RESEARCH IN MIXED FEED DISTRIBUTION LINE ON LATVIA UNIVERSITY OF AGRICULTURE TRAINING AND RESEARCH MILK FARM „VECAUCE”

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Abstract. The operation of the mixed feed concentrate distribution line that is installed on the Latvia University of Agriculture training and research farm „Vecauce” milk farm has been investigated if it does not ensure regular supply of feed to the feeding stations. It has been stated in the research that at different feeding stations that are connected to the line the consumption of feed concentrate is different, and it interferes with successful operation of the conveyor switching automation. In order to eliminate this drawback several factors are of essential importance: capacity of the feeding station tanks, the tank capacity part at the last station between the feeding conveyor switching on and off sensors as well as the amount of feed at the conveyor part between the two other feeding stations.

Key words: mixed feed concentrate, feeding station, dosimeter, feed conveyor, sensor, milking robot.

Introduction

The training and research farm „Vecauce” of the Latvia University of Agriculture in 2007 put into operation a new cattle farm where a part of cows are milked with two milking robots VMS of the company „DeLaval”. Nevertheless, application of robots change not only the kind of handling of cows and the milking technology but also feeding of animals. For instance, in Vecauce the cows that are milked in robots are fed in three places: at the feeding table (with feed mixture), in the milking robot stall and at the feeding stations (in both mentioned places – with mixed feed concentrate) [1, 2].

But it was stated that the management system’s computer shows a bigger amount of the consumed feed concentrate than it is recorded according to the amount of feed concentrate in the tank. Therefore, the aim of the present research was to state the possible interferences in operation of the technological line and to find solutions for their elimination.

Materials and methods

The scheme of mixed feed concentrate distribution is shown in Figure 1. It consists of the feed concentrate tank 1 and two feed concentrate distribution lines: the main and additional line. The main line ensures unloading of animal feed from the tank and supply to the feed concentrate feeding stations 11, but the additional line – supply of feed concentrate to both milking robots.

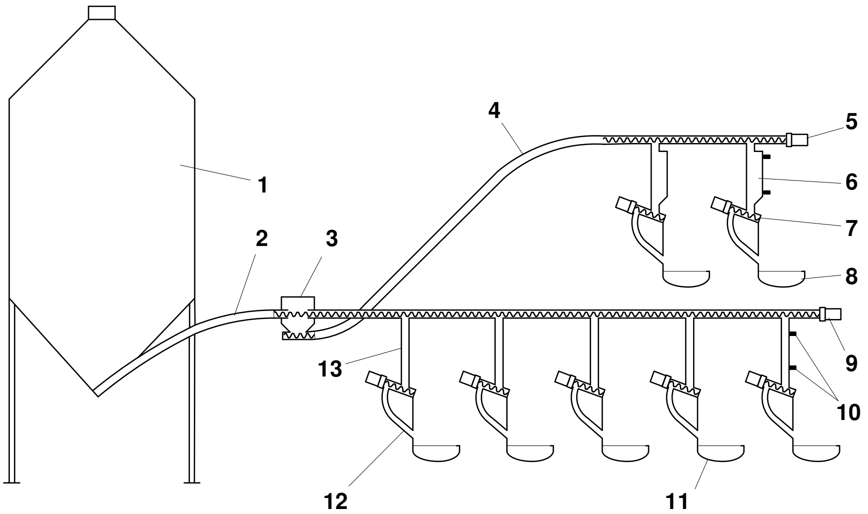

Fig. 1. **Technological scheme of feed concentrate distribution:** 1 - feed concentrate tank; 2 – main coil conveyor; 3 – feed flow distributor; 4 – additional coil conveyor; 5, 9 – electro motor with reducer for driving conveyors; 6 – dosimeter tank; 7 – dosimeter; 8 – milking robot feed troughs; 10 - feed concentrate level sensors; 11 - feed concentrate feeding station; 12 - feed concentrate passage way; 13 - feed concentrate accumulation pipe

Both lines use feed concentrate distribution stations of equal construction. They consist of a screw type dosimeter 7, dosimeter tank 6, feed concentrate passage way 11 and feed trough 8. Only the capacity of the dosimeter tanks used in both lines differ being larger for the milking robot feeding stalls.

