BULETINUL INSTITUTULUI POLITEHNIC DIN IAŞI
Publicat de
Universitatea Tehnică „Gheorghe Asachi” din Iaşi,
Tomul LIX (LXIII), Fasc. 1, 2013
Secţia
CONSTRUCŢII DE MAŞINI

EXPERIMENTAL RESEARCH REGARDING STATIC RIGIDITY IN AXIAL DIRECTION OF "NORMAL" MODULES FROM MODULAR FIXTURES STRUCTURE

II. RESULTS

BY

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Received: October 24, 2012
Accepted for publication: November 19, 2012

Abstract. The paper contains results of research on static rigidity of some "normal" modules from the structure of modular fixtures. Modules deformations were analyzed, under the action of axial static force, using advanced equipment. The static force considered was composed from: assembly forces, tightening forces and the static component of the machining forces. There were experimentally determined the overall deformation (rigidity) and the contact deformation (rigidity) of the "normal" modules from the SEM – 64 DISROM modular kit.

Key words: fixture, modular fixture, module, deformation, rigidity, contact rigidity, total rigidity.

1. Introduction

In this paper there are presented results of the research on the deformations that occur in the structure of the modular fixture and which can result in geometric deviations of the machined surface of the workpiece.

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The methodology used in the experiments has been presented in the first part of the paper (Chitariu & Gherghel, 2013).

In order to determine the rigidity on axial direction, the methodology will consider determining the ratio between the applied *force* to the assembled *modules* and the corresponding *deformation* (displacement) on the same direction in accordance with the indications from the *Machinery construction* field (Korsakov, 1963; Picoş *et al.*, 1992), the *Machine tools* field (Ispas, 1998; Chiriacescu, 2004; Yoshimi, 2008), and the Fixture field (Tache & Brăgaru, 1976; Gherghel, 1981; Tache *et. al.*, 1982; Gojinețchi & Gherghel, 1992; Zhu *et al.*, 1993; Rong & Zhu, 1999; Li & Melkote, 1999; Liao *et al.*, 2000; Rong *et al.*, 2005; Zheng, 2005), literature and Machine tools and Fixture literature.. Data processing was performed by filtration using the "moving average" filter. The measuring scheme used is presented in Fig. 1.

Force was applied to the *modules* axially and the force was measured using a force *transducer* (Fig. 1) which was oriented and positioned on top of the module. Deformations were measured in three points with three *displacement transducers*. Two displacement transducers (Fig. 1) were installed on top of the module and another transducer was mounted on the module at a distance of 32 mm from the base of *module*. Transducer *2* (Fig. 1) was oriented and positioned in the area corresponding to the T channels intersection. Transducer *3* (Fig. 1) was oriented and positioned in the most rigid area, and transducer *1* (Fig. 1) was oriented and positioned at a height of 32 mm from the *base plate*.

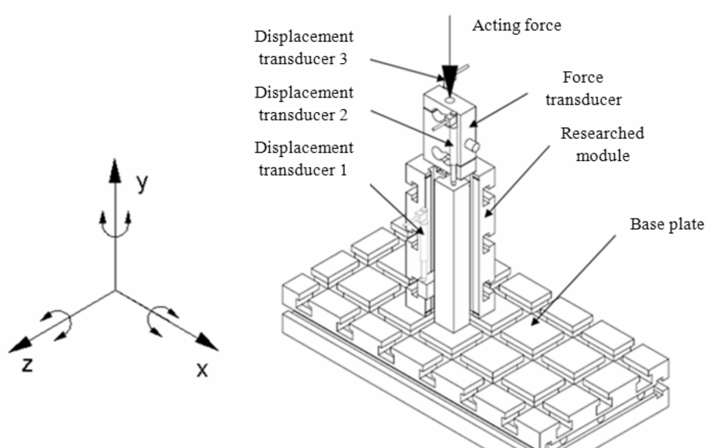

Fig. 1 – Measuring scheme of force and displacements used.

Since the *Ra* roughness has a high impact on the contact rigidity it was measured for each module. The *Ra* roughness for the analyzed modules varies between 0.3 µm to 0.6 µm.

3. Results

Results presented in Fig. 2 and Fig. 2 are filtered.

Fig. 2 presents the evolution of deformation “rigidity” curves for CCT – 003 module, containing transversal (perpendicular) T channels.

The maximum deformation is recorded by transducer *3* corresponding to the area of T channels intersection.

The maximum applied force has a value of 10.84 kN. The corresponding maximum deformation has a value of 0.0265 mm. The curve shape is non-linear, this aspect is specific to joint structures, presented in Machine tools literature (Chiriacescu, 2004; Yoshimi, 2008).

