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SUSTAINABLE SOLUTIONS FOR ANIMAL AGRICULTURE

Engineered housing designs for an enhanced environment for preweaned dairy calves

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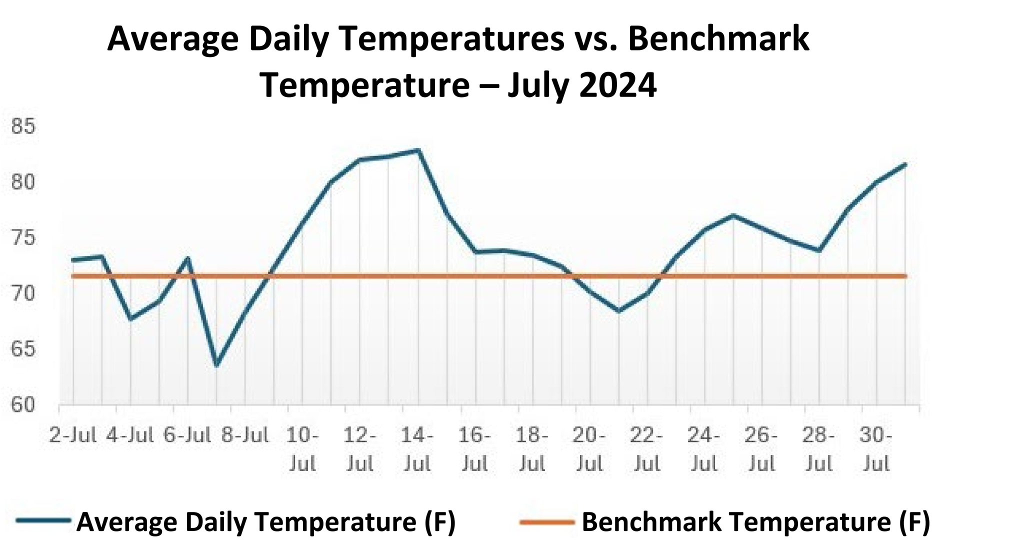
Background and Societal Impact

- Many dairy calves in the U.S. spend the first 60-70 days of their lives in plastic hutches
- Poor ventilation and heat stress are common challenges related to hutch design
- Poor ventilation represents animal health and welfare concerns
- Heat stress and mortality risks increase when average daily temperatures and THI exceed 71.6°F and 70 units, respectively [1, 2]



Bottom Line:

- Impaired calf comfort leads to a decrease in calf performance and an increased raising costs
- Improved housing environments may increase animal welfare and performance


Figure 1. Hutch with a dairy calf on a commercial dairy farm.

Customer Requirements

- No power or HVAC systems may be used
- Must be stackable
- Easy to sanitize
- Not be made from an absorbent or porous material
- Stable in high winds
- Equal or better manufacturability/durability
- Cost less than $1000

Features of Our Design

- Louvered vents
- A garage style door
- Anchoring points
- Rounded walls
- A lifted lip
- Roof vent

Prototype Selection & Testing

Problem-driven Methodology

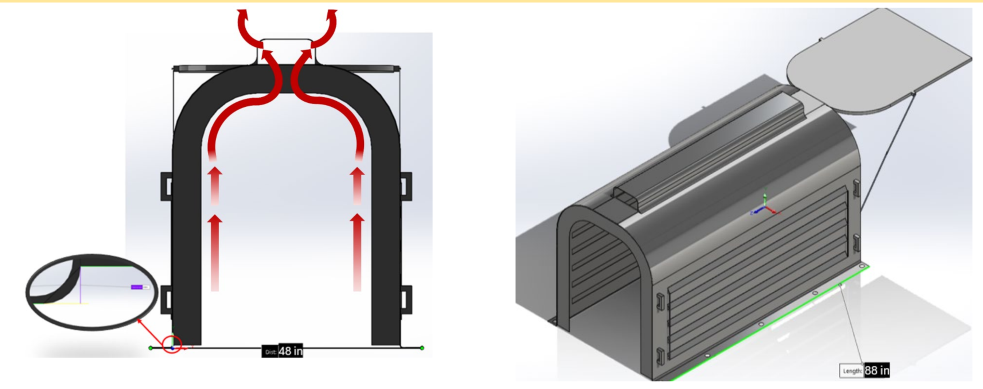


Figure 2: Features of prototypes.

