RESEARCH IN MOST ECONOMICALLY PROFITABLE TECHNOLOGIES FOR REMOVAL OF SLURRY FROM COW BARNs

Juris Priekulis, Ansis Kuplis
Latvia University of Agriculture, SIA “DeLaval”
Juris.Priekulis@llu.lv; Ansis.Kuplis@delaval.com

Abstract. In the given paper different technological solutions of removal of slurry from cow barns with the herd of 100 cows handled loose in boxes are compared. The criteria of assessment are as follows: specific capital investments, Ls/cow stall, specific consumption of work, man-hours/cow per year and specific operational costs, Ls/cow per year.

In the research it has been stated that the specific capital investments are less in case if deep boxes are used in the barn with sand or organic material litter and if in all the possible operations of removal of manure an accordingly completed tractor unit is applied. Nevertheless, evaluating the operational costs the priority is to be given to removal of manure with delta type conveyors that in case if it necessary can be replaced by the tractor unit envisaging the possibility that the tractor can be used also in other kinds of work with the load not less than 3 – 4 h/day.

Key words: cow barns, removal of slurry, comparison of technologies, capital investments, operational costs.

Introduction

In recent years there is a tendency to transfer to loose handling of milk cows and milking in a separate parlour. It reduces the consumption of work and increases the quality of milk.

But at the same time also the planning of the cow barn and the technologies of work are changing. The cows are not kept in stalls but in boxes that can have several constructive solutions.

If the cows are handled in the so called high boxes the floor of what is covered with a special cover or mat, the litter is not needed or it is used in a less amount (up to 0,5 kg calculating per one stall per day).

In this case slurry with the content of moisture 92-96% is obtained in the cow barn. But, if the so called deep boxes are used the floor of which is covered with a layer of sand or sawdust, or any other litter material, half – liquid slurry is obtained in the cow barn with the content of moisture 85-92%.

Besides, appropriate slurry removal and accumulation technologies as well as accordingly adapted equipment and devices should be used in every definite case. Therefore, the aim of the given research is to clarify what kinds of boxes for handling of cows and what slurry removal technologies corresponding to them are economically most profitable with loose handling of animals.

Materials and methods

In the research technologies of slurry removal from barns with a herd of 100 cows were compared using high as well as deep boxes and applying different slurry removal technologies that are widespread in Latvia and other countries with similar climatic conditions (Table 1). The above mentioned number of cows is selected considering our previous investigations [1; 2] in which it was stated that having a herd of 100 cows it is profitable to introduce up-dated technologies with obtaining of slurry. Besides, the barns of such size become more widespread in Latvia.

The technological versions were compared applying the general methods [3] using three different criteria: specific capital investments for introduction, Ls/cow, specific consumption of work, man-hours/cow per year, as well as specific operational costs, Ls/cow per year. For calculation of these criteria computer software developed by us was used. The necessary initial data were obtained from our chronometrical results, the current valid normative documents, price lists and machinery instructions, but in many cases also the information available at the companies “DeLaval” and “Kesko Agro” was used.

The profitability of application of tractor units for removal of manure comparing them to stationary equipment has also been researched in.

For this reason cases when the tractors have some additional load in distribution of animal feed and other kinds of work, including work also outside the cow barn, were considered.
Table 1

<table>
<thead>
<tr>
<th>Kind of handling of cows</th>
<th>Version No</th>
<th>Technological elements and equipment for removal of slurry excluding the storage tank</th>
</tr>
</thead>
<tbody>
<tr>
<td>High boxes with a cover</td>
<td>1.1</td>
<td>Delta conveyor with cable drive + crosschannel + auger type pump</td>
</tr>
<tr>
<td></td>
<td>1.2</td>
<td>Delta conveyor with push rod drive + crosschannel + auger type pump</td>
</tr>
<tr>
<td></td>
<td>1.3</td>
<td>Tractor with a hitched wheel + crosschannel + auger type pump</td>
</tr>
<tr>
<td></td>
<td>1.4</td>
<td>Longitudinal channel + crosschannel + auger type pump</td>
</tr>
<tr>
<td></td>
<td>1.5</td>
<td>Longitudinal channel + crosschannel + pump tank + centrifugal pump</td>
</tr>
<tr>
<td>Deep boxes with sand litter</td>
<td>2.1</td>
<td>Delta conveyor with cable drive + crosschannel + bucket tractor</td>
</tr>
<tr>
<td></td>
<td>2.2</td>
<td>Tractor with a hitched wheel + pump tank + centrifugal pump + bucket tractor</td>
</tr>
<tr>
<td></td>
<td>2.3</td>
<td>Tractor with a hitched wheel</td>
</tr>
<tr>
<td>Deep boxes with straw litter</td>
<td>3.1</td>
<td>Delta conveyor with cable drive + press conveyor</td>
</tr>
<tr>
<td></td>
<td>3.2</td>
<td>Delta conveyor with push rod drive + press conveyor</td>
</tr>
<tr>
<td></td>
<td>3.3</td>
<td>Tractor with a hitched wheel</td>
</tr>
</tbody>
</table>

Results of the research

The specific capital investments for introduction of slurry removal technologies compared in the research are shown in Figure 1.

