

Application of Polymer Concrete by Using the MKP Analysis

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Abstract: This article is focused on properties of polymer concrete and its application in design of machine tools. There will be presented the basic information about composition of polymer concrete mixtures and their properties. In the article is also described the MKP comparative analysis of deformation and stress of the steel bed with polymer concrete bed.

Keywords: Polymer Concrete; MKP Analysis; Stress; Deformation; Comparative of Material.

1 Introduction

Polymer concrete is increasingly used material that is alternative for cast-iron and steel in design of beds of machine tools. It is particle composite material composed of minerals which serve as a filler. The matrix is consists of resin and a hardener. This material provides interesting and design-advantageous properties, e.g. damping, dimensional and thermal stability, high stiffness, corrosion resistance, etc.

1.1 Important Properties of Polymer Concrete

This section will be focused on important properties of polymer concrete where will be describe the main pros and cons of polymer concrete in the comparison with steel or iron cast.

1.1.1 Thermal Stability

Thanks to high thermal capacity in combination with low thermal conductivity the polymer concrete responds slower to temperature changes in its surroundings in comparison with cast-iron.

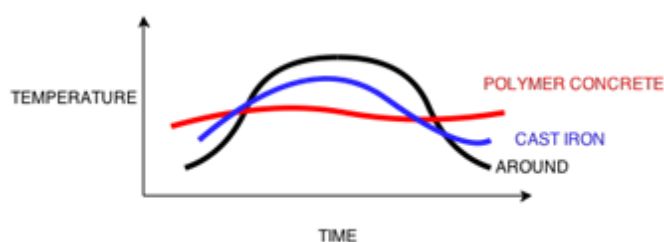


Fig. 1: Thermal stability of polymer concrete.

1.1.2 Damping Properties

Polymer concrete achieves up to 10-times better damping properties than the cast iron has. Due to that fact, it became convenient material for design of machine tools, because it improves the precision of machine tools. Thanks to its properties, in comparison with cast-iron polymer concrete reduces of number of free oscillations and allows the shift of eigen-frequencies out of critical range.

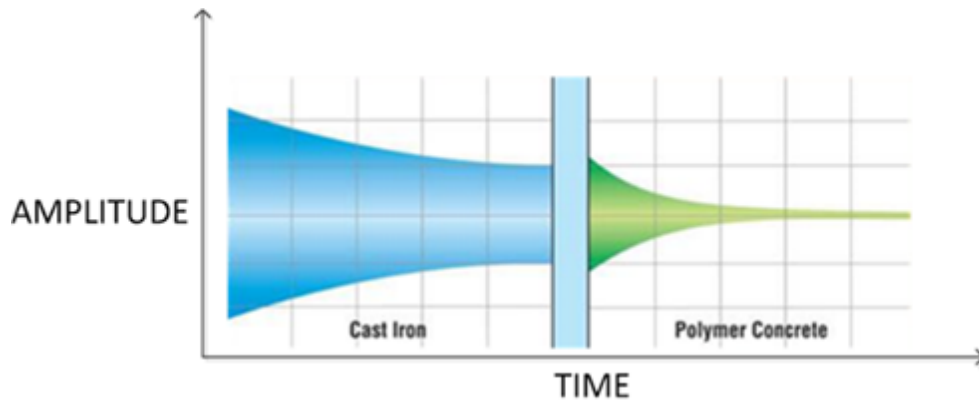


Fig. 2: Damping of polymer concrete and the cast iron.

Tab. 1: Measured values and calculated values of polymer concrete are used to calculate the MKP.

Measured value	Polymer concrete	Cast iron	Steel
E-Module [GPa]	35	110	210
Limit compressive strength [MPa]	115	800	400
Limit tensile strength [MPa]	15	300	400
Poisson's ratio [-]	0.24	0.18	0.3

1.1.3 Internal Tension of the Cast

After casting and subsequent cooling, internal tensions occur, caused by shrinkage of the cast. These tensions are minimal due to the composition of the polymer concrete, specifically epoxy resin characterized by a low shrinkage. Quality polymer concretes achieve shrinkage in the range from 0.02 to 0.03 %. As the manufacturers state, the dimensions are tolerated (within shrinkage) 0.3 mm to 1 m.

