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Modelling of Helical Spring and its Utilization based on Vibration Propagation

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This paper presents a vibration energy propagation model for coiled springs, which commonly used in automobiles and so on. This model is expressed by coupling loss factor, which is a most important parameter in statistical energy analysis (SEA). First of all, the static and the dynamic characteristics of the coiled spring are summarized and compared with the results of FEM calculation. Next, the vibration propagation through the springs with only the static spring constant, the continuous elastic property and the just steel bar are calculated and compared. After that, we formulate an SEA coupling loss factor from coiled spring to connected plate, and the formulation is carried out to be verified. Finally, some design coiled springs are tested by using the derived CLF formulation.

Figure A is a test system which is composed of one coiled spring with a plate. The coupling loss factor on SEA is modelling as shown in Fig. B and the formula is expressed

$$\eta_{1,2} = \frac{c_T}{\omega \pi L_S} \frac{d_1}{h} \tau_{1,2} \tag{A}$$

Where, η_{12} is the coupling loss factor from the coiled spring (subsystem No.1) to the plate (No.2). c_T is the speed of torsional wave on the spring coil. ω is the angular frequency and L_S is the expanded length of the coiled spring. d_1 is the connected line between the coil and the plate and h is an connection index, 1 is for connecting by the arm and 2 for connecting by the plane.

By using the Eq.(A), we designed three kinds of the coiled spring and compare the vibration transmissibility. One spec is baseline model which is named by Original. Other (named by Keq) is weak on the transmissibility with the equivalent spring constant of the baseline model. The other (named by Kx2) is strengthened on both the transmissibility and the static spring constant. The FEM calculation is carried out to compare the transmissibility of these designed spring with the results from Eq.(a) as shown in Fig.C. The solid lines are the results calculated by FEM and the dotted lines presents the results by Eq.(A). The FEM results show the desired transmissibility can be obtained from in turn which is Kx2 > Original > Keq. Also and of course, the results by Eq.(A) is of course same turn.

As a result, we can establish the analytical equation for the transmissibility from the coiled spring to the plate.

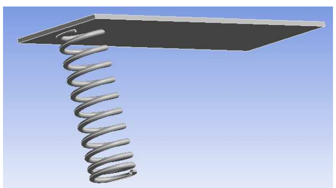

Fig.A Test model for coiled spring with a plate

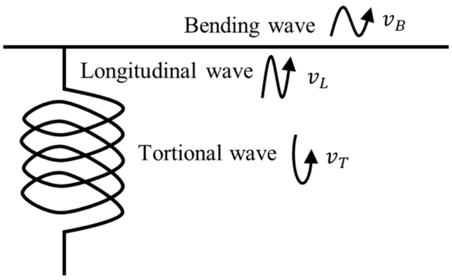

Fig.B Sketch for coupling loss factor modelling from the coiled spring to the plate

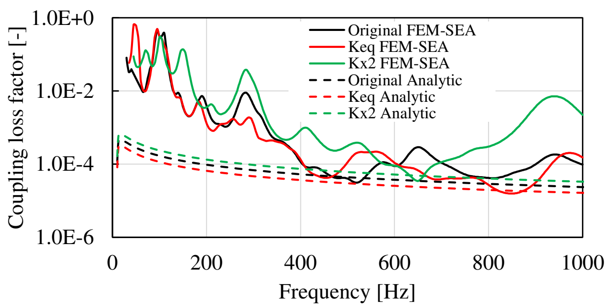

Fig.C Comparison of the coupling loss factors of the two designed coiled springs with the original spring