The influence of incubator design features on the incubation result

I A Korsheva, I V Trotsenko

Omsk State Agrarian University named after P.A. Stolypin, 1, Institutskaya Square, Omsk, 644008, Russia

E-mail: ia.korsheva@omgau.org

Abstract. This article shows the results of chicken eggs incubation by IUP-F-45 and BioStreamer 165HD. There were two different types of machines during two-lots of eggs incubation. The BioStreamer 165HD is equipped with such feature as flexible incubation environment tuning according to its technology of embryo feedback. The sensors control the temperature inside machine by using the temperature of egg shells. Also there are sensors which can monitor the humidity level by controlling and predicting the humidity loss of each egg lot and using the narrow-hatching window technology. The incubators are managed by controller and connected to one computer network. The eggs are set to cellular structure incubation tray. The pulsators are equipped with five wide blades to ensure the required air flow rate. In addition, the roof vents have been improved. The power of the heating elements has been increased, which provides a quick heating time for all eggs at the beginning of the incubation cycle. The larger diameter of the cooling coil creates a wider overall cooling surface. As a result of the research, it was found that the use of the BioStreamer incubator made it possible to increase the hatchability of eggs, to carry out the simultaneous hatching of young brood, reducing the hatching by 5.5 hours, to increase the yield of conditioned young chickens by 0.9% and its quality, to obtain a greater amount of meat products from broilers: the average weight of chickens increased by 2.7 per cent, the safety of brood - by 3.6 per cent.

1. Introduction

Poultry is a knowledge-intensive and dynamic branch of the agro-industrial complex, which is characterized by a rapid rate of poultry reproduction, intensive growth, high productivity and viability, the lowest cost of living labor and material resources per unit of the production, which takes a significant place in the people nutrition [1]. Poultry has developed in general due to the introduction of a method of reproduction without the participation of the mother's body – using the incubation machines [2]. Despite the improvement the incubation conditions and technology of the young brood hatching from the eggs of modern high-yielding poultry breeds has not generally increased, and about 20% of expensive breeding eggs are still lost in the form of incubation waste. The reserves of the hatchability improvement lie not only in the improvement of biological qualities of the eggs , but also in the organization of its effective incubation.

Optimal embryo development is possible only under certain conditions of the air environment in the incubator. Intensive embryo development provides not only high incubation results, but also improves the post-embryonic development of chickens, increases the productivity of the bird.

2. Materials and methods

The research material was the hatching eggs of the parent Cobb breed. The experiments were made in the
conditions of industrial poultry farm. To determine the influence of the incubator model on the incubation results, two batches of eggs were taken, the batches were formed randomly, according to the average weight, origin and shelf life, and they were similar.

The first batch was incubated in the IUP-F-45 incubation machine, the second - in the BioStreamer 165HD, the batch size was 45.0 and 76.8 thousand eggs, respectively. All eggs were placed in an incubator, incubated under the same regime; when hatching, the incubation duration of each batch of eggs, the hatching duration were taken into account, and the hatched chicks were counted at the hatching intervals (for 30 h, 24 h, 12 h). During the incubation period, a periodic control examination of the eggs was carried out on an ovoscope: the first – 7, the second – 11, the third - on the 18th day of incubation. An average examination was carried out after the end of the hatching of the chickens on the 21.5th day. Eggs from which chicks did not hatch were opened and the reasons of wasting were determined. After hatching on one-day old, two experimental groups of chickens were formed, which were grown up for 42 days. The conditions of keeping and feeding the birds were the same and corresponded to the recommendations for working with the breed.

The study took into account: fertilization of eggs (by ovoscopy), hatchability of eggs and hatching of young brood, results of control weighing of eggs and young brood (on electronic scales VK-600 with an accuracy of 0.1 g), poultry safety and increase in live weight. The work used devices and methods for assessing the morphophysical qualities of eggs, developed at the All-Russian Research Institute of Poultry.

3. Findings
The incubator universal preliminary IUP-F-45 and the hatcher IUV-F-15, produced by Pyatigorskselmash (Russia), are intended for incubation and hatching of eggs of all types of poultry.

The incubator body IUP-F-45 consists of three independently operating compartments with a single mechanism for turning the trays and electrical equipment. Each compartment contains a drum with trays, a fan, a heating, cooling, control and emergency cooling system. These systems can be controlled remotely from a computer. The control system is located on the incubator body, where the user selects the optimal mode for the operation of the device and all parameters will be automatically maintained in this case. The mode is controlled by four sensors: one for humidity and three for temperature. The rotation of the trays with eggs is carried out every hour automatically, by tilting 45 degrees to both sides of the vertical position of the eggs. Air circulation inside each compartment for even heating of air and eggs is provided by a four-blade low-speed fan, which is installed on the rear panel of the case.

