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Partial-Time Specific Diesel Fuel Requirement Calculations for Field Tasks

The costs of carrying out field tasks are rising and are effected to a considerable degree by fuel requirements, due to high diesel prices. Therefore, fuel requirement calculations must be as exact as possible and an objective comparison of work processes is necessary. Exact calculations are also required for the increasing demands for ecological evaluations.

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Keywords

Field work, diesel requirements, engine load, calculation of operation costs

Fuel requirements for a work process are the product of the engine power used, specific fuel consumption and working time. The specific fuel consumption for tractors was assumed until 2000 as 40% of the rated engine power (engine load) for all tasks within the entire working time. Due to the uniform engine load it was calculated with an uniform specific fuel requirement during the entire working time, too.

Using tractors for very different tasks results in an average engine load of about 40% annually.

Calculation procedures since 2001 - Partial time specific

For individual work processes the adjusted engine loads are assumed in relation to partial times, the respective specific fuel requirements are determined and are computed with the partial times. Since 2001 the resulting fuel requirements for the various work processes have been presented in KTBL publications.

Partial Times

The total labour requirements for a work process consist of effective time, turning time, supply time, ineffective time lost, waiting time, preparation time and travel time [1, 2, 3]. For these partial times, their respective (partial-time specific) fuel requirement are determined. In order to do this the power required within the partial time is ascertained and through it the engine load defined. The fuel requirements within the partial time are the product of the partial time specific power requirements and the partial time specific fuel requirements.

The total fuel requirements for a work process is the sum of the fuel requirements within the partial times.

$$B_g = (b_{eH} \bullet P_H \bullet t_H + b_{eW} \bullet P_W \bullet t_W + b_{eVo} \bullet P_{Vo} \bullet t_{Vo} + b_{eR} \bullet P_R \bullet t_R + b_{eL} \bullet P_L \bullet t_L + b_{eHF} \bullet P_{HF} \bullet t_{HF} + b_{eFF} \bullet P_{FF} \bullet t_{FF} + b_{eV} \bullet P_V \bullet t_V) / \rho$$

B_g [l/ha] total fuel requirements for a work process

b_{ex} [kg/(kW•h)] specific fuel requirement within the partial time x

P_x [kW] power requirement within the partial time x

t_x [h] partial time x

ρ [kg/l] weight of diesel

Indizes
- FF travelling from field to field
- H effective time mainland
- HF travelling from farm to field and back
- L loading and unloading processes
- R preparation on the farm and in the field
- V time lost, ineffective time
- Vo effective time in the headlands
- W turning processes

Power requirements

The power requirements within the partial times consist of vehicle self-movement (including working implement/trailer) and, when required, the power requirements for work execution. For vehicle self-movement, driving on various surfaces with different rolling resistance is taken into account. Different coefficients for driven and non-driven wheels are assumed. If the working implement/trailer transfers vertical forces to the tractor, this is included in the calculation. In

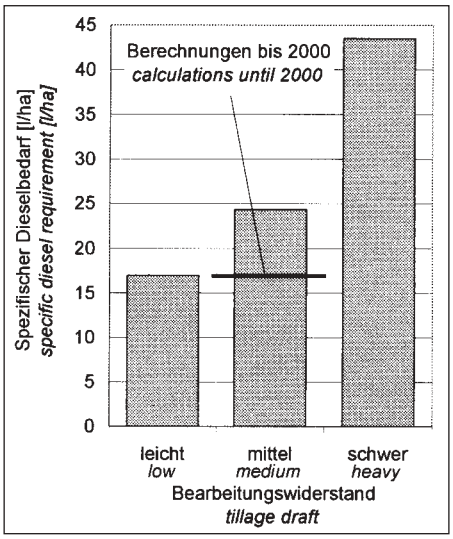

Fig. 1: Specific diesel requirement for ploughing 2-ha plots with a four-bottom plough (1.4 m working width) with low (67-kW-tractor), medium (83-kW-tractor) and heavy (140-kW-tractor) soil tillage resistance

