NAME: **Javier Flores**

PARENTS' NAMES: **Juan and Norma Flores**

HOMETOWN: **Ligonier, Indiana**

CAREER OBJECTIVE**: I want to be a Performance Verification & Validation Engineer where I get to conduct tests of products still in development.**

BIOGRAPHY: **I was born and raised in Ligonier, Indiana. I graduated in December 2021 with a BS in Mechanical Engineering from Purdue University. Currently, I am in John Deere's Engineering Development program, where I work with their tractor division in a variety of different engineering roles. During my time at Purdue I was a member of the Purdue Minority Engineering Program and MAES – Latinos in Science and Engineering, and I also worked as a Resident Assistant in Hillenbrand Hall. Outside of work I enjoy playing all types of sports, hiking, and riding my motorcycle.**

FACULTY LSAMP SPONSOR: **Dr. Robert M. Stwalley III, Assistant Clinical Professor of Agricultural and Biological Engineering**

LSAMP GRADUATE STUDENT NAME: **Tyler C. Field**

GOAL OF THE WORK: **The goal of this research was to further the development of the artificial sow cooling pad. This was done by programming the temperature sensors to turn the cooling pad on when the ideal sow temperatures were too high. We also wanted to redesign the electronic hub to make the pad more cost efficient.**

PERSONAL STATEMENT ABOUT THE LESSONS LEARNED FROM THIS EXPERIENCE: **The biggest lesson I learned actually came from failure. The Artificial Sow Cooling Pad research project was actually my first real engineering project. After freshmen year, there were still a lot of skills that I just didn't know yet. Instead of reaching out to my project lead, I kept quiet and tried to figure out how to code on my own. Although I was able to make progress by myself, I ended-up not being able to complete my part of the work, due to running out of time. If I had just asked for help when I was stuck on a section of the code, I would have been able to complete the coding project on time. This failure really taught me the importance of communication and team work.**

Effect of floor cooling on sows under heat stress

By Javier Flores

Abstract

With temperatures increasing steadily throughout the last century, the hog farrowing industry is beginning to confront an ongoing dilemma. Temperatures are now exceeding ideal conditions for optimal milk production, as well as maximum litter size. Temperatures that exceed optimal conditions can lead to significant heat stress among sows. Efficiently cooling-down sows, while keeping piglets at ideal temperatures, is the focus of this project. A cooling pad was built with copper pipes inside a high-density polyethylene board, covered by an aluminum plate. Experimental treatments included cool water flowing through the copper pipes at different levels depending on the specific sow. Intervals were controlled using a thermal threshold. Data shows that sows on HIGH flow rates saw more significant decreases in respiration rates compared to those with LOW/MED flow rates. Due to the removal of heat, sows also ate up to three times more feed, ultimately benefiting the sow in milk production, as well as litter size. Developing and manufacturing an efficient cooling pad for sows can solve the issue of heat stress which can ultimately save and earn millions of dollars for the hog industry.

Keywords

animal welfare; cooling pad; heat transfer; swine production

Introduction

This paper details the author's experiences during a faculty-directed research program through a Louis Stokes Alliance for Minority Participation (LSAMP) project under the supervision of Drs. Allan Schinckel of Animal Sciences and Robert Stwalley of Agricultural & Biological Engineering in the Precision Livestock Instrumentation and Nano-Climate (PLINC) Lab to help provide preliminary flow rate testing results and improve the design of the Purdue hog cooling pad. Average temperatures have been increasing steadily for the last century. According to the NASA (2018), the year 2017 brought an end to the three-year streak of new record temperatures that were set from 2014 – 2016. In fact, 17 out of the 18 warmest years ever recorded have occurred since 2001 (NASA, 2018). These temperature increases have caused many complications in various industries. One that has taken a big hit is the hog industry. The overall US hog industry is valued at approximately $20 billion, with more than 115 million hogs marketed annually (NPPC, 2018). Increasing temperatures are now exceeding ideal conditions for optimal milk production during the summertime, as well as for maximum litter size, which is truly troublesome for farmers.

