Parametres of energy crop biomass handling

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Abstract: Energy crop handling can be performed with standard handling machinery equipped with suitable adaptors. The authors describe and compare various types of handling of wood and herb energy crops. The published results have been gained by field measurements in operating conditions and calculated on the basis of bulk weight. Particular handling variants are supplemented with rough values of unit costs obtained by model calculation.

Keywords: handling; energy crops; renewable resources; biomass

That what makes energy crops disadvantageous as compared to fossil fuels is their low energy density (Syrový 1983). This means that the same amount of energy contained in the crop biomass takes up a larger volume than the same amount of energy contained in fossil fuel. According to Souček *et al.* (2003), the energy density in pellets and briquettes reaches 64 to 85% of the energy density in lignite (nut 1, Mostecká uhelná). Other forms of energy crops reach only 6% (chaff) to 32% (wood chips) (Kára 2006). The bales reach the energy density of 1.91 to 2.76 GJ/m^3, which represents 13% to 19.6% of the energy density in lignite. The above mentioned facts make clear that the energy crops involve handling of very large quantities. The machinery used for the herb biomass handling can be distinguished as self-propelled machinery and machinery integrated into an external vehicle.

Self-propelled loaders, or handlers, are mostly multifunctional machines used for more kinds of material. A handler fulfils the function of machinery designed for loading, unloading, handling, and short-distance transport. The loading capacity of handlers reaches 10 t, the telescopic boom lift normally reaches 10 m. The engine output of the middle power class varies up to 100 kW. The handler versatility is increased by the use of exchangeable adaptors. Some handlers are equipped with three-point linkage and power take-off and are used as a supplemental tool carrier, in some cases as a short-distance vehicle.

The machinery without its own energy source, used for fuel crop handling, is integrated into the tractor, in some cases to the universal tool carrier or vehicle (Kára *et al.* 2007). The harvested fuel crops are handled with loaders constructed as trailer loaders, carrier-mounted, or as a part of a vehicle (hydraulic arm), or in some cases as a part of the equipment store (full-portal crane). The loader drive is brought from the power take-off or by the hydraulic circuit, in the case of fixed installations by means of the electric motor. The loading capacity and handling capacity of integrated loaders are limited by the design concept of both the machine and the vehicle.

MATERIAL AND MEASUREMENT METHODS

The parameters of specific handling techniques were determined by field measurement calculation and recounted on the basis of specific weight. The parameters of specific handling techniques were determined by the following procedures (Souček & Šperl 2006):

Parameters determined by measurement

- fuel consumption (diesel oil) of all handling and transport vehicles by the full tank method
- handling means work time share course determined by measuring the working operations time duration
- measuring the harvested areas by GPS
- measuring the handled crop dimensions
- weighing the material on strain-gauge scales

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– total water content in the material (laboratory measurement based on ČSN 44 1377 rok)

Parameters determined by calculation

Fuel specific consumption

$$V_e = \frac{V_{sp}}{m_s} \quad \text{(l/t)} \tag{1}$$

where:

m_s – weight of the handled material (t)

V_{sp} – total fuel consumption (l)

Average performance

$$q_m = \frac{m_s}{t} \quad \text{(t/h)} \tag{2}$$

where:

m_s – weight of the processed material per relay (*t*)

t – time of relay (h)

Maximum performance

$$q_{\max} = \frac{m_{s\max}}{t_{\max}} \quad \text{(t/h)} \tag{3}$$

where:

$m_{s\max}$ – maximum weight of the processed material per operation cycle (t)

$t_{\max}$ – time of operation cycle (h)

For clarity, the presented results of the parameters of handling were sorted out by the forms of the actual handled material. Determining the parameters by calculation on the basis of bulk weight was used only for the materials whose handling by particular machines was impossible to determine by measurements under operating conditions. In these cases, the operating measurements could not be carried out because the operations that could use these handling techniques do not exist and the measurement management under these conditions would have been personally, technically, and financially demanding.

RESULTS

Figures 1 to 6 show variant technologies for fuel crop handling. For the purpose of determining the parameters, the handling techniques were chosen using the following machines:

– self-propelled loader (2 variants of use)
– lift truck
– hydraulic arm
– tractor with a front loader

All handling techniques were measured and calculated for the following fuel forms:

– round bales
– prismatic bales
– pellets
– briquettes
– wood chips
– lying hay

The loading in field conditions can be made almost exclusively by the means used for field operations. This group of means is represented by the cell of "self-propelled loader – loading". The hydraulic arms and the tractor with a front loader can also be used for loading, but their use is limited. The limiting factor of the tractor with a front loader is the lift elevation (normally up to 3 m), which means that its use for the bale loading onto higher layers becomes complicated. Classical use of the hydraulic arm is fixing onto a vehicle. It can also be used for the loading of materials that have been brought nearer to an easily accessible place (e.g. the edge of a plot, by the road or to a place of temporary storage). The principle of the loading mechanism on a vehicle is also utilised with the automatic handling vehicles which are increasingly used in the Czech Republic.

