

RESEARCH IN AUTOMATIC MILKING SYSTEM CAPACITY

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Abstract. The aim of the research is to state the capacity of automatic milking systems (AMS) in operation conditions and to determine the maximal size of the cow group that could be served by one AMS. The research was performed on three different farms. On every farm the cows are milked by two company “DeLaval” produced AMS. The main initial data are obtained processing the information in the farm management systems. A corresponding algorithm has been developed for calculating the AMS operation time, capacity and maximal size of the herd. The research results show that the AMS capacity is influenced by different factors: the size of the served group of cows, time spent in the milking stand, time for servicing of milking machines and milk tanks, kind of cow traffic to milking, design of the milking zone etc. Using the company “DeLaval” produced AMS the maximal size of the herd served by one AMS should not exceed 58 – 59 cows.

Key words: milking, automatic milking systems, capacity of milking equipment.

Introduction

Introduction of AMS is related to high capital investments. Therefore, AMS should be maximally loaded for their application to be economically profitable. But it is not always possible in practice.

Behaviour of cows is essentially important in loading AMS as they not always are willing to visit the AMS in time when the milking stand is vacant. Therefore, idle time of AMS occurs. This idle time is stimulated also by different other factors: the number of the cows, kind of cow traffic to the AMS, a possibility for a cow to enter the AMS repeatedly just after milking, configuration of the waiting yard, location of the AMS etc.

In scientific literature several investigations in the kinds of cow traffic to milking AMS and stimulating it are described (Harm, 2005; Artman, 2005 etc.) as well there is also research in the influence of the waiting yard configuration and AMS location on visiting AMS (Laurs & Priekulis, 2010) but the influence of the size of the cow groups on loading of AMS has been less investigated. Harm and Wendl (2009) have elaborated a AMS capacity reserve analysis model but in these investigations there is not the issue on the AMS capacity depending on the size of the cow group directly included.

Therefore, the aim of our research is to state the AMS capacity in operation conditions and to determine the maximal size of the cow group that could be served by one AMS.

Materials and methods

For research the following plan was made.

- To select the most appropriate milk farms for the research where AMS are used.
- To collect the necessary initial data for the research processing the information in the management systems of the corresponding farms.
- To develop the AMS operation time balance and calculate the AMS capacity coefficients for all in the research included farms.
- To develop an algorithm for calculating the maximal size of the cow groups served by AMS.
- To state the maximal size of the cow groups on the farms included in the research.
- To compare the calculation results with the size of the cow groups of the farms included in the research and evaluate the obtained results.

The experiments are performed on three farms (Table 1). On every farm a different kind of cow transportation to AMS is used. On farm A the cows can enter the feeding zone through a one-way gate but leave it only through the selection gate. The selection gate directs the cows either to the waiting yard or concentrated feed feeding department where automatic concentrated feed feeding stations are located. From the concentrated feed feeding department the cows through the one-way gate can return back to the recreation zone. In turn, the cows that have got to the waiting yard are served by two AMS. The milked cows from one AMS are directed to the feeding zone going through the special selection

gate. The cows that have not timely visited the AMS are directed to the waiting yard by a specially appointed person approximately five times a day.

Table 1

Information on farms under research

Indices	Farms		
	A	B	C
Number of cows milked by AMS	97	94	108
Number of AMS	2	2	2
AMS brand	VMS (DeLaval)		
Number of milk line washing times per day	2	2	2
Milk transportation frequency to processing	1	1	1

On farm B the cows from the recreation zone can freely get to the feeding zone but from there going through the selection gate they are directed to the waiting yard or back to the recreation zone. The milked cows from AMS go back to the waiting yard and through the selection gate they can get back to the feeding zone. Three times a day at about 6:00, 13:00 and 20:00 milking of cows is controlled and the cows that are not milked in due time are specially directed to the waiting yard.

On farm C the cows from the recreation zone get to the selection gate where they are directed to the waiting yard or feeding zone. In turn, the milked cows from AMS go to the feeding zone. Milking is regularly controlled by a person who directs the cows that are not milked in the selection gate and further they get in the waiting yard.

The total length of the experiment – 30 days. The data necessary for the research were taken from the AMS management systems.

