THE USAGE OF RANDOM DECREMENT METHOD FOR LINEAR DAMPING ESTIMATION

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1. Introduction

This paper presents a random decrement method (RDT) [1] in damping estimation while system is in operation conditions. For that purpose, it was developed mechanical, single degree of freedom (SDoF) experimental testbed, i.e air bearing [3], which can be seen in the Fig. 1. It is specifically designed to easily set and change system parameters, especially damping.

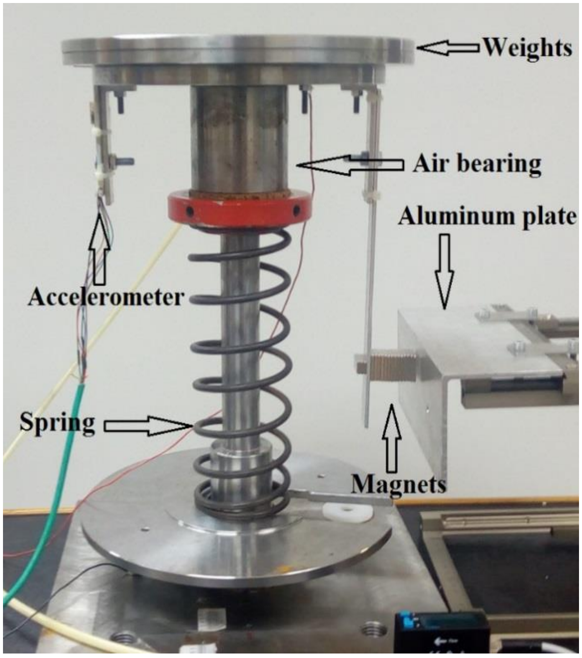

Fig. 1. Experimental test bed.

It is relatively easy to detect damping for simple SDoF system subjected to impulse or step input [4]. Dumping detection for the system while it is in operating condition is much more challenging, but regarding the technical diagnostic more realistic task. RDT method provides an easy way to estimate system parameters, while in operating condition, i.e. does not require knowledge of the input forces. The analysis demonstrated in the paper is directly applicable in technical diagnostics [2].

2. Testbed setup and data acquisition

Through the whole process of the data recording, mass and stiffness were kept constant and only damping was changed. It should be noted that mass and stiffness are also easy to change, by adding weight or use different spring respectively. The mass of the system is 10.9 Kg and the stiffness 3649 N/m. Regarding damping, several magnets and an aluminium plate (Fig. 1) were used. By movement of the magnet relative to the aluminium plate, Lorentz force is produced, which provides linear damping. Depending on the distance between plate and magnets the damping force is managed. Data collected from air bearing can be seen in Fig. 2. It represents acceleration, from a two-axes capacitive accelerator (only vertical axis), recorded with the NI-USB-6251 National Instrument module. Sampling rate was 1000 Hz, which is more than enough considering that the natural damped frequency of the system is just around 3 Hz.

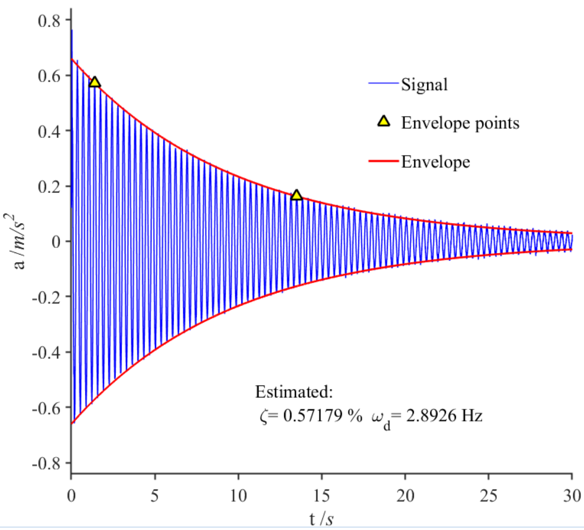

Fig. 2. System free decay and estimated values.

