Andreas Herrmann and Peter Pickel, Halle, and Norbert Fröba, Darmstadt

Transport speeds of tractors

The effect of different rated top speeds

For optimised transport, models for procedural performance of machines are important aids. Here, the average transport speed represents an important parameter. In the last years rated top speed of tractors has been increased from 25 km/h to 50 and in individual cases up to 80 km/h. Reliable information on actual possible travelling speeds in transport work were not possible up until now. Procedural investigations were used here under conditions similar to those in farming practice to give speed values that can serve as the basis for calculations.

Prof. Dr.-Ing. Peter Pickel is director of the Institute for Agricultural Engineering and Rural Culture at the Martin Luther University Halle-Wittenberg, Ludwig-Wucherer Str. 81, 06108 Halle (Saale). Dr. agr. habil. Andreas Hermann was senior assistant at the same institute until August 31, 2000;
e-mail: pickel@landw.uni-halle.de
Dr.-Ing. Norbert Fröba is a member of the scientific staff at the KTBL, Bartningstr. 49, 64289 Darmstadt;
e-mail: n.froeba@ktbl.de

Keywords

Process capacity, transport speed, maximum speed determined by design

For the evaluation of transport-associated work procedures, an important criterium is the procedural performance in the individual work components. Most parameters for concrete operational conditions can be determined for the calculation of transport performance [1, 2]. However, it is relatively uncertain which value can be used for average transport speed. As a rule, values applied here come from older investigations, or are according to experience. These are based on rated top speeds for tractors of 30 km/h. Results on the effects of tractor-trailer length, gross weight and road surface condition on the average transport speed are not available in any complete form. Investigations to clarify this question were carried out.

Tractors involved

A Fendt Xylon 524 and a Unimog 1400 were available for this investigation. Apart from engine power, average transport speed was influenced through differing types of transmission and of engine characteristics.

The Xylon 524 has a model rated top speed of 50 km/h. By blocking the highest and the second-highest gear, model rated top speeds of 38.5 and 32 km/h were simulated. Thus, three different rated top speeds could represented without have to take into consideration the constructional effects of different tractors.

Trial methods

Among further influence factors on the average transport speed are the weight (as the most important), the length of the transport unit, the road surface properties and the transport distance.

Available as trailers were two HW 80.11 models which were loaded with 8 t of gravel in the load variants. During the load trials with the Unimog, this was loaded with 1.7 t of gravel. Speed investigations featuring implement transport were carried out with a three-furrow semi-mounted reversible plough.

The investigation took place on a round course (length 12.27 km) in the countryside north east of Halle (Saale) and this was divided into 15 sectors with very different conditions (road surface, road width, built-up areas) which were classified from the point of view of the expected average speed.

Rated top speed and vehicle gross weight

The proportion of time on the course spent in traffic-caused waiting time was, with 0.85% on average for all variants, small and was therefore included in calculations. As expected, where the possible top speed was higher, the average transport speed also increased. Covering all variants this was:

- 23.5 km/h in the 32 km/h section
- 27.0 km/h in the 38.5 km/h section
- 28.5 km/h in the 50 km/h section
- 31.5 km/h in the 80 km/h section

Giving more details is the material from the calculations on transport work from the variant tractor with two trailers (empty) and tractor with two trailers (full). The average speeds achieved here were:

- 23.0 km/h in the 32 km/h section
- 26.0 km/h in the 38.5 km/h section
- 27.7 km/h in the 50 km/h section
- 28.6 km/h in the 80 km/h section

The recorded speed values indicate that the calculations up until now for 15 km/h are no longer representative of today's conditions. One reason for the very much higher average lies in the higher specific engine power of 3.5 kW/t which is already very near to the total orienting power for tractors given in [3] of 4 kW/t. But also the technical further development of the tractors (power shift transmission, front axle suspension) had an important influence in these results.

A differentiated observation of the average transport speed shows that, with lower rated top speed, the effects of different gross weights on the average transport speed is small (*fig. 1*). With a top speed of 32 km/h the difference between the average transport speeds between the tractor solo and the operation of the tractor with two full HW 80 was only 11.0%. This difference continually increased with increasing top speed. In the 38.5 km/h section the difference represented 24.8%, in the 50 km/h section 28.9% and in the 80 km/h section 33.0%. The average transport speed with the variant tractor with plough moved in all speed sections between

