Optimal management of incubation

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Managing incubation is often accepted as managing incubators. The display of the incubator shows the temperature, the relative humidity and CO_2 level at the location of the sensors. It does not show the microclimate around each egg and the exact temperature of the individual embryo.

During incubation temperature is a very crucial climatic condition.

Air temperature is not simply equal to embryo temperature and the difference between air temperature and embryo temperature can vary between different spots in one incubator.

The embryo temperature is a result of the heat production of the embryo, the ability of the air to transfer heat and the airflow over the egg. The factors that influence the transfer of heat are air temperature, humidity and air velocity.

Embryo temperature is the leading factor during the complete incubation process, to reach optimal hatchability and chick quality. Humidity, air velocity, cooling, inlet and outlet of air are the factors that can be used inside the incubator to regulate the right embryo temperature and the uniformity of temperature in the egg mass. These factors should be adapted to the requirements of the embryos, instead of vice versa.

Measuring embryo temperatures is the best method, but it is a destructive method. The use of eggshell temperatures as a reflection of embryo temperatures can solve this problem. Lourens et al., (2005) suggested that the eggshell temperature to achieve optimal hatchability and chick quality is 100°F. By measuring the eggshell temperatures it is important to realise that the real embryo temperatures are often higher than the eggshell temperatures. This difference can be as high as 2°F.

Each batch of eggs is unique and may require a specific incubation program.

Gas sealed incubators ensures highest incubation performance.

At the moment an egg is laid, the conductance of the eggshell and the weight of the egg is set. The conductance of the eggshell and weight of the egg changes with increasing age of the broiler breeders and can be different between strains. In every incubation process, eggs with different characteristics are used. Therefore, every incubation process may need different incubation requirements and management. Incubation management is also influenced by heat production of the embryo, season of the year and multi or single stage incubation.

Heat production

Nowadays, more fast growing and high yielding birds are used. The modern breeds grow both prenatal and postnatal a lot faster and produce much more heat than the traditional types. The incubators that are used nowadays have to be designed to deal with the higher heat production of the embryos.

The embryo uses the nutrients inside the egg for development and growth, and this process is controlled by temperature.

The energy that is needed to form the body tissues is mainly produced by burning the fat in the yolk. For burning this yolk fat, enough oxygen is needed and carbon dioxide, metabolic water and metabolic heat are produced as waste products.

During the incubation process, circumstances have to be created to allow the process of oxygen uptake and removal of the waste products and keep the embryo at the desired temperature level. Deviations from the optimum temperature may influence the metabolism of nutrients and therefore negatively influence the development, growth and maturation of the embryo.

In the first part of the incubation process, embryo tissues develop and heat must be transported from the air to the egg.

Humidity and air velocity play a major role to transfer heat in this part of the incubation process.

From approximately nine days the metabolic heat production of the embryo results

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in a significant increase of embryo temperature above air temperature. From this moment, the incubators have to start cooling when single stage setting is used. In this stage, air velocity plays an important role to transport heat. At high air velocity, more heat can be removed from the eggshell. At low air velocity, less heat can be removed from the eggshell and the embryo temperatures will rise.

The problem increases with increasing egg weights or thicker eggshells. When eggs are larger, the metabolic heat production is higher, but the surface to volume ratio is smaller and heat transfer is limited. It also occurs that some eggs are large enough to block the total air flow over the eggs.

Humidity is also a good transfer of heat, but using humidity as a transfer of heat during the last part of the incubation process is complex. If the humidity has to be high at the end of incubation, the nozzle is needed to keep the humidity high in the incubator.

The amount of water that is used for maintaining the required relative humidity has an impact on embryo temperature. The evaporation of water in an incubator takes considerable amounts of energy.

This energy is often produced by the eggs that are in the area of the nozzle in the incubator, these eggs will suffer from a relative high heat loss and therefore low embryo temperatures. Low embryo temperatures due to the spraying nozzle must be prevented as much as possible, that is why air velocity is a better heat transfer in the last part of the incubation process.

The embryo temperature at the end of the incubation process has a large influence on hatchability and chick quality. To achieve optimal hatchability and chick quality enough moisture loss from the egg is needed. Eggs should lose between 10-15% of weight during the incubation process. Heat transfer capacity of air is different between seasons. In Europe the low heat capacity time is during winter. In winter the relative humidity of the air is lower than in summer. Low air humidity problems are not easily solved.

Frequency regulated for variable air speed. This gives optimal temperature control and reduces energy costs.

Separate temperature sensing and control in each section of an incubator.

Artificial humidified air has not the same quality as naturally humidified air. If the problem is solved by using the water sprayer in the incubator, the air is cooled and the incubator starts to heat or decreases the airflow.

Steam humidification can be used instead of a water sprayer. A steam humidifier provides water droplets of 0.0006 microns instead of 2-100 microns of conventional humidifiers. Steam improves the heat transfer capacity of the air without cooling the room. The disadvantage is that steam humidification is expensive.

In Europe, the high heat capacity time is during summer. The conditions during summer are optimal for the start of incubation, because the heat transfer capacity of the air is high. However, at the end of the incubation process the chance of overheating the embryos is higher. The cooling capacity of the incubator is very important in these circumstances.

Multistage incubation

In multistage incubators eggs of different developmental stages are in one incubator at the same time. According to heat production there are two key stages in multistage incubation: chicken embryos that do not produce heat until approximately nine days of age and embryos that do produce heat.

The embryo temperature of the embryos younger than nine days is less than the air temperature and the embryo temperature of the embryos older than nine days is above air temperature. The set points of the incubator must be the best compromise between the embryos that need heat early in incubation and those who need heat removal later in incubation. It is not possible to create optimal conditions for all the embryos of different ages at the same time with multistage incubation.

Single stage incubation

Single stage incubation is necessary to provide the optimum environment at every stage of incubation. With single stage systems, the incubator can be sealed completely to trap the moisture escaping from the eggs, thereby increasing the heat transfer capacity of the air without the negative impact of the spray nozzle.

With the increased heat transfer capacity of the air and the higher air temperature, the eggs reach the correct incubation temperature earlier than in the multistage system. In single stage incubation the embryos begin to grow more efficiently at an earlier age than in multistage incubation. In multistage the embryos do not reach 100°F until they begin to produce sufficient heat at around nine days of age.

The high relative humidity environment in the first week of incubation means that more attention must be paid to achieve moisture loss later in incubation. In single stage incubation, optimum hatch and chick quality is obtained with approximately 10-11.5% moisture loss. At the end of incubation the eggs have to lose most of the weight. The relative humidity can not be too high and that is why the incubator must have the capability to adequately cool in a low heat transfer environment (low humidity).

To hatch chicks with a potential for optimal performance, the incubation environment must provide uniform embryo temperature control (by adequate and uniform cooling capacity), moisture loss control and a controlled gas environment (relative humidity and carbon dioxide) that can vary with the stage of incubation.

To provide a uniform environment within the egg mass, the air flow through the eggs must be uniform. For an optimal management of incubation, single stage incubation fits to the requirements of the embryo during development, growth and maturation. ■