

PRINCIPLE

Any ferromagnetic material is able to be subjected to magnetostriction. It means that there is a coupling between the mechanical and magnetic states of the material. Because of the “direct magnetostrictive effect”, the material displays a mechanical anisotropic deformation when it is put under a magnetic field. Conversely, the magnetic permeability of such a material changes as a function of the applied mechanical stress. This is called the “inverse magnetostrictive” effect.

Therefore, under appropriate magnetic conditions, a measurement of the material’s magnetic permeability gives an indication of its internal mechanical stress state.

Finally, the material’s permeability can be measured indirectly by using a coil placed next or around the material (Fig. 1)

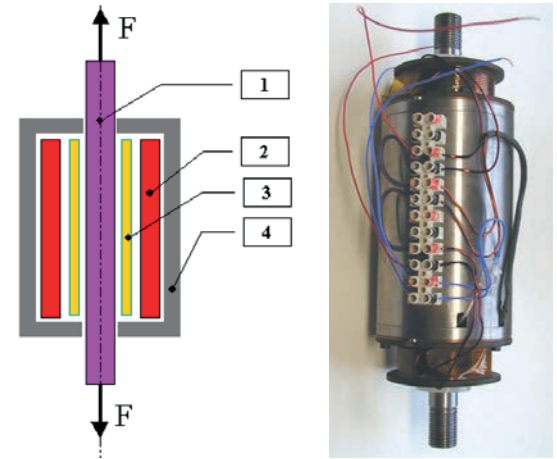


Fig. 1: Principle of a sensor using magnetostrictive effect.
(1) Ferromagnetic material,
(2) Magnetising coil to reach the operating point on the B(H) curve of the material,
(3) Measurement coil to obtain the impedance of the material
(4) Magnetic circuit.

DESIGN CONSIDERATIONS FOR A PROTOTYPE SENSOR

A sensor for the measurement of stresses in cables used in cable-stayed bridges has been developed.

From the electromagnetic analysis realised with our computer simulation tools such as Flux3D (Fig.2), to testing in laboratory, (Fig. 3 and 4), considering different design steps, we evaluated and adapted the various parameters of the sensor in order to get the best quality of measurement (frequency of measurement, level of magnetic polarisation versus the B(H) characteristic of the considered material, impact of eddy currents, temperature, electromagnetic compatibility of the magnetic circuit,...).

We built a laboratory test bench to measure the magnetostrictive effect of various materials in order to evaluate if we can use them in such kind of sensor.

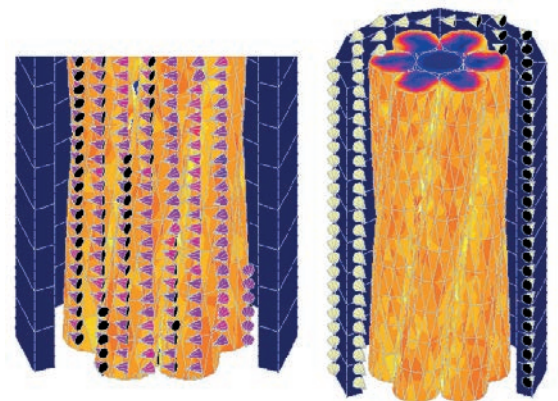


Fig. 2: Electromagnetic analysis of the sensor with Flux3D.

PERFORMANCES

CHARACTERITICS	UNIT	VALUES
Material		Magnetic steel
Diameter of the sample	mm	16
Active length of the sample	mm	300
Internal stresses	% Re	60
Relative variation of inductance	%	20
Precision	%	2.7
Power supply	w	2



Fig. 3: Design and assembly of the sensor around of the cable.



Fig. 4: Test of the sensor in laboratory.

APPLICATIONS

Stress sensor used in applications such as monitoring stresses in bridge and nuclear power plant structure.

Stress sensor put into structures such as on the bridge cables so as to prevent any risks of rupture or relaxation. Torsion and flexion stress sensors...



Fig. 5: A typical application of the magnetotriuctive stress sensor: monitoring stresses in bridge cables