Project Plans & Product Specifications

Project #17: Shuttle Valve

Deliverable #2

Group Members:

Ryan Laney –Team Leader

Billy Ernst – Team Webmaster

Samantha Zeidel – Team Treasurer

Sponsor:

Verdicorp Inc.

Robert Parsons

Faculty Advisor:

Dr. A. Krothapalli

Date Submitted:

Friday, October 11, 2013

Contents

Problem Statement

Renewable energy, also known as “green” energy, has been the focal point for many present day industries. There are many ways of achieving this goal, including modifying existing technologies in order to improve their efficiency. Verdicorp Inc. is one such company that is at the forefront of developing next generation clean technologies for existing systems [1]. The objective of this project is to increase the efficiency of the Organic Rankine Cycle (ORC) system developed by Verdicorp Inc. This will be achieved by decreasing the parasitic losses within the system by removing the pump and replacing it with a shuttle valve system.

Therefore, the purpose of this project is to design a shuttle valve to be used in ORC systems. These systems are used for producing electrical energy from waste and low grade heat. The concept for the shuttle valve is to transfer liquid from the low pressure side of an ORC to the high pressure side without the aid of a pump. The end goal will be to design a simple, inexpensive system that can be incorporated into existing ORC’s. The benefit of a successful outcome will be to decrease the energy consumption of the existing systems and increase the efficiency and overall profit for the consumer.

Project Scope

Verdicorp Inc. has improved a revolutionary power generation system (Figure 1) that converts low grade waste heat into electrical energy. Organic Rankine Cycle systems can best be described as a refrigeration cycle running backwards. Instead of using electrical energy to produce cooling, this system takes heat from a low grade source and turns it into electrical energy. The power is then phase matched to meet the local electrical grids.

Figure 1. Picture of one of Verdicorp’s Organic Rankine Cycles.

Verdicorp Inc. uses the environmentally friendly refrigerant 245fa. The refrigerant is heated from the waste heat in a series of heat exchangers and sent into a turbo generator. The refrigerant spins a turbine blade which turns an electrical generator, producing electrical power. Once the fluid passes through the turbine it then goes through a condenser and back to the pump to be recirculated through the system. The pump is a parasitic loss which consumes electrical energy and lowers the overall efficiency of the ORC. The design team is to mitigate this effect with the insertion of the shuttle valve system.

The final prototype must be incorporated into the existing ORC system in place of the original pump. The prototype must maintain a constant flow rate of 3 gallons per minute through the use of multiple storage vessels. It should sufficiently decrease the amount of electrical waste compared to the original pump. The physical model will use water, but the calculations will be based on both water and refrigerant 245fa since the ORC system will use the refrigerant. The overall expectation of the end product is to increase the efficiency of the existing ORC system.

Project Objectives

- Design a shuttle valve system to replace the pump within the ORC.
- Maintain the continuous flow of liquid within the ORC.
- With the use of solenoid valves and the aid of gravity, adjust the pressure inside the vessels up and down by balancing the gas pressure.
- Transfer the liquid from the low pressure side of the system to the high pressure side.
- Minimize parasitic losses in the system, i.e. use a very small pump or no pump at all, effectively minimizing the electrical consumption of the system.
- Confirm on a final design concept by mid-October 2013.

Methodology

The design process for our team should follow a particular schedule. The early stages of our design should include a full understanding of every element of the system we are analyzing and modifying. This should include research on the ORC, the properties of refrigerant 245fa, and different types of valves and flow regulators. After research is done, each team member should come up with their own theoretical design. Our sponsor specifically asked for a decision matrix, consisting of at least one design concept from each member. This decision matrix should be used to choose a final design. We were asked by our sponsor to decide on a final design by mid-October.

Once we have decided on a design, we should then come up with the appropriate measurements in order to simulate it. We will do this by building a model using CAD Software. Once we construct and simulate our design with CAD Software, we should purchase the required materials and build a physical prototype. Using the prototype, we can test our system, enabling us to analyze any relevant data. In order for consistency in data analysis, we will conduct any required tests several times. Once our data shows that our objectives have been completed, our project will be ready to present to our sponsor who expects to incorporate this prototype into their marketed physical systems.

