Assessment of comfort conditions of an agricultural tractor during operations with trailers

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Abstract

The growing interest in researches on comfort of agricultural tractor operators has conducted the CRA-ING Research Laboratory of Treviglio to define the main critical situations for the drivers.

In the frame of the Vibramag Project (Evaluation and control of the vibrations of agricultural vehicles through analysis methods based on four-post test bench) the CRA-ING has evaluated the influence on operator's comfort on a tractor with trailers and wagons in various work and transport conditions.

Tests were replicated on field and on road. An instrumental chain based on two triaxial and four monoaxial accelerometers was used for evaluating the ride comfort index (CI).

Results have shown that the forward speed and the type of trailer were the most important factors affecting driver's comfort.

On test track, the CI values obtained from tractor and tractor plus wagon were very similar validating the proposed methodology. The adoption of the trailer causes, generally, lower values for the higher weight of the tractor but higher level for the resonance of the trailer tires at certain speeds (27 – 30 km/h).

On grassed field for better understanding the discomfort values is necessary to analyse the values of the single axis. In example, the value at 12 km/h with trailer the contribute is almost completely from back X axis to indicate the hits of the implement at the hitch.

This first approach has confirmed that trailers have a great influence on operator's comfort. Beside, actual manufacturer technical solutions confirm the interest on this way to reduce the effects of trailers on tractor.

Keywords: vibrations; transport; trailer; safety.

Introduction

The researches on comfort of agricultural tractor operators have conducted the CRA-ING research unit to investigate the critical situation for the drivers (EEC, 2002). The evaluation of the real work condition is one of the most followed ways to define comfort and to define the conditions that engineering will have to approach.

Road and/or soil irregularities and forward speed are the most important parameter that influence the vibrations transmitted to the driver (Bukta *et al.*, 2002; Kornecki *et al.* 2006; Cutini *et al.*, 2007), but also mass distribution and implements could characterise the results.

The CRA-ING Research Laboratory of Treviglio in the frame of the Vibramag Project (Evaluation and control of the vibrations of agricultural vehicles through analysis methods based on four-post test bench) has evaluated the influence on operator's comfort on a tractor with different trailers in various work and transport conditions.

Materials and methods

The guidelines followed for this work were established by the ISO 2631/1997. Tests aimed to evaluate the ride comfort index of the driver measuring the accelerations at the three axis of the back and of the seat and the values of the pitch and of the roll.

A 4WD tractor fitted alternatively with a trailer and a wagon has been used (fig. 1).

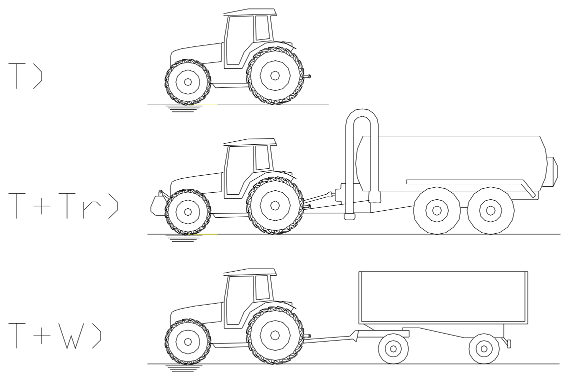

Figure 1. The tractor-trailer/wagon configurations adopted

The settings for the tests are reported in tables 1 and 2

Table 1. Vehicles' masses

	Weight (kg)		
Agricultural tractor * with trailer and front ballast	Front	1825	1755*
	Rear	1465	2685*
Wagon		6750	
Trailer		6800	

Table 2. Vehicles' main settings

Vehicle	Front tires (type)	Rear tires (type)	Inflate pressure (kPa)
Tractor	380/70R20	420/85R28	160 on track 100 on field
Wagon	11.5/80-15.3		120
Trailer	14.00R20		120

Tests were carried on the asphalt ring of the 1050 m test track of the CRA-ING Laboratory and were replicated on a grassed field.

