Shuttle Valve Design

Team #17

Date
December 3rd, 2013

Group Members
Ryan Laney – Team Leader
Billy Ernst – Team Webmaster
Samantha Zeidel – Team Treasurer

Instructor
Dr. Kamal Amin

Sponsor
Verdicorp Inc.
Robert Parsons

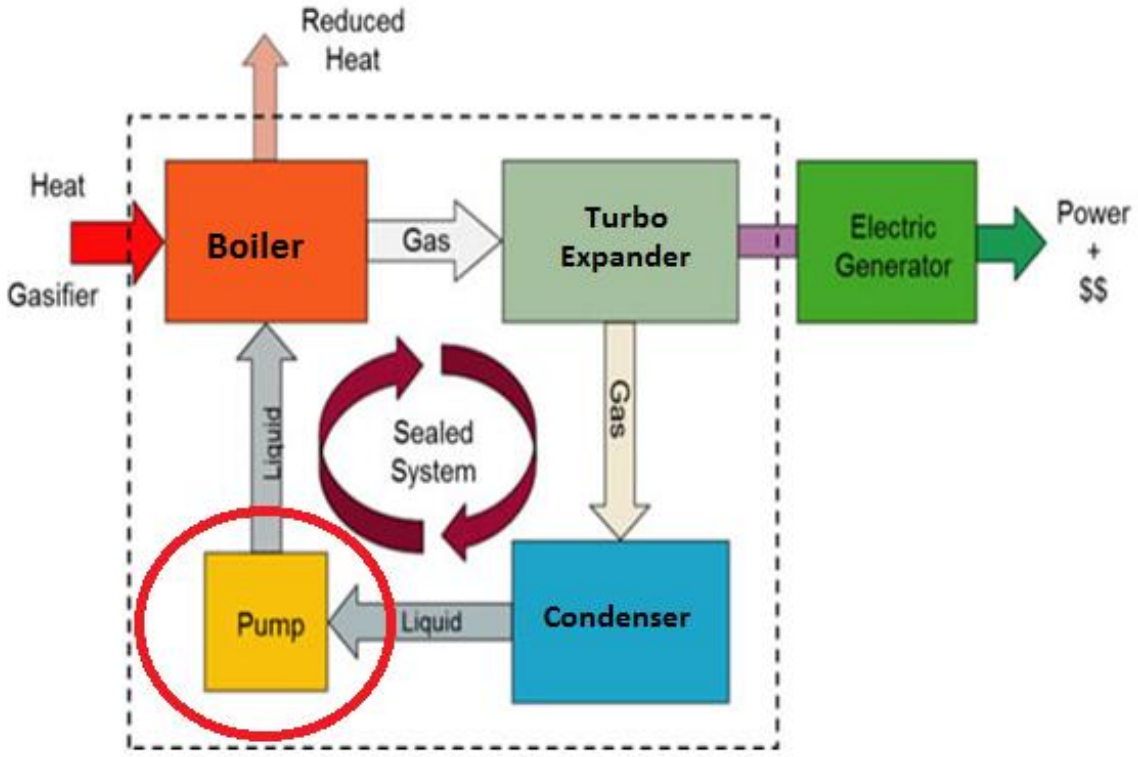
Faculty Advisor
Dr. Steven Van Sciver

Project Overview

- Verdicorp Environmental Technologies has developed a revolutionary Organic Rankine Cycle (ORC)
- ORC uses waste heat from a low grade source and converts it to useful power
- The ORC systems have somewhat low efficiency (~10-14%); Special concern within the company to maximize this efficiency in any way possible
- ORC is cable of producing ~125 kW
- Parasitic losses consume ~20 kW

  (Pump ~10 kW)
- Senior Design Team 17 has been tasked with increasing the efficiency of the system

  (Removal and replacement of the pump)



