Product Specification and Project Schedule

EML 4551C – Senior Design – Fall 2011 Deliverable

Team # 11

Richard Carter, Robert Rantz, Angela Silva, Wayne Weatherford
Department of Mechanical Engineering, Florida State University, Tallahassee, Florida

and

Felipe Merss
Department of Mechanical Engineering, Federal University of Paraná, Curitiba,Brazil

Project Advisors
Dr. Juan Ordonez
Department of Mechanical Engineering, FSU

Dr. José Vargas
Department of Mechanical Engineering, UFPR

Reviewed by Advisor:

Introduction

The goal of this project is to harvest the wasted energy and exhaust gases produced from an existing trigeneration unit for use in cultivating algae in a photobioreactor. The trigeneration unit operates by virtue of an internal combustion engine, and thus produces the typical waste products: carbon dioxide, carbon monoxide, and various nitrogen compounds. These products can be supplied to a photobioreactor to accelerate the algal growth, and the heat lost via the exhaust could be (further) utilized as a source of energy.

Trigeneration System

The trigeneration system is a product from a previous senior design team, and has been modified by a subsequent team to utilize liquid propane as a fuel source. This system produces electricity, hot water and a refrigerated space. It is comprised of a 16-HP Honda engine coupled with an electrical generator, an absorption refrigerator, and a helical heat exchanger. Waste heat present in the exhaust gases powers the refrigeration and heats water circulated through the heat exchanger and an insulated storage tank. At present, the trigeneraton system is in disrepair. The exhaust piping is badly corroded and much of it is missing, along with sections leading water to and from the heat exchanger. The original hot water pump has been removed but is operational, excluding a missing gasket that waterproofs the inside. Most of the pipe insulation has been damaged or removed. This system needs to be brought back to operational condition before our gas coupler can be mounted to it. We will take this opportunity to suit the exhaust piping to our needs.

Coupling System

At the heart of this project lies the coupling system. A system must be designed to extract the waste gasses, allow them to reach an appropriate temperature, and feed them to the photobioreactor.

This is no simple task; combustion byproducts can be extremely corrosive at the temperature at which they are exiting the trigeneration unit and may be at too elevated a temperature. Furthermore, if the pressure head of the exhaust gas increases too much as a result of the coupling system, the combustion engine will not function properly. This effect is a particularly important consideration with this project, as the exhaust gas is already routed through several pipes in the trigeneration unit. Lastly, the byproducts that are contained in the exhaust gas may be very harmful to the algae, as they are to most animals. However, some research exists that suggests that direct application of waste combustion gasses is permissible; algae may even thrive in these conditions.

The waste gasses will exit the trigeneration system at an elevated temperature. If time and budget permits, this energy could be harvested to aid in the regulation of the photobioreactors' temperatures, as well as other purposes. In any case, it is very likely that the exhaust gasses will need to be cooled before entering the bioreactors to prevent a destructive temperature increase.

Photobioreactor & Algae Growth

The existing photobioreactor unit consists of three individual growth chambers. Each chamber is individually circulated by independent water pumps and supplied with CO_2 from pressurized tanks. The pH and temperature of the water medium are monitored digitally. The system must be outfitted so it may make use of the waste gasses. This may mean only modifying the gas inlets and tubing, or, depending on design complications, may result in an overhaul of the entire system.

Costs

Costs to repair the trigeneration system and construct a new bioreactor array must be weighed against the budget needs of the gas coupler itself. Reusing as much equipment as possible from the existing systems will help reduce these costs. This decision will be easier to make once monitoring and measurement equipment has been tested and a full parts list for repairs has been established.

Life Cycle Analysis

The planning stages of this project will be carried out simultaneously at two universities: Florida State University (FSU) in Tallahassee, Florida, and Federal University of Paraná (UFPR) in Curitiba, Paraná in Brazil. The team in Brazil has been assigned the task of completing a complete Life Cycle Analysis (LCA) of the much larger photobioreactor system located at UFPR. This research is used to determine the total ecological impact of creating a bioreactor system. The information and skills obtained by the team will be used to assess the viability of implementing the prototype system as a means of reducing engine emissions; if the system developed has too large a carbon footprint, it will obviously not be useful in this regard.

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