

## SIMULATION MODELS OF TECHNOLOGICAL OPERATIONS IN MACHINE MILKING IN PARALLEL TYPE PARLOUR

## СИМУЛАЦИОННИ МОДЕЛИ НА ТЕХНОЛОГИЧНИТЕ ОПЕРАЦИИ ПРИ МАШИННО ДОЕНЕ В ДОИЛНИ ЗАЛИ ПАРАЛЕЛ

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### ABSTRACT

The hourly productivity of the milking parlour is significantly influenced by the organization of the technological process. Milkers perform a series of sequential operations (entry on the platforms, washing, drying, placing the milking units, removing them, disinfecting the teats, exiting the platforms of the milking parlour) the duration of which is a large part of the total milking time. The duration of the latent period from the release of oxytocin to its contact with the myoepithelial cells in the glandular part of the udder is from 30 s to 90 s (average 60 s). In this line of thought, the following questions arise: "in what time interval should the preparatory operations for milking be performed and what is their permissible duration". The aim of the present study is to develop methodologies (models) for simulating the work of milkers in "Parallel" type parlours. It was found that under the initially set working conditions of only two milkers in the milking parlour, all developed models are applicable for capacities up to 2x8. Models II, III and IV are unacceptable for capacities above 2x8, as the total duration of preparation of milking cows exceeds the time frame by between 30-80%. This finding proves that for a capacity over 2x8 it is necessary to perform technological operations with a larger number of milkers.

### РЕЗЮМЕ

Часовата производителност на доилната зала се влияе значително от организацията на технологичния процес. Доячите извършват поредица от последователни операции (влизане на платформите, измиване, изсушаване, поставяне на доилните апарати, свалянето им, дезинфекция на циците, излизане от платформите на доилната зала), чиято продължителност е голяма част от общото време на доене. Продължителността на латентния период от освобождаването на окситоцин до контакта му с миоепителните клетки в жлезистата част на вимето е от 30 s до 90 s (средно 60 s). В този ред на мисли възникват следните въпроси: „в какъв интервал от време трябва да се извършват подготовителните операции за доене и каква е допустимата им продължителност“. Целта на настоящото изследване е да се разработят методики (модел) за симулиране работата на доячите в зали тип „Паралел“. Установено е, че при първоначално зададените условия на работа само на двама доячи в доилната зала, всички разработени модели са приложими за капацитети до 2x8. Модели II, III и IV са неприемливи за капацитети над 2x8, тъй като общата продължителност на подготовката на доилните крави надвишава времевата рамка с между 30-80%. Тази констатация доказва, че при капацитет над 2x8 е необходимо извършването на технологични операции с по-голям брой доячи.

### INTRODUCTION

One of the main trends in the development of milking equipment is the constant search for innovative solutions aimed at greater profitability of the farm, precision in the implementation of processes and at the same time reduce the duration of technological operations. Milking installations are increasingly tolerated, creating conveniences for service personnel, animal welfare and the possibility of continuous improvement of the technological process (Da Borso et al., 2022; Douphrate et al., 2013; Reinemann, 2019).

Although, in practice different configurations of milking parlours are offered, the technological operations in the process of machine milking do not differ significantly (Chiumenti et al., 2022; Jakob, 2019; Sandrucci et al., 2019).

The hourly productivity of the milking parlour is significantly influenced by the organization of the technological process (Kic, 2015). Milkers perform a series of sequential operations (entry on the platforms, washing, drying, placing the milking units, removing them, disinfecting the teats, exiting the platforms of the milking parlour) the duration of which is a large part of the total milking time (Doupbrate et al., 2013; Dzidic et al., 2019; Reinemann, 2019).

In this sense, modern "good practices" emphasize the qualification of service personnel in order to optimize the work process, reduce milking time, increase the hourly productivity of the milking parlour and reduce stress for animals (Dineva, 2016; Palmer, 2005; Wagner et al., 2001; Uzunova et al., 2017).