Project Constraints

- The overall design budget is limited to $2000.
- The prototype developed by the senior design team must use water in place of refrigerant 245fa, which is the fluid used in the actual system. Our design team is prohibited to use this product by the FAMU-FSU College of Engineering because of its possible health hazards.
- The fluid within the system must maintain a constant flow rate, with an approximated flow rate of 3 gallons per minute.
- The design must be as small as possible, with a 2 meter height restriction in place.
- The system must contain numerous vessels which contribute to the constant flow rate. A system containing only one vessel would be considered a failed prototype to the sponsor company.
- The modified system must use minimal, to preferably no, electricity.
- The system must be completely closed to prevent any losses in the amount of refrigerant 245fa used in the system.
- The system must contain pressure gages to indicate the changes in pressure within the system; when and where the pressure is changing.
- The overall change in pressure within the system is restricted to a total of 50 psi.

Project Plans

A work breakdown structure (WBS) has been provided below; detailing all deliverables, tasks, and courses of action that are needed to ensure the success of the project in a time efficient manner. For a visual representation a Gantt chart has been provided to clarify the timeline for major deliverables and goals of the project which need to be achieved during the Fall 2013 semester.

WBS Fall 2013 Semester

- **Start:** August 26th, 2013
- **Formation of Design Team**
  - Weeks 1 - 3
  - Selection of Senior Projects (Aug. 29th)
  - Introduction to group members; establishes good lines of communication; devising a schedule for meetings outside of class (Sept. 3rd)
  - Complete/Submit a Code of Conduct (Sept. 5th)
  - Complete/Submit a REVISED Code of Conduct (Oct. 4th)
  - Ice-Breaker Project: Work together as a team for the first time, making sure team chemistry is good and the team is time-efficient (Sept. 3rd-10th)
  - Initial contact with senior design sponsor (Sept. 13th)
    - Sponsor: Robert Parsons (Verdicorp INC.)
    - Email: rob.parsons@verdicorp.com
    - Set up initial meeting the following week at Verdicorp facilities located in Tallahassee (1 PM on Sept. 18th)
- **Needs Assessment**
  - Weeks 4 – 5
  - Initial meeting with sponsor (Sept. 18th) to discuss overall project goals and expectation, and to also gather necessary information to complete the first deliverable of the project
  - Prepare/complete first deliverable: Needs Assessment Report
  - Due: Friday, Sept. 27, 2013
- **Concept Generation and Research**
  - Weeks 6 – 8
  - Second meeting with sponsor (Sept. 30th) to clarify components of the general design in order to start individual design concept generation
  - Personal/team research amongst team members to generate designs that fit all necessary constraint and parameters established by the sponsor
- **Project Plans and Product Specifications**
  - Weeks 6 – 7
  - Second meeting with the sponsor (Sept. 30th) will allow the team to gather the necessary information to complete the second deliverable of the project
  - Prepare/complete second deliverable: Project Plans and Product Specs
  - Due: Friday, Oct. 11th, 2013
- **Website (Construction/Maintenance/Completion)**
  - Weeks 8 – 16
  - Prepare/complete third deliverable: Initial Web Page Design
  - Due: Friday, Sept. 18th, 2013
  - The website must be updated and maintained with all major deliverables and goals of the project throughout the remaining semester.
  - Prepare/complete the ninth deliverable: Final Web Page Design