Presented by: Ryan Laney

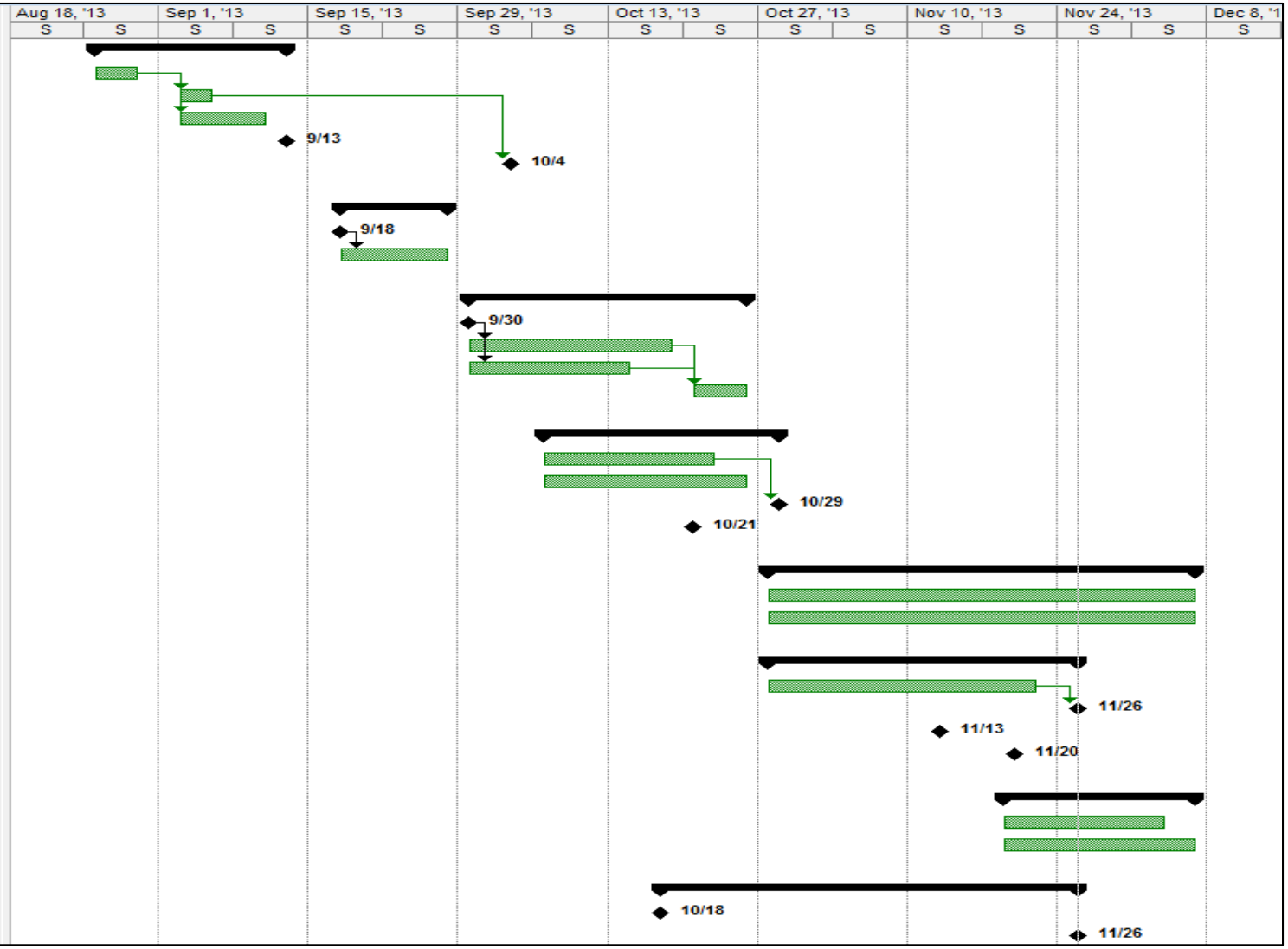
Project Objectives

- Design a shuttle valve system to replace the pump within the ORC
- Maintain the continuous flow of liquid within the ORC (~ 3 gpm)
- Use solenoid valves with the aid of gravity to adjust the pressure inside the vessels
- Transfer the liquid in the system from the low pressure side to the high pressure side
- Minimize the parasitic losses in the system (electrical consumption)
- Confirm on a final design concept by late-October 2013
- Order/purchase all components and materials by December 2013
- Construct a prototype of the final design during Spring 2014

