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Harvest and transport as a parallel process

Example: silage harvesting operation

The parallel process is a combination variant between harvest and transport operations. In this, a transport vehicle must always be driving alongside the harvesting machine to receive the harvested material. In order to be able to calculate the effect of various parameters on operational output, the required working time and the costs, models were applied. As typical example for a parallel process, forage harvesting with self-propelled harvester was presented as a subject for calculation of operational output as well as for working time requirements.

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The parallel procedure and the intermittent approach differ as basic combination possibilities between harvest and transport (fig. 1). In practice, however, there's a range of transitional approaches which, while showing a dependence on the concrete operational aspects, have demonstrated that they are influenced to various extents by points from both procedures. As a group, these transitional forms are described as „conditionally intermittent procedures“.

Parallel procedure

In the classical form of parallel procedure the transport vehicle is loaded whilst running alongside the harvesting machine. Because the harvesting machine has no bunker, it and the transport vehicle are completely bound to one another and dependant on each other during the operation.

The advantage of the parallel procedure lies in its high performance potential and in the avoidance of delay between harvest and transport. In every case, additional handling operations between harvest and transport are not necessary and this has a cost sinking tenancy. The disadvantage is the emergence of time losses through the cyclical nature of the operation. These losses are caused by periodically-repeated waiting times. They occur because the harvester output is generally not matched to the transport operations. The time losses associated with the cyclical procedure may be minimized through good work organisation, but very seldom can be completely dispelled [1].

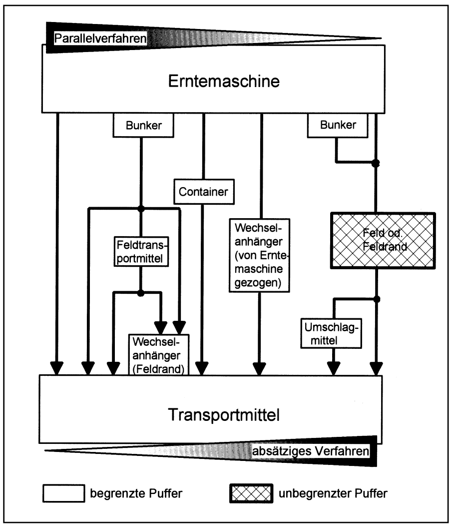

Fig. 1: Combination possibilities between harvest and transport

Legend

$\dot{m}_{T02E}$	= Harvesting machine bulk performance in the operative time T_{02}
$\dot{m}_{T02T}$	= Transport unit bulk performance in operative time T_{02}
$\dot{m}_{T025E}$	= Harvesting machine bulk performance in the extended operative time T_{025}
$\dot{m}_{T025T}$	= Transport unit bulk performance in the extended operative time T_{025}
n_E	= Number of harvesting machines
n_{TE}	= Number of transport units
m_L	= Load
t_{25E}	= Cyclical procedure time loss (harvesting machine)
t_{25T}	= Cyclical procedure time loss (transport equipment)

Silage harvester – process performance

Harvesting forage with the self propelled silage harvester is the classic example for the combining of harvest and transport operations in parallel procedures.

A variety of influences bear on the procedural performance of the machines in the harvest and transport operations. With the tendency towards larger working parcels the complexity of the connection increases. It can be seen from *figure 2* that the output of the machines in the harvesting and transport operations in part depend on the same parameters. Even on the level of the operative time T_{02}, the transport performance is controlled by the performance of the harvesting machine with regard to the time taken to load. This close combining of the harvesting and transport operations, and the associated mutual influence on the output performance of the machines involved in these operations, is typical for parallel processes [2].

The interaction between harvest and transport can be best explained in a model on the basis of the intermittently repeated work periods. From this, the extended operative time

