Analysis of losses in a magnetostrictive device under dynamic supply conditions

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This paper proposes an approach to effectively design a magnetostrictive device, taking also into account energy losses. The modelling approach is based on the finite element analysis of the device, including an advanced magneto-mechanical physical model of the magnetoelastic material, following the scheme proposed and validated in [1] and [2]. To this purpose, a magnetostrictive actuator has been designed and realized (Fig. 1-a) and the materials adopted (Terfenol-D as active material and low carbon steel (LCS) for the magnetic flux closure and casing) have been previously characterized. In particular, a Preisach model of the Terfenol-D has been identified from a set of measured hysteresis cycles at different mechanical loads; the loss behaviour of LCS has been evaluated separating the fundamental contributions (hysteresis, classical and excess), following the theory of losses.

To validate the proposed approach a set of measurements of the absorbed power has been carried out on the device. The behaviour of the device has been simulated and the numerical results have been compared with the measured device total losses. As an example, Fig. 1 shows the results obtained in the case of null preload and without actuation mass on the device. The maximum discrepancy on total power is 17%, and decreases down to 5% for frequencies above 50 Hz. The modelling approach allows the separation of loss contributions, showing how the main contributions in Terfenol-D are static hysteresis and classical terms, while the permanent magnets losses are found negligible.

In the full paper this analysis will be extended to different magnetization conditions of the device. The preload effect on power losses will be shown and the behaviour of the loaded device will be discussed, including some consideration on the device efficiency.

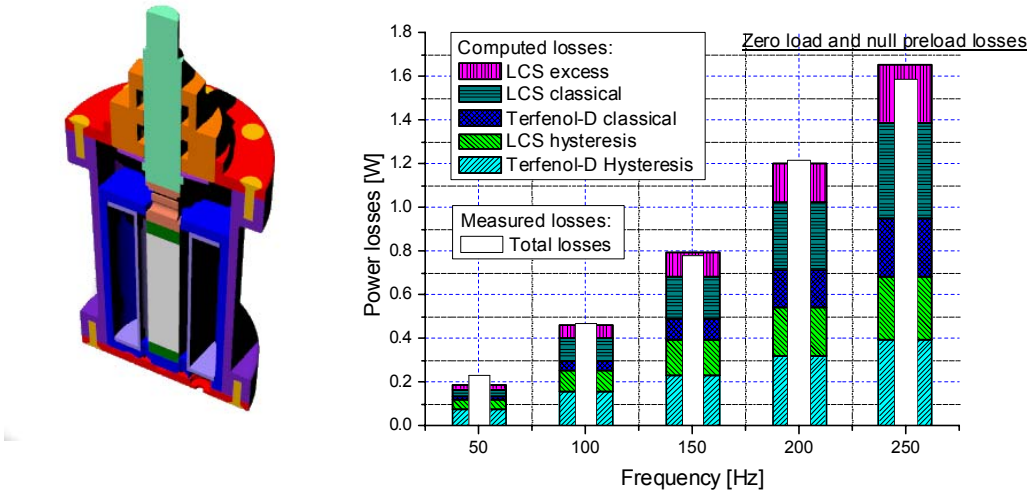

Figure 1: On the left: half section of the device. On the right: comparison between total measured and computed losses, and calculated loss separation, in absence of mechanical load and with negligible preload. Joule losses in the device windings (about 4 W in this case) have to be added to power losses to obtain the total electrical power supplied to the device.

[1] O. Bottauscio et al, Journal of Applied Physics. 103, (2008), pp. (07F121) 1-3
[2] O. Bottauscio et al, IEEE Trans. on Mag., 44 (2008), 3009-3012

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