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THE EFFECT OF ROAD ROUGHNESS ON THE HALF VEHICLE MODEL AT DIFFERENT SPEEDS

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Abstract: In this study, equations of motion have been obtained through different methods used in mathematical model of system based on car physical models. To determine system behavior in variable road inputs, half car and seat mounted half car models have been constituted. Using the method of Lagrange which is one of the mathematical modeling method responses to system's all physical models, mathematical models have been established. SIMULINK modeling program worked in MATLAB package has been used for computer solutions of system. Simulations have been made to the response to half car model hard road roughness and seat mounted half car model the to the road roughness at different speeds. As a result of made simulations, transmitted vibrations to seat and driver have been obtained.

Keywords: Half-car, Simulink, Lagrange, Road Roughness, Ride Comfort

Introduction

While important of motor vehicles in our life is known to all, effect of human health is not known exactly. Vehicles, beyond the damage to people due to accident, there may also be some effect on human health outside accident. For this purpose, a lot of scientist has made study about what can be this damage and they have published these studies.

In this study, using MATLAB and Simulink programs semi vehicle and seat entrained semi vehicle models have been constituted from equations obtained using Lagrange method. In created models to simulate, bump input has been given in step and model of seat entrained semi vehicle in addition to other models, vibrations which has been given of the same bump input on seat and chassis in different speeds have been obtained

Modeling and Solutions

Primarily, equation of motion has been taken for analytical solutions of suspension systems. Equation of motion has been derived by Lagrange method. The motion equation are given below according to figure 1.

