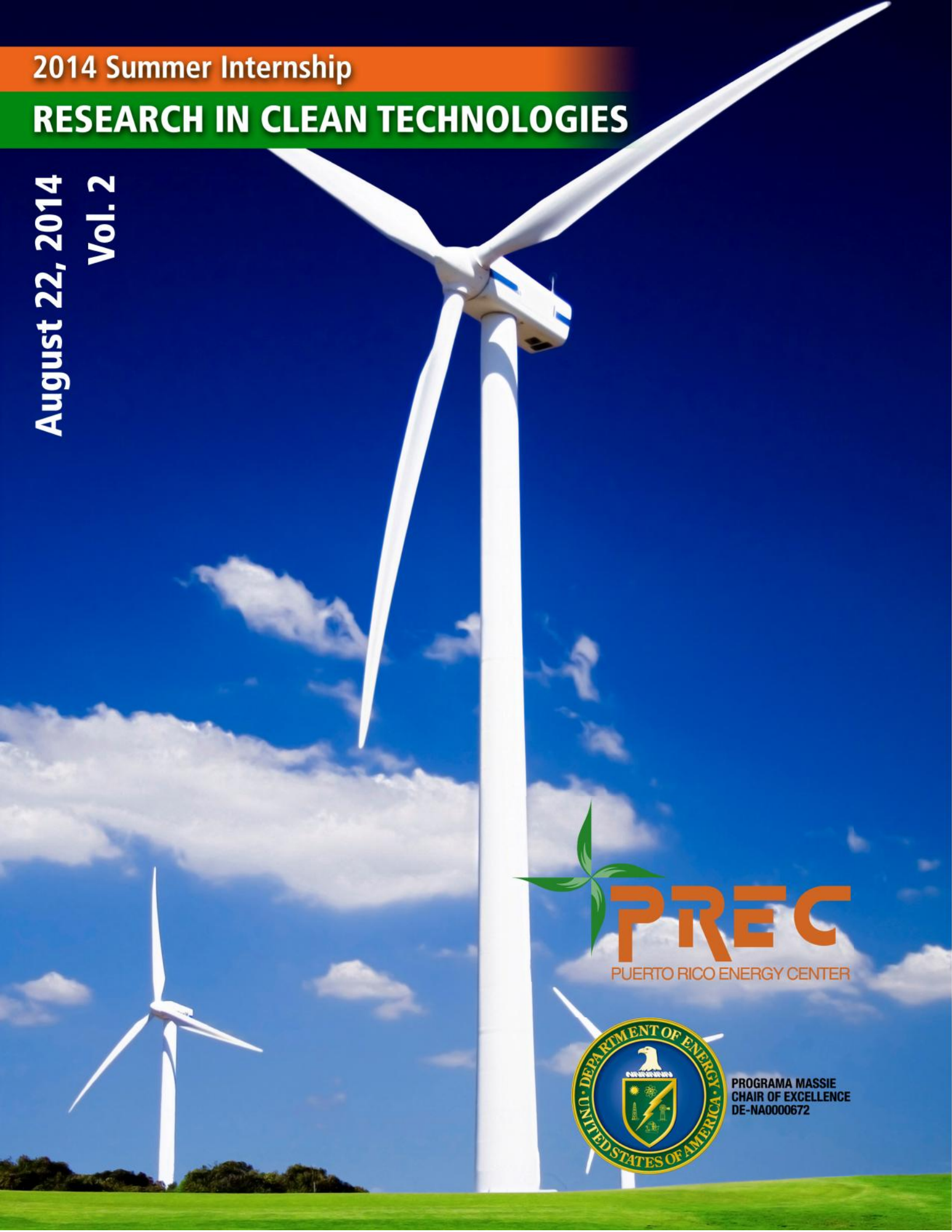
2014 Summer Internship

RESEARCH IN CLEAN TECHNOLOGIES

August 22, 2014
Vol. 2



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August 22, 2014

2014 Summer Internship

Research in Clean Technologies

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Preface

The success of the 5th Summer Research Internship on clean technologies is ascribed to the efforts of Puerto Rico Energy Center (PREC) and Universidad del Turabo with the sponsorship of the Samuel P. Massie Chair Program of Excellence of the Department of Energy (DoE). During eight weeks, thirteen students and eight mentors (professors, graduate students and industry representatives) participated conducting research on new technologies and solutions for solving the energy concerns that we face daily.

These proceedings include among others current issues of interest in areas such as biofuels, processes optimization, hydrogen production, nanotechnology . Seventeen proposals were reviewed by a multidisciplinary panel composed by professors and researchers of Universidad Interamericana, University of Puerto Rico and Universidad del Turabo. Sixty puertorican students applied pursuing a local internship experience.

We are grateful to the PREC team, to the Innovation and Commercialization Office and to the staff of Universidad del Turabo Vicechancellor Office for their contribution to accomplish successfully this experience.

Dr. Roberto Lorán
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Process analysis and tools development for ACT Global at Puerto Rico Energy Center

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ABSTRACT

ACT Global at Universidad del Turabo will help entrepreneurs develop their businesses in order to generate economic activity in the island of Puerto Rico. To support these activities, e-trainings related to operations improvement were created and published using Google Docs. The trainings created focus on the topics of Project Management, Lean Six Sigma, Lab Safety & Error Prevention and ISO 50001 related to the Energy Management QMS. These training are available on demand and can help any interested entrepreneurs in enhancing their knowledge and increase the competitive advantage of their companies. To enhance material comprehension and understanding the trainings were developed considering Bloom's taxonomy, and principles of error analysis. As a tool to measure the understanding of the topics, e-quizzes that were created to promote material comprehension and also published online, with successful completion of these earning a certification. The research will present the design considerations to create the training objectives, teaching materials and quizzes based on the recommend design principles.

Keywords: training, taxonomy, development, energy management, e-training

1. INTRODUCTION

The Puerto Rico Energy Center (PREC) has developed the ACT Global to accelerate companies that can develop economic activity and employment in the island. With the ACT Global support, companies can move their products to the manufacturability, distribution or deployment stage. These professionals must have some strategies to ensure compliant, cost effective and efficient operations from the design stage onward.

Operational Excellence tools can be useful to ensure operations that will maximize profitability and facilitate compliance. For an individual that has an idea it is important to have the tools required to ensure the end item will be able to be produced in the most economical and efficient manner. It will also be important to ensure that the activities required to research, design, produce and sell their ideas will be performed in time and with high quality. Since we are speaking of the term innovation, delays in developing the idea could risk the completion on time, thus allowing other competitors might be able to launch a similar product to the market.

The concept of acquiring knowledge is important, but for many starting entrepreneurs, it might not be feasible for them to enroll in formal courses due to monetary and time constraints, in that case, what are the alternatives? There are many online training and textbooks in these subjects that these persons can read, but are these materials didactical?

With this paper, the researchers evaluated the most relevant courses that persons related to ACT Global should take. With this evaluation, learning principles such as Bloom's taxonomy were taken into consideration to design trainings that are focus and will lead to material comprehension. The trainings are accompanied by an e-quiz that will verify knowledge and which successful completion leads to a certificate. These are free and on demand for participants of the program, allowing flexibility for learning.

An additional concept taken into consideration was the avoidance of errors as this topic can be of relevance for activities related to energy management practices in laboratory or research facilities. For these concepts, techniques to avoid human errors and accidents where considered for energy facilities and are integrated in the training.

The paper organization includes the review from literature that involves gathering information about Bloom's Taxonomy and Human Error Analysis. These topics will be used in order to create more focused and didactical learning materials. Additional literature review was performed to select the most related trainings based in the ACT's and PREC's objectives and available technology. With that information, some readings related to trainings design were also explored. The trainings and e-quizzes were then developed and the process utilized for its creation is discussed.

2. PROBLEM DEFINITION

Based on experience from the researchers in the project development stages at ACT Global, not all applicants have engineering or scientific backgrounds. Even those with these competencies might not be up to date with the most recent methods for process design and execution. Relevant topics for process improvement include Lean Six Sigma, which can help identify issues with both product variation and production flow. Another issues might arise once the product is within the development stage and multiple activities and resources are required; making the administration of limited resources imperative. Project Management tools are required to prepare the entrepreneurs with basic skills of resource allocation and control. Since developments presented at ACT Global are related to energy endeavors, knowledge of basic laboratory settings is important to ensure safety in any testing/qualification stages.

Since ACT Global projects are related to energy activities, these must also be aligned with quality practices within this sector, in this case with ISO 50001, the Energy Quality Management System (QMS). Some recommendations to adhere to the standard are shown within the training. This allows entrepreneurs to get an introduction to the topic and evaluate if their products should use this particular QMS.

From the Parliamentary Office of Science and Technology post note (2001) "Reducing accidents and minimizing the consequences of accidents that do occur is best achieved by learning from errors, rather than by attributing blame". Knowing what went wrong regarding how people perform a task can make systems more robust and less error prone. From the same article: "It has been estimated that up to 90% of all workplace accidents has human error as a cause. Human errors were a factor in almost all the highly publicized accidents, the cost in terms of human life and only are high." Errors can cost money, and even worse, human lives. It is the responsibility of persons in positions to create better and safer systems to use the best alternatives available to avoid these costs.

3. LITERATURE REVIEW

Human error is one of those subjects largely spoken of but seldom scientifically described. Hansen (2006) states that his term is part of the daily language and is intuitively understood by most people. However, it might have individual perceptions such as how it is caused, who caused it, is there any intention in it. The article states that human error is indeed inevitable. Human factors are a discipline aimed at studying the behavior of man in the

organizational environment to better understand their motivations and identify the causes of errors. The first studies were relevant the both physiological as well as those psychological/behavioral linked with aviation (Hansen, 2006) , establishing the base of modern flight medicine (attitude, fatigue, stress). Engineers typically view error as the difference between desired and actual performance.

Modern quality control speaks about manufacturing quality, and a similar philosophy should allow us to manufacture safety. In this way a good system should not allow people to make mistakes easily. This may sound obvious, but all too commonly system design is carried out in the absence of feedback from its potential users which increases the chance that the users will not able to interact correctly with the system. Safety is not inherent in systems.

Benjamin Bloom's Taxonomy of Educational Objectives, herein referred to as Bloom's Taxonomy, was developed at the University Of Chicago by a group of cognitive psychologists and conceptualized by educational psychologist Benjamin Bloom (Nentl and Zietlow, 2007) The group's intent to identify and standardize learning objectives for student's achievement led to the collaboration of banks of test items, each measuring the same educational objective. Although Bloom's taxonomic theory addresses three domains of learning (The cognitive, psychomotor, and affective), the primary interest of this article is the cognitive domain with its six successive stages of learning: the lower-order learning of knowledge, comprehension, and application; and the higher-order learning of analysis, synthesis, and evaluation. ''The appeal of Bloom's learning model is its elegance simplicity and versatility''. The advantages of developing this methodology in a company and the work area are to improve the user capacity. When we split these levels to implement at the training, we are establishing skills of the taxonomy that can benefit like outcome staff capable of performing any protocol, procedure or decision in the workspace.

Often researchers ask themselves where those key questions that must be made in order to improve, assist, or fill or analyze any situation that may arise. Errors in energy facilities might be critical or fatal. Deming's Plan-Do-Check-Act (Tague, 2004) (PDCA) is used as a model for continuous improvement and for planning data collection and analysis in order to verify and prioritize problems or root causes.

As part of the research it is imperative to determine which trainings are relevant to the users. In the case of energy facilities the scope is both to teach personal "soft" and professional "hard" skills to be able to determine the best course of action in any particular situations. Some authors (Slaven and Dennis, 2012) discuss the importance of trainings related to industrial safety, as well as those within OSHA's scope of occupational safety. These types of learning activities are relevant considering about 4,000 deaths occur yearly due to labor accidents. The authors recommend training especially for operators that require labor in wind turbines, due to issues in height and the use of scaffolds. On facilities such as nuclear plants, both safety and design of labor skills are required. Energy managers must also consider the advantages of sustainable development in the social, economic and environmental dimensions (Abbas, et all, 2009). This is aligned with knowing the quality management system for energy management, ISO 50001.

An application of the skills that are required for energy management roles included for example, improvements to a paint shop. In this case, improvements to the production system resulted in a significant impact in the bottom line. One method we propose for improving the production system is lean six sigma. (Arenas-Guerrero et al., 2011). Other perspectives include (Chang et al, 2012) how a methodology like Lean Six Sigma can be used to reduce the energy cost in a particular application, defining the CTQ's for a problem and then using problem solving methodologies. The application also shows significant effort in making a quantitative analysis that includes the application of SPC (statistical process control).

If errors are made while performing these activities, adverse consequences could occur in the work facilities. The risk of errors or accidents justifies the investment required for training in error avoidance and analysis.

Additionally, reviewing current training offerings worldwide, including offerings from the Association of Energy Engineers (AEE, 2014) one of the most recognized association for energy professionals, some of the proposed topics for training in this work are part of their professional certifications. Some topics are, for example, ISO 50001 and Energy Audits and Economics. The topics of audits are important for the function of an energy management, the recommended QMS will become the ISO 5001 and error analysis will also include examples to minimize errors in energy audits.

Lechene (Lechene, 2014) proposes guidelines for effective energy managers. There are authors that recommend us to classify skills as technical and non-technical (NTS) (Wachs et al., 2012). Those described as NTS are personal, social and cognitive skills. It also points out that failure is blamed on operators and that NTS's are not adopted as part of the workers routine. The NTS were defined based on different skills related specifically to everyday work.

The concept of Cognitive Systems Engineering CSE (Militello, et all, 2010) main purpose is to design technology, training and processes that support the technological complexity in socio technical systems that allow human work. CSE can be considered a part of Human Factors as this deal with elements that surround a person performing an activity, both within the task per se and the environmental, physiological and psychological elements that can interfere with the task. The concept will focus on information representation and information flow.

Barnett and Mattox (Barnett and Mattox , 2014) state that companies need to measure training effectiveness. The following components must be considered to measure training effectiveness:

a. Develop a strategy considering company
b. Use performance measurements aligned with this strategy
c. Use appropriate resources
d. Select the appropriate measures that align with your company
e. Manage company culture to ensure it's prepared for change.

4. TRAINING CREATION

Four trainings were created based on the needs identified: Lean Six Sigma, Project Management, Lab Safety & Error Management and ISO 50001. These trainings were enhanced using the concepts of Bloom's taxonomy. The Bloom's taxonomy can be considered can serve like two fundamental purposes. First, when the stakeholder completed a training based in a Bloom's taxonomy that can serve as a road map. This stages or levels are the result desired upon completion of the training experience. A second basic purpose served by Bloom's taxonomy is in the evaluation performance. It is impossible to evaluate performance of a system without some standards for evaluating performance with results that can be compared. The use of this methodology to create the training became the standard for evaluating performance. The enhancement was performed by creating evaluations on all six levels of understanding. These questions then became part of the review materials within the course and also part of e-quizzes. The quizzes were created using the Google Docs platform that permits free-on demand usage of the materials. The step by step considerations when creating the trainings were:

1. Determine trainings objectives – using the design principles described in the literature review, the trainings must bring technical skills to persons that might not have a strong engineering / scientific background. What type of dominance of the topic to the trainings require? How would this be measured? The trainings will have objectives related to:
    a. What to teach? Hands on applications, recommendations for applications, recommendations to avoid human error.
    b. How to teach it? Dynamic learning taking advantage of technological advances, ensure learning and comprehension, measure learning.

2. Identify relevant topics for ACT Global customers – trainings must have the key definitions, purpose and strategies to apply the methodologies for each of the subjects. Some quantitative concepts are discussed superficially. For a more in-depth understanding of those concepts, the trainings are linked to You Tube ® and other online sources. Any templates or worksheets are also linked. This is intended to offer the participants both the introduction to areas ok knowledge, but sources to find out more in depth information.

