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Weight Detection in the Three-point-linkage and in Trailers

by

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SUMMARY:

Different sensor applications for the weight detection in tractor three-point-linkage and in trailers are presented. Their accuracy has been tested and is discussed and their integration in a closed loop system for environmental and yield oriented fertilizing is shown.

KEYWORDS:

tractors, trailers, weighing-systems, electronics, fertilizer

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INTRODUCTION

As environmental protection becomes more and more important to our society, agriculture has to look for future strategies to meet this new demand. Therefore, future plant production will be guided not only by botanic and economical, but also by ecological considerations.

One strategy with great potential for succeeding is to build up a closed loop system for environmental and yield oriented fertilizing. Its aim is environmental protection by stopping the export of non-consumed plant nutrients out of the soil. Economical advantages are connected with the resulting fertilizer savings.

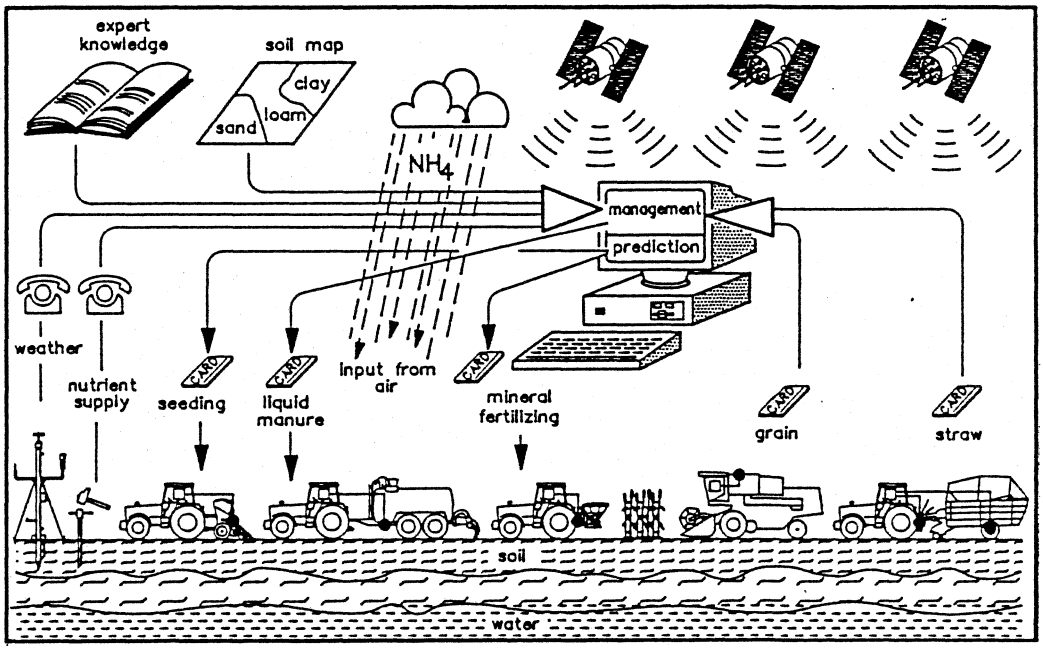

FIGURE 1: Closed loop system for environmental and yield oriented fertilizing

The shown loop was developed by AUERNHAMMER et al. and is explained in details in his paper (Paper No 911040). Some of the elements are already carried out like the network of small, electronic on-farm weather stations, others are still under examination. The problems of weight detection in three-point-linkages and in trailers have been solved, and now it is the task of the industry to offer weighing-devices for use in practice. Weight detection in the three-point-linkage is necessary for controlling the amount of distributed mineral fertilizer, in trailers it is used to get the exact weight of harvested grass, straw or corn-silage.

SENSORS

For weight detection on a tractor three-point-linkage or a trailer a wide range of sensors has been tested at the Institut für Landtechnik. They all are based on the technique of the strain gage sensors which transform stress in the construction into electrical signals.

Strain-gages for tension and shear forces have been used as well as ready to fit systems like load cells, tension receivers (strength sensors) as the MICROCELL from KISTLER MORSE or hermetically sealed strain-gage-sensors for drill-holes as the GOZINTA from REVERE. All trials were made with tractors or trailers not moving (static). The machines have been standing nearly horizontal, the gradient in both axles did not exceed 5 degrees.