The total time for milking the animals can be divided quite conditionally into two phases - "preparation of the animals for milking" and "actual milking". In the practice of modern intensive animal husbandry, those factors that lead to a maximum increase in the hourly productivity of the installed equipment are considered as priorities (Peychev et al., 2019; Wagner et al., 2001; Stewart et al., 2002). Such a concept can lead to an unjustified reduction in the duration of those technological operations that form the stage of preparation of animals for machine milking. The presumed consequence of such an approach is incomplete milking of cows and increased risk of udder health problems (Rasmussen et al., 1992; Thomas et al., 1997; Marinova et al., 1989).

The analysis of the above statements raises the following questions: "in what time interval should the preparatory operations for milking be carried out and what is their permissible duration".

According to literature data, the duration of the latent period from the release of oxytocin to its contact with the myoepithelial cells in the glandular part of the udder is from 30 s to 90 s (average 60 s). It follows from the stated physiological regularity that the average duration of the preparatory operations (entrance, washing, drying/massage) must correspond to the duration of the latent period. Any reduction or prolongation of the duration of preparatory operations below and above the latency period calls into question the concentration of oxytocin in the blood and the complete milking of the animals (Peychev et al., 2019; Kokorina, 1986).

The aim of the present study is to analyse the time structure of the performed manual operations in machine milking of cows in order to develop models for optimizing the work of milkers.

## MATERIALS AND METHODS

The object of the study are "Parallel" type halls with a capacity of 2x8, 2x10 and 2x12 milking parlours.

The subject is an analysis of the duration of the manually performed technological operations during milking and the way of movement of the milkers in the technological corridor between the milking platforms.

The following operations related to the preparation of animals for machine milking were studied - washing, drying and massage, placement of the milking unit and actual milking.

The following boundary conditions are accepted during the derivation of the models:

- the duration of all operations for preparation of the udder for milking (washing, drying and placement of the milking units) - 30 to 90 s (physiologically determined);
- washing time - 2 s (average value from experimental timing);
- drying time - 2 s (average value from experimental timing);
- time for placing the milking unit - 4 s (average value from experimental timing);
- time for movement of the milker between two neighbouring animals - 1 s (average value from experimental timing);
- time for movement of the milker between two adjacent platforms - 2 s (average value from experimental timing);
- travel time (idling) - from 1 ÷ 8 animals - 3 s; from 1 ÷ 10 animals - 5 s; from 1 ÷ 12 animals - 8 s (average value from experimental timing).

The proposed models are simulative and are based on the limit values set by us for the duration of each of the technological operations of the milking process. In this study, no real measurements of the duration of the technological operations were made. Our long-term experience as researchers of the machine milking process shows that the set times are quite sufficient. The statement is valid for milkers possessing the necessary qualification and routine. The derived simulation models are yet to be implemented in real working conditions and will be compared with the theoretical ones in a future experiment. This type of comparison would show whether there are significant differences. This would provide additional up-to-date information to refine our proposed milker work patterns.

**RESULTS**

The values of the duration of the preparatory operations recommended by Westfalia separator and set in the “Stimopuls C” system (Fig. 1) are in the range of 30-90 s (average 60 s). The probable consequences of a deviation from the recommended values of the udder preparation time would have a negative impact on the course of the neuro-hormonal phase of milk secretion and a decrease in the concentration of oxytocin in the blood. The finding necessitates rethinking and introduction of new methods and methods of work in which the duration of the preparatory operations (timed to the placement of the milking unit) is about 60 s/cow.

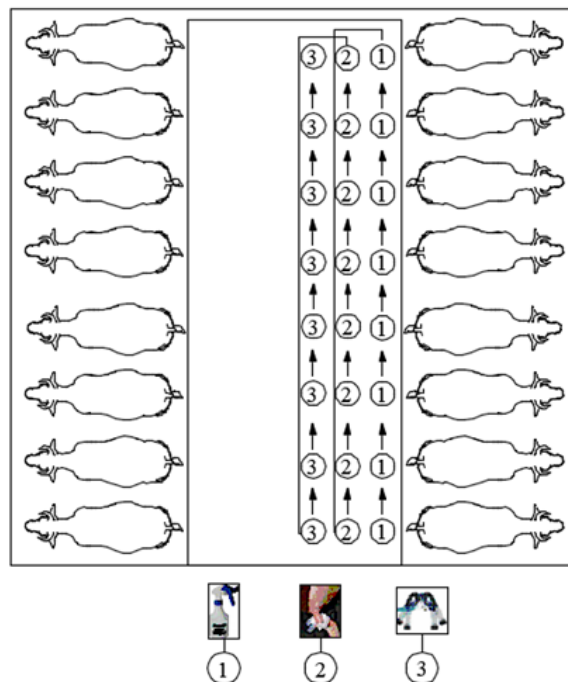


**Fig. 1 - General view of Westfalia Separator Stimopuls C pulsator**

Four simulation models have been developed for the way of milking operator movement in compliance with the technological sequence of operations in machine milking.

