Over the years, there have been many innovations that claim to improve hatchability and chick quality. Examples include - monitoring the egg shell temperature from a small sample of eggs in one location and then using this information to control and steer the incubation process for the entire egg pack or the use of load cells to monitor weight loss from one or more trays of eggs then extrapolated to control the entire incubator. It would be also fair to say that the innovation of laminar air flow improved performance through more even, positive, air distribution but at the expense of complexity, energy efficiency and bio security. All these innovations improved the ability to control the environment for developing chicks over, what can be achieved by merely measuring air temperature at a single point.

There is no doubt that all these innovations have had limited success but they do not address the fundamental issue of how to ensure a homogenous environment for every single egg, regardless of where it is positioned within the incubator. Only when this is achieved can you really start to significantly reduce the width of the hatch window so that all the chicks receive the same environmental conditions.

We at EmTech were in the enviable position of being able to rethink incubator design, literally from the ground up. The basic concept of one trolley each side of the paddle fan and individually controlled trolley turning were sound principles, based on industry experience. But no one recently had addressed the fundamental design and construction of the incubator cabinet itself. It was soon realised that by improving the seal between the individual panels and removing the aluminium supports our aim of achieving a temperature differential of 0.6° throughout the entire egg pack could easily be achieved.

The fundamentals of incubation

EmTech understands the incubation process inside and out. With over 25 years of 'hands-on' experience working with Buckeye and Chick Master, Ken Baker and Mike Osmond founded EmTech Hatchery Systems and soon recruited key personnel with similar backgrounds in the incubation industry.

It is easy these days to become mesmerised by the vastness and complexity of the technology that has crept into every aspect of our lives. For example - smart phones do just about everything but are they any better at making phone calls? Many may remember the Nokia 6310i, it was a great phone, it had proper keys and the battery would last a whole week. With today's smart phones you would be lucky if they lasted a day and the simple ability to make a simple phone call has not really improved.

This can relate to the development of incubation systems. With our many years within this industry we have gained a wealth of experience having been involved in countless development projects, searching for ground-breaking solutions, some successful, others less so. But at the end of the day sometimes the answers were right in front of our noses but were never fully understood, fine-tuned or exploited - until now.

Ken and Mike, with a blank canvas, have taken well proven concepts, refined them and with the aid of modern technology have made significant improvements to system performance but always mindful not to compromise on ease of operation and bio-security features.

Single stage is now widely accepted as the most efficient and bio-secure process of incubation for a modern-day hatchery. With the process of 'all-in and all-out', we are better able to provide the optimum conditions for the developing embryos, within a much tighter temperature bandwidth along with the ability to clean the equipment between cycles.

Some might say that the process of incubation is very sophisticated involving vast amounts of complex science. This is undoubtedly true, EmTech knows the basics of how an embryo develops but doesn't pretend to be an expert in the exact science of the biological process. We leave this to the embryologists who have specialist expertise and understanding of this subject. What we do know however, is how to design an incubator that can provide the optimum conditions to maximise the performance and ultimately highest possible number of chicks hatched from the fertile eggs set.

The process is relatively simple but to maximise performance the design of the incubator is crucial.

Let's review the basic principles:

The incubation process

- Provide an incubation environment with a weighted time average of 37.5°C and to achieve on average 10.6% to 11% weight loss, over a 504-hour period. Transferring from the setter at, typically, 18.5 days
- Turn the eggs at regular intervals. (This is especially critical is the first 7 days)
- Maximise the concentration of co2% within the first few days, controlling the peak to 1.2% within the first 7 days and then gradually reducing back the co2 to no higher than 0.45% at transfer
- Monitor and control weight loss as necessary with a control weighted time average of 58% to achieve the 11% weight loss
- Throughout the entire incubation process, maintain the egg shell temperature, between 37.8°C and 38.3°C

In the analysis of the above, considering the importance of turning, weight loss and oxygen requirements, the rate of how the embryos develop is a function of temperature. Hence the old adage 'Temperature is King' as it will significantly affect the hatchability and quality of the hatch.

Given a constant air supply, embryo, egg shell and the surrounding air temperatures are all relative to the air moisture content and velocity across the egg mass.

During the closed-up stage of incubation, the air is very high in moisture content and this aids heat transfer. With the opening of the damper and the introduction of fresh air, the moisture content reduces while at the same time the heat load from the developing embryos is increasing, so at that time we become increasingly reliant on the air velocity across the egg mass.