To say something about the accuracy of the systems the 95 % confidence interval of all deviations between real load and measured weight (absolute or relative) is used as characteristic error.

WEIGHT DETECTION IN THE THREE-POINT-LINKAGE

METHOD AND MATERIAL

Twenty different sensor applications for weighing in the three-point-linkage have been tested on a 59 kW 4wd Tool-Carrier-Tractor.

Two major categories of weighing equipment can be distinguished:

A. The stand-alone systems, represented by the three-point-coupled scales

B. Integrated systems in the three-point-linkage for example sensor applications

for the hydraulic pressure,
for the rockshaft arms and
for the lift links.

While the accuracy of the stand-alone systems is not influenced by different positions of the three-point and different positions of the center of gravity of the load, these circumstances may have influence on the accuracy of the integrated systems. Therefore it is necessary to use for every weighing process the same height of the three-point-linkage as used for calibration. The influence of different center of gravity positions can be eliminated by holding upper and lower link parallel at the weighing position. Trials have be done up to a load of 2 tonnes.

All tested sensor applications and equipment for the weight detection in the three-point-linkage, stand-alone and integrated systems are show in the following figure.

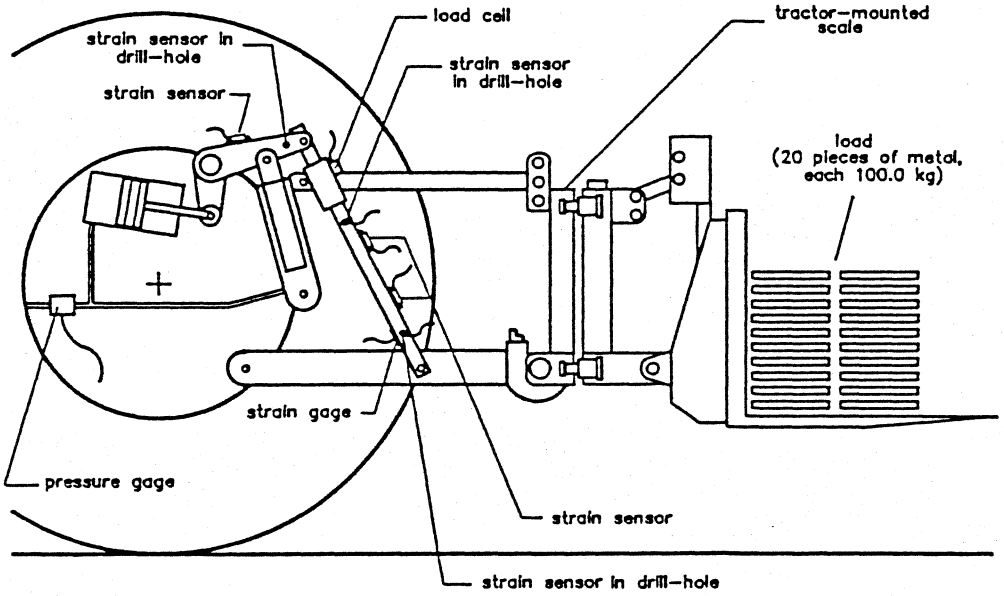

FIGURE 2: Different sensor applications for the weight detection in the three-point-linkage

RESULTS

Measuring the hydraulic pressures in the lift cylinder(s) of the three-point-linkages of different tractors as basis for weight detection has brought some good results but has also lead to unacceptable errors.