Model I - (one milker serves one platform)

In this model the sequence is as follows: the milker washes the udders of all the animals one after the other, then returns to the first at idle. Dry them in the same order and return again (second idle) to place the units from the first to the last cow on the platform (Fig. 2). Analogously to the described circuit works second milker which serves cows on the opposite platform.



**Fig. 2 - Movement and sequence of work of the milkers in Model I**

Model II - It is accepted that in the longitudinal direction the milking parlour is divided into two parts. Each milker serves the animals from his corresponding "half" at the same time as shown in Figure 3.

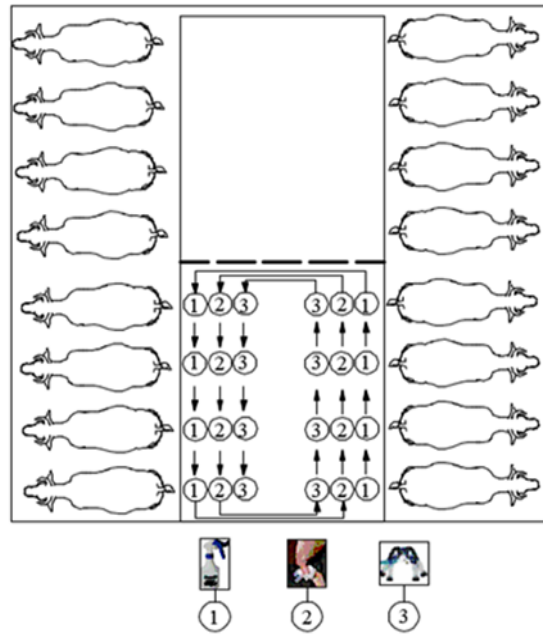


Fig. 3 - Movement and sequence of work of milkers in Model II

The way the service staff works is as follows: the first milker washes the udders of cows from №1 to №4 on the first "left" platform. Similarly, it serves the animals (from №5 to №8) from the "right" platform. He turns to the "left" again, dries the udders of cows from №1 to №4, goes to the "right" and manipulates the animals from №5 to №8 in the same order. It is transferred for the third time to the animals from the "left" platform and according to the established course of work it puts the milking units from №1 to №4. He turns to the "right" platform and performs the same activity with cows from №5 to №8. The work of the second milker is analogous to that described.

Model III- (one milker serves one platform)

The first milker washes the udders of the all cows on the platform (from №1 to №10). He returns to №1 (idle), dries the udder, immediately places the milking unit, then switches to №2, №3, etc. performing the same operations (Fig. 4). The second milker serves the cows from the opposite platform analogously to the described scheme.

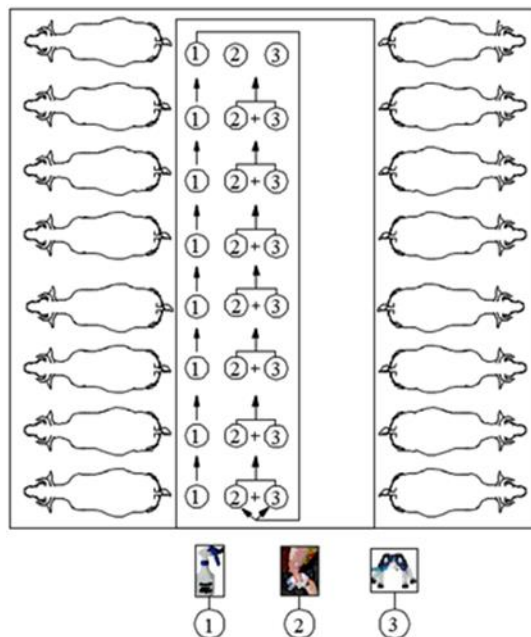


Fig. 4 - Movement and sequence of work of milkers in Model III

Model IV - The milking parlour is conditionally divided into two parts in the longitudinal direction. Each milker works in the corresponding part of the parlour according to Figure 5.

