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Extraction of failure signal feature based on physical modeling for the failure of mechanical equipment and feedback to the original design by set-based design method

Haruo Ishikawa [1)] **George Kuwabara** [2)] **Yasuhiro Fukunaga**[2)]

1) The University of Electro-Communications, Graduate School of Informatics and Engineering
1-5-1 Choufugaoka, Chofu, Tokyo, 182-8585, Japan (E-mail: ishikawa@mce.uec.ac.jp)
2) Photron, Co. , Ltd.
1-105 Kanda-Jinbocho, Chiyoda-ku, Tokyo, 101-0051, Japan

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If normal or failure status of equipments, devices, etc. can be grasped by predictive maintenance, it is economical to maximize the life of product and to efficiently allocate inspection personnel. In order to distinguish between normal and failure, it is necessary to understand the feature in the operating state of the equipment, and the process of extracting the feature from a large number of data in the operating state is required.In this report, regarding the acquisition of the failure data of the equipment, the physical model of the failure state is performed, and the failure data in the model is used. Simulink and Simscape (Mathworks) were used for modeling for actual simulation. It is assumed that vibration is generated in normal driving as the target equipment, and the failure of the equipment is judged based on the acceleration signal measured in the operating environment for the equipment.

Since the purpose of this report is to show the basic idea and procedure for the daignosis , the assumed equipment is a very simple model, and then the rotary motion of DC motor is reduced by a gear reducer to drive the lever crank mechanism of the 4-section link. Fig. 1 shows a conceptual diagram of the study model. The failure state of the equipment model driven by the rotary motion can be measured as the change of the vibration waveform due to the rotary motion. It is assumed that this vibration waveform is measured from the vibration state of the casing of the equipment to which the vibration sensor (acceleration vibration sensor) is attached.

In general, it is assumed that the accelerometer drifts in the above-mentioned failure state, and normality and failure are discriminated based on the threshold value introduced for the drift amount. At that time, we pay attention to the statistical properties of the vibration waveform distribution in each region of normal and failure, and as a result of histogram of the incidence of the statics, RMS was adopted, shown in Fig. 2. It is possible to clearly separate the regions of normal and failure by RMS. Therefore, the separation point corresponds to the ability to discriminate between normal and failure, and the larger this is, the clearer the separation is. The design variables that affect the separation point are the width, thickness, and density of each section of the present mechanism. A set-based design method was used to find the range of each design variable that can take the RMS separation point as large as possible. In implementing the set-based design method, a design of experiments using the three-level values of each design variable was used. As a result of applying the set-based design method, the range of realization of the separation point, which is the performance, is shown by red line in Fig. 3, and as an example of the range solutions of design variables, the result of width, w, is showned by red line in Fig.4.

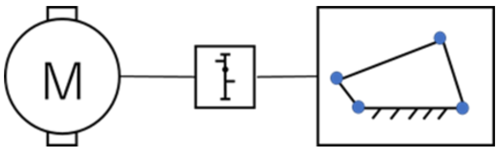

Fig.1 DC motor driven 4 node-link mechanism.

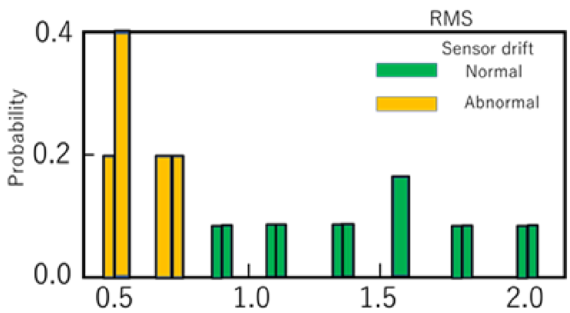

Fig.2 Histogram of RMS (Root mean square)

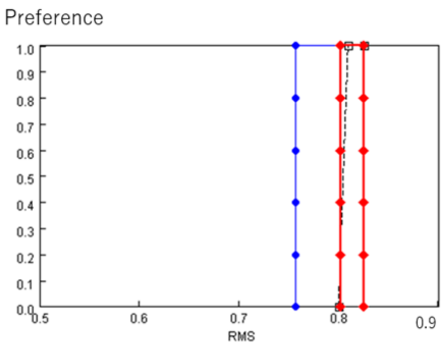

Fig.3 Range solution of Performance (Separation point of RMS histogram).

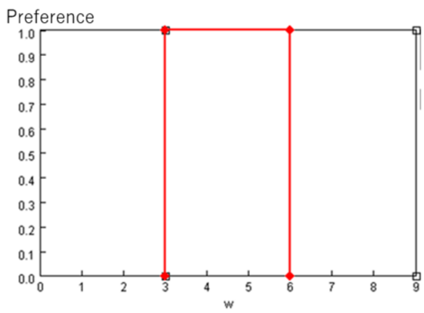

Fig.4 Range solution of design variable w.