THE TIGHTENING ACCURACY OF WORKPIECES IN THE MULTIPLE CLAMPING DEVICES

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ABSTRACT: Fixtures are used for orientation-positioning-tightening of workpieces during machining on machine tools. Multiple clamping fixtures are intended to clamp several workpieces for simultaneous or successive machining. Multiple clamping is characterized by a series of economical advantages, due to the reduction of total machining time. These advantages are more important once the number of workpieces is higher or if the machining is made with compound tools. Due to the complexity, overall size and the high number of components, the multiple clamping fixtures have diminished accuracy than simple fixture due to elastic and contact deformations of fixtures housing, of supports etc. Also, multiple clamping fixtures present diminished rigidity and dynamic stability. From the analysis of the specialized literature results that there are a few paper on the subject of multiple clamping. In the paper there are presented the causes that can lead to the diminishing of the accuracy of multiple fixture. The modalities for the determination of fixtures precision are presented, also, for the parallel and serial multiple clamping fixtures.

KEY WORDS: fixtures, multiple clamping, clamping mechanisms, accuracy, machine tools.

1. INTRODUCTION

The technological system composed of: machine, cutting tool, fixtures and work piece, is not perfectly rigid, and it deforms under the action process forces.

The notion of system rigidity (stiffness), in general, therefore of technological systems also, represents the system capacity to oppose deformation under the action of exterior forces (Korsakov V.S., 1963; Picoş C., & Pruteanu O., 1992).

Technological fixtures may be defined as auxiliary components of technological systems, with the function of orienting and positioning parts, tools, gauges, etc., in accordance with the requirements of cutting, assembly etc, which maintain this direction in time (Gherghel, N. 1981).

Of the entire complex of deviations that compose the total machining deviations, a special role has the deviations caused by the deformations of the technological system under the action of process forces.

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Among the deformations of the technological system, a significant proportion is due to the deformations of the regular or modular fixtures (Gherghel, 1981).

Multiple fixtures can be classified according to the papers (Gherghel, 1981), (Gojineţchi & Gherghel, 1983; Gherghel & Seghedin, 2002; Gherghel & Seghedin, 2006; Gojineţchi & Gherghel, 1992; Seghedin, 2008; Vasii-Roşculeţ et al., 1982), as regards the manner of applying the clamping forces on pieces arranged linearly (circularly) on one row (more rows), into the following categories:

- serial multiple fixtures (in rows, in bundles), to which the clamping forces resultants are collinear;
- parallel multiple fixtures (individual), to which the clamping forces resultants are parallel (Seghedin & Mircea, 2010).

Another classification of multiple fixtures takes into account the final element, which makes contact with the piece (which carries out the clamping itself). This point of view has the advantage of displaying a larger variety of solutions. Thus, fixtures can have as a final element: plungers, prisms, levers, chucks, springs etc.

The advantages of multiple fixtures are the following:

- reducing the helping (time) strokes for clamping and releasing pieces;
- reducing the main (time) strokes in the case of using multiple tools;
- overlapping the main strokes and the clamping-releasing helping strokes in the case of devices with charging- discharging stations.

The paper (Seghedin, 2008) reveals a comparative study of the advantages of using multiple fixtures. Therefore, taking into account machine works which do not use these devices, savings grow with 20% in the case of simple devices, with 50% in the case of division devices, and with 80 % when using division devices which clamp more pieces.

The disadvantages of multiple fixtures could be:
- the possibility of the occurrence of clamping errors because of the irregular application of the clamping forces;
- the possibility of the occurrence of vibrations because of the complex structure, the multiple joints or the elasticity provided for compensating dimensional, formal and positional deviations of the clamped pieces;
- relatively expensive cost;
- large gauge (Seghedin & Mircea, 2010).

Regarding the clamping precision of workpieces, a series of studies have revealed the influences of fixtures deformations on machining accuracy or various technological systems (Borgia et al., 2013), (Tadic et al., 2014; Varadarajan & Culpepper, 2007; Abellan-Nebot et al., 2012).

