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COMPARISON OF COMPOSITE MATERIAL DEGRADATION ASSESMENT METHODS USING ACOUSTIC ANALYSIS AND LASER VIBROMETRY

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Abstract: *Assessment of degradation rate of material can be carried out by many experimental techniques differing in complexity and sophistication. A relatively simple method based on acoustic analysis is described in this contribution. Degradation of material's properties due to fatigue loading is detectable in decrease of their modulus of elasticity that can be derived from natural frequencies of specimens. These measurements utilize self-designed device capable of specimen excitation and acquisition of its vibration. The recorded signal is then processed by spectral analysis enabling determination of natural frequencies. Usefulness of the above mentioned acoustic method can be seen in the fact that the measured changes of material's parameters are comparable to those obtained by laser vibrometry, which is by several orders more expensive technique.*

Keywords: ***natural frequency, material degradation, laser vibrometer, acoustic measurement***

1. Introduction

One of techniques used to determine degradation is measurement of sound exposure and so its typical acoustic characteristic. Measuring their changes can describe material state and its degradation [Pirner & Urushadze, (2004)]. Use of these premises led to development of custom-designed acoustic measurement device. Effort to prove that data acquired by this device and technique are correct and can be compared with other similar method led to comparative experiment. Laser vibrometer was selected as comparative device.

2. Basic principles of acoustic testing device

Basic principle of acoustic testing is based on fact, that if it was possible to measure sound characteristics of specimen repeatedly with constant conditions, any measurable change in natural frequency value would be labeled as material degradation indication [Rojek et al., (2007)]. Custom-designed testing device was fabricated in order to accomplish this premise.

3. Experiment description

Laser vibrometer uses principles similar to acoustic measurement and is suitable for measurement of dynamic response and determination of fatique degradation [Pirner & Urushadze, (2002)]. Impacts of steel pellets falling to the specimen's surface produced sound and vibrations that was recorded by microphone and laser vibrometer. Recordings with synchronized time was then evaluated and frequency spectrum with natural frequency peaks was determined. Specimens were repeatedly measured after degradation by given number of cycles. Measurement were made for 0, 1000, 10 000, 50 000 and 100 000 cycles.

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4. Results

Natural frequency close to 3000 Hz was used to determine natural frequency decrease. The results are summarized in Tab. 1 (M-microphone, V-vibrometer) and graphically displayed in Fig. 1.

Tab. 1: Mean values of natural frequency decrease (approx. 3000 Hz)

No.	1000 cycles		10000 cycles		50000 cycles		100000 cycles	
	M [Hz]	V [Hz]	M [Hz]	V [Hz]	M [Hz]	V [Hz]	M [Hz]	V [Hz]
1	-18	- 19.5	-29	-27	-58	-60	- 72.5	- 74
2	-23	- 24.5	-35	-34.5	-51.5	-52.5		
3	-15.5	- 16.5						
4	-21	- 20.5						

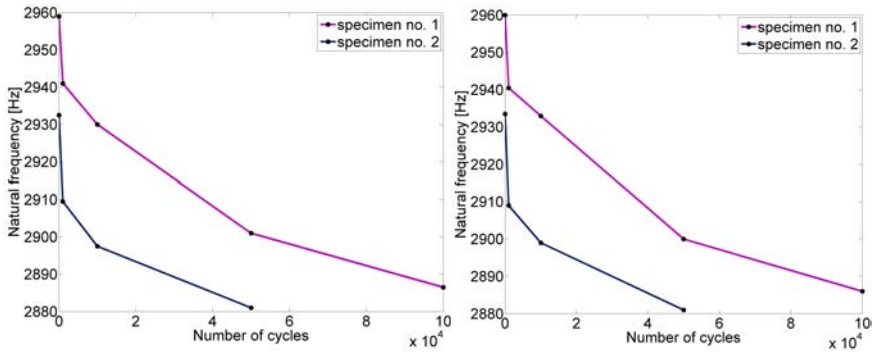

Fig. 1: Frequency decrease measured by microphone (left) and by vibrometer (right)

5. Conclusions and discussion

Correlation between natural frequency value and number of cycles of the specimen was confirmed. Data measured using acoustic method are fully comparable with data measured by laser vibrometer. However, natural frequency decrease could not be determined from first natural frequency. Higher frequency (approx. 3000 Hz) was succesfully used for decrease measurements. To conclude, the acoustic measurement using custom-designed experimental device proved ability to evaluate material degradation. This was proved in terms of precision, reproducibility and reliability by the comparative experiment.

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