Presented by: Ryan Laney

Fall Semester Gantt Chart

Task Name	Start	Finish
Formation of Design Team	**Mon 8/26/13**	**Fri 9/13/13**
Project Selections	Mon 8/26/13	Thu 8/29/13
Code of Conduct	Tue 9/3/13	Thu 9/5/13
Team Building (Ice Breaker)	Tue 9/3/13	Tue 9/10/13
Initial Sponsor Contact (Email)	Fri 9/13/13	Fri 9/13/13
REVISED Code of Conduct	Fri 10/4/13	Fri 10/4/13
Project Tasks Set 1	**Wed 9/18/13**	**Fri 9/27/13**
Initial Sponsor Meeting	Wed 9/18/13	Wed 9/18/13
Needs Assessment (D1)	**Wed 9/18/13**	**Fri 9/27/13**
Project Tasks Set 2	**Mon 9/30/13**	**Fri 10/25/13**
Second Sponsor Meeting	Mon 9/30/13	Mon 9/30/13
Concept Generation and Research	Mon 9/30/13	Fri 10/18/13
Project Plans and Product Specs (D2)	Mon 9/30/13	Mon 10/14/13
Concept Selection and Confirmation	Mon 10/21/13	Fri 10/25/13
Project Tasks Set 3	**Mon 10/7/13**	**Tue 10/29/13**
Midterm 1 Presenation (D4)	Mon 10/7/13	Tue 10/22/13
Midterm 1 Report (D5)	Mon 10/7/13	Fri 10/25/13
Peer Evaluation 1 (D6)	Tue 10/29/13	Tue 10/29/13
Third Sponsor Meeting	Mon 10/21/13	Mon 10/21/13
Project Tasks Set 4	**Mon 10/28/13**	**Fri 12/6/13**
Ordering of Parts	Mon 10/28/13	Fri 12/6/13
Simulation and Analysis	Mon 10/28/13	Fri 12/6/13
Project Tasks Set 5	**Mon 10/28/13**	**Tue 11/26/13**
Midterm 2 Presentation (D7)	Mon 10/28/13	Thu 11/21/13
Peer Evaluation 2 (D8)	Tue 11/26/13	Tue 11/26/13
Fourth Sponsor Meeting	Wed 11/13/13	Wed 11/13/13
Fifth Sponsor Meeting	Wed 11/20/13	Wed 11/20/13
Project Tasks Set 6	**Tue 11/19/13**	**Fri 12/6/13**
Final Design Presentation (D10)	Tue 11/19/13	Tue 12/3/13
Final Design Report (D11)	Tue 11/19/13	Fri 12/6/13
Website Maintanence	**Fri 10/18/13**	**Tue 11/26/13**
Initial Web Page Design (D3)	Fri 10/18/13	Fri 10/18/13
Final Web Page Design (D9)	Tue 11/26/13	Tue 11/26/13



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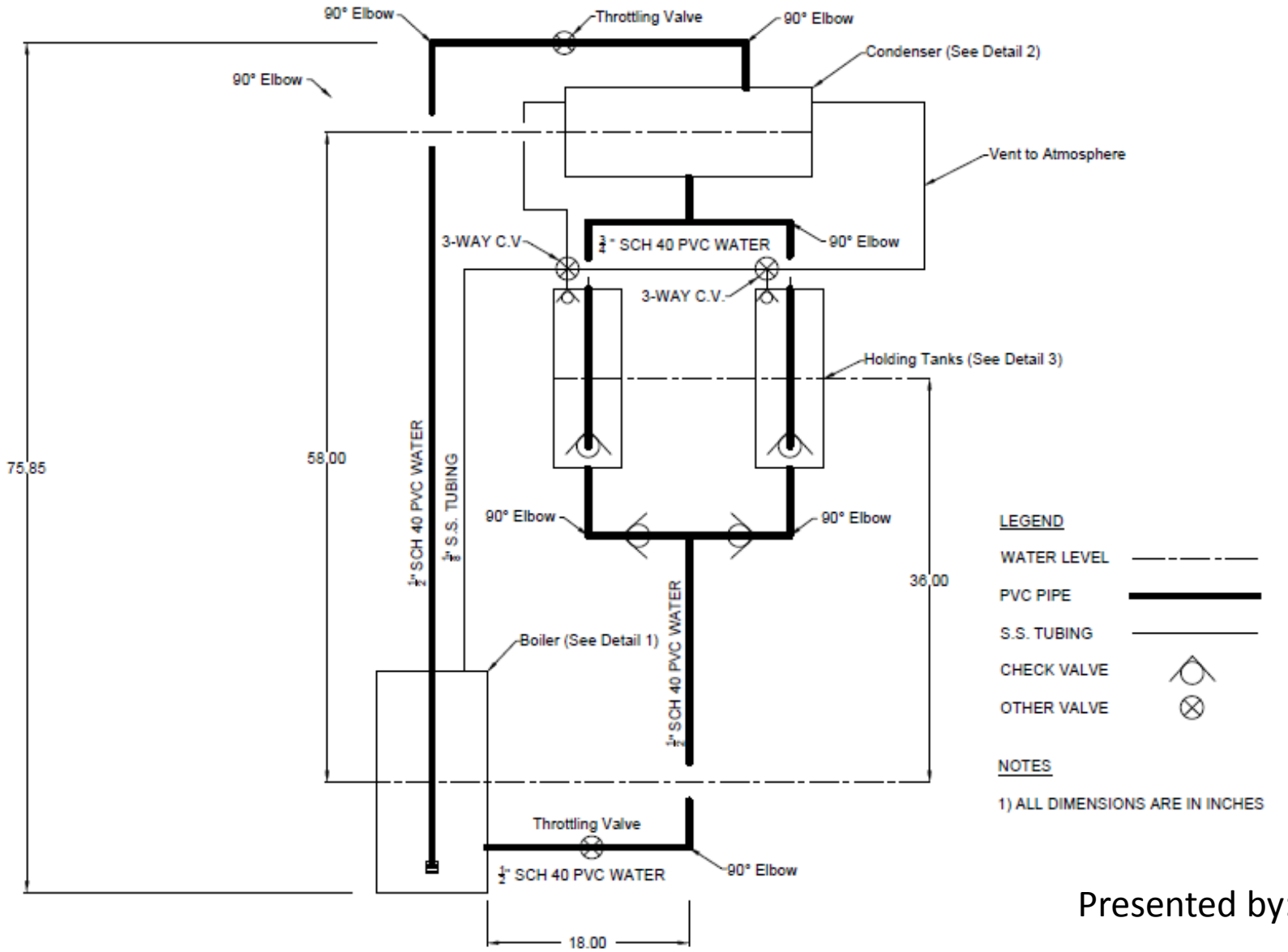
Final Design Concept