3. Divide the trainings topics – the trainings topics will be divided based on content and duration. It is expected that the trainings are completed in six hours with a two hour quiz. All trainings will be divided in about 1.20 hour (1 hour, 12 minutes) modules. The content will try to related to DMAIC – define, measure, analyze, improve and control. For project management and lean six sigma, these divisions are quite apparent. For both ISO 50001 and Lab Safety, organic divisions based on time are considered trying to align to DMAIC. Some basic definitions related to DMAIC that were used in the training include:
    a. D – define problem
    b. M – evaluate baseline
    c. A – analyze problem
    d. I – give recommendations
    e. C – ensure sustainability

4. Redact the quiz questions – for this redaction, the principles of Bloom's taxonomy are utilized. Figures 1 and 2 show some of the stages of the taxonomy and recommended keywords to construct review and quiz questions. In order to ensure that all the levels within the taxonomy were evaluated Pareto charts are shown in figures 1 and 2 that demonstrate the diversity of application of all taxonomy levels and keywords. This allows the evaluation of comprehension reducing any predictability or monotony, increasing interest in answering quizzes. This variety also allows the trainers to test comprehension and not just recalling of information from the persons being evaluated.

5. Divide the quiz questions using Lean Six Sigma principles - Table 1 shows the questions prepared for the quiz and also uses related stages from the Lean Six Sigma Methodology to create relevant stages in each phase. In the Kaizen stage presented of prepare marks the activities for preparation for the kaizen (progressive changes in process area) and associates them with the DMAIC stage of Define. This will introduce the activity of preparation and definition and include activities within the training with these concepts into consideration. The content of the questions must consider the stages of Bloom's taxonomy and in this case is also considering the keywords recommended when redacting questions.

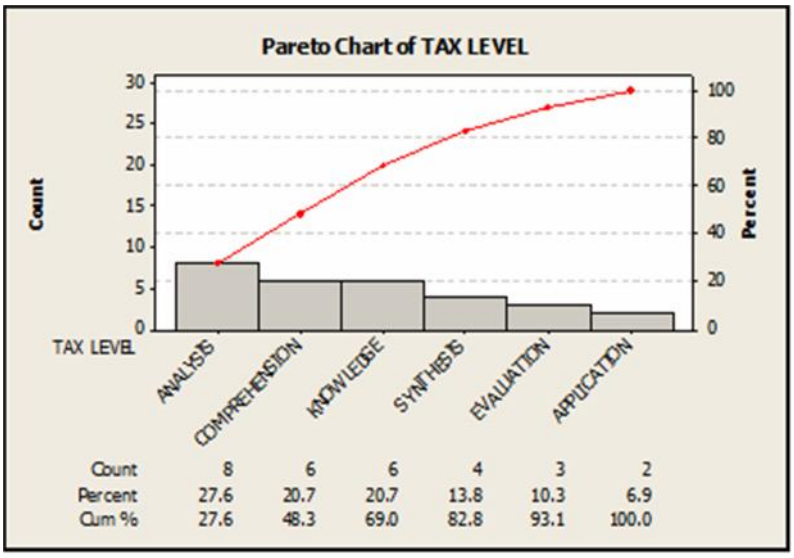

Figure 1: Pareto chart of usage of Bloom's taxonomy levels (Project Management Training)

Figures 1 and 2 refer to the creation of the Project Management quiz questions. The purpose of this question is to corroborate understanding of the topics by the persons taking the trainings. Literature states that learning should not be focused on just recalling information; but on proving comprehension and application. Those two topics, related to comprehension and application are quite relevant for ACT Global, as the users should be capable to use what has been learned in their ideas. Figure 1 shows a fairly uniform use of the Bloom's taxonomy levels, not focusing exclusively on the two lower levels (knowledge and comprehension). This will permit the trainers to introduce questions of various levels of difficulty and various methods to prove understanding of the topics. Figure 2 is based on what words are asked on the quiz questions. Again, this proves that not all quiz questions are focused on recalling the information but require the person performing the quiz to apply what was learned by performing activities such as comparing and recommending.

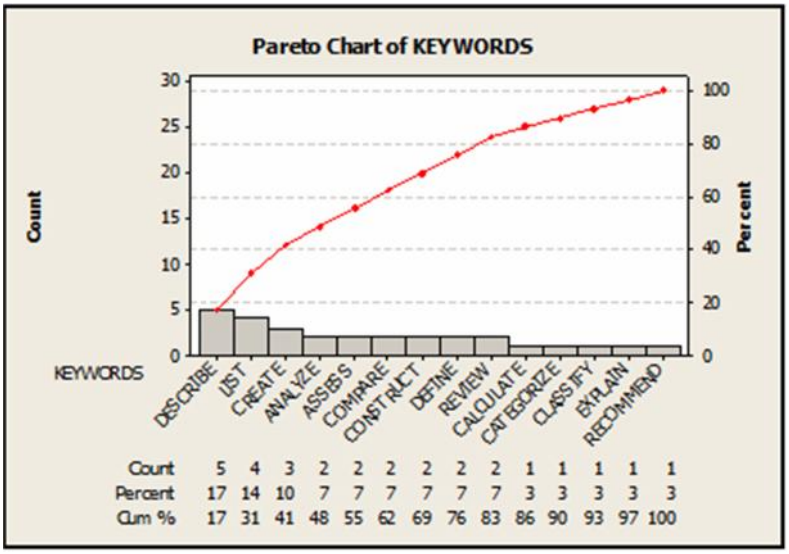

Figure 2: Pareto chart of usage of Bloom's keywords usage (Project Management Training)

Table 1: Quiz questions – Project Management Quiz

Question	Kaizen	DMAIC	Question Statement	Taxonomy Level	Verbs or Keywords
1	Stage 1 Prepare	DEFINE	Define a project	KNOWLEDGE (1)	DEFINE
2			Describe what can be created with a project	COMPREHENSION (2)	DESCRIBE
3			Define project management	KNOWLEDGE (1)	DEFINE
4			Describe the activities required to manage a project	COMPREHENSION (2)	DESCRIBE
5			List the steps for the project lifecycle	KNOWLEDGE	LIST
6			Construct an example that shows who the stakeholders are in a pet shop grooming department	ANALYSIS (4)	CONSTRUCT
7			Review in your own words, the activities required by a Project Manager	ANALYSIS	REVIEW
8			Assess that the interactions presented in figure 3.3 represent the required stakeholders in a project	EVALUATION (6)	ASSESS
9			Describe the power interest grid for stakeholders	COMPREHENSION	DESCRIBE
10			Create a sample stakeholder analysis matrix	SYNTHESIS (5)	CREATE

Table 1 shows some of the quiz questions from the Project Management training. The questions can be redacted as multiple choices or can require answering in essay style. Kaizen and DMAIC definitions were used to rationalize where these questions are place regarding the management stage of a project. In these particular instances, the questions are used to define the project and project teams. The taxonomy level column will be aligned to the Bloom's taxonomy levels. If you were to look and the keyword column, these were used to construct the questions for the quizzes and serve as guidelines for making questions aligned with the taxonomy.

5. DEPLOYMENT STRATEGY

The idea for these trainings is to make them different from other offers by making them interactive instead of passive. The difference is the usage of Google Docs, the interactive platform from Google ®. The trainings can be done on demand on any PC or tablet device and require the user interaction with slides, videos and quizzes. The system collects the answers from the users allowing the administrator to collect and grade the participant's responses. Any users that desire evidence such as a certificate, from the training can contact the administrator who can email the award based on quiz responses. Figure 3 shows the main page for the Lean Six Sigma training. The platform uses slide-like pages, where users can go back and forth to review information.

All trainings have an average of 100 slides, with graphs, photos, lectures and online references. The trainings can be completed in multiple seating's with an estimated completion time of six hours. This is similar to classroom based trainings currently on the market.

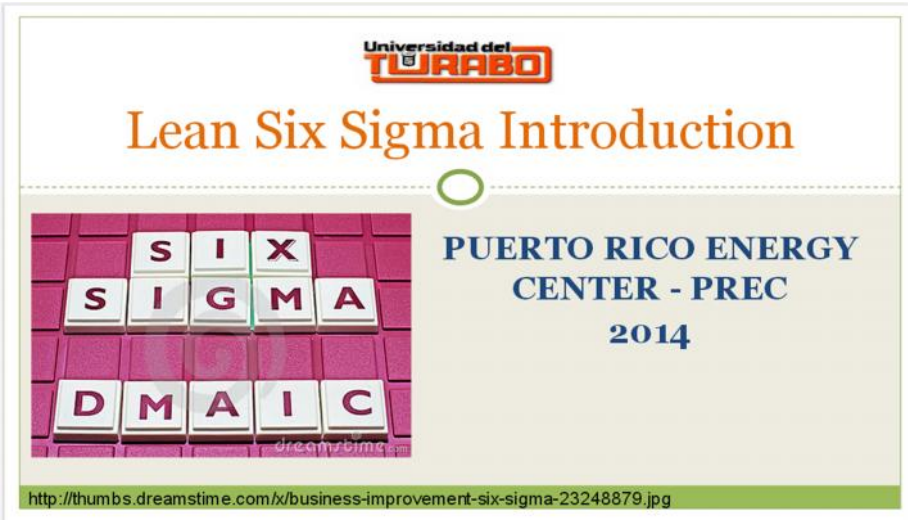

Figure 3: Lean Six Sigma Training Main Page

After the training is completed, the participant has to option of taking the quiz immediately or on a later occasion (see figure 4). The duration of the quiz is a maximum of two hours. With the current trainings, the user could gain significant proficiency in the areas discussed earlier with eight hours of study, on demand and at their own pace. There is a web spreadsheet that stores all answers, and the quiz is programmed to require all answers at once. The user can take the quiz on multiple opportunities, but the administrator can determine if the retaking was due to failure in a previous attempt or an attempt to gain advantage in answering the questions.

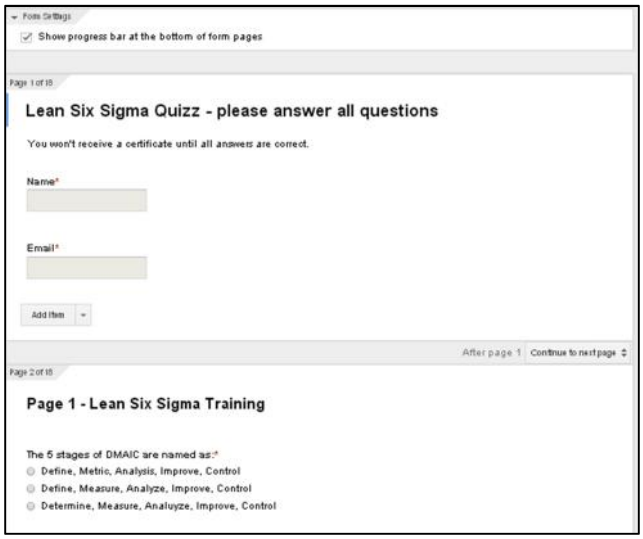

Figure 4: Lean Six Sigma Quiz Main Page

6. CONCLUSIONS

ACT Global at PREC gives entrepreneurs the opportunity to develop an idea into a business concept. The current research has created tools that can help those persons gain in depth knowledge in areas that can ensure a

competitive advantage. Due to time and monetary constraints, these trainings offer an alternative for a free and on demand training platform.

Bloom's taxonomy can be considered as a key guideline when creating training materials. The stages or levels in the methodology are the result desired upon completion of the planning period. The second basic purpose served by Bloom's taxonomy is in the evaluation performance. It is impossible to evaluate performance of a system without some standard for evaluate performance which results can be compared. The uses of this methodology to create training become the standard for valuating performance because they are the statement of results desired for the best performance of the laboratory or working facility.

Learning is a complex process that cannot be adequately captured by any one model. However, Bloom's revised taxonomy is "simple" and "robust." Its combination of process and content provides a solid framework for planning experiential learning, which requires learners to process vast amounts of knowledge to handle new and rapidly changing situations.

The use of e-training tools should be part of any future activities at PREC as a convenient and cost effective method for learning and sharing information. These trainings need to be adequately defined considering what the stakeholders should learn and organizing the learning materials to maximize attention and reduce monotony. If it is critical to create a training using the recommended methodology, even more critical is to create the appropriate evaluation method. With the recommended application of the methodology, users will be able to recall, understand and apply the topics learned and a gain competitive advantage.

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Gas Turbine Vibration Monitoring to Reduce Air Pollution

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ABSTRACT

This research aims to design and test a vibration monitoring system for gas turbines. It goal is to measure the efficiency on the gas turbine and relate it to its vibrations and determine whether the gas turbine is in good condition by using it vibrations solely. The research accomplishes to design a sensor out of an aluminum bar and a strain gage to measure pressure, other sensors measures temperature and acceleration.

The designed pressure sensor proved to be safe and reliable under the minimum and maximum conditions on the turbine. Even when the gas turbine presented mechanical problems, during a test the temperature profile suggest improving the thermocouples array.

If the gas turbine were in working conditions and the sensor were calibrated mounted on the turbine and also the thermocouple array were improved, then the system would have been able to calculate the efficiencies and verify if there is a relation between the Gas Turbine efficiency and the vibration.

Keywords: Turbine, Vibration, Efficiency, Monitoring

1. INTRODUCTION

This research aims to design a monitoring system for gas turbines. Gas turbines are a type of internal combustion engines where burning fuel mixed with compressed air produces gases that spin a turbine to generate energy. Gas turbines are composed of a compressor, which injects high pressure air into the combustion chamber; a combustion chamber where the air is mixed with a continuous fuel steam and then ignited; and a turbine which spins because of the hot gases that exit the combustion chamber reacting against the blades of the turbine which in turn rotates the compressor. The remaining high energy gases can be used to drive another turbine that generates electricity or to create a thrust used for propulsion.

Gas turbines have an advantage of being lighter compared to other engine of the same size, and are smaller the engines of the same power output, which makes them useful for aviation purposes where the weight is an important factor. They are also used for the generation of electricity, since natural gas is less expensive than other fossil based fuels. Due to the high speeds and high temperatures, designing and manufacturing gas turbines can be tough, which makes them more expensive than other internal combustion engines.

Gas turbines require a constant maintenance to prevent damages in the turbine that could reduce the efficiency. Some gas turbines have an air filter to prevent particles such as salt and other things that could damage the parts of the turbines. By maintaining the turbine in perfect conditions the efficiency can be maximize and the output will be higher and thus get more out of the fuel and cost of the turbine.

Table 1: List of Symbols

Symbol	Definition
Ta	Ambient Temperature
T1	Temperature at point 1 (Inlet)
T2	Temperature at point 2 (After Compressor)
T3	Temperature at point 3 (Before Turbine)
T4	Temperature at point 4 (Exhaust)
Pa	Ambient Pressure
P1	Pressure at point 1 (Inlet)
P2	Pressure at point 2 (After Compressor)
P3	Pressure at point 3 (Before Turbine)
P4	Pressure at point 4 (Exhaust)
Prc	Compressor Pressure Ratio
ηc	Compressor Efficiency
ηt	Turbine Efficiency
γc	Specific heat ratio at compressor
γt	Specific heat ratio at turbine
Fn	Natural frequency
K	Spring stiffness
M	Mass of the system
m	Unbalanced Mass
ξ	Damping Ratio

2. THEORETICAL BACKGROUND

2.1 GAS TURBINE COMPONENTS THERMODYNAMICS EFFICIENCY

Gas turbines work as an open cycle, which means it constantly renews the flow of air that enters from the surroundings. These types of turbine cycles consist of three processes. First, air from the surroundings enters the compressor at ambient temperature where its pressure and temperature are increased. The pressurized air then enters the combustion chamber where it mixes with the fuel and is burned at constant pressure. The hot gases from the combustion enter the turbine where it expands to atmospheric pressure and transferring energy to the turbine to keep the system running and the rest of the energy produces a thrust [Hill & Peterson, 1965].

