The application of embryo-response incubation

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Incubating eggs on an industrial scale is a process that requires four basic principles: keeping the eggs at the adequate temperature, providing sufficient ventilation, creating the appropriate humidity in the environment and periodically turning the eggs. In this article, temperature, ventilation, and humidity will be discussed in detail for both setter and hatcher.

Incubation on a large scale used to be mainly based on experience. The outcome of a hatch largely depended on the experience and craftsmanship of the hatchery manager.

Improvements in the process were achieved on a trial-and-error basis. Some hatchery managers would change the heating, cooling and ventilation settings very precisely based on their experience, resulting in good hatchability.

Many others however, had no real understanding why and to what extent they had to change all these actuators in order to optimise the hatchability.

Moreover, manually adjusting the settings of each incubator as a function of process time, flock age, fertility, etc is a very time consuming process.

In a small hatchery this might be still feasible, but as today's hatcheries keep on growing in capacity, optimising the settings of every incubator manually every day has almost become impossible.

Therefore, hatchery managers tend to automate the adjusting of the incubator settings. This is achieved by creating feedback from the embryos to the incubator. In this way, the incubator can 'listen' to the embryo and let the embryo decide what the settings of the incubator should be: whether it needs cooling, heating or ventilation. This working method is called embryo-response incubation. It is applied in both the setter and the hatcher.

Dynamic Weight Loss System installed in a trolley.

Setter

Temperature

The first requirement of the developing embryo is that is incubated at the right temperature. A deviation from the adequate temperature results in a drop in hatchability, changing hatch timings, etc.

It is known from literature and practice that the ideal temperature for the embryo is about 100.0°F (37.8°C) throughout the incubation process.

As it is impossible to measure the temperature of the embryo non-invasively, a good alternative is to measure the temperature of the egg shell.

In conventional incubators however, the only temperature measurement that is made is the air temperature at one specific point in the incubator. This is not the same, however, as the temperature of the shell of the eggs in the incubator.

For instance during the first days of incubation, in order to achieve an egg shell temperature of 100.0°F, the air temperature might be 100.5°F. This is because in the first part of incubation, eggs need to be heated by the air by means of convection.

Halfway during the incubation, the air temperature of the same incubator might need to be 100.0°F for the temperature of the egg shells to remain at 100.0°F. At this stage, the embryos start to produce heat themselves and thus require less heat to be added.

In the last part of incubation, in order to keep the egg shell temperature at 100.0°F, the air temperature of the machine should be reduced to 98.5°F for a young flock. At this stage, the embryos produce a lot of heat that needs to be dissipated by the cooling effect of the air.

In case of an older flock, the air temperature even needs to be brought to 97.5°F, as eggs from an older flock produce more heat.

We can conclude that there is no clear relationship between the air temperature of the incubator and the egg shell temperature as this depends on various factors such as the process time and the flock age.

In practice, this means that the hatchery manager needs to check the egg shell temperature on a regular basis and adjust the heating and cooling settings of his machine accordingly, for every flock that he wants to incubate. Checking the egg shell temperature can be done manually, but is very time consuming in large hatcheries. For instance, in a hatchery of 40 incubators, a hatchery manager wants to measure the egg shell temperature twice per day on every machine.

In order to get reliable results, he measures the egg shell temperature of 12 eggs per machine, writes down the results, calculates the average egg shell temperature and adjusts the incubator settings when necessary. If this took 10 minutes per machine, he would need 40 x 10 x 2 = 800 minutes or almost 13 hours per day!

Therefore, a device was developed based on infrared technology to measure egg shell temperature in an incubator online: OvoScan.

Per incubator, three of these devices each measure the temperature of the shell of four eggs every 10 seconds.

OvoScan thus automates the time consuming process of measuring egg shell temperatures, which eliminates the risk of human error and the need to open the incubator doors every time the egg shell temperature needs to be measured.

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OvoScan installed on a setter tray.

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In practice, if the egg shell temperature measured by OvoScan is too high, feedback will be sent to the incubator controller so that its air temperature is decreased. Similarly, if the egg shell temperature becomes too low, the air temperature of the incubator will be increased. In this way, OvoScan 'listens' to the needs of the embryo, and it is the embryo that decides how much heating or cooling it wants.

● CO_2

The second requirement for the embryo to develop is a correct supply of oxygen (O_2) and an adequate balance between O_2 and CO_2. It goes without saying that sufficient O_2 should be available for the embryos to breathe. As an incubator is a more or less closed environment, sufficient ventilation should be provided.

The level of O_2 and CO_2 go hand in hand: in a closed incubator, the level of O_2 will decrease and CO_2 will increase as the embryos breathe. Ventilating the air inside the incubator results in an increase in O_2 and a decrease in CO_2 as fresh air is brought in. Both the O_2 and the CO_2 level will influence embryonic development.