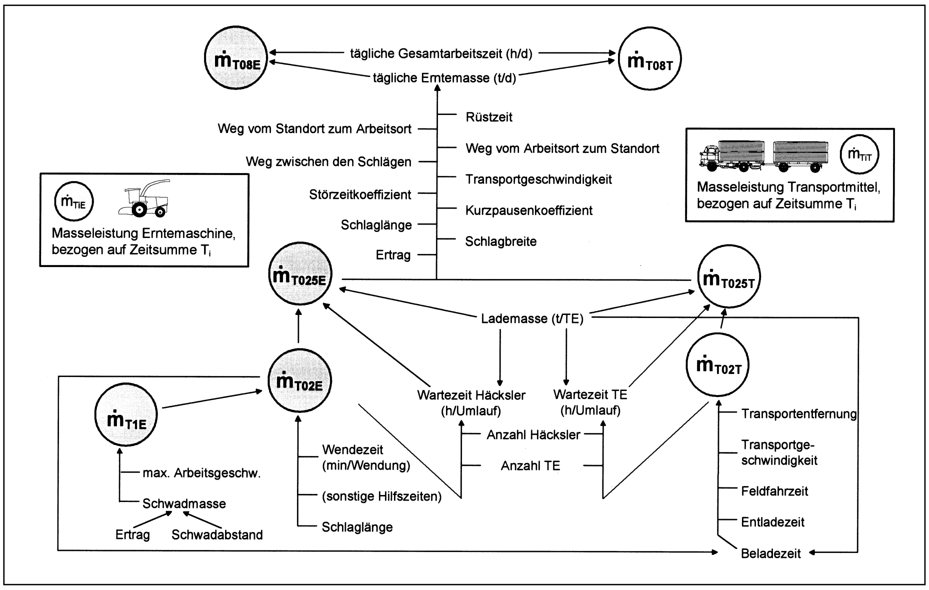

Fig. 2: Effect of process parameters on material capacity with the silage harvester in a parallel process

T_{025} is available as basis for the description of the interaction between the work processes at [3]. The following deterministic reference applies in parallel procedures:

((Gleichung einsetzen)) (1)

The calculation rules for the procedural performance in the extended operative time for the harvest – formula (2) – and for the transport – formula (3) – have the problem that the cyclical procedural associated time losses t_{25} represent an unknown variable, as do the target parameters mT_{025}:

((Gleichung einsetzen)) (2)

((Gleichung einsetzen)) (3)

When the process performance in the harvest operation is greater than the performance in the transport operation (basis operative time T_{02}), then the time losses associated with the cyclical process take place only in the harvester operation. They can be calculated on the basis of the formulas (1) and (3):

((Gleichung einsetzen)) (4)

When the process output in the harvester operation is smaller than that of the transport operation (basis operative time T_{02}), then the time losses associated with the cyclical process are to be found in the transport operation. The calculation can be addressed with the following references:

((Gleichung einsetzen)) (5)

The criterium „process performance“ is only conditionally suitable for the common observation of harvest and transport in that the performance from many work operations is not able to be totalled. Instead, the working time requirement offers itself as a criterium which can be demonstrated as the reciprocal value of the performance through occupying each of the machines with a worker.

Working time requirements and costs

With a differentiated approach to the connections – formulas (1) to (5) – the influences on the process performance or the working time requirements of all the parameters shown in fig. 2 may be represented.

Presented as an example in *figure 3* is the working time requirement for the silage harvest with the forage harvester and transport vehicles in connection with the number of transport vehicles employed on the basis of the extended operative time T_{025}.

In the operative time T_{02} the working time requirement for harvest and transport is constant and independent from the number of transport vehicles used. The difference in the working time required evolved first with regard to the time losses associated with the cyclical process within the extended operative time T_{025}. Taking the given transport distance of 10 km, the theoretical number of transport units, through which neither harvest nor transport operations would suffer time losses associated with cyclical procedure, was 3.69.

With three transport units used, 19% of the working time requirements for the harvester represented waiting time. This represents a share of nearly 5% of the working time requirement for the entire operation. Where four transport units were applied, the waiting time became applied to the transport vehicles and comprised 8% of their working time or 6% of the entire operation's working time. Every other reduction or enlargement of the transport units in the work process caused a drastic increase in the extent of waiting time and therefore a rise in the working time requirement. The costs in the working process correlated strongly with the working time requirements.

Conclusion

The parallel process offers good conditions for a high operational performance. The minimizing of the losses associated with the cyclical process demands, however, high organisational effort in the planning of the operational procedure.

Generally, a trend towards the reorganisation of transport-associated work procedures can be recognised. The target here is to have transport which can react more independently to the harvesting operation. The aim also is to increase the transport performance in the case of on-road work through larger loads and higher transport speeds (use of trucks!).

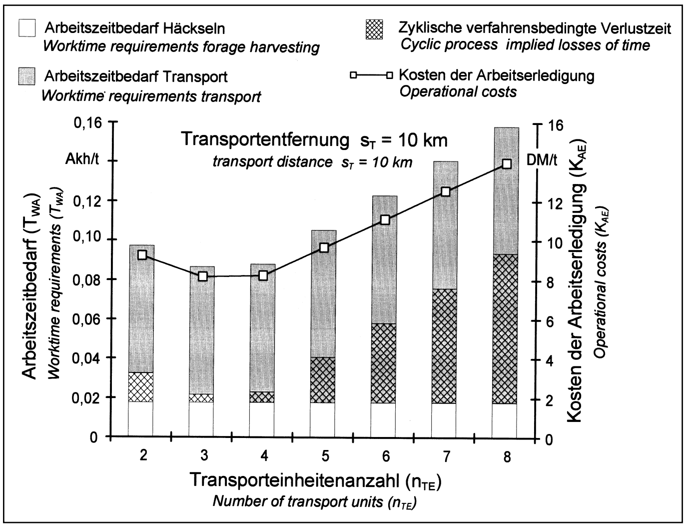

Fig. 3: Labour requirements for harvesting and transport tasks in the extended operative time T025, and operating costs for the total process depending on the number of transport units