CRITERIA FOR OPTIMIZATION OF MILKING PARLOUR ON DAIRY FARM

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Abstract. 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 a milking parlour. It is very important to find the appropriate criteria that would allow choosing the optimal type of a 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 the solution of the principal questions important for choosing and optimization of a milking parlour. The time for milking and the final specific direct costs are the main parameters which enable the evaluation and choosing of a suitable milking parlour for the dairy farm. The calculation for the verification of this method and these criteria shows that by optimizing of the milking parlour and increasing the capacity of the farm it is possible to reduce the final specific direct costs of milking per cow and year by 30 or 40 %.

Keywords: costs, cows, equipment, farm, milking process.

Introduction

Livestock production in countries with intensive agriculture is undergoing big and rapid changes. Capacity of farms is expanding and increasing the average annual milk production per cow. These factors lead to modernization of the milking equipment. European housing systems are steadily changing from stanchion barns towards loose cowsheds and larger herd sizes [1-4]. 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 the milking parlour is one of the factors which affect the efficiency of milk production on the farm. There are many problems which influence choosing and proper use of a milking parlour. Some of them should be solved in advance during the preparation and design of a dairy farm.

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 the principal questions important for optimization of the milking parlour: technical parameters, indicators of labour productivity, and economic criteria.

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. [5-8]. The 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 [9-11]. 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 parlours.

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 the 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 [12; 13] present models focused on choosing of milking parlours, but not in a complete universal approach which could be adapted everywhere. The results of research and basic equations used for calculation of several parameters of milking parlours are

presented in [2]. Similar calculations, completed with several important economic results, which are valid for rotary milking parlours are presented in [14]. Currently, there are a variety of mathematical models and computational programs, 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.

A practical problem which must be solved primarily is to find criteria which would be suitable to determine the type of the milking parlour for each farm. If we know them, according to them different milking parlours can be evaluated, as well as we follow them when considering specific aspects and individual issues, which influence the selection of a milking parlour for the farm.

For objective assessment and selection of milking parlours a lot of different aspects can be used and considered, 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 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.

A practical problem which must be solved primarily is to find criteria which would be suitable for determining the type of the milking parlour for each farm. These are intended as the primary targets. If we know them, then according to them the overall results would be considered and followed in solving partial reflection and individual problems that influence a parlour choice for the farm.

Materials and methods

The first criterion which is important for practical functioning of the farm is the time for milking. 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 equation (1).

$$T_{vd} = \frac{N}{Q_{LS}} + T_{pr} \tag{1}$$

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

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

$$T_{cd} = T_{vd} + T_p + T_c \tag{2}$$

where T_{cd} – total time of duration of one milking including preparatory operations and finishing work after milking, min;
T_p – time of preparatory work before milking, min;
T_c – 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 other activities (feed preparation, cleaning, control of animals etc.). Therefore, the time should be the primary criterion for optimization and 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 water, electricity, disinfections etc. per one cow and year.

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

where ${}^{u}C_{MP}$ – final specific direct costs of milking parlour, EUR·cow^{-1}·year^{-1};
${}^{u}C_{W}$ – specific labour costs per cow and year, EUR·cow^{-1}·year^{-1};
${}^{u}C_{P}$ – specific costs of the milking equipment, EUR·cow^{-1}·year^{-1};
${}^{u}C_{S}$ – 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 T_r (h·cow^{-1}·year^{-1}) calculated by using equation (4) and average hourly wage of the milker. The labour requirement T_d can be calculated by using equation (5).

$$ T_r = \frac{365.T_d}{60} \quad (4) $$

where T_r – labour requirement for milking per cow per year, h·cow^{-1}·year^{-1};
T_d – labour requirement during milking per cow per day, min·cow^{-1}.day^{-1}.

$$ T_d = i.\left[\frac{N.(t_{rc} + t_p + t_c) + T_{pr}.n_{ds}}{N}\right] \quad (5) $$

where i – number of milking per day, day^{-1};
t_{rc} – average net labour requirement for milking per cow, min·cow^{-1};
t_p – time of preparatory work before milking calculated per one cow, min·cow^{-1};
t_c – time of finishing and cleaning work after milking calculated per one cow, min·cow^{-1};
n_{ds} – real number of milkers, pers.

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 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 costs of servicing, maintenance and repairs, which are usually expressed as a percentage of the planned acquisition costs.

Specific costs of consumed supplies ${}^{u}C_{S}$ are calculated as a sum of the 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 the milking parlour during their operation, water, disinfection etc. All are re-calculated per cow and year (EUR·cow^{-1}·year^{-1}).

The real number of milkers for the whole farm n_{ds} is the rounded integer n_d. It is an important criterion to ensure successful functioning of the milking parlour in real farm conditions. The theoretical required number of milkers n_d is based on calculation of equation (6).

$$ n_d = \frac{Q_{PL}}{W_d} \quad (6) $$

where n_d – theoretical required number of milkers per one parlour, pers.;
Q_{PL} – required capacity of the milking parlour, cow·min^{-1};
W_d – working capacity of one milker, cow·min^{-1}.

