

# Designing an Automated Wood Briquette Feeding System for a GARN® Wood Fired Hydronic Furnace



Jared Baker  
Jeff Baumann  
Michael Leriger  
Andrew Morrison  
Brandon Schulte

# Problem

- GARN<sup>®</sup> uses split wood as fuel source
- Loaded as often as every 1.5 hours
- Burn chamber surrounded by 2,000 gal. H<sub>2</sub>O
- Water Reservoir needs to be maintained at a temperature above 120°F



# Objectives

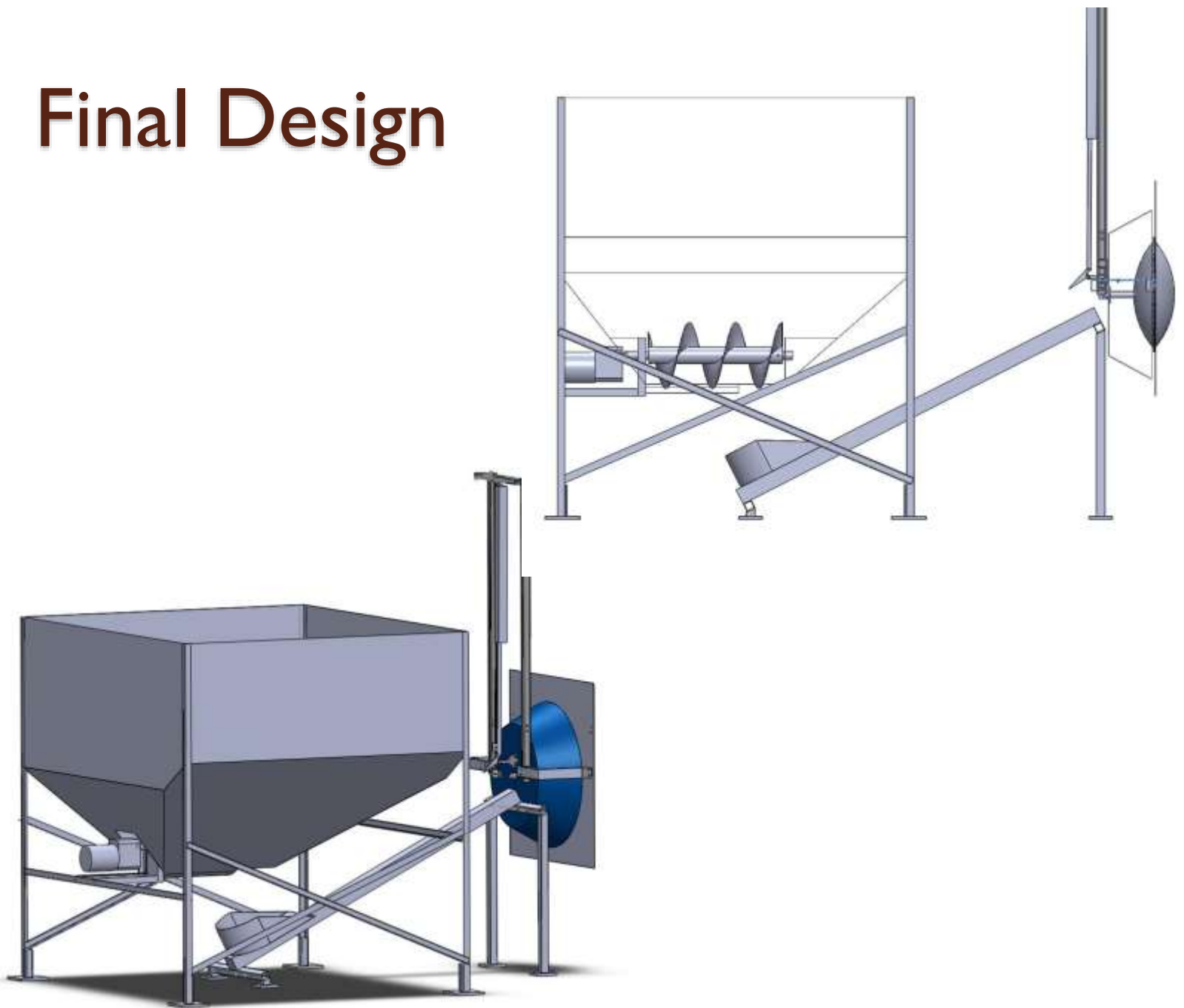
- Design an automated feed system for GARN<sup>®</sup> wood fired hydronic furnace
- System large enough to run 16 hours with optimal run time of 96 hours
- Maintain water bath temperature between 130°F and 180°F
- Fuel is 2 pound rectangular briquettes