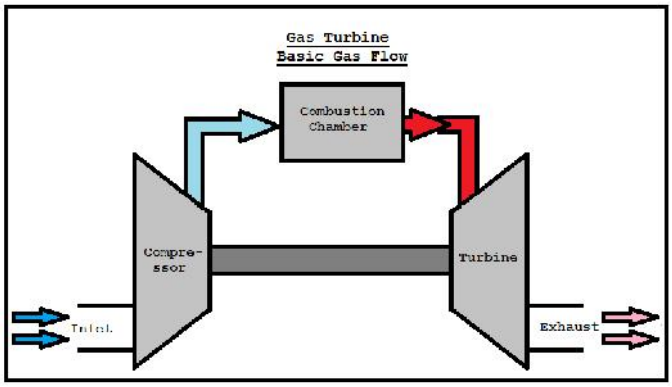

Figure 1: Gas Turbine Diagram

Figure 1 shows the steps in the cycle of the gas turbine used. The diagram below shows the behavior of an ideal gas turbine cycle. By assuming an ideal cycle the efficiency analysis becomes simpler and the energy input and output can be determined.

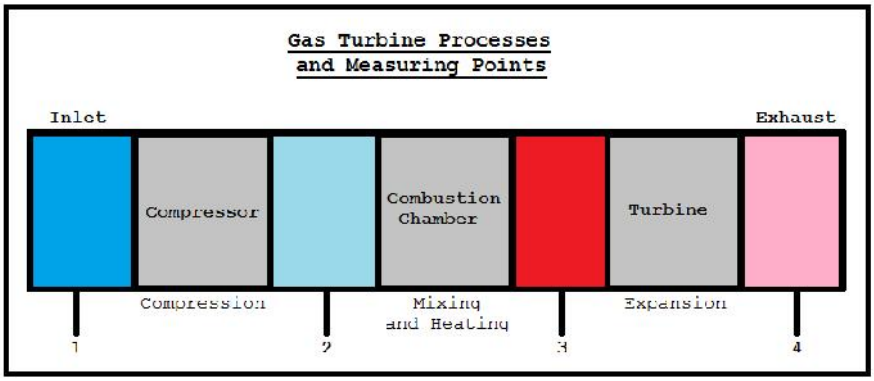

Figure 2: Gas Turbine Processes and Measuring Points

The figure 2 shows the processes that are occurring in the gas turbine and the points at which it is necessary to know the temperature and pressure. During each of the processes the temperature and pressure of the air and gases varies. To analyze the performance of a gas turbine, each of the pressures and temperatures before and after each process are needed. These results are to be measured at the inlet, after the compressor, after the combustion chamber and in the exhaust. The Inlet is identified as the point 1, compressor exit is point 2, turbine entrance is 3 and the turbine exhaust is 4.

By measuring the temperatures and pressures at those points, the other temperatures and pressures can be calculated. [Hill & Peterson, 1965]

The properties in the outlet of the compressor can be calculated using the formula:

$$T_2 = T_1[1 + \frac{1}{\Pi_c}\left\{P_{rc}^{\frac{(\gamma_c - 1)}{\gamma_c}} - 1\right\}]$$

Since all the temperatures are known, the efficiency of the compressor can be determined using that formula, which becomes:

$$\eta_c = \left\{ P_{rc}^{\frac{(\gamma_c - 1)}{\gamma_c}} - 1 \right\} \Big/ \left(\frac{T_2}{T_1} - 1 \right)$$ Where $P_{rc} = {}^{p_2}/_{p_1}$.

Same circumstances apply to conditions in the inlet of the turbine, where the pressure is given by the formula:

$$p_4 = p_3 \left[1 - \frac{1}{\eta_t} \left(1 - \frac{T_4}{T_3} \right) \right]^{\gamma_t / (\gamma_t - 1)}$$

Where: $T_4 \simeq T_3 - (T_2 - T_1)$

And as same as before, all the variables are known except for the efficiency of the turbine, and can be determined with the formula:

$$\eta_t = - \left(1 - \frac{T_4}{T_3} \right) \Big/ \gamma_t / (\gamma_t - 1) \sqrt{\frac{p_4}{p_3}} - 1$$

2.2 VIBRATION THEORY

Every mechanical system had it own vibration curve. This curve is a response of the material stiffness, mass, the working speed and external forces. Every system had a natural frequency, this frequency is important as it shows the frequency at which the vibration had its maximum amplitude. The natural vibration for a mass and spring system can be calculated as [3 & 4]

$$fn = \frac{1}{2\pi} \sqrt{\frac{K}{m}}$$

Where “fn” is the natural frequency, “K” is the spring stiffness and “m” represents the mass.

In the case of damped system the natural frequency will be [3 & 4]:

$$Wd = \sqrt{1 - \zeta^2} Wn$$

This will represent a small variation with respect to the un-damped natural frequency. It is easier to apply then the un-damped vibration theory and the results will be close to the damped values with lower effort.

As this is a rotational system it can be applied also the unbalanced system theory. This system will present lateral vibration due to the unbalanced mass. [3 & 4]

$$x(t) = \frac{m}{M} e \left(\frac{W}{Wn} \right)^2 \sin(wt - \Theta)$$

Therefore the amplitude of the vibration depends on different parameters that may bring information about changes in the turbine components.

2.3 SENSOR SELECTION

As the measuring requires obtaining measures of the temperature, pressure and vibration the system must use sensors to measure those parameters. Pressure sensor was manufactured using aluminum bars and strain gages, while temperature is going to be measured using thermocouples; the vibration will be measured using an accelerometer.

2.4 PRESSURE SENSOR

Pressure sensors or transducers are elements that convert physical energy magnitude of pressure or force another electrical quantity. Pressure sensors translate pressures in different electrical signals that are sent to the computer.

2.5 STRAIN GAGES

Strains are always caused by an external influence such as force, pressure, moment or heat. In most cases the amount of influence on the material can be derived from the strain measurements. In experimental stress analysis, strain values are widely used to predict safety and endurance. [Omega Engineering]

To collect these measurements "strain gages" are often used. A Strain gage is a sensor whose resistance varies with applied force; it converts force, pressure, tension, weight, etc., into a change in electrical resistance which can then be measured. Strain gages are an efficient way of converting mechanical quantities into electrical measurements, useful for the collection of data. Strain gages can be used to pick up expansion as well as contraction. [Omega Engineering]

This strain gages consist of a wire filament that works as a resistor bonded to the strained surface using epoxy resin. When a load is applied to the surface, the resulting change in surface length is communicated to the resistor and the corresponding strain is measured in terms of the electrical resistance of the foil wire, which varies linearly with strain. In order to measure the strain in the bonded resistance strain gage, it must be connected to an electric circuit capable of reading the changes in resistance corresponding to the strain. The strain gages must be connected forming a Wheatstone bridge, as shown in figure 3, to measure the difference in voltage between two of points in the circuit. This difference will change depending on the change in resistance due to the strain at the strain gage. The difference in voltage can be directly related to the strain; therefore it can be used to measuring the strain.

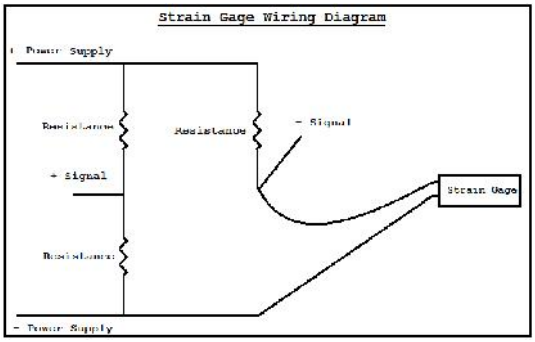

Figure 3: Strain Gages Wiring Diagram (Wheatstone Bridge)

2.6 THERMOCOUPLES

Temperature can be measured via a diverse array of sensors. All of them infer temperature by sensing some change in a physical characteristic. One of the most common methods uses an electrical circuit called a thermocouple. A thermocouple is a pair of conductors that constitute a thermoelectric circuit.

Thermocouple is a device based on the "See beck effect", which states that when two dissimilar conductors' junctions are kept at different temperatures a small electric voltage can be measured. The measured voltage is a function of the temperature difference, and so by knowing the reference temperature in one of the junctions, the other unknown temperature can be determined.

2.7 ACCELEROMETER

The accelerometers or sensors of accelerations, are to building dating to measure acceleration or vibration, provided an electrical signal according to physical vibration, in this case the physical variation is the acceleration or vibration.

3. EXPERIMENTAL SETUP

3.1 SENSOR DESIGN

To measure the pressure, a sensor was designed to obtain reliable pressure measurements while using strain gages. SolidWorks was used to achieve a design that meets the requirements of the pressures to which the turbine works. The sensor was made using an aluminum bar. The bar design is shown in the figure 4, it have external measures of 2.00 inches long, and diameter of 0.40 inches, the bar have a hole of 0.25 inches in diameter and 1.85 inches depth.

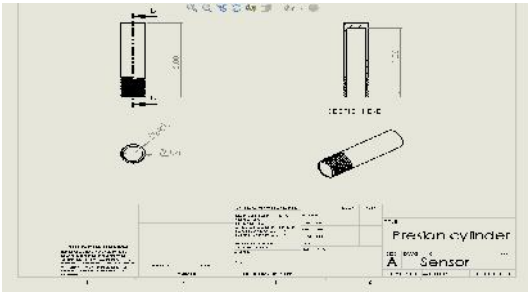

Figure 4: Sensor Dimensions

These measures did some tests with 2 psi to ensure the bar show deformation at low pressures. As it is shown in the figure 5, the bar deforms proving sufficient sensitivity to measure strain at low pressure.

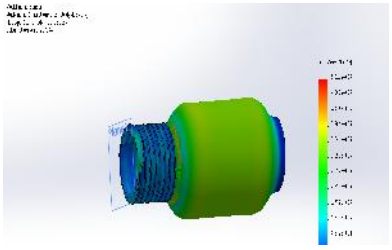

Figure 5: Sensor Deformation at 2 psi

A second test was analyzed with 15 psi to ensure that the sensor was safe to use at the system expected high pressure. As illustrated in the figure 6 the bar was safe to use at the 15 pressure max.

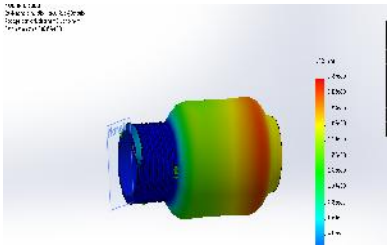

Figure 6: Bar Deformation at 15 psi

These measurements were designed to place the strain gage on the exterior surface of the rod. The bar has a NPT type which ensures tight sealing without leaks, and makes them removable.

When subjected to the pressure inside the bar it undergoes a deformation, stretching in axial and radial direction. This deformation can be measured with strain gages and hence calculate the pressure at which the rod is subjected, thus creating our pressure sensor.

The strain gages are made of an alloy of nickel and copper. The main characteristics of the strain gages alloy are sensitive to deformation, good corrosion resistance wing. The electrical resistance of this strain gauge is directly related to the elongation of the same, in this way one can measure the variation in electrical resistance and relate deformation.

To calibrate the strain gages and the pressure found inside one mounting bar which permits mounting the sensor made of a calibrated and calibrate the sensor thus prepared sensor manufactured. Expected calibrate the sensor mounted on the turbine, in this way take into consideration the change in elongation of the rod due to the pressure in the interior as well as due to temperature rise.

After building the sensors, one of which was placed at the inlet to the compressor is being measured the pressure of the atmosphere, in order to assemble a borehole with the size of the outside diameter of the sensor was made, then a tap was used to make the thread. A sensor in the compressor, combustion chamber and the exhaust outlet is also placed.

3.2 SENSORS CALIBRATION

To calibrate the designed pressure sensor which uses strain gages, an adapter was create to plug in the strain gage sensors and the already calibrated sensor to a pressurized hose. A program was created for the collection of the data using LabView. The program takes five measurements every second and saves them in an Excel file. With the equations for each one of the 3 sensors another program was created to obtain data at all 4 points in the turbine, as well as the temperatures using thermocouples, and the vibrations from an accelerometer located next to the turbine shaft, the interface and the program is shown in the figures 7 & 8.

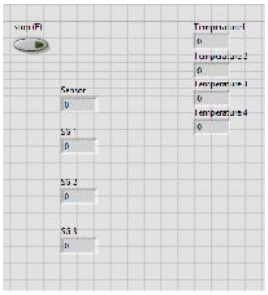

Figure 7: Program Interface

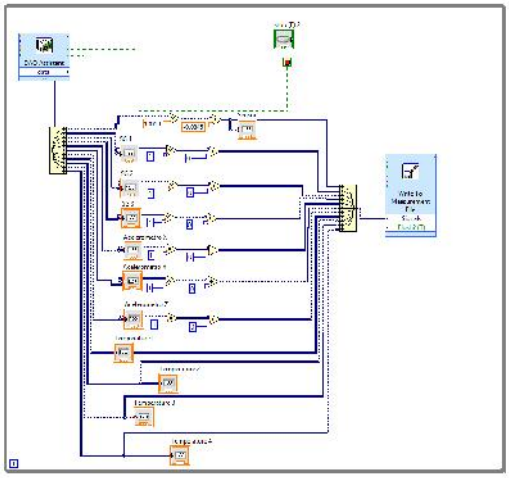

Figure 8: Program without Calibration Equations

To calibrate the accelerometer know accelerations are used while measuring the voltage output. The accelerations used were -1G, 0 G and 1G. The results are shown in the table below.

4. EXPERIMENTAL RESULTS

Table 1: Voltage Measured for Accelerometer Calibration

	Acceleration (G)	Voltage	Acceleration (G)	Voltage	Acceleration (G)	Voltage
X	-1	1.78197	0	1.49044	1	1.1889
Y	-1	1.784	0	1.34	1	0.9878

With this data graphed and using the measurements from the pressure sensor as the correct data, the equation for the strain gages can be determined. Obtaining the calibration equation, this equation relates the voltage measurements from the strain gages to a pressure value. Figure 9, shows the plot of the voltage versus the acceleration and the obtained calibration equations for the accelerometer in X-axis direction.

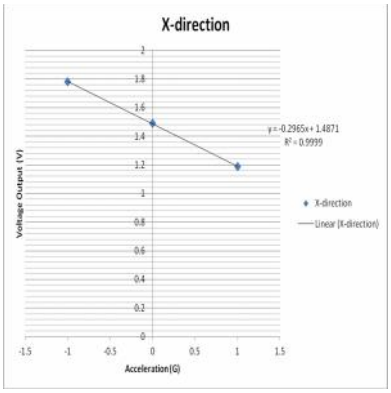

Figure 9: Calibration Plot for X-axis

Table 2: Measured data for Strain Gage Calibration

	Pressure (psi)	Voltage (V)	Pressure (psi)	Voltage (V)	Pressure (psi)	Voltage (V)
Strain gage 1	12.009832	-2.493862	19.240464	-2.496817	25.156435	-2.499115

The data obtained was plotted to find the calibration equation. The figure 10 shows the plot of the results and the calibration equation.

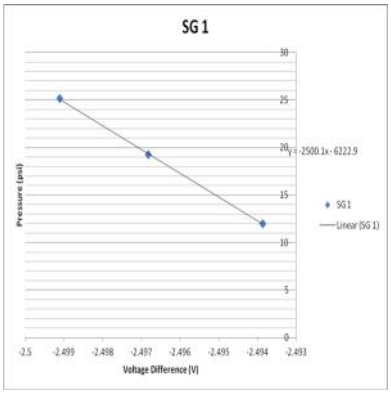

Figure 10: Calibration plot for Strain Gage Sensor 1 (SG 1)

4.1 TEMPERATURE DISTRIBUTION

Table 3 Temperature Distribution (Steady State)

T1 (°C)	T2 (°C)	T3 (°C)	T4 (°C)
35	50	150	450

5. CONCLUSIONS

The research was not able to be performed on the gas turbine due to mechanical problems. Only measure of the temperature was obtained. This measure was interesting as the fluid appears to be heated on the turbine and it is not possible. After analyzing, it was found that the temperature measured at the combustion chamber required other thermocouple as there is hot and cold fluid. The reason is that the combustion chamber is divided in which part of the fluid is heated in the combustion and other part pass without mixing with the combustion as shown in figure 11. Therefore another thermocouple must be used to measure the hot gases.