The unloading of any form of fuel crops on hard surfaces can be made by all the handling means noted in the charts.

In the tables describing the parameters of the bale handling, the columns "self-propelled loader – loading" contain parameters of the bale loading in field conditions without any previous collection or approaching. During the loading parameters measuring on the transport means, the bales were dislocated in the same points as they were discharged from the press machine. The columns "self-propelled loader – storing" contain the measured parameters including the unloading of the materials from the vehicle and their depositing into a long-term storage.

It resulted from the measured and calculated values for the monitored ways of the selected materials handling that, from the aspect of efficiency and energy specific consumption, the most effective handling is that with pressed materials having high volume weights and energy density (briquettes and pellets), where the average handling equipment efficiency and the hydraulic arm reached the values from 57.09 to 114.01 t/h. The handling efficiency can be increased (mainly with high – lift truck and front loader with a lower measured performance) by pelletising. The least effective appeared the handling of loose materials. In the case of loose straw, the average performance reached the values from 2.23 to 13.47 t/h. The wood chips handling showed slightly lower performance (7.77–46.96 t/h).

In the comparison of the round and square bales handling results, the round bales showed higher performance with the hydraulic arm utilisation. Other handling manners showed insignificant results as regards the measurement errors.

Energy specific consumption expressed by motor diesel consumption was also the lowest in handling the pellets and briquettes (0.03–0.21 l/t). When handling loose materials, the energy consumption was up to 0.78 l/t. The round and square bales handling is characterised by a comparable energy specific consumption. The specific energy consumption is higher merely with the square bales loading by the handling equipment and the hydraulic arm. Energy specific consumption was from 0.20 l/t (hydraulic arm, round bales) to 0.66 l/t (self-propelled loader – loading).

DISCUSSION

The handling is an indispensable operation in the technological procedure of processing and utilisation of biomass materials for energy purposes. At closer examination, the values determined by measurements and calculation that are published in this article show some differences. The particular handling means, their ways of utilisation and their integration into technological lines is to be evaluated in a complex way.

Specific total costs for the machinery used were calculated per hour of the machine operation. According to the model calculation in AGROTEKIS program, these costs range as follows:
– self-propelled loader (2 variants of use)
– lift truck
– hydraulic arm
– tractor with a front loader

Self-propelled loader: 16.80–14.30 €/h.
Lift truck: 10.40–20.00 €/h.
Hydraulic arm: 8.20–17.00 €/h.
Tractor with a front loader: 16.30–23.30 €/h.

