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QUASI-SMART OPTICAL FIBRE SENSOR SYSTEM FOR REAL TIME AND PREDICTIVE MONITORING ON LARGE ROTATING MACHINERY

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A new optical fibre sensor system including the fibre optic transducer, the optical channel, the optoelectronic unit, and a digital data acquisition and signal processing unit (DASPU), that has been fully developed and tested, both in the laboratory and in the field, is presented in this paper. From monitoring vibration on selected places of large rotating machines, the developed system is capable of processing the acquired signals in order to extract significant information for data trend analysis, and to take correction decisions with the aid of specific programs. Fig. 1 shows a schematic view of the system. The transducer operating principle is based on a fibre optic cantilever beam without any seismic mass on it, and a differential intensity modulation scheme that minimises the errors due to intensity undesirable changes and environmental perturbations. The optical fibre accelerometer is optimised for detection of mechanical vibrations in the frequency range 0.2 - 140 Hz, provides very good stability and accuracy, and has the inherent advantages of remote fibre optic sensing and electromagnetic immunity [1].

The DASPU unit is able to simultaneously sample and process signals from 16 sensors obtaining time and

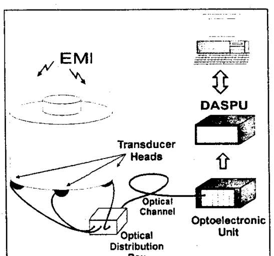

Fig. 1. System overview.

spectral information, and also to convert space-asynchronous sampled data (samples obtained through periodic sampling in time) into space-synchronous sampled data (samples obtained with respect to a keyphasor that provides the rotation speed of the shaft and serves as a phase reference). The DASPU is composed of the Acquisition Unit and the Signal Processing Unit. The Acquisition Unit performs the conditioning, antialiasing filtering and sampling of dynamic signals and its transmission to the SPU. The Signal Processing Unit receives the sampled data from the Acquisition Unit through two 2 Mbits/s serial lines (ports), which gives a total of 4 Mbits/s, and processes the data to get relevant parameters. The tasks performed by the DASPU are indicated in Fig. 2. The unshaded boxes represent the on-line processing (operations

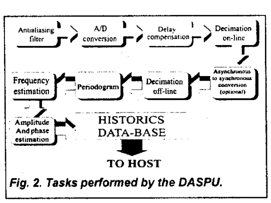

Fig. 2. Tasks performed by the DASPU.

performed while sampling) and the dark ones the off-line algorithms. The DASPU stores the temporal signals acquired during the last 24 hours and they may be retrieved from the host at any time.

In conclusion, a new quasi-smart fibre sensor system for real time and predictive monitoring on large rotating machines has been fully developed and in-lab and in-field tested. It has protective decision capability and supplies data for trend analysis. The system is working properly in real conditions on an electric power generating machine at present.

[1] J.M. López-Higuera, A.Cobo, M.A. Morante, F. J. Madruga. "Multipoint fiber optic accelerometer system for predictive monitoring: Field Test". OFS'12 Technical Digest. Vol 16. Pp. 608-611.October, 1997.

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SIMPLE COMPENSATED SPECTROMETRIC OPTICAL FIBRE ACCELEROMETER FOR VIBRATION MONITORING

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In this Paper, a novel design of a fibre optic accelerometer is presented, with simplicity and low cost as its main characteristics. It is based on a simple optical fibre cantilever beam as the vibration-sensitive element, and a diffraction grating to produce the spectral dispersion of the light from the fibre end. This wavelength-dependent modulation allows a simple compensation of the output signal against variations of the optical power emitted by the source or losses in the optical path.

Fig. 1 shows a diagram of the proposed sensor head. The end of the fibre optic channel is configured as a cantilever beam, with the fibre fixed to the housing at a length L from the free end. A reflective diffraction grating is placed in front of the fibre end at a distance s_0. The grating is placed at an angle θ_0 so the first diffraction order of the grating is parallel to the fibre. This single optical fibre carries the light from a white light source, and collects part of the light of the first diffraction order, making the optical channel of the sensor very simple. It has been proven that the fibre end angle and position change proportionally to the applied acceleration [1], thus modulating the spectral content of the collected light. A simple detection scheme at the distant end of the fibre optic channel, based on optical filters at two different wavelengths and the power ratio of the two detected signals, has been used to extract the vibration information. The theoretical simulation of the above-mentioned architecture showed the feasibility of the proposed sensor.

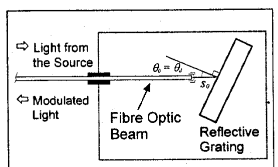

Fig. 1. Sensor head architecture.

A prototype has been built, employing multimode 100/140 optical fibre, a 1200 Lines/mm bulk grating and an LED emitting at 850 nm as a white light source. The design was optimised for the acceleration range of

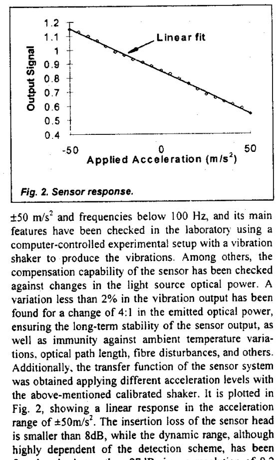

Fig. 2. Sensor response.

±50 m/s^2 and frequencies below 100 Hz, and its main features have been checked in the laboratory using a computer-controlled experimental setup with a vibration shaker to produce the vibrations. Among others, the compensation capability of the sensor has been checked against changes in the light source optical power. A variation less than 2% in the vibration output has been found for a change of 4:1 in the emitted optical power, ensuring the long-term stability of the sensor output, as well as immunity against ambient temperature variations, optical path length, fibre disturbances, and others. Additionally, the transfer function of the sensor system was obtained applying different acceleration levels with the above-mentioned calibrated shaker. It is plotted in Fig. 2, showing a linear response in the acceleration range of ±50m/s^2. The insertion loss of the sensor head is smaller than 8dB, while the dynamic range, although highly dependent of the detection scheme, has been found to be better than 27dB, i.e., a resolution of 0.2 m/s^2. The transverse sensitivity of the accelerometer is very low because the transverse motion is parallel to the grating grooves.

In conclusion, a novel and very simple spectrometric fibre optical accelerometer has been presented. Its characteristics make it very suitable for vibration monitoring in harsh environments.

[1] J.M. López-Higuera, M.A. Morante, A. Cobo, "Simple low-frequency optical fiber accelerometer with large rotating machine monitoring applications", Journal of Lightwave technology, Vol. 15, No. 7, pp. 1120-1130, July, 1997.