CO_2 sensor in the setter.

In the past, the ventilation of an incubator was adjusted based on experience. There was no precise measurement of the amount of fresh air brought in and the hatchery manager had no idea of the level of O_2 and CO_2 in the incubator at different stages of the process.

In order to increase hatchability, it was necessary to start measuring those values. Measuring oxygen is rather expensive, whereas the CO_2 sensors that are on the market are quite accurate and available at an acceptable price. Since the O_2 and CO_2 level are related to each other, it is sufficient to measure CO_2 levels only.

By means of CO_2 measurement, the hatchery manager has more control over the incubation process since he can optimise the ventilation of the machine. Scientific research has shown that during the first half of incubation, embryos benefit from higher CO_2 levels, as they lead to improved development of their cardiovascular system.

Synchro-Hatch installed on hatcher baskets.

To establish these higher CO_2 levels, ventilation is reduced to a minimum, which requires a hermetically sealed incubator.

During the second half of incubation, lower CO_2 levels (and thus higher O_2 levels) are required to allow optimal embryonic development. In this phase, the embryos produce more CO_2 and, as a consequence, more ventilation is needed.

This illustrates again the principle of embryo-response incubation. As the embryo breathes, the O_2 and CO_2 levels in the incubator change. By measuring the CO_2 level, feedback is given to the incubator and the ventilation is adjusted accordingly. Again, the embryo decides how much ventilation it wants.

● Humidity

Thirdly, incubating eggs should be able to lose sufficient weight (water). The amount of water loss depends on the humidity of the air surrounding the eggs. In the past, this relied once again on the experience of the hatchery manager.

He would adjust the ventilation of the incubator to reach an adequate weight loss, or maybe even increase the humidity by spraying water into the machine.

In order to understand what the embryo really needs, we first need to analyse the process of weight loss. An egg loses weight because water evaporates from the pores in the egg shell.

As the relative humidity inside the egg is 100%, the egg loses more water if the humidity in the environment is low. If for instance the incubator has a relative humidity of 35%, the egg loses more water than if the relative humidity in the incubator were 80%.

Now what does the embryo need in terms of weight loss? If the weight loss is too high, the embryo will dry out. If it is too low, it becomes more difficult for the embryo to hatch because the air cell is too small and it even risks drowning. For a chicken egg, the ideal weight loss after 18 days of incubation is 11-12%.

In order to measure the weight loss of the egg, a specific weighing device has been developed: Dynamic Weight Loss System, a weighing scale installed in an incubator that monitors the weight loss of one tray of 150 eggs by weighing it every hour.

By comparing the actual weight to the initial weight, the weight loss can be determined and the % of weight loss at 18 days of incubation can be predicted. Again, the hatchery manager can 'listen' to the embryo.

If the forecast for the weight loss at day 18 is too high, the relative humidity will be increased by reducing the ventilation (or spraying water in extreme cases).

If the predicted weight loss at day 18 is too low, the relative humidity will be reduced by increasing the ventilation.

The ventilation requirements for CO_2 and for humidity will interact. Closing the incubator in the first part of the incubation process to reach high CO_2 levels, results in high humidity, whereas ventilating more in the second half of the incubation process reduces CO_2 levels and humidity. Extensive trials have shown that this results in higher hatchability, reduced first week mortality and improved feed conversion ratios.

The Petersime Air Mixing Centre creates homogeneous distribution.

Hatcher

During the last days of incubation, when the eggs are placed in the hatcher, the same principles are valid. The main challenge in the hatcher is to achieve a synchronised hatch. Reducing the hatch window (period of time which a determined majority of chicks have hatched) results in improved chick uniformity and reduces the time that early hatchlings remain without water or food.

In order to reduce the hatch window, a specific device called Synchro-Hatch has been developed. It detects the moment that the embryos move into the stage of internal pipping and start using their lungs. Based on this trigger, the hatcher then starts to modify parameters such as temperature and CO_2 to achieve a more synchronised hatching process.

Once more, Synchro-Hatch is a tool for hatchery managers to listen to the embryos. As soon as the embryo is ready (internal pipping), the hatching process is initiated.

The embryo decided when the temperature and CO_2 level in the hatcher should start to change, just like in nature the embryo would start making calls so the mother hen knows when she can start initiating the hatching.

In conclusion, by applying embryo-response incubation, the hatchery manager can listen to the embryo. Incubator settings like heating, cooling, and ventilation can be optimised with devices such as OvoScan, Dynamic Weight Loss System or Synchro-Hatch, allowing the embryo to decide which temperature, CO_2 or humidity levels it needs, or to give the signal when it is ready to hatch.

Applying these principles results in higher hatchability, reduced first week mortality and improved feed conversion ratios. ■