- MAXIMIZE AIR FLOW
- PROVIDE EXTRA SHADE
- EASY TO TRANSPORT
- PREVENT LIFTING DURING WINDS
- MAXIMIZE AIR CONVECTION
- PROMOTE COOLING

Selection of Prototypes

FEATURES:

- **ROOF SHAPE**
  Flat X Round
- **WALL STRUCTURE**
  Corrugated x Non-corrugated
- **SIDE VENT SHAPE**
  Slat X Circle

STRUCTURAL STRENGTH SIMULATIONS ON SOLIDWORKS:

WIND LOAD TEST: 1000 N force distributed load applied directly parallel to the ground and to the side

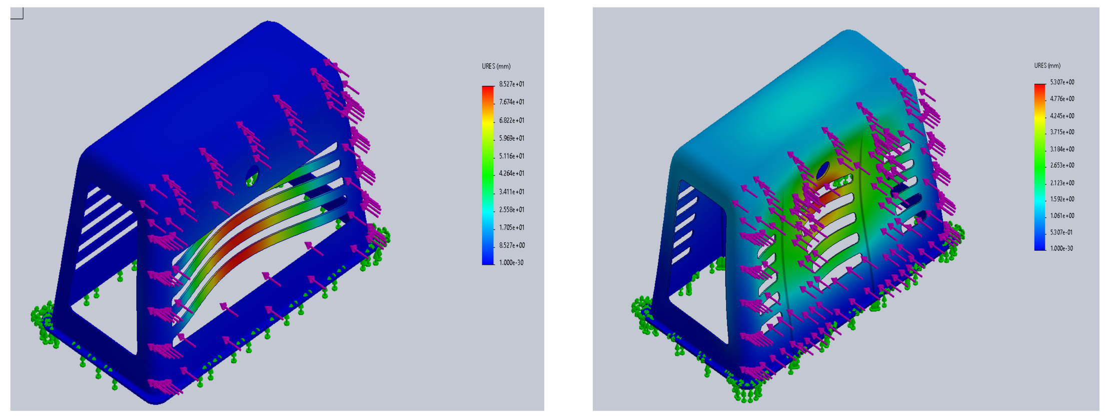


Figure 3. Wind load test - Prototype non-corrugated (left) x corrugated(right).

SNOW LOAD TEST: 1000 N force distributed load applied directly downward onto the hutch roof

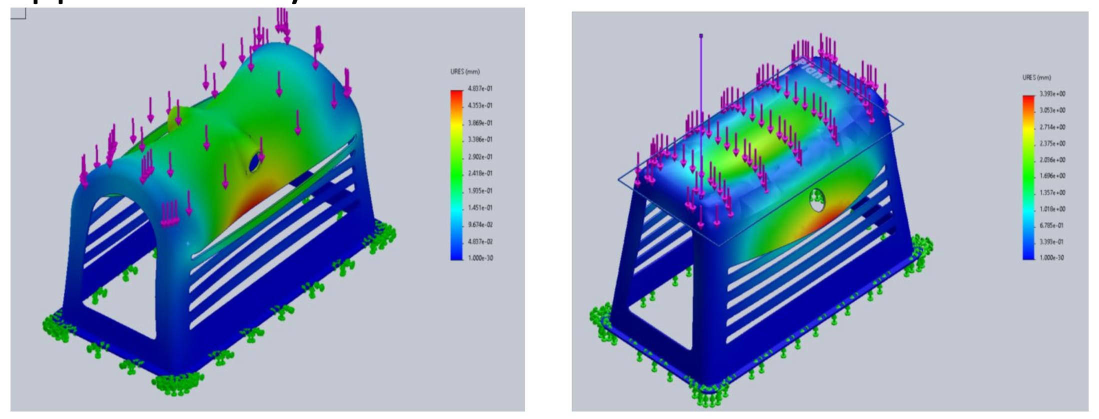


Figure 4. Snow load test – Round (left) x Flat roof (right).