These increasing temperatures are causing an increase in heat stress among lactating sows. Heat stress in lactating sows is the situation where too much heat is retained inside a sow and cannot be effectively dissipated, which can lead to physical stress and illness, along with diminishing milk production and litter size. Unlike most animals, pigs have no functional sweat glands and relatively small lungs, thus causing them to be more prone to heat stress. Pigs with heat stress will see an increased respiration rate, as well as loss in appetite (DPIRD, 2018). Heat stress has an estimated annual cost of over $360 million to the U.S. pork industry (St-Pierre et al., 2003).

For an industry that strives for optimal milk production and litter size, this is an alarming problem. Efficiently cooling down overheating sows to ensure maximum growth and production of milk was the goal of this project. To try and solve this problem, the Purdue Sow Cooling Pad was designed and is being tested. This cooling mechanism’s process includes flowing cool water through a copper pipe at different rates depending on the specific sow, ultimately cooling her body.

Materials and Procedure

Ten lactating sows were housed in individual farrowing pens, where all sows were living under the same conditions. Each sow was provided with a cooling pad (Cabezon et el, 2017). Each cooling pad was composed of an aluminum diamond plate top, a high-density polyethylene base, and 8 coil coolant water copper tubing assembly. Each cooling pad also had an outlet valve to regulate the water flow and an inlet tee with a valve to draw inlet water samples. Figure 1 below is a drawing of the cooling pad design used in the current round of testing.

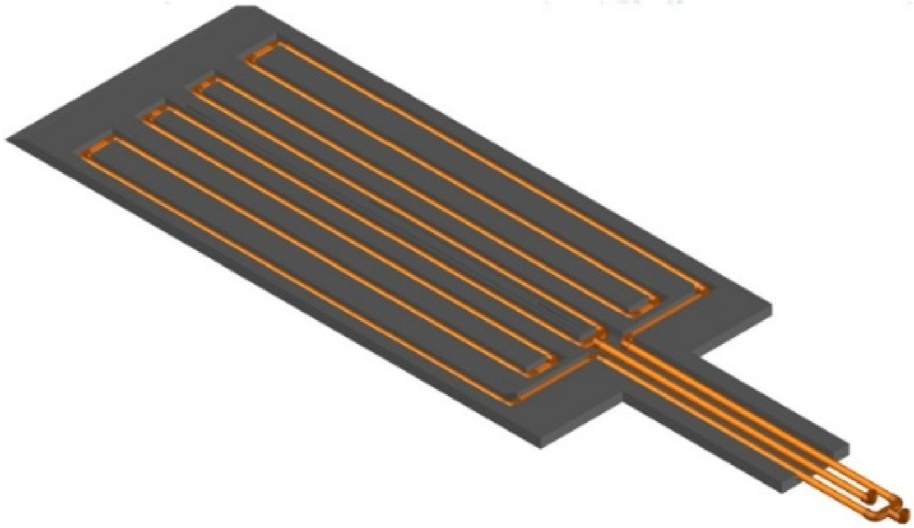

Figure 1 - Cooling pad base and cooling water pipes. The dimension of the cooling pad is 1.2 × 0.6 m.

This specific round of testing included cool water flowing through the copper pipe at different flow rates for specific sows. In order to operate the cooling pad and collect data, two programs had to be used. These programs were an Arduino operating system and Hog Buddy, a custom developed application. Arduino is an open-source electronics platform, based on publicly-available hardware and software. Arduino boards can read inputs and perform tasks as outputs. With the cooling pad, Arduino boards are critical for controlling the water flow into and out of the cooling pad. Intervals of water flow were controlled one of two ways, using time interval or thermal threshold. Hog buddy was an application that was created in order to be able to collect data via Bluetooth for pads operating with both thermal threshold and time interval coolant flow settings.

The thermal threshold setting for the controller consisted of using temperature probes to determine when to start and stop the flow of cold water. For lactating sows, optimal temperature for maximum milk production ranges is between 65-70^{o}F (Whitney, 2010). When the temperature probes detected skin temperatures that exceeded these conditions, cold water would then begin being pumped through the cooling pad. This process continued until skin temperatures were regulated to a comfortable temperature range for the lactating sow. Lastly, the warm water was then flushed-out, exchanged for cooler water. The time interval for the controller setting consisted of manually inputting specific time intervals for different cycle components, such as water flow duration and non-flow interval.

