



Dairy Cattle Mechanized Farming Equipment Applications and Future Development Trends

Peifang Cai ^{a*} and Rong Dong ^a

^a *School of Mechanical Engineering, North China University of Water Resources and Electric Power, Zhengzhou - 450000, China.*

Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJRAF/2022/v8i4173

Open Peer Review History:

This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: <https://www.sdiarticle5.com/review-history/92885>

Review Article

Received 09 August 2022
Accepted 17 October 2022
Published 21 October 2022

ABSTRACT

With the rapid development of China's dairy industry and the continuous increase in the number of dairy cows, mechanized dairy farming equipment has been widely used. Therefore, mechanized dairy farming equipment in China has entered a new stage of development. From the current development of the dairy farming industry, mechanized farming has made outstanding contributions to improving the output of a single cow, ensuring the production safety of milk products, and improving the level of feeding management technology. Therefore, the implementation of mechanized dairy farming is the key to the development of China's dairy industry, and the R & D of standardization, finalization, serialization, and the complete set is also its future development direction. Dairy equipment is the basis of large-scale dairy farming, this paper briefly analyzes the development of feeding equipment, milking equipment, feed processing equipment, manure collection equipment, etc., and outlines the advanced and applicable characteristics of some products. The research in this paper provides a reference for the improvement and application of related products, effectively promoting the mechanized development of China's cattle industry and meeting the increasing consumer demand of residents.

Keywords: Dairy farming; mechanization; intelligence; trend.

1. INTRODUCTION

In recent years, with the improvement of living standards of Chinese residents, the demand for high-quality meat, eggs and milk has increased year by year, especially the demand for milk and beef has increased significantly. As the dairy industry in China develops, the overall trend of dairy cows' yield capacity as well as raw milk processing level is on the rise. Domestic milk production will continue to grow in the coming years, with production expected to reach 41.24 million tons by 2026[1]. Meanwhile, China is also a big consumer of beef. In 2019, China's beef output was 6.67 million tons, an increase of 230,000 tons or 3.6%, ranking steadily as the third largest beef producer in the world [2]. Our country's cow feeding develops rapidly, but compared with the developed countries, there are certain gaps. With the technology of animal breeding, feeding, and epidemic prevention close to the level of developed countries, the fundamental way to improve the benefit of dairy farming is to reduce the cost of breeding, reduce labor and enhances the mechanization level of dairy cows. Shaanxi Qianyang County Agricultural machinery management service station undertook the construction project of the Shaanxi dairy farming mechanization demonstration park. Given the current situation and mechanization development level of the dairy cattle industry in our country, centering on the demand for equipment and development trend of key weak links of dairy cattle farming, the whole mechanization farming mode process of a large-scale dairy farm is created, namely: whole corn silage mechanization → dairy concentrate feed processing, mixing mechanization → Total Mixed Rations (TMR) feeding mechanization → milking mechanization → epidemic prevention and health disinfection mechanization → manure collection and processing mechanization, etc. 6 key aspects of farming mechanization.

2. APPLICATION OF MECHANIZED DAIRY FARMING EQUIPMENT IN CHINA

China's dairy mechanized breeding, started in the early days of the founding of the country, when the main development of dairy feed processing. As the introduction of some foreign forage, feed machinery and milking machinery and equipment, coupled with the strong support of national policies, Chinese dairy farming mechanized development also opened the

prelude. In the process of standardization and specialization of dairy farming technology, advanced cattle breeding equipment and welfare health breeding process technology has basically formed a facility breeding engineering technology with Chinese characteristics.

In a broad sense, dairy mechanized breeding equipment includes daily breeding link equipment, milking, milk transportation, and storage equipment, manure treatment system equipment, feeding machinery and equipment and manure throwing equipment, new energy utilization equipment, etc.

