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Some aspects regarding the thermic behaviour of a basalt parts in machine building industry

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Abstract: This work aims to present some aspects regarding the opportunity of using basalt in manufacturing the subassemblies of machine tools. Melted and recrystallized basalt has demonstrated promising behavior with regards of its use in manufacturing, as reported in the literature. The researches presented in this work were focused on analyzing the behavior of basalt parts for machine tools submitted to thermic stress. The tests were made using grey cast iron and steel parts as reference for a comparative study. Testing methodology, specific measuring apparatus used, experimental test data records, data processing and resulting conclusions regarding the possibility of using basalt in machine tools manufacturing are presented in the paper.

1 Introduction

In the present worldwide context to find new resources of now materials in order to replace the traditional ones, the study and use of basalt, a cheap, accessible and widespread material, in machine tool building and textile machinery is doubtless an interesting challenge because these industrial branches have completely different particularities compared to chemistry or construction in which basalt has been already largely used.

Structural elements of the machine-tool are subject to stresses in different ways due to all previously presented factors, consequently a lot of research work regarding the use of different materials for manufacturing machine-tools elements is reported in the literature [1, 3]. There are quite few studies reporting basalt as building material for machine-tools elements. However, a literature survey [2, 4] shows a tendency to use mineral casting instead of iron casting, due to their superior characteristics. A composition containing basalt, spodumenne and fly ash was found to have the highest flexural strength and lowest thermal expansion coefficient [5].

To achieve this goal as a thorough knowledge with regard to the thermic behaviour of basalt parts is needed, mainly the temperature field and the resulting deformations [7]. Bibliographical studies show that from this point of view basalt has not been examined until now so this research includes the own contribution of the authors to the thermic behaviour of basalt parts submitted to specific stresses and loads.

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The main purpose of the presented research was to demonstrate that when taking into consideration machine-tools beds and other structural parts, basalt can be accepted as building material. This work is structured in the following directions: establishment of the problem, presentation of the test conditions and methodology, the experimental results and their interpretation, conclusions and recommendations regarding implementation fields.

The factorial quantitative type of experiment has been used. Planning and guidance of the experimental research as well as collection, methods and statistical processing of data have been carried out according to standards of force [6].

2 Problem statements

During operation the machine tool is submitted to various factors determining the predominant forms of stress as follows:

- the own weight of fixed and mobile assemblies, of the workpiece and rigs - acting as a static working load;
- the cutting forces and the parts in motion - acting as a dynamic load;
- frictional losses; the heat generated by the cutting process determines thermic deformations [8].

Thus, the structural elements of machine tools are stressed in different ways when taking into consideration the a. m. factors.

As a material for body and housing parts for machine tools, basalt has not been studied yet, but can be accepted as a possible replacement solution.

Technologically, a main size of 800 mm seems to be the upper limit for basalt parts. A complex machine structure (like housing, body, trunk, lug support, base) is composed by joint basic parts (rungs, plates).

3 Test and data acquisition

3.1 General remarks

The test was performed using two types of cast basalt plates as well as a gray iron plate (Fc 250) of similar size for the comparison of the results.

According to analysed 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 proccessing and resulting conclusions. During performed test thay were considered all disturbant factors who could affect the measuring results.

During the test both plates (basalt and gray cast iron) have been warmed up in order to simulate real operation conditions. The heating was carried out by using an electric resistor powered by an adjustable voltage source. Planing the resistor inside a box (Fig. 1) the whole amount of the generated beat is transferred to the plate surface [9].

3.2 Experimental tests conditions:

Experimental tests conditions:

- plates made of cast and recristallized basalt using the following heating rates: Q_{11} = 210 Kcal/h (150 W) and Q_{12} = 390 Kcal/h (280 W);
- plates made of gray cast iron warmed up by the heating source Q_{31} = 390 Kcal/h

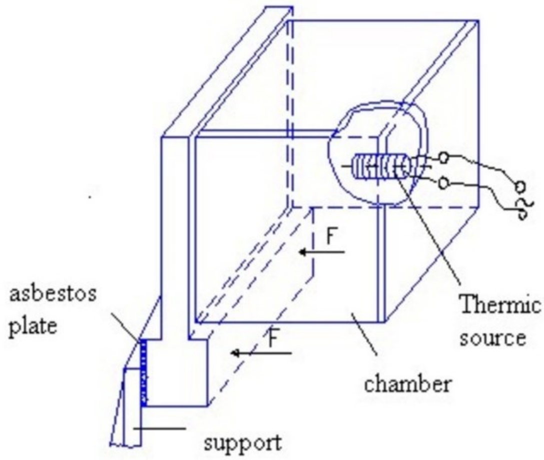

Fig. 1. Scheme of experimental plant.

The temperature values in the measurement points were measured using an ELR 12 channels temperature recorder, a Termophil type contact thermometer and a Hg thermometer, all of them fixed on the plate during the test. Ultrakust brand Fe-Const thermocouple elements were used as temperature transducer.

Data were recorded for the following measured parameters: inside box temperature; surrounding temperature; selected points temperature T_1 - T_6 (Fig. 2); relative shiftings measured on the co-ordinates of the selected points C_1 - C_6 (Fig. 2).

Parameters variation was measured having an Δt_1 = 15 min increment during the first test hour and Δt_2 = 30 min up to thermic stability.

