The 4th International Conference
″Advanced Composite Materials Engineering ″
COMAT 2012
18- 20 October 2012, Brasov, Romania

THE BASALT-A MATERIAL USED IN MACHINE TOOLS PARTS MANUFACTURING

I.O. Popp
"Lucian Blaga" University, Sibiu, ROMANIA, ilie.popp@ulbsibiu.ro

Abstract: *This paper presenst some results of the theoretical and experimental research made upon basalt parts which were submitted to specific static stress of machine-tools. This research is conducted according to specific parts loading. This work presents the basalt structures modeling used in (parallel) test, the final output data, specific comparative references between theoretical and experimental results and detached conclusions.*
Keywords: *materials (basalt), machine tools, FEM, experimental techniques*

1. INTRODUCTION

Is ascertaining he course of new materials introducing for supporting parts in machine building. According to that, it was included the preoccupation to extended basalt practical applications in body or housing machine parts. It is imperative those big components must have the required static dynamic and thermal comportment as well as they must guarantee working precision of machine they are included in. Basalt is a material in big quantities available in actual natural reserves. It has a low price and can be used in various domains. As a raw material the basalt is a igneous rock it has a wild geographic location. It is relative mining accessible and can be not difficult processed. Technologically, basalt confers the following advantages [3]:
a) The present casting process permit to obtain relatively big parts having many shapes and good precision
b) Basalt casting does not require special conditions and can be performed on existing installations having low processing costs.

2. GENERAL REMARKS

During the machine is working, it is loaded by different stresses which awards the prevalent nature of load: orderly weight of stationary or moving (sub)assembly, of semi-fractured article or facilities actuating like stating loads. Static stiffness is a very important test indicator to evaluate stabile domain comportment of structural parts manufactured by different materials. Part or structure stiffness represents the capacity to impede the external forces which tends to deformation it. Mathematical, it is defined by the ratio between the force size which acts in assigned direction and the traveling size of respective structure. It comes from stiffness definition the general approaching mode used in test methods: taking measurement of displacement generated in closing paint by a force well defined in size, direction and sense.
While running the machine tool is stressed by various factors which confer the predominant form of stress. The most important factors are:

- the weight of supporting and mobile assembly, of workpiece rigs acting as a static working load;
- the cutting forces, the running mobile assemblies, acting as a dynamic working load;
- frictional loss, the heat recessed while chipping cutting determine thermal deformation.

Structural elements of the machine tool are stressed in different ways due to all previously presented stress factors. Related to body and housing machine parts building, basalt can be accepted as a construction possibility. Previously it must be studies the stress comportment and must elaborate an appropriate building technology. Technological is a 800 mm main dimension limit for actual basalt parts. A complex machine structure (like housing, body, trunk, and lug support, base) is composed by many basic parts (rungs (draw bar), plates) joint together [3]. Behavior basalt analysis was performed on a representative structural element. According to structural machines analysis and technological limits of basalt manufacturing, it was selected a natural embedded rectangle plate having dimensions: 250 x250x40 mm. The number and the coordinates of measuring points were selected as well as to confer an accurate interpretative routine of measurement results.

3. TESTS AND RESULT INTERPRETATION

To determine the static stiffness of tested parts the force loading system was generated using a hydraulic device. The continuous force measuring apparatus includes an inductive force transducer and amplifier bridge. While loading and unloading the real displacement in the selected points (of tested parts) is continuously measured using contact inductive transducers. The collected signal is amplified in a bridge amplifier. This signal is proportionate with loading force and deformation. A graphic X-Y printer records the measuring data. The loading force was applied consecutively on 3 points. Every time the structural deformation data was recorded.

For the performed test it was used the machine tools testing Laboratory apparatus [1]:

- 6 channel Hottinger amplifier bridge;
- Hottinger force transducer: output signal u- 60 mV, frequency = 7,5 KHz;
- displacement inductive transducer (Wit-ADT 10/8 type): output signal U - 50 mV, amperage = 0,1 mA, frequency = 7,5 KHz;
- Hewlett-Packard X-Y graphic plotter; signal convertor;
- Osciloscope.

Through performed test it was possible to determine static stiffness (static elasticity value) of structural parts used. In addition it was possible to obtain the static stiffness charts force [daN] - displacement [µm]

3.1. Static behaviour

The structure design is presented in figure 1. That includes particular load and contains the directions, senses and application points of the (loading) forces. In addition there is presented the directions and senses of measured deformation.