Experiment/Results

The base effectiveness experiment for the cooling pads was conducted from July 22nd to July 26th, 2016, at the swine farrowing facility at Purdue University Animal Sciences Research & Educational Center Farm. During the testing, the sows feed and barn temperature were held constant. The target barn ambient temperature for the duration of testing was 95°*F*. Testing consisted of ten multiparous sows housed in individual farrowing crates each with a cooling pad. Treatments were randomly allotted to sows to receive a constant cool water flow of 0.00 (CONTROL), 0.25 (LOW), 0.55 (MEDIUM) or 0.85 (HIGH) L/min for 100 min twice a day for four days (Cabezón et al., 2017).

During testing, respiration rates as well as vaginal temperatures were recorded in order to see if signs of acute heat stress in sows had decreased. Due to pigs having no functional sweat glands and relatively small lungs, respiration rates and vaginal temperatures are an acceptable way of measuring heat loss (DPIRD,2018). Results showed that respiration rates among the tested sows did decrease when under the cooling pad treatment. Figure 2 below shows the differences in respirations between all the flow rates (Cabezón et al., 2017).

As seen in Figure 2, all sows under treatment were seen to have lower respirations than the control group which received no cooling treatment. Further results, shown in Figure 3, showed that the vaginal temperatures among sows under treatment also decreased (Cabezón et al., 2017).

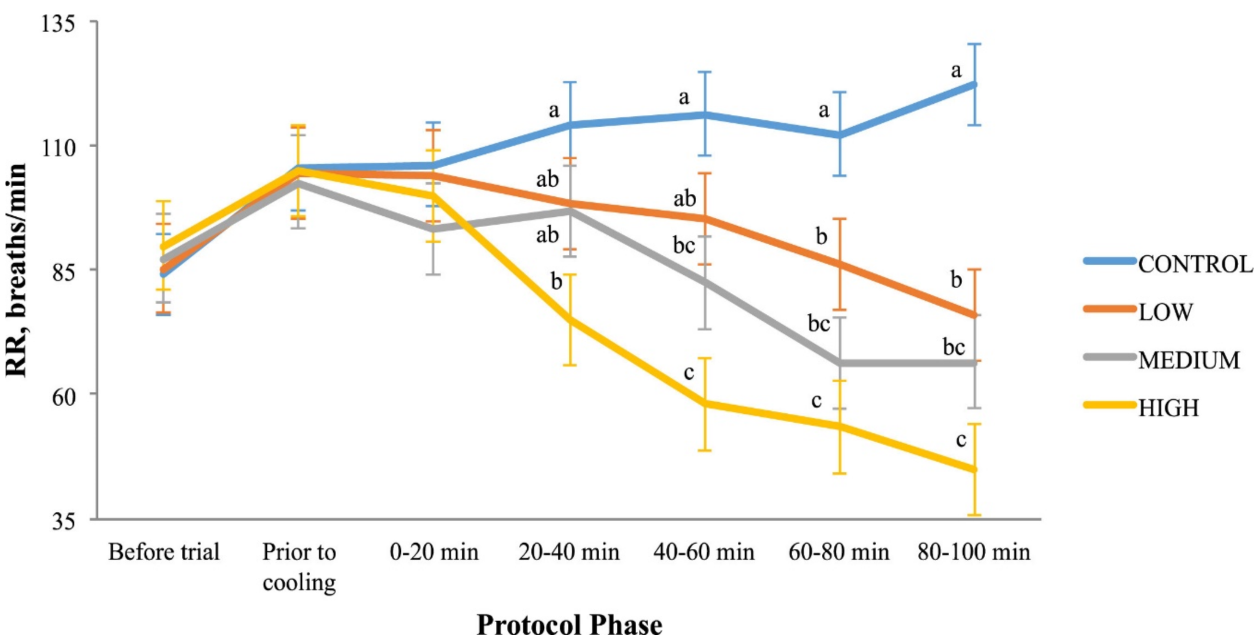

Figure 2 - Least square means and standard errors for respiration rates (RR) during the trial for sows on the CONTROL, LOW, MEDIUM, and HIGH flow rate treatments (Cabezón et al., 2017).

