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THE FARM TRACTOR: IS IT WORTH IMPROVING THE RIDE?

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INTRODUCTION

The farm tractor of today has evolved as the result of a progressive series of developments. These have included increase in power, in the tractive efficiency of the wheels and tyres and in the capacity to power additional machinery and implements. Most recently the developments have been related to the safety and comfort of the driver. He has been given a safety cab to protect him in the event of an overturn, to protect him from the weather and to reduce the effects of engine noise and he has heating, ventilating and improved access and control layout. But first of all he was given a seat with a suspension mechanism to reduce the effects of low frequency vibration and shock in off-highway driving. However, that was 20 years ago, and many farmers are asking for further improvements in ride. Unfortunately, no improvement is likely to be made without a substantial change in tractor design, which could add 10% to 20% to the cost price. Farmers have been willing to pay for all of the improvements so far, but if they are to be offered a better ride, then they must be shown the benefits to justify that price.

Tractor ride has been studied at NIAE since the introduction of the suspended seat. Work has been directed mainly towards the measurement of vibration and its prediction through simulation. A fully suspended drivers cab was built and showed that ride improvements of 50% and more were possible, but the cost and complexity appeared too much for industry to take it up. More recently we have been working on a rather simpler modification and the work reported here covered preliminary field trials which showed the potential of ride improvement of up to 25%, together with the first set of drivers' responses. The way in which the field trials were designed to show the effect of ride improvement on work rate is outlined below.

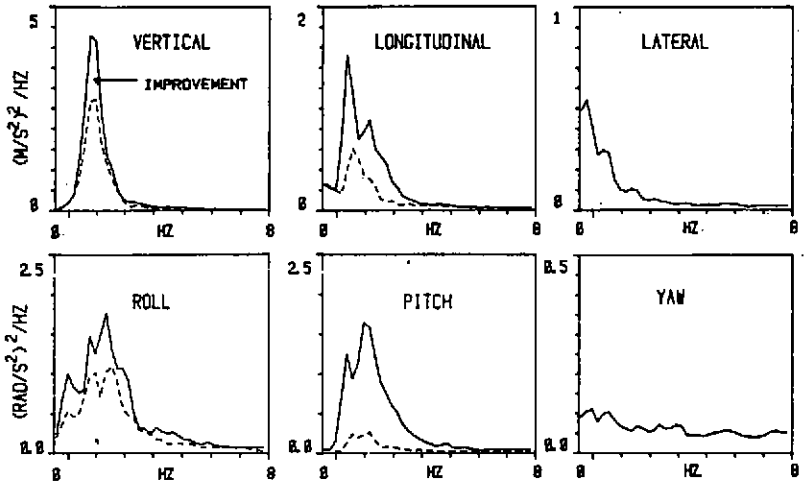

Fig.1. Tractor ride vibration psd functions, disc harrowing at 8.5 km/h, showing improvement resulting from the modification

FIELD TRIALS - EXPERIMENTAL METHOD

Operating conditions

Six operating conditions were chosen, all of which are normally carried out at relatively high forward speeds:

1. Twin gang disc harrow
2. Rear mounted drum mower
3. Mounted sprayer
4. Plough in transport
5. Two wheel trailer
6. Four wheel trailer

Vibration measurements

Vibration was measured for each task for a range of operating speeds. Six accelerometers were mounted at the seat attachment point, and their outputs combined to give signals representing vertical, lateral and longitudinal motion together with pitch, roll and yaw. Two to three minute samples were recorded for each task and analysed to give frequency power spectral density (psd) functions which were then modified by weighting functions chosen to take account of human response to vibration. The weighting functions were those proposed by Griffin et al of the ISVR [1]. The weighted psd functions were integrated, and combined to yield total weighted rms values in units equivalent to vertical acceleration at 10 Hz.

