GVI: Straw Stamp and Slicer

Team: Catie King, Lydia Miller, Megan Lee, Janice Amornthanomchoke, Varenya Vegesna, Emma Stroshane

Clients: Sarah Hanson, Brett Breidor, and Ben Goss

Advisor: Professor Justin Williams

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Motivation

- Quality control (QC) procedures for artificial insemination (AI) of bull semen are time and labor intensive
- Each plate is processed for 1 hour, with 8-10 plates processed per week
- Straws are currently processed individually using scissors and a paperclip
- Reducing plate processing time would increase weekly throughput

Goal:

- Optimize the quality control procedures by creating a stamper and slicer that can process 12 straw at once, while avoiding cross contamination

Background

- Using genomic selection and AI improves livestock quality and decreases environmental harm [1]
- Genetic Visions-ST (GVI) uses genetic sequencing to execute the quality control program [2]
  - QC uses low-pass sequencing and bioinformatics
- QC needed to ensure DNA matches one listed on straw and no cross contamination occurred
- QC procedure: cut bottom of straw and place into well, push contents of straw into well plate

Competing design:

- Nasco MiniCutter: Only cuts one straw at once
- Does not empty contents of straw

Figure 1: MiniCutter for AI straws [3]

Design Criteria

- Overall
  - Procedure time less than 30 minutes
  - Durable for 8-10 times per week
  - Durable against cleaning solutions
  - Prevent cross contamination
  - $1000 budget
- Frame
  - Align and secure straws above the well plate
- Stamp
  - Uniformly push 12 straws at a time without bending
- Cutter
  - Uniformly cut 0.20-0.50 inches off the straw
  - Cut up to 12 straws at a time

References

[1] Navid Ghavi Hossein-Zadeh, "An overview of recent technological developments in bovine genomics," Veterinary and Animal Science, vol. 25, pp. 100382–100382, Sep. 2024, doi: https://doi.org/10.1016/j.vas.2024.100382.

[2] "About Us." Genetic Visions, 2022. Accessed: Sept. 17, 2025. [Online]. Available: https://www.geneticvisions.com/about-us.aspx

[3] Nasco, "MiniCutter for Semen Straws - Nasco Education," Nasco Education.

Final Design

Figure 2: Guillotine style paper cutter setup for slicing procedure

Figure 3: Final compartment 3D print

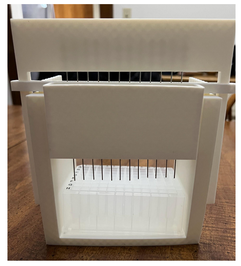

Figure 4: Final physical assembly with well plate frame, compartments, and stamper with rods

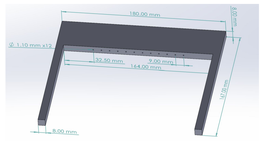

Figure 5: Dimensioned CAD model of stamper handle with holes for rods

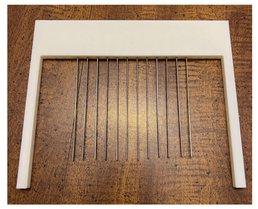

Figure 6: Stamper handle with rods attached

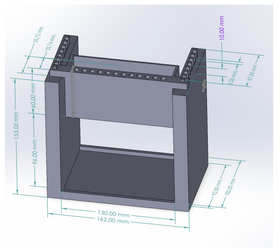

Figure 7: Dimensioned CAD model assembly of well plate frame and compartments

Key Features:

- Precise fit around well plate
- Triangular holes for snug fit of straws
- Repeatable cutting height

Testing

- Contamination testing
  - Cut straws and empty contents into tube → vortex and resuspend
  - Split contents into two tubes
    - First tube: 0.625 uL/mL concentration of fluorescein in semen
    - Second tube: 0 uL/mL concentration of fluorescein in semen
  - Draw 50 uL of solution into syringe and push into straw
  - Perform GVI procedure (load, cut, push)
  - Run in microplate reader (535 nm emission, 485 nm excitation, 30 flashes)

Figure 8: Fluorescent well plate with alternating conditions

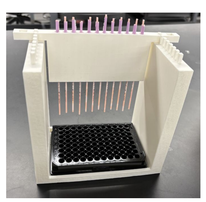

Figure 9: Procedure set-up before pushing

- MTS testing
  - Place compartment and straw on base of the MTS machine
  - Mount the 3D-printed testing fixture on the load cell with the rod inserted
  - Run TWE Elite program
  - Stop data collection once the rod has fully pushed the contents of the straw into the well plate

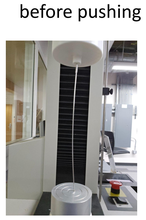

Figure 10: Testing force on rod

Results

- MTS test
  - Max force to push contents of straw into well plate: 1.120 ± 0.929 N
  - Max force to bend steel rod: 6.54 ± 0.100 N

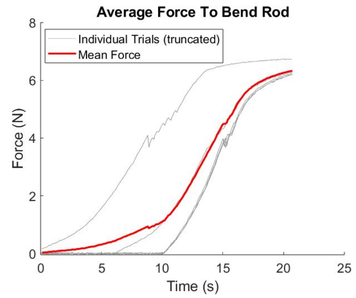

Figure 11: Average force to bend steel rod

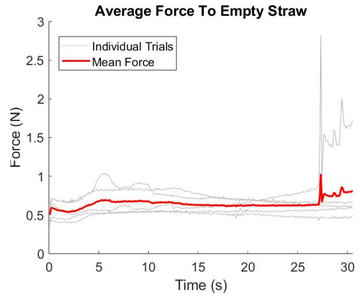

Figure 12: Average force to push contents of straw in well plate

- Cross-contamination test
  - No significant difference between procedure and micropipette controls
  - Procedure fluorescein vs no fluorescein: 34131.2 ± 10965.7 vs 501.5 ± 77.9 RFU (significant difference, p = 7.05e-7)
- Timed test
  - 4 minutes 30 seconds per row, 36 minutes total
- Compliance with PDS requirements
  - Force to empty straw less than force to bend rod
  - 40% time decrease
  - No cross-contamination
  - Design allows for 12 straws to be cut and stamped at a time
  - Average cut length: 0.269 ± 0.986 in

Figure 13: Contamination levels measured by fluorescence

Future Work

- Optimize design to slice and stamp multiple rows at once
- Design a better way to align stamper prongs with the straws
- Determine the best cleaning method
- Perform full procedure at GVI
- Sources of error
  - Linear progression of force for single straw vs 12 straws
  - Uneven distribution of dye in semen

Acknowledgements

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