Towards optimization of washing machine suspension systems

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A washing machine is a product which is familiar to almost everyone in the developed countries. Development of efficient and high speed spinning washing machines raises the problem of designing and optimizing advanced suspension systems to control vibration and noise in real-time. From technical and scientific point of view a modern washing machine is an example of an electromechanical system with many degrees of freedom, which together with sensors and controller make the machine a mechatronic system. To successfully solve different optimization problems for such a complicated system, well developed and validated mathematical and computational models of washing machines are desirable.

In this paper a theoretical-experimental methodology for vibration dynamics modeling and for optimization of washing machines suspension is presented. The methodology is based on mathematical and computational models which were built in MSC.Software/Adams connected to an Adams/Matlab interface for clustered simulation and optimization. Several full-scale test rigs were built and the experimental data obtained were used for model validation. The developed models make it possible to analyze vibration dynamics of washing machines and to solve suspension optimization problems. Both conventional passive suspensions as well as active suspensions of frontloaded washing machines can be and have been investigated. Numerical simulations have shown that the structural parameters of the suspension (e.g. bushing stiffness, strut damping, strut mounting angle, and others) play important roles in the performance of the suspension system in washing machines, especially when the movement of the container is limited. Resonances have been found, modeled and their sources have been identified. The biggest resonance has been clearly recognized and identified to be at between 10.5 Hz and 12.5 Hz giving dynamic force amplitude of about 40% of the force at static conditions. Several optimization problems have been solved. In particular, one of the intentions with the optimization work was to show the possibility of reducing the number of struts while keeping the same or less vibration output during spinning. The obtained results have shown engineering feasibility of a 3-strut based washing machine suspension. The solution to the problem of optimal placement for the third strut which minimizes the transmitted forces during spinning process was also found. The use of magnetorheological fluid based variable damping for suspensions has been investigated by using models and by experiments. Semi-active controlled damping for the container suspension has been shown with experiments to reduce amplitudes of vibration output. Compared to the conventional passive suspension, up to 40% lower amplitudes can be achieved by using a relatively simple control algorithm[1].

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[1] T. Nygårds, *Modeling and Optimization of Washing Machine Vibration Dynamics during Spinning*. Thesis for Licentiate Engineering 2009:1, Department of Applied Mechanics, CHALMERS, 2009.