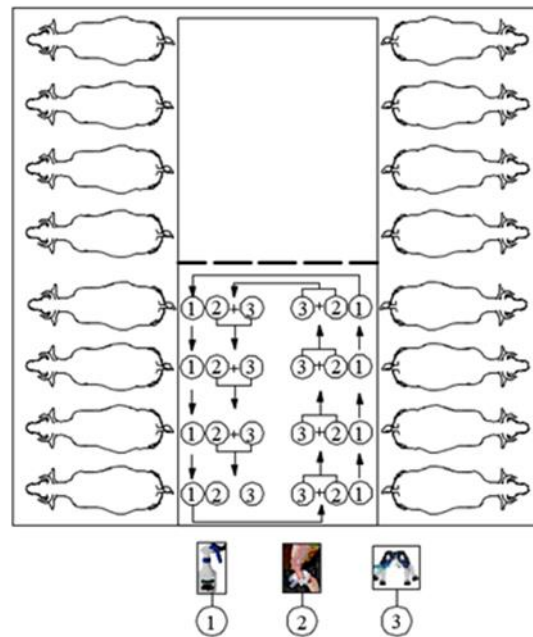


Fig. 5 - Movement and sequence of work of milkers in Model IV

The milker washes the udders of the animals from №1 to №4 from the "left" platform. Moves to the "right" and serves cows from №5 to №8. He returned and dried the udders, immediately placing the milking units successively on cows from №1 to №4 on the "left" platform. He continues his work with the cows on the "right" platform in a similar order.

The hypothetical results from the use of the presented variant modeling are systematized in Figure 6. The same are referred to "Parallel" type milking parlours with a capacity of 2x8, 2x10 and 2x12.

Model I

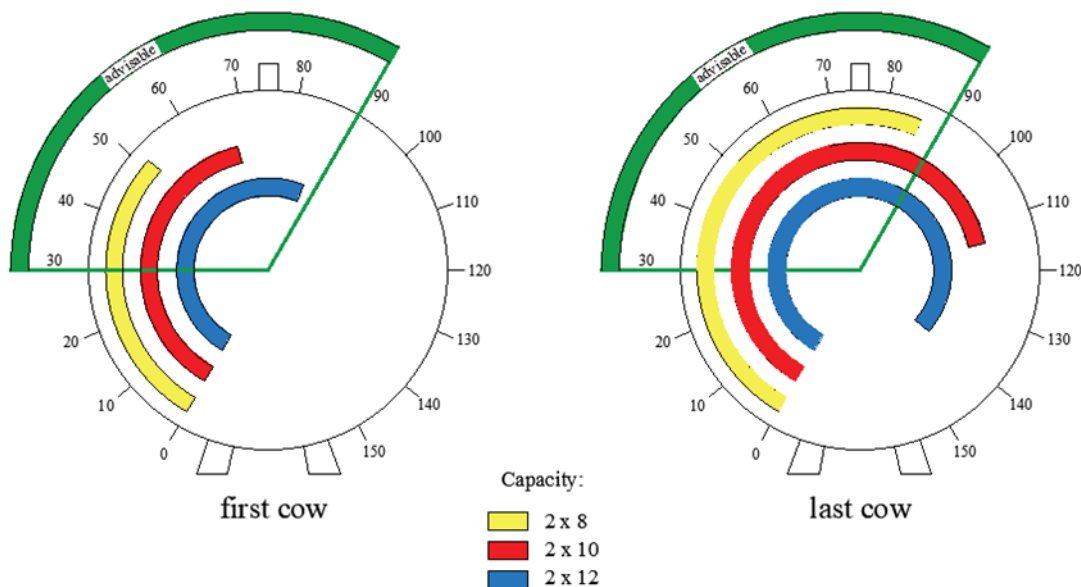
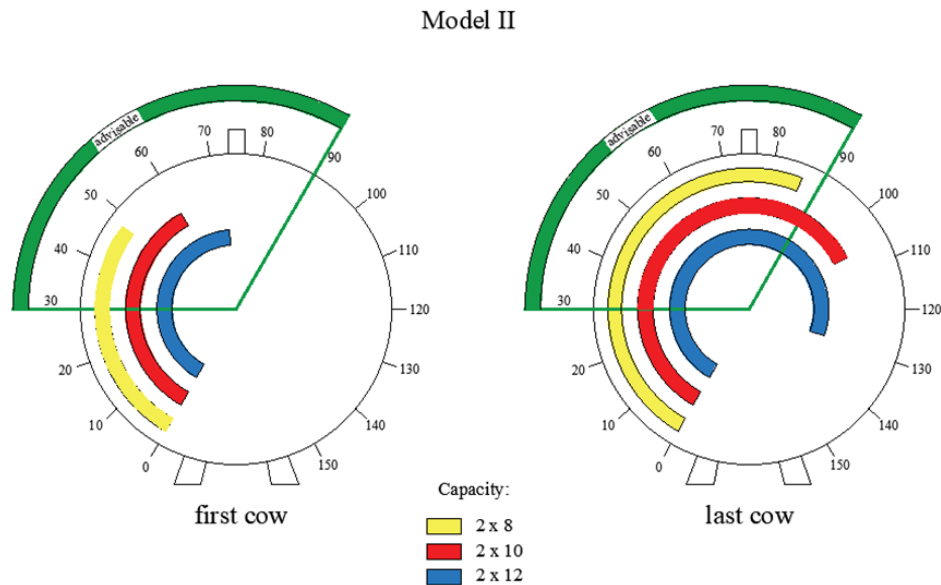