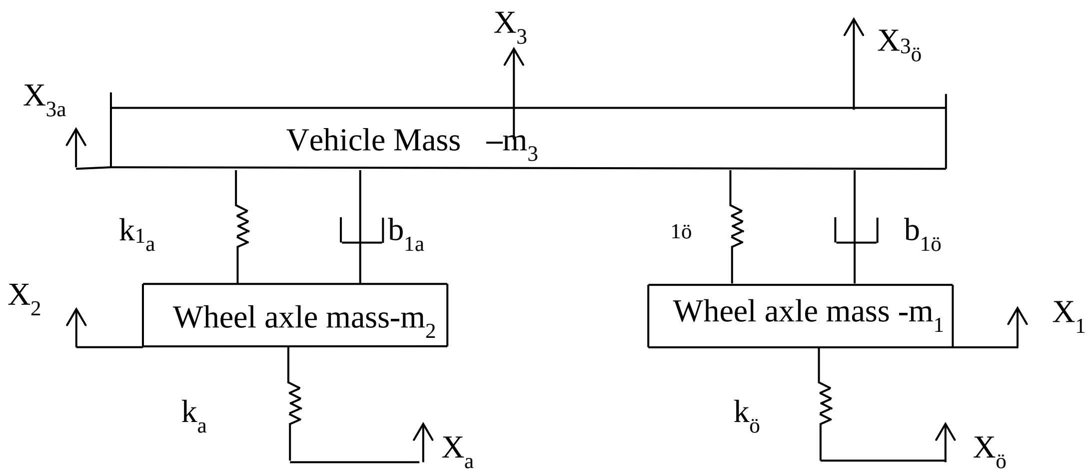

Figure 1. Semi Vehicle Model

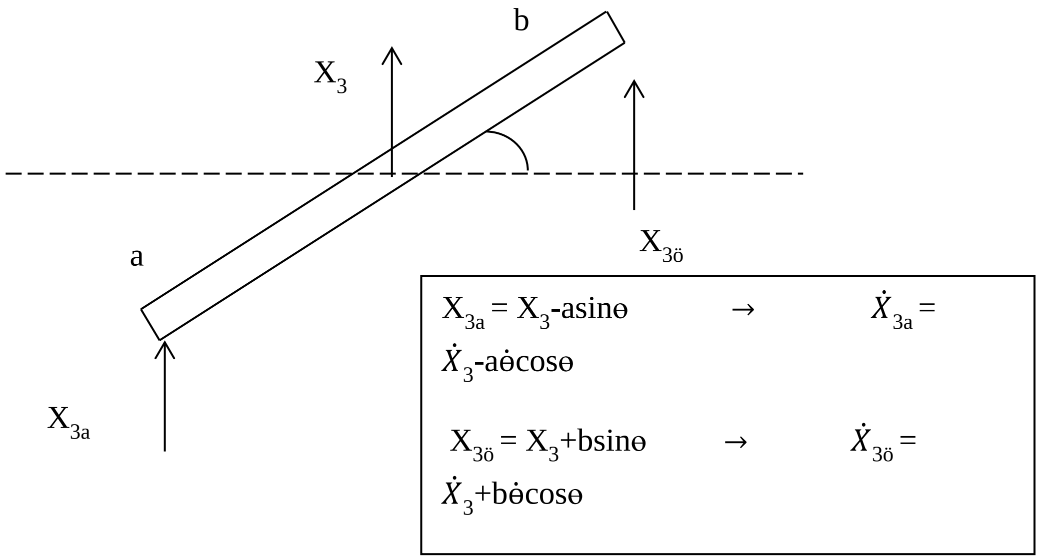

Figure 2. Motion of Inertia

$$\ddot{x}_1 = (b_{1ö}(\dot{x}_3 + b\dot{\theta} - \dot{x}_1) + k_ö(x_ö - x_1) + k_{1ö}(x_3 + b - x_1))\frac{1}{m_1} \quad (1)$$

$$\ddot{x}_2 = (b_{1a}(\dot{x}_2 + \dot{\theta}a - \dot{x}_3) + k_a(x_a - x_2) + k_{1a}(x_3 - a - x_2))\frac{1}{m_2} \quad (2)$$

$$\ddot{x}_3 = (k_{1ö}(x_1 - b - x_3) + k_{1a}(x_2 + a - x_3) + b_{1ö}(\dot{x}_1 - b\dot{\theta} - \dot{x}_3) + b_{1a}(\dot{x}_2 + \dot{\theta}a - \dot{x}_3))\frac{1}{m_3} \quad (3)$$

$$\ddot{\theta} = (b_{1ö}b(\dot{x}_1 - b\dot{\theta} - \dot{x}_3) + b_{1a}a(\dot{x}_3 - \dot{\theta}a - \dot{x}_2) + k_{1ö}b(x_1 - b - x_3) + k_{1a}a(x_3 - a - x_2))\frac{1}{I} \quad (4)$$

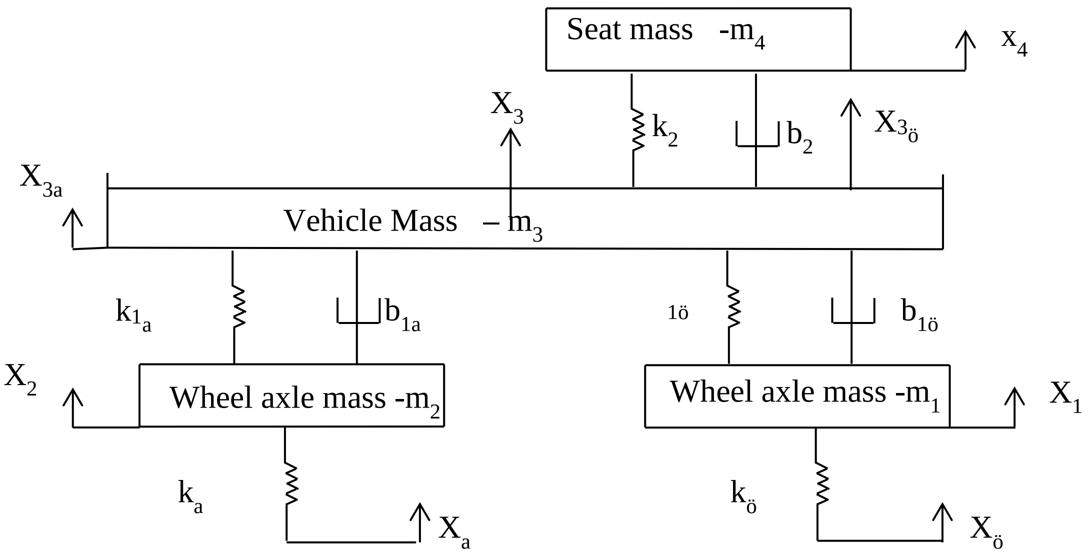

Figure 3. Seat Entrained Semi Vehicle Model

The inertia movement that occurs when the car brakes or accelerates is shown in figure 2. Seat entered semi vehicle model is shown in figure 3.