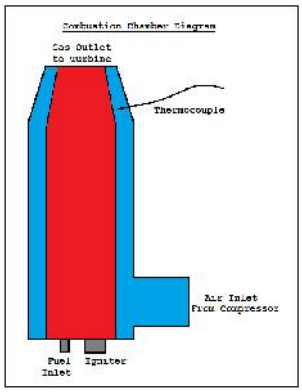

FIGURE 11: FLUID ACROSS THE COMBUSTION CHAMBER

Tests were performed on the sensor fabricated to verify correct functioning under the pressure and they proved to be reliable. The sensor was proved to be successfully calibrated. The accelerometer was calibrated also but requires more testing to verify for correct functioning under the frequency at which the gas turbine works.

If the gas turbine were in working conditions and the sensor were calibrated mounted on the turbine and also the thermocouple array were improved, then the system would have been able to calculate the efficiencies and verify if there is a relation between the Gas Turbine efficiency and the vibration.

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Degradation of Sunscreen Active Ingredient by a Photocatalytic Process

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ABSTRACT

Sunscreens are considered as one of the most important pharmaceuticals and personal care products to prevent skin cancer. The effects of sunscreens on the environment and human health are being investigated because they some of them contained p-aminobenzoic acid (PABA). This paper attempts to showcase this process of photocatalysis with the use of P25 (the catalyst) for the degradation of PABA, taking it out with a system called photoreactor. We studied the photocatalytic degradation of PABA in a range of 0.4 to 1.2g/L to a 5 $x10^{-5}$ M PABA. The optimum catalyst loading for the photocatalytic degradation of PABA occurred with 1.2 g/L of P25 degrading 79% of PABA. We effectively degrade PABA with a 97% of degradation decreasing PABA concentration to 4 $x10^{-5}$ M. We demonstrated the photocatalysis did not proceed without a radiation source or catalyst. Surprisingly, 92% of PABA was degraded even without oxygen sources to promote hydroxyl radicals.

Keywords: Sunscreens, photodegradation, p-aminobenzoic acid, P25.

1. INTRODUCTION

The pollution is a detrimental alteration of normal conditions of any resource by the presence of physical, chemical or biological agents oblivious to them (Aguados et al., 2001). Pharmaceuticals and personal care products have aroused great interest in the scientific community because of the pollutants that contains and it dangerous effect to the environment and human health (Zhou et al., 2013).

The skin is one of the most important organs of the body; through the years there has been a great concern and interest about the protection and care that must be taken to it. Many scientists such as dermatology experts recommend sunscreen products to protect your skin from the sun because this is one of the causes of its deterioration. Ultraviolet (UV) radiation are the main cause for the high incidence of skin cancer and other diseases.

Due to this in the 90's sunscreens were made (Rogers and Harris, 2014) because they minimize the effects of UV radiation on the skin, which are transmitted by the sun. Actually, the sunscreens can be found in different ways and different modes of employment, for example: lotions, "spray-on", clothing, pet products, pharmaceuticals, and cosmetics, among many others. In addition, there are water resistant and last longer when being applied directly to the skin (Rogers and Harris, 2014).

Active ingredients of sunscreens are 2-ethylhexyl 4-methoxycinnamate, 3-benzophenone, octocrylene and p-aminobenzoic acid (PABA). As is known, all sunscreens are formulated to protect the skin from the sun, but what

many people do not know is that these are polluting ingredients for both the body skin as well as the environment, especially water bodies such as rivers and lakes. Sunscreens are the main causes of environmental pollution in terrestrial and aquatic organisms (Diaz and Gago, 2011).

According to a study (Diaz and Gago, 2011), these contaminants were found in tap water, mineral water, swimming pool water, seawater and surface waters. This indicates the recalcitrant effect that contains these products and therefore the hardness for the degradation of the sunscreen active ingredients. Degradation is the process of decomposition by the action of physical, chemical or biotic agents (Vera and Tevar, 2001). That degradation will help to minimize or eliminate adverse effects focusing on water resources. Photocatalysis refers to the oxidation and reduction reactions on the surface of semiconductor catalysts, mediated by the valence band holes and conduction band electrons, which are generated by the absorption of ultraviolet or visible light radiation (see Figure 1).

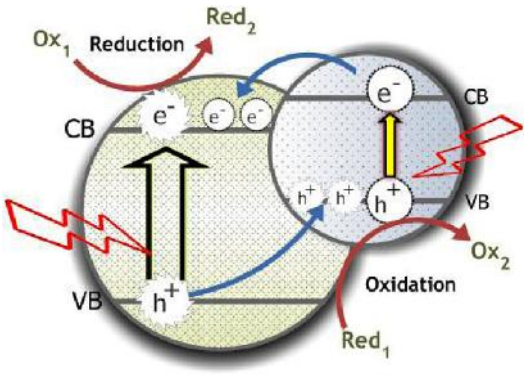

Figure 1: Charge transfers produced during a photocatalytic process (Vinu and Madras, 2010)

In the presence research we aim to degrade PABA by a photocatalytic process in order to minimize water pollution, which has a significant effect on the human beings, flora and fauna. We applied a commercial catalyst known as Aeroxide P25, which is titanium oxide. P25 is one of the catalysts commonly used when performing a degradation using a photocatalytic process. Furthermore, the oxygen sources are also added to the reaction to generate hydroxyl radicals. The P25 is being used in various applications such as environmental remediation and water treatment, particularly in the disinfection and air purification.

2. REAGENTS AND MATERIALS

All the reagents were used as received without further purification. Sigma-Aldrich® Titanium (IV) Oxide nanopower 21nm particle size, Sigma-Aldrich® 4-aminobenzoic acid, Fisher Scientific® H_2O_2 (50%), Ultra pure water (Milli-Q water, 18.2 MΩcm^{-1} at 25 °C, Sigma-Aldrich® HCl 1.0 M (1.0 N) Standard Solution and 0.45 µm syringe filters.

For the photocatalytic degradation measurements we used a Shimadzu® UV-2401PC Spectrophotometer, Varian Cary Eclipse Fluorescent Spectrophotometer and quartz cuvette cells. The photoreactor used consist of magnetic stirrer surrounded by seven light bulbs and three mirrors to reflect the incident light. A black blanket was used to cover the system to avoid any other incident radiation to the reaction media (See figure 2).

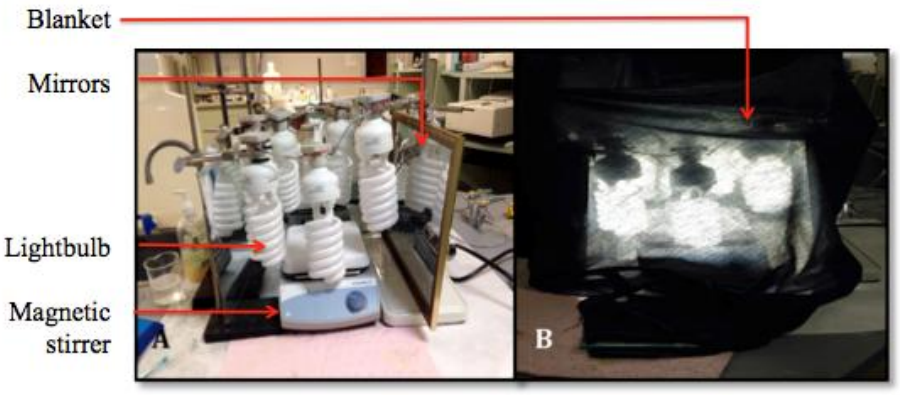

Figure 2: Photocatalytic reactor

Figure 2A shows the full equipment described as the photoreactor with seven light bulbs, the three mirrors and the magnetic stirrer. Figure 2B shows the photoreactor covered with the black blanket during the photocatalytic process.

3. METHODOLOGY

3.1 PHOTOCATALYTIC DEGRADATION OF PABA

3.1.1 CATALYST LOADING

The photocatalytic experiments were performed by adding different amounts of the catalyst in the range of 0.4 to 1.2g/L to a 5 x 10^{-5}M PABA solution. The pH was adjusted to pH 3 followed by 30 minutes of darkness in order to allow the system to reach the absorption-desorption equilibrium. Finally, the hydrogen peroxide and a constant air bubbling were added to the system and the radiation was turned on. The reaction progress was carried out under continuous stirring during three hours, and aliquots of 15-20 mL were taken every 30 minutes. The aliquots were doubly filtered by using 0.45 µm membranes and analyzed using UV-Vis and fluorescence spectroscopies.

3.1.2 PABA OPTIMUM CONCENTRATION

The optimum PABA concentration was determined following the procedure described above with a constant P25 concentration of 1.2 g/L and varying PABA concentration from 2 x 10^{-5} M to 7 x 10^{-5} M. The degradation percent was determined by the following equation $(\frac{A_t - A_0}{A_0})x100$, where A_0 and A_t are the absorbance at time 0 and time t respectively.

4. RESULTS AND DISCUSSION

4.1 CATALYST LOADING EFFECT

The effect of the photocatalyst concentration on the degradation of PABA was determined using different concentrations of P25 (ranging from 0.4 to 1.2 g/L). Our results suggest that photocatalytic degradation of PABA is more effective by increasing P25 loading as shown in figure 3.

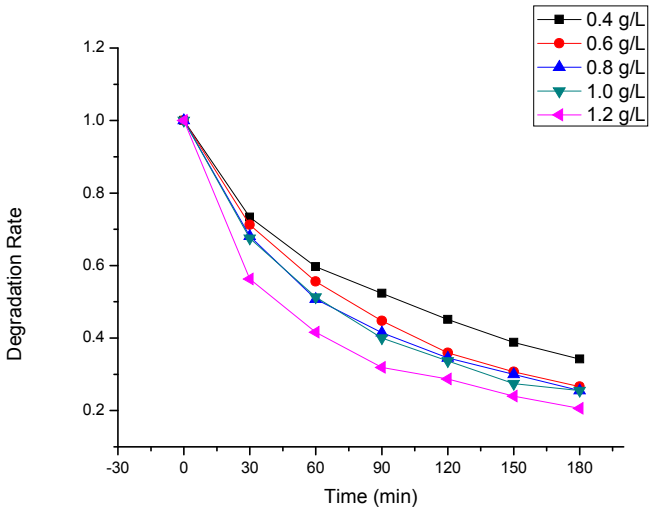

Figure 3: Graph showing the PABA degradation under different catalyst loading

Figure 3, shows that if the catalyst concentration decreased, more light may be transmitted through solution. In a similar research performed in 2009, the catalyst P25 was used to degrade the pollutant Vallinin through process, where the optimum degradation was 160 mg/L. That result was because as well the concentration increased on the pollutant solution, the compound molecules are adsorbed on the surface of the photocatalyst (Muneer, M. Qamar, M., 2009). A higher absorption of light can lead to the formation of high suspended photoactivated volume thus increasing system efficiency. The higher reaction rates to a greater amount of catalyst loading can be explained in terms of the full utilization of incident photons striking the surface of the catalyst and/or the availability of active sites on the surface. When a semiconductor such as TiO_2 absorbs a photon of energy equal to or greater than its band gap width, an electron may be promoted from the valence band (vb). When an electron is promoted from the valence band (vb) to the conduction band (cb) leaves behind an electronic vacancy or "hole" (h+) in the valence band creating the electron-hole pair. If charge separation is maintained, the electron and hole may migrate to the catalyst surface where they participate in redox reactions with the sorbed species. Specially, h+ vb may react with surface-bound H_2O or OH^- to produce the hydroxyl radical and e^- cb is picked up by oxygen to generate a superoxide radical anion (O_2^-) (Qamar and Munner, 2009). In this research we found that the optimum catalyst loading for the best degradation of PABA was 1.2 g/L for PABA, as shown on figure 4.

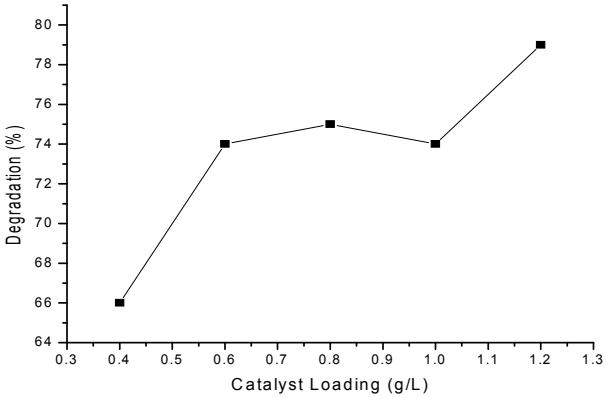

Figure 4: Graph showing the degradation percent using different concentrations of P25

4.2 PABA CONCENTRATION EFFECT

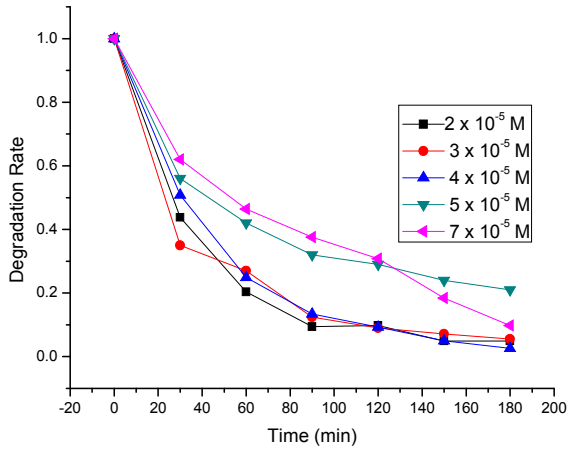

Figure 5: Graph showing the degradation of PABA at different times

According to the experimental results shown in figure 6, the optimal PABA concentration with the highest percent of degradation was 4 x10^{-5} M. Under those experimental conditions a degradation of the 97% of PABA was measured.

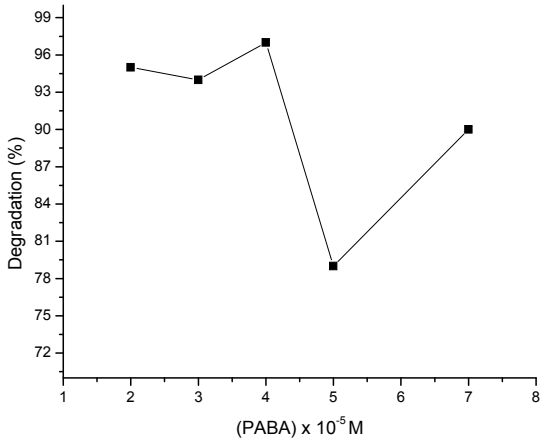

Figure 6: Graph showing the degradation percent of PABA at different initial concentrations.

This is because the compound molecules get adsorbed best at 4 x 10^{-5} M, on the surface of the photocatalyst. The requirement of catalyst surface needed for the degradation also increases re adsorbed on the surface of the photocatalyst which is required to increase the degradation through the catalyst (Qamar and Munner, 2009).

Furthermore, we performed several studies and the same experimental conditions of PABA with the optimal concentration of P25, but testing the degradation of PABA and modifying the experimental conditions. The photocatalytic process was performed three times. The first test was conducted without hydrogen peroxide and oxygen; in the second, with no radiation; and finally, without the catalyst, table 1 shows the results.

Table 1: Degradation percent without different conditions

Without Conditions	Degradation percent (%)
Radiation Source	<1%
H_2O_2/Oxygen	92%
P25	11%

For example, in the Indian study (Qamar and Munner, 2009), H_2O_2 was used as oxygen source in presence of three different catalysts. In that research authors observed that the presence of H_2O_2 significantly increased the degradation rate of the contaminant using P25 as catalyst. The main objective of H_2O_2/O_2 is capture electrons acting through preventing recombination of electron hole pair. The photocatalysis theory indicates that with no oxygen source who promotes the radical formation the degradation the reaction should not proceed. However, in this research without H_2O_2/O_2 PABA degradation occurred with a 92% of photodegradation in contrast with the study previously described. This can occur because photocatalysis is not a specific reaction and other substances besides H_2O_2/O_2 may be promoting the radicals formation.

The percentage of degradation of PABA without the use of radiation was inefficient, below 1%. This is because without a radiation source the catalyst cannot be activated to promote the radicals formation that produce the photocatalytic degradation. This is also confirmed when the experiment is performed without a catalyst when only 11% of PABA can be degraded.