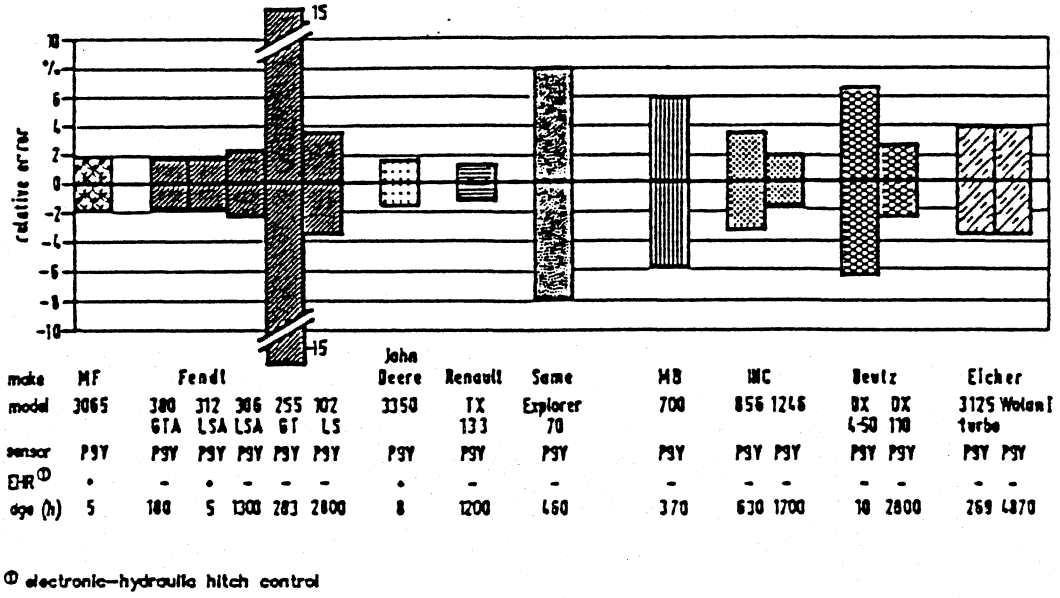

FIGURE 3: Confidence intervals of the relative errors for the weight detection in different tractors using the hydraulic pressure

Trials have shown that the hydraulic pressures react differently in each of the 16 tested tractors. There is no systematic connection between make, model, age or hydraulic system of the tractor and the accuracy of the system.

For the all tested weighing equipment the following course of the absolute errors in relation to the load is typical.

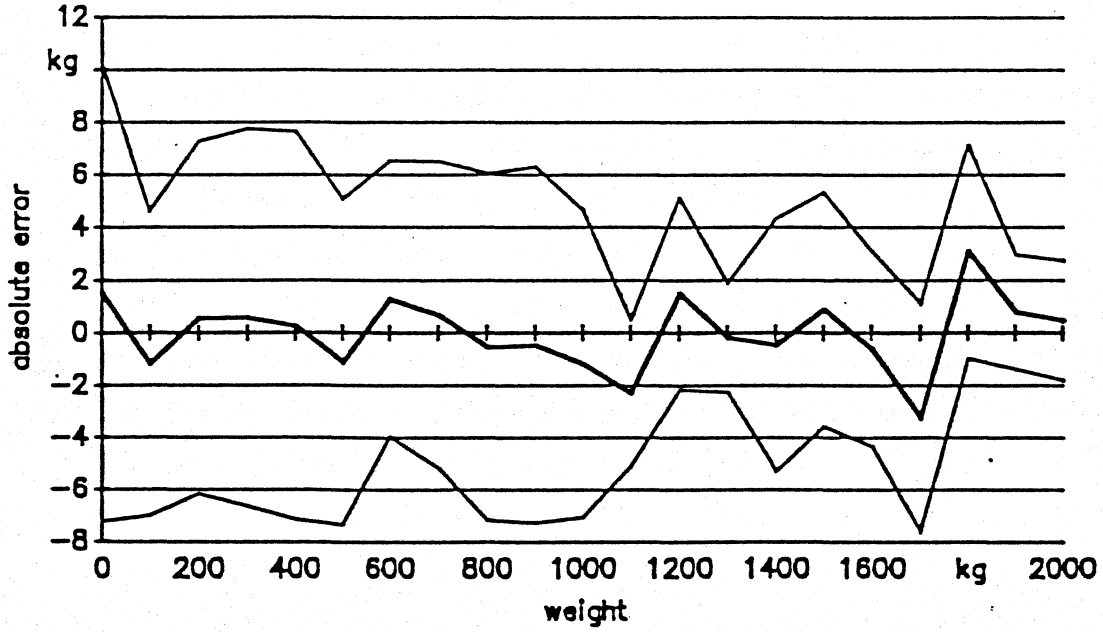

FIGURE 4: Absolute mean errors with 95 % confidence intervals for the weight detection in the three-point-linkage (GOZINTA in lift link)

As the absolute errors of all systems are nearly constant from the low load up to the high load these absolute figures are significant for the accuracy of the systems on the whole range of loads.

