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Choosing and evaluation of milking parlours for dairy farms in Estonia

O. Sada[1,*], A. Leola[1] and P. Kic[2]

[1]Estonian University of Life Sciences, Institute of Tecnology, Department of Husbandry Engineering and Ergonomics, Fr.R.Kreutzwaldi 56, EE51014 Tartu, Estonia
[2]Czech University of Life Sciences Prague, Faculty of Engineering, Department of Technological Equipment of Buildings, Kamycka 129, CZ16521 Prague 6, Czech Republic
[*]Correspondence: oliver.sada@emu.ee

Abstract. The aim of this paper is to present the main criteria, which could be used for the choosing, optimization and evaluation of a milking parlour in two large capacity Estonian dairy farms. The choosing and evaluation of milking parlours parameters is based on the available information and results of previous research in dairy farms in the Estonia, using the mathematical model created in the Czech Republic. Time for milking and final specific direct costs are main parameters which enable evaluation and choosing of suitable milking parlour for the dairy farm. Calculation of the first farm with a capacity of 300 cows showed that in the case of rotary milking parlour with 32 milking stalls total specific direct costs per milking per cow and year would be by 25% higher than in the case of Side by Side milking parlour 2 x 12, but the time for milking would be reduced by about 25%. The second farm with capacity of 1,850 cows is equipped with a rotary milking parlour with 70 milking stalls. There are three milkers. Six milkers would bring shortening of one milking from 6.3 h to 3.3 h while preserving approximately the same total specific direct costs per milking per cow and per year. This milking parlour could be used also for the planned increase in capacity at farm to 3,300 cows. Time of one milking would be 5.6 hours, but total specific direct costs per milking per cow and per year would be reduced by 18%.

Key words: Costs, cows, equipment, farm, milking process.

INTRODUCTION

Livestock production in countries with intensive agriculture is undergoing big and rapid changes. Capacity of farms are expanding and increasing the average annual milk production per cow. These factors lead to modernization of milking equipment. European housing systems are steadily changing from stanchion barns towards loose cowsheds and larger herd sizes (Maton et al., 1985; Bottema, 1992; Hansen, 1999; Gaworski et al., 2013; Gaworski & Leola, 2014; Gaworski & Priekulis, 2014). Due to these changes, many dairy farmers will have to design and build new milking parlour systems.

The milking process is the key operation on dairy farms. The function of milking parlour is one of the factors which affect the efficiency of milk production on the farm. There are many problems which influence the choosing and proper use of milking

parlour. Some of them should be solved in advance during the preparation and design of dairy farm.

Modern large-scale farms require appropriate modern technical equipment. Equipment producers want to sell you the most expensive product which is not always appropriate. Operation is affected e.g. by selected number of milking stalls, by high or low number of milkers, sometimes by incorrectly selected or by choosing insufficient automation equipment. Therefore, it is important to compare different possibilities of milking parlours and try to find the strengths and weaknesses of some proposals. Model calculations allow comparing options and making decision according to the accurate and uniform criteria correctly according to the results of calculations.

Therefore it is very important to find the appropriate criteria that would allow choosing the optimal type of milking parlour, corresponding to the overall concept of the farm and meeting all operational requirements under acceptable economic conditions. The aim of this paper is to present the main criteria, which could be used for solution of principal questions important for optimization of milking parlour: technical parameters, indicators of labour productivity, and economic criteria.

The same milking parlours have different operating conditions in different countries around the world. Dairy farms in Estonia are interesting, because at present arise in addition to traditional small farms also new large-scale farms with thousands of cows. For these farms it is necessary to calculate (model in advance) different variants of equipment and operating conditions by precisely selected and uniform criteria.

MATERIALS AND METHODS

There are available solutions offered by manufacturers of either milking parlours, or automated milking systems (AMS), equipped with milking robots. Many books, reports and scientific publications present results of research and recommendations focused on the problems of AMS, usually also including comparison of AMS and milking parlours, in some publications information related to problems of performance and economic analysis e.g. (Bottema, 1992; Kic & Nehasilova, 1997; Kic, 1998; Priekulis & Laurs, 2012).

Leading companies producing milking equipment usually offer a variety of constructions of milking parlours recommended for different capacity of farms. They also recommend the possible level of automation and number of milkers which should work in the milking process (Brunsch, et al., 1996; Dolezal et al., 2000; Chiumenti, 2004). But there are rather big differences in local conditions of the farms according to the production, economic, market and labour situation of the country or province. Although the use of AMS for large farms with a big capacity is developing, the high cost of this solution discourages many farmers. The question for medium and large farms is to currently choose an appropriate type of milking parlour.

It is possible to say that there are two divergent interests and goals in choosing the appropriate type of milking parlour. On the one hand there is interest of manufacturer and dealer who strives for the highest price contract and on the other hand, a farmer who would like to receive the best parlour, but for the price as favourable as possible, i.e. the lowest.