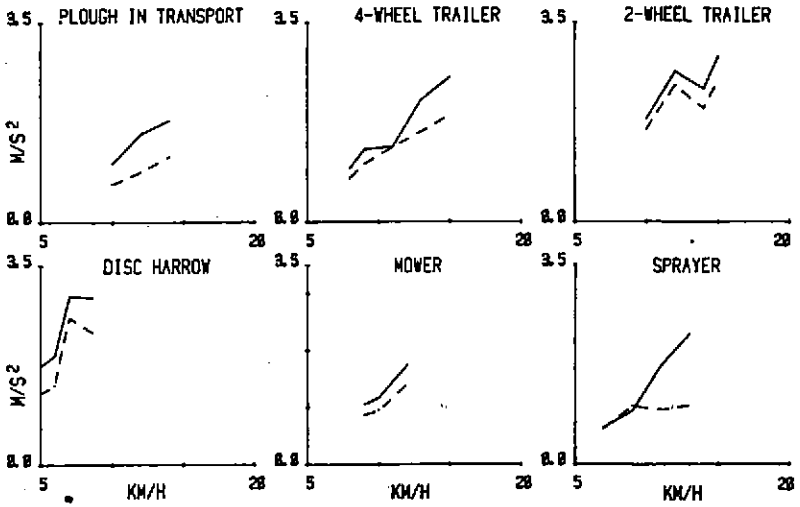

Fig.2. Effect of forward speed on overall vibration level, 6 components combined (see text)
——— standard - - - - - modified

Subjective assessment and working speed

Nine tractor drivers were presented with the tractor in standard or modified conditions selected at random, and asked to set their own working speed. They were allowed a period of at least 20 minutes, at the end of which their speed was noted and their subjective assessment obtained on rating scales. The tractor condition was then altered and the drivers asked to continue working at the same speed as before. After a few minutes they completed a second set of ratings and ranked the two rides. Ratings were made on a 10 cm line whose end points were marked "very uncomfortable" (0) and "very comfortable" (100). This method was used so that any improvement would be reflected naturally in the working speeds which the drivers chose.

VIBRATION - THE OBJECTIVE RIDE IMPROVEMENT

Tractor ride comprises shocks and vibration which are restricted to narrow bands of low frequency. Fig. 1 shows typical acceleration psd functions for one field operation, for both the standard tractor and the modified condition. The overall, weighted levels for the full set of field conditions are shown in Fig. 2, from which it can be seen that the improvement ranges from nil to 100% with a mean for all conditions of just over 20%.

SUBJECTIVE ASSESSMENT

The ranking questions gave 100% response in favour of the modification. The overall rating varied between 0 and 72 for the standard tractor and between 28 and 97 for the modification. For any pair of ratings the difference was always positive. Table 1 shows how the mean values varied with tractor and task. Using the drivers as replications, the difference between tractor and modification is significant at better than 1%, and that between tasks at better than 5%. This compares with vibration differences which are significant at better than 1% for both effects.

Table 1. Subjective ratings, mean values for all drivers (100 = very comfortable)

Tractor \ Task	Mowing	Plough in Transport	2 Wheel Trailer	4 Wheel Trailer	Tractor mean
Standard	34	36	25	36	33
Modified	72	80	52	60	66
Task mean	53	58	39	48	49

OPERATING SPEED

There are only half as many results for operating speed as for subjective assessment of comfort. These are too few for any useful statistical inference as the range for the different tasks is very wide. In addition, some drivers chose their speed to suit the implement (in the case of the mower). Speeds for the standard tractor ranged between 7 and 18 km/h with a mean of 12.6 km/h, while for the modified tractor the range of speeds chosen was 7 to 30 km/h with a mean of 14.4 km/h. This represents an improvement in the means of 14%, but further trials are needed to support it.

CONCLUSIONS

We have devised a modification which improves the ride of conventional farm tractors by an amount which is reliably detected by the drivers. Preliminary trials suggest that it may bring a useful increase in work rates. The results so far justify further development so that farmers can see for themselves that the improvement in ride is worthwhile.

REFERENCE

[1] M.J. Griffin et al, "Vibration and comfort. IV. Application of experimental results", Ergonomics, Vol. 25, no. 8, 721-739