Now, as mentioned earlier, some systems use a small sample of eggs to both control temperature and weight loss. But we are not just talking about a few eggs, are we? No - larger capacity setters can hold up to 133,824 eggs so, would it not be better to consider the entire egg mass when controlling temperature and weight loss?

Forget all the gimmicks, measuring weight loss on a tiny sample of egg trays is not going to be representational. We want to know the conditions of the entire egg mass.

Temperature Bandwidth

The temperature bandwidth is a term that we use to denote the maximum temperature variation across the total egg mass within an incubator. This does not include the temperatures around the egg mass or areas covered by an air conditioning unit, such as a paddle fan or an overhead fan.

Temperature bandwidth is a direct measurement in respect to the temperature uniformity within the entire egg mass. With our new innovations our incubators can achieve a very tight temperature bandwidth and we are now able to use the air temperature within the setter environment to control the entire egg mass!

Many incubator systems have a very poor temperature bandwidth, 1.5°C to 2.5°C is typical and often worse for a multistage process.

The temperature bandwidth within a setter has a direct relationship to the duration of the hatch window, hatchability and quality of the chicks. A wide temperature bandwidth will inevitably results in a poor hatch. Low egg pack temperatures will result in a draggy hatch, while high temperatures will stress the embryos, accelerate development and hatch early. This leads to a dragged out, prolonged, hatch window. Conversely, a very tight temperature bandwidth will provide a short hatch window that optimises hatchability, chick quality and on-farm performance.

So, what are the main factors that affect the temperature bandwidth within a setter?

- **The stage of Incubation**

  With any setter design, the temperature bandwidth will be tighter in the early stages of incubation than at the end of incubation. This is because in the early stages of incubation, after the initial heating stage, the egg mass will be neutral, that is say, not requiring or producing very much heat.

- **The Incubator Cabinet Design**

  The thermal characteristics in the construction of the cabinet is very important. Surprisingly, this factor is not very well observed with most incubator suppliers. Many designs, incorporate steel or aluminium frames that destroy the thermal insulation properties of the cabinet. To create the best possible temperature bandwidth the incubator needs to be a totally insulated box. Aluminium frames act as thermal bridges that result in heat loss/gain, causing pockets of chilled air, which is often made worse through condensation especially

when cabinets are built against a cold external wall, or two adjacent setters are running at opposing stages of incubation cycle.

- **The Ability to Properly Seal the Setter Cabinet**

  A sealed cabinet is very important to take advantage of the high air moisture content and the associated inherent thermal transfer benefits. This in conjunction with the early concentration of CO_2 and the promotion of embryonic development.

- **Air Flow**

  Air flow will become increasingly more important as the process develops and will be vital prior to transfer. Air flow is also a fundamental element in how the incubator is designed and constructed.

- **Air Moisture Content**

  There is a direct relationship to the stage of incubation and how well the cabinet seals. In the 'closed-up' stage of incubation, a well-sealed cabinet will promote high levels of moisture as the eggs transpire. The amount of moisture within the air also dictates the efficiency of heat transfer and by direct association temperature bandwidth.

- **Changing Air Flow Conditions**

  While we might believe that a consistent air flow condition is a good thing in reality it is not. By making constant changes, forward fan, reverse fan, varying the speed for example, this helps to promote a more even heat transfer. In essence by breaking the regular air flow pattern air gets to all the areas that wouldn't otherwise be reached and, in turn, helps to reduce the temperature bandwidth.

- **Turning Angles**

  Along with the essential requirement to turn the eggs for the correct embryonic development, good turning angles will also promote a better air flow.

- **Trolley Orientation**

  When you take into account all of the features that contribute to the efficiency of heat transfer and air velocity trolley, orientation is a major contributing factor. Relying on air flow to pass through two or more trolleys from the fan will significantly reduce air velocities. Also trolleys that turn directly against the air flow will hamper the flow of air throughout the egg pack.

What is the >EmTech Effect< 0.6˚C ?

Taking all the above factors into consideration the >EmTech Effect< produces a temperature bandwidth of no greater than 0.6˚C throughout the entire egg mass within the setter. How? Please read the following summary:

- **Cabinet Construction**

  The EmTech cabinet design does not utilize an aluminium framework - there are no thermal bridges. The cabinet uses interlocking panels, negating the need for the metal framework. This eliminates thermal losses, cold air pockets and condensation. The 51mm wide EmTech panels are more thermally efficient and have a PIR fire rated core. PIR also provides 30% better thermal insulation than the commonly used high-density polystyrene panel.

- **A Cabinet That Seals Very Well**

  The EmTech setter has high quality air inlet and exhaust dampers along with an improved door seal design. This promotes good levels of moisture and early percentage concentration of CO_2.