When the cows are eating, feed concentrate is taken from the dosimeter tank of every corresponding station. Therefore, the amount of feed in these tanks gradually decreases. In order to ensure automatic refilling of feed, the feed concentrate distribution line is equipped with corresponding level sensors 10 that trace the amount of feed concentrate in the last tank of the corresponding line and give orders for switching on and off of the feed supply coil conveyors 2, 4. Thus, the feed level in the last dosimeter tank (feed accumulation pipe) periodically changes in the frame from the upper level sensor to the lower sensor, but in all the other dosimeters – from the top of the tank to its partly or full emptying (if it is not repeatedly filled by the conveyor).

In previous experiments we have stated that cows are using the first two feeding stations most often (counting from the side of the feed concentrate tank) as they are closer to the entrance into the feed concentrate feeding zone. Therefore, a situation is possible that in the last station where the feed level sensors are located there is still some feed left, but in the others it has already been consumed and not refilled.

In order to prove the possibility of such hypothesis theoretical as well as experimental research was carried out.

The amount of feed concentrate necessary for every cow, that is fed in the feed distribution stations, is calculated by robot software VMS Mgnt Alpro, using the formula

$$M_b = \frac{Q_d \cdot t}{24}, \tag{1}$$

where M_b – amount of feed necessary for the corresponding cow in the given moment, kg;
Qd – planned amount of mixed feed concentrate for the corresponding cow, kg/24 hours
t – period of time since the corresponding cow has last visited any of the feeding stations, h.

The amount of feed concentrate that accumulates and moves along different places of the technological line can be calculated according to the situation given in Figure 2.

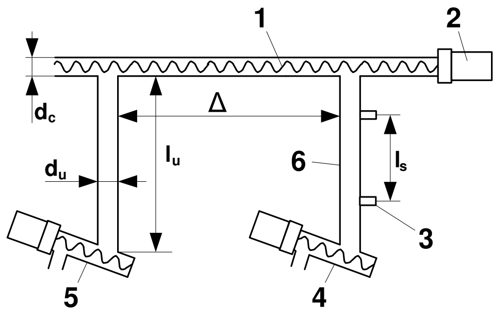

Fig. 2. **Feed concentrate supply line calculation scheme:** 1 – coil conveyor; 2 – drive electro motor with reducer; 3 – feed level sensor; 4, 5 – feed concentrate dosimeters; 6 – feed accumulation pipe

The amount of feed to be accumulated in one feed concentrate station (except the last one)

$$V_{st} = \frac{l_u \cdot \pi \cdot d_u^{\,2}}{4 \cdot 10^6} \cdot k, \tag{2}$$

where V_{st} – capacity of one feed concentrate station, l;
l_u – length of feed concentrate stand feed accumulation pipe, mm;
d_u – diameter of feed concentrate stand feed accumulation pipe, mm;
k – accumulation pipe filling coefficient, $k \approx 0.9$.

The amount of mixed feed concentrate that accumulates in one meter long section of the coil conveyor

$$V_{liet} = (V_c - V_s) , \tag{3}$$

where V_c – capacity of conveyor pipe calculating on one meter length, l/m;
V_s – capacity of the part taken up by the coil calculating on one meter conveyor length, l/m.

$$V_c = \frac{\pi \cdot d_c^{\ 2}}{4 \cdot 10^6} \cdot k , \tag{4}$$

where V_c – capacity of feed concentrate conveyor pipe, l/m;
d_c – conveyor pipe diameter, mm.

