# Progress Report

Nestle Purina Team 2

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Nestlé PURINA

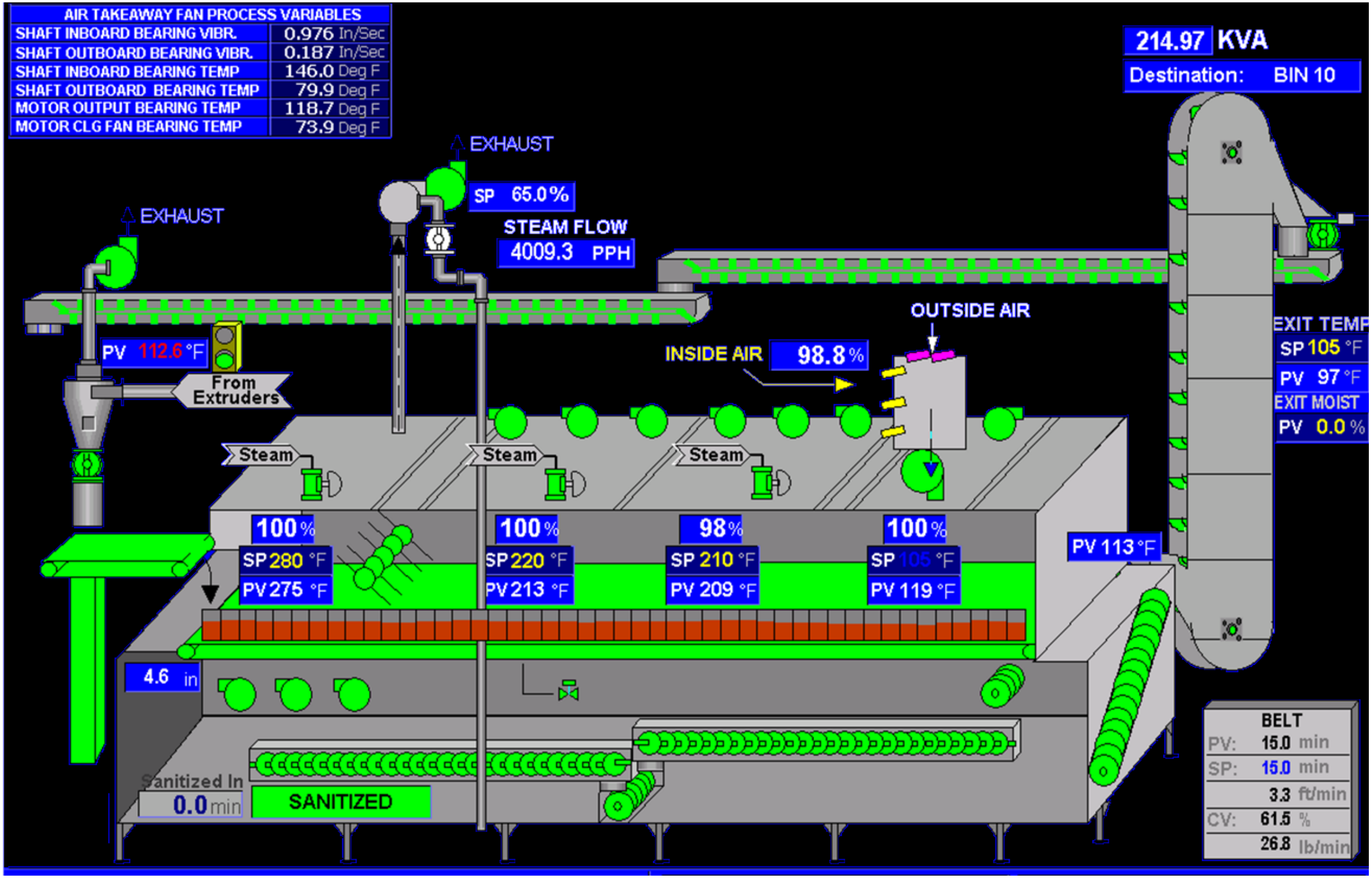
# Overview of Presentation

- Review of problem statement
- Operation of dryer
- Current situation
- Design options
- Future tasks
- Gantt Chart
- Conclusion

