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Effect of Suspension Parameters on Vibration Exposure

Wang Peng*

Department of Environmental Sciences, University of Rome, Cracovia, Rome, Italy

***Corresponding author:** Wang Peng, Department of Environmental Sciences, University of Rome, Cracovia, Rome, Italy. E-mail: liujia@gmail.com

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Description

Sleeping in India is the largest manufacturer of farm equipment like tractor, harvester and tiller. It accounts one third global tractor production. Tractor sale in the country is expected to increase 11-13 per cent in the financial year 2019 while the tractor industry is expected to grow at 8-10 per cent during 2019-23. In the country, the agricultural tractors used for different farm operations starting from land preparation up to harvesting and transportation of agricultural products. Due to this various types of random vibrations, generated from terrain and tractor engine, is transmitted to the operator through seat suspension. Most of the tractors available in India are attached with a passive type vertical seat suspension which is found to decrease vibration in vertical direction. Many research works have been done in optimization, modification of the seat suspension parameters alone and development of new seat suspension. But none of them optimize the seat suspension parameters in combination. Hence, the following study was conducted to determine the optimized value of seat suspension parameters for which the vibration transmitted to the operator could be minimum. For this a seat suspension model was developed in AME Sim software.

Selection for Modelling

The model requires input signal which was tractor seat mounting vibration data and gives the model output data as seat cushion vibration. When the model output data was compared with the test result data for the same vibration input, it was found to have 77.93 per cent correlation. The optimization result of seat suspension parameters alone, spring stiffness of 12000 N/m damping coefficient of 4225 N.s/m was observed to have minimum vibration. While optimizing both the suspension parameters, the combination of 3000 N/m and 2225 N.s/m was found to have minimum vibration. However, it was only 10.79 per cent less than the measured vibration value which might not be an economical decision though there is reduction in vibration. India is one of the largest manufacturers of farm equipment like tractor, harvester and tiller. It accounts for one third of total global tractor production. Tractor sale in the country is expected to increase 11-13 per cent in the financial year 2019-2020 while the tractor industry is expected to grow at 8-10 per cent during 2019- 23. In the country, the agricultural tractors are mainly used for tillage operations, seeding and planting operation, spraying and fertilizing operation and transportation of agricultural goods as well as people in the country.

The tractor operated machines and equipment used in farming generate vibrations which are more detrimental than the physical work to generate fatigue and discomfort in operators. These vibrations, generated from the engine and ground surface, are transmitted to the operator through seat suspension system attached in tractors. The modern days' high power agricultural tractors are equipped with suspension at front axle, rear axle, cabin and at seat. However, in most of the Indian tractors due to its lower rated power (less than 55 hp), fitted with passive type seat suspension system which is less costly as compared to other off-road vehicle seat suspensions. This type of seat suspension has two springs attached in parallel and a damper in series. It is a vertical type suspension system and its effectiveness to reduce vibration depends on operator weight and spring stiffness adjustment. The vibration in the frequency range of 2-6 Hz was reported to be most harmful for the operator due to resonance of different body parts. Hence, the seat must be designed to lower the vibration within these ranges. A study was conducted to analyse the SEAT (Seat Effective Amplitude Transmissibility) value of different tractor seats with discomfort value when a subject was exposed to vibration in the frequency range of 0-50 Hz. The result confirmed that corresponding frequency for highest SEAT value was observed to be 2.5-6 Hz. Exposure of occupational whole body vibration for longer duration resulted in low back pain and other degenerative pathologies among the tractor operators.

Suspension Parameters

There is no definite relationship between amount of vibration and risk disorder. However, it was concluded from some research work that the vibration resulted in micro-damage of intervertebral disc and eventually resulted in lower back pain. Lienhard et al. conducted a study on lower limb activity and reported that it was directly and strongly related to whole body vibration exposure. McCann et al. conducted research on vibration exposure from platform and found that excessive dynamic loading induced by repeated vibration exposure resulted in knee injuries. Many research works have done on measurement and reduction of vibration in vehicle level. Paddan and Griffin conducted a research work on vibration measurement of different vehicles including tractors. The vehicles were operated on standardized track and the mean vibration values were reported along with the standard deviation. However, it was not possible to conclude that the deviation was due to the influencing factors like vehicle speed, terrain or operators weight, posture and movement. Pinto and Stacchini investigated on uncertainty in whole body vibration exposure. The source of uncertainty was machine type and work rest cycle. Rakheja et al. evaluated the whole body vibration exposure with different seat setups like variation in seat height, backrest inclination and pan angles with different hand position. The seat pan height was observed to have higher vibration response whereas the seat pan orientation was found to have negligible effect. Toward and Griffin observed that the transferred vibration to the operator through seat suspension depends on seat impedance and seat occupant apparent mass. Many research works have done on effect of damper in seat on whole body vibration exposure. Zohu and Griffin verified damping capacities of seat through vibrating bench in laboratory condition. Some researchers found that the damping was effective only in vertical direction and it had negligible effect on horizontal and longitudinal vibration reduction. Langer analyzed occupational whole body vibration exposure experimentally on agricultural tractors and

observed that the longitudinal dynamics has greater effect on vibration during downward movement of 4WD tractors. Most of the tractor vibration related studies from the reviews was found to be confined to tractor dynamics, working posture of operator, effect of seat suspension damper or spring alone on whole body vibration exposure and health effect of vibration. Therefore, it is of great interest to analyze the effect of combined seat suspension parameters on vibration reduction. To analyze the effect of different combination of seat suspension parameters on transmitted vibration to the operator. The hypothesis behind this study is the model output data and measured data would be significantly and positively correlated. The final hypothesis is that though there would be difference in transmitted vibration for different combination, but they were not significantly different.