2. THE PROPOSED METHODOLOGY

In order to determine the irregularity degree of clamping pieces in multiple fixtures, the following methodology is suggested (Seghedin N., Mircea T., 2010):

1. Acknowledging the type of fixture for which the clamping irregularity degree will be determined.
2. Establishing initial conditions (the type of piece, the parameters of the cutting operation, the size of the clamping force and stroke etc.);
3. Determining the accuracy conditions imposed to the workpiece surfaces that will be worked on;
4. Identifying the directions of the accuracy conditions influenced by clamping irregularity of the analyzed fixtures;
5. Analytically determining the workpiece displacements in the directions established in the previous stage;
6. Experimentally determining the workpiece displacements in the directions established;
7. Comparative study of the theoretically and experimentally determined displacements of the analyzed workpieces;
8. Determining the clamping irregularity degree of the clamped workpieces in serial and parallel clamping fixtures.

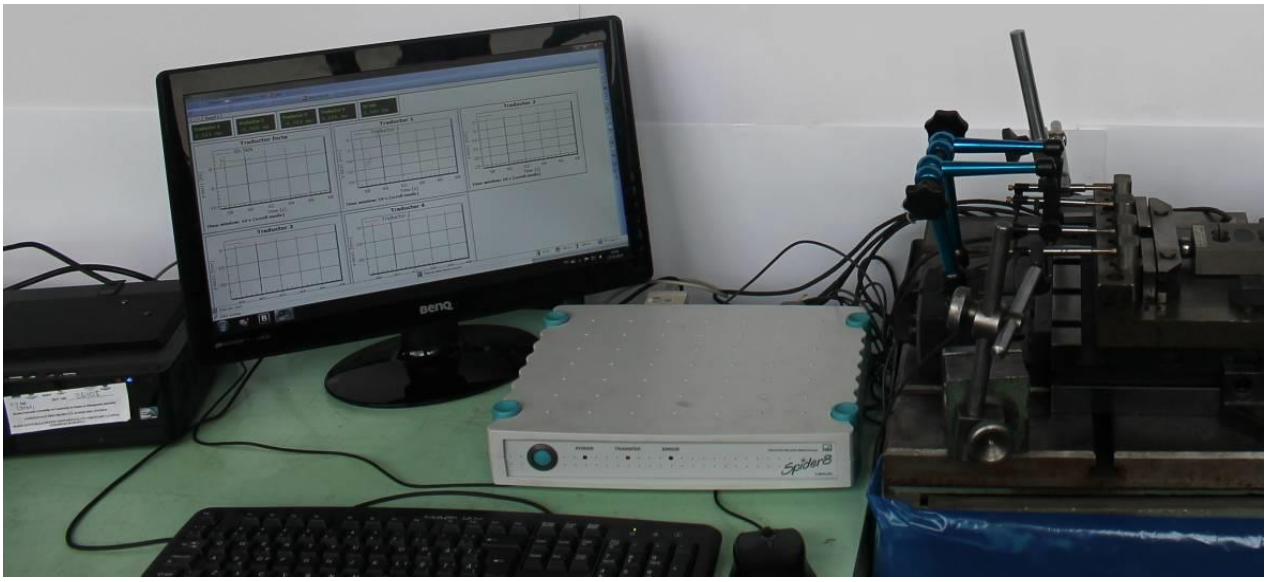

Figure 1. Reseach equipement used

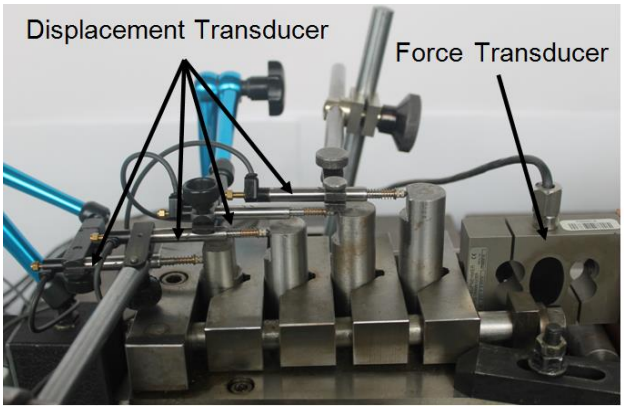

Figure 2. Serial clamping fixtures

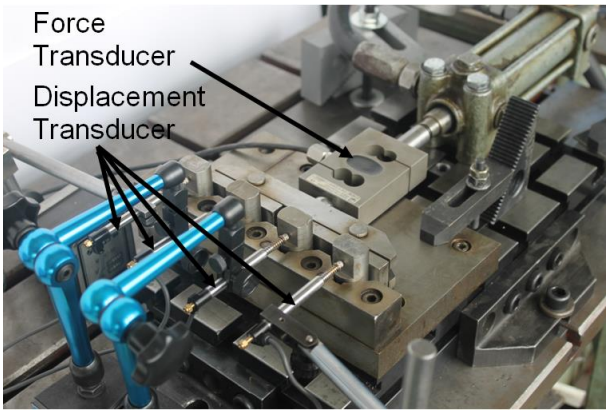

Figure 3. Parallel clamping fixtures

3. THE EXPERIMENTAL INSTALLATION

The method for the determination of the clamping accuracy consists in measurements of displacements of the clamped workpieces, on the directions of the clamping force at various force values.

The measurement equipment consists of: force transducer type S9 made by Höttinger Baldwin Messtechnik; inductive displacement transducer type Wl/ 10 mm made by Höttinger Baldwin Messtechnik; multi channel electronic PC measurement unit made by Höttinger Baldwin Messtechnik; and computer using Catman Easy/AP, versions 2.2 data acquisition software (fig. 1).

There were determined the displacements of workpieces clamped in two multiple clamping fixtures, in a parallel and serial multiple clamping fixture.

In figure 2 and figure 3, there are presented the analyzed fixtures and also the measuring equipment placed according to the measuring scheme used in the study.