# Design Breakdown

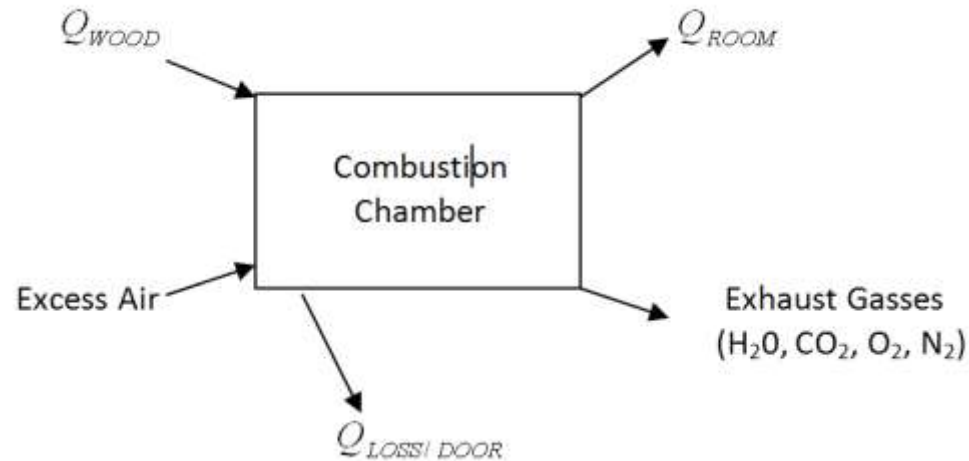
- System divided into 4 subsystems
  - Hopper
  - Briquette Transportation
  - Door Assembly
  - Control System

# Final Design



# Hopper

- Need container to last 96 hours
- First approach: thermodynamic energy balance



$$Q_{Room} + Q_{Loss/Door} + \sum N_p (\bar{h}_f^\circ + \bar{h} - \bar{h}^\circ)_p = \sum N_r (\bar{h}_f^\circ + \bar{h} - \bar{h}^\circ)_r$$

# Hopper

- Second approach: Ucross Employee Data
- Excess Space Calculated at 87.1%
- Both approaches results within 12% of each other
- Final Hopper Volume: 93 ft.<sup>3</sup>
  - Includes Excess Space
  - Includes Factor of Safety of 1.15
- Fabricated with 16 gauge sheet metal plasma cut and welded together

# Hopper





# Briquette Transportation

- Auger Design
  - Used as gateway for transporting briquettes from hopper to belt driven linear actuator
  - Flighting pitch distance is twice the height of the briquettes: 8 inches.
  - Diameter chosen to move 2 briquettes in radial direction: 13 inches.



# Briquette Transportation

- Transportation Design
  - Initial Ideas:
    - Gravity fed ramp
    - Conveyor belt
  - Final Design: Belt Driven Linear Actuator
    - Throw briquettes 2.5 feet into center of furnace
    - Optimum Launching Angle:  $30^\circ$
    - Corresponding Launch Velocity: 7.1 ft/s