- Due: Tuesday. Nov. 26th, 2013

- **Concept Selection and Confirmation**
    - Week 8
    - With aid of a decision matrix, all individual design concepts will be analyzed by the team and selection of the best (or top choices) will then be presented to the sponsor for their critique and confirmation.
    - CAD drawings of the final selection(s) must be made.
    - Third sponsor meeting will be held during week 8 to accomplish this task in time
- **Midterm 1 Presentation/Report**
    - Weeks 7 – 9
    - Prepare presentation of project progress up until Week 9 of the semester: project scope, goals, design conception and selection
    - Prepare/complete fourth deliverable: Midterm 1 Presentation
    - Presentations will take place on Tuesday, Oct. 22nd and Thursday, Oct. 24th
    - Prepare/complete fifth deliverable: Midterm 1 Report
    - Due: Friday, Oct. 25th, 2013
- **Ordering of Parts/Components**
    - Weeks 10 – 16
    - With a selection of a final design and confirmation by the sponsor, the team can now order the necessary parts and components which will be needed to construct the prototype during the spring semester
- **Simulation and Analysis of Final Design**
    - Weeks 10 – 16
    - Simulation and analysis of the final design with the use of computer programs will be implemented in these weeks to make sure that the prototype will be ready for construction in the Spring semester without anything that could possibly delay the progress of the project
- **Midterm 2 Presentation**
    - Weeks 10 – 13
    - Prepare presentation of project progress up until Week 12 of the semester: Analysis of components/part needed for the final design; update on any information not presented during the Midterm 1 presentation
    - Prepare/complete seventh deliverable: Midterm 2 Presentation
    - Presentation will take place on Tuesday, Nov. 12th and Thursday Nov. 19th
- **Peer Evaluations**
    - Week 10 and Week 14
    - Prepare/complete sixth deliverable: Peer Evaluation 1
    - Due: Tuesday, Oct. 29th, 2013
    - Prepare/complete eighth deliverable: Peer Evaluation 2
    - Due: Tuesday, Nov. 26th, 2013

- **Final Design Presentation/Report**
    - Weeks 13 - 15
    - Prepare presentation of project progress up until Week 15 of the semester: final design analysis and explanation, actions to be taken next semester, and anything accomplished during the entire semester.
    - Prepare/complete tenth deliverable: Final Design Presentation
    - Presentations will take place on Tuesday, Dec. 3rd and Thursday, Dec. 5th
    - Prepare/complete eleventh deliverable: Final Design Report
    - Due: Friday, Dec. 6th, 2013
- **End:** December 13th, 2013

Assignment of Resources

In regard to selecting members to the tasks presented in the work breakdown structure and displayed in the following Gantt chart, the following actions will be taken:

- Every team member will participate in all major components of the project. The team must work effectively and efficiently to finish all of the tasks presented by their desired due dates. Individual tasks will begin in Week 6 as the team begins to generate various design concepts individually to be analyzed by a decision matrix in Week 8 with the task of selecting a final design to pursue.
- The team leader (Ryan Laney) will handle all scheduling and communication with the team and also with the team and sponsor. It is their main objective to keep the team working effectively and efficiently throughout the remainder of the semester.
- The team webmaster (Billy Ernst) will hold the responsibility of maintaining the website with the aid of their fellow team members. This includes having an initial web page design created by Sept. 18th, maintenance throughout the semester, and a final web page design completed on Nov. 26th.
- The team treasurer (Samantha Zeidel) will hold the responsibility of maintaining the projects financial budget with the aid of their fellow team members. This will come into effect during Week 10 when the project's components and necessary parts will begin to be researched and purchased.