The maximum reasonable number of milkers per a parlour n_{dm} is a very important criterion to avoid the idle time or complicated work of milkers. It is calculated by the number of milking stalls m_Z divided by the number of clusters n_s that one milker can operate.

$$ n_{dm} = \frac{m_Z}{n_s} \quad (7) $$

where n_{dm} – maximum number of milkers per one parlour, pers.;
m_Z – number of milking stalls in the milking parlour, pcs;
n_s – maximal number of clusters per milker, pcs.

An important technical parameter is the theoretical number of milking stalls in a parlour m_T, calculated by using equation (8).

$$m_T = Q_{PL}.(t_d + t_v) \tag{8}$$

where m_T – theoretical number of milking stalls in the parlour, pcs;
t_d – average duration of milking by milking machine per one cow, min;
t_v – average idle time of a cluster, min.

$$t_v = t_n + t_s + t_m \tag{9}$$

where t_n – average time for cluster attachment, min;
t_s – average time to remove the cluster, min;
t_m – average time for manipulation with a cluster, min.

The aim of this paper is to present the method of calculation and examples of the decision model according to the proposed criteria. The calculations and the decision process in the real conditions of the dairy farm will be specified according to the local conditions of the agricultural region or the country. The described criteria were used for evaluation of the milking process in two types of farms typical for the Czech agriculture. All data used for the calculation were based on the usual real data from the farms in the Czech Republic. As there are rather different detail data, parameters and values which are important for calculation and the decision process on different farms and regions, the input data used for calculations were collected from many different farms and companies.

The first farm A is representing a small or medium dairy farm with 120 cows. There are calculated criteria and compared results between the variant A1 equipped with a milking parlour Side by Side 2 × 10 milking stalls and variant A2 with a milking parlour Side by Side 2 × 6 milking stalls.

The second farm B represents a typical large scale dairy farm with 400 cows. There are calculated criteria and compared results between the variant B1 equipped with a herringbone milking parlour 2 × 12 milking stalls, variant B2 with a herringbone milking parlour 2 × 9 milking stalls, and B3 with a rotary milking parlour with 32 milking stalls.

Results and discussion

The results of calculations of the farm A are presented in Figures 1 and 2. Two milkers are supposed to work in both variants of the milking parlours. There is a standard level of technical equipment in both variants of milking parlours, therefore the labour requirements are the same in both variants, and so the time for milking is also the same (Fig. 1). The prise of the milking parlour A1 is higher because of the higher number of milking stalls and larger construction which results just in the bigger specific costs of the milking equipment $^{u}C_P$.

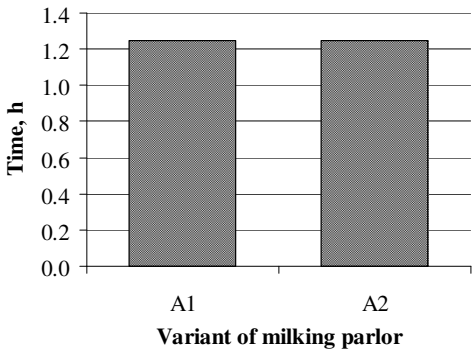

Fig. 1. **Time for milking, farm A**

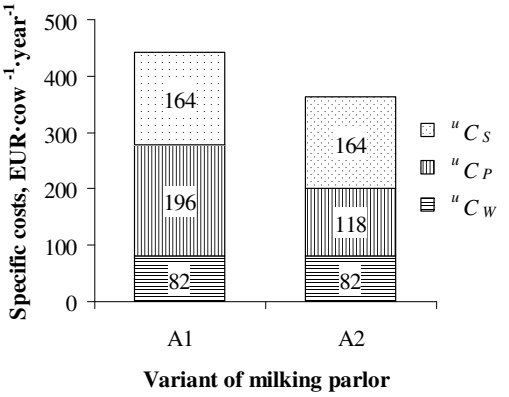

Fig. 2. **Specific costs, farm A**

The results of calculations of the farm B are presented in the Figures 3 and 4. The variant B1 equipped with a herringbone milking parlour 2 × 12 milking stalls has standard technological equipment and 2 milkers are working in it, therefore the time for one milking is more than 5 hours. The big number of milking stalls is not used efficiently if the milkers follow exactly the milking procedure and do all working operations.

The variant B2 has the same level of technological equipment but only 2 × 9 milking stalls, so this variant is cheaper, and relatively sufficient number of milking stalls enable 3.5 milkers to work in this parlour (which means that one milker could partly work also in other activities on this farm). The variant B3 with a rotary milking parlour with 32 milking stalls is the most expansive (Fig. 4) which results in the highest specific ${}^{u}C_P$ costs. The use of this milking parlour with 2 milkers results in the shortest time of one milking.