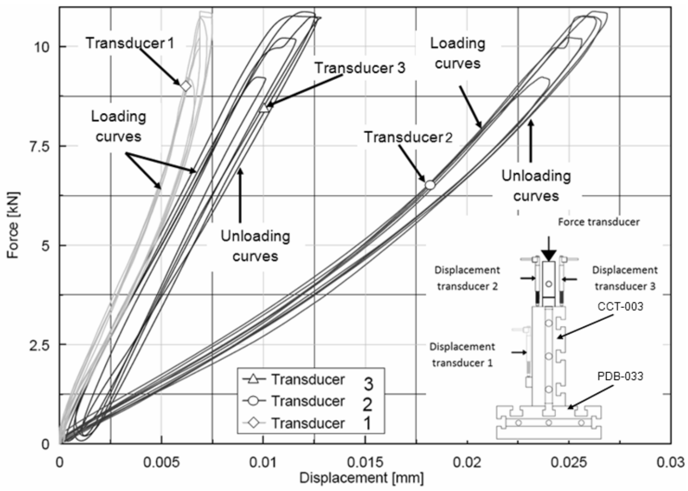

Fig. 2 – The deformation (rigidity) curves for CCT – 003 module (filtered experimental result).

The curve corresponding to transducer *2* (Fig. 2), indicates the evolution of displacement in the area without channels and holes. This area, by analogy, can be considered a bar. The maximum deformation is 0.0131 mm, considering 10.84 kN of force. The deformation measured by transducer *2* and *3* contains both *contact deformations* and *elastic deformation* of the *module*.

The curve corresponding to transducer *1*, from Fig. 7, indicates the evolution of the *contact deformations* and the *elastic deformation* of a part of the *module*. The maximum value indicated is 0.0075 mm.

Large differences, between maximum deformation values, presented (Fig. 2) indicate an inclination of the *module* under the action of a symmetrically applied force to the module on axial direction, which can lead to orientation-positioning deviations and therefore deviations of the machined surfaces of the workpiece.

Fig. 3 presents the evolution of deformation (rigidity) curves for CSN – 003 *module* that contains holes.

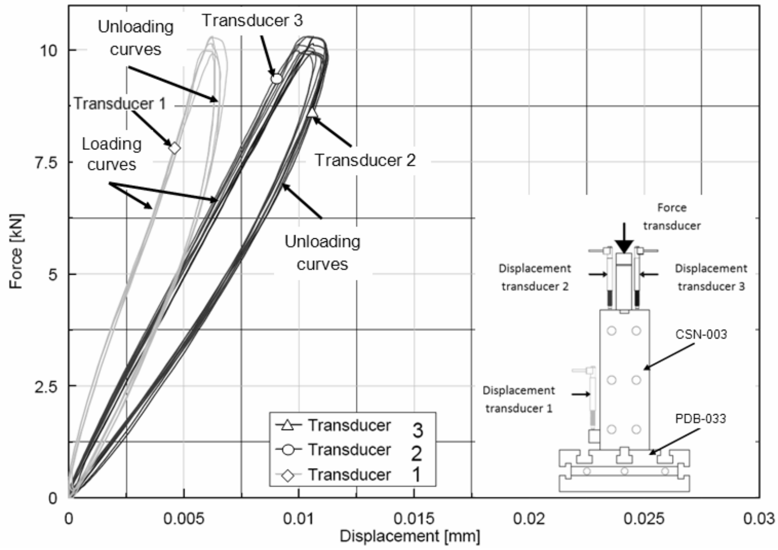

Fig. 3 – The deformation (rigidity) curves for CSN – 003 module (filtered experimental result).

The deformations measured by transducers *2* and *3* contain the contact deformations between *base plate* and the *module* and the elastic deformation of the *module*. Maximum deformation measured by transducers *2* and *3* have similar values, thus the deformation has the value of 0.0118 mm at a force of 10.27 kN.

The curve corresponding to transducer *1* indicates the evolution of the contact deformation and the elastic deformation of a part of the module. The maximum deformation has the value of 0.0118 mm at a force of 10.27 kN.

The allure of the deformation (rigidity) curves regarding the analyzed structure is linear. It is noted that the deformations measured on the top of the module show a uniform overall deformation.

The maximum values of rigidity for the researched modules are shown in Table 1.

The values presented for contact rigidity are lower than values indicated in Fixture literature (Gojinețchi & Gherghel, 1992). The contact deformation indicated has a value of 300.000 daN/mm, these value is higher than the values determinated experimentally.

Table 1
Values of Rigidity for the Researched Modules

Module	Rigidity value measured by transducer 1 [daN/mm]	Rigidity value measured by transducer 2 [daN/mm]	Rigidity value measured by transducer 3 [daN/mm]
CCT - 003	144.533	40.605	82.748
CCT - 002	127.750	53.789	79.843
CSN - 003	146.714	86.302	86.302
CSN - 002	160.882	97.678	97.678

In Fig. 4 are presented, as a histogram, the maximum deformations considering a force of 10 kN for the analyzed modules.

In Fig. 4 there are represented: the maximum total deformations measured, the minimum total deformations measured, and the contact deformations measured.

