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Tractor Seat Vibration optimization with Active Control System during Tillage using Modelling and Simulation in Ansys.

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Abstract: Most of the tractors are without suspensions and tractors have to operate for many hours in fields for soil preparations for crop production. The frequency of vibrations which is most harmful to humans is in the range of 4-6 Hz. This article is to adopt modern approaches to reduce the vibrations at tractor seat to improve the comfort levels. Real time seat accelerations were measured at seat base using tri-axial accelerometer at three different forward speeds of tractor and using different type of tillage equipments. Model of tractor seat was created and has been analysed in Ansys for total deformation and random vibrations. PID and Fuzzy-PID controllers were designed in MATLAB and the tractor seat was modified by installing electronic damper and tested for improved results. Results shows that vibrations accelerations were reduced to notable values to improve the comfort level of tractor operator.

Keywords: *Tractor Seat, Tillage Equipments, Vibrations, Controller, Simulation*

1. Introduction

In low frequency range of 2-6 Hz resonance occurs and the operators are affected badly in this range. To provide the comfort to driver's tractor seats needs to be redesigned. Because vibrations are directly related to driver comfort, safety, and health, it is critical to reduce seat vibrations. Vibrations are also very harmful to mechanical systems because they cause component and material failure. Vibrations are also detrimental to structures and reduce the performance of equipment and machinery. Furthermore, if vibrations are present in the environment, they can cause system malfunction or failure, as well as injury to citizens. As a result, it is necessary to control the vibrations.

Only tyres provide flexibility and some vibration absorption. Because of this, vibrations in tractors have a high amplitude [1, 2 and 3]. The main source of vibrations in tractors is the road surface. The magnitude, frequency, and direction of vibrations have an effect on the human body [4]. Higher vibration levels are transmitted to the human body during soil tillage operations [5, 6 and 7]. High-level vibrations are extremely dangerous to the operator, causing deafness and spinal column and stomach disorders. Inadequate conditions, such as surface roughness, high forward speed, faulty tillage equipment, and so on, cause such high level vibrations [8, 9 and 10]. The forward speed of a tractor during tillage is a critical parameter that contributes to vibration levels. Some researchers have found that increasing the speed by 3 km/h increases the vibration level along all three axes by 40% at the same tillage depth [11].

The primary goals of this study were to 1) develop a tractor seat model and correlate measured data with model output data, and 2) examine the effect vibrations at tractor seat of various combinations tractor forward speeds and types of tillage equipments. 3) to design a Fuzzy-PID controller to control the electronic damper for vibration reduction

2. Data Collection, Modelling and Analysis

Real time data in all three axes were collected from conventional seat of tractor using accelerometer at the base of seat. The tractor used for data collection is shown in figure 1(a) and suspension of seat in figure 1 (b). The figure 1 (c) represents the position of accelerometer and figure 1(d) shows the schematic diagram for measurement of vibrations. Data was measured for three different forward speeds of tractor at 2.30 Km/hr, 4.20 Km/hr and 6.50 Km/hr with two different tillage equipments namely chisel plough and disc harrow as tillage implements.

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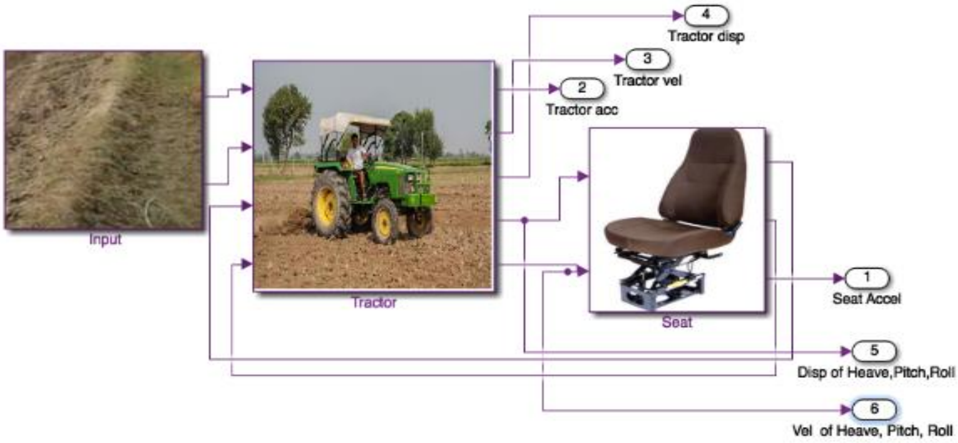
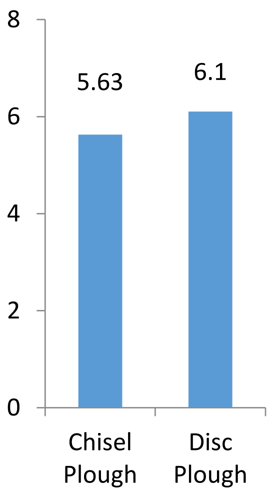
(a) (b) (c)



(d)

Fig 1. (a) Tractor used for data recording (b) suspension arrangement of conventional seat (c) position of accelerometer (d) schematic diagram for data collection.