# Introduction

- **Problem**
  - **Dryer 3 uses significantly more energy than the other four dryers to extract moisture from the product.**

# Dryer 3




Nestle Purina iFix Interface

# Current Situation

- Previously determined
  - Efficiency compared to other dryers
    - 34.7 % less inch food per steam flow rate
  - Where largest losses occur
    - Steam traps
    - Heat exchangers
- Progress
  - Cost analysis of natural gas dryer complete
  - We have modeled the existing steam system
    - Interactive Thermodynamics
      - steam
      - natural gas
  - Model adjusted to match dryer data
    - Assumptions
    - Correction Factor

# Design Plan – Option 1

- First option: replace steam coils in the dryer with natural gas heat exchangers
  - Analyze natural gas heat exchanger
  - Use data from Clinton heat exchangers

- Heat Exchanger Properties:
  - 5.38 MBTU/h

# Option 1 – Natural Gas Calculations

| Natural Gas | |
|---|---|

| Plant Usage (cf) 2/27/13 | |
|---|---|
| Top Meter | 927,400.00 |
| Bottom Meter | 165,400.00 |
| West Meter | 3,000.00 |
| Dryer 5 | 98,076.00 |
| **Total:** | **1,193,876.00** |

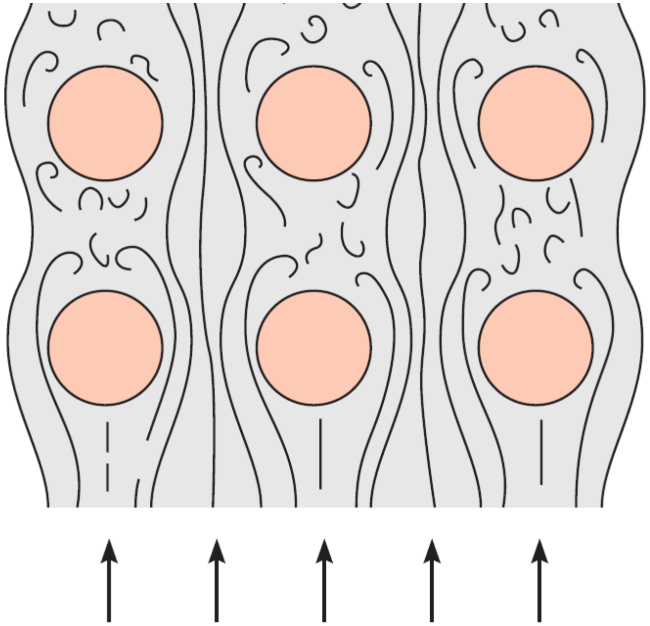
| Calculations | | |
|---|---|---|
| Energy per cf (btu) | 1,028.00 | |
| Total Energy in a day (btu) | 1,227,304,528.00 | |
| Total Energy in kbtu's | 1,227,304.53 | |
| Cost January 2013: | $155,547 | |
| Plant Usage January 2013 (cf) | 29,356,000.00 | |
| cf/dollar | 188.73 | |
| Price / Mcf: | $5.30 | NOTE: 1 Mcf = 1000 cf |
| Price / MBTU | $5.16 | BTU x 10^6 |
| Clinton Nat. Gas Dryer Usage | 98.076 | Mcf per day |
| Price / Mcf | $5.30 | |
| Price / Day | $519.80 | |

# Design Plan – Option 2

- Second Option: Replace steam in system with hot exhaust gas
  - Run analysis for replacing steam with hot exhaust gasses