The figure shows separately the specific capital investments that are necessary for construction work: installation of stalls (boxes) for the animals, concreting of manure passages and channels, installation of pump tanks as well as the specific capital investments for purchasing and assembling of the necessary machinery (manure conveyors, pumps, tractor units etc.). Besides, the fact has been considered that the tractor will be additionally used for unloading of animal feed from the storages and transportation of it to the barn as well as for distribution of animal feed so being used for one more hour on the farm additionally to the removal of manure.

The results of the research show that using the high boxes with covers (Version 1) the total capital investments calculating per one cow are in the average by 30% higher than using the deep boxes (Versions 2 and 3). That is mainly related to the costs of the coverage that can vary from 25 to 80 Ls/m² (In our case the price of the coverage is accepted to be 50 Ls/m²). The amount of these capital investments is also essentially influenced by the construction of slurry channels and pump tanks as it requires high expenses.
Introducing the Version 1, the highest capital investments are needed for the Subversion 1.4., when they reach 514 Ls/cow, but the lowest – for the Version 1.3. with 410 Ls/cow. So, considering this criterion, it is cheaper to use the tractor unit than to install stationary manure removal conveyors.

In turn, introducing the Versions 2 and 3, capital investments are the highest in Subversions 2.1. and 3.1., 374 and 348 Ls/cow correspondingly, but the lowest – for the Subversions 2.3. and 3.3., i.e., capital investments are lower in case if all the manure removal operations are done using one mobile unit – a tractor with a hitched wheel.

The comparison of the versions of slurry removal according to the consumption of work is shown in Figure 2.

Fig. 2. Comparison of the versions of slurry removal according to the consumption of work, man-hours/cow per year

The consumption of work is less in barns with the high boxes and stationary manure removal solution. Using other versions the specific consumption of work is 2-3,5 times higher. Besides, it is especially high if the mobile tractor unit is applied. Nevertheless, we should mention that it is not possible to determine the consumption of work precisely in this case as it depends upon the definite conditions, for instance, from organization of work of the employees. Therefore, the data given in Figure 2 can serve mainly for relative comparison.

The most important criterion of assessment is the specific operational costs (Figure 3) according to which we can consider the economic profitability of application of different versions within a longer period of time.

In this figure for all the technological versions in which a tractor is used for removal of manure two subversions are given: the first (in darker colour) when the tractor besides removing of manure is used also for distribution of animal feed, and the second (in lighter colour) when the tractor in addition to removal of manure is used for seven more hours in other kinds of work that can be also outside the farm. As it can be seen in the figure such additional usage of the tractor is essentially important, therefore a wider analysis of it is summarized in the next figure.

Using the high boxes, the Versions 1.5. and 1.4. have the lowest operational costs, i.e., manure is gathered in channels that are installed in the barn under grated floor and it flows to the crosschannel. Then these costs are by 25-30% lower than in the case if manure is removed by the delta type conveyor and approximately by 50% lower than using the mobile tractor unit.

If in the barn the deep boxes with sand litter are used, then the tractor unit is necessary in all cases. But it, comparing to the high boxes, increases the operational costs of the technological process even up to 66% reaching 58 Ls per cow per year. Nevertheless, the difference between all three subversions of the Version 2 is not big. The costs are a little lower (by 6-7%) in the case if manure is
gathered in the passages between the boxes by delta type conveyors and the tractor unit is used only for removal of the sandy manure sediment from the pump tank (Subversion 2.1.).

There are also relatively small operational costs using the deep boxes with straw litter, especially if the stationary equipment is used in the technological processes: delta type conveyors (in the passages along the boxes) and press conveyors (in the crosschannel). But if for this purpose a tractor unit is used and it is not applied in other kinds of additional work, the operational costs use to increase by 18-24%.

Therefore, we can state that usage of the tractor units makes the operational costs of the technological processes more expensive. Nevertheless, it is mainly in the case if the tractor unit is not used with sufficient load.