There are various practical recommendations in the literature, however, there are usually not sub-economic data included which results in a specific numerical data,

characterizing the overall result of milking parlour solutions. Some publications (Provolo, 1992; Provolo & Marcon, 1993) present models focused on the choosing of milking parlours, but not in a complete universal approach which could be adapted everywhere. Results of research and basic equations used for calculation of several parameters of milking parlours presented by Gaworski & Priekulis, 2014. Similar calculations, completed with several important economic results which are valid for rotary milking parlours are presented by Ozolins et al., 2012.

Currently there are a variety of mathematical models, which can help us to optimize the solution of various functional dependencies. It is always necessary to find appropriate criteria for the decision-making process. Some results of optimization and calculation based on mathematical model focused on the conditions of dairy farms and milking production in Czech Republic are presented by Kic 2015a; and by Kic, 2015b. The following calculations are based on the same calculation model, just changed with parameters according to the data valid for the Estonian dairy farm and production conditions.

The question is which criteria would be suitable to determine the type of milking parlour for each farm. If we know them, according to them can be evaluated different milking parlours, as well as we follow them when consider specific aspects and individual issues which influence the selection of milking parlour for the farm.

For objective assessment and selection of milking parlours can be used and considered a lot of different aspects, e.g.: animal welfare, capacity, price, the number of milkers, the complexity and sophistication of the operation, reliability, the dimensions and complicated installation in the building, demand of maintenance and service, some other aspects.

Overestimating or underestimating some aspects may result in problems during the normal operation of the milking parlour in practice and thus negatively affect the operation of the farm. In some cases this may lead to unnecessary wastage of finance for investment, without any real benefit to the operation of the farm.

The first criterion which is important for the function of the farm is the time for milking. The fast milking of all cows enables to have enough free time in which cows have the opportunity to eat and relax, to go to pasture and so on. The duration of one real milking of all cows can be calculated according to the equation (1).

$$T_{vd} = \frac{N}{Q_{LS}} + T_{pr} \quad (1)$$

where: T_{vd} – the duration of one real milking, min; N – the number of lactating cows on the farm, cow; Q_{LS} – the real capacity of a milking parlour, cow min^{-1}; T_{pr} – the time of working breaks, min.

As regards of a human working process and working operations there is important the total time of duration of one milking including preparatory operations and finishing work after milking, calculated according to the equation (2).

$$T_{cd} = T_{vd} + T_p + T_c \quad (2)$$

where: T_{cd} – the total time of duration of one milking including preparatory operations and finishing work after milking, min; T_p – the time of preparatory work before milking, min; T_c – the time of finishing and cleaning work after milking, min.

When this period T_{cd} is short enough then there is enough time for workers (milkers) to carry out the other activities (feed preparation, cleaning, control of animals etc.). Therefore the time should be a criterion for optimization and the selection of a suitable milking parlour for the farm.

The second decisive criterion for choosing the appropriate milking parlour should be the economic criteria. It is necessary to compare the specific data, which are in this case the final specific direct costs of a milking parlour per cow and year $^{u}C_{MP}$, which are calculated according to the equation (3) as a sum of specific labour costs of milking per cow and year $^{u}C_{W}$, specific costs of the milking equipment per cow and year $^{u}C_{P}$ including the parlour construction, and specific costs $^{u}C_{S}$ of consumed supplies including the water, electricity, disinfections etc. per one cow and year.

$$^{u}C_{MP} = {}^{u}C_{W} + {}^{u}C_{P} + {}^{u}C_{S} \quad (3)$$

where: $^{u}C_{MP}$ – the final specific direct costs of milking parlour, EUR cow^{-1} year^{-1}; $^{u}C_{W}$ – the specific labour costs per cow and year, EUR cow^{-1} year^{-1}; $^{u}C_{P}$ – the specific costs of the milking equipment, EUR cow^{-1} year^{-1}; $^{u}C_{S}$ – the specific costs of consumed supplies, EUR cow^{-1} year^{-1}.

Specific labour costs $^{u}C_{W}$ are calculated on the basis of labour requirements per cow per year and average hourly wage of the milker.

Specific costs of the milking equipment $^{u}C_{P}$ are calculated as specific data of total operating costs of the milking machine converted per one cow. Therefore it includes the amortization of machinery, which is the purchase price of the machine expressed by percentage of machine amortization, further amortization of construction that includes construction costs and percentage of building amortization and the cost of servicing, maintenance and repairs, which are usually expressed as a percentage of planned acquisition costs.

Specific costs of consumed supplies $^{u}C_{S}$ are calculated as a sum of costs of all necessary operating materials and energy. The consumption of electricity is proportional to the power inputs of motors and all electrical appliances of milking parlour during their operation, water, disinfection etc. All is re-calculated per cow and year (EUR cow^{-1} year^{-1}).