4. RESULTS

Figure 4 presents the experimentally determined displacements of workpieces clamped in a serial multiple clamping fixtures, on a single row.

In figure 4 it is presented, also, the measuring scheme utilized. The maximum force applied has the value of 3.8 kN.

The research results show some differences between workpieces displacement; these differences can directly influence the machining accuracy.

Figure 5 presents the experimentally determined displacements of workpieces clamped in a parallel multiple clamping fixtures, on a single row. In figure 5, the measuring scheme utilized is also presented. The maximum force applied has the value of 3.8 kN.

The clamping precision is influenced by the displacements of workpieces on all directions.

The irregularity degree of the clamped workpieces in the two devices is determined by calculating the differences between the maximum and minimum displacements of parts, on the set directions, where the inductive displacement transducers were placed.

Fig. 6 shows the comparative irregularity degree of the clamped workpieces in serial and parallel clamping fixtures the measured maximum deformations for the clamped workpieces in serial clamping fixtures are between 0.0633 mm and 0.103 mm. The measured maximum deformations for the clamped workpieces in parallel clamping fixtures are between 0.0298 mm and 0.0379 mm.

From figure 6 it can be seen that, in the case parallel clamping, the measured deformation difference between minimum and maximum deformation is 20% and, in the case of serial clamping the measured deformation difference between minimum and maximum deformation is 38.5%. The measured deformation difference between the maximum deformation of the parallel clamped workpieces and the serial clamped workpieces is 63.2 %.

The shape of the deformation curves, for serial multiple clamping fixtures, presented in figure 4, is non linear, due to the fact that the fixture structure presents multiple joints. This behavior is specific to the structures with multiple joints, as presented in machine tool and fixture field (Rong & Zhu, 1999).

