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ORIGINAL ARTICLE

Influence of dust content in milking rooms on operation modes of milking machine pulsators

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Biochar, which is rich in aromatic carbon and minerals, is a product of biomass pyrolysis at temperatures ranging from 350°C to 1000°C in oxygen-limited environments. In recent years biochar has generated much interest in the field of water treatment in view of low production costs, availability of the feedstock (e.g., lignocellulosic biomass waste) and adsorptive properties. This review incorporates researches on artificial and natural modifications of biochar towards adsorption of potentially toxic elements on biochar. The aim of this study was to provide a comprehensive review of recent research findings and theory developments on the existing modifications of biochar for adsorption of potentially toxic elements (i.e., inorganic compounds) from aqueous solutions. Factors affecting adsorption of potentially toxic elements by lignocellulosic biochar and modification techniques for lignocellulosic biochar towards enhanced adsorption of potentially toxic elements were analyzed. The novelty of this study is discussion of the natural modifications of biochar and smart properties of biochar towards adsorption of potentially toxic elements. Recommendations are offered for modifying the lignocellulosic biochar to produce designed, engineered or smart biochar with high adsorption capacity for potentially toxic elements.
Keywords: Engineered biochar; adsorption; lignocellulosic biomass; pyrolysis

Introduction

In modern facilities for the maintenance and milking of cattle, the impact of microclimate on the health and productivity of animals has increased significantly. This is due to the high concentration of dairy cattle, the intensive use of animals, keeping of animals indoors without run, in conditions of almost complete movement constraints.

The experience (Paliy, 2016; Ferneborg et al., 2015) shows that to create a comfortable habitat that simultaneously provides a maximum productivity and animal health, normal working conditions of personnel, technological equipment and meeting sanitary, ecological and economic requirements is practically impossible - it is only possible to create an optimal variant of it for the existing milk complex with the use of initial data.

To create optimal conditions for animal maintenance is one of the main tasks for raising their milk productivity, according to (Davis et al., 2000; Mihina, 1990); it will increase the use of their genetic potential on the basis of the implementation of engineering and technological factors.

For machine milking, it is important that the conditional and unconditional factors that cause the milk let-down reflex are interconnected and only combined they reveal it (Wall et. al., 2007). Therefore, the design of milking units, apparatus and milking technology should provide a maximum stimulation of conditional and unconditional reflexes of milk let-down in cows. With such a functioning of physiological processes, the animal can fully unlock its genetic potential (Paliy, 2015; Boast et. al., 2008).

The researchers (Van Vleck, 1998; Volohina, 2007) note that dry or wet fodder significantly affects the dustiness of the room, which needs to be taken into account in the design of ventilation systems.

The intensity of the milk yield depends to a large extent from the efficiency of the milking machine pulsators. The pulsation rate in dusty areas may change due to the dust getting into the pulsators. The concentration of dust in the air of the milking rooms during the distribution of dry concentrated fodder into the feeders reaches in average 12.6 mg/m^3 (for n=72), and the permissible concentration of aerosols of plant and animal origin equals to 6 mg/m^3 which rates to the 4th grade of danger for a man (O'Shea et. al., 1980; Vinogradov et al., 2002; Volohina, 2007).

In some pulsators, the pulsation rate reaches 80 cycles per minute, at the required speed of 58-60 cycles. Furthermore, the duration and the ratio of the pulsation phases (which is also very important) can not be adjusted (Reitsma et al., 1981; Besier et al., 2016).

As noted by (Palij, 2016; Christian et al., 2003; Mahle et. al., 1982), an increase in the pulsation rate does not accelerate the milking process, but may leave a milk duct open which increases the risk of spreading the infection of mastitis. The study and determination of the values of this factor remains relevant and has both practical and scientific interest.
Therefore, the problem of milking machines stability in production conditions and the determination of the optimal pulsation rate and the vacuum level during milking of high-yielding cows remain urgent.

Materials and methods

The scientific and economic experiment was aimed at determining the amount of dust clogged in the pulsator that changes its working parameters, with the use of a weighing method (Retnjov, 1979; Meshhaninova, 2013), which is based on the weighing of dust extracted from the air by the aspiration method. This method consisted in the fact that a certain volume of air was drained through the AFA-B-18 filter. Samples were taken in ten places along the line of animal placement.
To study the influence of different modes of ADU ½ pulsators operation on the milk let-down of high-yielding cows, the study was carried out on 4 analogue groups of Ukrainian black-and-white dairy breed, 15 heads in each one. The experiment included a preparatory and experimental periods with a duration of 5 days 30 days respectively for each group. The research was carried out on the State Enterprise "Experimental farm "Kutuzivka", NAAS, and in the dairy complex of the agricultural firm "Agrotis". The scheme of scientific and economic experiment is presented in Table 1.