5. CONCLUSION

The degradation of PABA by a photocatalytic process carried out with a concentration of 1.2 g/L of the catalyst P25 was very efficient. We successfully photodegraded 97% of PABA when it concentration was 4×10^{-5} M. This suggests that under these experimental conditions the pollutant get well adsorbed to the P25 surface promoting the photocatalysis. We confirmed that the photocatalysis is a good technique that can be employed in the remediation of polluted waters such as rivers and lakes. This process is one of great opportunities that exist today in the field of technology for large-scale applications in the contamination of the environment.

6. FUTURE WORK

With the aim to identify all experimental conditions parameters involved in the photocatalytic process of PABA, additional research using different catalyst should be done.

7. ACKNOWLEDGEMENT

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Biotechnological conversion of lignin for the production of biofuels by microorganisms

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ABSTRACT

The search for new sources of renewable energy has taken a new turn in recent years. Scientists around the world are in search of cleaner energy through biofuels to protect the environment. Would thus preventing pollution and dependence on existing fossil fuels. Lignocellulosic compounds contain chemistry similar to components found in nature such as aliphatic alkanes, aromatic rings. The degradation of lignocellulosic compounds is essential in recycling plant matter in ecosystems. This research is based on the isolation of bacteria capable of degrading lignocellulosic composites and alkanes. Plant and soil samples were collected in order to find potential degraders. Native microbiota for each sample was cultivated in general and selective media to isolate and purify strains with degrading potentials. Lignin degradation was observed in liquid media with variations in color for native microbiota but not for isolates. A total of twenty-two isolates were examined for alkane degradation and three were capable of using decane as a sole carbon source. Our results suggested the possibility of essential bacteria consortium to undergoes lignin degradation. This research provides novel consortiums with lignin degradation capabilities. Further research must be done in relation to the production of biofuel by these consortiums.

Keywords: lignin, alkane, biodegradation

1. INTRODUCTION

Today there has been a decrease in most non-renewable energy sources. The use of fossil fuels cause an increase in the polluting gases released into the atmosphere. In the last years researchers have been able to find viable sources of renewable energy that causes minimal impact to the environment. Biofuel can be produced by several methods. One of these processes includes the isolation of microorganisms with lignin degradation capabilities. Lignin is a polymer present in the cell wall of plants and it is resistant to degradation processes. The ability of lignin to resist degradation can be attributed to its distinctive polymeric structure (Wen et al. 2008).

Biomass can be converted into biofuel using microbial degraders of lignocellulosic material. Biomass is all matter derived from living organisms, it may be of plant or animal. Degradation of lignocellulosic compounds is essential in recycling plant matter in the ecosystem. It has been found that some microorganisms, such as bacteria and fungi, have some degrading capabilities for this compounds making sugar available for its fermentation to ethanol (Castro-Martínez et al., 2009). There is some literature reporting bacteria involved in the degradation of lignin, some of the most important are *Streptomyces viridosporus* T7A, *Nocardia* spp. and *Rhodococcus* spp.

(Bugg et al., 2010). Studies on the microbial degradation of lignin have focused primarily on breakdown by white-rot and brown-rot fungi, which are able to mineralize lignin (Bugg et al., 2010). Lignocellulosic compounds contain analog subunits which are relevant environmental contaminants, these units are aliphatic alkanes. Aliphatic alkanes are carbon and hydrogen compounds singly-bound.

The focus of this research is to evaluate the capability for degradation of lignocellulosic compounds, present in the vegetable matter, between bacteria. These involved the isolation and characterization of microorganisms and its capability to degrade aliphatic alkanes. Questions for this research are: 1) Is it possible to find potential lignin degraders? 2) Is it possible to find potential lignin degraders? The objective of this research is to find microorganisms that have a degrading potential of lignocellulosic compound and fermentation capabilities for the production of biofuels. The hypothesis is that our diverse Neotropical environments harbors novel potential degraders for lignin and alkane compounds.

2. METHODS2.1 SAMPLE COLLECTION

The samples used in this research were already collected by Dr. José R. Pérez-Jiménez and Yomarie Bernier from diverse ecosystems.

2.2 MEDIA PREPARATION

Solid medium (*Figure 1*) was prepared and transferred using aseptic techniques to prevent contamination. We use three different media: Tryptic Soy Agar (TSA), Lignin Agar and Mineral Agar. Liquid medium was prepared and transferred using aseptic techniques to prevent contamination. Lignin Medium is composed of yeast extract (2 g/L), peptone (2 g/L), remazol brilliant blue (0.5 g/L) and SeW (10 µL/100ml). The medium was sterilized at 121°C for 15 minutes in an autoclave inside tubes.

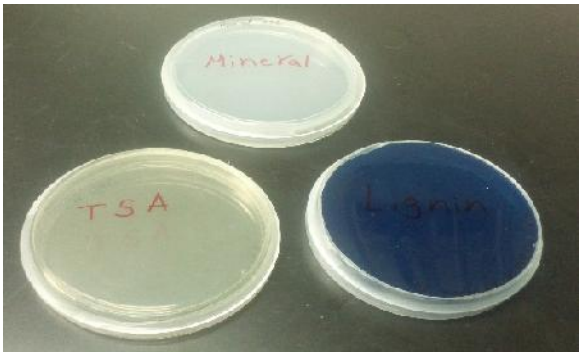

Figure 1: Solid medium plates.

Figure 2: Native Microbiota growing in media broth.

2.3 REACTIVATION OF CULTURES *(Figure 2)*

To reactivate microorganisms we transferred 600 µl from the original culture to new tubes with lignin media. After reactivation, the lignin media was observed daily for changes in color for five days. When the color changed, we proceeded to put the tubes in the fridge for preservation. Three dilutions were made to purify microorganisms with lignin degradation capabilities. From the original culture we also transferred 400 µl into sterile plates. Observations were made for five days. Once they changed color we proceeded to put them in the fridge for preservation.

2.4 PURIFICATION OF LIGNIN DEGRADERS

Tubes with color changing were selected for purification. Using aseptic techniques we transferred 100 µl from the tubes to the plates with lignin and spread out with beads. The plates were put on observation at 25°C during a week waiting for changes in color and microbial growth. The purest colonies were picked and transferred to TSA plates. In the TSA plates the colonies were spread using the streak technique. The plates were incubated for 24 hours at room temperature. Once the time came, the plates were observed again and we took the isolated colonies and using aseptic techniques we took a sample out of each chosen colonies. Using an inoculation needle we transferred the samples to TSA plates. The colonies where spread out again using the streak technique to ensure purity. The plates were left again for a period of 24 hours (*Figure 3)*. Once the time of incubation was reached, we observed the plates in search for the purest colonies. We isolate colonies out of each plate. None of the isolated bacteria degraded the lignin by itself. Our observations suggested the possibility of an atmosphere with less oxygen to perform the degradation process.

2.5 LIGNIN DEGRADATION WITH LESS OXYGEN

None of our aerobic isolates were positive for lignin degradation, because of this we decided to change the inoculation technique. We prepared lignin as solid media as describe before. Cultures (tubes) with any type of growing microbe were selected. Out of each one, a 100 µl where transferred to empty Petri plates. Once the lignin medium was sufficiently cold, it was poured into the plates. We wait for the plates to cool off and then they were placed on observation for a week (*Figure 4*). We did have bacteria growth but there was no color change representing lignin degradation (*Figure 4*). This could indicate that the degradation of lignin can be done with the contribution of various microorganisms, as a consortium.

2.6 GROWTH IN THE PRESENCE OF DECANE

In the search for new results for this project we decided to expose our isolated bacteria to the presence of decane. We chose the purest cultures from lignin media and using aseptic techniques we transferred 100 to plates with mineral media. The samples where spread using beads. Decane was provided as vapor using Durham tubes. The plates were placed on observation inside anaerobic chambers so that the decane would not escape from the interior of the plates. The plates were left on observation for one week (*Figure 5*). As a result we chose pure colonies from 3 plates and using aseptic techniques were transferred to TSA plates and these where inoculated using the streak technique in the plates. The plates were left incubation during 24 hours once the time finished they were placed on the fridge to preserved them and use them for future research.

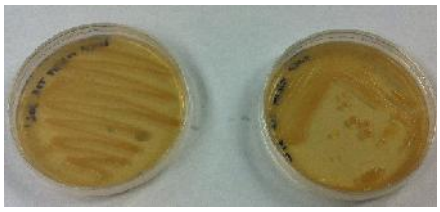

Figure 3: Streaked Purification

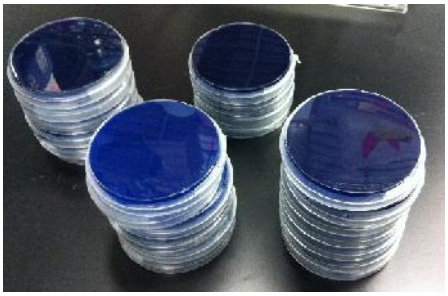

Figure 4: Pour plates technique

Figure 5: Contained incubation of culture with decane

3. RESULTS

Our results showed degradation in native culture placed in liquid lignin media (*Figure 6*). With the positive reactivations we made three dilutions. From thirty-five samples three did not showed changes in the dilutions. Only six samples did not showed color changing after the first dilution, seven samples showed no change after the second dilution and nineteen samples have no change of lignin degradation in all the dilutions. Lignin degradation is known when occurred because of the color change in the medium. The fifty-five positive samples were placed in liquid lignin, when they were passed through lignin dishes showed no degradation. Microbial growth on these plates was observed.

Cultures placed on lignin agar after purification showed negative results. After being purified and inoculated in lignin liquid medium, these samples showed no degradation.

In tests to observe degradation of decane, positive samples were three of twenty-two isolate tested.

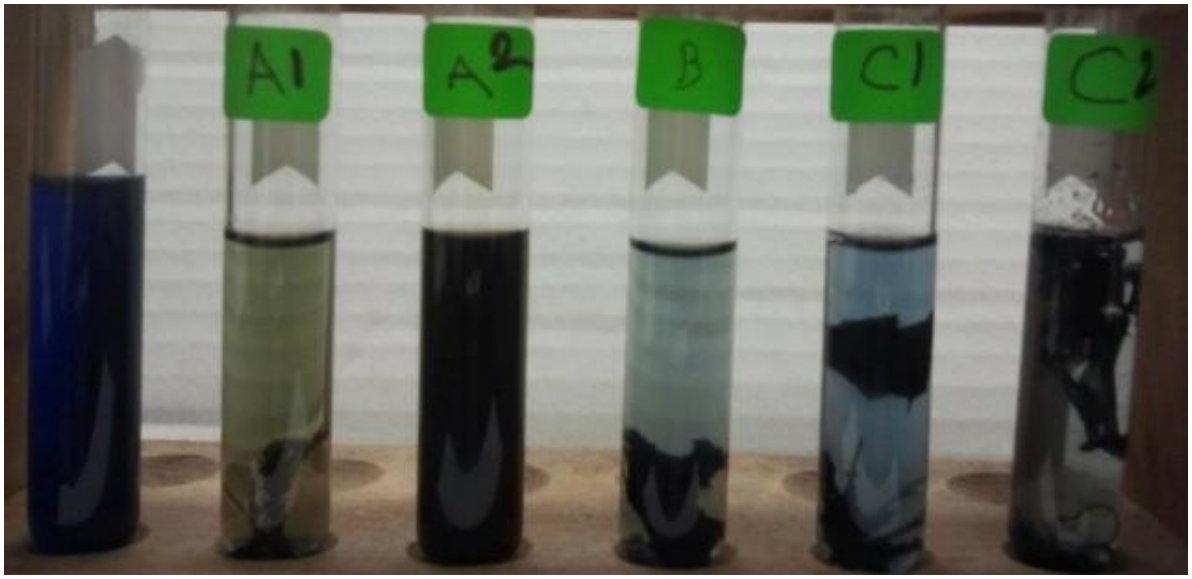

Figure 6: Microbial response to lignin media represented by color changes.

4. DISCUSSION AND CONCLUSION

Our research highlighted the reactivation of cultures with native microbiota for the search of possible lignin degraders. When activated the native microbiota changes are observed in the growth medium which means that no degradation of lignin. Positive samples were purified and placed again in the lignin media. The purified samples were negative, leading us to conclude that these bacteria work together to lignin degradation. Getting no results was thought that these bacteria could work better an anaerobically. Therefore we decided to prepare lignin media poor plates technique to minimize the oxygen availability. With this technique did not obtain any positive results lignin degraders but we observed microbial growth therein. It is observed that microorganisms may work together or individually, it is said that only were positive for lignin degradation samples with the native microbiota.

By not get accurate results, we decided to study lignin alkanes. Alkanes are present in gasoline and lubricating oils. Are contaminants in the environment, so bacteria that have the potential to degrade them. In this way, we

would be improving the environmental quality. As future work, isolates and consortium could be used for molecular studies such as, amplification of catabolic related genes, sequencing for characterization and TRLFP-based description of communities. With these techniques can identify microorganisms responsible for degrading lignin and alkanes.

As a conclusion, production of biofuels is important because is an alternate energy source for the decrease of petroleum, it is renewable and beneficial for the environment. My research focus in the possibility of finding microorganisms that have the potential to degrade compounds that are essential fot the production of biofuels.

5. ACKNOWLEDGMENTS

We want to thank Dr. José R. Pérez Jiménez for the opportunity to participate in this summer research. For giving us the opportunity to work in his laboratory and support at all times. We also want to thank my mentor Yomarie Bernier for all the help I provide during our summer research. We gratefully recognize the financial support provided by the Department of Energy through the Massey Chair project at Turabo University, Summer Internship Puerto Rico Energy Center 2013, the great opportunity provided Dr. J. R. Pérez-Jiménez and the contribution of my lab mates, and colleagues in the Interdisciplinary Research Institute research. Many of the materials and instruments used were provided by *NSF-ATE PRIMER Tropical Bioprospecting Venture at CETA* (DUE-0903274) and *PRIMER Bioprospecting for Bioenergy* (US Forest Service 11-DG-11330101-111) to Dr. Pérez-Jiménez. Without the support and help of all these resources could not carry out such work**.**

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Optimization in Continuous Culture of *Chlorella vulgaris* for the Production of Fuel Oils

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ABSTRACT

Energy demand increases everyday. Production of biofuel could be a solution. It is considered a clean energy because the production of greenhouse gases (i.e., CO_2, CH_4) are reduced. For the production of biofuel we will use *Chlorella vulgaris*, a microalgae that has a very fast growth rate according to the industry. It is recommended that the microalgae used for biofuel production come from the groups of *Cyanobacteria* and *Chlorophyceae*. In this case *C. vulgaris* come from *Chorophyceae* group. For this project the objective is to find the best substrate for the optimal development of these microalgae in conditions that favor static and constant growth for *Chlorella vulgaris*. A significat growth was observed in *C. vulgaris* in a dextrose-supplemented under static (batch) and constant (continuous) conditions.

Keywords: *Chlorella vulgaris*, optimal nutritional parameters, photobioreactor, biofuel, oil extraction

1. INTRODUCTION

Over the last few years, one of the main problems at a global scale has been to obtain alternative carbon sources. This is mainly due to the exponential increase in consumption of petroleum-based fuels, which in turn has affected many other resources. Sustained use of petroleum-based fuels has been implicated as a major cause of increased atmospheric greenhouse gases, which may contribute to global climate change (Quadrelli and Peterson, 2007). These challenges have sparked the quest for alternative energy sources to serve as viable replacements to reduce dependence on fossil fuels and improve environmental sustainability. (Dalrymple el al., 2013). Currently, biodiesel is produced from different crops, such as soybean, rapeseed, sunflower, palm, coconut, jatropha, karanja, used fried oil and animal fats (Spolaore et al., 2006; Khan et al., 2009).