To analyse the AMS utilisation time on every separate farm the milking time balance was prepared for one day.

$$T = T_s + T_b + T_m + T_o, \quad (1)$$

where T – number of hours per day, $T = 24$ h;

T_s – time used for milking cows, $\text{h} \cdot \text{day}^{-1}$;

T_b – time when milking equipment is loaded by cows that need not be milked, $\text{h} \cdot \text{day}^{-1}$;

T_m – time when milking equipment and milk tanks are washed, $\text{h} \cdot \text{day}^{-1}$;

T_o – time when milking equipment is not loaded, $\text{h} \cdot \text{day}^{-1}$.

Separate parts of the working time balance can be calculated according to the following formulae:

$$T_s = \frac{t_s \cdot n_s \cdot z_{g.fak}}{60 \cdot n_a}, \quad T_b = \frac{t_b \cdot n_{g.b}}{60 \cdot n_a}, \quad T_m = \frac{t_{m.s} \cdot n_{m.s}}{60} + \frac{t_{m.t}}{60 \cdot n_p}, \quad (2, 3, 4)$$

$$T_o = T - T_s - T_b - T_m, \quad (5)$$

where t_s – average time of a cow being in AMS during one time of milking, min;

t_b – average time of a cow being in AMS if it is not milked, min;

$t_{m.s}$ – time of one AMS milk line washing, min;

$t_{m.t}$ – time of one milk cooling and storage tank washing, min;

n_s – number of one cow milking times per day;

n_a – AMS number serving the corresponding herd;

$n_{g.b}$ – AMS visiting times per day in the corresponding herd without milking;

$n_{m.s}$ – AMS milk line washing times per day;

n_p – milk transportation frequency to processing (transporting once a day $n_p = 1$, transporting once in two days $n_p = 2$);

$z_{g.fak}$ – present or actual number of cows in herd served by AMS.

The maximally possible number of cows that can be milked by one AMS can be calculated according to formula

$$z_g = \frac{t_d}{t_s \cdot n_s + t_b \cdot \frac{z_{g,b}}{z_{g,fak}}}, \tag{6}$$

where z_g – maximally possible number of cows in the herd;
 t_d – time interval used for milking, min/day.

In turn, the time interval used for milking can be calculated as follows

$$t_d = 1440 - \left(t_{m,s} \cdot n_{m,s} + \frac{t_{m,t}}{n_p} \right), \tag{7}$$

where 1440 – number of minutes per day.

The AMS capacity coefficient was calculated according to formula

$$\eta_s = \frac{T_s}{24 - T_m}, \tag{8}$$

Results and discussion

The initial data collected on farms A, B and C that are necessary for preparation of the time balance can be seen in Table 2.

Table 2

Initial data collected on farms A, B and C

Indices	Farms		
	A	B	D
One cow average milking time, min	7.5	7.5	7.5
One cow average time in AMS without milking, min	1.7	2.4	0.0
AMS milk line washing time, min	37	34	42
Milk tank washing time, min	22	20	45
One cow average milking times per day	2.7	2.7	2.7
AMS total visiting number without milking per day	17	24	0

The AMS working time balance for farms A, B and C is shown in Figure 1.

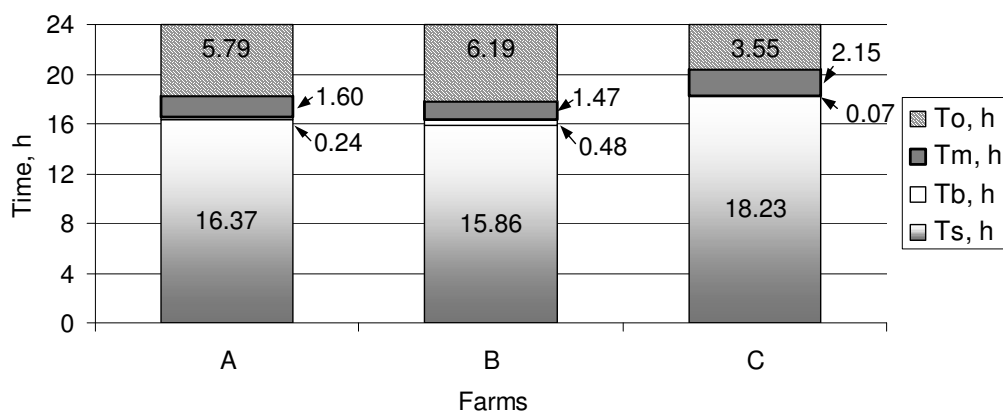


Fig. 1. AMS working time balance for research farms

From the working time balance it can be seen that most part of the day (16 – 18 h) is used for milking applying AMS. Approximately 1.5 – 2.2 h every day AMS milk lines and milk tanks are serviced but 3.5 to 6.2 h per day the AMS is not loaded.