Table 1. The scheme of scientific and economic experiment.

Group	Preparatory period (5 days)	Experimental period (30 days)
	Pulsation rate of milking pulsators ADU ½, cycles per minute	
I (experimental)	60 ± 5	40-55
II (experimental)	60 ± 5	56-70
III (experimental)	60 ± 5	71-85
IV (experimental)	60 ± 5	86-95

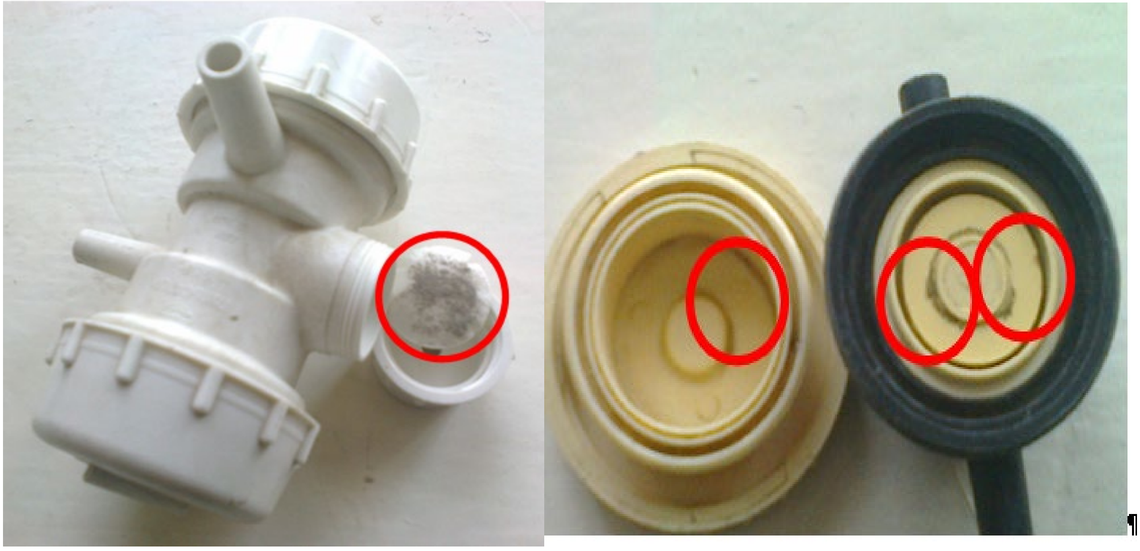
During the preparatory period, the cows were treated with an apparatus with a pulsation rate 60 ± 5 cycles per minute and a vacuum pressure of 0.49-0.5 kg/cm^2 (48-49 kPa). During the experimental period the cows from the first group were milked with an apparatus with a pulsation rate 40-55 cycles per minute. The cattle from the second group were treated with a milking pulsator ADU ½ 56-70 cycles per minute. The cows from the group III were milked with an apparatus with a pulsation rate 71-85 cycles per minute, and the forth group - with a pulsation rate 86-95 cycles per minute.

Results and discussion

It is well-known that the greatest milk losses, about 50%, are caused by technical factors because of the discrepancy between the design and operating modes of milking machines and the physiological characteristics of cows (Adamchuk et al., 2015; Troger, 1990; Dmytriv, 2014).
Theoretically, the intensity of milk yield can be determined by different categories of parameters, some of which are quantitative and temporal indicators of milking: the dynamics of milk let-down, the duration of milking, the average milking speed and the maximum milking speed.
In the course of the research it was determined that the intrusion of dust into the pulsator negatively affects its operation, namely, the pulsation rate. Therefore, the question that now arises is which quantity of dust in the pulsator changes its working parameters.
Studies indicate that the dust content in the air of the milking room before milking was about 2 mg/m^3 and the pulsation rate was 60 ± 5 cycles per minute.
But during the milking process, when cows are given 500 g of concentrated feed, the dustiness increases up to 20-25 mg/m^3, and 30-35 mg/m^3 if given 1000 g of feed (Figure 1; Table 2).

Table 2. The changes in the pulsators rate caused by the dust content in the air, (X ± SX), n=60.