The depicted free decay was generated by a 2 mm initial displacement, and to estimate damping a simple logarithmic decrement technique was used [4]. As it can be seen in Fig. 2 the damping value is 0.57% (relative damping coefficient) and it is linear. Recorded data were compared with a dynamic model and shows very good match.

3. Discussion and analysis

The aim is to detect the same damping value as in the previous section (0.57%), while system is in operational condition. By applying RDT to the system response, it is possible to reconstruct a free decay response (impulse response function). The key is to have a long enough signal, so it can be divided into a sufficient number of segments. Averaging those segments, it filters out the noise, and leaves just free decay. In this paper segment length was 2 seconds. This is long enough to estimate the damping by the logarithmic decrement technique, while it enables a large number of segments. The analyzed case is depicted in Fig. 3. Top panel represents a detailed system response and middle panel is the full system response. Bottom panel is frequency analysis.

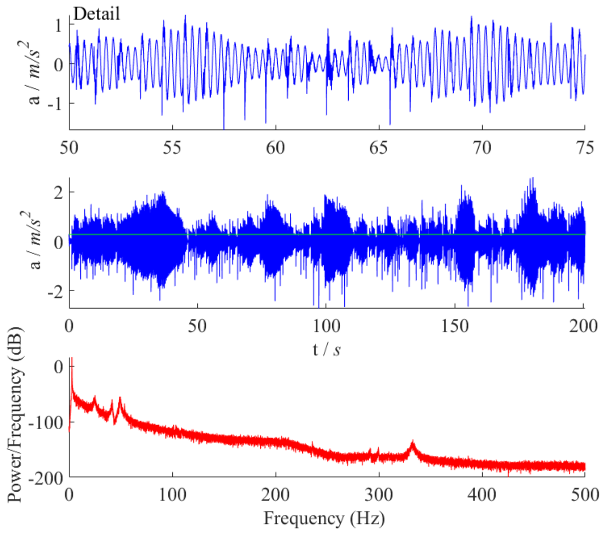

Fig. 3. System response subjected to random excitation.

Fig. 4 shows a comparison of model and RDT response. Although there is certain deviation present, deviation in damping is negligible because the envelopes slope between model and RDT is practically the same. The estimated value of the damping is 0.53%, which is more than satisfactory.

Change of damping could indicate a fault or a failure, so for the same system the greater value of damping is used. Graphical view of results is omitted due to the brevity. The result of analyses shows an estimate damping value was 0.7%. This is also satisfactory because the true damping was 0.8%, although comparing with previous case the estimated value shows the greater deviation.

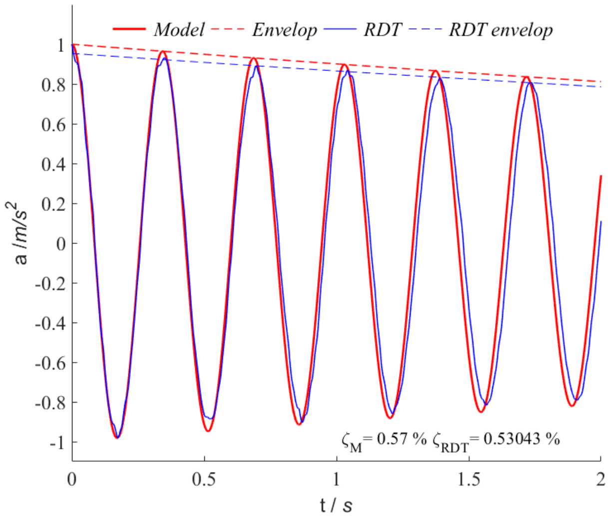

Fig. 4. RTD response and estimated damping.

4. Conclusion

The estimation of system parameters can be obtained using the RDT method. Since the method does not require knowledge of input forces, it is suitable for detecting a parameter while the system is still in operation. However, if the analysis is reduced to the evaluation of only one parameter, it is possible to make a much more efficient estimation, and such parameter could be used as a technical indicator. In this paper the highly sensitive testbed with the ability to change the system parameter was used. It has been shown that the damping can be estimated via RDT method reasonably well.

References

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