Computers and Electronics in Agriculture 124 (2016) 318–324

Contents lists available at ScienceDirect

Computers and Electronics in Agriculture

journal homepage: www.elsevier.com/locate/compag

Original papers

Proper farm tractor seat angles for the right posture using FEM

Shohre Daeijavad, Ali Maleki *

Department of Mechanical Engineering of Biosystems, Faculty of Agricultural Sciences, University of Shahrekord, Iran, P.O. Box 115, Shahrekord, Iran

A R T I C L E I N F O

Article history:
Received 16 October 2015
Received in revised form 26 February 2016
Accepted 28 February 2016

Keywords:
Simulation
Operator seat
Tractor
FEM
Vibration
Comfort

A B S T R A C T

The uncomfortable seat in a tractor can lead to the operators' discomfort, hence an increase in operational malfunction and even accidents. The attempt is made in this article to determine the appropriate angles of the tractor operator seat as to have a better posture using Finite Element Method (FEM). Here, different angles of the operator seat are compared and the best are introduced for his/her comfort at set position. The test sample is a MF 285 tractor seat the different angles of the backrest and the seat-pan of which are simulated by (FEM) in an ABAQUS software. The output vibration magnitude from the simulated seat obtained from 0.5, 1, 1.5 and 2 m s^{-2} at 3–66 Hz frequency with three different operator anthropometries are extracted from the software and analyzed. The evaluation of the output vibration magnitude variance at body-seat connection points indicates that the averages of the effect of angles of the backseat and seat-pan have a statistical significance at 5% level. Evaluating the body seat contact points with the 100–115 range of degree, 110 in specific for the backseat and 10–15 deg for the seat-pan indicate the appropriate angles for this tractor's seat to provide operator comfort.

1. Introduction

A tractor operator performs all his operational duties in seating position where the body is exposed to many loadings; therefore his/her seat design and set up has a major contributive role in this respect. In seat design the seating comfort and the forces imposed on the body through the seat most be a major engineering concern in order to provide comfort; hence, better performance and efficiency for and by the operator. The operator seating position during operation has a direct effect on his comfort directly related to the seat angles of backseat and the seat-pan segments.

In their study Nawayseh and Griffin (2005) evaluated the seat angle effect on the superficial forces during vertical vibration and found that a seat-pan degree over 15 in the vertical apparent mass has insignificant effect while showing significant effect on the horizontal apparent mass.

Nawal and Griffin (2007) studied the back-fort vibration amplitude through the backrest of the seat and found that by increasing the backrest angle from 90 to 105 deg back-fort movements due to vibration especially at 4 to 8 frequency in addition to an increase in seat-pan degree from 10 to 15 increases the amplitude.

Mansfield and Griffin (2002) compared different seating postures and reported that at all postures the vibration magnitude is uniform around the body and no position reduces the pressure exerted on the pelvis in a significant manner.

The body position while set in subject to different factors: the seat, its design and the moves that body makes. People who spend most of this time sitting are exposed to back pain 30% more than others (Boggs, 2004).

Most equipment (vehicle) operators of any sort suffer from back pain which is mostly caused by the vibrations during the vehicle movement. In many studies where body vibration is studied the results indicate a direct and positive relation between exposure to vibration and back pain of any kind. An increase is reported in the risk of being subject to back pain among tractor, truck, Crain, bus and other heavy and light equipment (vehicle) operators (Lings and Leboeuf-Yde, 2000).

The relation between operator comforts in vehicle seat and the whole-body mass vibration and magnitude are coded in ISO (1997) where it is indicated that if two vibrating objects have similar mass magnitude frequencies, then both would have the same discomfort rate.

Some of the recent studies have focused on the point that operators subject to whole-body vibration on a random manner even with uniform mass magnitude frequencies, according to ISO (1997), receive different frequency spectrum (Maeda et al., 2008).

Nevertheless, most of the studies in this respect make a reference to the ISO (1997).

Studies evaluating the body vibration due to operating/driving through simulation and computerized modeling in the recent

* Corresponding author. Tel.: +98 3832324401; fax: +98 3832324428.
E-mail address: Malekia@iran.ir (A. Maleki).

http://dx.doi.org/10.1016/j.compag.2016.02.025
0168-1699/

decades have expanded and improved making it possible to predict the forces and displacements at the body-seat interface in different postures.

In this sense, the FEM is adopted to evaluate the interaction between seat-operator functions. Grujicic et al. (2009) studied the contact pressure, shear contact stress and body tensions at body-seat interface and their effect on the passenger automobile seat comfort.

Siefert et al. (2008) simulated the static and dynamic effects on operator seating comfort through FEM and found that the static effect corresponds to non-linear geometry due to the big displacement on the seat cushion caused by operator's mass force.

According to the findings above this issue is the major concern and this study concentrates on the comfort in the farm tractor operators' seat by considering the degree of the backrest and the seat-pan. For this purpose different anthropometries undergo FEM at four vibration magnitudes in a determined frequency range on MF 285 tractor seat. By comparing different seat sets up at designated degrees the appropriate angles are found to increase operator comfort.

2. Method and material

The method here is description comparative where FEM is adopted and for simulation the ABAQUS 6-10 software is used. For the validity of FEM, the results obtained from output vibration magnitude accelerometer. To determine a proper range of degrees, the results obtained from vibration magnitude at different degrees by FEM in the SPSS, version 14 are evaluated.