2.1 Daily Breeding Link Equipment

It is mainly dedicated to improving the living environment of cows, improving their rest quality, creating a clean and comfortable living environment, improving their welfare, reducing their sickness rate, and increasing their milk production. Daily breeding equipment is divided into the following categories:

2.1.1 Feeding equipment

Cow neck shackles is installed between the cow's living area and the feeding channel (Fig. 1). Through the unique device of the cow neck shackle, the cow can control the fixed feeding head, and the cow can feed independently and it is convenient for the staff to conduct a routine physical examination, immunization, artificial insemination, pregnancy check, treatment, dehorning, calving and other veterinary treatment activities. The application of this equipment greatly reduces manual labor intensity and improves overall dairy farming management.



Fig. 1. Cow neck shackles

Drinking water tank is designed according to the cow's drinking needs, automatically controls the water level, and has the functions of automatic

water in and out, cleaning, heating, heat preservation, etc. It ensures the cow's drinking water safety, provides convenience for the cow to take in enough water after eating, promotes the digestion of food and the absorption of marketing, and plays an active role in the increase of milk production. The precision feeding system can automatically run and identify cows according to the manually set program, and deliver precise feed for each cow separately, realizing regular scientific feeding in small batches of multiple batches [3].

2.1.2 Sleep devices

Cow lying pen is designed according to the cow's size and combined with the cow's rising and lying movements to standardise the cow's resting position without interfering with each other. This prevents cows from standing on the bedding mat and discharging manure at will, facilitating the central disposal of manure and providing a clean and comfortable living environment for cows. This maintains the cows' health and improves their milk production.

The new cow mattress is composed of a rubber pad on the upper layer, a sponge on the lower layer, and a high-strength nylon net in the middle. The mattress is designed with numerous massage dots on the upper layer to promote blood circulation in cows and prevent mastitis and other diseases, thus reducing the culling rate of cows [4]. The overall mattress is non-slip, anti-static, heat-insulating and cool-insulating, easy to wash, easy to change and odourless, changing the poor environment of cows on concrete and muddy ground, improving their resting comfort, increasing their bedtime rate and improving their milk production.

2.1.3 Welfare equipment

The cow body brush (Fig. 2) is made of a special material for durability. The use of a unique induction device, so that when the cow's body passes through the cow body brush automatically rotates work, when not in use can also automatically stop, easy to use, energy saving, and safe, greatly reducing the breeding of dirt and parasites on the cow's body, reducing the spread of germs and infection rate of cows, promote blood circulation, to ensure the health of cows, to protect the high yield of milk; bail frame. The new holding frame is now mainly divided into fixed, mobile, multi-functional, and other kinds. Its main purpose is to fix the cow, convenient for

veterinarians and breeders for breeding, hoof trimming, treatment, immunization, expectation testing, embryo transfer, and other work.



Fig. 2. Cow body brush

2.1.4 Ventilation, cooling, and ventilation equipment

A rolling curtain is installed in the side wall of the barn, using the role of the film rollers, film roll cloth, and other components to automatically open up and down, with wind, rain, air, ventilation, cooling, lighting, sun, and other functions. Roller blinds provide a comfortable living environment for cows. The equipment mainly reflects the application of cooling and ventilation technology. Low-pressure high flow type fan and evaporative cooling wet curtain, has become new technology for cattle barn ventilation, solving the dead end of livestock and poultry barn ventilation and summer high-temperature stress problems. The application of this technology leads to an overall improvement in the environment of the barn, ensuring the comfort and safety of the cattle [5].

Sliding cattle barn roof mainly uses the motor, sliding track, and sliding wheel to finally achieve the function of opening or closing the barn roof. This technology mainly provides a dry, comfortable, ventilated, and well-lit living environment for the cattle barn, so that the cattle can achieve the effect of free movement indoors.

2.1.5 Cross-contamination prevention system

Hydraulic flap installed at the intersection of the feeding channel and the milking channel. When the cows need to pass for milking, the hydraulic flap opens and the cows pass under the flap. The hydraulic flap is lowered when all the cows pass or when the feeding trolley needs to pass, thus ensuring that stains and other debris carried on the cow's body or hooves do not contaminate the

feeding channel and preventing the cows from entering the feeding channel. This technology mainly solves the cross-pollution of feeding trucks and milking channels, ensures the cleanliness of dairy farm feeding roads, guarantees the cleanliness of farm roads, and improves the overall farm road hygiene and environmental conditions [5-7].

