ALGORITHM FOR REAL-TIME IDENTIFICATION OF FAULTS IN SEMI-ACTIVE SUSPENSION

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1. Introduction

In recent years semi-active and active suspensions are more often used in automotive vehicles, which contributes significantly to driving comfort and safety of users. The key component of semi-active vehicle suspension is a controllable damper and an electronic controller, which allows for the generation of control signals and changes of damper characteristics. In order determine the correct values of the control signals, the dedicated algorithms taking into account assumed control criterion and the signals from a number of sensors are used. Generally, two opposing control criteria are adopted: comfort and safety. The first one is based on minimization of vehicle body acceleration, while the second one is based on minimization of variation in vertical wheel forces acting on the road surface. With the control occurring up to 1000 times per second, the vehicle's semi-active or active suspension system can be to some extent resistant to disturbances caused by damper's damage. Therefore, one of the most important problems in vehicle diagnostics is to detect and recognize different types of dampers' damages adequately early in order to prevent dangerous traffic incidents.

2. Suspension fault identification algorithm

In this paper we investigate the possibility of identifying the changes in parameters of vehicle suspension while driving. Such assessment of the vehicle's suspension state enables detection of potential dampers' faults and allows the driver to consider the need for service. The preliminary results indicate that based on well-tuned mathematical model of the suspension and measurements of selected physical quantities, we are able to assess the suspension condition in real-time. The basic scheme of suspension parameters identification algorithm is shown in Figure 1.

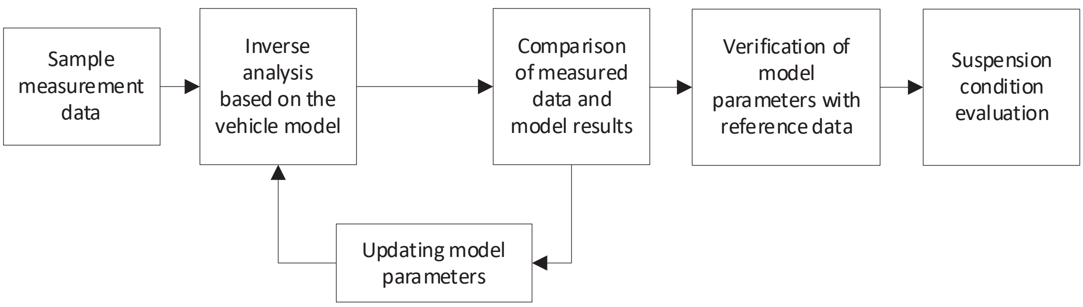

Figure 1. General algorithm for evaluating vehicle suspension condition.

The method assumes that it is possible to develop a mathematical model of the undamaged suspension (e.g., for a new vehicle) and identify a range of acceptable values of its parameters. In particular, it is possible to determine the values of parameters describing vehicle's mass and damping forces generated by the applied dampers. The algorithm starts with measurement of selected physical quantities, including suspension deflection, vehicle body's and wheel's acceleration. Based on measurement data and developed suspension model it is possible to conduct inverse analysis providing preliminary identification of model parameters. This allows to compare the values of deflections and accelerations from the model with measured data, and to update model parameters accordingly. After final identification of the actual values of the model parameters, the algorithm compares them with the preliminarily determined range of acceptable parameters. In the case of differences exceeding the permissible variance, it informs a driver about a damage to the vehicle suspension and its severity.

The operation of the proposed algorithm for identification of the faults in semi-active suspension will be demonstrated using hydraulic damper with a piezoelectric valve [1], presented on experimental test stand in Figure 2a. The results of exemplary numerical tests conducted using developed mathematical model indicate significant difference in damper response resulting from changes in damping coefficient and stroke clearance (Figure 2b). As it will be shown, such results can be effectively used for precise identification of the changes in damper parameters and detection of damper faults. In addition, we will present the simplified version of the identification algorithm which does not require full numerical model of the damper.

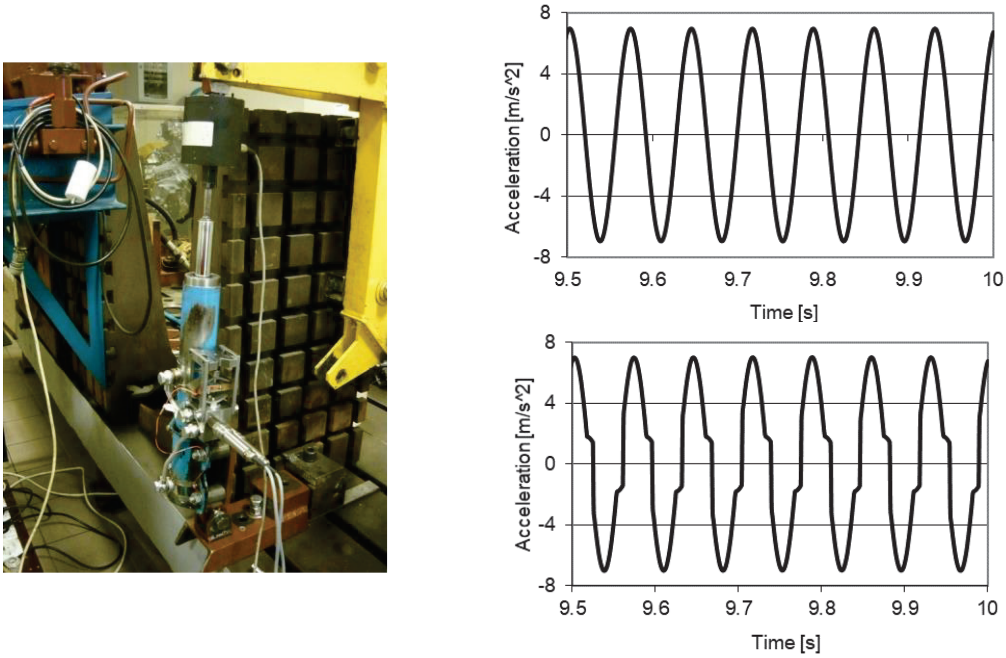

Figure 2. a) View of the PZD damper with the piezoelectric valve on experimental test stand, b) exemplary numerical results presenting vehicle body accelerations in case of damping coefficient γ=0.2 and two different values of clearance: top – clearance Δ=0 m, bottom - clearance Δ=0,002m.

3. Conclusions

In this contribution we propose a novel algorithm for the identification of the parameters of dampers used in vehicle's suspensions. We show that proposed algorithm is operates effectively and can be successfully used to diagnose the actual state and the potential faults of vehicle suspension while riding.

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References

[1] M. Makowski, L. Knap. Study of a Controlled Piezoelectric Damper. *Sensors, Vol. 21 (10)*, 1:20, 2021.