Project Plans and Product Specifications Report

Design and Development of an Automated Continuous Harvesting System for Microalgae Photobioreactors

Team Number: Group 9, FIPSE: UFPR - FSU Senior Design
Submission Date: October 9, 2015
Submitted To: Dr. Nikhil Gupta
Authors: Kaelyn Badura[α], Ben Bazyler[β], Courtnie Garko[β], Yuri Lopes[β], Tomas Solano[α]

α – Department of Mechanical Engineering, UFPR – Universidade Federal do Paraná
β – Department of Mechanical Engineering, FSU – Florida State University

CONTENTS PAGE

Page#

Table of Contents

Page #

Problem Statement

As a result of waning fossil fuel resources it is desirable to have access to a sustainable alternative energy source. Microalgae photo bioreactors are viable options for simple and sustainable energy source production. The operation of these bioreactors has the potential for automation and produces environmentally friendly biomass and biogas which have many widespread applications, as aforementioned. The current state of microalgae photo bioreactors is very dependent on consistent maintenance and check-ups to keep the algae growing. In addition, there are no viable methods for automated harvesting of the microalgae. This is unsatisfactory because it limits the scope of utilizing microalgae as a large scale biofuel source. UFPR in conjunction with FSU are sponsoring the Senior Design team to develop a continuous harvesting system which requires minimal intervention as a solution to the harvesting problem.

Project Scope

The goal statement specified within a project outlines the general aims of the project. For Group 9, the FIPSE: FSU – UFPR Senior design team, the goal statement is given below.

Goal Statement: "**Design of an automated and continuous harvesting system for microalgae**"

Project Objectives

Objectives are tangible milestones against which to gauge progress and quantify success in fulfilling the outlined goal. The relevant objectives for the design of an automated and continuous harvesting system for microalgae are defined below.

<u>Objectives:</u>

- Biomass production process must be fully automated.
- From cultivation through collection and flocculation to separation.
- System must have ability to separate produced biomass and clarified water.
- Must work for batch, semi continuous, and continuous collection.
- Must incorporate continuous flocculation and sedimentation.
- Must be sustainable, both in construction and in process.
- Minimized energy and resource consumption.
- System must be scalable and will show functionality at both lab and pilot scales.
- Harvesting system will work with different species of algae.

Methodology

The design of an automated microalgae cultivation and separation system consists of 3 major components. These are the control for the automation of the system, the control is composed of the microcontroller, source code, and actuators. The other two parts are the flocculation system and the separator/clarifier tank.

The design process of these systems starts with literature review. Reading and compiling an ample library of relevant research that will aid or guide us through the design of these systems. The literature agglomeration will also include papers that will give us insight to what the problems in the industry are that limit these systems. The literature will teach us about the microalgae cultivation, something necessary to have as background knowledge in order to proceed. Once this material is well understood, a review on flocculation along with design of clarifiers will enable our creative process to begin.

Following the literature review a lab scale prototype design of the systems will commence. This will include breaking down the systems into the major or important components. Once the components have been identified, research on how the components operate how these can be substituted or omitted completely if possible, will be conducted. Taking advantage of the five group members each member of the team will present his or her own unique ideas and designs for each component. Once the designs have been completed, according to schedule (Table 1 and Figure 1), the decision on which will design will be used will be finalized. This decision will be reached with the aid of a morphological method of design decision and a pugh matrix. This tools will help us narrow our decisions to two top designs, from which in a democratic vote one will be chosen after an in depth discussion on them. A house of quality will help us during the design process by showing the importance of each requirement and characteristic going into the design (Figure 2).

Due to the nature of the project; i.e the group, as well as the equipment is split between two countries; different tasks or stages of the project will be completed by each part of the team. The team as a whole will take part in the design process for the prototype the first semester. Once the design has been finalized, a lab scale prototype will be built in order to prove its viability and allow for testing to later be optimized. The building of this prototype will be done in Brazil by the two group members located there. While the building of the prototype is underway the Tallahassee group members will start setting up micro algae cultivation equipment and cultivating microalgae to then run a trial inoculation of a mini photobioreactor. The mini photobioreactor will be used to scale up the designs next semester (Spring 2016).

Starting the 2016 Spring semester, the entire team will be in Tallahassee and the scaling up, optimization, and final system will be completed.

