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EVALUATION AND ANALYSIS OF OCCUPATIONAL RIDE COMFORT IN ROTARY SOIL TILLAGE OPERATION

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Abstract

The present study investigates the effect of tractor ride conditions like forward speed, pulling force and tillage depth on overall vibration total value (OVTV). Taguchi's L_{27} orthogonal array was used to conduct experiments on post-harvested paddy field. Response Surface Methodology (RSM) was utilized to obtain linear and quadratic predictive models that can be used to optimize the ride conditions for minimizing OVTV. The magnitude of overall vibration total value varies from 0.727 to 0.913 m/s^2 among all the experiments. Analysis of variance (ANOVA) shows that forward speed and pulling force are significant at 5% level. The percentage contribution of forward speed, pulling force, and tillage depth is found to be 76.249%, 21.174%, and 1.794%, respectively. Suitable ride condition with respect to forward speed, pulling force, and tillage depth is 0.6 m/s, 6 kN, and 0.14 m, respectively. The calculated response of linear and quadratic regression models show 1.747% and 1.224% error, respectively. The quadratic regression model is found to be the best suitable with 93% desirability.

Keywords: Agricultural tractor; Ride comfort; Overall vibration total value (OVTV); Taguchi's method; Response surface methodology (RSM); Regression model

1. INTRODUCTION

Improvement of occupational tractor ride comfort during rotary soil tillage operation is the key activity of the present study. The window period required for two major crops like wheat and paddy needs to be shorter for speeding-up the productivity [1]. Moreover, a large amount of energy is needed for certain activities i.e. cultivation for seedbed preparation and harvesting which necessitates the use of mechanized operations instead of human labor. Nowadays, conventional methods of land preparation have been replaced by mechanized tillage operation due to mainly a reason for providing the required quality of work in reduced time. Tillage is the mechanized agricultural operation of soil manipulation for developing optimal conditions of crop growth. Every agricultural field passes through a number of soil tillage operations after harvesting to prepare desired soil conditions for the sowing of next crop. It is very difficult to prepare a seedbed for the wheat crop on a paddy harvested field due to deep cracks and formations of clods. It may turn out to be a very challenging task to carry out tillage on such a hard field. Therefore, the farmers prefer rotary tiller to overcome this critical issue for the preparation of field in considerably less time and efforts. The rotary tillage operation is performed by using tractor mounted rotavator (rotary tiller) affixed to a shaft that is driven by a three-point linkage system of a tractor. It comprises different types of blades mounted on flanges as shown in Figure 1.

Figure 1. Representation of Rotavator Blades

These blades are operated by rotating the shaft, and the rotary motion tends to cause smashing of clods and overturning of soil to mash up with manures or fertilizers for the improved sowing of crop. The use of rotavator increases rapidly due to its versatility in performing better tillage quality [1]. Tractor and its operated machinery cause vibratory motion while making interactions over uneven terrains [2]. This vibration is transmitted to the operator's body through seat pan, backrest or floor which may affect the human ride comfort [3, 4]. Most important factor influencing towards ride comfort is low vibrating frequencies between 1 to 10 Hz [5]. Usually, tractor operators work under the exposure of whole body vibrations with low frequency [6]. Kumar et al. [7] reported that the tractor ride becomes more critical due to dominant natural frequencies (1-7 Hz) lie within the most critical frequency range of the human body (4-6 Hz). These frequencies may cause a high risk of musculoskeletal disorders especially in the back region of tractor drivers [1]. Moreover, the risk of low back issues is found significant among occupational drivers due to whole body vibration exposure [8, 9, 10]. Boshulzen et al. [11] indicated that occupational low back issues are predominant among tractor drivers. This is due to high amplitude vibration exposures during various off-road activities [5].