- **Air Flow**

  The fan cabinet, trolley orientation is based on a proven bi-directional paddle fan concept with only one trolley deep and end-on orientation. In this configuration, trays do not turn against the airflow. The six- bladed paddle fan has a unique tapered design which significantly improves the 'air-off' pressure and subsequently air velocities through the egg mass.

- **Sectional Control and Trolley Orientation**

  EmTech setters are sectional controlled with a maximum of 6 trolleys per section. Each individual section has its own heating and cooling system able to very accurately control the temperature for up to a maximum of 33,456 eggs (if using the 82 egg tray). Our largest single stage PrimoTech setter has 4 sections.

- **The Brilliance and Intelligence of the Eclipse Control**

  With the well-sealed cabinet, offering superior thermal insulation properties, a unique paddle fan design and optimum trolley orientation we have created the foundation for the optimisation of heat transfer and temperature bandwidth within the egg pack. All achieved by good old fashioned engineering principals.

Now, if we couple our excellently engineered incubator design with the Eclipse controls and the latest in PLC technology (incorporating variable fan-speed and forward and reverse functionality) we now have the capability, not only to adjust the speed of the paddle fans, but to run them in forward or reverse direction, in accordance to heat and cooling loads and the stage of incubation.

The Eclipse also provides the capability for 20 stages of control and the flexibility to make changes to the system over the incubation period to transfer. With this fine control and the ability to regularly change the pattern of air flow, we now have all the tools to stimulate and promote heat transfer and the optimisation of the temperature bandwidth.

- **The Two Temperature Probe Control System**

  The EmTech PrimoTech setter has two temperature probes per section.

  Probe 1 is for primary temperature control and is positioned at the centre of the paddle fan hub to measure the return air from the egg mass.

  Probe 2, is positioned at the top of the paddle fan assembly and measures the temperature of the conditioned air that is thrown off the fan, in essence the air supply temperature to the egg mass.

  When the setter is freshly set with cold eggs, the machine will be heating for several hours. Until the setter has reached temperature the lower probe will be show significantly lower temperature values than the upper probe.

  When the machine reaches temperature, heating will cease except for sporadic activity to maintain temperature - this is an excellent indicator of a very well insulated cabinet.

  At this time and for several days the eggs are in a neutral state (neither endothermic or exothermic) and, consequently the temperature measurement of both probes will be similar.

  As the incubation process progresses, eggs will become increasingly exothermic as they give off more and more heat. As this time, probe 1 will be warmer than temperature probe 2, with probe 1 relative to the egg mass air return temperature. Probe 2, will be cooler due to the cooling activity and the air temperature from the paddle fan assembly.

- **Benefits of the Two Temperature Probe Control System**

  The two-probe system provides the eclipse controls with valuable information about the status of the egg mass and, most importantly, the necessary fan speed to effect optimum air velocity and heat transfer. This optimises energy efficiency with reduced fan speeds during the early stages of incubation when there is a high air moisture content.

  The two-probe system provides valuable information to the Eclipse, and the status of the cooling and heating systems. The system will be able to immediately identify, for example, a problem with a heater circuit, as any heating activity will cause a rise in temperature at the upper probe 2 which is measuring the air-off temperature from the fan. Conversely, during cooling activity the opposite will be true and when a cooler temperature will be expected at the upper probe. The Eclipse control can then notify with an alarm for a heating or cooling system failure.

  Probe Failure backup – In the rare event of a probe sensor failure, the upper probe can serve as a backup control probe, until the failed sensor is replaced.

- **Trolley Turning Activity**

  The eclipse system, along with the Voyager system interface, offers the ability to adjust the turning interval throughout the incubation period. Early stages of incubation require frequent turning to promote embryo development.

  EmTech setter trolleys each have their own individual 24VDC IP rated actuator. This ensures that each trolley turns to the optimum 45 degrees. Unlike common mechanical systems employed in other competitor's equipment, there is no loss of angle due to mechanical linkages that can become even more inefficient over time due to wear and tear.

- **Paddle Fan Assembly - Full Frame Assembly**

  The EmTech paddle fan design features a full frame, from floor to ceiling. This fully supports the roof making a very strong rigid construction. As a result, vibration is minimal, the machines run much quieter and more efficiently. Most importantly, due to the elimination of vibration, there is no movement in any of the panels, or resonance effects that will in time cause a potential break down.

These are just some of the excellent features that can come together to produce the >EmTech Effect< for your hatchery.

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