Described criteria were used for evaluation of milking process in two types of farms typical for current situation in the Estonian agriculture. All data used for the calculation were based on the data from dairy farms in the Estonia. The first farm A is representing the medium dairy farm with 300 cows. There are calculated criteria and compared results between the variant A1 equipped with a milking parlour Side by Side 2 × 12 milking stalls and variant A2 equipped with a rotary milking parlour with 32 milking stalls.

The second farm B represents very special large scale dairy farm with 1.850 cows. There are calculated criteria and compared results between the variant B equipped with a rotary milking parlour with 70 parallel milking stalls. There can be used milking parlour with different number of milkers (variants B1 and B2). As the farm capacity could be increased to 3,300 cows is the variant B3 solved for the same milking parlour functioning in the conditions of this farm with 3,300 cows.

RESULTS AND DISCUSSION

The results of calculations of the farm A are presented on the Figs 1 and 2. Two milkers are supposed to work in both variants of milking parlours. There is a standard level of technical equipment in both variants of milking parlours. The variant A1 milking parlour Side by Side 2 × 12 milking stalls has lower labour productivity as well as lower milking capacity therefore the labour requirements are higher in this variant and time of one milking (Fig. 1) is longer than in the variant A2 (rotary milking parlour). On the other side milking parlour Side by Side is cheaper ($^{u}C_{P}$), which results in the lower final specific direct costs of milking parlour $^{u}C_{MP}$ (Fig. 2). The price of milking parlour A2 is higher because of the higher number of milking stalls, more complicated and sophisticated construction which results just in the bigger specific costs of the milking equipment $^{u}C_{P}$.

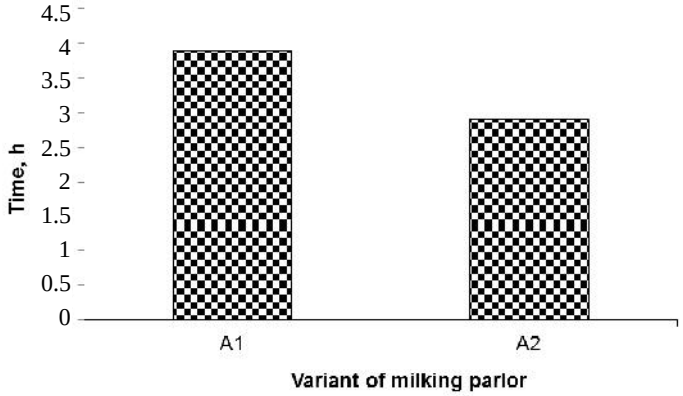

Figure 1. Time of one milking in the milking parlour A1 (Side by Side 2 × 12) and in the rotary milking parlour A2 (with 32 milking stalls) at the dairy farm A (300 cows).

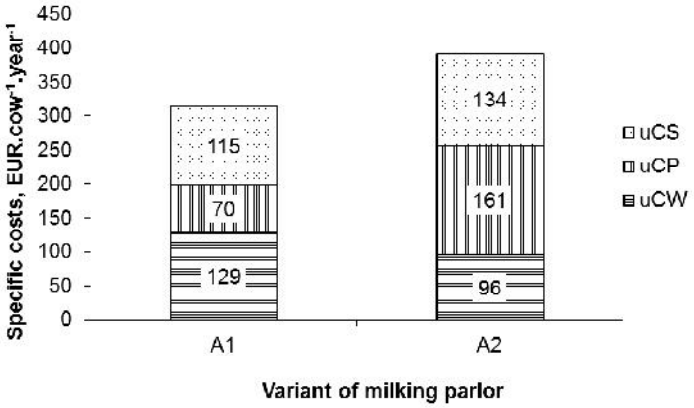

Figure 2. Specific costs of milking in the milking parlour A1 (Side by Side 2 × 12) and in the rotary milking parlour A2 (with 32 milking stalls) at the dairy farm A (300 cows).

The final decision of choosing the suitable milking parlour will depend on the priorities of the farmer, if he prefers cheaper variant solution A1 or more expensive variant A2 but with higher capacity and shorter time of milking.

The results of calculations of the farm B with 1,850 cows are presented on the Figs 3 and 4. These results of calculation are rather influenced by the real milking process as well as by the auxiliary activities in the preparation of cows before the milking outside the milking parlour, etc., which cannot be completely included in the optimization model. The variant B1 equipped with a rotary milking parlour with 70 milking stalls has standard technological equipment and 3 milkers are working in it, therefore the time for one milking in the optimum working conditions and help of auxiliary activities is more than 6 hours. The big number of milking stalls is not used efficiently, if the milkers follow exactly the milking procedure and do all working operations without ony help.

