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TOPOLOGY OPTIMIZATION OF TRANSMISSION HOUSINGS FOR MINIMIZING THE GEAR RATTLING NOISE

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ABSTRACT

The objective of this paper is to present the development and application of a topology optimization method based on an improved density distribution method. Using the method, an optimum design can be obtained by manipulating sizes and frontiers of material territories which are lumps of material with specified properties [1]. An artificial material model [2] was suggested and compared with the density distribution method [3,4]. The improved method was successfully applied to topology optimization of an automotive transmission casing in order to reduce gear rattling noise.

An innovative flexible multi-body dynamic model is newly developed to predict fluctuating contact loads on the surfaces of two meshing gears and their accurate rattling impact forces when unloaded, which fluctuate within tooth backlash at each gear stage due to the irregular combustion torque of internal combustion engines and resulting noise radiated from manual gearboxes [5] due to the gear rattle using ADAMS and finite element method. In addition, the fluctuating bearing forces which are transmitted to the housing of a manual transmission are predicted and used to analyze noise and vibration ofm a housing. Gear rattle is a typical noise phenomenon that is primarily occurred by torsional fluctuation due to the backlash of unloaded gears [6]. All factors of torsional vibration of gear shafts, bending and twisting of mating gear teeth, helical gear-tooth sliding, amount of backlash, inertia of gears, differential gears and a car body were considered in the flexible multi-body dynamic model to calculate fluctuating loads precisely.

Most of previous studies have focused on a single gear pair and dynamic interaction between two meshing gears localized at the contacting teeth, but in the present model both mating and unloaded gear trains at the same time were considered for realistic prediction, as in Figures 1 and 2. The noise level of a gear box due to gear rattle was predicted using calculated dynamic loads. Fluctuating bearing reaction forces (Figures 3 and 4) were calculated and applied for the noise analysis of a gear box casing. The resulted fluctuating forces were utilized for topology optimization for minimizing rattle of the gear housing. The proposed method may be extensively applied for reduction of noise in a transmission system at an early stage of design.

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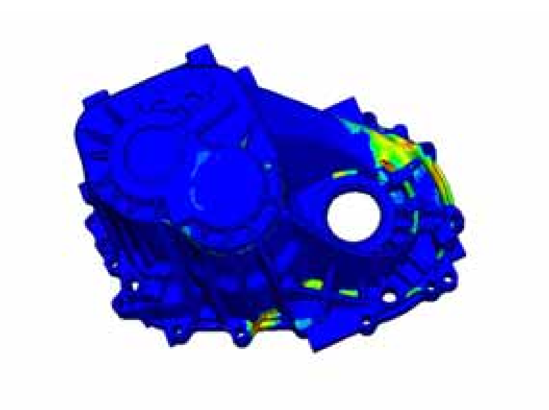

Fig. 1 A model of a transmission housing

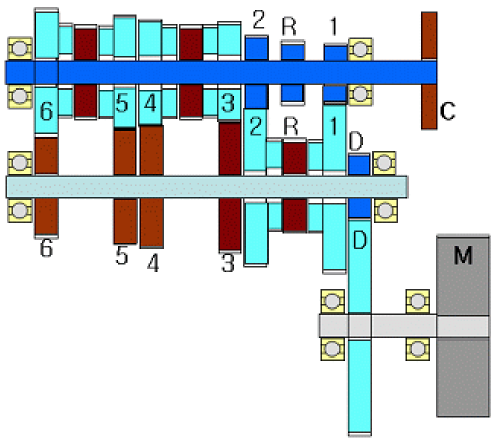

Fig. 2 Multibody dynamic analysis model of a gear transmission

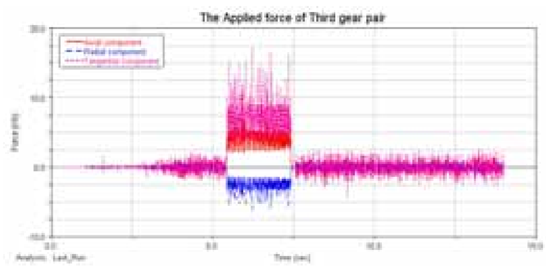

Fig. 3 Fluctuating loads at the third stage of a gear shift

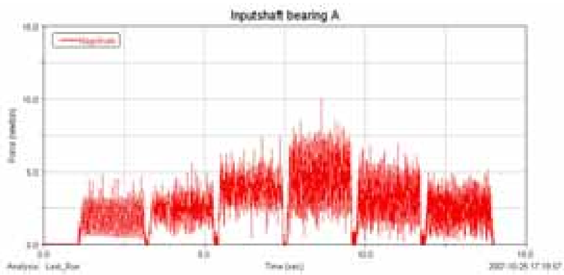

Fig. 4 Fluctuating loads at a supporting bearing on a shaft