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Work Time Requirements and Costs of Different Manure Removal Technologies in Stall Stables for Boarding Horses

Removing manure from box stalls for horses makes up a high proportion of the total working time requirements. Therefore, increasingly with a growing number of horses, stationary manure removal facilities are being installed. In this study, various solutions for mechanizing manure removal were compared on their working time and procedural costs.

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Keywords

Working time requirement, procedural costs, manure removal systems

Literature

Literature references can be called up under LT 07SH16 via internet http://www.landwirtschaftsverlag.com/landtech/local/literatur.htm.

The housing of horses in stall stables requires an amount of work similar to those in dairy cow husbandry. Even if the data regarding working time requirements for the housing of horses in stall stables vary widely from 25 to 60 labour hours (Lrh) per horse, data bases compiled by the authors of reference [4] show that manure removal, which accounts for 25 to 40 % of total work time, is always the most work-intensive process among all work steps. For this reason, mobile manure removal systems are used in particular in this form of housing in an attempt to save expensive work time and to reduce physical labour. While the use of mobile manure removing machines (e.g. farmyard loaders) is standard in stall and in loose houses, mechanical and pneumatic manure removal systems are currently still found rarely. Especially for larger herds, different technical solutions are offered on the market and installed on farms, whose purpose is the acceleration of the demanuring process and the reduction of the physical work load. For the comparative assessment of the different technologies, no results have been available so far. Therefore, it was the goal of this study to evaluate stationary manure removal systems, based on data collected on farms and model calculations.

Material and Method

For the removal of manure from stall stables for horses, different stationary manure removal systems can be found on the market and on farms. These systems include:

- Sliding bar manure removal
- Push-type dung channel cleaners
- Flat slide manure removal
- Endless chain manure removal
- Band manure removal
- Pneumatic manure removal

First, data from these manure removal techniques were collected on ten farms (*Table 1*). The important operational data (workers, number of animals/stalls, buildings, process technology, costs and satisfaction with the system) had already been collected in a questionnaire before the first visit on the farm. The collected data also included daily working time spent on removing manure. Unclear points as well as work procedures during manure removal and details of construction (construction work done by the farmer, construction materials, etc.) were addressed in a conversation during the first visit on the farm.

Stall sizes of 3 • 4 m and 3.3 • 3.3 m were found on the farms listed in *Table 1*. On four farms, additional paddocks of 3 • 6 m and 3.3 • 7.0 m in size were installed. On six farms, a mixture of straw (75 %) and wood shavings (25 %) was used as bedding. On three farms, sawdust and straw were used, while one farm exclusively used wood shavings. On the three farms with sliding bar manure removal as well as on one farm with push-type dung channel cleaners, the manure was fed into the demanuring system in the central passage. On all other farms, covered openings in the stall corner or in the side wall were used for this purpose. For endless chain systems, push-type dung channel manure removers and band manure removing, the power of the driving units of the stationary systems varied between 1.5 and 3 kW. The respective values for sliding bar manure removal and pneumatic manure removal ranged from 2.2 to 8.5 kW and from 15 to 18.5 kW.

The collection of operational data was followed by working time measurements on the farms, based on the time element method. In order to avoid influences of the farm and the workers, a model farm with 24 horse stalls (3 • 4 m) and paddocks (3 • 6 m) was formed for each demanuring method, for which all relevant comparative parameters were calculated. Data of earlier time measurements [1, 3, 4, 5] were also included in the calculation of the working time requirements. Manual manure removal with wheelbarrows was considered as standard technique. The determination of the investment requirements for manure removal equipment was based on systems offered by companies and specially built for the model stable. For the calculation of the construction expenses for the demanuring channels, the information from the farms and, if required, literature data [6] were used, which also served as a basis for comparison.

Results

In order to be able to estimate the influence of the manure quantity per stall on the working time spent, the quantity of manure produced on farm 3 and 9 was measured, and average values of 29.1 kg ± 4.4 and 24.8 kg ± 2.0 per stall were determined. Due to the insignificant variation of these values, no influence on the working time requirements was expected. Therefore, the manure was not weighed on all farms and in all stalls.

On average, the daily working time spent for manure removal, determined by the farm managers amounted to 4.45 labour minutes (Lmin) per stall and day. Between the farms, it varied from 1.30 to 7.69 Lmin. For comparison, the measured working time for demanuring work for an average of 140 stalls amounted to 3.76 Lmin, with a standard deviation of 1.91 Lmin (*Table 1*). These values do not include about 0.3 Lmin per stall for work before and after direct manure removal.

The very large differences in the values between the farms were confirmed by the measurements. In addition, it became clear that considerable differences in working time spent were recorded even within the farms. The working time requirements for manure removal from stalls were never restricted by the capacity of the demanuring system. Under comparable conditions, they always resulted from the skills and the quickness of the personnel.

Since farm-related influences outweighed system influences, it was necessary to calculate the working time requirements on the model farm, based on standardized time elements.