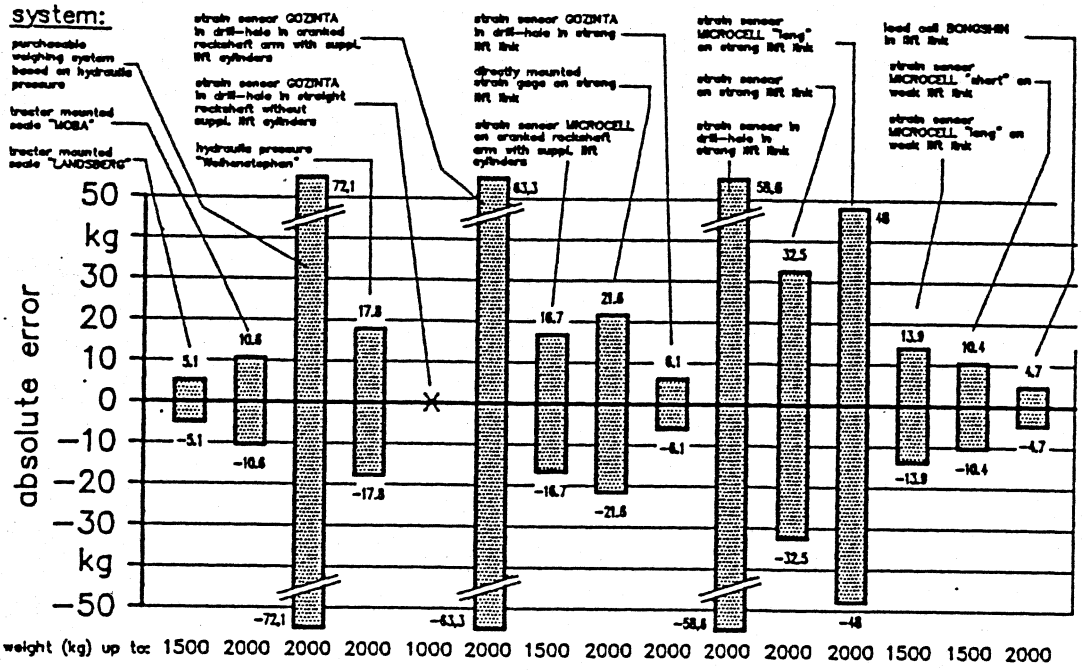

FIGURE 5: Confidence interval of the absolute errors for the weight detection in the three-point-linkage

In Figure 5 the absolute errors of all tested weighing systems are shown. The absolute errors of the nine "best systems" remain within a limit of +/- 20 kg.

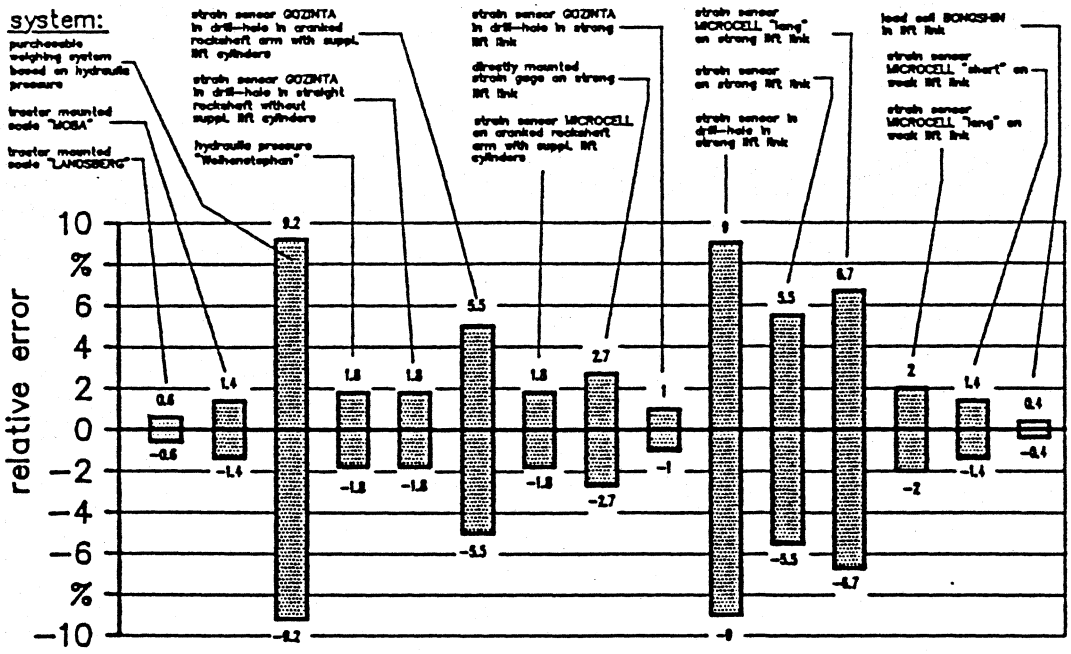

FIGURE 6: Confidence intervals of the relative errors for the weight detection in the three-point-linkage

Looking at the relative errors the nine "favorite systems" show less than +/- 2% deviation. A relative deviation of +/- 2 % of the actual load is regarded as the limit for agricultural use.