2.1.6 Cattle catcher

The cattle drive is used to drive cows through the milking aisle for ease of management. This technology has greatly improved the efficiency of the staff [8,9].

3. WHOIE-PLANT CORN SILAGE MECHANIZATION

The main model: silage special maize continuous order mechanical narrow rows of dense planting + silage crop combine harvester harvesting shredding + special transport vehicles with self-unloading function transport + heavy machinery heap high-pressure solid sealing cellar. The introduction of screening and promotion of special silage corn varieties Ya Yu 8, An Yu 2166, Aoyu 5102, Yao Qing 2, Qin Long silage 1, and Yu silage 23 varieties. Using 3 kg of seed per 666 m² of land, requiring 40 kg of maize compound fertilizer and a density of about 6,000 plants, 4 to 5 tons of the whole plant with cob silage can be harvested [10].

Whole corn silage harvesting in the corn seed waxing pre-mature, the whole plant's lower 4 to 5 leaves become brown when the best use of corn silage harvester mowing. Maize silage mowing height is usually better than 15 cm. The cutting length should be controlled at 1.5 to 2 cm. Field harvesting cutting at the same time, with a special transport vehicle with self-unloading function synchronized pick-up (Fig. 3), filled with fast transport to the silage cellar, and finally with heavy machinery loader using progressive wedge silage, each filled 20 ~ 30 cm, with heavy machinery pile high pressure solid [11]. After the silage raw materials are filled, it is necessary to continue loading until the raw materials are about 60 cm above the edge of the cellar, then covered with plastic film, and then compacted with soil or tires, soil thickness 30 ~ 40 cm, so that the top of the cellar rises[12]. After heavy machinery compaction and sealing, a density of 750 kg/m³ can be achieved. In general, cows need an average of 25 kg of corn silage per day; breeding cows need an average of 15 kg of corn silage per

head per day. That is, according to the average 305 days of milk production of 7000 kg, the daily consumption of corn silage needs 19.65 tons, a thousand cattle farms need at least 10,000 cubic meters of silage cellar and the annual storage of at least 7000 ~ 8000 tons of whole plant silage corn[13].



Fig. 3. Specialized transport vehicles with self-unloading function

4. DAIRY CATTLE CONCENTRATE FEED PROCESSING, MIXING MECHANIZATION

Main mode: mechanical crushing of raw materials + mixing according to recipe requirements + bagging and sealing for storage. Dairy cattle concentrate feed mainly has grain solid feed and cake meal feed. The processing methods of grain feed include crushing, grinding, puffing, pelleting, roasting, steam pressing, and pressurized cooking. Mechanical crushing is the most common processing method of seed feeds and the cheapest. Cake meal feed is the residual part of the oil crop seeds after the extraction of oil, which has a crude protein content of roughly 30% to 45%. Pastry meal is rich in protein, oils, starch, vitamins, and minerals. It is well suited as a feed, easily digestible and resourceful, and is by far the most commonly used vegetable protein feed ingredient. The commonly used cake meal feeds are soybean cake (meal), rapeseed cake (meal), cottonseed cake (meal), peanut cake (meal), and so on. But this kind of feed contains a variety of anti-nutritional factors, improper use is likely to cause livestock poisoning should be limited feeding. The ingredients are crushed and mixed thoroughly according to the recipe and placed in sacks. The crushed particles can be coarser, where the corn is crushed, with a particle diameter of 2 to 4 mm. In addition to 1 kg of concentrate feed for adult cows at 2.5 to 4 kg of milk, each head needs to add 3 kg of basic

feed per day; pregnant young heifers average 2.5 to 3 kg of concentrate feed per head per day; 2 kg for breeding cows; 1.5 kg for calves [14].

5. TOTAL MIXED RATION (TMR) FEEDING MECHANIZATION

Main mode: Silage special (electric) picker cutting and loading silage + mechanical feeding of green hay + TMR special mixer truck mixing and feeding according to recipe + mechanical pushing and sweeping truck pushing the material.