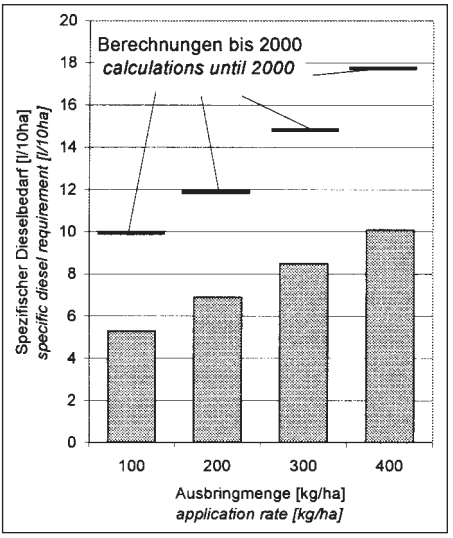

Fig. 2: Specific diesel requirement for fertiliser application from the farm (1.5 t mounted disc broadcaster 24 m working width with 67-kW-tractor) on 5-ha-plots depending on application rate

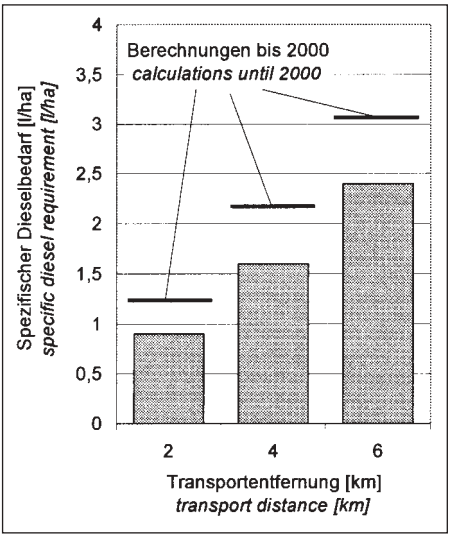

Fig. 3: Specific diesel requirement for transporting grain from the field to the farm (three-axle three way tipping trailer with 16 t payload and 83-kW-tractor, loaded at the headland , yield 8 t/ha) depending on transport distance

addition to operations on plain fields or contour lines on sloped land, the power requirement for driving up and down for slope operations can also be determined.

Special cases are the partial times, where the vehicle stands still. For the preparation times (farm and field) and the time lost it is assumed that the vehicle engine is running on idle. For filling and unloading times, a work process specific power requirement is assumed (e.g. driving the chain slats of a self-loading wagon - 20% engine load, filling a seeding machine manually - idle operation, filling a fertiliser spreader with an hydraulically driven auger, operated with a „fertiliser tractor“ - 10% engine load.).

For the effective time the power requirements are specifically determined for the work process. Based on measurements from DLG-tests, coefficients for the relations were determined, which present the power requirements as a function of the process specific operation parameters. Besides working speed there is working width, throughput, the number of rows or the number of knives in a short-chop forage wagon. For all tillage tasks, a differentiation can be made between light, medium and heavy draught required for tillage. In these tasks there is a quadratic relationship between working speed and power requirement, whereas working depth and width are considered to be linear functions.

In transport tasks, besides the different power requirements for loaded and empty travel with different masses, also different transmission efficiencies are considered.

Specific fuel requirements

Within the new calculation procedure, the partial time specific fuel requirement is determined for various engine speeds depending on engine load. An exponential relationship, based on the results of fuel consumption measurements from DLG tractor tests, is assumed. This is the basis for an average consumption model.

In simple form only two rpm levels are considered for partial time consumption. With higher engine loads (> 60%) it is assumed that operation is within the pto-rpm range (about 90% of rated engine speed, whereas for lower loads engine speed is 60% of rated engine speed.

Comparing calculation procedures

Regarding engine load, there are large differences for field tasks. With the old method, engine load for heavy tillage was assumed too low (*Fig. 1*) and too high for husbandry measures (*Fig. 2*). With a high percentage of travel and loading time or for transport tasks (*Fig. 3*), the global assumption of a 40% engine load is too inaccurate.

Literature

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