The capacity taken up by the conveyor coil is approximately

$$V_s = \frac{a_s \cdot b_s \cdot l_s}{10^9} , \tag{5}$$

where V_s – capacity taken up by the coil in one meter long conveyor pipe space, litres;
a_s – width of one coil side, mm;
b_s – height of one coil side, mm;
l_s – full length of coil in one meter long conveyor space, mm.

The full length of the coil is calculated according to the formula::

$$l_s = \frac{1000}{s} \sqrt{(\pi(d_c - b_s)^2 + s^2} , \tag{6}$$

where d_c- inner diameter of the coil conveyor, mm;
b_s – width of the conveyor coil, mm;
s – conveyor coil step, mm.

Productive capacity of coil conveyor between two feed dosimeters

$$V_l = V_{lietd} \cdot \Delta , \tag{7}$$

where V_l – productive conveyor capacity between two feed concentrate accumulation pipes, l;
V_{lietd} – productive capacity of one meter long conveyor section, l;
Δ – distance between proximal accumulation pipes, m, on Vecauce farm l = 1,07m.

The amount of feed concentrate that can be in the last (fifth) station accumulation pipe between both sensors can be calculated according to the formula

$$V_{st5} = V_{st} \cdot \psi = V_{st} \cdot \frac{l_s}{l_u} , \tag{8}$$

where V_{st5} – capacity of the fifth feeding station accumulation pipe between switching on and off sensors, l;
V_{st} – total capacity of feed accumulation pipe, l;
Ψ – coefficient evaluating what part of the feed accumulation pipe total capacity is taken up by its capacity between both sensors;
l_s – distance between both sensors in feed accumulation pipe, mm.

Switching on the conveyor, feed in turn fills the feed accumulation pipes of the first, second, third etc. stations. But at the beginning in all feed accumulation pipes except the first one also a part of feed that is in the conveyor part up to the previous accumulation pipe also falls in. Besides, in the last accumulation pipe this part of feed after falling in cannot reach the highest level sensor as in that case the feed supply conveyor will be stopped.

In order to state the filling in of the last feed concentrate pipe with feed just after switching on the coil conveyor (in the zone between both sensors) the following formula can be used

$$\gamma = \frac{V_{st5} - V_l}{V_{st5}} \cdot 100\,, \tag{9}$$

where γ – coefficient evaluating what part of the feed concentrate accumulation pipe between the sensors stays unfilled after feed has fallen in from the conveyor pipe space (just after switching in the conveyor), %

Considering that with the conveyor working in automatic regime the feed accumulation pipe in the last dosimeter fills by the volume in the inter-sensor zone, in all the other stations the supplied amount of feed cannot exceed the following margin

$$M_f = \frac{M_5}{\psi}\,, \tag{10}$$

where M_f – maximally possible amount of the rationed feed concentrate in one of the four first feeding stations, kg;
M_5 – amount of feed concentrate rationed in the last feeding station, kg.

The error shown by the computer on rationing feed that has occurred in one of the feeding stations can be calculated according to the formula

$$\lambda = \frac{M_{izsn} - M_f}{M_f} \cdot 100\,, \tag{11}$$

where λ – feed rationing error, %;
M_{izsn} – maximal rationed amount of feed concentrate shown by the computer in one of the stations, kg.

The necessary for calculations mixed feed concentrate rationing line constructive parameters were measured in Vecauce, but the information on the consumed amount of feed concentrate at feeding stations was obtained from the computer of the milking robot control system. For this purpose selection of information was done by the software VMS Mgmt [3], after that these data were processed by the software MS Excel.

Results and discussion

The research in the operation of the feed concentrate distribution line that was carried out in Vecauce proved that in different feeding stations the consumption of feed is different (Figure 3).