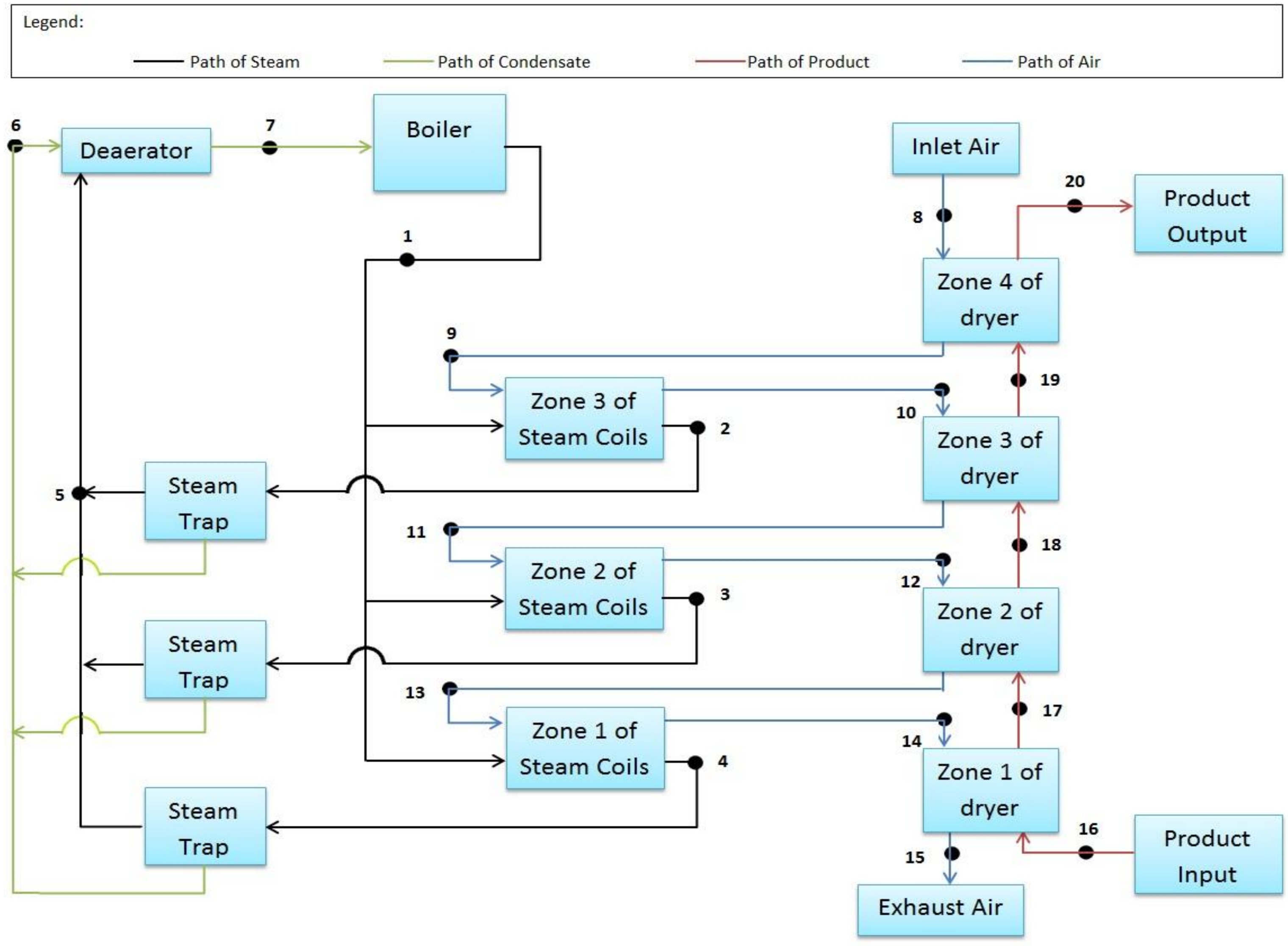
- Make reasonable assumptions…
  - temp of exhaust gas approx. 500F
  - pressure approx. 20 psi.
  - thermo analysis
  - heat transfer can be approximated

# Heat Exchanger



Source: Moran, Michael J., and Howard N. Shapiro. *Fundamentals of Engineering Thermodynamics*.

