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Analysis of major errors in the design of pumping stations and manure storage on pig farms

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Summary. We consider the manure removal system, which is used in most pig farms being built and reconstructed at present in Ukraine, and it has been discovered that there are major mistakes during the baths construction in the correct geometry and depth, and therefore discusses their rules of operation. If the baths geometry is wrongly executed, for instance, if the slope is made to slant toward the bottom of the tub filler drain pipe, which in itself is unacceptable, or not properly executed in the form of a special pit steps towards the neck drain, and etc., then a number of problems is inherent of its exploitation. The basic requirements for laying fused-pipe is compliance with its slope. The considered equipment must be equipped with pumping stations to pump manure. The pumps for pumping manure: submersible sewage pumps and dry-installed in the mine and long sewage pumps with electric or PTO shaft of a tractor were analyzed. Attention was paid to the designing of modern equipment for the distribution of manure waste into fractions. The classification of manure storage and the basic requirements for their placement and arrangement was carried out, and recommendations are made for the designing of pumping stations, to select pumps for the pumping stations and the design during the modern construction and reconstruction of old pig farms.

Key words: Pig manure, manure disposal, pumping stations, manure storage.

INTRODUCTION

Ukraine has considerable natural potential, thus able not only to provide their needs in basic food products of plant and animal origin, but also become an exporter of high-quality, competitive, biologically pure products [1, 2]. In the construction of modern and reconstruction of old pig farms, quite a huge number of questions arises, and unfortunately, experience shows that the problems associated with the disposal and processing of manure are the least resolved [3-6].

Timely cleaning of livestock buildings and manure, the effective use of manure are the most important economic problems, which increases depending on the consolidation of farms, improvement of technical equipments, increasing requirements for the sanitary conditions of animals, as well as on the products quality.The problem of cleaning and disposal of manure view, considering the following issues such as providing physiological comfort for the animals, the environmental protection, and the usage of manure primarily as an organic fertilizer.

This issue covers three challenging tasks such as: (1) The cleaning of livestock buildings and manure in storage; (2) storage, disinfection and storage; and (3) its use.

Currently, the most important error is that inherent of the disposal and processing of manure and must be set before the start of design work or otherwise should avoid delays in the introduction of the complexity into operation, increase in the capital and operating costs for manure disposal which ultimately leads to an increase in the cost of basic products - meat [7-11].

ANALYSIS OF RECENT RESEARCH AND PUBLICATIONS

Basic requirements for the technology and tools for the removal, storage, processing, and use of manure by regulatory and technical documents for the design of such systems, as well as the veterinary, sanitary and hygienic requirements for equipment production involves lines cleaning, handling, decontamination and disposal of manure on livestock farms and complexes.

During the systems designing, the cleaning, removal, handling, and the use of manure should be considered as advanced technologies and must comply with the following conditions to ensure:

- full use of all its components and manure as fertilizer to agricultural land or raw materials for the production of complex organic fertilizers or for other industrial purposes;
- implementation of veterinary and sanitary requirements for the operation of livestock enterprises at reduced water costs, as well as the requirements of the legislation on environmental protection;
- increasing the level of mechanization and automation of manufacturing processes.

The system and method adopted for manure removal depend on the direction of production, capacity of livestock enterprise, its place of location, technological maintenance and feeding of the animals, the availability of water and energy resources and etc. It is important to create normal conditions for the operation of livestock premises and waste removal in particular. Additionally, structural and technical solutions stalls should be provided, animals farrowing and an efficient-choice of mechanization of cleaning and manure must be ensured. The problems encountered in the development of animal husbandry, improvement of pig products competitiveness, creation of proper microclimate in livestock production system, development of optimal characteristics of livestock buildings and the development of methods for

the calculation and design of general plans of livestock farms and complexes have attracted the attention of numerous scholars both locally and internationally, and amongst them are V.A. Medvedskyy, D.F. Kolha, V. Smirnov, G.A. Sokolov, A.F. Trofimov, V. Zavodov, N.A. Popkov, P.N. indexing, J.P. Shejko, G.V. Rodyonov, V.M. Jakub [12-16], but quite a number of issues remain yet unresolved.