WEIGHT DETECTION IN TRAILERS

METHOD AND MATERIAL

The weight detection in different types of trailers should be used to get the yield of grass, straw and corn-silage. The tested systems can be used on self loading trailers as well as on tipping trailers. Applications on two-wheel trailers and on four-wheel trailers have been examined at the Institut für Landtechnik.

Two principle ways of detecting the load are possible:

A. Directly applied sensors detect the stress at the structure (f.e. axle and shaft)

B. Load cells between axle and chassis detect the load force

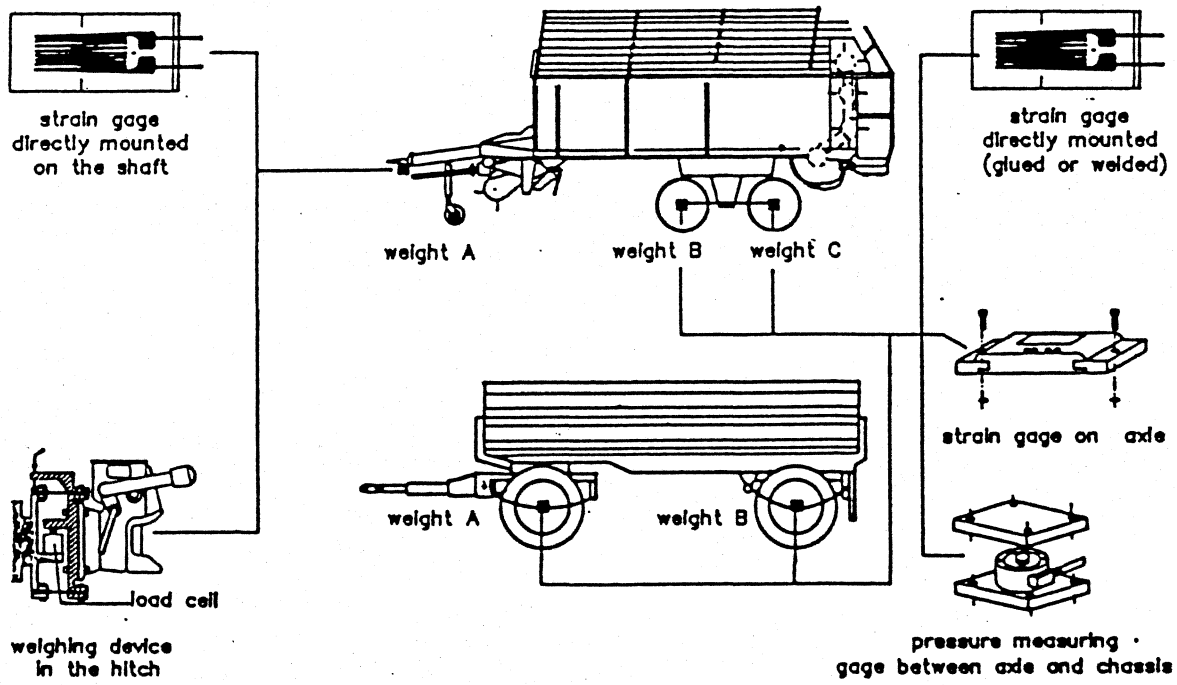

FIGURE 7: Possibilities of the weight detection on different types of agricultural trailers

After many preliminary tests three different sensor applications have been selected for more detailed investigations on three types of trailers:

Detection of the bending forces in axle and shaft
Detection of shearing forces in axle and shaft
Detection of the load forces (with load cell) between axle and chassis and in the trailer hitch of the tractor

tested on:

Single axle self-loading trailer
Tandem axle self-loading trailer
Four-wheel tipping trailer

For weight detection in single axle and tandem axle self-loading trailers a sensor has to be applied on the axle(s) and on the shaft.