Operation time, days	Dust content in the air, mg/m^3			
	Pulsation rate of milking pulsators, cycles per minute			
	below 10	20-25	30-35	>35
1st	60 ± 4	60 ± 5	60 ± 5	60 ± 4
2nd	60 ± 5	60 ± 1	58 ± 4	48 ± 4
3d	60 ± 4	58 ± 5	55 ± 3	clogged
4th	60 ± 5	57 ± 4	50 ± 4	
5th	59 ± 5	55 ± 4	45 ± 4	
6th	60 ± 5	51 ± 5	41 ± 5	
7th	60 ± 3	50 ± 3	35 ± 4	
8th	59 ± 5	48 ± 4	clogged	
9th	60 ± 3	46 ± 4		
10th	60 ± 4	45 ± 5		



Pulsator ADU 02. 200 Pulsator ADU 1/2

Figure 1. Clogging of pulsators caused by the dustiness of the room.

Thus, the research has found that the release of dry concentrated fodder (500-1000 g) during milking leads to the dustiness of the room and causes failures in the operation mode of pulsators (as early as on the first day) and, as a consequence, negatively affects the milking process.
The next stage of these studies was to determine the effect of changing the pulsation rate on milk yield. The research was carried out on the dairy farm of the State Enterprise 'Experimental farm 'Kutuzivka'. The main indices of milk yield during milking cows in the preparatory period are presented in Table 3.

Table 3. Indices of milk yield during milking cows in the preparatory period, (X ± SX).

Index	Pulsation rate of milking pulsators. cycles per minute 60 ± 5			
	Groups			
	I	II	III	IV
Number of cows, heads	15	15	15	15
Milked with a machine, kg	10.21 ± 1.28	10.18 ± 1.12	10.20 ± 1.31	10.19 ± 1.18
Amount of machine after milking, kg	0.20 ± 0.07	0.19 ± 0.04	0.18 ± 0.06	0.19 ± 0.07
Amount of manual after-milking. ml	8.3 ± 0.3	8.6 ± 0.2	8.4 ± 0.2	8.4 ± 0.4
Duration of machine milking. min	4.4 ± 0.52	4.5 ± 0.65	4.4 ± 0.22	4.2 ± 0.85

In the preparatory period, the pulsation rate of all pulsators of four milking units of "Yalynka" type was calculated and the pulsators with a low pulsation rate (40-55 cycles per minute) and those having a pulsation rate of 56-70 cycles per minute; 71-85 cycles per minute and 86-95 cycles per minute were selected.
During milking of cows in the experimental period with milking machines with different pulsation rates (Table 4) it was found that at a pulsation rate of 56-70 cycles per minute (according to the instruction), the average intensity of milk yield was 1.36 kg/min.

Table 4. Indices of milk yield during milking cows with milking machines with different pulsation rate in the experimental period, (X ± SX).

Indices	Pulsation rate of milking pulsators. cycles per minute			
	40-55 group I	56-70 group II	71-85 group III	86-95 group IV
Milked. kg/min:				
during the 1st min	2.1 ± 0.55	2.5 ± 0.65	3.0 ± 0.35	2.2 ± 0.25
during the 2nd min	2.8 ± 0.65	3.0 ± 0.60	3.2 ± 0.45	2.6 ± 0.20
during the 3d min	2.0 ± 0.55	2.7 ± 0.25	2.8 ± 0.55	2.2 ± 0.35
Milked with a machine. kg	8.31 ± 0.2	9.45 ± 0.3**	10.55 ± 0.2***00	10.46 ± 0.2***00
Amount of machine after-milking. kg	0.49 ± 0.09*00	0.18 ± 0.08	0.19 ± 0.05	0.38 ± 0.04*00

Amount of manual after-milking. ml	15.0 ± 0.2***000	8.2 ± 0.2	11.3 ± 0.1***	12.5 ± 0.1***000
Duration of machine milking. min	7.4 ± 0.61	4.5 ± 0.63	4.4 ± 0.75	5.7 ± 1.35
Duration of machine after-milking. min	2.22 ± 0.08	1.38 ± 0.09	1.76 ± 0.06	2.15 ± 0.04
Average intensity of milk yield. kg/min	0.88 ± 0.55	1.36 ± 0.45	1.34 ± 0.47	1.22 ± 0.50
Maximum intensity of milk yield. kg/min	1.4 ± 0.65	1.9 ± 0.6	1.7 ± 0.45	1.2 ± 0.25
Teats inspected. pcs	60	60	60	60
Positive response to subclinical mastitis. %	13.3	-	13.3	23.3

*Notes: * - P<0.05; ** - P<0.01; *** - P<0.001; 00 - P<0.01; 000 - P<0.001.*

According to the research results, the operation of milking machines with a pulsation rate of 71-85 cycles per minute provides an average index of milk yield of 1.34 kg/min and indices of machine and manual after-milking at the rate of 0.19 kg and 11.3 ml of milk. On the 20th day, 13.3% of the cows of this group had signs of disease of the udder lobes with a latent form of mastitis and the experiment was discontinued.