AIM OF THE RESEARCH

To consider the basic errors in the design of pump stations, pump selection and design, and the design of manure drive storage during the modern construction and reconstruction of old pig farms.

THE MAIN RESULTS OF RESEARCH

Currently, the majority of pig farms are being built and reconstructed using gravity manure removal batch

system. In this system, the accumulation of manure is under the slotted floors in special channels separated by partitions into the bath. One major mistake during construction of the baths is a violation of their correct geometry and depth. Therefore, prior to the designing of bathrooms, the sizes for the different groups of animals must be accurately calculated because they have different manure composition due to the varying concentration of solids and moisture. If the baths geometry are wrongly executed for instance made sloppy toward the bottom of the tub filler drain pipe, which in itself is unacceptable, then a special pit (Fig. 1) should not be expected but if made around the neck of drain pipes, then it is properly executed (Fig. 2) - in either way, the operation of baths posses a number of problems:

- resetting the manure from the bath may fully or partially wreak havoc, causing additional water consumption and labor costs for cleaning baths;
- an increased level of gas emission baths (ammonia, methane, hydrogen sulfide, carbon dioxide, etc.), affects not only the quality of the air inside the pig, but also of animal's health and consequently on their growth.

Fig. 1. Incorrect pit

Fig. 2. Correct pit with a gradient of step

It is important not only to observe the correct geometry baths during construction but also follow them through since it has, for instance, been majorly observed that most bath operational staff often does not comply with the instructions of technologists and does not fill the tub for 10 to 15 cm of water. This leads to the fact that the first manure that falls to the bottom of the baths dries up, emits gases, and the descent of the bath is not removed, even if the geometry of the baths are flawless. If the level of water in the bathroom is below the norm (for example 5 cm), the manure will not be covered by the water and the top layer becomed dry, thus resulting to all of the above-mentioned problem.

In the event that the bath is operated correctly and after each descent is filled between 10 to 15 cm of water, the manure that gets into it, drops to the bottom and are completely covered with water, and as a result does not emit gases and any odour.

After a while, solid components of manure (undigested food debris, coarse food particles and etc.) stand out from the crowd, float, and form bath carpet crust that prevents stand gases, and a new manure, falling in the bath, freely penetrate through the floating crust. In that case, if the geometry of the baths is made incorrectly or improperly operated, then, it is necessary to stir for complete removal of manure from the bath, which uses special mobile mixers to stir the manure in tanks without raising this slotted floors.

After the descent of pus from the bath, it passes through the collector pipes to the sewage pump station (SPS) or to the plant division. In this case, a pipe diameter between 250 to 350 mm must be used depending on the filling because pipes of smaller diameter silt, leads to incomplete removal of manure from the baths.

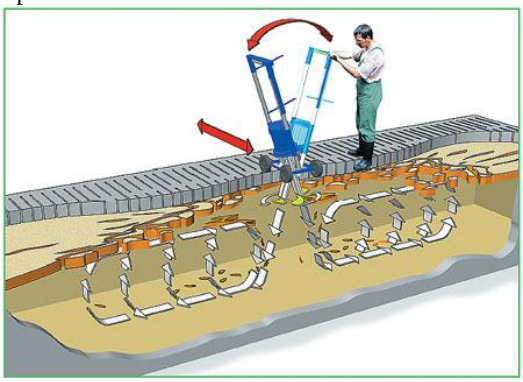

Fig. 3. Mixers for mixing the manure in baths

When laying fused pipes, it is very important to observe its slope - which should be between 2 to 5%. A more liquid component of manure slope away faster, and solid is removed slowly clogging the pipe. If the slope is less than 2 to 5%, the flow velocity of manure into the tube through the pipe is not ensured. In that case, when the pig farm is located on terrain that has a significant slope, the collector runs at an angle of 45 º. The error in this case is due to the implementation of the overall slope of collector above 5% than required, which may lead to dysfunction of the manure removal system [17, 18].

