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# A Simulation Model to Analyse the Operation and Capacity Parameters of Harvesters

*Further cost reductions for harvesting by increasing combine harvester capacity will require ever increasing efforts in the future. Of farm monitored field efficiency factors, between 50 and 65 %, indicate the potential of numerous other parameters to optimize the general economics of harvesting. Using a model on economic efficiency, a great number of input variables can be examined regarding their effects on economic relevance. This simulated model of the "combine harvesting" process chain reveals problems and potentials for optimal coordination of the process elements.*

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**Keywords**

Simulation, calculation, combine harvester, economic efficiency

**Literature**

Literature references can be called up under LT 07SH23 via internet http://www.landwirtschaftsverlag.com/landtech/local/literatur.htm.

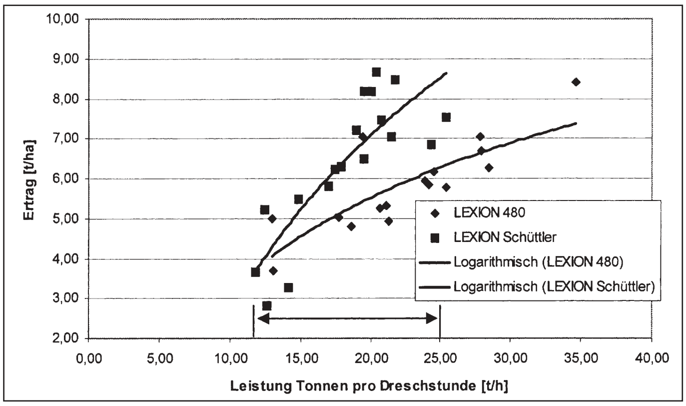


*Fig. 1:Online logbook evaluation of 24 combines*

Agricultural machinery development has been focussing over the last decades on increasing capacities as well as on improving working conditions and working quality. In average the capacity of combine harvesters retailed in Europe has risen by 3% p.a. over the last 10 years. The capacity of the top range models of most manufacturers has developed even more dynamically. As spot performance under ideal conditions a throughput of more than 100 tonnes of wheat per hour has been recorded with a LEXION 600 in Great Britain in 2006.

From a customer's point of view the top throughput of wheat or MOG (material other than grain) on a 100 m test distance is not really important. A customer cares about the achievable daily or seasonal output of a combine on his individual farm and its economic parameters.

Consequently, product planning for new development projects or improvement of existing machinery lines should as well primary deal with the question, how efficiency and actually achieved performance of the harvesting process chain can be improved. Just an ongoing increase of the technical throughput capacity is not necessarily the most appropriate path.

Simulation models basically offer the potential to identify relevant variables for the optimisation of the harvesting process chain. However, many simulation exercises of the past failed due to a lack of data quality and the high effort for programming.

## A Calculation Model for Combine Harvesting

In industrial environments the collection of operational data is a standard procedure for controlling purposes and the generation of planning data. Today agriculture is as well capable to record various process data of the production process and to evaluate them according to individual targets.

A major progress has been achieved from simple field records to geo-referenced classification of all processes to a subarea. Modern sensing technology is not only capable to record input and output quantities but as well to collect and classify all kinds of operating data from farm machinery.

In the past calculation data for operations planning could only be surveyed by time-consuming measurements of working hours and performance. Not surprisingly the published reference values depended on a very limited database. During the last decades, science showed less and less interest in generating planning data for crop production and did just some basic work. The published calculation data for agricultural machinery are partially getting perceived as an insufficient extrapolation of aged data, which are only of little importance for the manager of a future-orientated farm.

The availability of new sensors for data recording opens the potential to boost the database of management relevant information to a qualitatively new level. Geo-referencing

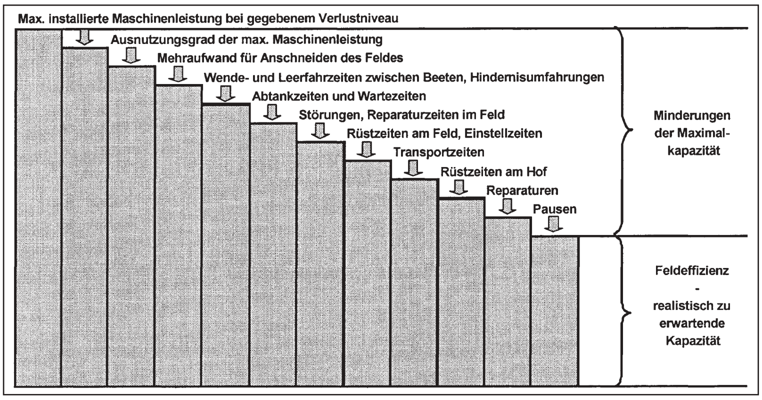


*Fig. 2: Proposal for classification of efficiency-influencing parameters*

and cross-linking of acreage performance, combine performance, working time or crop parameter to other data available for the particular subarea allow for further possibilities of interpretation of the data recorded, which could finally end up in a considerably improved data quality.