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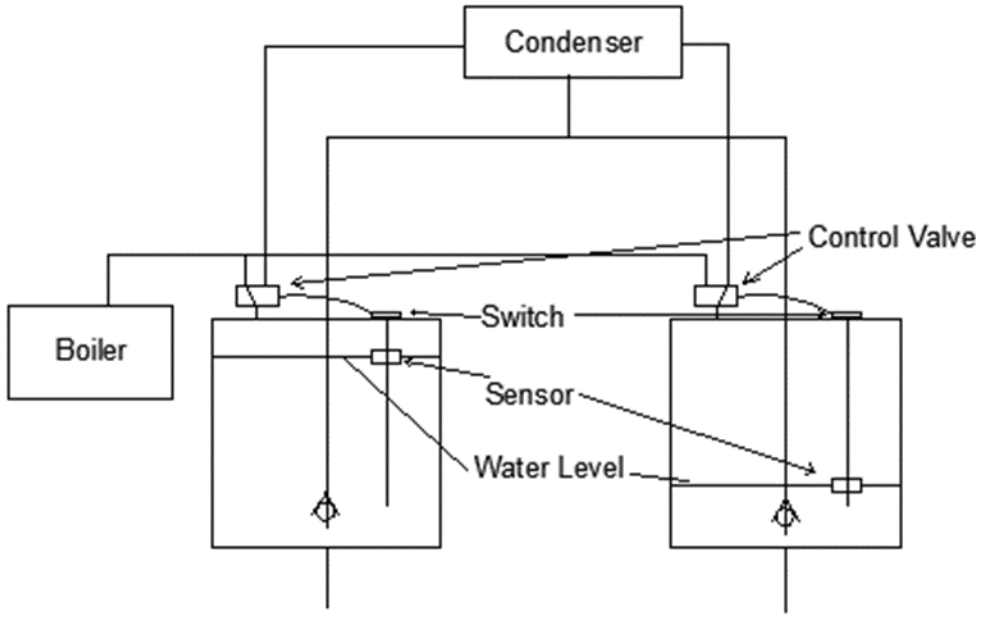
Final Design Concept