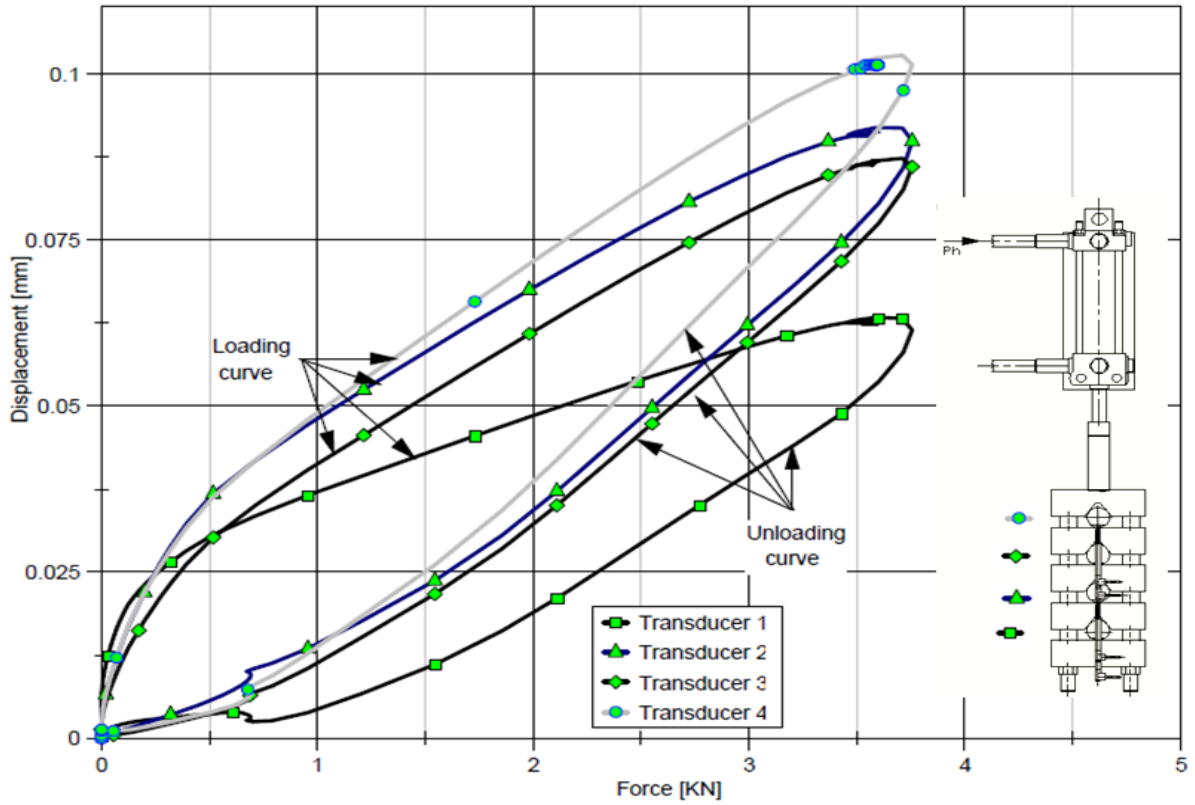

Figure 4. Displacements of workpieces clamped in serial clamping fixtures

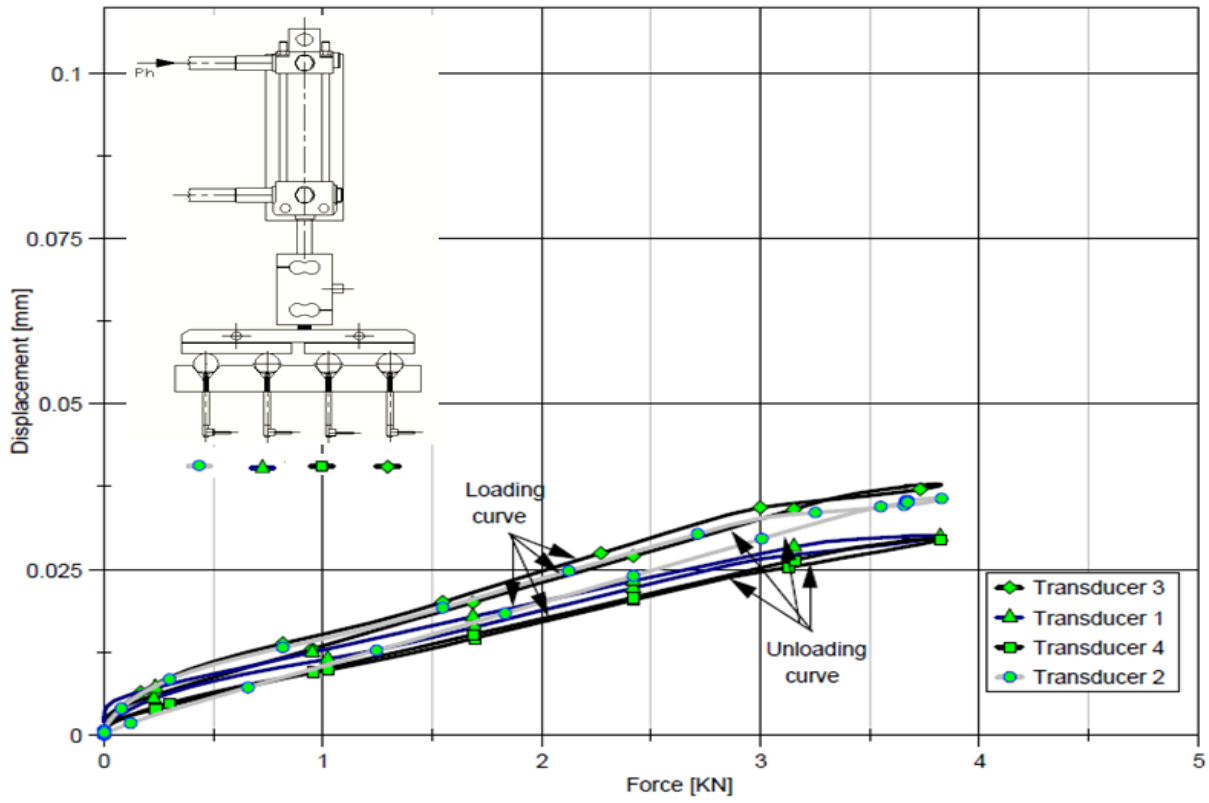

Figure 5. Displacements of workpieces clamped in parallel fixtures

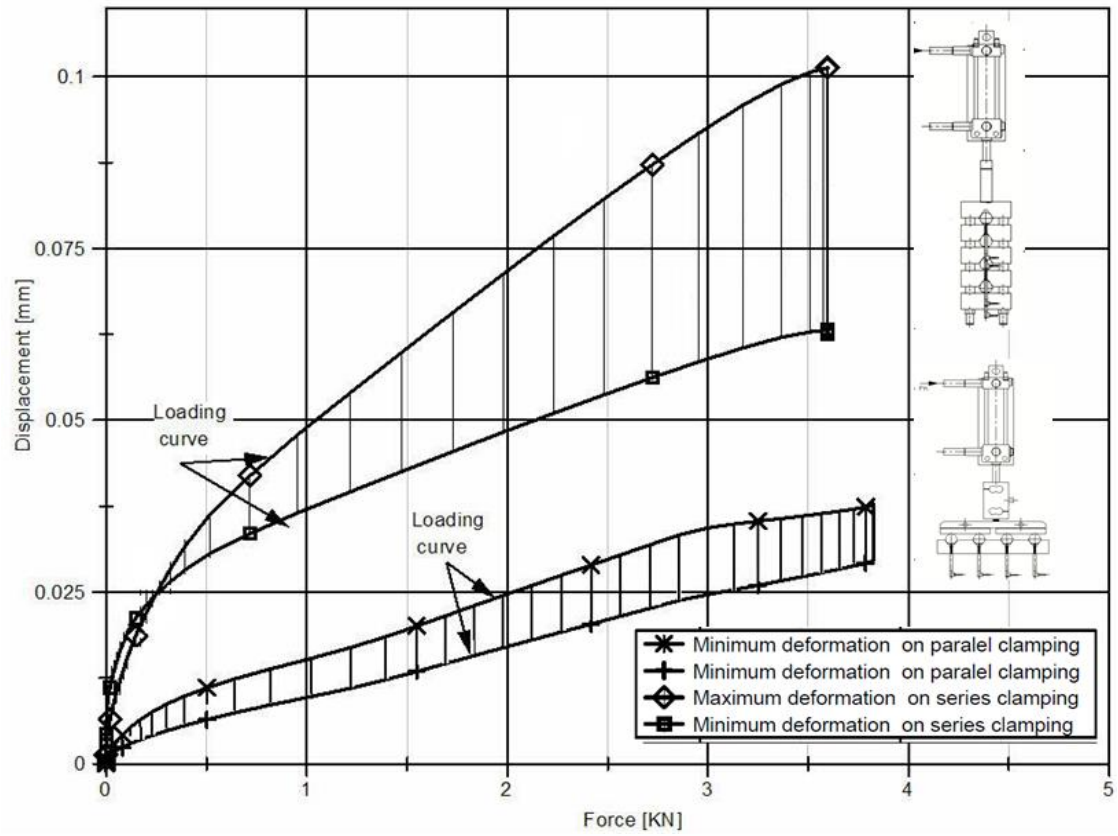

Figure 6. The irregularity degree of the clamped workpieces serial and parallel clamping fixtures

Considering, that, the rigidity (stiffness) of a regular or a modular fixture can be defined as the ratio of the force (or torque) acting on the fixture, in a particular direction, and the deformations (linear or angular) of the structure, in the same direction or not S. (Korsakov V.S., 1963); Picoş C., & Pruteanu O., 199), (Yoshimi, I. 2008). (Chiriacescu 2004), in Table 1 are presented the values of stiffness for the researched fixtures.

Tabel 1. Values of stiffness for the researched fixtures

Fixture type	Minimal stiffness value measured [daN/mm]	Maximal stiffness value measured [daN/mm]