Microalgae have been recognized as a promising alternative source for oil production (Glacio et al., 2011). They are photosynthetic microorganisms that convert sunlight, water and carbon dioxide to biomass (Chisti, 2007). In microalgae, lipids have as a basic function the synthesis of lipoproteic membranes and are important in floating and as an energetic reserve (Lee et al., 1989). Accumulation of lipids can be attributed to consumption of sugars at a rate higher than the rate of cell generation, which would promote conversion of excess sugar into lipids (Chen and Johns, 1991). The algae *Botryococcus braunii* is regarded as a potential source of renewable fuel because of its ability to produce large amounts of hydrocarbons, it depends on the strain and growth conditions; up to 75% of algal dry mass can be hydrocarbons (Banerjee et al., 2002). Among the green algae, some of the species included *Chlamydomonas reinhardtii*, *Dunaliella salina*, and various *Chlorella* species, as well as *Botryococcus braunii*,

which although slow growing can contain over 60% lipid, much of which is secreted into the cell wall (Metzer et al., 2005). Since the productivity of *B. braunii* is well known, and various species of *Chlorella* are developed in a very similar process, *Chlorella vulgaris* was used in our experiment. The objective of this project is to find the best substrate for the optimal development of these microalgae in conditions that favor static (batch) and constant (continous) growth for *Chlorella vulgaris*.

2. METHODS

2.1 GROWING CONDITIONS The algae *Chlorella vulgaris* was reactivated using a general substrate media (2.5 g of NaCl, and 10 µl of F/2 algae nutrient per liter of distilled water). In 50 ml test tubes, we put 30 ml of the substrate and inoculated them with the pure algae. Then it was placed into white light for a week to accelerate the process of growing. It was continually observed to learn how *C. vulgaris* grows in general substrate and put in a small photobioreator in the laboratory under various rediation regimes (white, blue, and dark blue lights).

2.2 CONTAMINATION TEST This test was used to verify that the culture of the algae was completely pure, and it consisted of two tests. One consisted of a liquid substrate and the other had a general culture medium with agar. There were six test tubes of 50 ml with normal substrate and pure microalgae. The first three tubes had 30 ml (small scale) of general media and 100 µl of the stock culture of *C. vulgaris,* and the other three tubes had 30 ml of general media and 150 µl of the stock culture of *C. vulgaris*, and it had 20 ml of space for CO_2. Then it was tested for contamination in a petri dish. In a 500 ml-Erlenmeyer flask , 400 ml of water and 3 drops of F/2, 1.00 g of NaCl, 6.0 g of agar were placed. It was heated to dilute all solids and then it was put in the autoclave. After the autoclave was done, the media was poured into the petri dish, and when cooled, we inoculated the plates.

2.3 NUTRITIONAL PARAMETERS Algae commonly consume almost every carbon source. Some work has also gone into improving the algal capacity to absorb foreign sources of glucose and therefore generate more hydrogen by catabolic processes (Doebbe *et al.* 2007). But in previous studies reveals that glucose it one of the sources that works effectively. Glucose makes algae grow faster in less time. In this experiment was attempted to replace glucose for any other carbon source. *C. vulgaris* it was inoculated in substrate enriched with food residues such as breadfruit water. Dextrose substrate was also performed. Furthermore, these were observed every physical change: color, lumps, particulate, turbidity and that any other change.

2.4 PHOTOBIOREACTOR The photobioreactor (PBR) is an instument for the production of microalgae outside their natural environment. This is not only mechanical engineering but also genetic engineering approaches can solve parts of the problems (Lehr 2009). PBR is a new system that provides a good way to growth algae in a big scale view. After it was gather a good portion of the small scale (around 500 ml-1.0L), we were ready to move the culture to the PBR. The system was running for 1 week using white light with a medium intensity. After *C. vulgaris* grew in the PBR, it was removed with aseptic techniques all the algae those how were in constant movement and those that were in the tank. After the second run, we were gathering the absorbance and optical density each day to verify the growing.

3. RESULTS

Our results show that the substrate with the best growth rate for algae was the dextrose (figure 1). Of the three samples that contained dextrose, the greatest growth was observed in the pure inoculate (DXP), followed by an intermediate algae growth from the PBR that were in constant movement (DXC). In the case of the dextrose

sample with the tank algae (DXT), the F/2 substrate with the pure algae inoculated had a greater growth but only in the light blue light, since in the dark blue light the growth observed was the same. The normal substrate with pure algae culture inoculated (MN) showed very little growth. The normal substrate with continuous culture (MNC) showed minimal growth with dark blue light when compared to all the rest. A repetitive pattern in our results shows that algae grow and develop in optimal conditions with the light blue light.

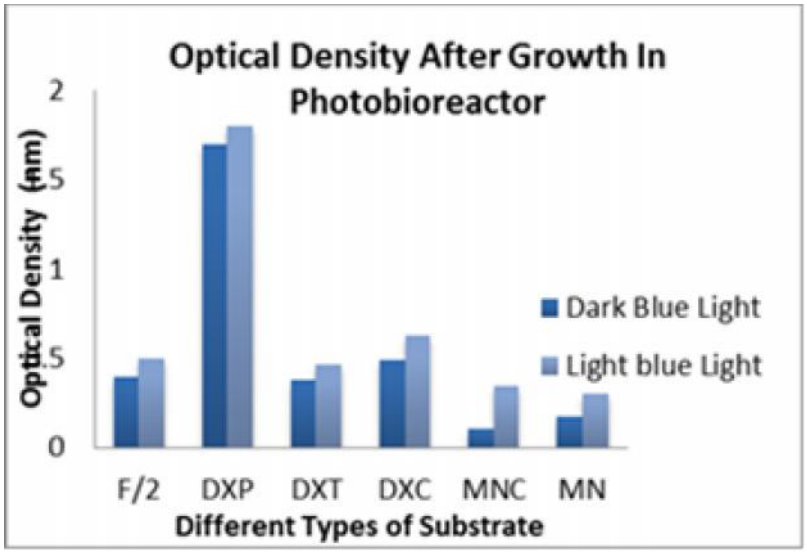

Figure 1. Growth comparison of the different substrates in the light blue and dark blue lights.

4. DISCUSSION & CONCLUSION

Research reveals nutritional parameters in *C. vulgaris* that have enabled advanced and optimal growth of the algae. As soon as *C. vulgaris* recognized new sources of food it had an impact in the development of the algae. Having an optimal medium for growth and development is essential since this in turn provides us with a better yield of bio-fuel from the algae.

After a variety of substrate was used to grow *C. vulgaris*, the most effective one was the substrate with dextrose on light blue light. Dextrose and the cell's ability to utilize this organic source were stimulated by light the organism's ability to use this organic source was stimulated by light (Martínez and Orús, 1991). As expected, when the cells were not supplemented with dextrose, raising the light intensity had no effect on their growth rate. Otherwise, in dextrose presence, the light intensity strongly affected the growth rate.

The microalga green pigment chlorophyll absorbs the blue light more efficiently than the dark blue light, making light blue light the optimal for *C. vulgaris* growth, and the optimum light intensity of the experimental illumination time was determined as 160 hours.

This investigation has spawned new questions, such as how temperature and cold conditions may affect the algae growth, and also since the optimal growth and development conditions are known thanks to this research, the next step would be to make an extraction of the oil produced and make bio-fuel.

5. ACKNOWLEDGMENTS

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this project every step of the way. We gratefully recognize the financial support provided by the Department of Energy through the Massey Chair project at Turabo University, Summer Internship Puerto Rico Energy Center 2014, and the contribution of my lab mates, and colleagues in the Interdisciplinary Research Institute research. Many of the materials and instruments used were provided by *NSF-ATE PRIMER Tropical Bioprospecting Venture at CETA* (DUE-0903274) and *PRIMER Bioprospecting for Bioenergy* (US Forest Service 11-DG-11330101-111) to Dr. Pérez-Jiménez. Without the support and help of all these resources could not carry out such work.

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Fluoroquinolone-metal complexation chemistry and adsorption isotherms as a water treatment technology approach

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ABSTRACT

Fluroquinolone-type antibiotics can be widely found in waters as anthropogenic pollutants. These organic compounds can form complexes with metal ions soluble in water solutions, creating a treatment problem. The specific objectives of this research plan were (1) to synthetize fluoroquinolone-metal complexes, using ciprofloxacin (cip), levofloxacin (lev), lomefloxacin (lom) and norfloxacin (nor) with Ni and Cu metals; (2) to characterize the complexes with spectroscopic techniques; (3) to study the adsorption capacity isotherm on powdered or granular activated carbon as a water treatment technology approach. The development of an adsorption method using activated carbon will improve tap or natural water quality. We expected to find the appropriate adsorption isotherm model (Freundlich or Langmuir) that best describes the behavior of fluoroquinolone-metal complexes over granular activated carbon (GAC) or powdered activated carbon (PAC). Ni and Cu complexes were prepared and partially characterized with UV-Vis, XRD and FTIR techniques.

Keywords: *antibiotics, fluoroquinolones, metal complexes, adsorption isotherms*

1. INTRODUCTION

The adsorption of organic compounds found in aqueous solution has been of special interest in the application of GAC and PAC (Moreno, 2004). This covers a wide spectrum of systems such as drinking water and waste water treatments, and applications in the food, beverage, pharmaceutical and chemical industries. Activated carbon adsorption is considered by the US Environmental Protection Agency as one of the best available environmental control technologies (Moreno, 2004). The increasing demand for the manufacturing of such pharmaceutical compounds has provoked another problem: presence and occurrence of antibiotics (macrolides, quinolones, etc.) in wastewaters and surface water sources that represent an environmental exposure pathway to humans, animals and agriculture. Point sources of pollution have been listed ranking from hospitals to septic tanks, livestock activities and effluents from wastewater treatment, among other not characterized sources (Focazio, et. al., 2008).

Although contamination is an important concern in the United States and the European Union, no regulations have been established to control the myriad of pharmaceutical compounds, antibiotics among them, which are manufactured on a big scale yearly. On the other hand, antimicrobials are the most often discussed since their presence in the environment could eventually develop resistance in pathogens (Golet, Alder, & Giger, 2002). The environmental concern with fluoroquinolones is not based in the potential of developing resistance but also in the ecotoxicity profile of these compounds, especially the hazard to food crops irrigated with antibiotics-contaminated water.

2. EXPERIMENTAL

Metal complexes were synthetized as per Kumar and Yadad (2009). Metallic salts were purchased from Sigma Aldrich®. An amount corresponding to a molar ratio of 2:1 (fluroquinolone- metal) was dissolved into 10 mL 0.1M HCl and 10 mL H_2O under slight heating. The pH was adjusted with 0.1M HCl to avoid the precipitation of metallic hydroxide. By stirring the solution of the metal ions dropped into the solution of the antibiotic, the pH value was increased by adding 0.1M NaOH solution until a change of color was observed, but no precipitation. With continued stirring, 10 mL methanol was added into the solution and the system was kept at room temperature for three days. The precipitation of the complex was filtered off and the solid was washed repeatedly with ethanol. The compound was dried at 50-60°C for 48 hrs. Characterization was conducted using a Bruker® D8 Advanced XRD, a Nicolette iS-50 FT-IR and a Schimadzu 1800 UV-VIS as per Adam (2012).

To study the adsorption behavior, standard solutions of 1.00, 0.750, 0.500, 0.250, 0.125, 0.0625 mM of each complex or pure antibiotic were prepared and analyzed by UV-Vis. In small test tubes, approximately 0.1000 g of activated carbon, GAC or PAC, was weighed and put in contact with 10-mL of a 1.00 mM solution of each complex or pure antibiotic for 0.5, 1, 3, 24 and 48 hrs. The Freunlich and Langmuir models were applied to each system to determine which one explains better the adsorption behavior of the compounds.

Laboratory safety measures and institutional policies were followed throughout the duration of this study. Safety precautions with the use of antibiotic solutions were taken into consideration. Responsible conduct of research policies were also strictly followed in the gathering of information, performance of analyses and when reporting results.

3. RESULTS AND DISCUSSION

The following complexes were synthetized and characterized (Table 1). Solubility of each complex in water was also tested. All products were water soluble.

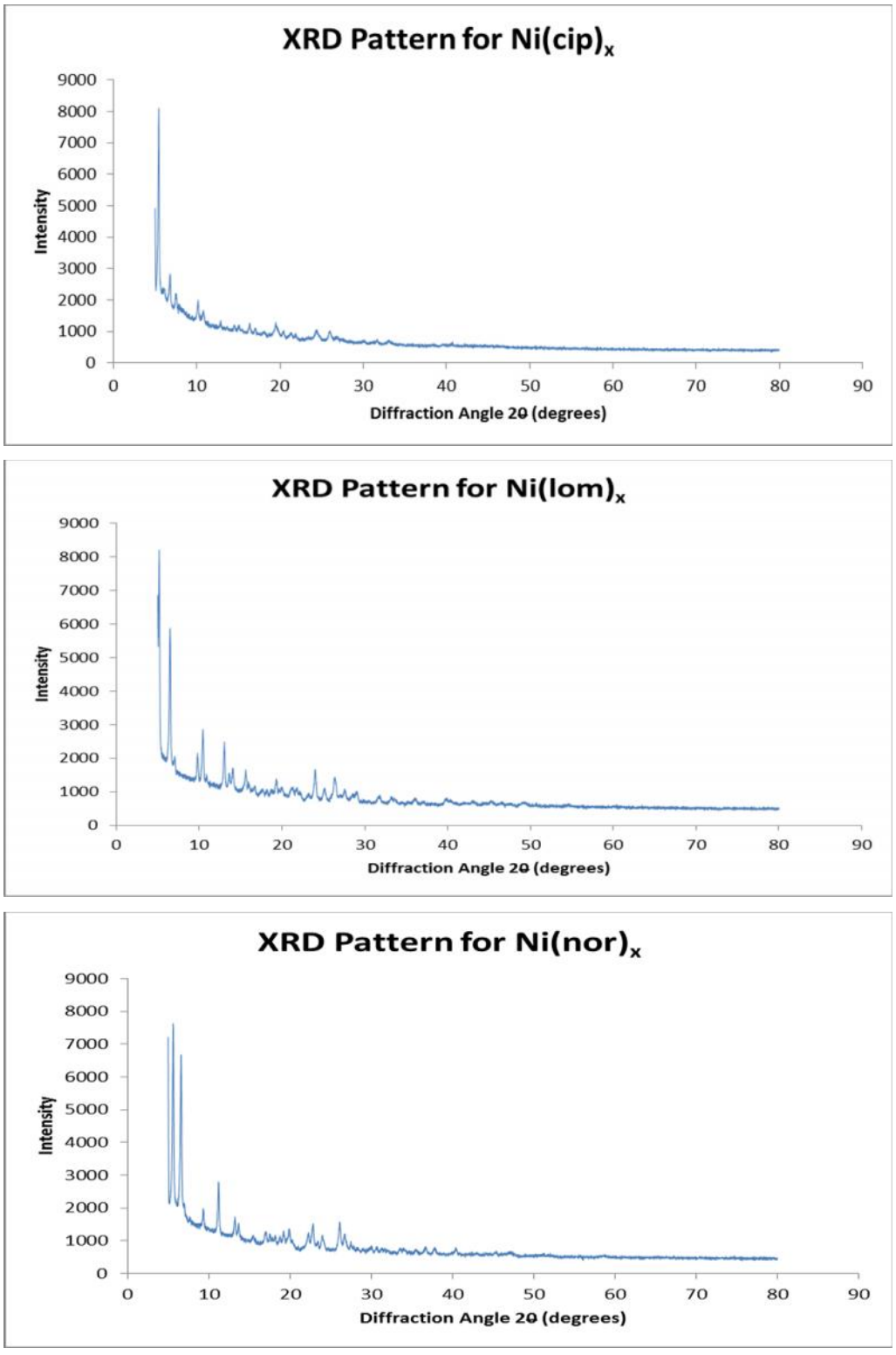
Table 1: Synthetized fluoroquinolone-metal complexes