An instrumental chain based on two triaxial and four monoaxial accelerometers was used during the tests for evaluating the ride comfort index, completed with a sixteen channels data recorder. The tractor was tested at different forward speeds for taking into account tires' influence both on grassed field and on track. The chosen speeds were:

- Test track: 27, 30, 33, 36, 39, 42 km/h
- Grassed field: 6, 9, 12 km/h

Results

The comfort index was evaluated taking into account the vibrations at the seat, at the back and at the rotational pitch and roll axes. Results have shown that the forward speed and the type of trailer were the most important factors on tractor behaviour and, consequently, on its influence on driver's comfort (fig. 2).

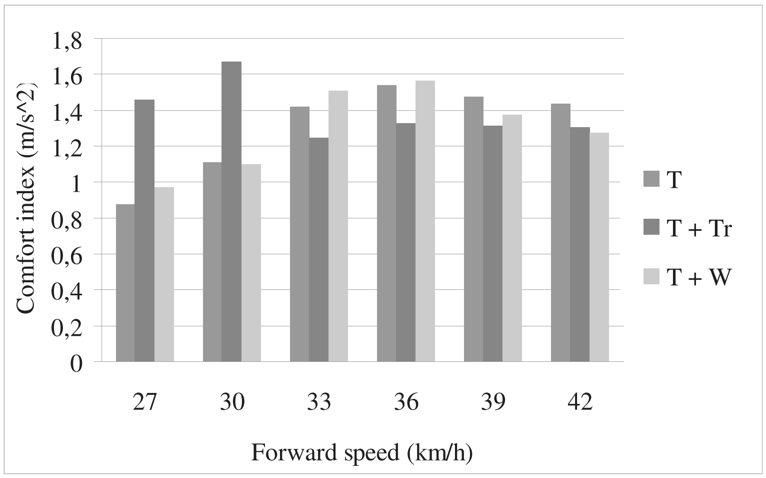

Figure 2. The comfort index (rms) during transfer on track at different forward speed

The value of the tractor alone (T) is the reference compared with the adoption of wagon (T+W) and of the trailer (T+Tr). It's interesting to note as on test track the values of T and T+W are very similar validating the methodology. The adoption of the trailer causes, generally, lower values for the higher weight of the tractor but higher level for the resonance of the trailer tires at certain speeds (27 – 30 km/h).

For better understanding the results on track, it's possible to analise the values at the seat and at the back. The analisys of the values at the seat shows a similar trend (fig.3).

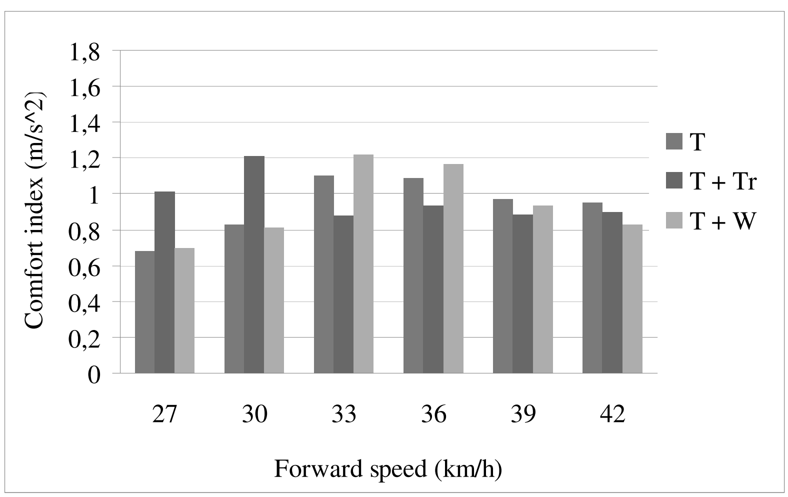

Figure 3. The comfort index (rms) during transfer on track at the seat

Beside, the analysis of the single channels shows a different situation; infact, looking at the longitudinal axis (seat X), for the T and the T+Tr the values are very low but is not negligible for the the configuration T+Tr (fig.4).