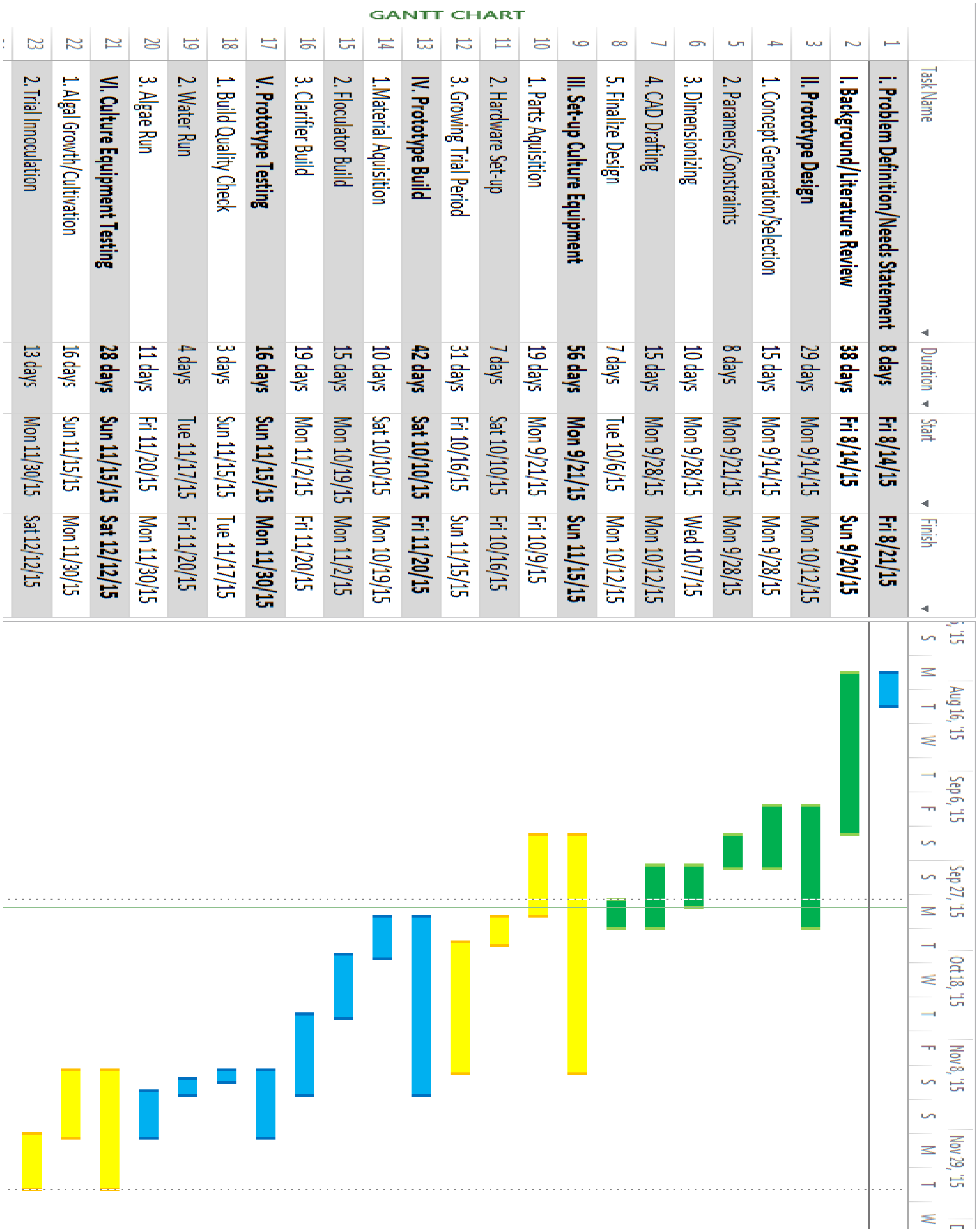
Project Constraints

These are the requirements that potential designs must meet in order to be considered legitimate and appropriate designs.

Constraints:

- The developed system must work with FSU’s current skeleton photobioreactor infrastructure.
- The total cost may not exceed $1,500.
- The clarified medium must be recyclable.
- The produced biomass must remain usable.
- The entire system’s flow rate will be dictated by the growth rate of the utilized microalgae. The growth rate of each algae is different and therefore the system must be able to adapt.