Product Specifications

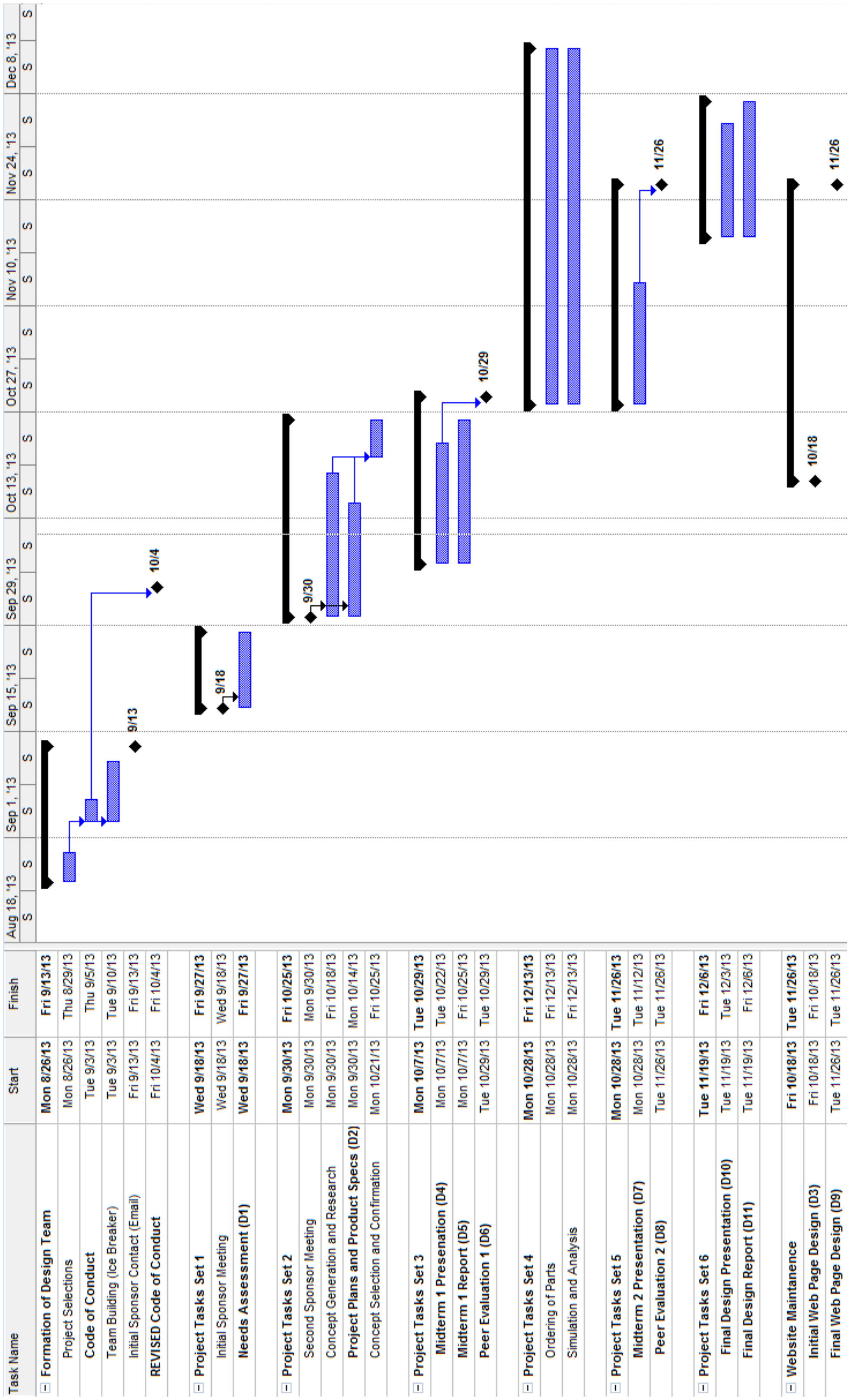
• Design Specifications

1. The entire system must have a maximum height of 2 meters.
2. The length and width of the system are to be reasonable compared to the height but their exact dimensions are not critical.
3. All system components must be able to withstand an internal pressure of 75 psi (the design pressure with a safety factor of 1.5).
4. Power required should be minimal (enough to run a small circulation pump).
5. Components include: Pressure vessels (boiler and condenser), orifice (for pressure drop), holding tanks, check valves, control valves, small circulation pump, pressure indicators, air compressor (pressure source), Schrader valve, PVC pipe and fittings, controller (PLC).

• Performance Specifications

1. Reduce work input from 10% to about 2% of the total work produced by eliminating a high pressure pump.
2. Float sensors must control when to open and close specific control valves to balance system pressure with the aid of a PLC.
3. Pressure indicators must display the working pressure at significant points in the system.
4. Must operate between a pressure differential of 50 psi within 10%.
5. Maintain a flow of 3 gal/min.