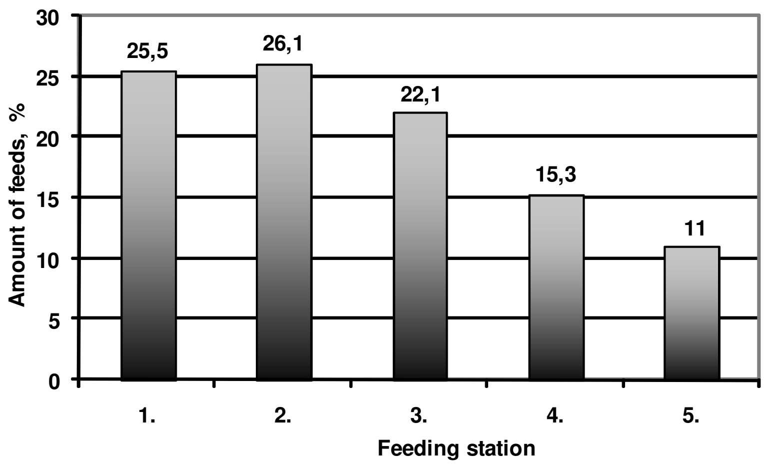

Fig. 3. **Distribution of the consumed feed concentrate along separate feeding stations, %, according to the data of the management system**

At stations 1 and 2 that are opposite the gates along which the cows enter the feed concentrate feeding zone 2.3-2.5 times larger amount of feed is consumed than at the last feeding station.

The total view how the amount of the rationed feed shown by the computer and the actually possible supplied amount (considering the formula 10) have changed can be seen in Figure 4. From that a conclusion can be drawn that wrongly rationed feed is shown by the computer only for the first two feeding stations, that is, those which are visited most.

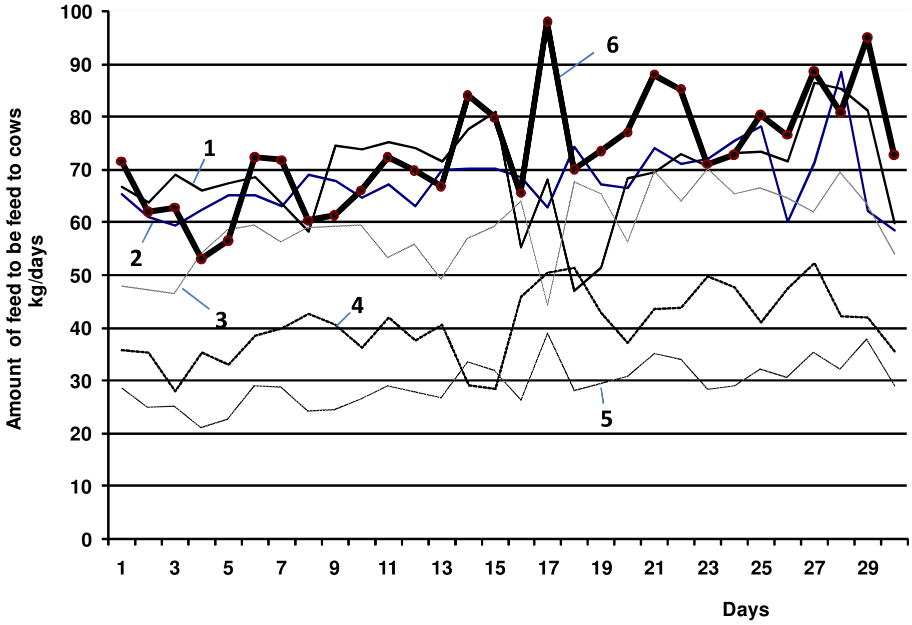

Fig. 4. **Actually supplied and shown by the computer amount of feed concentrate at feeding stations:** 1, 2, 3, 4, 5 – rationed amount of feed correspondingly at the first, second, third, fourth and fifth stations, 6 – actually possible amount of rationed feed

The error in feed rationing shown by the computer that has been calculated according to formula 11 is shown in Figure 5. Comparing Figure 4 and Figure 5 it can be seen that the necessary amount of feed concentrate was not supplied on the days when it was not fed by the feeding conveyor sufficiently. Besides, sufficient amount of feed was not rationed approximately in a half of the days included in the experiment, but the maximal deficiency of feed has reached even up to 20 %.