Deliverables



	Task Name	Duration	Start	Finish
1	**I. Problem Definition/Needs Statement**	**8 days**	**Fri 8/14/15**	**Fri 8/21/15**
2	**I. Background/Literature Review**	**38 days**	**Fri 8/14/15**	**Sun 9/20/15**
3	**II. Prototype Design**	29 days	Mon 9/14/15	Mon 10/12/15
4	1. Concept Generation/Selection	15 days	Mon 9/14/15	Mon 9/28/15
5	2. Paramers/Constraints	8 days	Mon 9/21/15	Mon 9/28/15
6	3. Dimensionizing	10 days	Mon 9/28/15	Wed 10/7/15
7	4. CAD Drafting	15 days	Mon 9/28/15	Mon 10/12/15
8	5. Finalize Design	7 days	Tue 10/6/15	Mon 10/12/15
9	**III. Set-up Culture Equipment**	**56 days**	**Mon 9/21/15**	**Sun 11/15/15**
10	1. Parts Aquisition	19 days	Mon 9/21/15	Fri 10/9/15
11	2. Hardware Set-up	7 days	Sat 10/10/15	Fri 10/16/15
12	3. Growing Trial Period	31 days	Fri 10/16/15	Sun 11/15/15
13	**IV. Prototype Build**	**42 days**	**Sat 10/10/15**	**Fri 11/20/15**
14	1.Material Aquisition	10 days	Sat 10/10/15	Mon 10/19/15
15	2. Floculator Build	15 days	Mon 10/19/15	Mon 11/2/15
16	3. Clarifier Build	19 days	Mon 11/2/15	Fri 11/20/15
17	**V. Prototype Testing**	**16 days**	**Sun 11/15/15**	**Mon 11/30/15**
18	1. Build Quality Check	3 days	Sun 11/15/15	Tue 11/17/15
19	2. Water Run	4 days	Tue 11/17/15	Fri 11/20/15
20	3. Algae Run	11 days	Fri 11/20/15	Mon 11/30/15
21	**VI. Culture Equipment Testing**	**28 days**	**Sun 11/15/15**	**Sat 12/12/15**
22	1. Algal Growth/Cultivation	16 days	Sun 11/15/15	Mon 11/30/15
23	2. Trial Innoculation	13 days	Mon 11/30/15	Sat 12/12/15

Assign Resources

As far as assignment allocation goes, Kaelyn and Tomas will be responsible for the design of the clarifier and extractor as well as the means by which the recycled medium will be sent back to the photo bioreactor for reuse. Yuri, Courtnie and Benjamin will be responsible for the design of the coagulation and flocculation mixing mechanisms and the means by which the photo bioreactor will be connected to the mixing mechanisms. Both parties will be responsible for growing microalgae in their respective locations in order to conduct experiments.

Product Specifications

Design Specifications:

At the moment, the only limiting engineering feature of this design is the size of the system. For this project, our goal is to have two fully functioning systems of varying size. The first system will be designed for collegiate purposes and will be restrained to the size of an average table so that universities can use the device in a simple lab setting. The second device will be created for quasi-industrial purposes and will make use of a mini-photo bioreactor.

The purpose of creating these two devices is to test the scalability of the device and to see if any drastic changes need to be made depending on the size of the system. For example, one limiting agent when dealing with a larger scale for photo bioreactors is the amount of light that can reach the algae based on the diameter of each tube and the distance between each tube.

Currently there is no concern with constraints such as stress, load, power and weight because no constraints were given in the problem statement. In the design process, we will still be mindful of these aspects in order to be good stewards of our resources but we will not spend the majority of our time on optimizing the system. The purpose of this project is to simply make the system operational at various sizes without the assistance of people. If in the future another team or company desires to optimize the weight, size or power of the system, by all means, let them do so.

Performance Specifications:

As far as expectations go, the only expectation for this project is to create a fully functioning autonomous photo bioreactor biomass extractor that is capable of being used on various levels of size. In the same way that no concerns were addressed toward the design specifications, no concerns were addressed toward the performance specifications. Thus, we will not spend the majority of our time trying to optimize the efficiency of the system but will instead spend our time ensuring that our device is operational at various magnitudes of size.