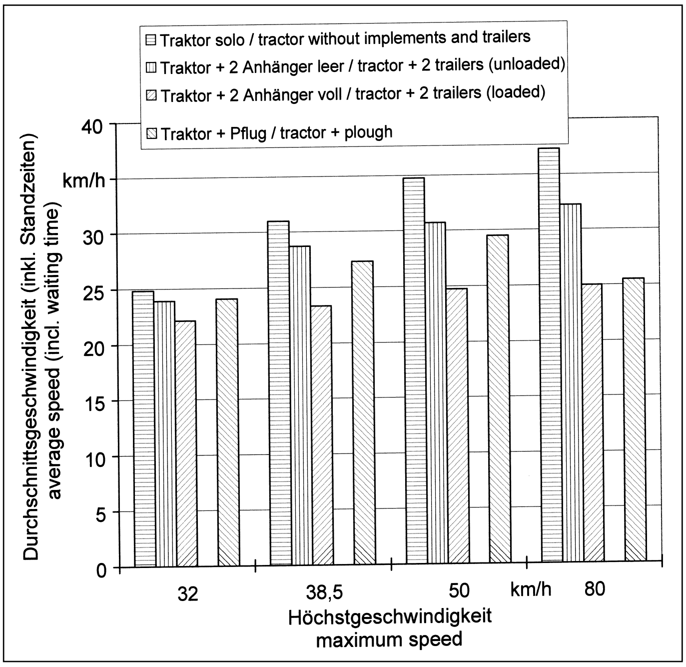

Fig. 1: Average transport (incl. laid-up time), depending on maximum speed determined by design

the variants "Tractor with two HW 80s empty" and "Tractor with two HW 80s full". With the Unimog and plough, the transport speed was, however, comparatively low. The reason for this was the driver's poor view of the implement. The result was cautious driving to ensure that nothing happened to the implement during transport.

With the same motorisation, an increasing rated top speed had the strongest positive influence on transport speed where gross weight was low. Where the vehicle gross weight is high, a higher rated speed offered hardly any advantage for the actual achievable transport speed. More powerful engines promote the expectation of somewhat higher speeds with high gross weight through better acceleration performance. Under the given conditions of the course an increase in the transport speed through the given road and traffic conditions had, however, objective limits.

Complex effect of variants

Moreover, for the solo and for the trailer variants calculating the complex effect through multiple regression gave the following parameters:

- Rated model top speed v_{max}
- Weight of transport unit m_{ges}
- Length of transport unit l_{ges}

As a result it was shown that the average transport speed for the course with parameter "Top speed v_{max}" and "Weight of transport unit m_{ges}" can be well described through:

((**Formel einsetzen**))

The length of the transport unit is not of decisive importance for the average transport speed. With both parameters "Top speed" and "Weight of transport unit" a coefficient of determination R^2 of 0.83 was achieved. For procedural investigations this can be estimated as high (*fig. 2*). It must be observed that the regression from the point of view of the statistic is only usable for the investigated value area (m_{ges} = 4600 to 29610 kg; v_{max} = 32 to 80 km/h). It can, however, deliver orienting values for tractors with different power output and other operational conditions.

Outlook

These trials analysed the effects on transport speed of important parameters. Finely detailed evaluation of the available data material also enabled the calculation of the effect of the road conditions on the average transport speed (not presented here). However, models for calculating the procedural performance only seldom show so high accuracy demand on the parameter transport speed.

In order to extend the statement area on average transport speed in a practical way, future investigations must pay attention to different motorisation of the tractors, uphill and downhill gradients and also different constructional design of certain parts, e.g., stepless transmissions.

During the investigation it became apparent that transport speed, as opposed to the working speed during harvest, is relatively dependant on the driver. However, the setting of standard speeds for certain "driver categories" in the future is not advisable.

Literature

[1] *Herrmann, A.*: Modellierung verfahrenstechnischer Bewertungskriterien bei unterschiedlicher Verknüpfung von Ernte- und Transportarbeitsgängen. Halle, Forschungsbericht Agrartechnik des Arbeitskreises Forschung und Lehre der Max-Eyth-Gesellschaft Agrartechnik im VDI, Nr. 335, Habilitation, 1999

[2] *Herrmann, A.* und *P. Pickel*: Transport performance – a result of complex influence factor coupling. Gießen, International Workshop Agricultural Transport vom 4. bis 6. Oktober 1999, Tagungsband S. 10 – 25

[3] *Fröba, N.*: Landwirtschaftlicher Transport. RKL-Schriftenreihe 3.0 (1999), S. 313-392

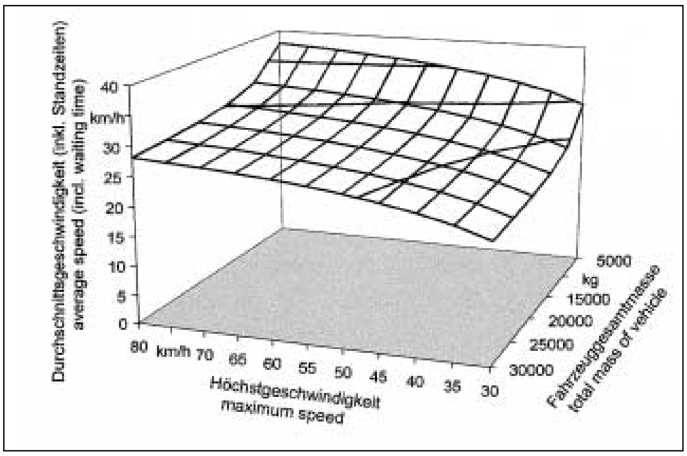

Fig. 2: Average transport (incl. laid-up time), depending on total vehicle mass and maximum speed determined by design