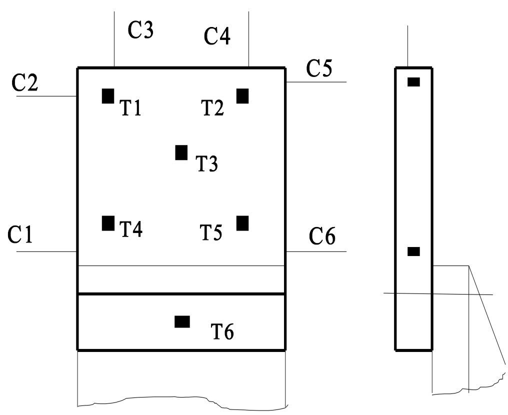

Fig. 2. Measurement points of temperatures and shifting.

4 Results interpretation

The behaviour of melted and recrystallized basalt has been studied as a possible material for machine parts.

Based on the experimental findings the following graphs were drawn:

- the graph of temperatures measured during the plates heating (Fig. 3);
- the graph of relative process shiftings recorded in the measurement points (Fig. 4).

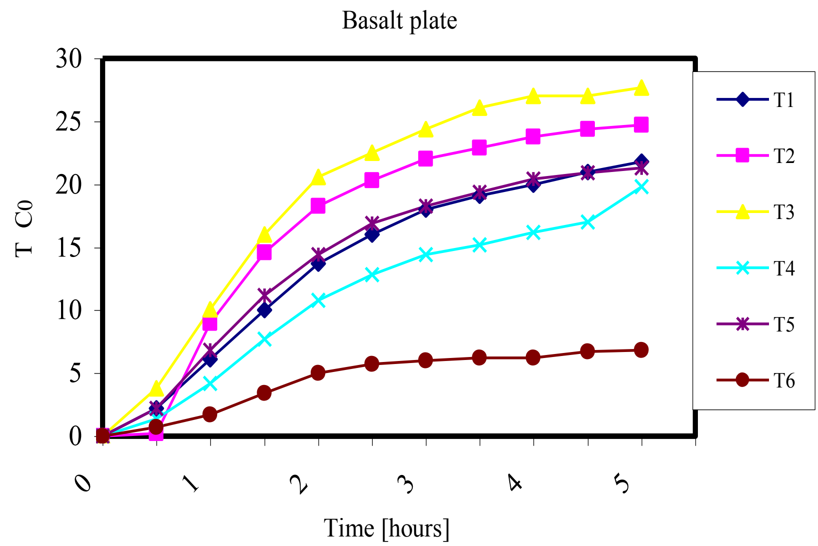

Fig. 3. The graph of temperatures measured of basalt part (thermic source = 150 V).

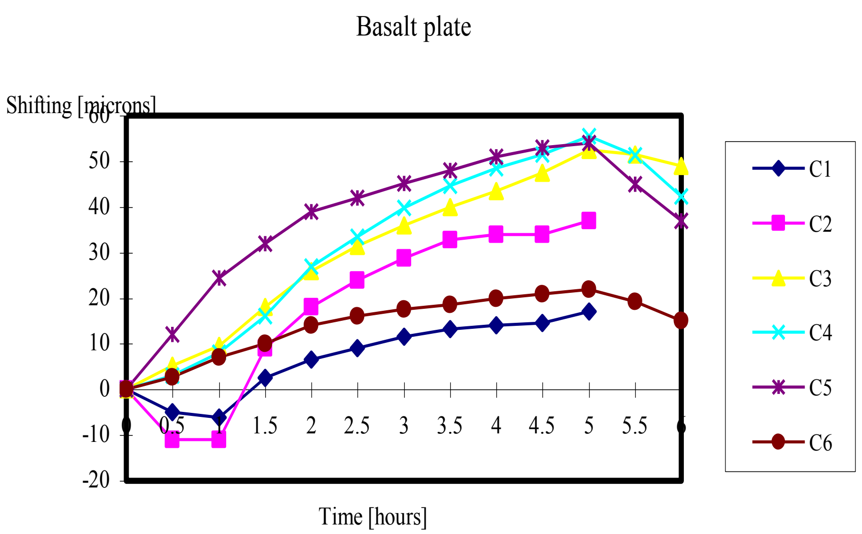

Fig. 4. The graph of relative shifting of basalt part.

5 Conclusion

Technologically, basalt confer the following advantages:

- the present casting process permit to obtain relatively big parts having many shapes and good precision

- the basalt casting does not require special conditions and can be performed on existing installations having low processing costs.

This experimental research is leading to the following conclusions:

- The thermic stabilization time of the cast iron model is lower then the similar time for basalt (4 respectively 5 hours), the thermo-convection factor of basalt being by 40% lower then for gray cast iron.

- The conduction heat transfer coefficient of basalt is also lower than for gray cast iron. Therefore elements of basalt should be as thin as possible in order to achieve an optimal thermic behaviour.
- For the same length the linear dilatation coefficient of basalt is by ca. 22% lower than for cast iron.
- For heat conduction reasons the thermic behaviour of basalt may be improved by heat exchangers placed on the hottest surfaces.
- For make the heat exchange more effective a pump should be used for cooling the heated basalt surfaces.
- Having a low thermic deformation factor machine tools bodies of basalt enable a high machining accuracy.

According to experimental tests there are following conclusions and recommendations regarding basalt using as a body material for tools machine building:

- The building of the main machine-tools parts (bodies, transit paths, supporting tables, rest slides) maybe in combination with traditional metallic materials which must correct some drawbacks of this material - the depressed toughness and the small plasticity in order to obtain lighter and cheaper machine - tools structures, with a good static and thermic behaviour.

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