It should be mentioned that the indices of a milk let-down in cows, which were milked with milking machines with a reduced pulsation rate of 40-55 cycles per minute are insignificant, which makes it possible to state that this level of pulsation does not provide the necessary mode of milking, reduces the maximum intensity of milk yield by 26.3 and 17.6% as compared with the pulsation rate of 56-70 and 71-85 cycles per minute.

In this case, it is necessary to carry out a long machine and manual after-milking, since a significant amount of milk is left in the cow's udder. At this mode of pulsation, the duration of milking increases (up to 7.4 minutes), which negatively affects the capacity of the milking unit and the efficiency of milking operators.

It should be also noted that the group of cows milked with a pulsation rate of 86-95 cycles per minute probably surpassed the analogues from the group for a pulsating rate of 40-55 cycles per minute by 2.15 kg or by 25.9% (P<0.001), in addition, the pulsation rate of 71-85 cycles per minute was also likely to affect the amount of milk yield as compared with the pulsation rate of 40-55 cycles per minute by 2.24 kg or 27.0% (P<0.001). With the decrease in milk yield at a pulsation rate of 56-70 cycles per minute, these differences were 1.14 kg or 13.7%, with P<0.01.

At least, a pulsation rate of 86-95 and 71-85 cycles per minute probably influenced also the milk let-down in cows at pulsation of 56-60 cycles per minute by 1.01 and 1.10 kg, or by 10.7 and 11.6 respectively % (P<0.01 in both cases).

With machine milking with a pulsation rate of 86-95 cycles per minute, the average intensity of milk yield was 1.22 kg/min. On the 10th day of the experiment 23.3% of the cows from this group had signs of disease of the udder lobes with a latent form of mastitis and the experiment was discontinued. Thus, an increased pulsation rate negatively affects both the milk yield indices and the cow health status. Therefore, the operation of the machine with such a pulsation rate is unacceptable.

In the process of statistical processing of data values of machine after-milking, a slightly different situation was revealed. Thus, a pulsation rate of 40-55 and 86-95 cycles per minute slightly affected the volume of milk yield as compared with the pulsation rate of 56-70 cycles per minute in 2.7 and 2.1 times, but this difference turned out to be probable (P<0,05) as well. In its turn, the amount of the machine after-milking for these levels of the pulsator was also highly probable as compared with the pulsation rate of 71-85 cycles per minute in 2.6 and 2.0 times respectively (P<0.01). At the same time, the volume of manual after-milking using the vast majority of operating modes of the pulsators was also highly probable as compared with the pulsation rate of 56-70 cycles per minute (P<0.001 in all the cases). Moreover, the amount of milk obtained in manual after-milking mode at 40-55 and 86-95 cycles per minute turned out to be probably higher in contrast with a similar pulsation rate of 71-85 cycles per minute (P<0.001).

According to other milk yield indices, no significant intergroup difference was found. Thus, it has been proved that the feeding on concentrated dry feed in the milking room during a milking process (500-1000 g) leads to dustiness of the room and is a factor in the failure of the ADU ½ pulsators operation. It has been established that failures in the operation of pulsators, in turn, negatively affect the milking process itself and cow health status. Therefore, the necessity of checking and cleaning the milking pulsators during the daily servicing of milking equipment when applying such technology of dairy cattle breeding has been substantiated.

Conclusions

It has been established that the dust content in the air of the milking room below 10 mg/m^3 does not affect the pulsator operation and the pulsation rate does not change; 20-25 mg/m^3 of dustiness for 10 days reduces the pulsation rate from 60 ± 5 to 45 ± 5 cycles per minute; 30-35 mg/m^3 for 7 days reduces the pulsation rate to 35 ± 4 cycles per minute; at the concentration of dust in the air over 35 mg/m^3 pulsators become clogged in 2 days, and their further work without cleaning is impossible. It has been proved that the deviation of the operating parameters (pulsation rate) of milking unit pulsators from the normative values (60 ± 5 cycles per minute) negatively affects the milking process of high-yielding cows by reducing the average intensity of milk yield by 10.3-35.7% and makes the animal health worse.

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