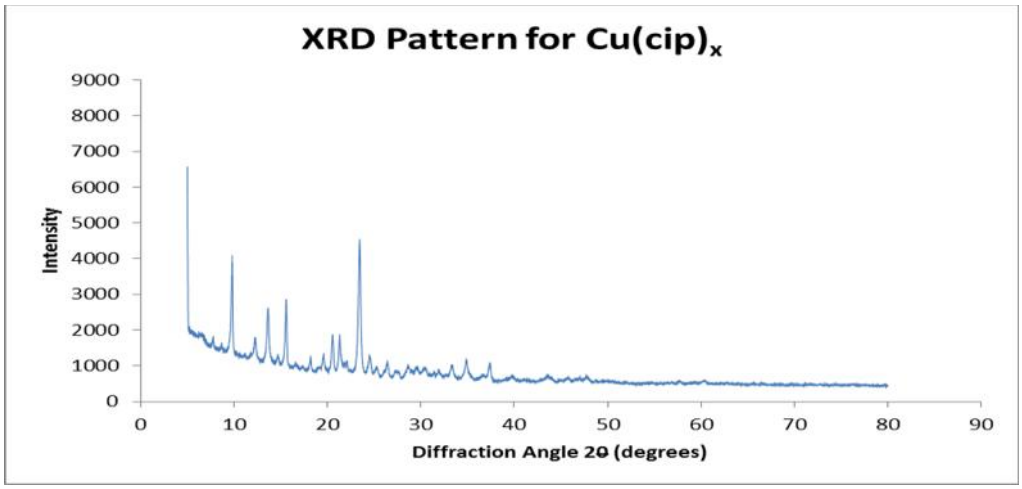
Characterization						
Product	Color	UV-Vis λ_{max} (nm)	XRD	FTIR	NMR	Solubility in Water
Ni(cip)	green	X 274.00 nm	x	x	*	Yes
Ni(lom)	green	X 209.00 nm	x	x	*	Yes
Ni(nor)	green	X 338.00 nm	x	x	*	Yes
Cu(cip)	green	* 249.00 nm	x	x	*	Yes
Cu(nor)	green	x 254.00 nm	x	x	*	Yes
Pb(cip)	white	*	*	x	*	*
Pb(lom)	white	*	*	x	*	*
Pb(nor)	white	*	*	x	*	*

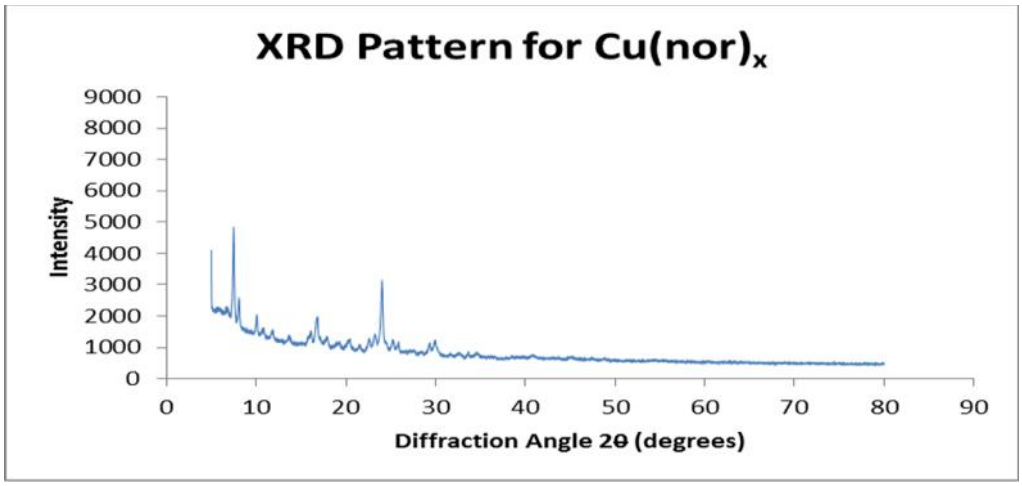
***** Characterization was not accomplished using this technique.

UV spectra for each of the 1mM aqueous stock solutions of each complex were obtained in order to determine the maximum wavelength (Table 1). For the XRD, solid samples were analyzed to obtain the diffraction pattern of each complex (Figure 1).

Figure 1: X-Ray Diffraction Pattern of the Synthetized Complexes

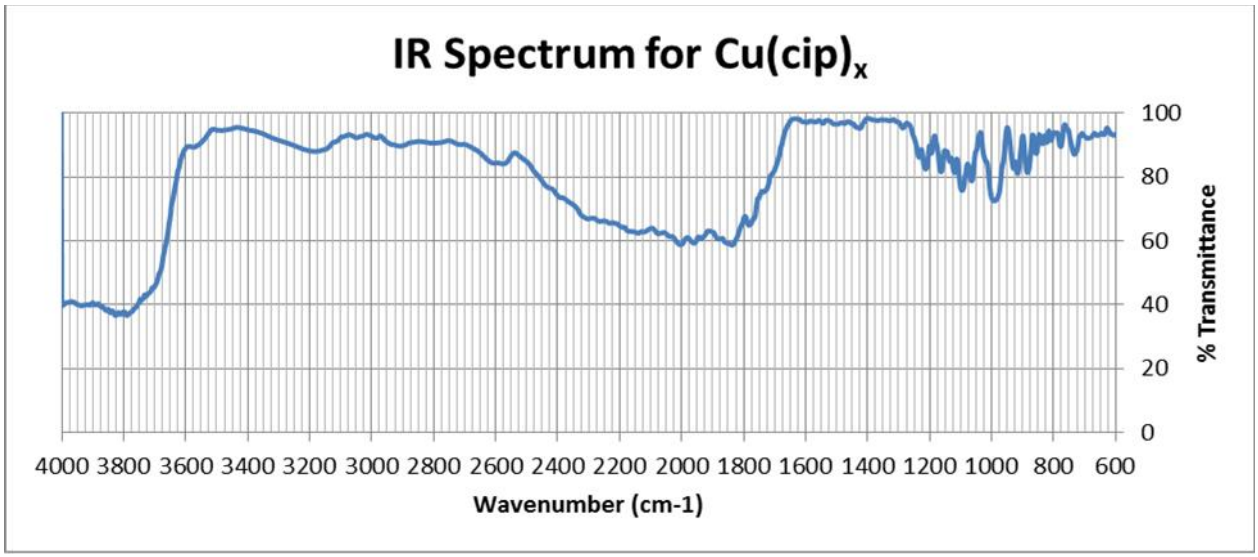


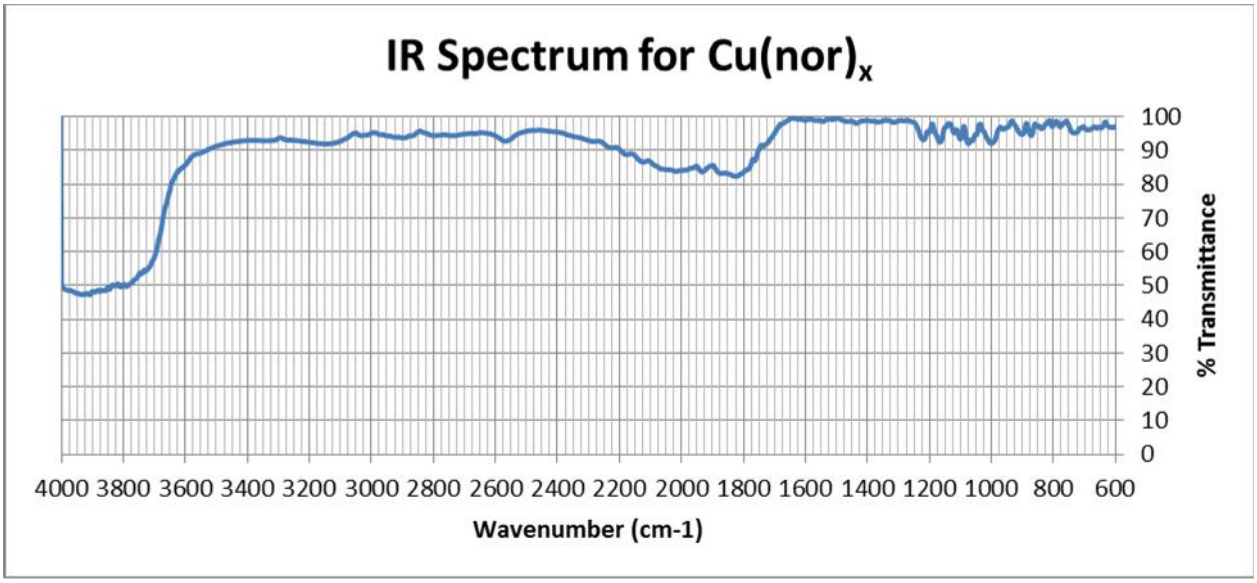


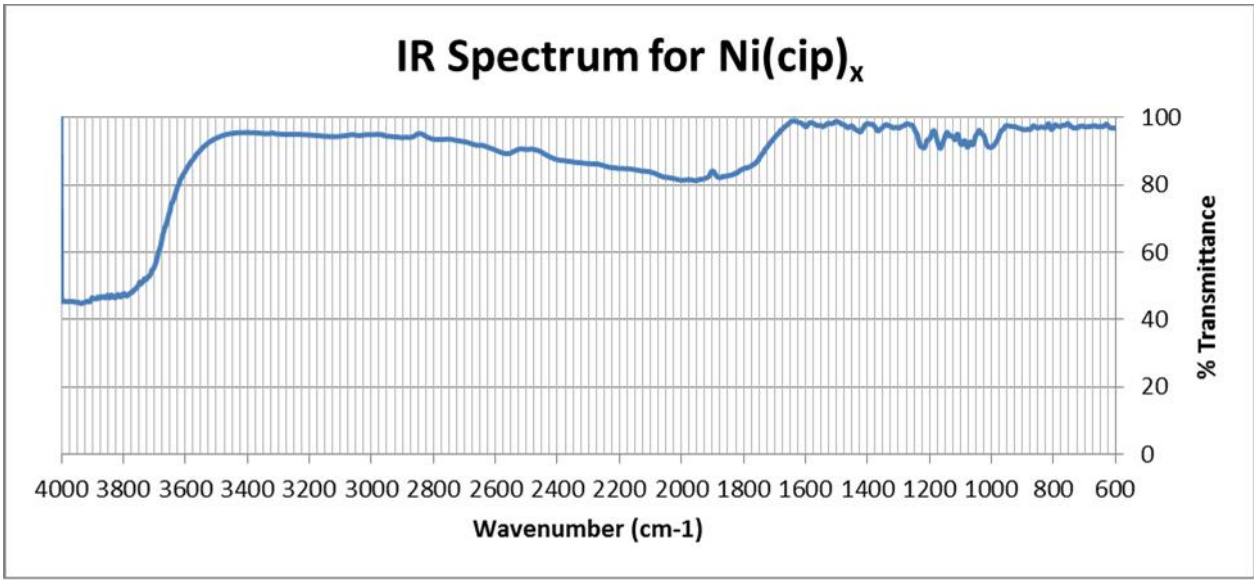


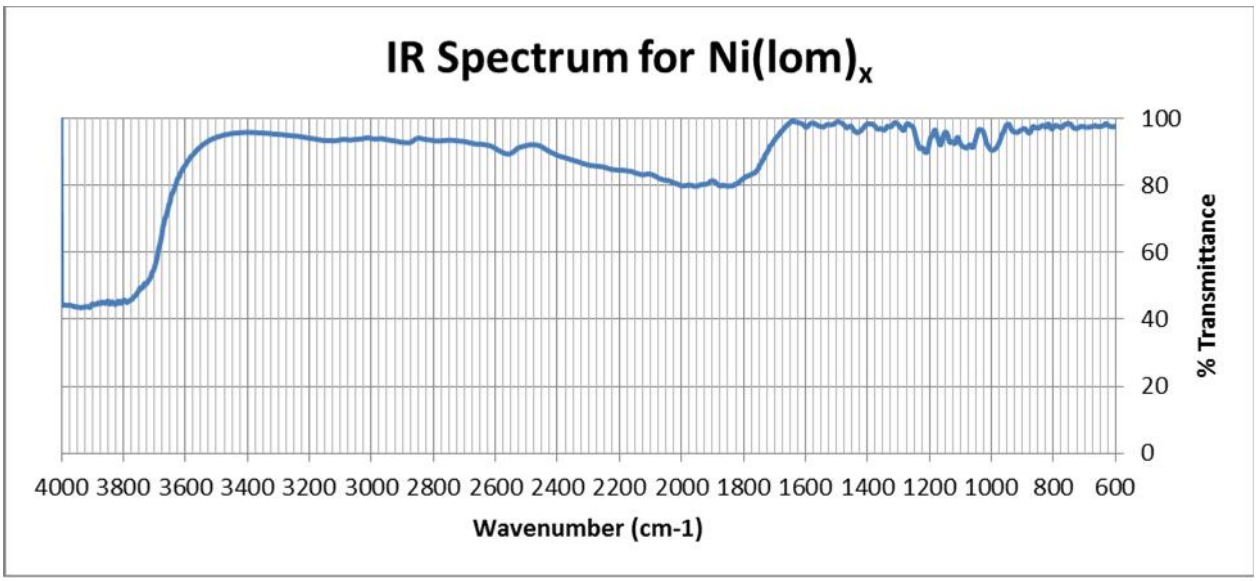
The IR spectra of the products are presented below; that is, those for the Ni, Cu and Pb complexes. Note that main bands are located in the fingerprint region as well as the hydroxyl characteristic region (Figure 2).

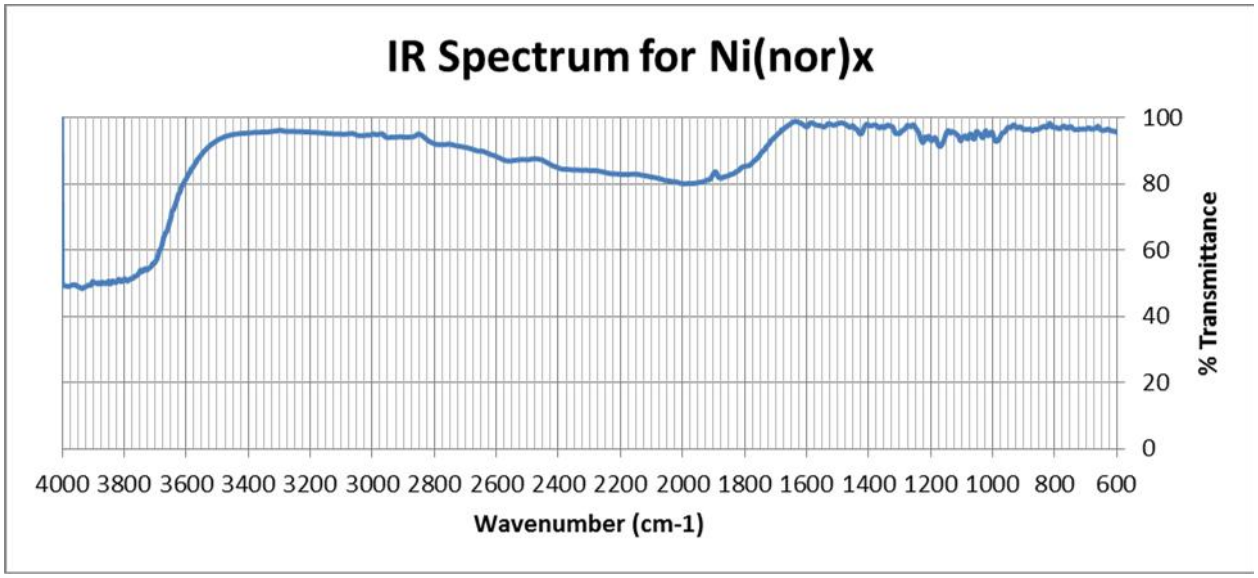
Figure 2: IR Spectra of the Synthetized Complexes