$$\ddot{x}_1 = (b_{1\ddot{o}}(\dot{x}_3 + b\dot{\theta}cos\theta - \dot{x}_1) + k_{\ddot{o}}(x_{\ddot{o}} - x_1) + k_{1\ddot{o}}(x_3 + bsin\theta - x_1))\frac{1}{m_1} \tag{5}$$

$$\ddot{x}_2 = (b_{1a}(\dot{x}_3 + \dot{\theta}acos\theta - \dot{x}_2) + k_a(x_a - x_2) + k_{1a}(x_3 - asin\theta - x_2))\frac{1}{m_2} \tag{6}$$

$$\begin{aligned} \ddot{x}_3 = (&k_{1\ddot{o}}(x_1 - bsin\theta - x_3) + k_{1a}(x_2 + asin\theta - x_3) + k_2(x_4 - bsin\theta - x_3) \\ &+ b_{1\ddot{o}}(\dot{x}_1 - b\dot{\theta}cos\theta - \dot{x}_3) + b_{1a}(\dot{x}_2 + \dot{\theta}acos\theta - \dot{x}_3) \\ &+ b_2(\dot{x}_4 - \dot{\theta}bcos\theta - \dot{x}_3))\frac{1}{m_3} \end{aligned} \tag{7}$$

$$\ddot{x}_4 = (b_2(\dot{x}_3 + \dot{\theta}bcos\theta - \dot{x}_4) + k_2(x_3 + bsin\theta - x_4)) \ \frac{1}{m_4} \tag{8}$$

$$\begin{aligned} \ddot{\theta} = (&b_{1\ddot{o}}bcos\theta(\dot{x}_1 - b\dot{\theta}cos\theta - \dot{x}_3) + b_{1a}acos\theta(\dot{x}_3 - \dot{\theta}acos\theta - \dot{x}_2) \\ &+ b_2bcos\theta(\dot{x}_4 - \dot{\theta}bcos\theta - \dot{x}_3) + k_{1\ddot{o}}bcos\theta(x_1 - bsin\theta - x_3) \\ &+ k_{1a}acos\theta(x_3 - asin\theta + x_2) + k_2bcos\theta(x_4 - bsin\theta - x_3))\frac{1}{I} \end{aligned} \tag{9}$$

Case to effect the simultaneous on two wheels was examined in semi vehicle simulation applied bump model. However, this simulation just can be viable in theory. In practice, the first vehicle's leading wheel would enter bumps; rear wheel depending on the speed would enter after a certain time. In figure 4, figure 5 and figure 6, simulation of seat entrained semi vehicle model exposed to h=0.1m bumps is made at different speeds.