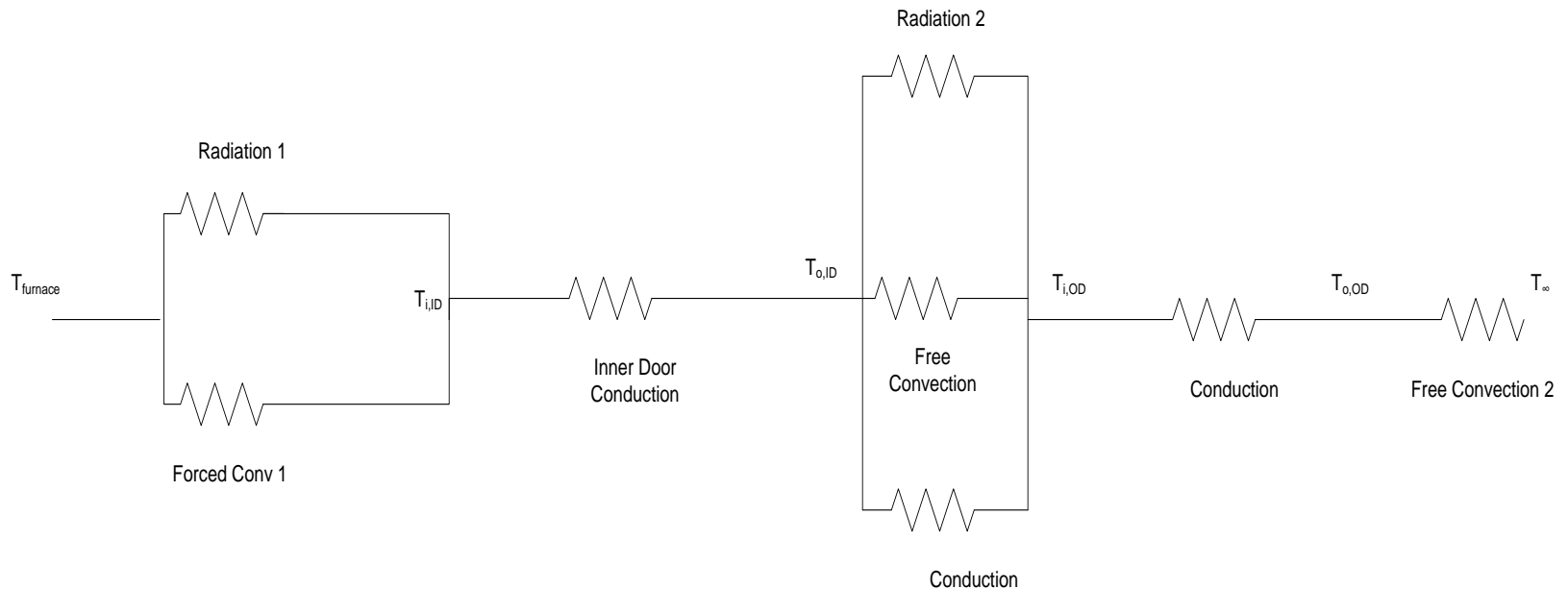
# Door Assembly

- Double door design with single displacement motion.
- Moves in plane with furnace surface as to not impede with other components
- Actuator slides door assembly into place.
- Cam rotates and seals inner door.
- Springs used to pull inner door into outer door



# Door Assembly

- SolidWorks motion study to verify dynamics
- Abaqus used to verify component design for stresses and deflections
- Heat transfer modeled through door assembly



# Door Assembly

- Fabricated a pseudo GARN<sup>®</sup> face
- Tested Door and successfully opens and closes fully with one linear motion