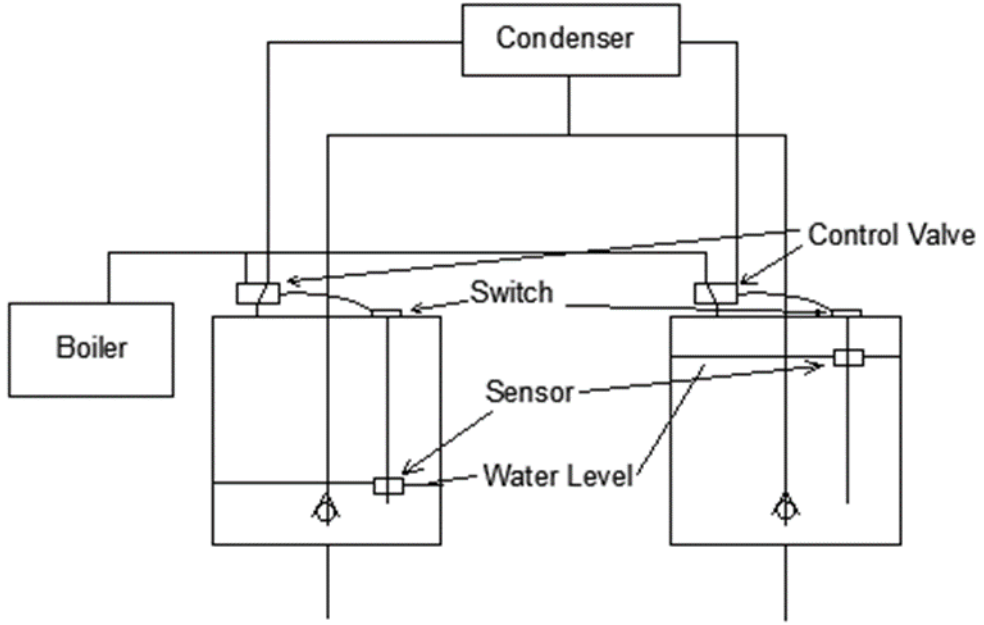
- Execution of Holding Tank 1

Phase 1



- Execution of Holding Tank 2

Phase 2



Presented by: Billy Ernst

Relevant Equations for Pipe Flows

- *Modified Bernoulli Equation*
- $\frac{p_1}{\rho g} + \frac{V_1^2}{2g} + z_1 = \frac{p_2}{\rho g} + \frac{V_2^2}{2g} + z_2 + \frac{fLV^2}{D2g} + \sum K \frac{V^2}{2g}$
- $\Delta P_L = \frac{\left(\frac{fL}{D} + K_t\right)V^2}{2g}$
- $\frac{fL}{D}$ term applies to friction in piping
- K term applies to minor losses in fittings

Daniel Bernoulli – Bernoulli Principle

Presented by: Billy Ernst

PIPE-FLO Software Calculations

- **Boiler to Condenser**
  - dZ = 58 in. (Hydrostatic Head)
  - Minor Losses (Two 90° Elbows) – Major losses (L = 72 in.)
  - With an internal pressure in the boiler of 50 psi and using ½” PVC, the flow rate will be 39.04 GPM
  - A throttling valve will be used to model the turbo expander and provide the pressure drop and decrease the flow rate to the required 3 GPM

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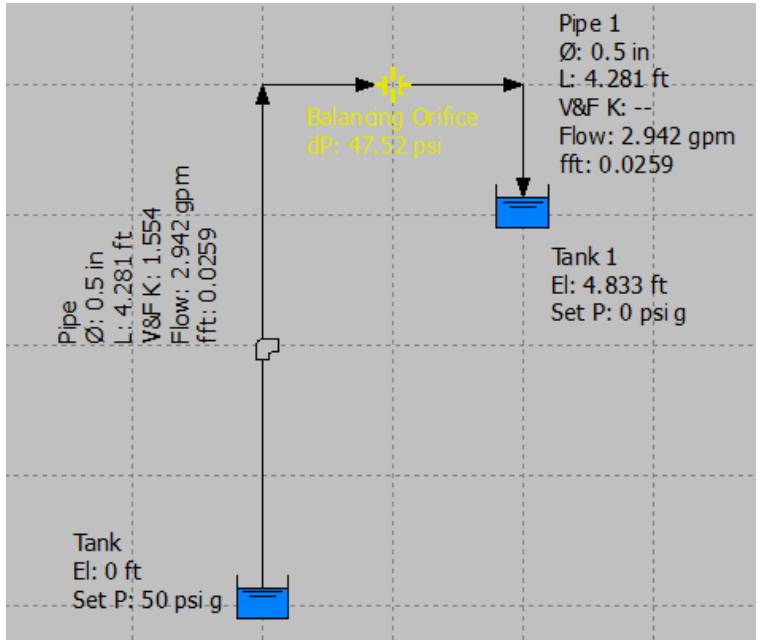