TMR is a process where all the forages in a recipe are calculated and put together, followed by kneading, mixing, and thorough blending in a special mixer truck. It is an advanced feeding process for feeding cows, who receive balanced nutrition with every bite they take [15]. The implementation of TMR has a good effect on improving the feed conversion rate, ensuring the health of the rumen and the body, and improving milk production and quality. In modern-scale farms, feeding labor productivity can be increased by more than 10 times compared to traditional farms [16].



Fig. 4. Full mixed ration push sweeper

Adopt silage special (electric) reclaimer, high efficacy, reclaiming material at the same time with shredding function, neat and smooth cutting surface, no secondary fermentation, no loss caused by rainwater soaking in the open air, and can finish loading at the same time [17]. According to the size of the cattle herd, the mobile TMR mixer can be selected to feed 3 times a day, and the total feeding work of the feeder is 6 hours, which is 12 cubic meters for 1000 heads. The mobile TMR mixer can walk to

the silage cellar, hay storage, and concentrate storage for loading and transport directly to the barn for feeding cows, which is highly efficient and saves labor costs. The Total Mixed Ration sweeper pushes the feed into the mouth of the cow during the cleaning of the feed trough (Fig. 4) and mixes the feed at the same time. During the feed pushing and brushing process, the feed is also mixed evenly and the same moisture level is maintained.



Fig. 5. Mechanized milking equipment

6. MILKING MECHANIZATION

Main model: mechanized milking for healthy herds + regular milk sample collection for DHI production performance measurement + online detection and metering system metering + dairy farm management information system to manage the herd. The centralized use of mechanized milking for healthy herds can reduce human labor intensity (Fig. 5), improve production efficiency, and reduce production costs [18,8]. The ring parlor can accommodate up to 480 cows, milking 3 times a day and doing all the work in 12 hours. This stall is also equipped with a cooling system, hot and cold water supply, washing and disinfection solution, teat disinfection equipment, automatic cluster removal, and milk yield display and recording. To improve the overall quality and production level of the herd, milk samples can be collected periodically for DHI production performance measurement, which is a comprehensive physical examination of the cow, and the DHI measurement data gives parameters such as somatic cell count (SCC), milk composition, peak daily milk yield, lactation duration, average fetal spacing, and lactation loss, which can reflect problems in cow feeding, reproduction, and management and help It helps managers to evaluate the degree of harm of problems, find the

causes of problems and improve them in time. At the same time, the dairy management information system can be used for intelligent early warning, decision support, herd management, reproduction management, milk production management, DHI analysis, veterinary care, feed formulation and nutrition, and material management. It completely realizes the standardization, science, and transparency of the whole life cycle of cow growth and breeding, the milk production cycle of the litter, and the daily production and operation management of dairy farming enterprises [19].

7. EPIDEMIC PREVENTION AND SANITATION DISINFECTION MECHANIZATION

Main model: disinfection of vehicle disinfection pool at the gate + mechanical fogging disinfection of personnel disinfection channel at the side gate + disinfection of the whole field epidemic prevention and disinfection vehicle + cattle body brush to clean cattle body + hoof trimming machine to trim hoof health. A disinfection pool is set up at the entrance of the gate and the entrance of the cattle barn, with the pool being as wide as the gate, 4 meters long, and 30 cm deep. Disinfection solution with 2% to 4% sodium hydroxide, to ensure the effectiveness of the solution, generally 15 days to replace the solution; around the field and the field cesspool, sewer outlet, disinfection with bleach once a month, each cubic meter of sewage can use 6 to 10 grams of bleach [20]. Staff should enter the gate and production area through the disinfection channel. The disinfection channel is equipped with a mechanical atomization disinfector. Foreign visitors entering the farm to visit should be thoroughly disinfected, change their farm work clothes and work shoes, and comply with the farm epidemic prevention system. The barn is regularly disinfected by washing the cattle bed with a high-pressure water gun and spraying; the sports field and its surroundings are disinfected once a week with 2% sodium hydroxide or sprinkled with quicklime. Feeding utensils, troughs, and feed carts are disinfected regularly, once every two weeks in summer and once a month in winter. Daily utensils such as veterinary utensils, midwifery utensils, breeding utensils, milking equipment, and milk tankers should be thoroughly cleaned and disinfected before and after use. Regular disinfection of the environment with cattle, especially during the infectious disease season, is beneficial in reducing pathogenic

