# CASTTRONICS - Direct Integration of Piezo Ceramic Materials in High Pressure Die Casting Parts for Vibration Control

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**Abstract:**
Intelligent cast parts should be able to sense their environment, to monitor themselves and potentially detect structural damages, to transfer respective data to the user or system and to even actively adjust structural characteristics e.g. damping within a changing operational environment. By direct integration of piezoelectric components such as piezo actuators through high pressure die casting process even more robust active components could be realized at potentially lower cost and higher reproducibility. As a potential application scenario, the semi-active vibration control of a bearing is studied.

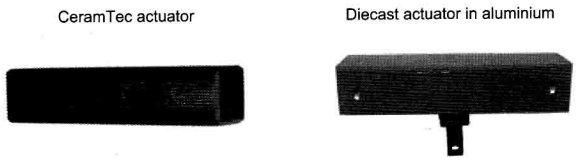
Keywords: die casting, integration of actuators, active vibration control (AVC), structure health monitoring (SHM)

## Introduction

Piezoelectric actuators and sensors are widely used for the design of smart structures. Main applications so far are active shape and vibration control, however structural components with integrated sensors for monitoring loads or structural damage are investigated as well. By directly integrating piezoelectric elements into structural components, the reduction of the number of subcomponents and thus price, an increased robustness or an improved reproducibility, mandatory for the success of adaptronic systems in series applications, become possible [1]. The direct integration of piezoelectric elements into aluminium die cast parts leads to several challenges. In the following, examples are given for the Fraunhofer research activities in this field. It was proven that different electronic components can be directly integrated into aluminium and zinc high pressure die casting parts during the manufacturing process without being destroyed.

## Example for direct integration of piezo actuators

The integration of the actuators in solid structures permits to realize robust housed piezo actuators at a low price when compared to standard housed piezo actuators. Low Cost piezoelectric multilayer actuators (SP 505, dimensions 7x7x32 mm) from CeramTec have been chosen for integration into aluminium high pressure die casting structures (Fig. 1). The aim is to develop a manufacturing process which maintains the piezoelectric effect of the actuators. The actuator is placed in the middle of the aluminium structure with the contact electrodes rising out of the material and is mechanically directly contacted with the aluminium structure by its two end planes without any additional bonding system.




***Fig, 1:*** *Actuator before and after integration*

The consequence of the casting procedure is an extreme thermal loading for the actuators. Therefore it is mandatory to reduce and control the heat transfer to the actuator during the cast process with respect to the Curie temperature as well as with coating, glue, etc. of the piezo element. By a specially designed heat protection cover, it is possible to adequately control the thermal loads of the cast process. But, even in case that the piezos are being exposed to thermal loads above the Curie temperature, it has been possible to repolarize them after cooling-down. By measurement of the electrical impedance it was possible to check and assess the quality of the piezos (Fig. 2).
One interesting feature of a cast piezo is the integrated mechanical pre-stress which results from the thermo-mechanical contraction during cooling-down of the metal which encapsulates the piezo. Similar to conventionally housed actuators the encapsulation defines the effective elastic actuator stiffness and thus the piezo performance (Fig. 3).

As a potential application, the direct integration of piezoelectric transducers into a shaft bracket is studied (Fig. 4). By proper electrical shunting of the piezo elements, it is possible to realise a semi-active vibration control system similar to a vibration absorber (Fig. 5), yet fully integrated and compact [2]. First investigations on a prototype with the piezo multilayer transducers showed a good reduction of the vibration amplitudes at the bracket in the resonance, which the shunt system was tuned to. (Fig 6). Obviously, the design of the shaft bracket could be simplified by direct integration of the piezo elements and a proper mechanical pre-stressing.

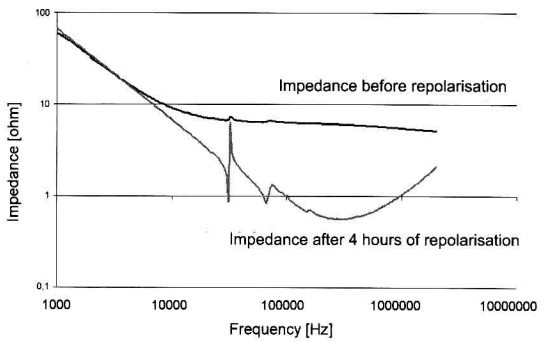



*Fig. 2: Impedance before and after repolarisation*

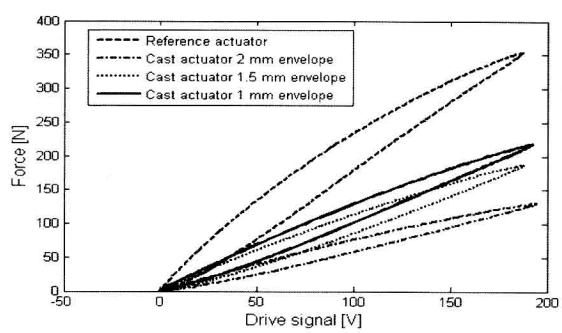



*Fig. 3: Measurements of actuator forces*

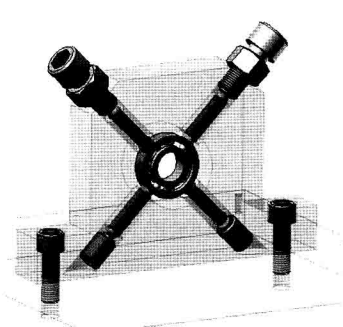


*Fig. 4: Shaft bracket with integrated piezos*

## Conclusions and outlook

The direct integration of piezo elements into high pressure die cast parts has been investigated. It has been shown, that the piezo elements can be used as an actuator after repolarization. The next steps will include the integration of the piezo element into the presented application scenario of a shaft bracket for semi-active vibration control.

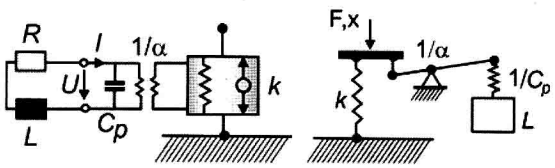



*Fig. 5: Analogy of a shunted piezo and a vibration absorber*

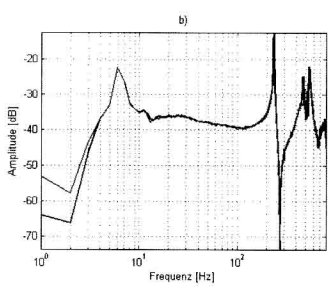



*Fig. 6: Acceleration spectrum measured at the bracket*

## References

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