Gantt Chart


Task Name
Start
Finish
Aug 18, '13
Sep 1, '13
Sep 15, '13
Sep 29, '13
Oct 13, '13
Oct 27, '13
Nov 10, '13
Nov 24, '13
Dec 8, '13
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
Project Tasks Set 4 Mon 10/28/13 Fri 12/13/13
Ordering of Parts Mon 10/28/13 Fri 12/13/13
Simulation and Analysis Mon 10/28/13 Fri 12/13/13
Project Tasks Set 5 Mon 10/28/13 Tue 11/26/13
Midterm 2 Presentation (D7) Mon 10/28/13 Tue 11/12/13
Peer Evaluation 2 (D8) Tue 11/26/13 Tue 11/26/13
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
9/13
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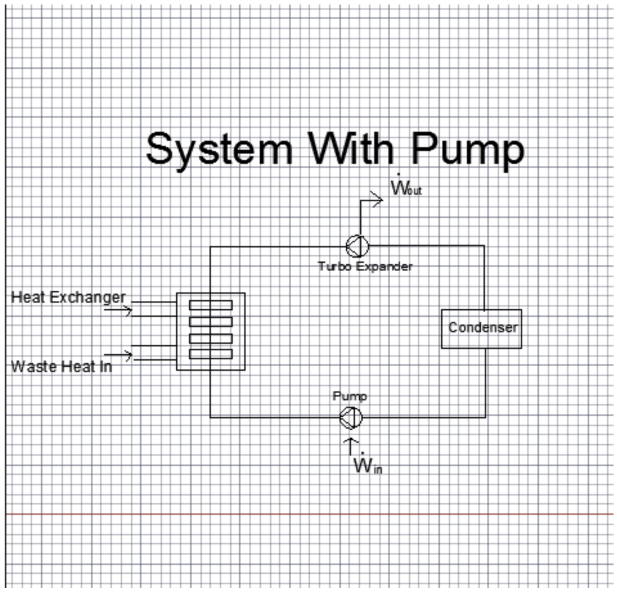
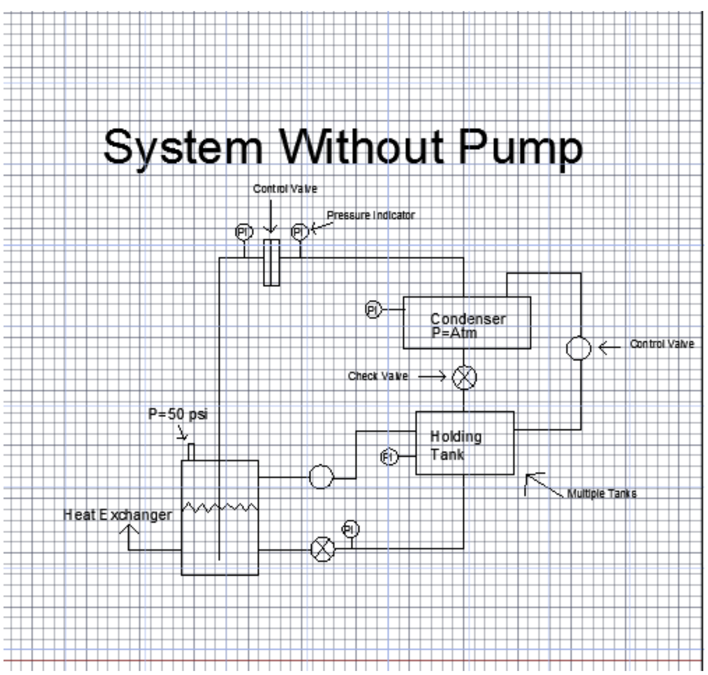
11/26

General Design Layout (CAD)





References

[1] "Verdicorp Environmental Technologies," Verdicorp INC., [Online]. Available: http://verdicorp.com/. [Accessed 18 September 2013].