Chapter 5
Use of the Neural Network Controller of Sprung Mass to Reduce Vibrations From Road Irregularities

Zakhid Godzhaev
Federal State Budgetary Scientific Institution "Federal Scientific Agroengineering Center VIM", Russia

Sergey Senkevich
https://orcid.org/0000-0001-6354-7220
Federal State Budgetary Scientific Institution "Federal Scientific Agroengineering Center VIM", Russia

Viktor Kuzmin
Federal State Budgetary Scientific Institution "Federal Scientific Agroengineering Center VIM", Russia

Izzet Melikov
Dagestan State Agricultural University Named After M.M. Dzhambulatov, Russia

ABSTRACT

Hydraulic systems that damp active oscillation operate according to a certain non-linear and time-varying algorithm. It is difficult to create a controller based on its dynamic model. This chapter proposes a new operation regime of the controller based on neuron nets by combining the advantages of the adaptive, radial, and basic functions of the neuron net. Its undoubted advantages are a learning (tilting) ability in real time to process indefinite, nonlinear disturbances, and to change the value of the active force in the hydraulic leaf spring by adjusting the weight coefficients of the neuron net and/or the radial parameters of the basic function. The model is a ¼ hydraulic active sprung mass of a mobile vehicle. The modeling shows that the use of a neuron net controller makes the sprung mass much more efficient.

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INTRODUCTION

Most of the operating time, wheeled agricultural tractors have to work in fields with different soil backgrounds, along dirt or rough roads or even off roads (Senkevich S. et al, 2019; Senkevich S.E. et al, 2019). These conditions require sprung mass which allows supporting a regulated smooth ride and an effective protection of the operator from vibrations. The sprung mass must also keep the tires in contact with the road surface in order to support good stability and controllability of the vehicle (TC). This is especially important when a vehicle turns, brakes or accelerates (Frolov, 1995). The parts of sprung mass are usually located in the corners of the vehicle and connect the transmission and the frame with the wheels. Typically, the sprung mass includes elements of such two main types as elastic elements and dampers installed in parallel. Elastic elements smooth dynamic loads caused by moving along rough road. When the sprung mass is transmitted a dynamic disturbance from the irregularities of the roads, the elastic elements are deformed and accumulate potential energy, which is then released. When the vehicle moves forward and back, the suspension dampers dissipate the oscillation energy. Similarly, elastic elements and dampers keep controlled movement of the vehicle frame during the turns (Derbaremdiker,1985). Most of the vehicles use steel elastic elements in the sprung mass, which are divided into 3 types: coil, torsion, leaf springs. Some vehicles use pneumatic and hydro-pneumatic elastic elements. As dampers in the vehicle sprung mass hydraulic shock absorbers are basically used (Derbaremdiker, 1985; Senkevich, S.E. et al, 2020; Senkevich S. et al, 2020a; Senkevich S. et al, 2020b).

BACKGROUND

Smooth Ride

The primary task of the vehicle sprung mass is to ensure a regulated smooth ride. This indicator is also very important for agricultural tractors, in which the value of vibration accelerations under the operator's seat is higher than that of other vehicles during operation (Deboli, R., Calvo, A. & Preti, C., 2017). In addition, agricultural tractor operators spend a lot of time in the field, when dynamic effect from the soil surface is significantly larger than when driving along the road (Gurhan & Cay, 2008). The resulting noise and vibration affect the operator's work efficiency and his health (Marjoram, et al, 2008; Duke, 2007). Traditionally, the sources of oscillations that affect the noise and vibration load on the operator's workplace are divided into two classes: inboard and road. The inboard sources are all rotating components of the tractor including an engine, wheels, transmission, etc. The fluctuations caused by the sources range from 25 to 20000 Hz, which are perceived by a human ear as noise. The second category of sources is a rough road. The oscillation frequency usually ranges from 0 to 25 Hz. This range includes frequencies that are uncomfortable for a human body. For this reason, vibrations from road bump are the most negative in terms of smooth vehicle ride and effect on a vehicle operator (Silayev, 1972). The upper limit of the frequency range, within which the sprung mass operates, usually does not exceed 25 Hz. The smooth vehicle ride largely depends on the dynamic behavior of the vehicle body (i.e. the suspension linkage), which is exposed to a combination of vertical, longitudinal-angle and cross-angular vibrations during operation (Hansson, 2002). The vibration effect on a human body, especially on passengers of the vehicle, was considered in many studies (Marjoram, et al, 2008; Pobedin, et al, 2016; Sukhorukov, 2003). At the same time, a human body reacts differently to different