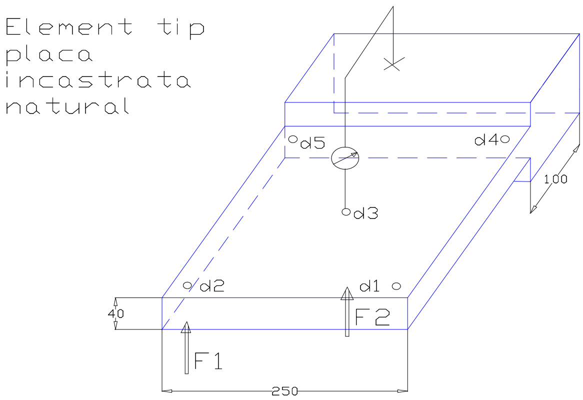

Figure 1: The basalt part

Loading forces were 250 daN and they were applied consecutively on the two points mentioned in the picture (F1 eccentric at 40 mm from the (piece's) edge and F2 centric at 125 mm from the table's edge). For both forces they were measured the produced deformation in everyone of those five symmetrical positioned points marked on the upside face of the structure. It was used the specific methodology to establish the indicators of directly static stiffness. The synthetic results of performed tests are presented in table 1 which encloses the values of static elasticity of flexure recorded in measuring points.

Table 1: The static elasticity values

Measuring points	Static elasticity (µm/daN)	
	F1	F2
d1	0,1917	0,1215
d2	0,3186	0,1161
d3	0,1242	0,0675
d4	0,0216	0,0108
d5	0,0108	0,0108

3.2. Modeling

Presented structure was design using finite element method (FEM) to compare and proof the performed test results. The complete set of equation which generally describes the structure comportment has subsequent relation [2]:

$$[M]\{\ddot{u}\} + [C]\{u\} + [K]\{u\} = \{R\} \qquad (1)$$

where: [K] represent the stiffness matrix;

[M] represent the mass matrix; it contains the terms which defines the net weight of component parts or other implicated mass in dynamic comportment of structure;

[C] represent the damping coefficient matrix;

{u} represent the branch point displacement vector;

{u} represent the branch point speed vector;

{ü} represent the branch point acceleration vector;

{R} represent the external loading vector.

Particular on static analysis the speed and acceleration vector are null and the terms of loading vector are constant. Static comportment analysis is applied to evaluate the values of structure deformations and stress. That can be performed by using MARC, a finite element computer program. The results obtained running this program contains complete information about dimensional variation and about normal and tangential stress distribution. The initial conditions:

- plate dimensions 250x250x40 mm (supported: 250x100x100 mm);
- material: basalt with elasticity modules E = 85230 MPa, contraction coefficient ε = 0,33;
- load F = 250 daN applied in the two points indicated in figure 1.

The static elasticity modules value was experimentally measured using the electrical strain ganged method [1]. Due to the geometrical symmetry and of the loading and supporting mode the analyzed structure was transformed in a finite element mesh containing hehaedric three-dimensional solid elements resulting 1131 mash point having 3393 degree of freedom. The FEM performed analysis results for both tests are listed in figure 2, 3. They have subsequent meaning:

- displacement u_y [µm]
- comp. σ_{11} of Stress [MPa].

The analytical solution for the main stress component on OX direction in F2 loading case is:

$$\sigma_{11} = \frac{M}{W} = \frac{F\,l}{\frac{b\,h^2}{6}} = \frac{125 \times 2500}{250 \times 40^2}6 = 4,687 \; MPa \qquad (2)$$

The analithycal solution of d3 point displacement equation is:

$$f_{(3)} = u_{y(3)} = \frac{1}{3}\frac{Fl^3}{EI_z} = \frac{1}{3}\frac{2500 \times 125^3}{85230 \times \frac{250 \cdot 40^3}{12}} = 0,014322 mm$$

FEM determinate solution: u_y = 17,977 µm.