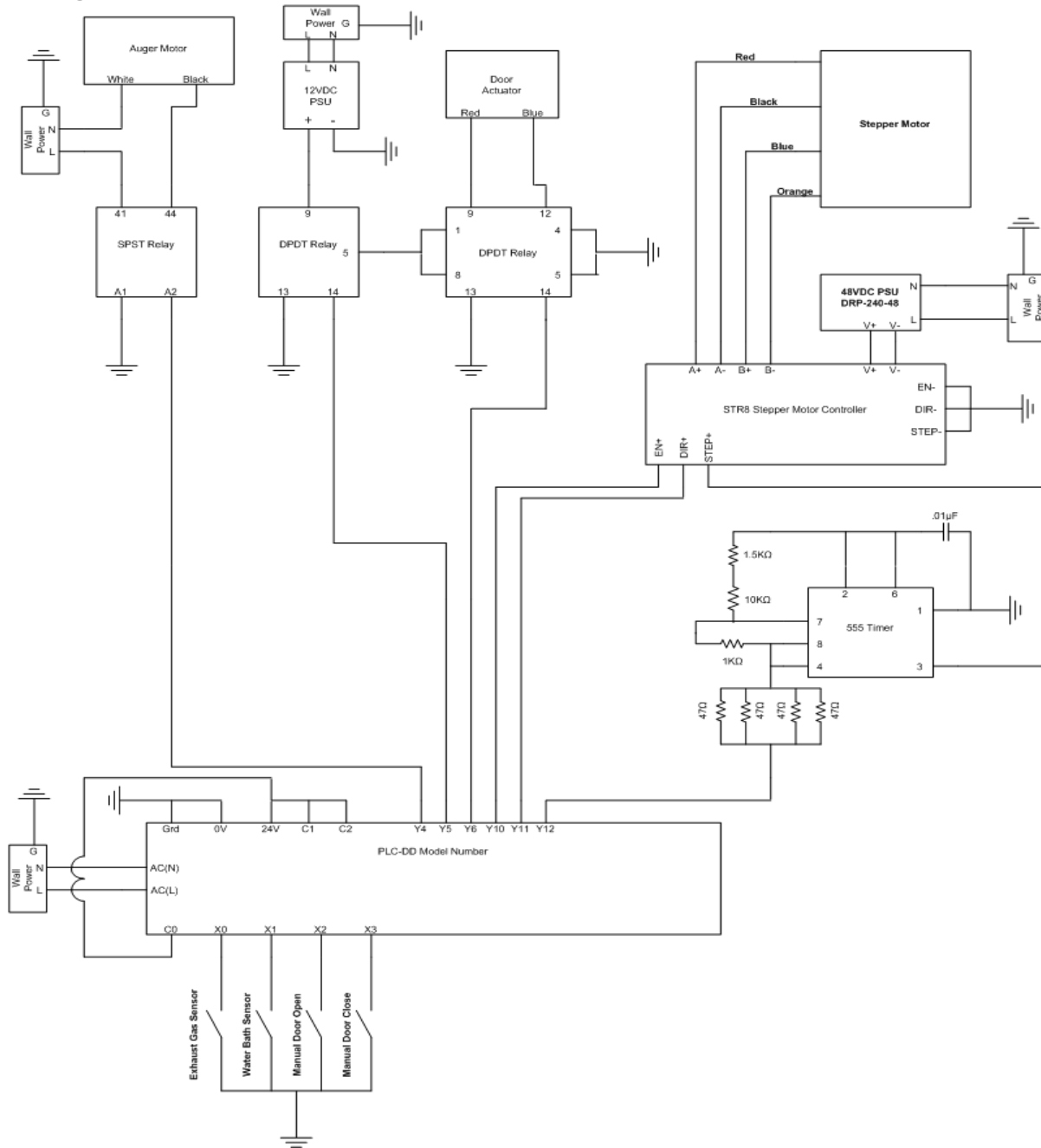
# Control System

- Monitors exhaust and water bath temperatures
- Runs events in sequence based on timers
  - Open Door
  - Turn Auger
  - Launch Briquettes
  - Close Door

# Control System



# Wiring Diagram:





# Budget

- Total approved budget \$4000
- Itemized Budget:

Door Assembly	\$ 422.20
Hopper/Auger	\$ 1,285.50
Control System	\$ 805.84
Briquette Launcher	\$ 1,243.35
<b>Total</b>	<b>\$ 3,756.89</b>
Budget	\$ 4,000.00
<b>Remaining Funds</b>	<b>\$ 243.11</b>

- Under Budget: Supplies
- Over Budget: Time

# Conclusions

- Initial prototype in final stages of assembly
- Testing results:
  - Control system successfully runs all motors in sequence
  - Door operates as designed
  - Stepper motor is undersized for weight requirements
- Auger remains to be tested in hopper

# Further Improvements

- Ash Removal System
- Automatic Ignition System
- Fully comprehensive control system up to building code including:
  - Control Box
  - Limit switches instead of timers

# Special Thanks

- **Project Advisors:**
  - Dr. Dennis Coon
  - Dr. David Walrath
  
- **Faculty Support:**
  - Scott Morton
  - Vic Bershinsky
  - Dr. Steve Barrett
  - Dr. Jonathan Naughton
  - Dr. O.A. Plumb
  
- **College Shop:**
  - Dr. Rob Erikson
  - Mike Schilt
  
- **Additional Thanks:**
  - Debbie Craft