Fig. 6 - Time structure (s) of the technological operations (performed by the milkers) in machine milking referred to Model I

The graphic interpretation of Fig. 6 shows how long after the first irritation (after washing the udder) the milking units are placed on the first and last animal from the milking platform for the considered capacities. For milking parlours with a capacity of 2x8, the placement of the milking units for the first and last animal is within the recommended range (30-90 sec). Model I is unsuitable for 2x10 and 2x12 capacities as the time for placing the milking units of the last animals on the platform significantly exceeds 90 seconds.

Figure 7 illustrates the time structure of the performed technological operations performed by the milkers in simulation Model II.



**Fig. 7 - Time structure (s) of the technological operations (performed by the milkers) in machine milking referred to Model II**

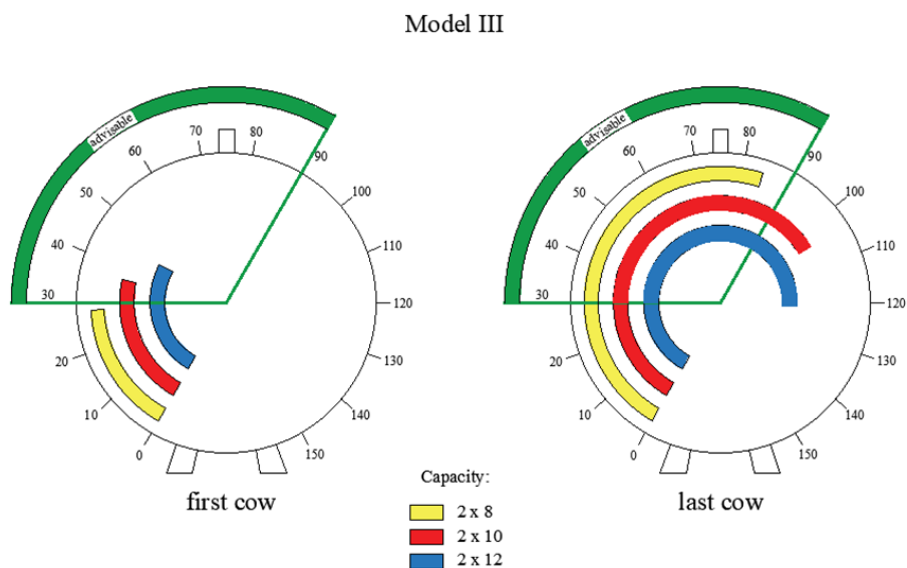
Although in model II the milking parlour is divided into two parts (Fig. 3) the sequence of technological operations is analogous to Model I (washing all animals, returning to the first animal, drying all serviced cows and placing the milking unit of the first animal). The results are close in terms of time spent.