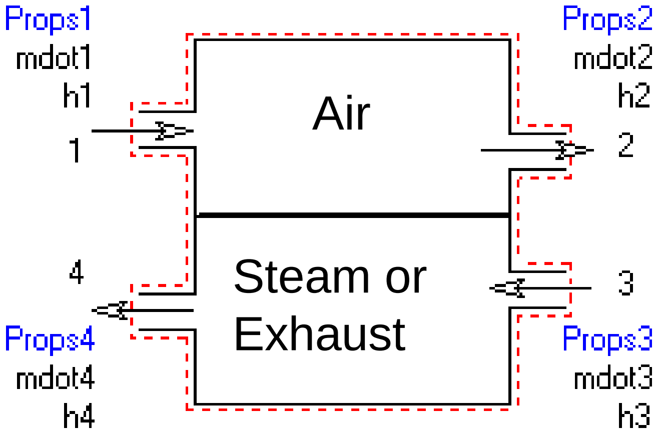
# Thermodynamic Model



# Thermodynamic Analysis

- $\frac{dE}{dt} = Q_{in} - W_{out} + \sum \dot{m}i\left[h_i + \frac{V^2{}_i}{2} + gz_i\right] - \sum \dot{m}i\left[h_e + \frac{V^2{}_e}{2} + gz_e\right]$
- **Where:**

| | |
|---|---|
| **h** | **Enthalpy** |
| $Q_{in}$ | **Heat in** |
| $W_{out}$ | **Work done** |
| $\dot{m}$ | **Mass flow rate** |
| **V** | **Velocity of fluid** |
| **g** | **Gravitational constan** |
| **z** | **Elevation** |




- **Heat exchanger control volume analyzed twice with steam and exhaust gas/air**
- Source: Moran, Michael J., and Howard N. Shapiro. *Fundamentals of Engineering Thermodynamics*.

# Thermodynamic results

```
//*Neglect Kinetic Energy

//Steam Inlet
T1 = 350
p1 = 40
mdot1 = ((4009.3/3)/60)
h1 = h_PT("Water/Steam", p1, T1)

//Steam Outlet
T2 = 267
p2 = p1
mdot1 = mdot2
h2 = h_PT("Water/Steam", p2, T2)

//Air Inlet
T3 = 120
p3 = 10
density3 = 0.115
//0.115 [lb/ft^3] at 120F and 10psi
mdot3 = 4800*density3
h3 = h_T("Air",T3)

//Air Outlet
T4 = 280
p4 = p3
mdot4 = mdot3
h4 = h_T("Air",T4)

//Balance
Qdot_steam = mdot1*(h1-h2)
Qdot_air = mdot3*(h4-h3)
Qloss = Qdot_steam - Qdot_air

Price = 6.19 //$/BTU
Cost = Qdot_steam*Price
//Cost = $/min
```

| | | |
|---|---|---|
| h1 | 1212 | |
| h2 | 235.8 | |
| h3 | 138.6 | |
| h4 | 177.2 | |
| mdot2 | 22.27 | |
| mdot3 | 552 | |
| mdot4 | 552 | |
| p2 | 40 | |
| p4 | 10 | |
| Qdot_air | | 2.128E4 |
| Qdot_steam | | 2.174E4 |
| Qloss | 458.7 | |
| density3 | | 0.115 |
| mdot1 | 22.27 | |
| p1 | 40 | |
| p3 | 10 | |
| Price | 6.19 | |
| T1 | 350 | |
| T2 | 267 | |
| T3 | 120 | |
| T4 | 280 | |