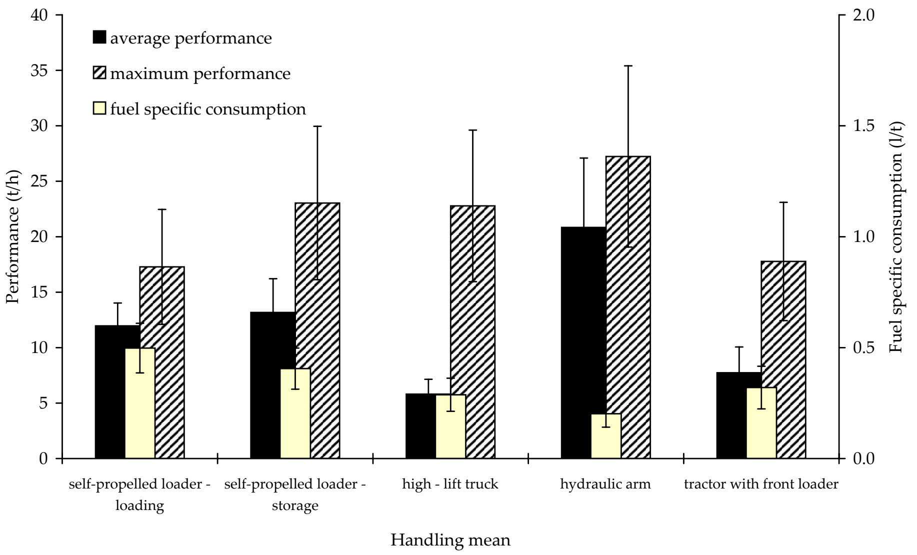

Figure 1. Parameters of round bales handling

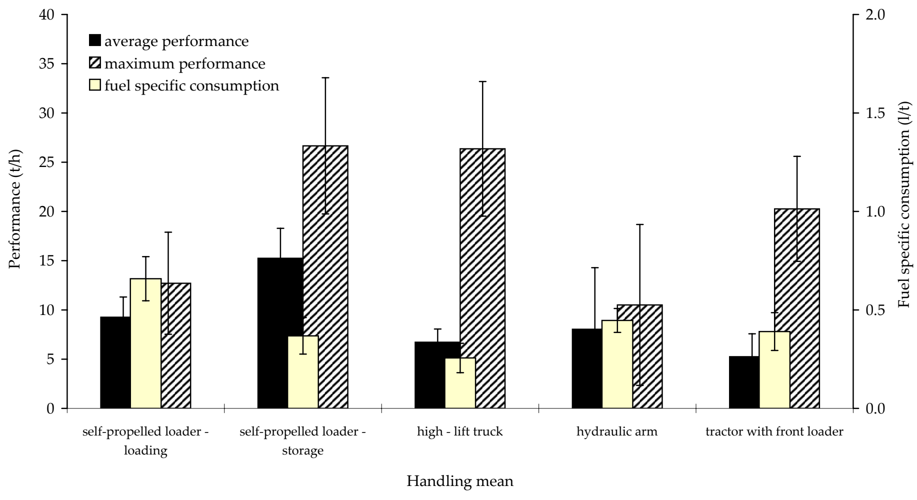

Figure 2. Parameters of prismatic bales handling

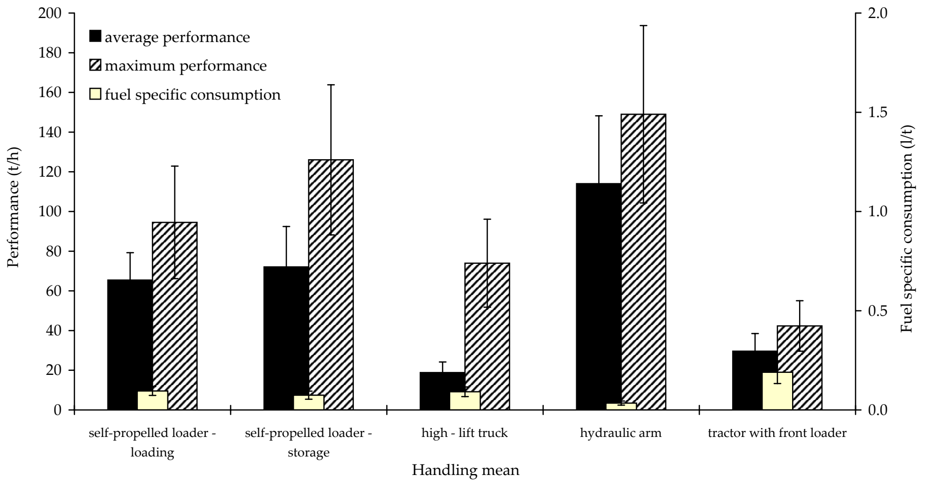

Figure 3. Parameters of pellets handling

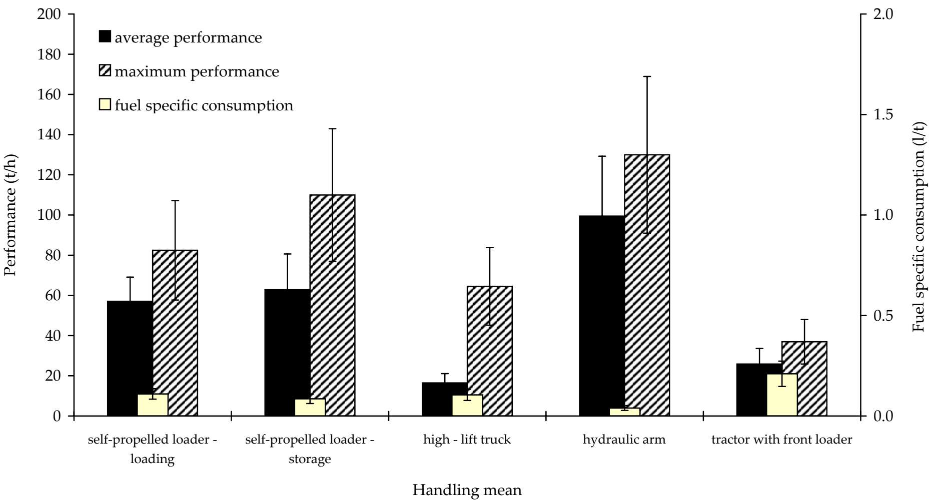

Figure 4. Parameters of briquettes handling

The values shown graphically in Figures 1–6 represent the mean values. Depending on the particular conditions, they varied in the range of ± 30%. The measurement errors are illustrated in the graphical form by means of error line segments in Figures 1–6.