Air heating in each compartment is carried out by four electric heaters up to 4 kW. Air humidification in the compartment is carried out due to the evaporation of water supplied to the fan blades. The accuracy of automatic maintenance of the relative air humidity in the area of the sensors installation is not more than ± 5%. Air cooling in each compartment occurs when water passes through the closed heat exchanger. The accuracy of automatic maintenance of the set temperature in the area of the sensors installation is not less than ± 0.2°C. Air exchange in each compartment is carried out through holes with throttle valves.

The composition and operation of the IUV-F-15 hatching incubator is similar to the IUP-F-45 incubator: the IUV-F-15 incubator consists of a body, a thermostat, 4 platforms with stacking trays, a fan, electrical equipment, a heating, cooling, humidification and removal system down, as well as emergency cooling and air exchange systems. Thus, a high-performance centrifugal fan and an open heat exchanger are installed on the rear panel of the case - a combined device that performs the functions of a water cooler and an air humidifier, as well as a device for settling and removing fluff outside the compartment.

The open heat exchanger is made in the form of vertical sheets of galvanized iron, to which, at the commands of the temperature controller, water is supplied from the water supply system of the hatchery in case the air temperature rises above the value set for regulation. The heated air, moving along the humidified sheets of the heat exchanger, comes into contact with the open surface of the water, which is in motion. At the same time, it cools and moisturizes. The fluff particles contained in the air settle on a damp surface and are taken out of the incubator to a special fluff collector filter.

The parameter of relative air humidity is maintained spontaneously at the required level due to automatic temperature control. The incubator is heated by two closed tubular heating elements with a total power of 2 kW. They are installed behind the fan in the plane of the open heat exchanger.
Air exchange is carried out through the supply (back panel) and exhaust (top panel) openings, equipped with automated dampers and a mechanism that allows you to control their preliminary opening.

Automatic stabilization of the air temperature in the compartment is carried out by an electronic unit, two heaters and a water-cooled solenoid valve. When the air temperature is lower than the set one, the heaters work, and at the temperature higher than the set one by 0.1-0.3°C, the water cooling is turned off. The temperature is averaged over the entire volume of the compartment by air recirculation carried out by a fan with a motor. The accuracy of automatic maintenance of the set temperature in the area of the sensors installation is not more than ± 0.2°C.

The tray installation consists of four platforms. Each of them has four wheels, two of which are full-turn. Remnants of shells accumulate on the plane of the platform, which fall through the mesh bottom of the tray during hatching.

The incubators are equipped with an authorized monitoring and control system, which provides round-the-clock control of the current and set values of temperature and humidity on the monitor: fixing deviations, voice notification in case of deviation from the set mode indicating the compartment number, viewing and displaying values per day, during the incubation period, by batches from the archive.

Incubators of the Belgian company "Petersime" BioStreamer 165HD work on the patented technology of feedback from the embryo. Sensors installed inside the machine allow you to control the air temperature inside the cabinet by monitoring the egg shell temperature, humidity by monitoring and predicting the shrinkage of each batch of eggs and the technology of narrowing the hatch window.

The incubators are controlled by a controller and are connected to a common computer network. The software lets remotely control the incubators, as well as analyze their condition, monitor the conditions of egg storage and handling of chickens.

Eggs are laid in incubation trays with a cellular structure, in contrast to traditional matrix ones. The cellular structure of the tray allows you to set 12% more eggs using the same area while maintaining optimal air flow between the eggs. In addition, according to the cellular structure of the trays, the transport of eggs is more compact. A 12% increase in incubation eggs while maintaining the same area means additional cooling and heating requirements.

The pulsators are equipped with five wide blades to ensure the required air flow rate between the eggs. In addition, improved roof vents provide additional ventilation.

The power of the heating elements has been increased, which ensures a quick warm-up time for all eggs at the beginning of the incubation cycle.

The larger diameter of the cooling coil creates a wider overall cooling surface. This allows the setter to handle the 12% increase in heat production with ease.

Controlling the humidity level in the incubator allows you to adjust the amount of water (and weight) loss. At all stages of incubation, the eggs are constantly weighed and the humidity level is adjusted in accordance with the needs of the embryos.

During incubation, the loss of egg mass occurs due to the evaporation of water, which is especially pronounced in the second half of the development of embryos [3]. The decrease in egg weight and the dynamics of water evaporation by incubation periods reflect the intensity of metabolism and characterize the development of the embryo [4]. The more intensive the development of the embryo, the more water evaporates from the egg after the allantois covers the entire contents of the egg.

