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ACTIVE STRUCTURAL ACOUSTIC CONTROL OF GEAR NOISE USING A PAIR OF PIEZO-BASED ROTATING INERTIAL ACTUATORS

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Summary: This paper presents a novel actuation concept for suppressing gear whine noise based on piezo-based rotating inertial actuators (PBRIA). The idea behind the design of the PBRIA is to use a piezoelectric actuator to introduce a force between a rotating element (e.g. the shaft) and a ring-shaped mass rotating together with the shaft. The benefits of this approach are twofold: (i) it is relatively easy to be implemented in a practical setting as no major structural modification is required and (ii) it does not affect the machine stiffness. As the developed prototype consists of one piezoelectric element and can only generate forces in one direction, two identical modules are manufactured, which are perpendicularly installed on a rotating shaft. In such a configuration, a global control authority of the transmission vibration is guaranteed. The performance of the actuator concept is evaluated on a simplified representative set-up of a gear-box system, where the disturbance force is artificially introduced by an electro-dynamic shaker. Noise is radiated by a plate that is attached to the frame. Two control approaches based on the Filtered Reference Least Mean Squares (FxLMS) algorithm have been implemented and compared. Firstly, a Multiple Input Multiple Output (MIMO) form of the standard Filtered Reference Least Mean Squares (FxLMS) control algorithm is used. The focus is on modeling the time varying secondary plants. The experimental results show up to about 12 dB reduction in the noise radiation level can be achieved when the rotating speed is below 90 rpm. However, the control performance degrades as the rpm increases. With the secondary control approach, a modified form of the FxLMS algorithm is employed, where the output of the controller is filtered through an inverted rotation matrix to compensate for the angular dependency of the secondary plant behavior. The control effectiveness of the secondary approach is similar to that of the first approach at low rpms, but the degradation is less at high rpms.