Laying of fused pipes allow turns no more than 30 to 45 º, and the angles of rotation have to be fitted with special lugs to prevent damage to pipes at water hammer.

Fused tube that comes from the pig farm must be elevated to the receiving tank or DPS separation plant above the maximum filling level of the reservoir. If the maximum filling level of the tank is above the level of inlet pipe when filling the tank, manure gets into the tube collector, becomes stratified and deposited in it. Since the collector tube is filled and clogged, then the shutter bath manure will not be removed from it. The most common mistake in the construction of receiving tanks or DPS shop divisions is due to the use of wrong equipments. If the receiving tank diameter is greater than 2 м, then it must be equipped with stationary mixers (Fig. 3), because the swine manures are quickly stratified 20 minutes into the sediment falls about 80% of the solid manure components. If pig manure is not mixed, the reservoir is rapidly silted up, and will require additional expenses to clean it. In the design of pumping stations to pump manures, the pumping equipments and the pipelines should be acked up since there is a high probability of manure separation in pipes and their subsequent siltation. In addition, the pressure line should be fitted with inspection chambers at every 500 м to ensure pipeline flushing. The device pipeline inspection chambers, of course, would increase the cost of construction, but the would ensure the cleaning up of clogged pipeline. Therefore, it is cheaper to make inspection chambers in line than to relay the pipeline. Twists in the pressure pipe must be must be carried out at an angle of 30º. This is due to the fact that the turns in the pipes are the most vulnerable processs for the occurrence of water hammer or blockage, in short, cause damages to the pipes.

Manure pumps can be divided into three large groups: submersible sewage pumps, dry-installed in long mines, and sanitary pumps with electric drive or driven by the PTO tractor shaft. Submersible sewage pumps of medium and high pressure are specially designed and manufactured for use with thick of straw and manure. The rushing system is designed so that the suction opening is always free from clogged-particle. The electric motor power ranges from 1.1 to 30 kW. Submersible pumps do not require rigid installation in the manure pit. They may simply be omitted (using the crane) on the bottom of the filled manure pit, however, if necessary, a pump may easily be used in several manure pit. They are available for vertical and horizontal design. Power is supplied via a sealed cable. Manure can be fed through the corrugated galvanized pipe, pump or by using the clutch once it is connected to underground pressure pipeline. Sanitary pumps dry installation is a centrifugal pump with open impeller wheels and air-cooled engines with a capacity between 0.55 to 30.0 kW. They are specially designed to pump manure with high dry matter content. VD pumps of the type H MRTK are designed for pumping of thick manure and waste over long distances (up to 3 км).

The distinguishing features of these pumps are::

- high efficiency at low power;
- the powerful design of the casing and the impeller pump;
- system ducts in the body prevents clogging pump solid particles.

Long pumps with electric drive or driven by GDP tractor - reliable and powerful pumps (raised to 4,200 m^3 of manure per hour to a height of 40 m) are designed for pumping thick manure substances that are difficult to transfer for quarantine and basic manure storage depth of 6.4 m. The telescopic pipe is adjustable in height. The grinding system is made of a high-strength steel. External blades are used to effectively cut foreign solids and straw and to prevent clogging of the pump inlet. The solid particles are discarded or milled on the side without falling into the pump without damaging the impeller. The output diameter of 114 to 168 mm are driven by electric motors and tractors of power motors between 5.5 to 30.0 kW [19,20].

When selecting pumps for NS, the determining factors are pressure and performance. Pumps are selected so that the pipeline creates flow-path with speed of about 1.5 м/s. For normal pumping manure pumps must have cutting and crushing mechanisms so that solids do not clog the impeller, and disable large components of the machinery.