These included approximately 25 different time elements for manure removal from the stalls and the paddocks, as well as manure transport to the storage place. *Table 2* lists the results of these calculations for the model stall with 24 horses and different manure removal techniques. As compared with manure removal with a wheelbarrow, a demanuring system allows an average of 224 labour requirement hours (Lrh) or 9.3 Lrh

Farm	Year of construction	Number of stalls	Stall rows	Demanuring frequency /day	Number of workers for manure removal	Working time spent / stall and day (L min) Estimate of farm manager	Time measurement n	Ø	s
Sliding bar manure removers									
1	1984	41	4	1	2	3.60	20	2.88	0.37
2	1999	30	2	2	2	4.19	13	2.60	0.76
3	2002	40	4	1	1	4.60	18	5.77	1.55
Endless chain manure removal									
4	2001 a	17	2	2	2	3.34	14	1.69	0.53
4	2003	24	2	2	2	3.34	14	1.69	0.53
5	1994	22	3	1	1	1.30	12	1.53	0.77
Push-type dung channel removers									
6	1986	26	4	1	2	7.69	14	6.20	0.89
7	1990 a	10	1	1	2.2	4.59	17	5.37	0.90
7	1992	25	2	1	2.2	4.59	17	5.37	0.90
Pneumatic manure removal									
8	2001	14	2	1	1	5.84	12	5.05	1.78
9	2003	48	2	1	1	3.75	20	2.75	0.61
Band manure removal									
10	1996	60	4	2	1.5	5.62			
Farms 1 - 10					4.45	140	3.76	1.91	

a = altered building

Table 1: Data on manure removal procedures and working time spent in the farms investigated

GLÜCKWUNSCH ZUR EMERITIERUNG

Mit Prof. Dr. agr. Dr. agr. habil. Hermann Auernhammer geht einer der führenden deutschen Landtechnik-Experten in den verdienten Ruhestand. KRONE verdankt ihm viel. Mit seinem großen Wissen und exzellenten Praxis-Know-how, das er in die Entwicklung der KRONE-Landmaschinen einbrachte, leistete er einen wichtigen Beitrag zum Erfolg unserer Hochleistungsprodukte. **Alles Gute, Hermann Auernhammer!**

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Technique of manure removal	-	Wheel-barrow	Sliding bar	Push-type dung remover	Flat-slide dung remover	Endless chain	Band system	Pneu-matic system
Working time req.	Lrh [5])	971	741	770	712	741	764	755
Demanure stalls	Lrh	861	644	674	624	644	668	659
Demanure paddocks	Lrh	110	97	97	87	97	97	97
Labour costs[1])	Euro	12,621	9,627	10,013	9,251	9,627	9,935	9,817
Investment req.	Euro		31,742	9,709	26,933	29,071	29,181	17,696
Tax depreciation[2])	Euro		3,174	971	2,693	2,907	2,918	1,770
Interest on assets[3])	Euro		794	243	673	727	730	442
Maintenance and repair costs[4])	Euro		635	194	539	581	584	354
Energy requirements	kWh		3,650	273	132	2,190	479	11,315
Energy costs	Euro		548	41	20	329	72	1,697
∑costs of manure removal	**Euro**	**12,621**	**14,777**	**11,461**	**13,176**	**14,171**	**14,238**	**14,080**
∑costs / Stall	**Euro**	**526**	**616**	**478**	**549**	**590**	**593**	**587**
Danger of injury for horses		low	middle	middle	middle	middle	middle	low
Operativeness, Reliability (Long straw, winter operation)		well	poor	well	well	middle	middle	poor
Accessibility during malfunctions		—	poor	middle	well	u-floor poor	u-floor poor	u-floor poor
Construction expenses		—	high	u-floor, high	middle	u-floor high	u-floor high	u-floor high
Retrofitting sensible		—	no	overfloor	yes	no	overfloor	overfloor
Work comfort		poor	middle	middle	well	middle	well	poor

[1]) 13 Euro/hour; [2]) Tax depreciation = 10 % of the investment requirements; [3]) Interests = 5 % of one half of the investment requirements; [4]) Maintenance and repair costs = 2 % of the investment requirements; [5]) Lrh = Labour requirement hours

Table 2: Annual working time requirement and costs for manure removal for a 24-stall stable

per stable and per year to be saved. Of the mechanization solutions, the flat-slide manure removal system provides the best values (712 Lrh), whereas push-type dung channel cleaners were the least efficient system. The resulting differences in work expenses are also shown in table 2 assuming a rate of € 13 per Lrh. If capital costs, maintenance and repair expenses, as well as energy costs are taken into account, the total costs of manure removal can be calculated. Push-type dung channel cleaners (€ 478 per stall) and the wheelbarrow (€ 526 per stall) are the manure removal techniques, which provide the lowest annual expenses because they are clearly more advantageous than the others with regard to investment requirements and energy costs even though their work time requirements are the highest. This is in particular the result of the high construction costs of underfloor systems. For pneumatic manure removal, the high energy costs must be pointed out as a particularly significant expense. In addition to cost evaluation, other factors are decisive for the use of mechanized manure removal. Other evaluation criteria, which result from the experiences of the examined farms, are listed in *Table 2*.

Conclusions

The results of this study show that mechanization enables working time savings of approximately 20 % to be realized. However, this reduction comes at the expense of follow-up costs. Especially if underfloor systems are used, follow-up costs on the model farm for 24 horses range significantly above the work expenses. In large stables, lower investment requirements per housing unit can be expected so that the relative preferability of manure removal systems grows. Making work easier through mechanization could not be expressed in numbers.