Presented by: Billy Ernst

PIPE-FLO Software Calculations

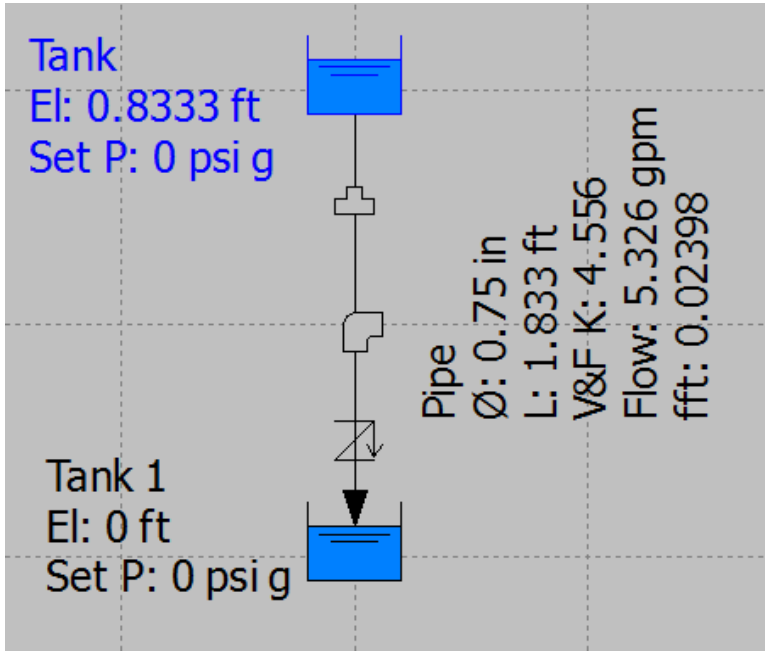
- **Condenser to Holding Tanks**
  - Flow rate will be gravity driven
  - dZ = 22 in. (Hydrostatic Head)
  - Minor Losses (One 90° Elbow, 1 Tee, One Check-Valve) (To each tank)

  - Using ½” PVC, GPM (max) = 2.86 GPM

  (Not sufficient for design flow rate of 3 GPM)

  - Using ¾” PVC, GPM (max) = 5.33 GPM

  Therefore ¾” PVC must be used

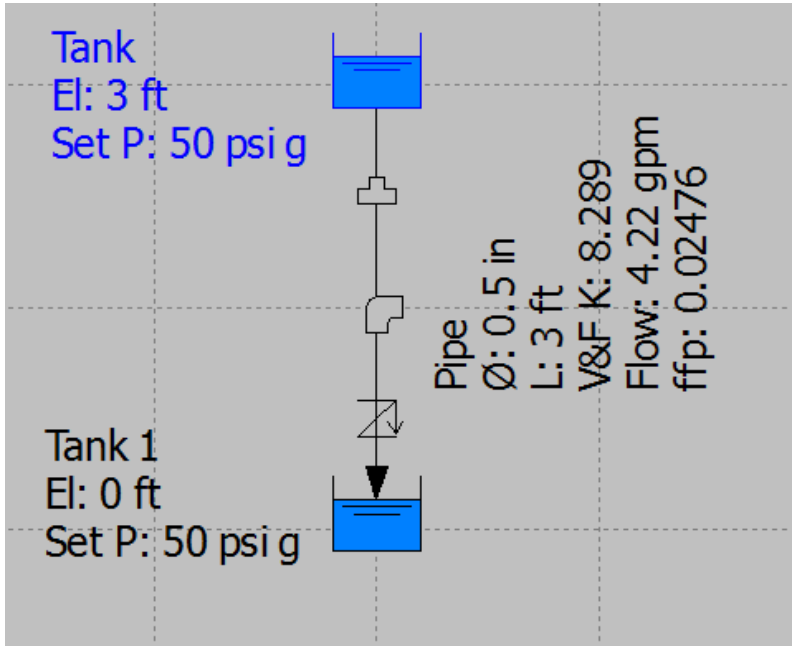


Presented by: Billy Ernst

PIPE-FLO Software Calculations

- **Holding Tanks to Boiler**
  - Flow rate will be gravity driven
  - dZ = 36 in. (Hydrostatic Head)
  - Minor Losses (Two 90° Elbows, 1 Tee, One Check Valve)(To each tank)
  - Using ½” PVC, GPM (max) = 4.22 GPM

  Therefore ½” PVC must be used along with a throttling valve to restrict the flow down to 3 GPM



Presented by: Billy Ernst

Components of Design

- **Boiler**
  - Pittsburgh Automotive 6.25 Gallon Oil Extractor
  - Pressurized vessel in our system (50 psi)

- **Condenser** (Changed)
  - Ace / DenHartog 3 Gallon Rectangular Specialty Rinse Tank
  - Changed = 5 Gallon Tank has 8-10 week lead time
  - Thickness: 1/4 in. (Allowing for modifications)
  - Non-pressurized vessel in our system