For pig farms with livestock more than 12 000 animals, the distribution of manure fractions is required in order to reduce the manure drives volumes by reducing the period of quarantine manure extracts. If manure distribution is not done, then the rules must be maintained in the manure drive within 12 months, while the isolated liquid fraction is held in the summer for 6 months, and in winter - a period of 9 months. Modern and relatively inexpensive equipment for distribution of manure effluent fractions is a screw separator that performs compression by a screw that allows to extrude the entire free water and most of the bound water. Compared with the very expensive presses, centrifuges or separators roller screw design with high performance designs is separated from the solid manure components that go sufficiently dry with a separation efficiency of more than 85%.

For separation plants and pumping stations, it is recommended to purchase not only the basic set of equipment, but also backup equipment to the warehouse (pumps, mixers), as well as basic spare parts. Timely replacement and repair of equipment will help avoid serious consequences.

Manure storage is a key element of modern livestock farms. Animal manure is a valuable organic fertilizer that contains all necessary power plants, large amounts of bacteria and nutrients that determine its high value as a fertilizer. But at the same time, it may contain dangerous carriers of diseases (tuberculosis, brucellosis,

paratyphoid, paratuberculosis, foot and mouth disease, salmonella, ascariasis, and others.). Hence the clear need for the preparation and disinfection of manure on the fields is very essential before proceeding. Manure storage can be ground, or half depth underground. They are made of concrete, stainless steel or PVC film. Each option has its advantages and disadvantages.

The best and most common version of manure storage in advanced pig is a concrete tank. They effectively protect the environment and the ground water have long life, require no maintenance, most convenient to mount and use a mixing equipment. These storage facilities fully meet the EU safety standards. The basic requirements for manure pit are tightness and the corresponding strength. For concrete tanks, these requirements are adhered to. For reduction of unpleasant fumes, according to the modern European standards, concrete manure storage should be closed on top of an awning or a floating layer of straw. Sealed manure storage (lagoons) is required to store the manure liquid fraction so as not to lose opportunity to its loading and disposal. All sewage pumps and mixers are designed to work with the substances of the dry matter content of 13%. In the standard version with swine manure substrate content is between 6 to 8% of solids. Therefore, the loss of liquid manure fraction in the course of emptying manure storage can be a daunting technical challenge. The bottom of the lagoon is reinforced with concrete, and material for the walls is a thick metal profile with a special coating or plain concrete.

During the construction of concrete, manure storage can apply a variety of technologies:

- A poured concrete manure pit and the assembled vertical wall must be prefabricated from the concrete elements joint to joint. The joints of the panels are sealed with concrete and a special technology;
- All manure pit, bottom and walls, poured concrete, and the joints must not form a single monolithic structure.
- The most reliable type of manure, the best in terms of reliability, environmental safety, and ease of operation of pumping and mixing equipment is the manure pit made of concrete or stainless steel (Fig. 4).

Manure pit sizes are made to ensure the effective application of mixing technology: The diameter should be between 4 to 25 m and the height of walls up to 7 meters. The height of the vertical wall above the ground level usually is set no lower than 180 to 190 cm.

Fig. 4. Stainless steel manure pit

In countries with weak economies, it is observed that the cheapest option is the buried or insulated film open manure storage. Manure storage are made from PVC film called “film” or often referred to as “lagoons” (Fig. 5). On the farm should be at least two manure storage lagoons that provide a consistent accumulation of 6-month aging (disinfection) and unloading for the spring-autumn application fields of the annual volume of manure.

Fig. 5. Manure storage PVC film

Film manure storage necessarily required enclosed fence. All piping gets into the manure storage only through the top of the side walls. The tightness is ensured by the concrete wall thickness of 20 mm (for walls up to 6 m tall) and between 22 to 25 mm (for walls more height). Manure storage is placed so that their paths do not intersect on the farm with other ways, especially for the delivery of feed.