On farms A and B a small part (up to 0.5 h per day) the AMS is loaded by cows that are not milked as the milking time for them has not come yet. It can be explained by the fact that on these

farms the milked cows return back to the waiting yard. In order to prevent such a possibility the milking zone should be arranged rationally and direct directing of the milked cows from the AMS to the feeding zone not through the waiting yard should be planned.

The maximal number of cows that can be milked by one AMS as well as the AMS capacity coefficient on the research farms can be seen in Figure 2.

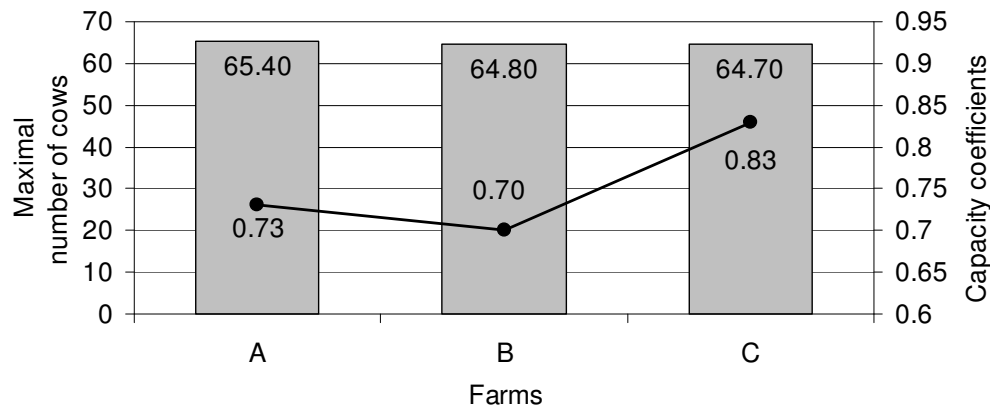


Fig. 2. Maximally possible number of cows that can be milked by one AMS as well as the AMS capacity coefficient on the research farms

The AMS capacity coefficients on farm A are 0.73, B – 0,7, but C – 0.83, and it means that on farm A 6.03 h of the useful time per day are not used profitably, on farm B – 6.67 h but on farm C – 3.55 h. Such AMS idle time is inexcusably large.

As on all farms the cows visit the AMS in average 2.7 times a day it can be considered that the kind of cow directing to milking AMS is relatively successful (Hulsen, 2008 – normal AMS visiting times are ≥ 2.5 per day) and the low AMS capacity coefficients can be explained by insufficient number of cows in the group.

The maximally possible number of cows that on the corresponding farms can be milked with one AMS is approximately 65 cows. But it should be considered that using AMS the cows go to milking voluntarily. Therefore, visiting AMS is not regular per day. As our previous research shows (Laurs et al, 2009) the visits increase in the morning from 8.00 to 11.00 and in the afternoon from 18.00 to 20.00. In this period of time visiting AMS is even 10 % higher than the average. Therefore, the AMS permissible capacity coefficient value is 0.9. but means that on the research farms the maximal size of the herd can reach 58 – 59 cows calculating per one AMS.

Conclusions

1. On the research farms the AMS capacity coefficient is in the frame from 0.7 to 0.83 but the maximal value of this coefficient can be 0.9.
2. In order to ensure maximal AMS capacity the size of the herd should be appropriate, the planning of the milking zone optimal, the cow directing system rational and efficient organization of work should be ensured. A possibility of the milked cows to enter the AMS till the next milking time should be eliminated.
3. The size of the cow group served by one AMS can be calculated according to the algorithm given in the present article. Using the company „DeLaval” produced AMS it should not exceed 58 – 59 cows.

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