Another quantum leap in data collection is opened up by the Telematics-development. Telematics provides the potential to log on to the on board information system of a machine by the use of telecommunications services to supervise location, settings, or performance information in realtime. Similarly it is possible to save the real process data of the last hours or days on a server, which may be accessed by a secure internet port.

Furthermore critical conditions of individual elements such as pressures, temperatures or fill levels can be monitored. Telematics offers manifold approaches to optimise the whole harvesting process management.

- By surveillance and comparison of settings and performances of different machines the manager or a supervisor is able to provide advice for the optimisation of machine settings and for a better exploitation of the machine capacity.
- On many farms a considerable part of the capacity of a harvest chain is not getting fully utilised, because the different machines are not harmonised and significant waiting times occur. A realtime analysis of Telematics data enables to adapt and optimise the individual components of the logistics chain.
- The use of Telematics for remote monitoring of operational data, filling levels or temperatures of different aggregates helps to avoid damages and breakdowns. If it comes to a breakdown anyway, by analysis of the relevant performance data dealers or service mechanics are able to do a remote diagnosis. Before visiting the machine, necessary spare parts or specific know-how can be gathered. Depending on the case of damage the effective downtime of a machine can be considerably shortened.
- Especially for rental machines or on large farms in the East the ability of "Global Fencing" may get prime importance. Telematics can not only record if and how a machine is working, but also where. A supervisor is able to verify that a vehicle is really on the territory it is scheduled for.
- Besides further possibilities to improve machine management and efficiency Telematics finally offers excellent potential for context oriented data collection for calculation and planning purposes.

Improved data availability is going to offer new possibilities to create customised decision models for large-scale investment projects. On the other hand simulation models, which reflect the essential performance- and economically relevant parameters, open up substantial insights on reasonable approaches for new development projects.

Online recording of data on the utilisation level of the technically installed capacity of combined harvesters prove that performances in reality vary by up to 100% (*Fig. 1*).

The "installed capacity potential" which is a key figure for developers of machinery, is not useful for real capacity planning. The effectively achieved performance depends on a multitude of operating and driver-specific variables, which, in many cases, may be easily recorded by Telematics.

To evaluate the relevance of diverse parameters on efficiency and to identify important variables for further development, CLAAS is developing the simulation model com.econ (combine economics). With com.econ different operating conditions of the combine harvesting process and the influence of a modification of important parameters can be easily analysed.

The individual components of the model are based upon established agricultural cost accountings.

Working time classification used by KTBL (Association for Technology and Structures in Agriculture), common in Western Germany, into total time, basic time, primary processing time and secondary processing time should become more subdivided for evaluation of efficiency of processes and for identification of variables with potential. Additionally to the working time classification known from the USA (*Fig. 2*) one should consider, that a driver is hardly able to drive a machine a whole working-day long at its technical capacity limit without additional auxiliary means. Therefore, the variable "utilisation level of maximum machine performance" should find supplementary consideration (*Fig. 2*).

## Analysis of cost relevant parameters

The model results in various efficiency and profitability figures, which allow for an analysis of the overall profitability of an investment and a comparison of the relative excellence of process alternatives (*Fig. 3*).

Altogether 44 variables are at disposal. By analysis and systematic iteration of variables, priorities between different factors may be identified, which can give valuable directions for future developments.

The simulation of real harvesting process conditions based on individual operational data, which have been collected via Telematics, underline the conclusion that the majority of all farms achieve a field efficiency of not more than 50 to 65%.

| | | |
|---|---|---|
| Theoretische (max.) Flächenleistung | ha/h | 4,47 |
| Zu erwartende Flächenleistung | ha/MDh | 2,92 |
| Wirkungsgrad (tatsächliche Flächenleistung/Motor-h) | | 65,4% |
| | | |
| Kampagneleistung in Tonnen | t/a | 6.052 |
| Kampagneleistung in Hektar | ha/Jahr | 672 |
| | | |
| Feste Kosten insgesamt | €/Jahr | € 40.260 |
| Veränderliche Kosten insgesamt | €/Jahr | € 16.872 |
| | | |
| Gesamtkosten pro Tonne | €/t | € 9,44 |
| Gesamtkosten pro Hektar | €/ha | € 84,90 |
| Gesamtkosten pro Jahr | €/Jahr | € 57.132 |
| | | |
| Erzielbarer Erlös / Hektar | €/ha | € 95,00 |
| Umsatz | €/Jahr | € 63.880 |
| | | |
| Jahresüberschuss Mähdrusch / Hektar | €/ha | € 10,04 |
| Jahresüberschuss Mähdrusch | €/Jahr | € 6.748 |
| Return on Investment (ROI) | % | 3,1% |

*Fig. 3: Calculation results of „com.econ"*