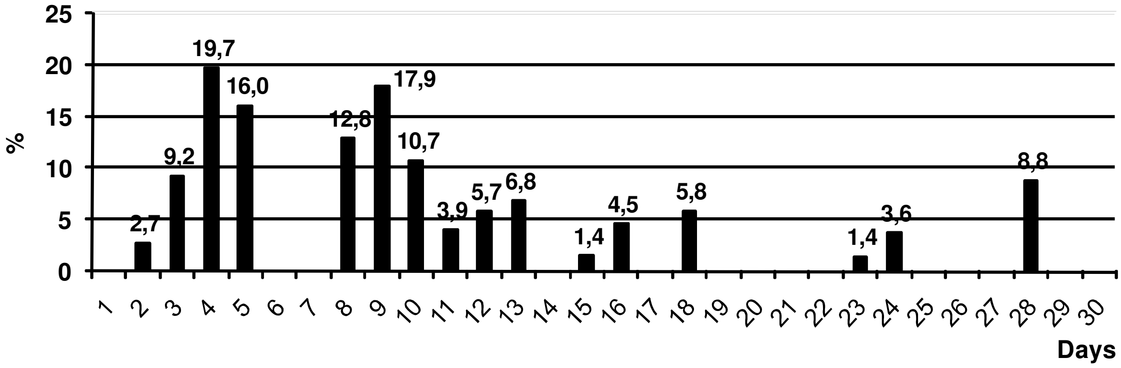

Fig. 5. **Amount of feed concentrate not rationed at separate days of the experiment**

Applying the above mentioned methods it was calculated that in the case of Vecauce, when the feed concentrate conveyor switches on, the inter-sensor space of the last feeding station is filled in the amount of 78 %.

Therefore, the distance between the sensors l_s could be reduced by 15 %. It would increase the frequency of the conveyor switching on without creating a situation that in the inter-sensor space that part of feed is filled that is in the conveyor pipe between the fourth and the fifth feed accumulation pipe.

Though, other solutions for eliminating of this problem are possible:

- To increase the volume of all feed concentrate accumulation pipes by 20 % increasing the length of the feed concentrate accumulation pipes by 20 % for this purpose, that is, by 50 cm;
- To replace the feed concentrate accumulation pipes of the first and second dosimeter with larger diameter pipes that are used in milking robots;
- To reinstall the line for feeding feed concentrate to the feeding stalls from the opposite side, that is, starting with the stall 5.

Conclusions

1. At the feeding stations that are installed in the feed concentrate distribution zone and are opposite the entrance into the concentrated feed feeding zone 2.3-2.5 times larger amount of feed is consumed than at the last feeding station where the least amount of feed is consumed.
2. In order to guarantee correct operation of the feed concentrate conveyor switching automation, the amount of feed that accumulates in the conveyor pipe between the last two feeding stations, the volume of the inter-sensor zone that forms in the feed accumulation tank of the last station cannot be exceeded.
3. If the feed concentrate supply line serves several feeding stations and there is different consumption of feed, then this consumption at the last feeding station where the feed conveyor switching sensors are installed can be as many times less compared to the most loaded station as many times the capacity of the feed tanks (accumulation pipes) of the corresponding stations is larger than the volume of the inter-sensor zone at the last feeding station. Otherwise due supply with feed concentrate is not ensured to all feeding stations.
4. In order to improve the operation of the feed concentrate distribution line on the training and research farm of the Latvia University of Agriculture several solutions are possible: to reduce the distance between the feed concentrate conveyor control sensors (by 15 %), to increase the capacity of the feed concentrate station tanks (at least by 20 %) or to supply feed concentrate from the opposite side achieving that the conveyor control sensors are at one of the most loaded feeding stations.

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