1.1.4 Comparing of Mechanical Properties

When comparing the mechanical properties of polymer concrete with metals, polymer concrete has specific advantages and disadvantages. One of the major advantages of concrete is its damping properties, which can be up to 10 times better than steel or cast iron. That is the reason why it is used in the design of high-precision machine tools. Another advantage is its density, which is 3 times lower, which makes final products lighter. The advantage of metal materials is especially their tensile, compressive and flexural strength, which reach up to 10 times higher values than polymer concrete can provide.

2 MKP Analysis

This section introduces the concept of a comparison of two beds. The first has the material properties of cast iron. The second has the material properties of polymer-concrete (Tab. 1). The evaluation of results will be based on the resulting deformations and stresses

2.1 Definition of the Task

Designed concept of both beds is different. The Cast iron bed is ribbed. The Polymer-concrete bed is full cast (Fig. 3). Polymer-concrete bed uses a different type of fixator, that's the reason why Polymer-concrete bed doesn't have side pockets.

In the picture Fig. 4 (left side) is magnitude and direction of forces. In next part of the picture is assembly of bed with support. In the assembly shows constrains (blue color), forces (red color) and contact (orange color).

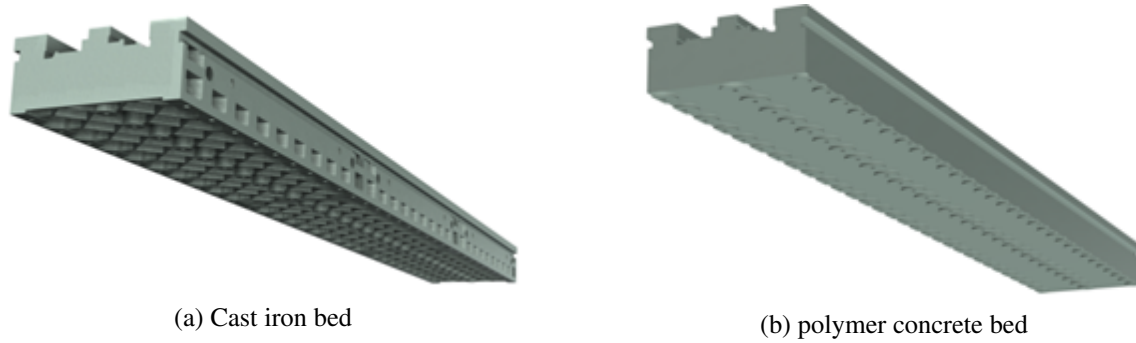


Fig. 3: Construction of beds.