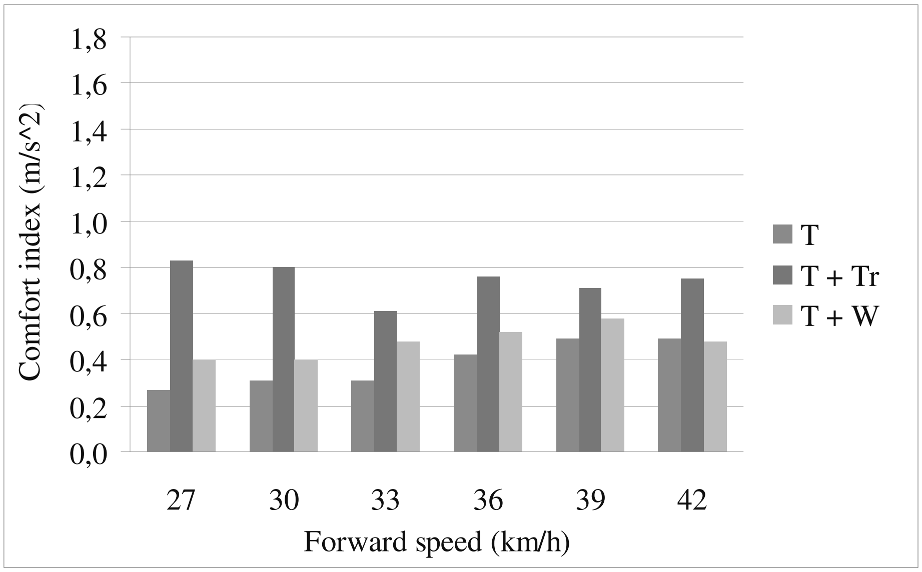

Figure 4. The comfort index (rms) during transfer on track at the seat X

Quite different is the analysis at the vertical channel of the seat (seat Z) where is negligible for the configuration T+Tr and has a great contribute for the T and T+W configurations (fig.5).

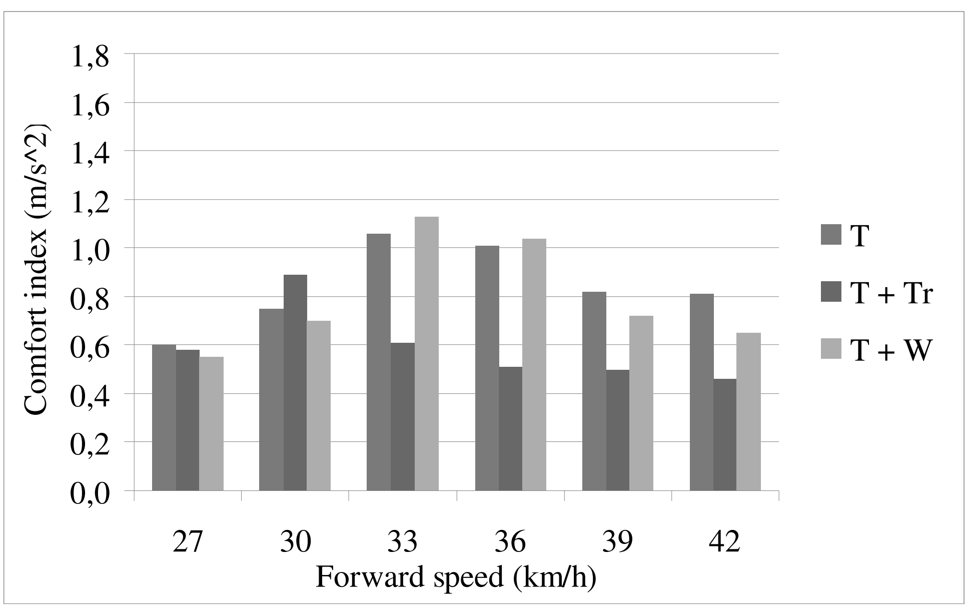

Figure 5. The comfort index (rms) during transfer on track at the seat Z

Very similar to the data recorded at the seat are the values obtained at the back (fig.6) but analysing the single channel it's possible to see as almost all the contribute is from the longitudinal channel (back X, fig.7).