In accordance with our chronometrical data in barns having 100 milk cows the tractor is used for 30-45 minutes for removal of manure, but if it is used for unloading of animal feed from the storage and for mechanized distribution of it, then the tractor is additionally used for approximately 60 more minutes per day. Therefore, including the idle, preparation and finishing work we can calculate that the tractor works in the barn for 2,0 to 2,5 h/day. When not busy on the tractor the tractor driver carries out the responsibilities of a mechanic or does other kinds of work. There is still a possibility that in the rest of the day the tractor is used in different other kinds of work outside the barn, for instance, in transportation. It increases the coefficient of the load of the tractor and reduces the specific operational costs for it. This situation is shown in Figure 4.

In the figure it can be seen that with the increase of the load of the tractor the operational costs for removal of manure decrease. This decrease is especially sharp if there is small additional load for the tractor. If, for instance, in the case of the Version 1.3. the load for the tractor in additional work increases by one hour, i.e., the tractor is used also in distribution of animal feed, the specific operational costs decrease by 22,8%, but if this load increases up to 3 hours – by 31,1%. If, in turn, the additional load for the tractor increases up to 7 hours per day, the reduction of the specific operational costs reaches 34,8%. So, it is especially important to use the tractor at least 3-4 hours per day. Of course, it is economically more profitable to use the tractor even much longer, but then the obtained reduction of the specific operational costs will not be so expressed any more.

![Fig. 3. Comparison of slurry removal technologies according to the specific operational costs, Ls/cow per year](image-url)
Discussion

Utilisation of slurry in Latvia dates back to the sixties of the last century, when it was introduced on a pig farm (Talsi region, Pastende), but in the seventies this technology was introduced also on milk cow farms that were built in accordance to the experimental designs elaborated in the leading Cattle farm complex mechanization specialized design office (VSKB Riga).

Fig. 4. Operational costs of technologies for removal of slurry for Versions 1.3., 2.2., and 3.3. using the tractor unit depending on the time of application of this tractor in other kinds of work

Wider application of slurry in Latvia has started mainly in recent years. It is to some extent related to the climatic conditions as winters in Latvia are colder than in most Western European countries.

Therefore, in Latvia more attention should be paid to such solutions of slurry removal that can be operated also at small negative ambient temperatures, for instance, the solution using delta type conveyors and mobile tractor units. In turn, it would be good to avoid drift crosschannels as there is a great possibility that they can freeze.

Different systems and technological versions are described in the special literature abroad [4, 5] as well as in Latvia [6, 7].

According to the information available to the authors of the article an average economic comparison has been done only from the point of view of construction of farms [8].

As our research shows, the economic profitability of different versions of slurry removal is mostly influenced by two factors: equipment of the boxes and the choice between application of stationary and mobile machinery. In the case of high boxes considerable cover prices should be taken into account as they can surpass the stall concreting prices 2-3 times. But later during the usage of the barn it is much easier to maintain such a stall and the consumption of time is less.

The idea of application of the tractor units in manure removal is under discussion. As our experiments show it is especially influenced by the total load of the tractor that should be not less than 3-4 hours per day. In a barn with the herd of 100 cows it can be achieved if the tractor is regularly used not only for removal of manure and distribution of animal feed bet also for other kinds of work. Working in manure removal then tractor becomes dirty. Therefore, before usage of it in other kinds of work it should be washed that in turn makes the operation of the tractor more expensive.

In practice also the usage of sand litter has not justified itself. For storage of it a shelter is necessary. Beside, sand is an abrasive material and its presence not only makes removal of manure more complicated but also causes depreciation of machinery, including even silting of milk coolers.
Conclusions

1. Solutions of manure removal from barns where cows are handled in boxes and on the cover can be divided in three versions: solutions with high boxes and cover, solutions with deep boxes and sand litter as well as solutions with deep boxes and cover of organic material litter (chopped straw, sawdust etc.).

2. Using the high boxes with a cover the capital investments, Ls/stall, for installation of boxes and slurry removal systems are in the average by 30% higher than with the versions with the deep boxes.

3. Evaluating according to the operation costs, Ls/cow per year, the slurry removal versions with high boxes are approximately similar to the versions with deep boxes where organic material litter is used, and they are for about 25% more profitable than the versions with deep boxes and sand litter.

4. Using loose handling of cows in boxes removal of manure with the delta type conveyor is preferable. But it can be replaced by application of the tractor unit if this tractor can be used also in other kinds of work with the load not less than 3-4 h/day.

Bibliography