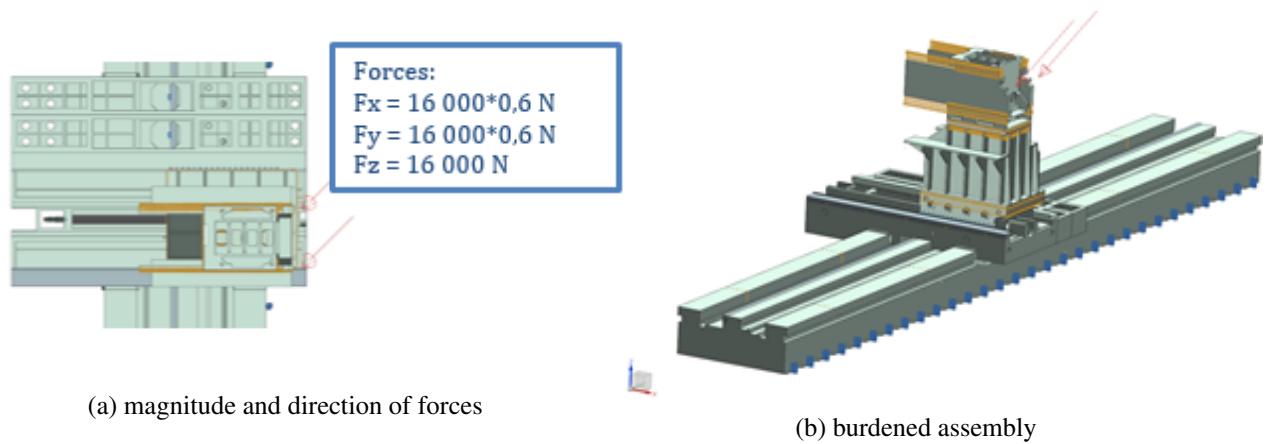


Fig. 4: Definition of boundary conditions.

2.2 MKP Analysis Results

This section shows the results of MKP analysis. In the picture (Fig. 5) is a comparison of tensions. Thanks to complexity of the cast iron bed's design, local tensions are higher than 20 MPa. Average tensions are about 3 MPa on the guiding surfaces. Tensions in polymer concrete bed has maximal tension 4.5 MPa. It's thanks to simplicity of design, which is without pockets.

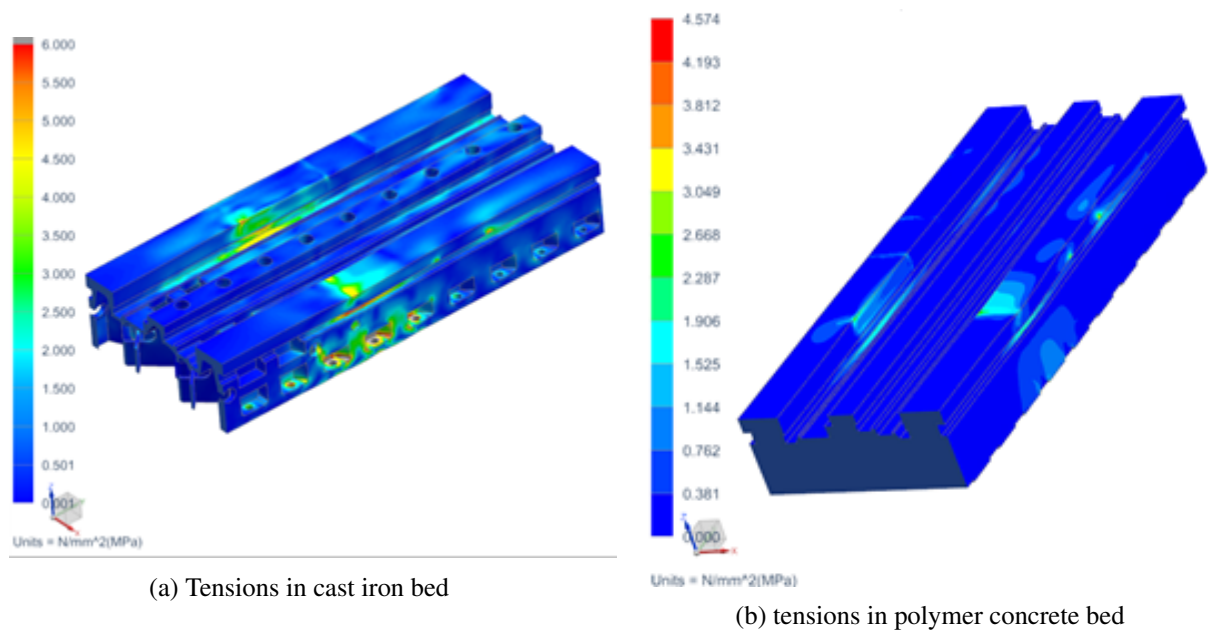


Fig. 5: Comparison of tension in the cast iron bed and polymer concrete bed.

Maximal deformation in the cast iron bed is 0.046 mm. Average deformation is about 0.02 mm on the

Tab. 2: Summary of results and important properties of materials.