- **Holding Tanks**
  - 6 in. Acrylic Tubes (Walls)
  - 2 – 3 in. Acrylic Sheet (End Caps)
  - Needs to be constructed by the team
  - Pressurized vessel in our system (50 psi)

Presented by: Samantha Zeidel

Manufacturing/Machining Approaches

- **Boiler**
  - All modifications will be done at Verdicorp machine shop
  - Top of oil extractor must be modified
  - Components must be removed to insert ½ in. PVC and two 1/8 in. Stainless Steel tubing
  - Bottom of tank must be modified to insert ½ in. PVC from holding tanks

- **Condenser**
  - All modifications will be done at Verdicorp machine shop
  - Holes must be cut into top and bottom of condenser for pipe inlets/outlets

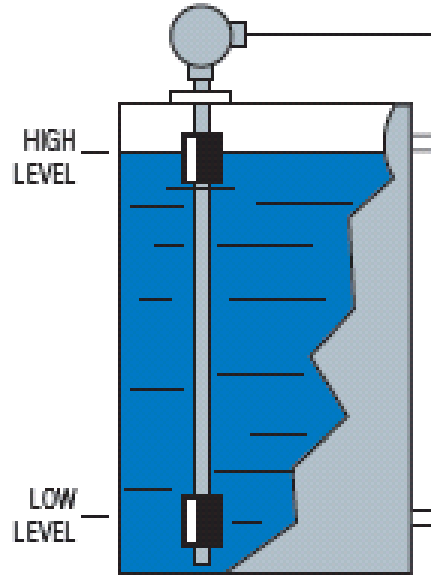
- **Holding tanks**
  - Will be made from 6 in. Acrylic tubes (Walls) and 2-3 in. Acrylic sheet (End Caps)
  - Top and Bottom end caps will be threaded and attached to the ends of the tubes
  - All holes for valves and switches will be drilled and threaded by machinist at Verdicorp

Presented by: Samantha Zeidel

Components of Design

- **Control Valves**
  - Parker Pneumatic Single Solenoid, 3-way, 2-position, NC
  - Air Control Valve; Port Size: 1/8 in. NPT
  - Voltage: 24 VDC

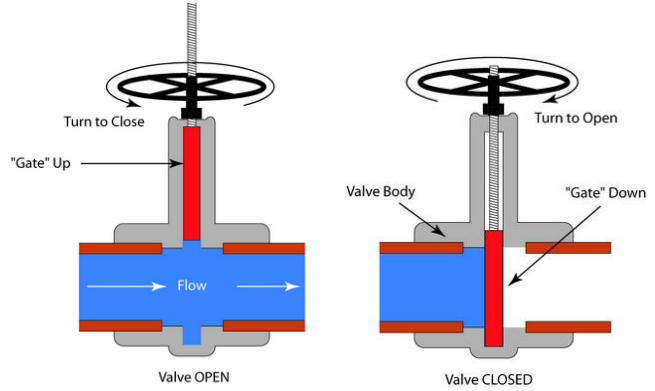
- **Sensor** (Possibly Changing)
  - Gems LS-300 Series Multi-Point Level Switch
  - Simple and efficient way of monitoring water levels
  - Very expensive due to customization
  - Other Float Switch Sensors are being explored



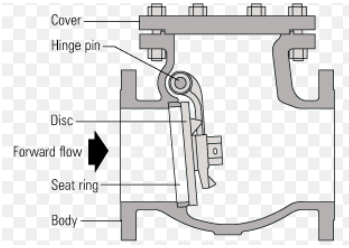
- **Relay**
  - Provided by Verdicorp
  - Voltage: 24 VDC (Control Valve voltage)

Presented by: Samantha Zeidel

Components of Design



- **Piping**
  - **Water Pipes:** ½ in. and ¾ in. PVC Schedule 40
  - **Pressure Pipes:** 1/8 in. Stainless Steel Tubing



- **Throttle Valves (Plug Valves?)**
  - Homewerks Worldwide ½ in. Brass FPTxFPT Gate Valve
  - Threaded connection, Max Pressure = 125 psi

- **Check Valves**
  - Homewerks Worldwide ½ in. and ¾ in. Lead Free Brass FPTxFPT Swing Check Valve
  - 1/8 in. Ingersoll-Rand/Aro NPT Check Valve
  - Threaded connection, Max Pressure = 200 psi

- **Pipe Fittings**
  - Mueller Streamline ½ in. and ¾ in. PVC SCH 40 SxS 90° Elbow
  - Mueller Streamline ½ in. and ¾ in. PVC SCH 40 SxSxS Tee