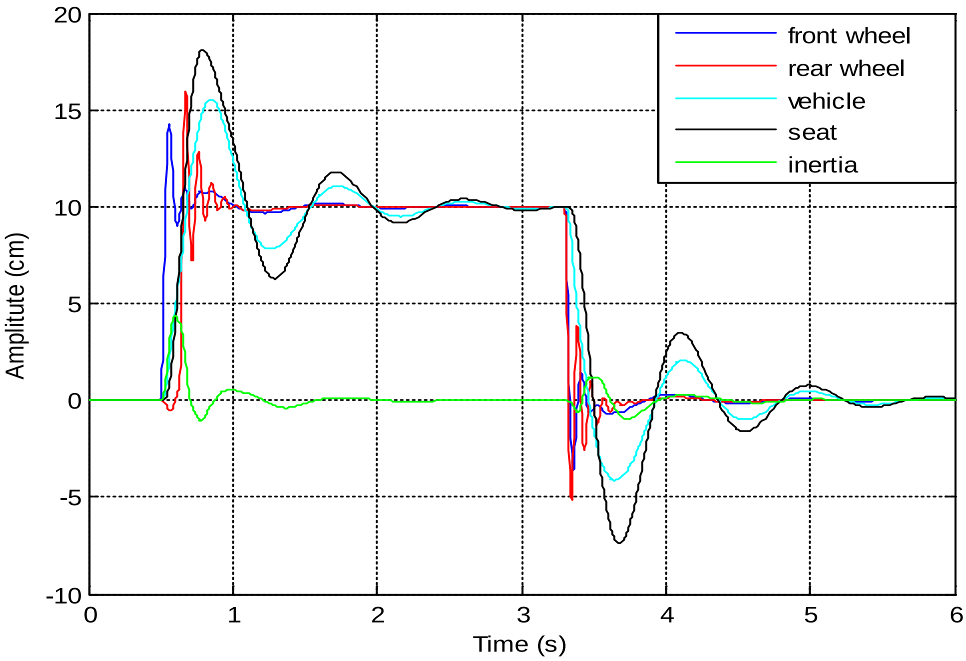

Figure 4. Step input Position-Time Graph For V= 75,6 km/h ve h=0.10m

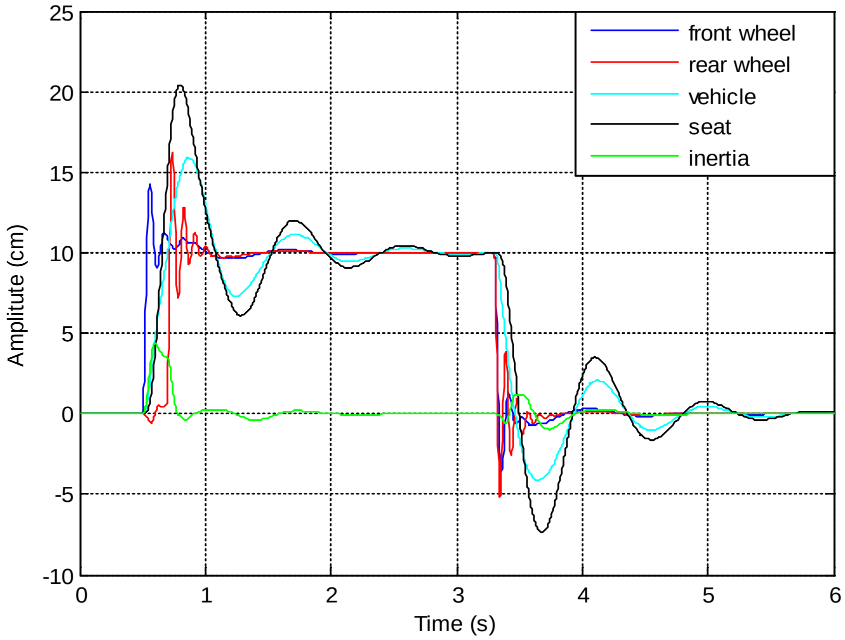

Figure 5. Step input Position-Time Graph For V= 50,4 km/h ve h=0.10m

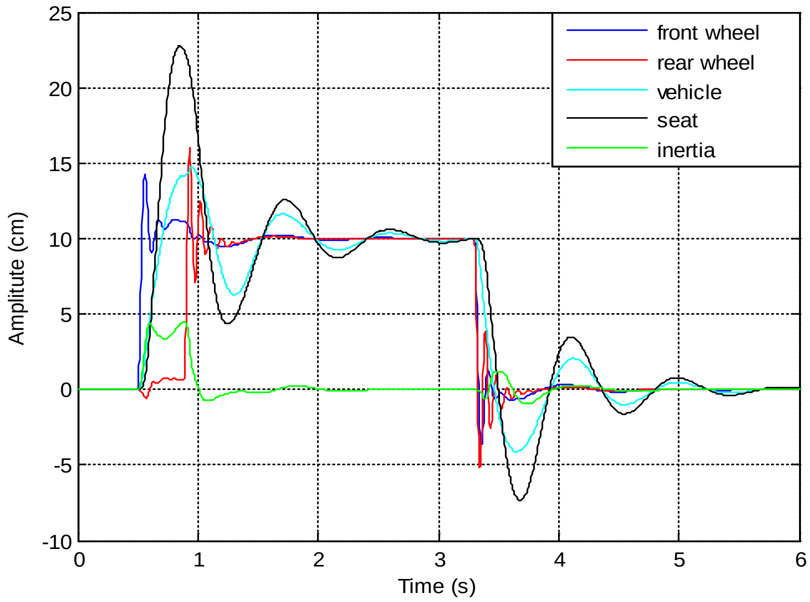

Figure 6. Step input Position-Time Graph For V= 25,2 km/h ve h=0.10m

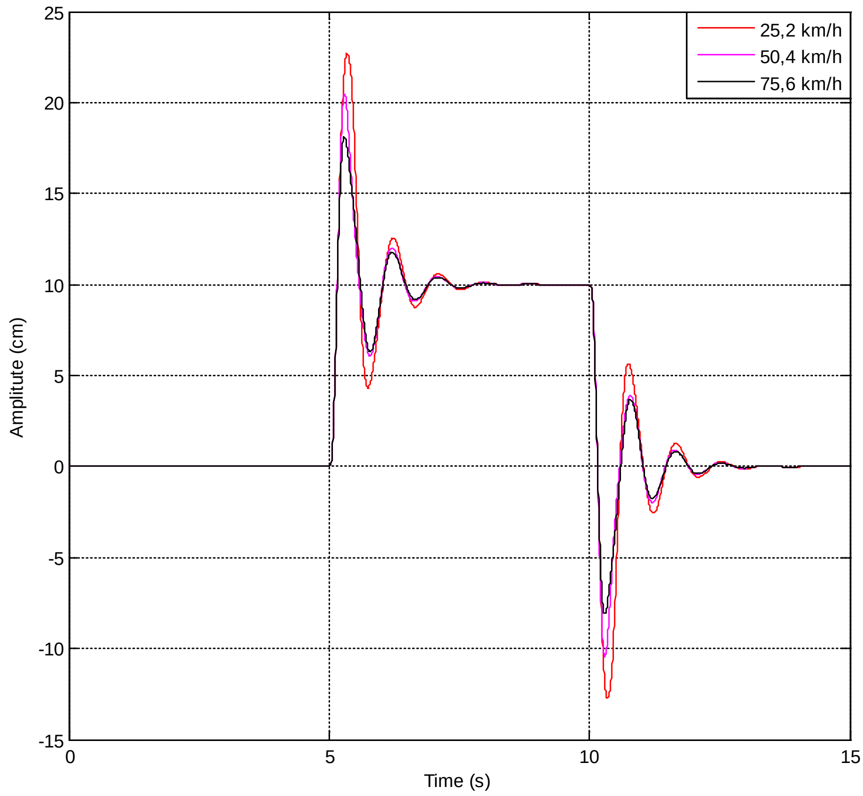

Figure 7. Seat Entrained semi-vehicle model at different speeds time dependent displacement graph

Results and Discussions

As a result of analysis, semi vehicle and seat entered semi vehicle models, motion of inertia is less about %27 in with seat models.

In this study, semi-vehicle model, phase difference occurring in the front and rear wheels depend on vehicle axle length and speed staking the route entry has been applied and effect of speed on system has been tried to scrutinize. According to the simulation results, it is noted that changing the location of the seat decreases with increasing speed but the front and rear suspension with increased displacement.

Conclusion

The results of this analysis, the value of these positions that vary depending on the system parameters have been shown to occur inevitably in the passive suspension system. This study conducted has a basis for analysis through passive suspension system of full vehicle and seat entrained full vehicle models. It was observed that vehicle comfort of a semi-active or active suspension can be improved by controlling the dynamic comfort systems and condition of comfort can be improved in limited circumstances in the passive suspension system with fixed-valued parameters.

In next studies, it is recommended that Conducting research about suspension characteristics and the structure will be developed implementation on a real vehicle for improvement of vehicle dynamics and safer driving at high speeds.

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