Figures 8 and 9 show the duration of the technological operations performed by the milker respectively for the simulation models III and IV.

The time component of the technological operation "placement of the milking machine" of the first animal is within the recommended values for all considered capacities in both models.

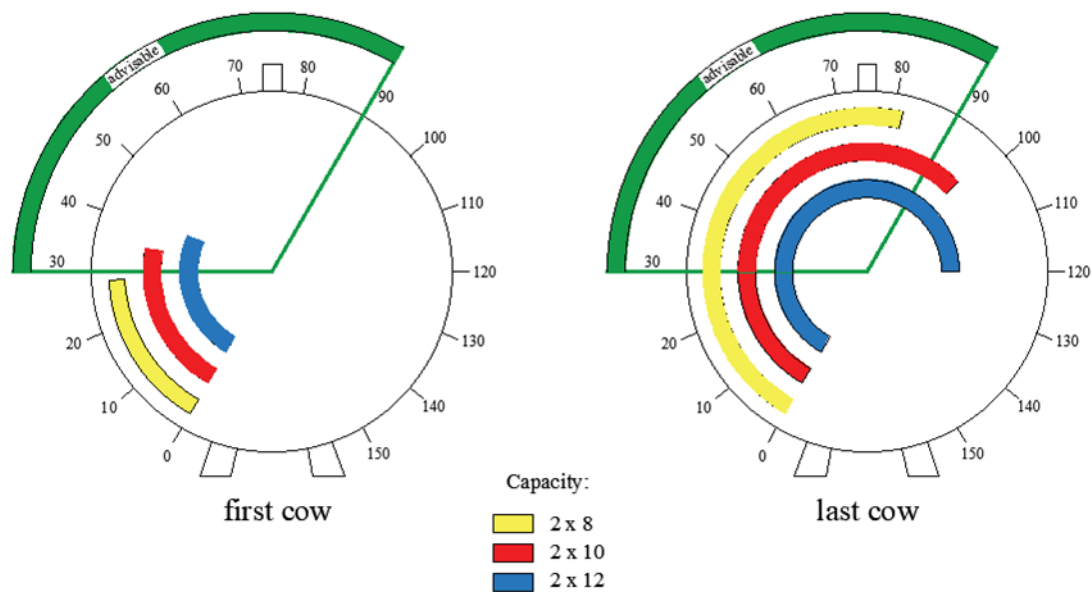
The simulation models III and IV, developed for 2x12 capacity, are unsuitable for practical application, as the time for placing the milking unit on the last animal exceeds by more than 30% the upper limit of the reference values (90 sec).

Only as a compromise option for implementation in real production conditions can model IV for 2x10 capacity be accepted. The graph shows that in this simulation arrangement for performing technological operations the placement of the milking machine on the last animal is 96 seconds. This value is very close to the maximum (of the pre-set time frame).



**Fig. 8 - Time structure (s) of the technological operations (performed by the milkers) in machine milking referred to Model III**

Model IV



**Fig. 9 - Time structure (s) of the technological operations (performed by the milkers) in machine milking referred to Model IV**

## CONCLUSIONS

The organization of the work of the milkers in "Parallel" type parlour significantly influences the time for preparation of the animals before the "actual milking".

All simulation models are suitable for use in milking parlours type "Parallel" type parlour with a capacity of up to 2x8.

Model IV may be used in "Parallel" type parlour with a capacity of up to 2x10.

All developed models are unsuitable (except for model IV with capacity 2x10) for milking parlours type "Parallel" with capacity over 2x8 as the time for preparation of animals significantly exceeds the maximum 90s.

The models may be used in case the number of milkers is increased or they perform the preparatory operations in a shorter time.

Recommendation: It is necessary to achieve a "kind of optimum" between the productivity of technical equipment and the overall productive and healthy status of animals. This is feasible by properly organizing the work of milkers so as to ensure the duration of the preparatory operations (until the placement of the milking machines) before the "actual milking" in the interval 30-90 s.

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