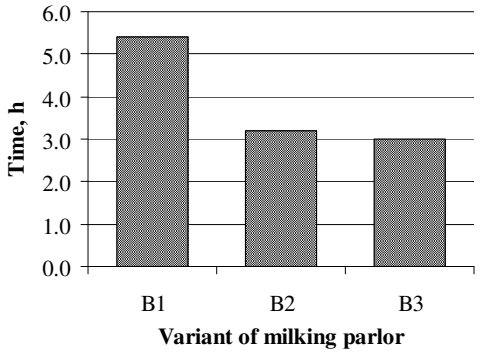

Fig. 3. **Time for milking, farm B**

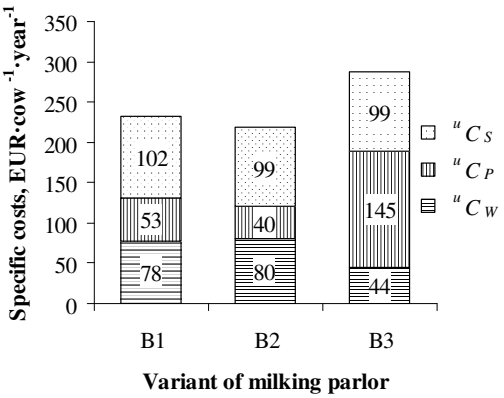

Fig. 4. **Specific costs, farm B**

Conclusions

The main ideas, principles of calculation and the decision process presented in this paper can be generalized in the following conclusions:

1. The time for milking and the final specific direct costs are the main parameters which enable evaluation and choosing of a suitable milking parlour for a dairy farm.
2. Neglect or promotion of only one of the mentioned criteria may lead to uneconomic investment or impaired operation of a farm.
3. Both previous mentioned parameters in the proposed methodology include the main technical parameters, indicators of labour productivity and economic criteria, which can be used for determination of optimal parameters of the milking parlour.
4. Increased capacity of a dairy farm enables to reduce the final specific direct costs for milking, e.g., the difference between a farm with 120 cows and 400 cows creates conditions for reducing the final specific direct costs of milking per cow and year by 30 or 40 %.
5. The preliminary calculations in the preparatory phase before developing a project enable to evaluate (positives and negatives) various solutions of milking parlours.
6. Evaluation of the existing milking parlours on the farms can help improve the milking process and operations from the point of view of either technical improvement or improved activity of milkers.

References

1. Gaworski M., Leola A. Effect of technical and biological potential on dairy production development. Agronomy Research, 2014. 12 (1), pp. 215-222.
2. Gaworski M., Priekulis J. Analysis of milking system development on example of two Baltic countries. Proceedings of 13th International scientific conference Engineering for Rural Development, May 29-30, Jelgava, Latvia University of Agriculture, 2014, pp. 79-84.

3. Hansen M.N. Optimal number of clusters per milker. Journal of Agricultural Engineering Research, 1999. 72 (4), pp. 341-346
4. Maton A., Daelemans J., Lambrecht J. Housing of animals. Amsterdam, Oxford, New York, Tokyo: Elesevier, 1985. 458 p.
5. Bottema J. Automatic milking: reality. Proceedings of the International Symposium on "Prospects for Automatic Milking", November 23-25, 1992, Wageningen, Netherlands, pp. 63-71
6. Kic P., Nehasilova D. Dojicí roboty a jejich vliv na zdravotní stav mléčné žlázy (Milking robots and their effect on mammary gland´s health). Prague: UZPI, 1997. 75 p. (In Czech).
7. Kic P. Nove trendy v zemedelske technice (Trends in farm mechanization). Prague: UZPI, 1998. 56 p. (In Czech).
8. Priekulis J., Laurs A. Research in automatic milking system capacity. Proceedings 11th International scientific conference Engineering for rural development, May 24-25, Jelgava, Latvia University of Agriculture, 2012, pp. 47-51.
9. Brunsch R., Kaufmann O., Lupfert. T. Rinderhaltung in Laufstallen (Loose housing of cattle). Stuttgart: Eugen Ulmer, 1996. 132 p. (in German).
10. Chiumenti, R. Costruzioni rurali (Rural buildings). Milano: Edagricole scolastico, 2004. 479 p. (in Italian).
11. Dolezal O., Hlasny J., Jilek F., Hanus O., Vegricht J., Pytloun J., Matous E., Kvapilik J. Mleko, dojeni, dojirny (Milk, milking, milking parlours). Prague: Agrospoj, 2000. 241 p. (in Czech).
12. Provolo G. Technical and economic assessment of the operations of milking machines by using a simulation model. Proceedings Informatica e Agricoltura, Supplemento agli Atti dei Georgofili. Firenze, VII serie, 39, 1992, pp. 411-420. (in Italian).
13. Provolo G., Marcon L. Simulation model for the technical-economic choice of milking equipment. Proceedings Atti del V. Convegno Nazionale AIGR, Maratea, vol. 3, 1993, pp. 153-160. (in Italian).
14. Ozolins A., Priekulis J., Laurs A. Research in rotary parlour operation. Proceedings 11th International scientific conference Engineering for Rural Development, May 24-25, Jelgava, Latvia University of Agriculture, 2012, pp. 43-46.