Best- performing prototypes were 3-D printed and selected for wind-tunnel testing

WIND TUNNEL TEST

Steps:

- Hutch was placed under a heat lamp until the roof center reached ~54 °C.
- Copper thermocouple heated to ~60 °C.
- Wind tunnel operated at 5 Hz (6.2 mph).
- Hutch was placed into the wind tunnel, with either the side wall or the door facing the flow.
- Thermocouple placed inside the hutch and temperature recorded every 30s for 5min.
- Thermocouple cooling rate used as the primary performance metric for vent comparison

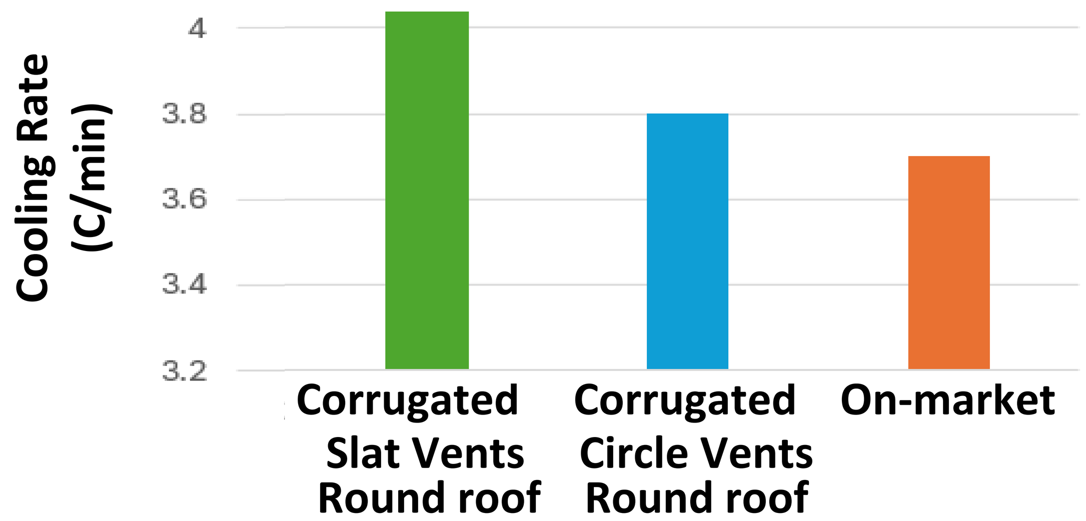


Figure 5. Thermocouple Cooling Rate Side On during the Wind Tunnel Results.