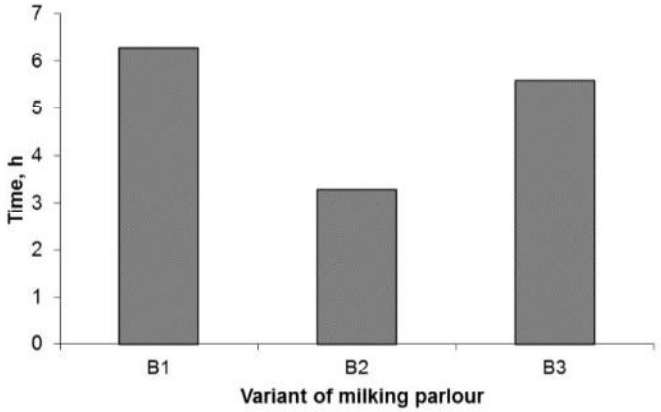

Figure 3. Time of one milking in the rotary milking parlour with 70 milking stalls on the dairy farm 1,850 cows and 3 milkers (B1), and 6 milkers (B2) and at the dairy farm 3,300 cows with 6 milkers (B3).

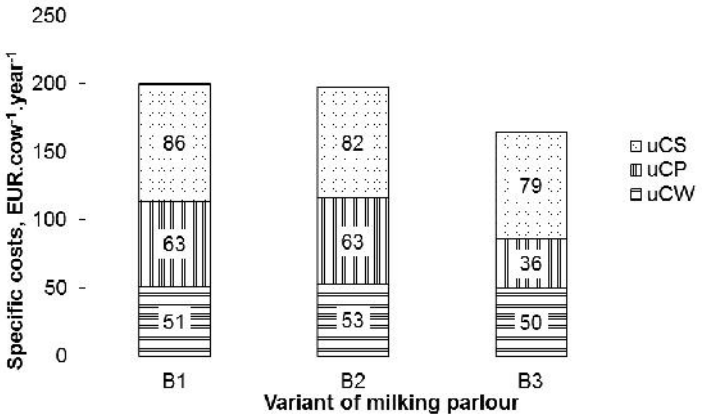

Figure 4. Specific costs of milking in the rotary milking parlour with 70 milking stalls on the dairy farm 1,850 cows and 3 milkers (B1), and 6 milkers (B2) and at the dairy farm 3,300 cows with 6 milkers (B3).

The variant B2 has the same level of technological equipment but with 6 milkers, so this variant is more efficient, and big number of milking stalls enables to 6 milkers to work in this parlour. Time of milking can be reduced (Fig. 3) and final specific costs of milking parlour $^{u}C_{MP}$ have similar level like the varian B1 (Fig. 4). The variant B3 is also the same rotary milking parlour with 70 milking stalls but used for the large dairy farm with 3,300 cows which seems to be efficient solution (Figs 3 and 4). It results in the lowest specific $^{u}C_{P}$ costs. The use of this milking parlour with 6 milkers results in the acceptable time of one milking.

Generally, the organisation of milking process in this huge type of dairy farm is not easy. It is very probable that in the practical application can be time of milking longer than results of this calculation due to the time loses and practical problems with the organisation of movement dairy cows in the farm and auxiliary activities in preparation of cows for milking, etc.

CONCLUSIONS

The time for milking and the final specific direct costs are the main parameters which enable evaluation and choosing of suitable milking parlour for the dairy farm. Both previous mentioned parameters in proposed methodology include the main technical parameters, indicators of labour productivity and economic criteria which can be used for determination of optimal parameters of milking parlour.

Calculation for the first farm with a capacity of 300 cows showed that in the case of rotary milking parlour with 32 milking stalls total specific direct costs per milking per cow and year would be by 25% higher than in the case of Side by Side milking parlour 2 x 12, but the time for milking would be reduced by about 25%.

The second farm with capacity of 1,850 cows is equipped with a rotary milking parlour with 70 milking stalls and with three milkers. Six milkers would bring shortening of one milking from 6.3 h to 3.3 h while preserving approximately the same total specific direct costs per milking per cow and per year. This milking parlour could be used also for the planned increase in capacity at farm to 3,300 cows. Time of one milking would be 5.6 hours, but total specific direct costs per milking per cow and per year would be reduced by 18%. Increased capacity of dairy farm obviously enables to reduce the final specific direct costs for milking.

It is advantage that this model allows, unlike the calculations solved earlier by other authors, to change all basic parameters of the construction and operation of the milking parlour on dairy farms. The preliminary calculations in the preparatory phase before developing a project enable to evaluate (positives and negatives) various solutions of milking parlours. The evaluation of existing milking parlours in the farms can help to improve the milking process and operations from the point of view of either technical improvement or improved activity of milkers.

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