At the beginning of incubation, high humidity increases the heating of the eggs, and at the end - heat transfer. At low humidity, the eggs lose a lot of water, their heating worsens, the embryos lag behind in growth, and mortality increases [5]. The premature hatching of chickens is difficult, since the shell membranes are dry and strong, therefore, the death of embryos increases at the end of incubation. The hatched young are small, mobile, dry, poorly fluffed down [6].

The main reference point for the regulation of humidity in the incubator should be the indicators of egg weight loss, which depend on the relative humidity, temperature conditions and ventilation inside the machine. For the entire incubation period, the decrease in the weight of eggs should be 12-13%. Deviations from this value are caused by imbalances in temperature and humidity.
In the course of the research, it was found that when setting for incubation, the weight of eggs in both groups did not have statistically significant differences. During subsequent observations (control examinations), the eggs of the first group had a greater mass in comparison with the second by 1-2 g (1.6-5.3%). Analysis of the total loss of egg weight by the end of incubation showed that in the first group it was more by 3.7%.

The study of the distribution of incubation wastes over the periods of control viewing indicates the death of the largest number of embryos during the first week of incubation - 7.2-7.3%. The success of incubation during this period depends primarily on the technology for the production of hatching eggs and their quality. Inadequate eggs lead to the formation of weak embryos, which die at the beginning of development after the formation of their circulatory system [7]. The number of embryos that died during this period in groups was at the same level.

The next stage of incubation is the formation of the system of organs of the embryo and its rapid growth [8]. During this period, the eggs of the second group had an advantage - the amount of waste was 1.1% less.

The focus should be on the category of embryos that died in the last week of incubation [9]. The embryo flips towards the air compartment and begins breathing with the lungs, which leads to a change in blood circulation and retraction of the yolk sac. During this period, the waste is determined primarily by the incubation parameters: temperature, relative humidity and air exchange [10]. When incubating the eggs of the experimental batches, an increased mortality was noted in the last week of incubation in the first group - 4.9%, which is 0.7% more than in the second.

The hatching of young brood in the BioStreamer incubator was more synchronous - it started 4 hours later than in IPV-F-15 and ended 1.5 hours earlier, which led to a narrower hatching period. This is a favorable phenomenon, since a prolonged hatching negatively affects the results of incubation - part of the young do not have time to leave the egg and will be attributed to incubation waste, and the other part, which appeared before everyone else, may die.

After the end of incubation, the quality of the young was assessed. The number of substandard chickens in the first group exceeded the second by 0.9%. In addition, in the first group, a greater number of poorly developed chickens were noted.

The results of rearing the hatched young animals showed the advantage of the second group. Higher viability resulted in a 3.6% increase in poultry safety, mainly due to the initial feeding period. At 42 days of age, the average live weight of chickens in the second group was 2314 g, which is 2.7% more than in the first.

4. Conclusion
At the end of the study of the effectiveness of incubating chicken eggs in two types of incubation machines, it can be concluded that the best results of incubation and subsequent rearing of broiler chickens can be obtained using the BioStreamer incubator.

The BioStreamer is featuring a more flexible system for regulating the incubation environment, made it possible to increase the hatchability of eggs, to carry out the simultaneous hatching of young brood, to improve its quality, and later allowed to get more meat products from broilers.

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References
[1] Ivanova I P, Trotsenko I V and Trotsenko V V 2019 IOP Conf. Ser.: Mater. Sci. Eng. 582 011001
[2] Chaunina E and Korsheva I 2020 Handbook of Research on Globalized Agricultural Trade and New Challenges for Food Security (Hershey: IGI Global) pp 242-251
[3] Syed Fasi Uddin, Sudha Arvind 2016 International Journal of Innovative Technology and Research 4(4) 3325-3330
[4] Brannan K E, Livingston K A, Jansen van Rensburg C 2021 Journal of Applied Poultry Research

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[5] Uyanga V A, Onagbesan O M, Oke O E, Abiona J A, Egbeyale L T 2020 Journal of Applied Poultry Research 29(3) 535-544
[6] Kapen P T, Mohamadou Y, Momo F, Jauspin D K, Anero G 2019 Health Technol. 9(1) 57-63
[7] Attila Salamon 2020 International Journal of Poultry Science 19 51-65
[8] Al-Zghoul M B, Sukker H, Ababneh M M 2019 Poult. Sci. 98 991-1001
[9] Hamidu J A, Torres C A, Johnson-Dahl M L, Korver D R 2018 Poult. Sci. 97 2934-2946
[10] Zaboli G, Rahimi S, Shariatmadari F, Torshizi M A K, Baghbanzadeh A, Mehri M 2017 Poult. Sci. 96 478-485