The values at the single channel are not weighted, so they could result greater than the CI.

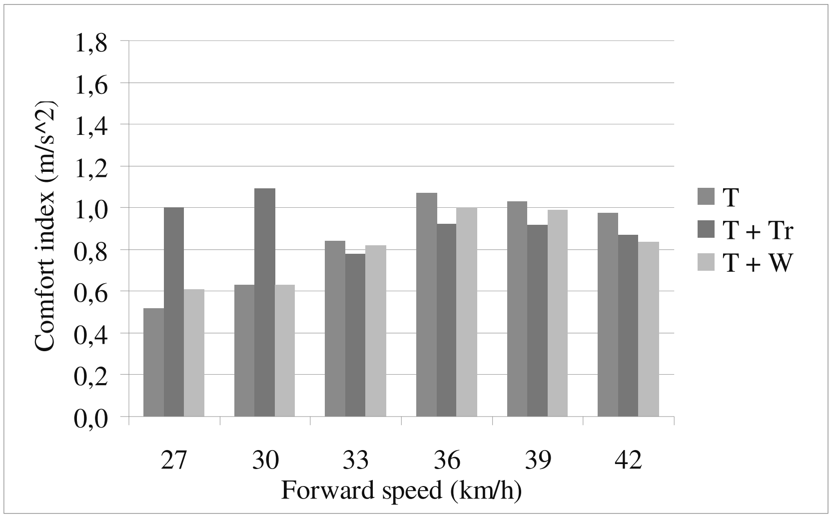

Figure 6. The comfort index (rms) during transfer on track at the back

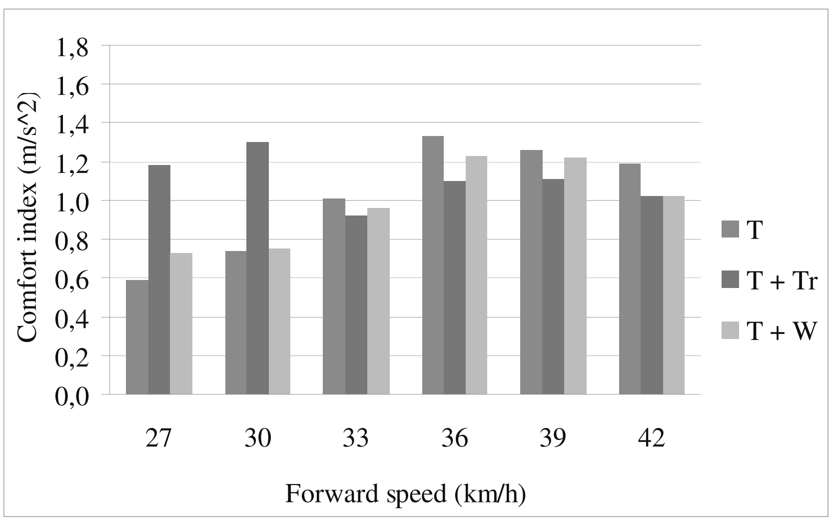

Figure 7. The comfort index (rms) during transfer on track at the back X

On grassed field the situation results very different (fig.8) and, for better understanding the discomfort values (i.e. T+W, 12 km/h), is necessary to analyse the values of the single axis.

Generally, the discomfort is always increasing with speed.

During test with T+Tr, is still present the resonance frequency at certain speed, i.e. 9 km/h.

Tests with T+W give now different values from T, to understand which is necessary to analyse the single channels.