2.1. The stress distribution at body-seat interfaces

Pressure distribution differs at different body interfaces' contact points. To find these points at backrest and operators' back a pressure map is obtained by installing sensors on the operator's seat's backrest at the body-seat contact points to record the exerted pressures.

The data by Naseri (2011) regarding the pressure map (Fig. 1) is used in this study. The numbered contact point marks on the seat-pan makes in Fig. 1 are described as: MO1, tail bone, MO2 and MO9, the horizontal shoulders to keep the soft parts of the hip sides-MO3 and MO4, the buttocks- MO5 and MO6, the back side of the thighs-MO7 and MO8, the back side of the knees. These points are covered by 256 sensors.

The same procedure is adopted for the seat backrest where 9 contact points are selected (Fig. 2), (Zenk et al., 2006). These

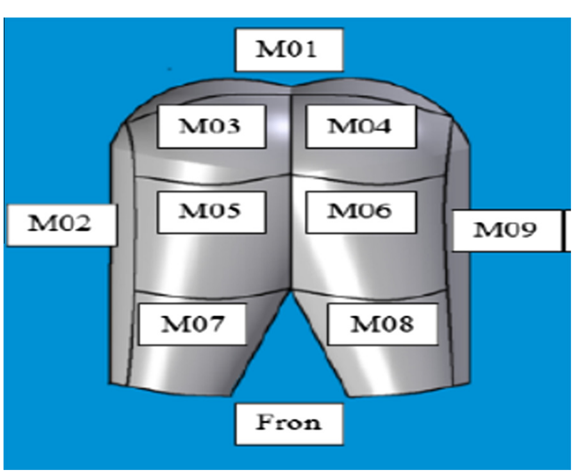

Fig. 1. Body seat-pan contact points (Naseri 2011).

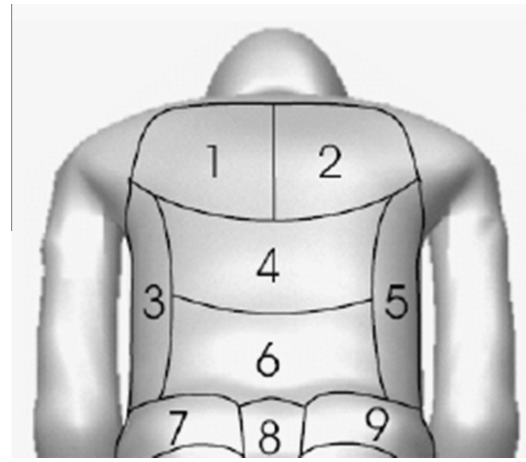

Fig. 2. Body-seat backrest contact points (Zenk et al. 2006).

contact points are described as: BP1 and BP2, the back shoulders-BP4, the upper back portion-BP6, the middle and the lower back portion-BP8, the section above the tail bone-BP7 and BP9, above the pelvis and BP5 and BP3 are the vertical wings.

2.2. The variables used

One of the main variables here is the changes made in the selected degree of the back rest as 0, 5, 10, 20, 25 and 30 deg (vertical) and the seat-pan as 0, 5, 15 and 20 deg (horizontal).

The selected operator weights are 55, 70 and 85 kg. For simulation the input data of: stress forces, material property limiting conditions at 4 vibration magnitudes of 0, 5, 1, 1.5 and 2 m s^{-2} in 3–66 Hz range are considered.

2.3. FEM

The operator seat with different angles is simulated in ABAQUS software. The Dynamic Explicit analysis is performed through the data obtained from the body- seat contact points, where, alternate time is selected as 0.3 in relation to the least frequency implemented on the seat system.

The modeling consists of the four segments of the seat: seat-pan, backside, seat skeleton and the seat-base. These are defined in the 3D. Deformable form in four-node first-order tetrahedron solid finite element (C3D4).

The seat skeleton steel material properties are determined by Young modulus of 200 GPa, Poisson coefficient of 0.3 and 7900 kg m^{-3} density. Poly-urethane foam is used as the hyper elastic material resembling the actual seat. The hyper elastic has non-linear compacted physical properties as a tensile energy potential function presented by Eq. (1).

$$W = \sum_{i=1}^{N} 2\mu_i/\alpha_i^2 \left[\hat{\lambda}_1^{\alpha_i} + \hat{\lambda}_2^{\alpha_i} + \hat{\lambda}_3^{\alpha_i} - 3 + \frac{1}{\beta_i}\left(\left(J^{el}\right)^{-\alpha_i\beta_i} - 1\right)\right] \quad (1)$$

According to Eq. (1), the Ogden equation is used in analyzing the non-linear proportion of the foam used in the tractor seat. The coefficients of Mircheski et al. (2010), are defined as the tensile energy function of second degree ($N = 2$) and the parameters of temperature as (α_i) and (μ_i) where the initial sheer modulus (μ_1) and (μ_2) are 18.3 and 0.21 kPa, respectively and the standard material coefficient (α_1) and (α_2) are 18.4 and −2 (no-unit) respectively. The appropriate coefficient with compaction rate of the foam (β_1) and (β_2) 0.4 and foam density of 50 kg m^{-3} are considered here.