microorganisms in the environment [21]. Disinfection of the environment with cows should avoid contamination of milk with disinfectants. Cow body brushing can easily enable cows to achieve self-cleaning and reduce dirt and parasites on their bodies. The cow body brush also promotes blood circulation, keeps the cow's coat clean, and increases cow feed intake. It allows cows to comfortably clean their heads, backs, and tails and stop rubbing and scratching everywhere, thus saving money and preventing accidents.

The hoof trimming machine frees the hoof trimmer from physical labor by allowing him to work on his feet. The technician treats the wound accurately, thus making hoof trimming easy and significantly reducing cow abortions. Not only is it handy for trimming front hooves, but it can also be used for a variety of purposes such as surgery, breeding, cesarean section and rectal examination of cows.

8. MECHANIZATION OF MANURE COLLECTION AND PROCESSING

The manure collection and processing machine first collects the manure with an electric scraper, followed by a sewage pump to a mechanical manure cleaner for solid-liquid separation. The mechanically separated solid manure can be composted and fermented to produce organic fertilizer and can also be fermented in liquid digesters to produce biogas.

At present, the manure-cleaning method of large-scale cattle farms in China is based on scrapers and tractor shovels, and the manure-cleaning method of smaller cattle farms is mainly manual [5]. Most of the cattle farms have concrete floors. To separate the dry manure from the urine, mechanical manure removal equipment needs to be equipped in the barn for harmless treatment. This equipment improves resource utilization and reduces labor costs. The manure of the sports field adopts a dry manure cleaning process dry manure is cleaned or collected by hand or machinery, and then transported to the storage or processing place. This method of manure removal can be used at any time and is easy to operate, safe and reliable. The height and speed of the scraper are moderate and there is no noise, which does not affect the walking, feeding, and resting of the cattle. The manure collected and conveyed is firstly sieved once for solid-liquid, and the fibrous solids sieved out are fermented and used as cattle mattress material

or organic fertilizer, and the solids after the second sieving can be made into high-grade organic fertilizer. The screened effluent can be realized as a biogas project or otherwise treated and returned to irrigation.