Serial clamping fixtures	39.68	63.01
Parallel clamping fixtures	100.26	138.38

From Table 1 it can be seen that, that the clamping stiffness is lower in the case of the serial clamping fixture than the parallel clamping fixture in the direction of application of clamping forces, both in the case of minimal and maximal values measured.

The shape of the deformation curves presented, for parallel multiple clamping fixtures, presented in figure 5 are linear, due to the fact that number of joints in the fixturestructure is reduced compared to the serial multiple clamping fixtures.

5. CONCLUSIONS

After conducting the experiments and corroborating the results with those from the literature, the following conclusions were drawn:

- the clamping accuracy is lower in the case of the serial clamping fixture than the parallel clamping fixture in the direction of application of clamping forces;
- the clamping accuracy is influenced by the way of the supports on the fixture body, especially by the number of joints found in the structure;

- the clamping accuracy is influenced by the rigidity of the fixture body;
- the clamping accuracy is influenced by sum of contact deformations between the workpiece and supports, the elastic deformation of the workpiece, and the fixture components elastic deformation, and also the contact deformation between fixture components;
- it is necessary to perform a comparison between mathematical and physical models related to contact of deformations between workpiece and supports;
- from the performed experiments has resulted the effect of sum of contact and elastic deformation of the entire workpiece-fixture assembly;
- it is necessary to conduct research regarding the dynamic stability of serial and parallel clamping fixture.

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