According to sanitary standards, in addition to basic manure storage for permanent storage of manure on farms, it is very important to provide quarantine or sectional area quarantine tanks. These sections should be at least two. Removed from farm manure storage is a quarantine daily dose of manure which is kept there for at least 6 days and, if during this time, the farm were found infectious with diseases, the reloading of the main manure storage is required.

Indecomposable manure may withstand only manure drive provided they are equipped with agitators to ensure mixing and to homogenize the manure before pumping as the process of aging manure strongly foliates due to its physical and mechanical properties, forming a bundle of three levels:

- floating crust, consisting of a solid clay particle, undigested feed, coarse residues, etc., and peel height depending on the animals and their ages ranged from 0.3 to 1 m;
- shar liquids without suspended solids, the height of the layer is between $^{1}/_{2}$ to $^{3}/_{4}$ of the total depth of manure drive;
- mulkyy residue, consisting of large, medium, small organic and colloidal particles - from $^{1}/_{5}$ to $^{1}/_{4}$ of the total depth of manure drive.

Pumping manure drives without prior mixing will lead to the fact that its useful capacity with each cycle of filling and pumping will decrease and thus between 2 to 3 years, the unpumped solid components become

completely silted. This is due to the fact that the pump can not pump out the muddy bottom layer of high density (greater than 1.2 kg/dм^3) and packed floating upper layer (crust). In addition, there is no agronomic control of fertilizers, and as a consequence results to minimum benefit from the use of unmixed manure due to uneven distribution of nutrients (N - P - K) and organic matter in different layers of manure drive. Storage of unrequited manure in the manure drive film (lagoons) not equipped with agitators is generally unacceptable, since clean silting is quite impossible, and therfore, film basis calls for mechanized cleaning of silt deposits. Many farm enterprises simply leave these lagoons, investing money in new construction.

The distribution of liquid manure fractions can be maintained in the lagoons not equipped with agitators. Installation of agitators in this case is not required, since the separated liquid fraction after expiry of the quarantine exposure is pumped from the lagoon and completely leaves no residue. The extraction of the separated liquid fraction requires the construction of fewer lagoons, lagoons of smaller volume, and the construction cost of the manure drive film are significantly cheaper than the concrete and metal. The distribution of manure fractions budget for construction of manure drives can be reduced by 2 to 4 times, given the structure of the plant and equipment of the separation plant. Often, the design and construction of the pig farms involves the undermining the amount of manure drive to ensure significant savings on the construction part. But when calculating the volume of lagoons, it is important to not only put the amount of manure into consideration, but also that in most parts of our country, for five months of the year - the application of manure during winter on the field is impossible, and the manure, which has already passed the period of quarantine extracts stays in the manure drive until spring. Thus, building construction on a pig farm lagoon is unacceptable because after it rains, it is impossible, and manure must undergo a period of quarantine exposure. It is therefore, necessary to build at least two manure drive, but the best choice would be to build three or four smaller volume.

Simultaneously with the design of manure drives, it is important to predict and find ways of pumping and mixing of manure, as it may affect the configuration of the lagoons and the optimization of current expenses for their operation. If this node is designed incorrectly or not designed at all, the work of the pig farm is at risk of being paralyzed because of the impossibility to pump and dispose manure. As noted above, unrequited pumping manure after a period of quarantine excerpts from storage is impossible without stirring, so it is necessary to foresee the installation of stationary mixers. For mixing the manure in the deep drives, mobile mixers working from the PTO of tractor with the arrow length between 5 to 12 meters can be used. In this case, savings on installation of stationary mixers can be achieved since the mobile mixer can serve several lagoons.