Cost: 193.8 $/day

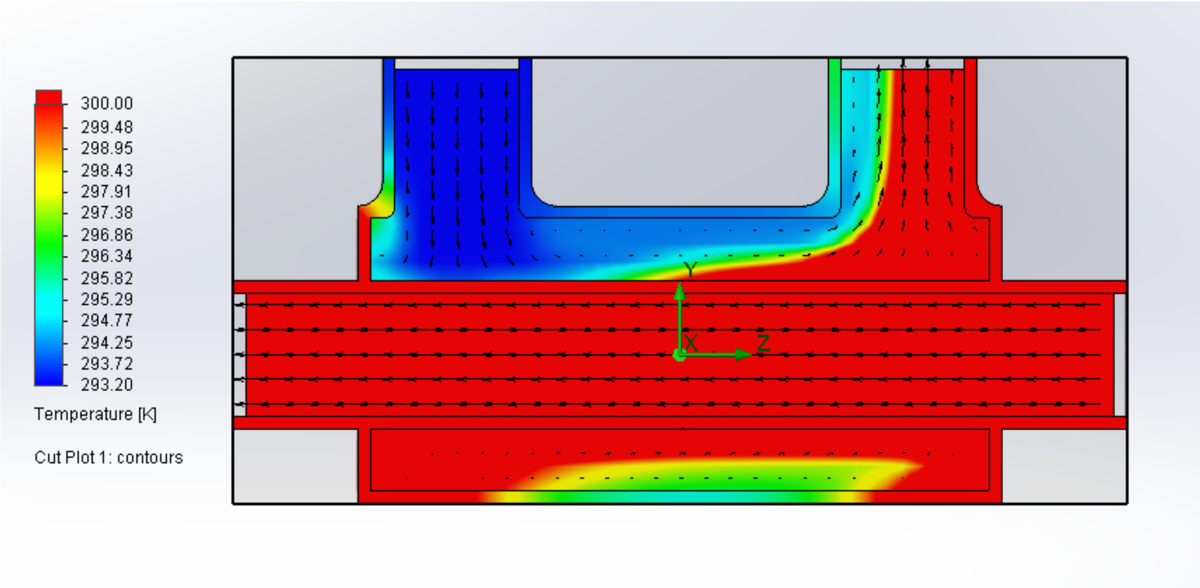
```
//*Neglect Kinetic Energy

//Exhaust Inlet
T1 = 500
p1 = 10
density1 = 0.070
mdot1 = 8000*density1
h1 = h_T("Air",T1)

//Exhaust Outlet
T2 = 345
p2 = p1
mdot1 = mdot2
h2 = h_T("Air",T2)

//Air Inlet
T3 = 120
p3 = 10
density3 = 0.115
//0.115 [lb/ft^3] at 120F and 10psi
mdot3 = 4800*density3
h3 = h_T("Air",T3)

//Air Outlet
T4 = 280
p4 = p3
mdot4 = mdot3
h4 = h_T("Air",T4)

//Balance
Qdot_exhaust = mdot1*(h1-h2)
Qdot_air = mdot3*(h4-h3)
Qloss = Qdot_exhaust - Qdot_air

Price = 5.16 //$/MBTU
Cost = (Qdot_exhaust/1000)*Price
//Cost = $/min
```

| | | |
|---|---|---|
| h1 | 231 | |
| h2 | 193 | |
| h3 | 138.6 | |
| h4 | 177.2 | |
| mdot1 | 560 | |
| mdot2 | 560 | |
| mdot3 | 552 | |
| mdot4 | 552 | |
| p2 | 10 | |
| p4 | 10 | |
| Qdot_air | | 2.128E4 |
| Qdot_exhaust | | 2.129E4 |
| Qloss | 9.337 | |
| density1 | | 0.07 |
| density3 | | 0.115 |
| p1 | 10 | |
| p3 | 10 | |
| Price | 5.16 | |
| T1 | 500 | |
| T2 | 345 | |
| T3 | 120 | |
| T4 | 280 | |

