensitive Resistors (FSR) at the contact region of the workpiece with the locating system, the support reaction forces at the locator's location can be measured directly.

2-DESIGN OF EXPERIMENT

According to Fig. 1, an experimental process is made to measure the reaction forces of locators. In this study, assuming that the shape of the workpiece is a rectangular cube and frictional contact is established between the fixture components and the workpiece, and also assuming that the fixture components and the workpiece are rigid at points in contact with each other, a 3-2-1 locating system with 6 locators and 2 clamps is designed in such a way that by applying the normal components of the clamping forces, the reaction forces of the locators can be applied in a controlled manner and measured.

In this study, in order to measure the normal component of the reaction force of each locator, the FSR model 402 sensor was used which Fig. 2 illustrates the experimental setup for the workpiece-fixture system.

3. RESULTS AND DISCUSSION

In this study, model 402 of FSR sensors were used to experimentally measure the tangential and normal components of the locating reaction force. These types of sensors show a change in pressure by changing their resistance so that with increasing pressure, the resistance of their two ends decreases. In order to increase the measurement accuracy in data mining, FSR sensors were calibrated by a KISTLER dynamometer model B9257. Contact friction coefficients were also measured experimentally. Finally, all components of the reaction forces were measured at the locating points. The advantage of using this method is the easy installation of sensors at the point of contact between the locator and the

*Corresponding author's email: nategh@modares.ac.ir

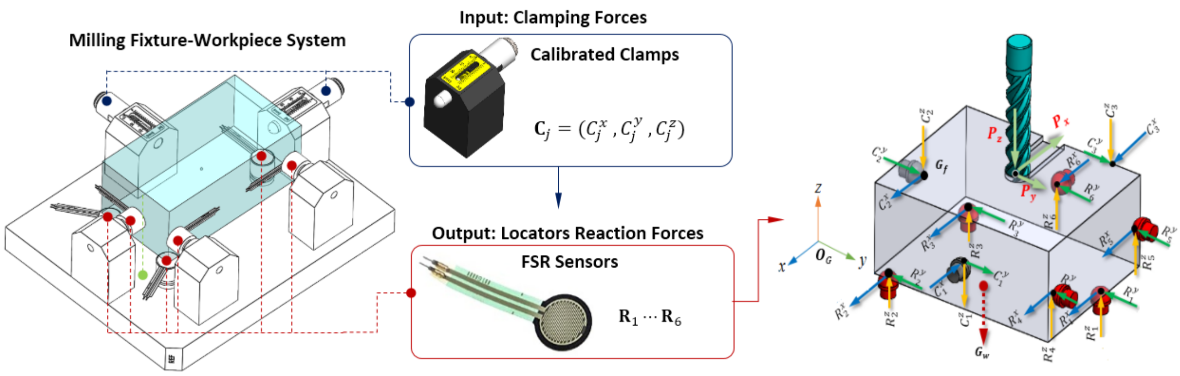

Fig. 1. The proposed process for experimental calculation of reaction forces at the locating points

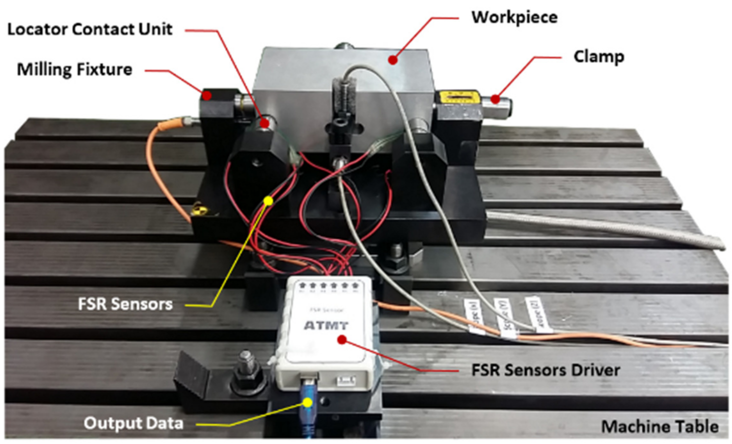

Fig. 2. Workpiece-fixture system equipped with FSR sensors

workpiece due to their small size and the relatively long life of these sensors (provided that no overloading is applied). It is also more economical to use these sensors than other sensors. In order to ensure the reliable operation of FSR sensors and thus achieve the best results, it is best to design and build locating surfaces as parallel as possible to the workpiece surface profile.

4. CONCLUSIONS

By observing the results obtained from the test, it can be said that:

● The experimental method presented in this research can be a suitable solution to validate the optimization methods in calculating the reaction forces of locators in milling fixtures.

● FSR sensors will have a high ability to measure the reaction forces of locators in the limited space of the locating system due to their long life, high heat resistance, good sensitivity and repeatability, and small enough dimensions.

● Due to the limited capacity of FSR sensors, it is better to use power-adjustable clamps.

● The experimental method used in this research can be applied on parts with flat and parallel surfaces, also on parts with free geometry.

● In order to prevent damage to the FSR sensors, it is best to avoid point contact as much as possible.

● The forces calculated in this experimental method can also be used directly in calculating the stiffness of the contact between the workpiece and the milling locating system.

● The proposed experimental method can be used in small-scale machining processes as well as machining of flexible materials in order to measure the reaction forces of the support and to estimate the optimal force of

● the clamps, thus avoid applying excessive

● force by the clamps and the resulting errors.

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