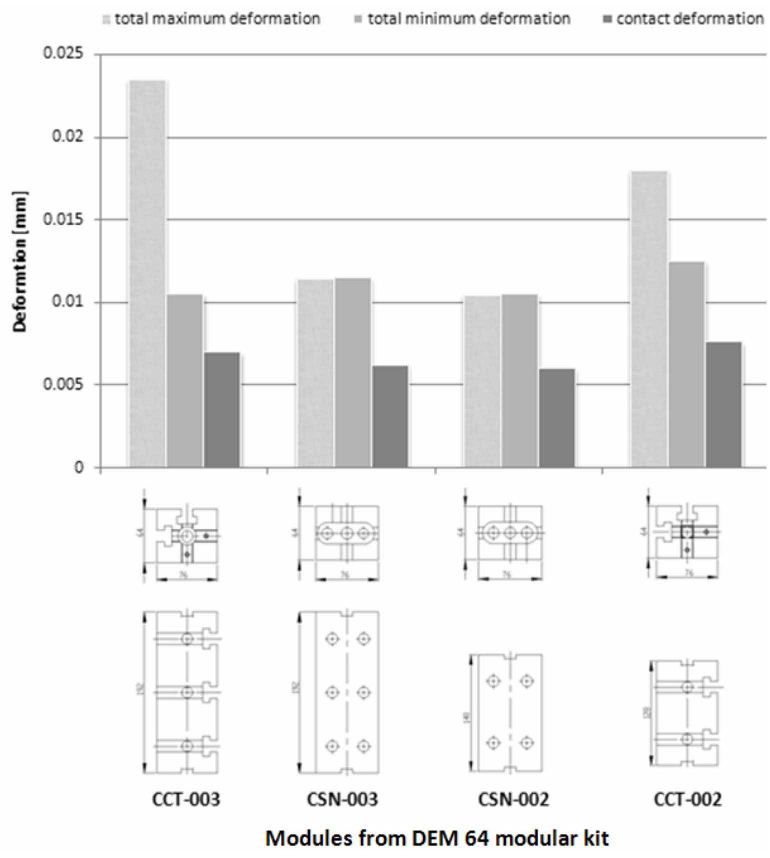

Fig. 4 – Maximum deformations considering a force of 10 kN for the analyzed "normal"modules.

From the presented histogram is observed that the modules, which do not have cross – channels and which have a symmetric structure (CCT – 003, CCT – 002), deform uniformly, under the action of axial force. This uniform deformation doesn't cause inclinations under the action of axial uniform applied force.

The measured deformations may cause *clamping deviations* and *machining deviations* due to modules deformation. The clamping deviations caused by the deformation of modules with symmetrical structure will be a "dimensional"/ position deviation (the linear displacement of the measuring base). In the case of modules which have transverse T channels in their structure, a uniformly distributed force may lead to angular displacement of the measuring base and, also, to shape and relative position deviations.

4. Conclusions

1. The research targeted the determination of deformations (rigidity) values for normal modules from DEM 64 modular KIT, highlighting the rigidity curves, considering clamping force and the static component of the machining forces on axial direction.

2. The research has considered the determination of the *total deformation* (*rigidity*) and the *contact deformation* (*rigidity*) between the modules and base plate.

3. The research conducted showed the different evolution of deformation curves in the case of modular structure composed of modules, with different shape and different sizes, in the case of similar loads.

4. Measured deformations, of modules from fixture structure, may cause deviations during clamping and machining. Deviations caused by the uneven rigidity, of modules from fixture structure, may cause "dimensional"/ position deviations (linear displacement of the measurement base) and deviations of shape and orientation-position (angular displacement of the measurement base) of the machined surfaces of the workpiece.

5. The construction of the fixture body must be such as the flow of forces to close through modules with a symmetric construction. Therefore "dimensional"/ position displacements (linear displacements of the measuring bases), of the machined surfaces, may appear (which are easily compensated by technological system adjustment) and avoid angular displacement of measuring bases that can generate shape and orientation deviations (angular displacements of measuring bases of the machined surfaces).

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CERCETĂRI EXPERIMENTALE PRIVIND RIGIDITATEA STATICĂ PE DIRECȚIE AXIALĂ A UNOR MODULE „NORMALE” DIN STRUCTURA DISPOZITIVELOR MODULARE

II. Rezultate

(Rezumat)

Sunt prezentate rezultate ale cercetărilor experimentale privind rigiditatea statică a unor module „normale“ din structura dispozitivelor modulare. S-au analizat deformațiile modulelor sub acțiunea forțelor statice, pe direcție axială: forța de asamblare, de strângere şi componenta statică a forței de prelucrare, utilizând echipamente performante de măsurare a forțelor şi deplasărilor. Au fost determinate, experimental valorile pentru deformația (rigiditatea) totală, cât şi deformația (rigiditatea) de contact. Au fost evidențiate curbele de deformare (rigiditate) a modulelor din setul SEM – 64 DISROM.

Deformațiile elementelor de dispozitiv, măsurate, pot determina apariția *abaterilor de strângere* şi, ca urmare, abateri *de prelucrare*. Abaterile cauzate de *rigiditatea* neuniformă a *modulelor,* din cadrul *structurii modulare* de dispozitiv pot fi abateri „dimensionale“/ de poziție (deplasări liniare ale bazelor de cotare) ale suprafețelor prelucrate ale pieselor, cât şi abateri de formă şi de orientare (deplasări unghiulare ale bazelor de cotare ale suprafețelor prelucrate ale pieselor).