Fig. 6. Automated manure cleaning machines

9. CONCLUSION

Mechanization is an inherent requirement of large-scale dairy farming, advanced and applicable. Mechanical equipment is conducive to improving the production efficiency of large-scale farms, automation, information technology, and intelligence for the development direction of feeding equipment, milking equipment, breeding monitoring equipment, through the collection and analysis of data in all aspects, to enhance the refinement of farm management, and achieve cost reduction and efficiency.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. China Milk Industry Analysis Report 2020 - Market Operation Trend and Development Prospect Forecast. [EB/OL].<http://baogao.chinabaogao.com/rupin/417917417917.html>,2020-08-08.
2. China Beef Industry Analysis Report 2020 - Market Operation Trends and Development Prospects [EB/OL]. (2020-02-21). Available:<http://market.chinabaogao.com/nonglinmuyu/02214P4462020.html>.
3. Yang Cunzhi, Li Yanyuan, Yang Xu, Chen Lei. Development of FR-200 type intelligent precision feeding robot for dairy cows [J]. Agricultural Mechanization Research. 2014,36(02):120-126. DOI:10.13427/j.cnki.njyi.2014.02.030.
4. Zheng G. S., Shi Z. H., Teng G. H. Research progress of equipment technology for dairy farming facilities in China [J]. Chinese Journal of Animal Husbandry,2019,55(07):169-174. DOI:10.19556/j.0258-7033.2019-07-169.
5. Peng Xiaopei, Huang Kejing, Guo Yi, et al . Research on mechanical manure removal methods in domestic livestock farms [J]. Report [J]. Contemporary animal husbandry. 2020(7):24-26.
6. He Dongjian, Liu Dong, Zhao Kaixuan. Research progress of animal information intelligent sensing and behavior detection in precision animal husbandry [J]. and behavior detection [J]. Journal of Agricultural Machinery. 2016,47(5):231-244.
7. Shao Lin, Liu Shuxia, Huo Xiaojing, Zhao Xiaoshun, Wang Hui. Application of data fusion algorithm in environmental monitoring system of livestock and poultry house[J]. Agricultural Mechanization Research,2013,35(08):162-165+169. DOI:10.13427/j.cnki.njyi.2013.08.059.
8. China Dairy Association, Institute of Agricultural Information, Chinese Academy of Agricultural Sciences. Automatic milking machine Weapon innovation technology analysis report [R].2021;4.
9. Ministry of Agriculture and Rural Affairs of the People's Republic of China. DG/T 219-2021 cow behavior monitoring equipment[S].2021:1.
10. Huang Wenyu. Research and design of a refined dairy farming management system based on data on animal husbandry [J].and design [J]. Journal of Yichun College. 2017,39(3):46-49.
11. Lv Zhanmin, Jin Hongwei, Liu Shengchun, et al. Analysis of the application of dairy cattle behavior monitoring equipment analysis[J]. Chinese dairy cattle,2021,06:51-54.
12. Cao Linlin. Analysis of the feed characteristics of silage maize and its application in dairy farming [J]. Shandong Animal Husbandry and Veterinary Medicine. 2022,43(09):24-25+29.
13. Liu Haibo, Fu Tie Ning. Fengning Wudaoying Township:Dairy farming helps revitalize the countryside [N]. Yanzhao Rural News, 2022-08-18(002).

- DOI:10.28323/n.cnki.nhbnm.2022.000405.
14. Wen Shouye. The influence of environmental factors on dairy farming [J]. Animal Husbandry and Veterinary Medicine Today. 2022;38(06):43-45.
 15. Jin Hongwei, et al. Full mixed ration preparation machine options and maintenance [M]. Beijing: China Agricultural Science and Technology Press. 2014:3-12.
 16. Qu Ailing, Ma Changlu. Environmental pollution of dairy cattle breeding and countermeasures for prevention and control[J]. Modern Agricultural Science and Technology. 2022(10):142-145.
 17. WANG Hui, TAO Zhenxiang, SUN Xiaohong. Evaluation of drug resistance and virulence of *Klebsiella pneumoniae* in dairy farming environment[C]//. Abstracts of the 18th Annual Conference of the Chinese Society of Food Science and Technology. [publisher unknown], 2022:121-122.
DOI:10.26914/c.cnkihy.2022.001814.
 18. Department of Agricultural Mechanization Management, Ministry of Agriculture and Rural Affairs. 2019 National Agricultural Mechanization Statistics Annual Report [M].2020;14.
 19. Zhang Xiaoliang, Tian Jinming, Li Wei, Wang Guoliang, Xu Zisheng, Shang Steadyqi. Analysis of the quality of milking machines in China [J]. Chinese dairy cows. 2011(01):8-12.
 20. Li Chunping, Zhu Xinpei, Sun Kelan, Zhu Qiyao, Gao Yuqiong, Zhao Jiakai. Research on the current situation and countermeasures of dairy cattle breeding industry development[J]. China Dairy Industry. 2022(02):22-25.
 21. Hou Shizhong, Wu Jie, Song Lei, Qu Xuxian. Survey on the current situation of application of animal husbandry machinery and equipment in Shandong Province and development countermeasures[J]. Heilongjiang animal husbandry and veterinary medicine. 2014(11):89-95.
DOI:10.13881/j.cnki.hljxmsy.2014.0402.

© 2022 Cai and Dong; This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Peer-review history:

The peer review history for this paper can be accessed here:
<https://www.sdiarticle5.com/review-history/92885>