RESULTS

The results of the chosen systems differ very much. Up to loads of 3000 kg the 95 % confidence intervals of the absolute deviations between load and real weight vary between 2 kg and 70 kg.

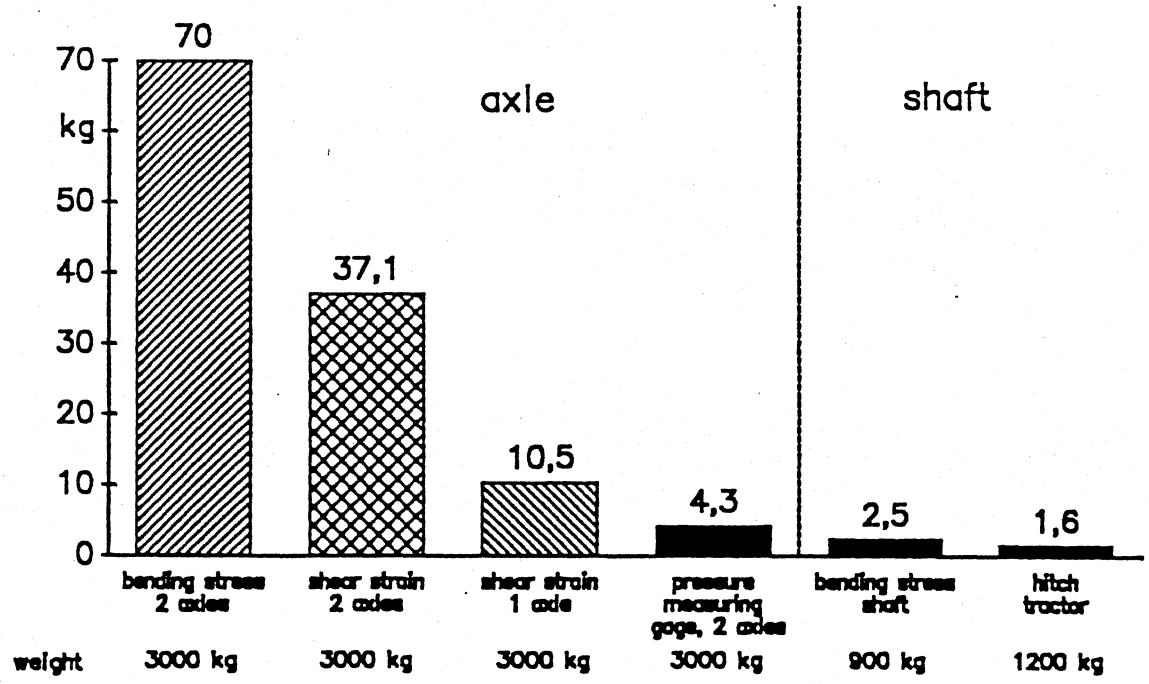

FIGURE 8: Confidence intervals of the absolute errors for the weight detection in trailers

Like for the weight detection in the three-point-linkage the absolute deviations over the whole course of loads is nearly constant.