Presented by: Samantha Zeidel

Environment and Safety

- ORC Environmental benefits
    - Reduces the amount of CO_2 emissions
    - Refrigerant 245fa is non-flammable and long-lasting

- Safety Risks
    - Irritation with eye contact
    - Dizziness and increased heart rate if inhaled
    - Testing and calculations will be done with water and compressed air

Presented by: Samantha Zeidel

Project Procurement (By December 6th)

Part #	Component	Product Description	Quantity	Vendor	List Price (Each)	Status
1	Heat Exchanger	6.25 Gallon Oil Extractor	1	Harbor Freight Tools	$134.99	Received
2	Condenser	Ace / DenHartog 3 Gallon Rectangular Specialty Rinse Tank	1	The Tank Depot (Online)	$33.99	Ordered
3	Holding Tanks	6” Acrylic Tubing (Walls) 2-3” Acrylic Sheet (End Caps)	2	N/A	N/A	Pending
4	Throttle Valve 1	1/2” Brass FBTxFBT Gate Valve	2	The Home Depot	$6.35	Received
5	Throttle Valve 2	3/4" Brass FBTxFBT Gate Valve (Possible Inclusion – Pending)	1	The Home Depot	$7.73	Received
6	Check Valve 1	1/2" Lead Free Brass FPTxFPT Swing Check Valve	2	The Home Depot	$7.02	Received
7	Check Valve 2	3/4" Lead Free Brass FPTxFPT Swing Check Valve	2	The Home Depot	$9.41	Received
8	Check Valve 3	1/8” INGERSOLL-RAND/ARO NPT Check Valve	2	Grainger Industrial Supply	$18.97	Received
9	Control Valve	Parker Air Control Valve Single Solenoid, 3-way, 2-pos, 1/8” NPT	2	Global Industrial (Online)	$51.95	Ordered
10	Sensor	LS-300 Series Multi-Point Level Switch	2	Gems Sensors & Controls (Online)	$163.60	Pending

Presented by: Ryan Laney

Project Procurement (By December 6th)

Part #	Component	Product Description	Quantity	Vendor	List Price (Each)	Status
11	Relay	Provided by Verdicorp	2	Verdicorp	$0	Received
12	Pressure Line	1/8” x 6’ Stainless Steel Tubing	~11 ft.	Grainger Industrial Supply	$23.70	Ordered
13	Water Pipe 1	1/2" x 10’ PVC Schedule 40 Plain-End Pipe	~16 ft.	The Home Depot	$1.81	Received
14	Water Pipe 2	3/4" x 10’ PVC Schedule 40 Plain-End Pipe	~6 ft.	The Home Depot	$2.28	Received
15	Water Pipe Elbow 1	1/2” PVC Pipe 90° Elbow	5	The Home Depot	$0.46	Received
16	Water Pipe Elbow 2	3/4” PVC Pipe 90° Elbow	2	The Home Depot	$0.46	Received
17	Water Pipe Tee 1	1/2" PVC Pipe Tee	1	The Home Depot	$0.47	Received
18	Water Pipe Tee 2	3/4” PVC Pipe Tee	1	The Home Depot	$0.47	Received
19	Air Compressor	Porter-Cable 3.5 Gallon 135 psi Pancake Compressor	1	The Home Depot (Online)	$99.88	Ordered

Presented by: Ryan Laney

Financial Analysis

- Overall Budget: $2000

- Estimated Expenditure (so far): $840.92
  - Excludes tax on items; Excludes shipping and handling
  - Piping Components (Pipes, Standard Valves, Fittings): $140.96
  - Components (Boiler, Condenser, Control Valves, Relay, Air Compressor): $372.76
  - Sensors: $163.60 (each) = $327.20
  - NOT INCLUDED: Acrylic Material for Holding Tanks = $$$

- Analysis of cost savings for implementation into the actual ORC to be included in final report

Presented by: Ryan Laney

Project Summary

- Final Design
  - Final design concept has been finalized
  - Modifications may need to be made after prototyping and testing has been completed

- Project Components
  - Almost all components have been selected and will be used pending that the prototype works sufficiently during testing
  - All components will be purchased/ordered before the end of this week

Presented by: Ryan Laney

Future Plans for January 2014

- All components and materials for the prototype should be received
- Construct and machine parts and components that require modification
- Start building and testing individual portions of the system
- Begin construction of the entire prototype
- Analyze the operation of the prototype and make any warranted improvements

Any Questions??

Presented by: Ryan Laney