Except of small bales, the fuel crops cannot be handled manually. Consequently, they have to be handled with the machinery of the corresponding loading capacity and the lift elevation required.

The choice of the handling means for the deposition of the fuel crops into the storage area is influenced by the local conditions and the way of storing. The loading capacity and the height of the handling means also play an important role. The most versatile means used for depositing is the self-propelled

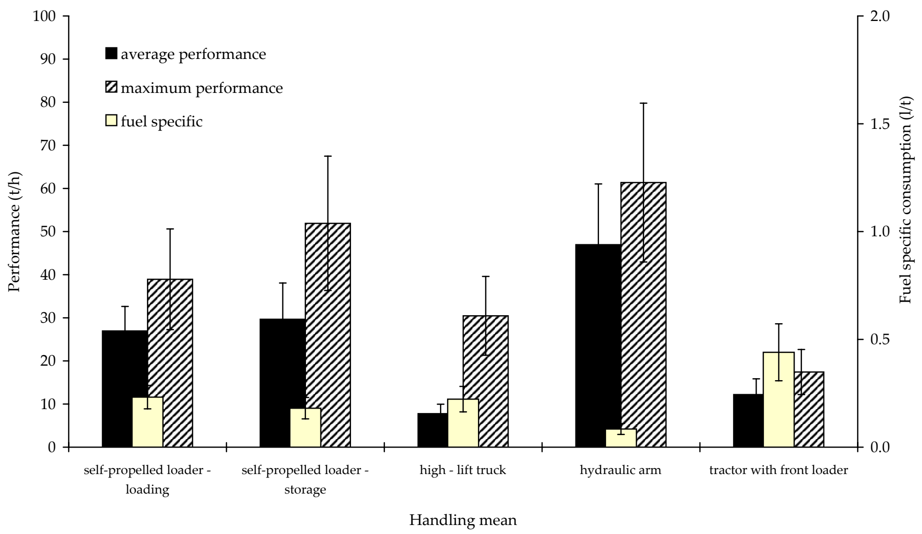

Figure 5. Parameters of wood chips handling

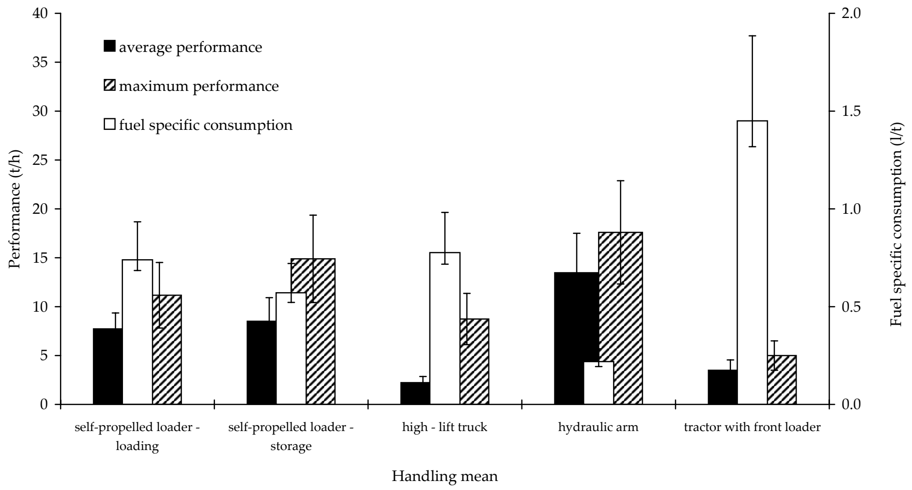

Figure 6. Parameters of lying hay handling

loader with exchangeable adaptors. If the materials need not be deposited in high layers, the use proved to be effective of lift trucks with undercarriages designed for easy terrain operation. The tractor with a front loader and the hydraulic arm vehicle can be used for depositing only in the cases of a suitable space solution of the storage area.

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Abstrakt

Souček J., Kocánová V., Novák M. (2007): **Parametry manipulace s rostlinnou energetickou biomasou**. Res. Agr. Eng., **53**: 161–165.

Manipulaci bioenergetických surovin je možné realizovat pomocí standardní manipulační techniky vybavené vhodnými pracovními adaptéry. Autoři popisují a porovnávají různé způsoby manipulace bioenergetických surovin na bázi dřevin a bylin. Publikované výsledky byly získány pomocí terénního měření v provozních podmínkách a vypočteny na základě sypné hmotnosti. Jednotlivé varianty manipulace jsou doplněny orientačními hodnotami jednotkových nákladů, získaných modelovými výpočty.

Klíčová slova: manipulace; bioenergetické suroviny; obnovitelné zdroje; biomasa

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