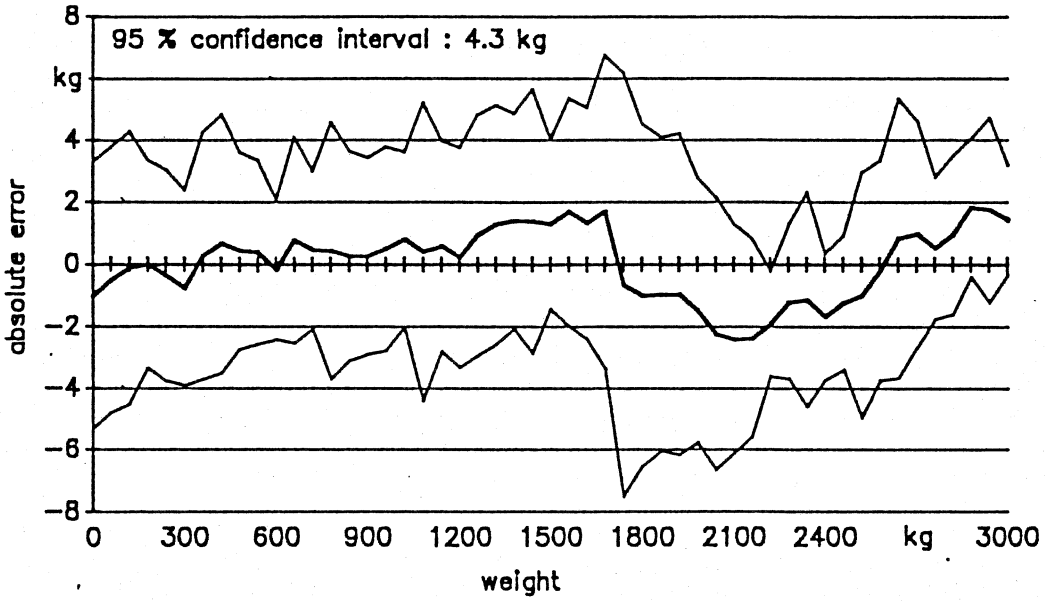

FIGURE 9: Absolute mean deviations with 95 % confidence intervals for the weight detection in trailers

Looking at the relative errors, four sensor applications remain below the required +/- 2 % accuracy limit. Only the bending force with +/- 8% and the shearing force with +/- 4.4 % are over +/- 2 %, but better results could be aimed by an improved application technique. The shearing force at the single axle self-loading trailer shows an accuracy of +/- 1.1 %.

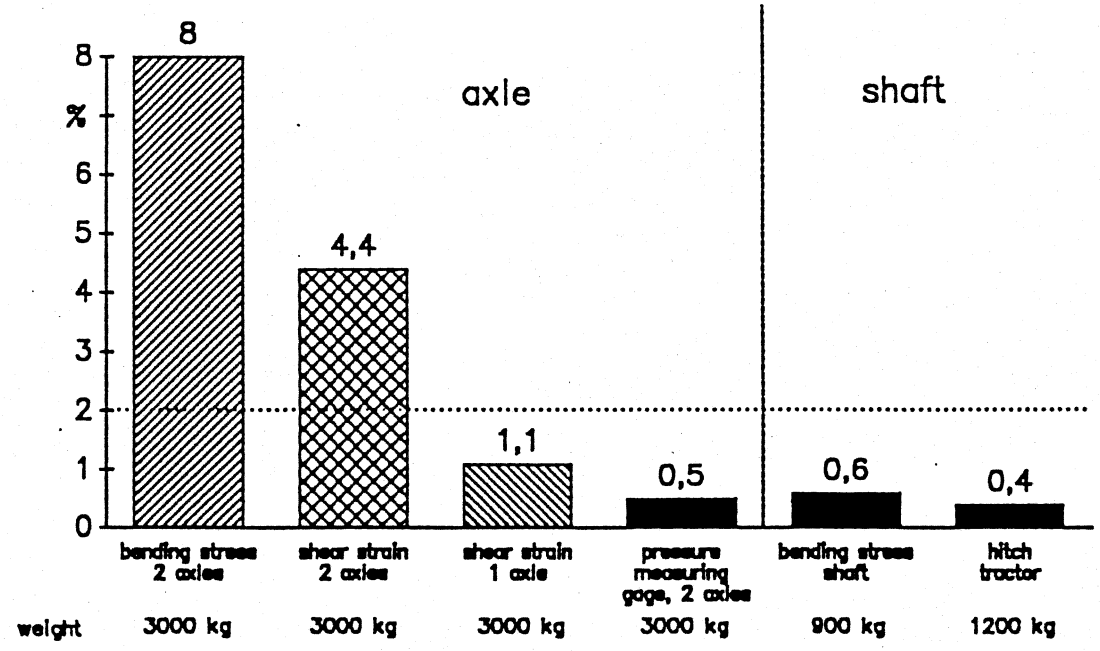

FIGURE 10: Confidence intervals of the relative errors for the weight detection in trailers

The accuracy for detecting the weight at the shafts of the single and tandem axle trailers is very high, though the whole system also has a high accuracy.

CONCLUSION AND PREVIEW

During the last three years at the Institut für Landtechnik at the Technical University of Munich extensive trials have been done on the weight detection in the three-point-linkage and in trailers. Many of the tested sensor applications have enough accuracy for use in agriculture.

In most cases they are technical satisfying and easy to fit solutions which can be produced for low costs.

Trials have started this year to detect the correct weight on moving tractors and trailers. This "dynamic weighing" needs new algorithms, new filters and additional information like the acceleration. Early results show that there is a way to reach this further aim within the next year.

ACKNOWLEDGEMENTS

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