Vibrations were measured on test tractor's seat for two different types of tillage implements. Figure 2 (a) illustrated that the vibration for chisel plough is 5.63 m/s^2 and for disc plough/harrow is 6.1m/s^2 at a speed of 2.30 km/hr. Figure 2 (b) represents the magnitude of acceleration in the horizontal (x) direction is 4.02 m/s^2, in the transverse (y) direction is 5.63 m/s^2 and in vertical (z) direction is 4.52 m/s^2



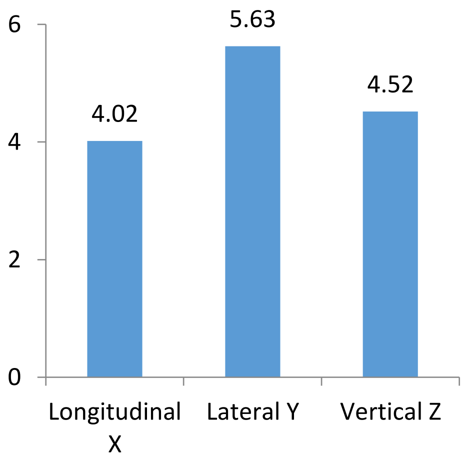
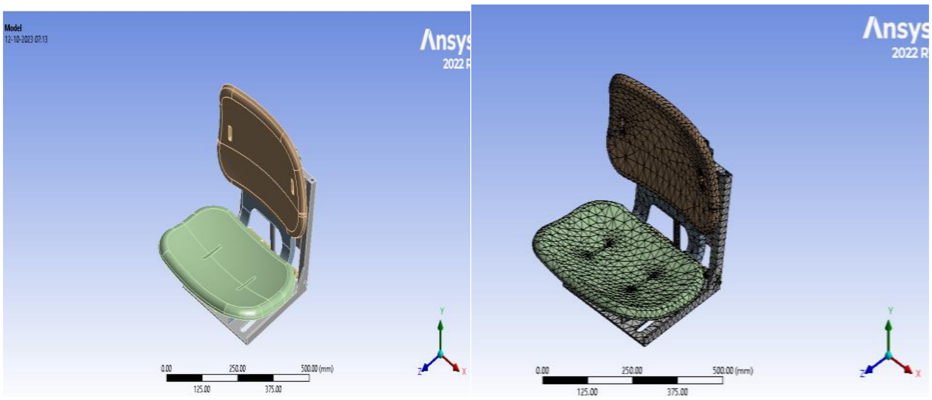


Fig 2. (a) Root Mean Square vertical acceleration for chisel plough and disc plough at seat (b) RMS acceleration in three directions at tractor's seat at speed.

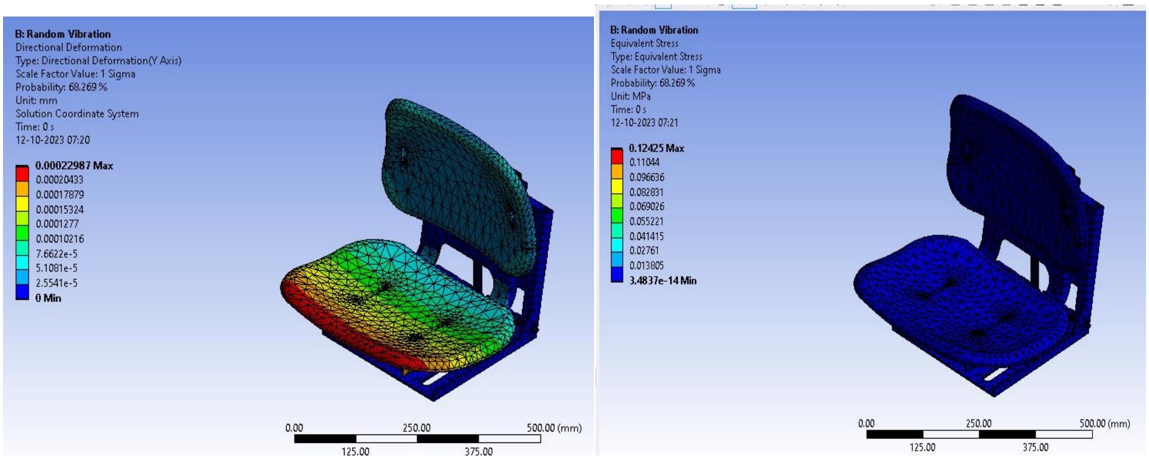
Model of seat was created to analyse in Ansys workbench. Figure 3 (a) represents the seat model and (b) shows the meshing of model.



(a) (b)

Fig 3. (a) Model of tractor seat (b) Mesh generated model of tractor seat in Ansys

The seat model was then analysed for directional deformation and equivalent stress for random vibrations and same has been represented in figure 4 (a) and (b).