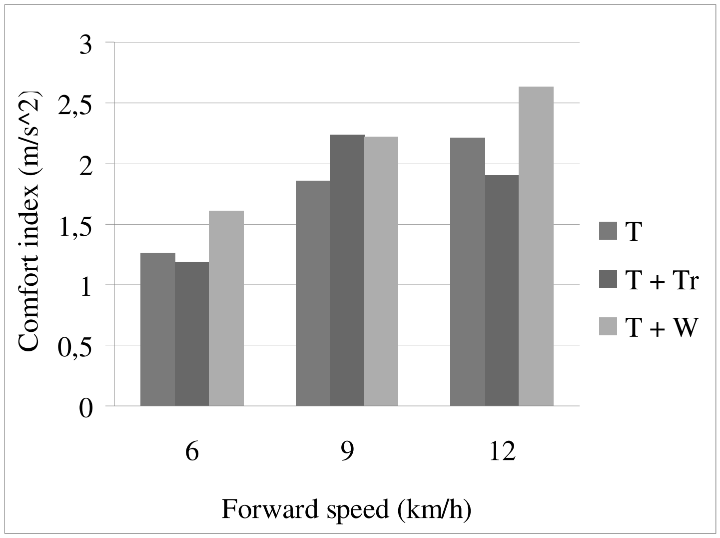

Figure 8. The comfort index (rms) during transport on grassed field

In example looking at the value at 12 km/h with trailer is interesting to note as the contribute is almost completely from back X axis (fig. 9) to indicate the hits of the implement at the hitch.

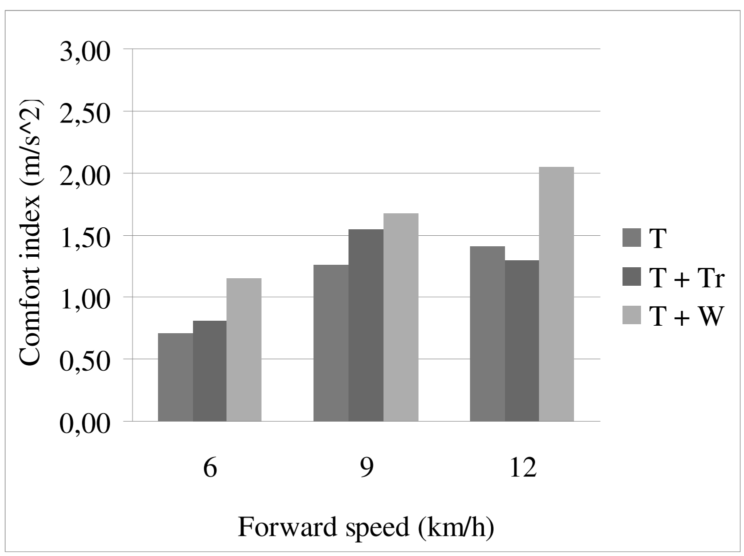

Figure 9. The comfort index of the X channel of the back during test on field

The same phenomena appears at the seat but the values are lower (fig. 10) .

The channel Y, not reported, has a sensible value only in test on field and at low speed and is not influenced from the convoy configuration.

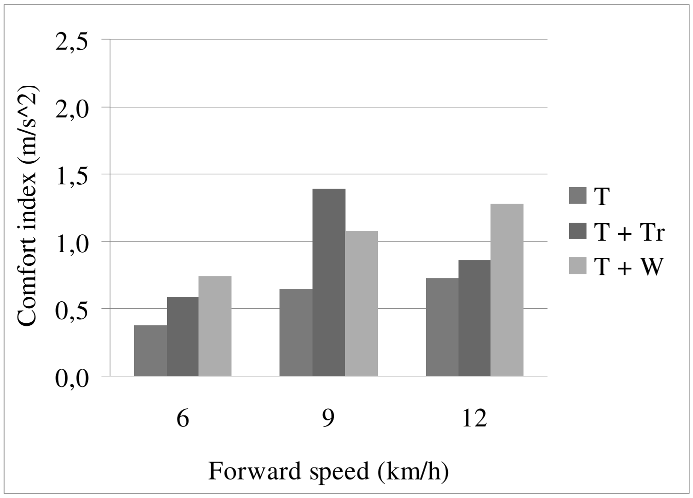

Figure 10. The comfort index of the X channel of the seat during test on field

Conclusions

This first approach has confirmed that trailers have a great influence on operator's comfort. Main factors are the resonance frequency of the trailer's tires and the effect on field on the longitudinal axis of the tractor.

Manufacturer in the last years have introduced several new technical solutions at the hitch to confirm the interest on this way to reduce the dynamic effects of trailers on tractor.

Acknowledgements

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