Cost: 158.2 $/day

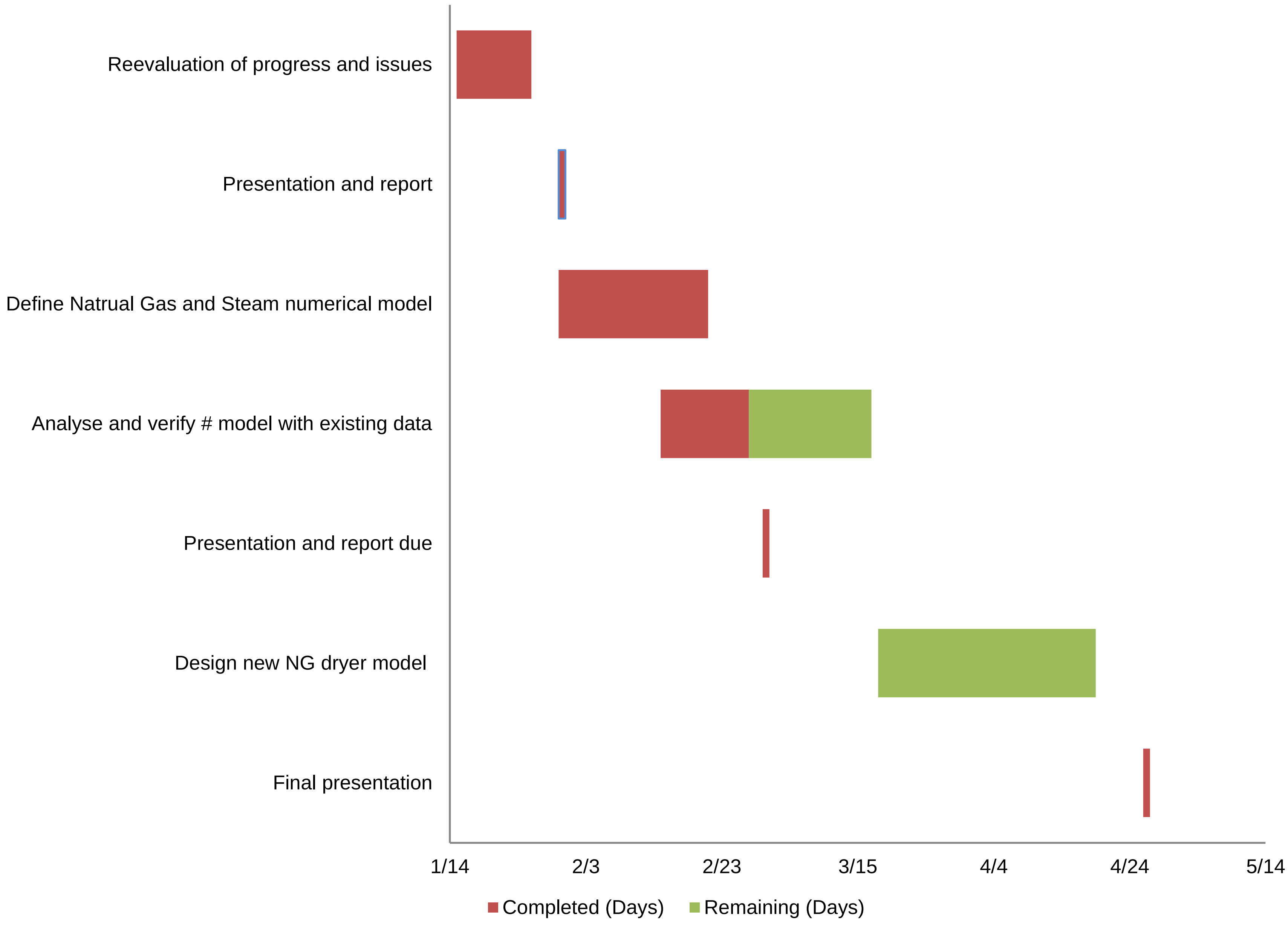
# Future Plans

- **Expand model**
- **Verify data with existing natural gas dryer**
- **Design a modified natural gas dryer and analyze it using our numerical model**
  - **Solidworks heat exchanger model**




Source: Solidworks example

# Spring Semester Gantt Chart



# Conclusion

- Dryer efficiency improvement
- Design plan (2 options):
  - Analysis using natural gas heat exchanger
  - Analysis replacing steam with exhaust gas
- Numerical simulation
  - Fuel/cost efficiency
  - IT (Interactive Thermodynamic) software
- Future plans
  - Design modified natural gas dryer
  - Expand model to include steam traps

# References

- Clint Chadwick
  - Environmental Coordinator
  - Nestle Purina Pet Care, Flagstaff, AZ

- Chad Girvin
  - Processing Maintenance Team Leader
  - Nestle Purina Pet Care, Flagstaff, AZ

- Buhler Aeroglide Natural Gas Dryer
  - http://www.aeroglide.com/snack-dryers-roasters-ovens.php