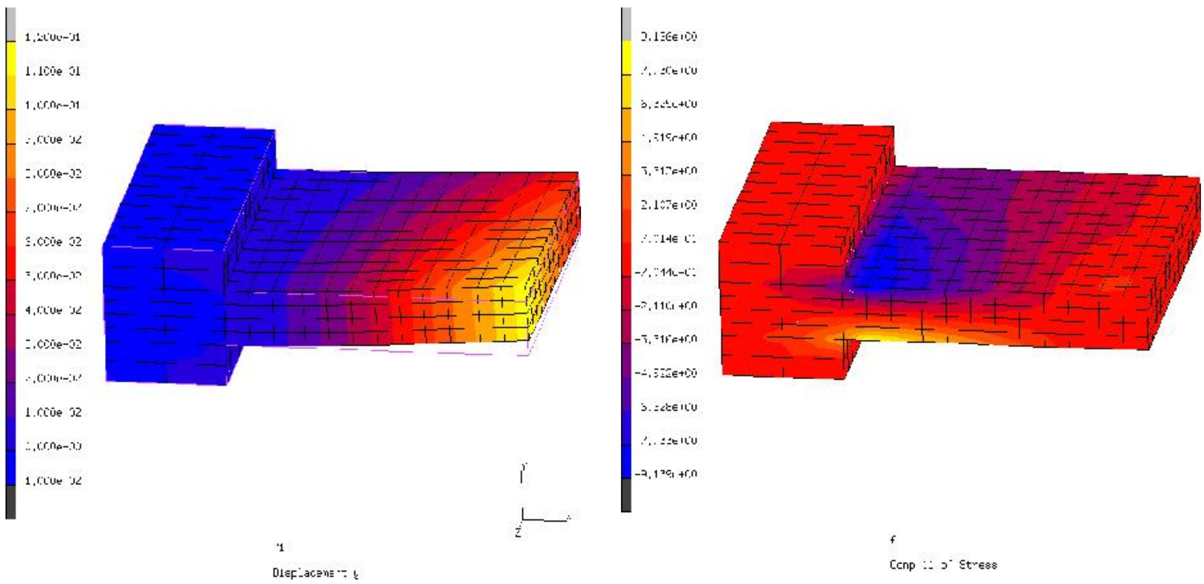

Figure 2: The FEM analysis results for F1

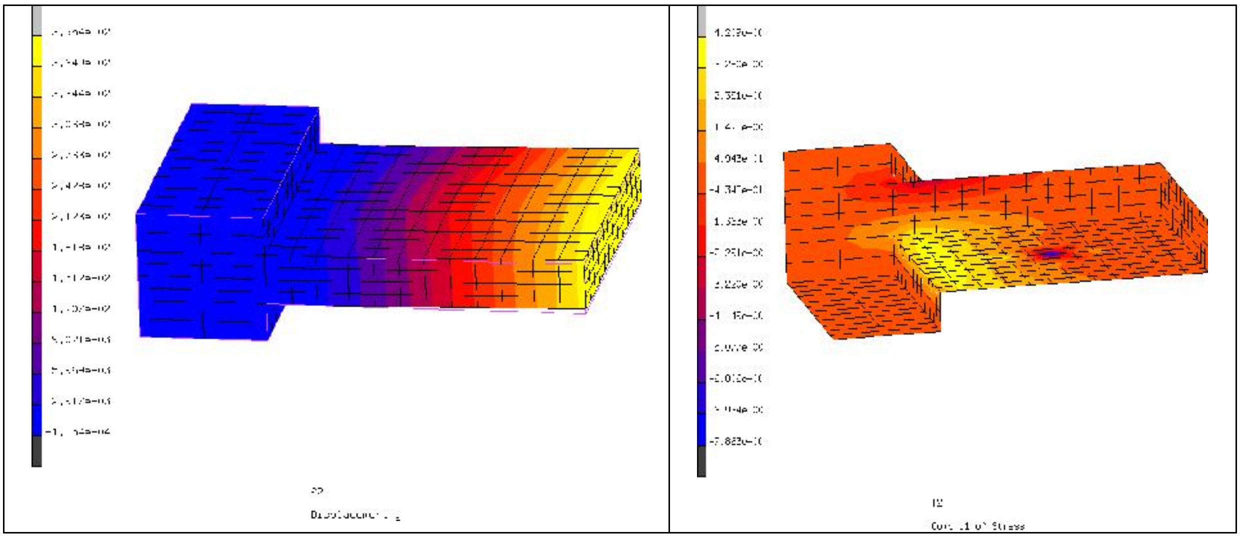

Figure 3: The FEM analysis results for F2

The maximum determinate value of σ_{11} performing FEM is 4,209 MPa. The difference may be caused by the stress located phenomena in restraining zone where the geometrical structure is different by ideal structure. The displacement values are influenced by elastic modules E and structural geometry. Table 2 contain the displacement values in every one of the 5 measuring points obtained performing FEM and experimental tests.

Table 2 The displacement values

Measuring points	Displacement u_y [μm]			
	FEM		Experimental	
	F1	F2	F1	F2
d1	50,780	31,143	47,925	30,375
d2	85,516	31,143	79,651	29,025
d3	31,142	17,977	31,051	16,875
d4	6,95	2,925	5,413	2,715
d5	3,015	2,925	2,712	2,715

4. CONCLUSION

Melted and recrystallized basalt comportment was studied as a material used in machine construction. According to analyzed output parameters it was drafted three experimental test programs. Each program has the same experimental development including; testing methodology, specific measuring apparatus used, experimental test data records, data processing and resulting conclusions. During performed test they were considered all disturbing factors who could affect the measuring results.

The experimental researches lead to following conclusions:

The deformation of tested elements can be approximate as linear. In the same way are acting end restrained basalt plate type elements. Simple shape basalt plates (parallelepiped type) have a nonlinear deformation. There are realistic the experimental test results and they are confirmed by the FEM pattern results.

Maximum values of deformation amplitude were obtained in those areas positioned on the direction which contains application points of loading force, on their proximity.

Static stiffness has a linear variation on restraint plate structures.

When eccentric forces (F1) applied, the deformation increase approximate 2.5 times.

When centric forces (F2) applied the deformations are symmetrical.

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