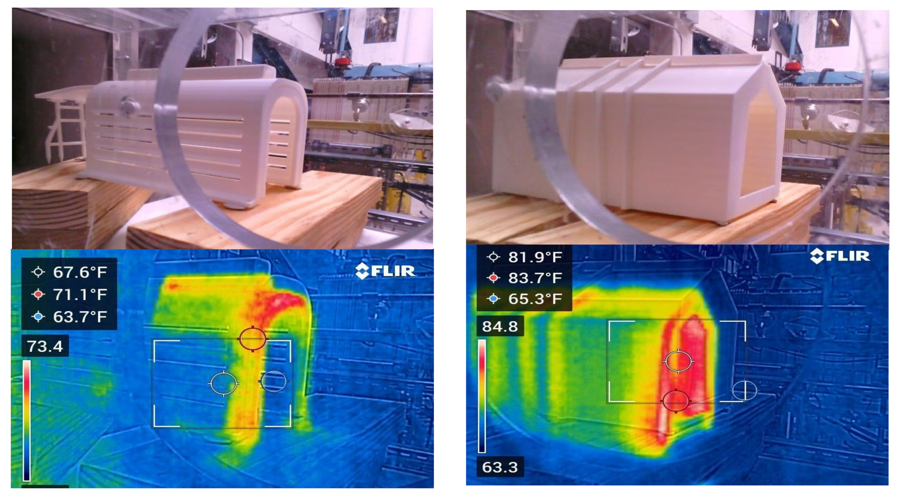


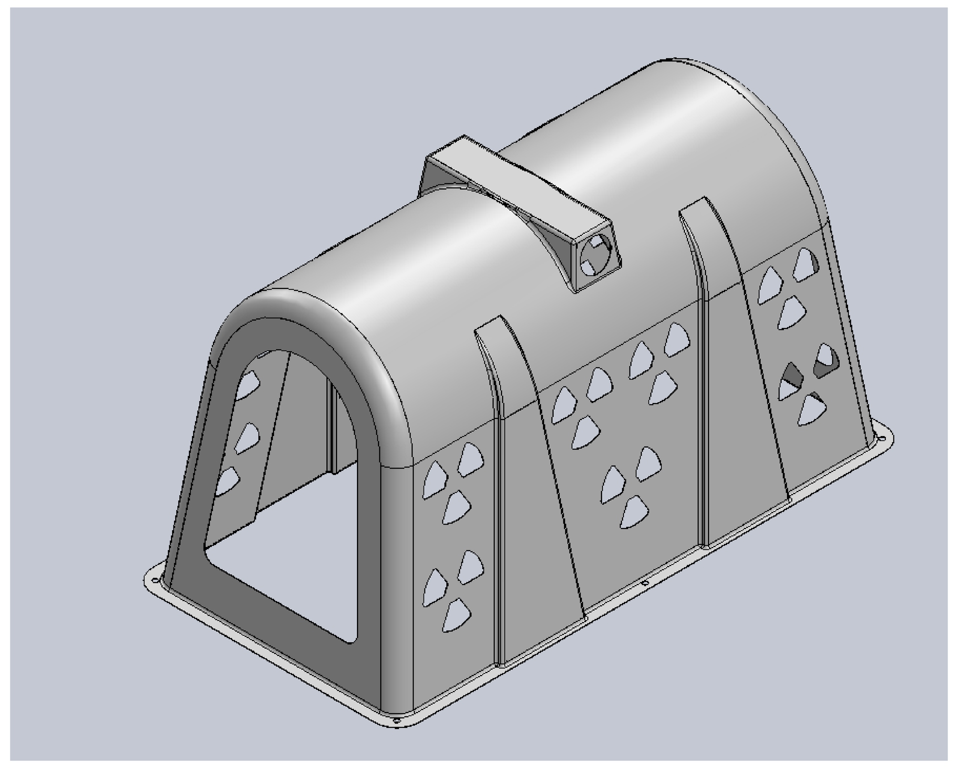
Figure 6. Thermal image of the new prototype (left) and the on-market (right) design hutch during the Wind Tunnel test.

Conclusions

In summary, our results show the potential of the new prototypes to improve ventilation and maintain cooler temperatures during the hot season, which may promote better calf comfort. The next steps of this project include the full-scale production of the best performing prototypes to conduct field testing with calves.

Future Steps

- **To manufacture a real-size model**
- **Field tests with real-size model, including winter**


US Provisional Patent Filed

References & Acknowledgements

[1] Jurkovich, Victor., Bakony, Mikolt., Reiczigel, Jeno. *A retrospective study of thermal events on the mortality rate of hutch-reared dairy calves* [Online]. Available: https://pmc.ncbi.nlm.nih.gov/articles/PMC10980180/

[2] *Diego Manriquez, Afrin Jannat, Ana Velásquez-Munoz, Pablo Pinedo, Effects of perinatal exposure to daily maximum THI and THI fluctuations on serum total proteins and health of preweaned Holstein heifers raised in a dry climate, Journal of Animal Science, Volume 102, 2024, skae218,*

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