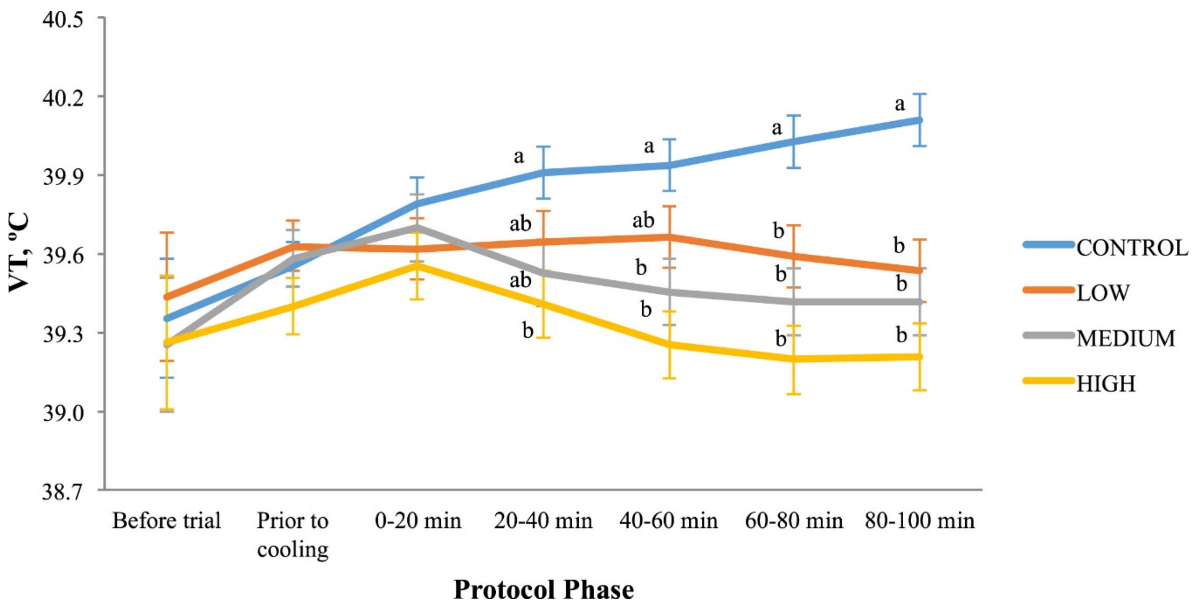

Figure 3 - Least square means and standard errors for Vaginal Temperature (VT) during the trial for sows on the CONTROL, LOW, MEDIUM, and HIGH flow rate treatments (Cabezón et al., 2017).

Conclusion

With a growing population, demand for hog products has never been higher. This is why heat stress is costing the US hog industry up to 360 million dollars annually (NPPC, 2018). Finding an efficient way to reduce heat stress in sows could save the industry millions of dollars and improve the animal welfare of the sows during gestation and lactation. As seen by the cooling pad results, the unit is very effective at cooling-down sows, while lowering their rate of respiration, one of the key indicators of heat stress in swine. This improved physiological condition ultimately leads to increased milk production, as well as an increased survival rate among piglets.

Future steps in the cooling pad development include redesigning and manufacturing an improved final prototype in order to run further tests. With regards to the redesign, manufacturing the final prototype as cost efficiently as possible has been one of the main priorities. As of now, the sow cooling pad is an open-flow coolant system, meaning a continuing input source of cold water is required for operation. Being able to design the pad with a closed system coolant loop is also top priority. A closed system would be able to reuse and re-cool water without needing an external source of cold water for coolant. The design and materials used in the present cooling pad model proved the ability to efficiently remove excess heat from sows while using low quantities of water, and the improved design should build upon these efforts.

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