	Polymer concrete	Cast iron
Maximal deformation [mm]	0.0324	0.046
Maximal tensions [MPa]	4.5	25.8
Weight [kg]	45 254	53 382
Mass [mm ³]	6.817e ⁹	1.968e ¹⁰
Density [kg/m ³]	2300	7150
Estimated price [€]	105 000	98 850

guiding surfaces Maximal deformation in the polymer concrete bed is 0.032 mm. Average deformation is about 0.012 mm on the guiding surfaces.

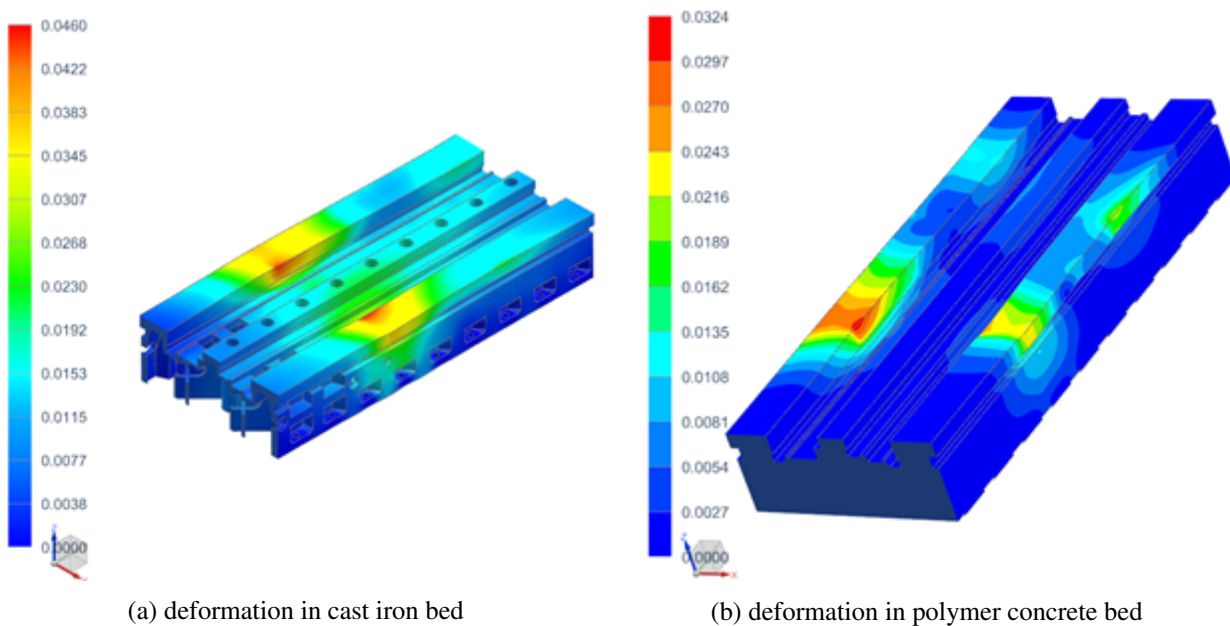


Fig. 6: Comparison of deformation in the cast iron bed and polymer concrete bed.

3 Conclusion

The polymer concrete has a few better physical characteristics than the cast iron. Among the most important characteristics belongs a lower density that makes it lighter than cast iron. Next properties are good thermal stability, very good damping properties and a really small shrinkage after casting.

We can see that the estimate price from explored polymer concrete cast and cast iron is comparable which we can see in the Tab. 2. One of the disadvantages of the polymer concrete is higher cost of cutting. Convention technology of cutting of polymer concrete is the grinding, which is really costly.

From the results of MKP analysis is clear, that the deformation of the both beds is comparable. Despite the higher mass of the used material is still lower weight on polymer concrete bed which is advantage.

In view of the fact that the most critical value for the polymer concrete bed are limited tensile strength and limited compressive strength it can be said, for this particular bed that the application of polymer concrete is admissible respect to the resulting values.

From the above summary, it can be seen that if the cutting machine have to work more accurately than it is possible to replace the cast iron bed for polymer concrete bed.

Acknowledgement

Content reported in this paper was supported by the SGS - 2013-050 - Comprehensive support for designing technical equipment, ZČU in Pilsen.

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