The method of pumping manure lagoons depends on how the field is made after a period of quarantine exposure. If evacuation is planned, and self-priming pumps are installed on the drums, it is necessary to provide access to the edge of manure drive. For manure drives, the depth does not seem to be the issue but a wider implementation of the layer by layer compaction and soil stabilization which greatly increases construction costs. Therefore, for the strengthening of manure drives, it is better to use permanently installed pumps.

Thus, it is necessary to choose a pump that fills the barrel for not more than 5 minutes because the simple technique for seasonal manure on fields is unacceptable. There are cases when the pig farm is placed under sanitary protection zone (SPZ), but manure drives turns out that they need to move to a new place, which results at best, to the additional costs for the construction of pumping station, and at worst- the construction of new manure drives or run-time transfer of pig farm.

The distance from manure drive open to residential area, in accordance with applicable law, with livestock pig more than 12 thousand head should not be less than 1000 м, and with population up to 12 thousand heads, Heads - must be at least 500 м. Although, it is relatively easy to solve the problem of reduction of the SPZ at the stage of design because if the manure drive run is closed, the SPZ distance is subsequently halved.

Mistakes are often assumed to be the deepening of manure drives below the groundwater level, although the rules is that the bottom of manure drives should be above the groundwater level. If the groundwater lies closely, it is advisable to build a diked storage (Fig. 6), or to use prefabricated metal containers mounted on the ground.

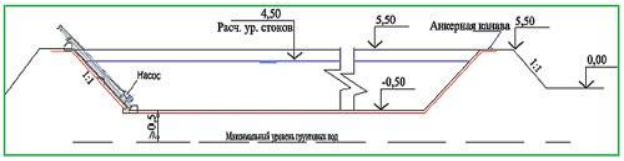

Fig. 6. Profile lagoon project

A manure drive depth of no more than 6 meters is recommended. If the depth is greater, problems with mixing and pumping manure from lagoons may arise, mainly because all the special equipment's are designed at the maximum depth of 6 m.

CONCLUSIONS

1. Careless attitude towards the issues of recycling and processing of manure can lead to the diversion of resources from the primary production to fix errors inherent of the design and the operation of manure removal system possibly due to downtime in the main economic activities. It is mention-worthy that fixing the design errors is very expensive.

2. Designing the entire removal and the manure systems must be strictly carried out by organizations that specialize in this subject so as to provide all the necessary details of the system operation and to minimize the construction and operation costs.

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АНАЛИЗ ОСНОВНЫХ ОШИБОК ПРИ ПРОЕКТИРОВАНИИ НАСОСНЫХ СТАНЦИЙ И ХРАНЕНИИ НАВОЗА НА СВИНОФЕРМАХ

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Аннотация. Рассмотрена система гноєвидалення, что применяется на большинстве свинокомплексов, что строятся и реконструируются на данное время в Украине, основные ошибки при строительстве ванн относительно их правильной геометрии и глубины и рассмотрены правила их эксплуатации. В случае если геометрия ванны выполнена неправильно - например сделанный уклон дна ванны в сторону горловины сливной трубы, что сам по себе является недопустимым; не выполнен специальный приямок в виде ступеньки перед сливной горловиной и др., - то при эксплуатации ванн возникает ряд проблем. Определены основные требования к прокладке самосплавной трубы с соблюдением ее уклона. Рассмотрено оборудование, которым должны оснащаться насосные станции для перекачивания навоза. Приведен анализ насосов для перекачивания навоза: погружные фекальные насосы, насосы сухой установки в шахте и довговальные фекальные насосы с электроприводом или приводом от вала отбора мощности трактора. Уделено внимание современному оборудованию для разделения стоков навоза на фракции. Приведена классификация навозохранилищ и основные требования к их размещению и обустройству. Рассмотрены основные ошибки и сформулированы рекомендации при проектировании насосных станций, подборе насосов для насосных станций и проектировании навозонакопителей во время строительства современных и реконструкции старых свинокомплексов.

Ключевые слова. Свиноводство, удаление навоза, утилизация навоза, насосные станции, навозохранилища.