(a) (b)

Fig 4. (a) Directional deformation (b) Equivalent stress for random vibration analysis in Ansys.

3. Simulink Model in MATLAB

For reduction of vibrations at seat and to design Fuzzy-PID controller the full tractor model was created in Matlab Simulink shown in figure 5.

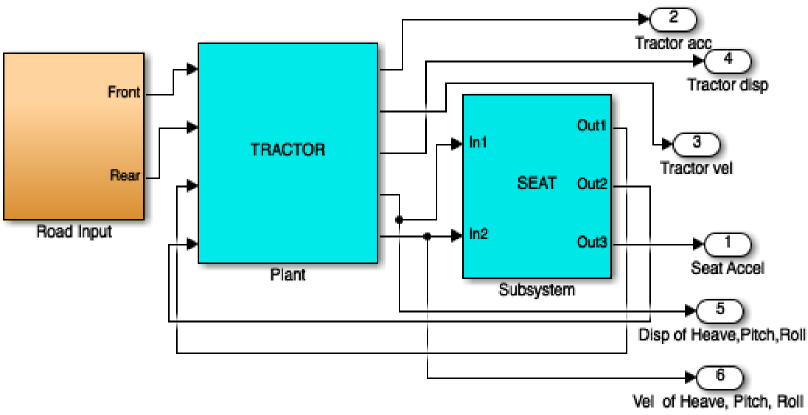


Fig 5. Tractor and Seat Simulink Model

This model was analysed and results were compared with conventional suspension system of the seat.

4. Results and Discussions

In general an improvement in system performance is considered if a drop in the amplitude is observed in the system curve. With a view to assess this effectiveness of the proposed controllers (to improve riding comfort), simulation results obtained with Passive, PID and Fuzzy logic controllers were compared and depicted graphically in Figure 6.

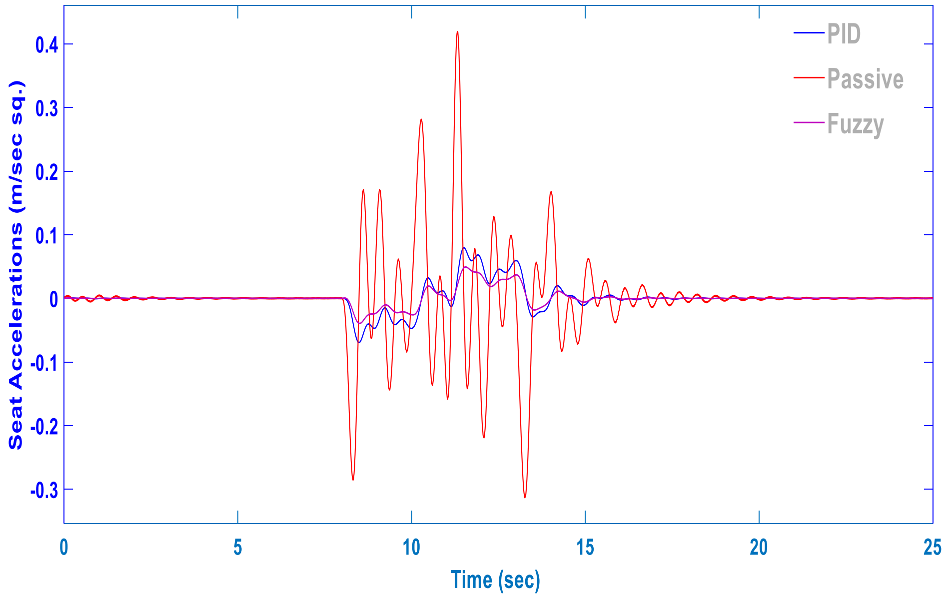


Fig 6. Simulation results of Passive, PID and Fuzzy Controller

From figure 6, it is inferred that the accelerations of driver's seat have been significantly reduced with fuzzy controller thereby providing better ride comfort as compared to passive and PID controller.

With the modelled step input disturbances, comparison of RMS values of accelerations obtained using PID and Fuzzy controllers were performed. The RMS values of seat accelerations for Passive, PID and fuzzy logic controllers were computed using Matlab and are listed in Table 1. With a view to quantify this comparison, the percentage improvement of ride comfort was computed.

Table 1. Simulation RMS results of suspended seat acceleration

System	Seat Accelerations (RMS values, m/s^2)	Percentage improvement w.r.t. Passive System
Passive	0.4706	-----
PID	0.3433	27.05
Fuzzy Logic	0.1036	77.99

Results clearly indicate that there is a reduction of 27.05 % in RMS values of seat accelerations with respect to passive system with PID control system and reduction of 77.99% with Fuzzy Logic controller. These results specify that the performance of proposed fuzzy controller for seat suspension is better than PID controller. This indicates that proposed system provides an appreciable enhancement in the riding comfort of tractor operator.

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