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Design Guidelines for Mineral Casting as a Material for Base-Frames of Precision-Machines

Abstract

The task of the machine frame is to guarantee a stable position of sub-systems e. g. drive-systems and measuring-systems to each other. Particularly in precise measuring and processing machines high static and dynamic rigidity to mechanical and thermal loads are demanded as well as long term stability. Usually these machine-base-frames are produced of natural stone, but other materials like cast-iron, steel or ceramics are also in use.
An alternative to those materials is mineral cast [1, 2]. Mineral casting is comprehended as mineral fillers of wide grain-size distribution curves bound in epoxy resin. The volumetric percentage of the epoxy resin thereby is below 10%. Most of the mechanical properties result from the high-density filler-network with direct mineral grain contacts, the resin acts as an interlayer holding these contacts together. Figure 1 shows the principle draft of fillers in mineral cast.

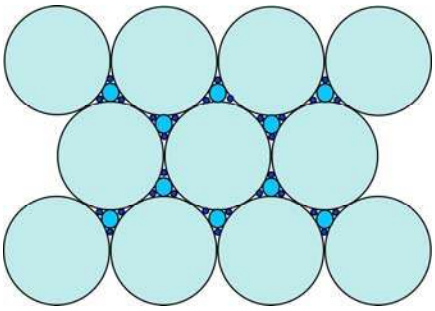

Figure 1: Principle of the filler-network of mineral cast

Mineral cast is considered as a lightweight, easy to shape construction material with good thermal characteristics, outstanding material damping and it has a low level of intrinsic tension. Compared to natural stone, closed porous mineral cast has very low water absorption. Since 20 years mineral casting is used as a material in grinding machines [1, 2] but until now it is not used in highly precise machines working in the range of submicrometer.
At the Department of Precision Engineering of TU Ilmenau characteristics of mineral casting were evaluated in respect of usage as base-frame in measuring machines and devices with submicrometer resolution. These design guidelines have been compiled for

the use of mineral casting in high-precision machines.

While mineral casting and forming allows tight tolerances in shape, position and dimensions, it allows cost efficient production of high precision machine base-frames in small batches by minimizing grinding expenses. Monolithic integration of functional surfaces or the usage of cast-in parts reduces the number of parts and mechanical interfaces, thus reducing cost and potential sources of faults.

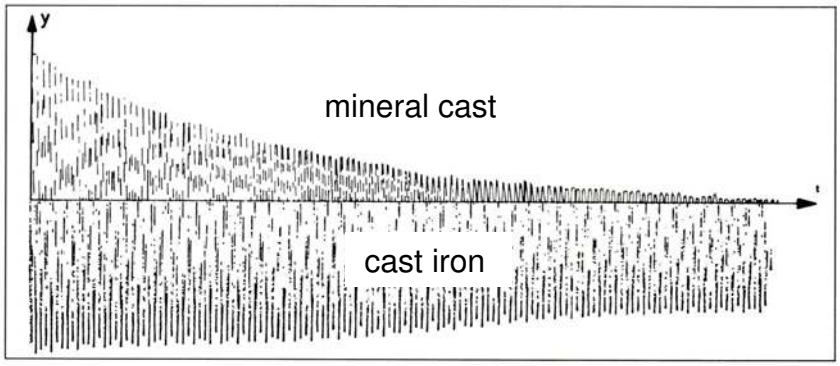

Figure 2: Damping curves of mineral cast and cast iron upon excitation [3]

The guidelines intention is to lead to the construction of long-term-stable mineral-cast base-frames for precision machines. Thermo-mechanical deformations caused by small thermal conductivity in combination with high thermal expansion of the material have been addressed. Shrinkage during the casting process and creeping under load were taken into account. Limitations to wall thickness and shape, e. g. the options to integrate additional components into the frame structure, are specified.

The research work deals with characteristics of mineral casting as a material for machine bases, and the guidelines are a contribution to design for manufacturing in precision engineering.

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