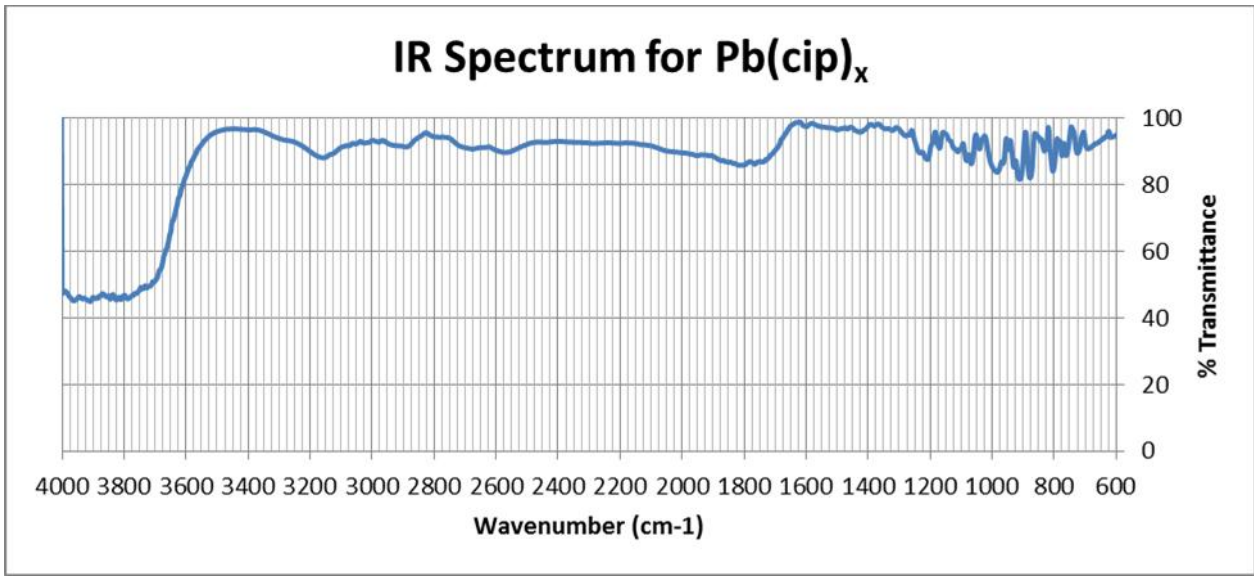


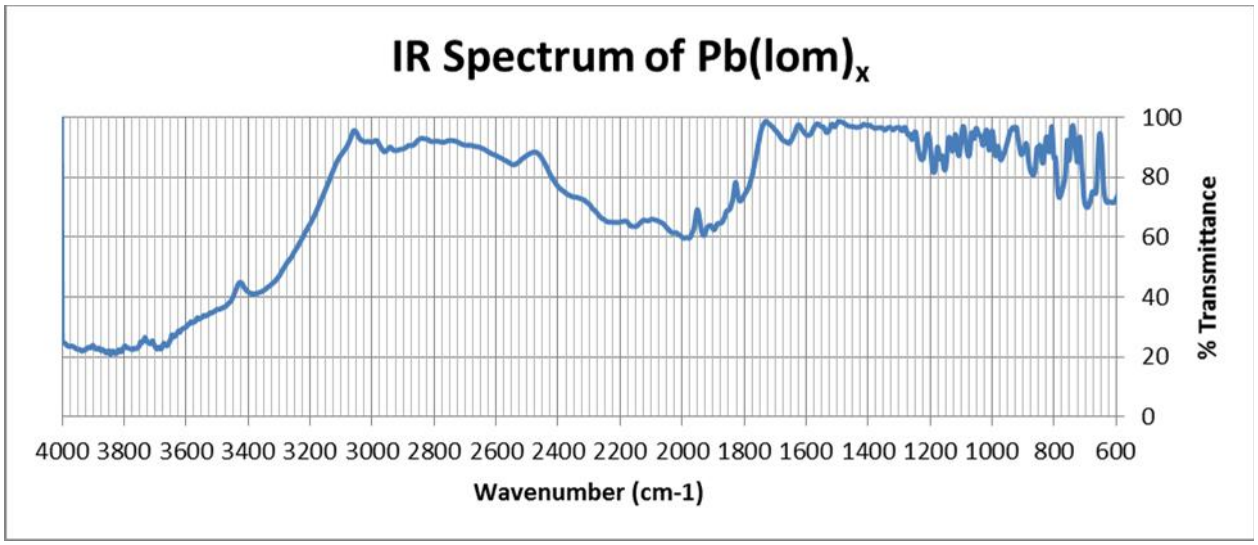

IR Spectrum for Cu(nor)x
100
90
80
70
60
50
40
30
20
10
0
% Transmittance
4000 3800 3600 3400 3200 3000 2800 2600 2400 2200 2000 1800 1600 1400 1200 1000 800 600
Wavenumber (cm-1)

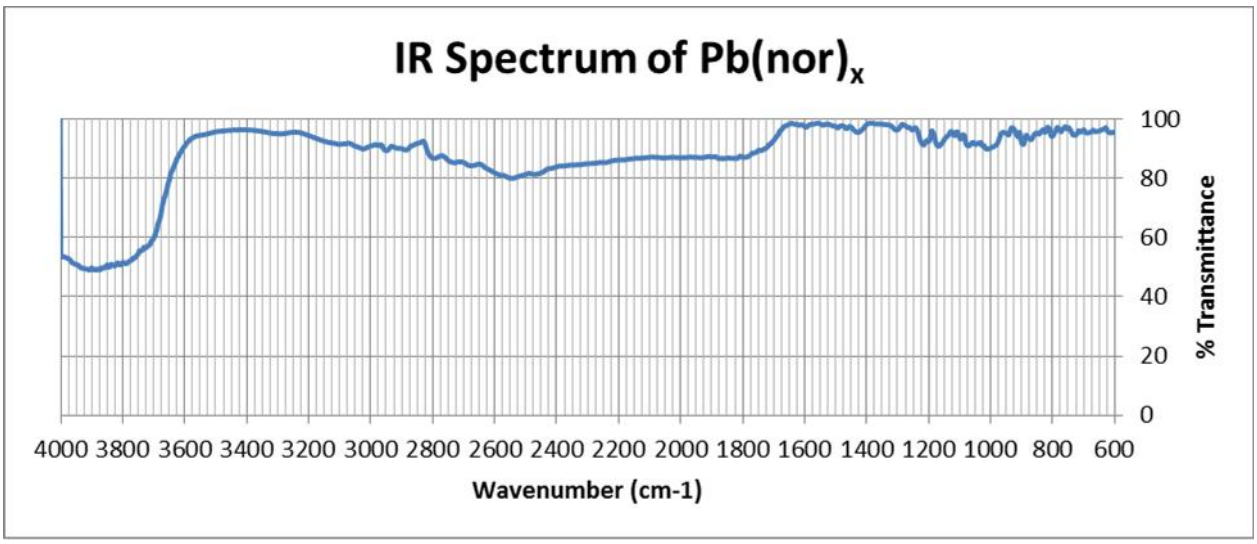

IR Spectrum for Ni(cip)x
100
80
60
40
20
0
% Transmittance
4000 3800 3600 3400 3200 3000 2800 2600 2400 2200 2000 1800 1600 1400 1200 1000 800 600
Wavenumber (cm-1)


IR Spectrum for Ni(lom)x
100
80
60
40
20
0
% Transmittance
4000 3800 3600 3400 3200 3000 2800 2600 2400 2200 2000 1800 1600 1400 1200 1000 800 600
Wavenumber (cm-1)


IR Spectrum for Ni(nor)x
100
80
60
40
20
0
% Transmittance
4000 3800 3600 3400 3200 3000 2800 2600 2400 2200 2000 1800 1600 1400 1200 1000 800 600
Wavenumber (cm-1)


IR Spectrum for Pb(cip)x
100
80
60
40
20
0
% Transmittance
4000 3800 3600 3400 3200 3000 2800 2600 2400 2200 2000 1800 1600 1400 1200 1000 800 600
Wavenumber (cm-1)


IR Spectrum of Pb(lom)x
100
80
60
40
20
0
% Transmittance
4000 3800 3600 3400 3200 3000 2800 2600 2400 2200 2000 1800 1600 1400 1200 1000 800 600
Wavenumber (cm-1)



The IR spectra of $Cu(cip)_x$ and $Pb(lom)_x$ have characteristic bands of absorption in the aromatic region (~2000 cm^{-1}), indicating less contribution of these groups to the chelate. A better characterization is needed using Scanning Electron Microscopy and Nuclear Magnetic Resonance Spectrometry.

Table 2: Results for adsorption analyses

Isotherms (GAC)					
Rx	**Absorbance at $^{a}_{max}$**				
	0.5h	**1.0h**	**3.0h**	**24h**	**48h**
Ciprofloxacin	3.97861	2.48003	2.48003	2.67262	x
Lomefloxacin	x	0.78476	1.49792	2.81503	0.36363
Norfloxacin	1.79660	x	0.95387	0.27444	x
Ni(lom)	3.61588	0.03307	3.70963	0.03577	3.19067
x means no data was obtained					

In this table, some analyses for the adsorption over GAC were performed. Some data is not available because it could not be obtained. The table shows an erratic pattern which leads to the conclusion that the UV lamp in the instrument was not functioning properly and/or solutions were not correctly prepared. These trials need to be repeated to reach the objectives of the investigation. Results highlighted in green somehow demonstrate a tendency, but are not conclusive.

Isotherms (PAC)					
Rx	**Absorbance at $^{a}_{max}$**				
	0.5h	**1.0h**	**3.0h**	**24h**	**48h**
Ciprofloxacin	0.24840	x	0.03835	0.04648	x
Lomefloxacin	2.73271	0.03011	0.03011	2.97925	3.27847
Norfloxacin	3.05467	2.25745	3.40132	0.02168	x
Ni(lom)	0.06190	2.69777	0.01794	3.55246	0.02278
Cu(nor)	0.01810	3.64467	x	3.17653	x
x means no data was obtained					

The team was unable to conduct the studies of adsorption as expected. Future research will be conducted to determine the best model that explains the adsorption behavior of these complexes.

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Deployable Wing System

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ABSTRACT

The main objective of the summer internship with the Puerto Rico Energy Center in Universidad del Turabo was to develop the solar panel and deployable wing system for the Cube Satellite model QB50. The model for the design will be a 2U model (20 cm height, 10 cm length and 10 cm width). With this, was able to create a hinge and wings with the release mechanism to work properly out in space with less chance of a failure. The tolerance permitted for this research was .1mm, that changing it to percentage, the maximum difference can be no more of 10%. For modeling the deployable system were used Solidworks Program and Comsol Multiphysics for the thermal simulations. A main aspect of this project was to create a design that can be created in the machine shop without any trouble.

1. INTRODUCTION

The number of missions in space using numerous satellites has been increasing in modern times and concepts of space missions involving many different space crafts are intended for scientific applications. Improved functionality is amongst the main inspirations for mission using distributed space systems.[1, 2] Space missions using massively distributed satellites are especially encouraging for standardized small spacecraft like CubeSats that have a low development cost and short development time.

Figure 1: Cube Satellite 2U Device

The CubeSat reference design was proposed in 1999 by professors Jordi Puig-Suari and Bob Twiggs. [4] The goal was to enable graduate students to be able to design, build, test and operate in space a spacecraft with capabilities similar to sputnik which was the first spacecraft. The CubeSat became a standard over time by a process of emergence. The first CubeSats were launched in June 2003 on a Russian Eurockot. Approximately 75 CubeSats have been positioned into orbit as of August 2012. [5]

A CubeSat is a miniaturised satellite measuring 10 x 10 x 10 cm and having a mass of about 1kg.[6] They offer all of the standard functions of a normal satellite like altitude determination and control, uplink and downlink telecommunications, power subsystem including battery and body-mounted solar panels. CubeSats have been developed primarily as an educational tool and in recent years are being more and more exploited for military applications, commercial services and business. [3] Because of their small size, they are not serious contender for scientific missions. However, new application scenario like distributed space missions and continued miniaturization of payload and subsystems enhace the scientific contribution of CubeSat missions. It takes about two years to develop a CubeSat from the provision of founding until launch. The main objective of developing, launching, and operation a CubeSat is to educate graduate students.

2. METHODOLOGY

For this research were used programs for modeling and study our designs. Some of this programs are Solidworks, Comsol Multiphysics, Microsoft Word and Power Point. Solidworks was used for do the finite element analysis for determine the stress, strength displacement and factor of safety of the design. With Comsol Multiphysics was simulated the temperatures differences across the entire design. Also, the thermal stress across all the part to see the weakest points of the parts when are exposed to the extreme temperatures of the atmosphere. Tables must be provided as close as possible to their reference in the text. Tables and their heading should be centrally aligned. Table titles and their headings must be bold. Table captions appear centered above the table. A sample is shown in Table 1.

3. DISCUSSION OF RESULTS

For the design research were developed 3 different models of hinges to study them and make a decision matrix to choose witch one was going to be used for the Cube Satellite 2U. Were designed a simple hinge (Figure 10), a Staggered hinge (Figure 12) and a Curved/Shaved hinge (Figure 11). The three hinges were analyzed and tested with Solidworks and Comsol Multiphysics to know how they are going to work at the atmosphere.

Table 1: Decision Matrix

Properties	Percent	Simple Design 	Staggered Design 	Shave/Curved Design 
Mass	20%	5	4	3
Deformation	20%	5	4	3
Factor of Safety	20%	4	2	5
Machinability	20%	3	3	5
Strength	20%	5	3	4
Results	100%	4.4	3.2	4.0

Legend: 1: Poor 2: Deficient 3: Fair 4: Good 5: Excellent

At the moment for create the hinge at the machine shop, were made last minute changes to the Shaved/Curved Hinge with all the corners. The equipment with the machine shop weren't able to create the shaved curves and was decided to create a squared design. The same analysis was made to this hinge (stress, strength, displacement and factor of safety with Solidworks and Thermal Conductivity and Strength with Comsol). After analyzing the new hinge we got that the Yield Strength of the assembly was of 275 MPa or 275,000,000 Pa (Figure 2). The displacement of the assembly was seeing at the upper part of the hinge that is the area holding the solar wing. The maximum displacement of this part was .002734mm that is a very small displacement (Figure 3). After analyzing it, the number that shows that the design was able to use was with the Factor of Safety (Figure 4) that means how many times the piece can withstand at the conditions analyzed. These conditions were assumed as 5N of force and the Factor of Safety of it was 1.69. This means, this piece can hold a maximum of 8.45N without having any failure. Figure 5 is a picture of the steel prototype hinge system manufactured by the machine shop.

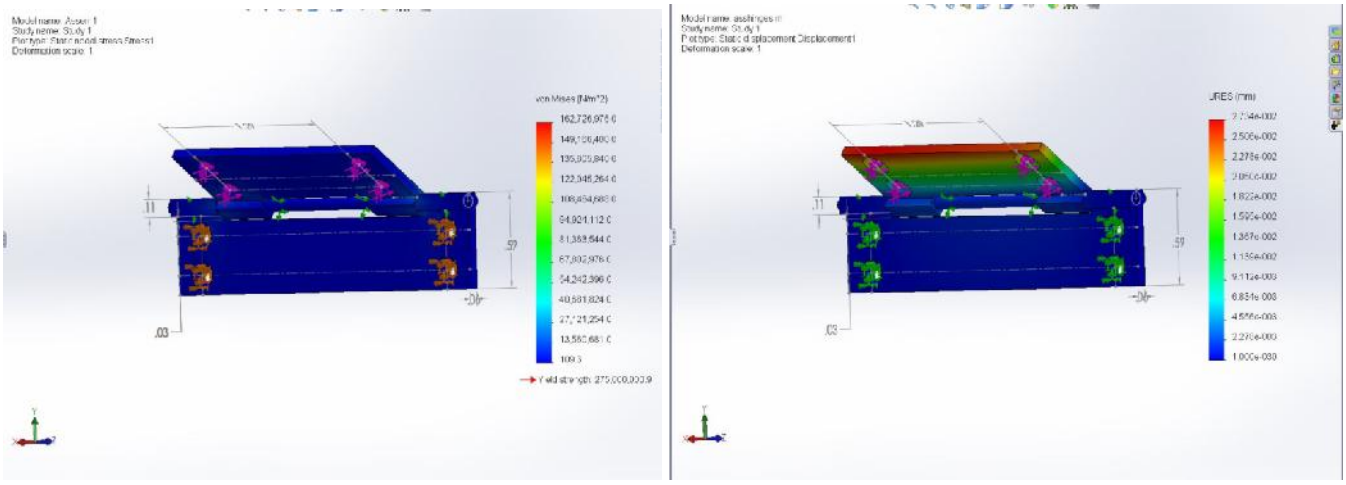

Figure 2: Cube Satellite 2U Deployable Stress (left) Displacement (right)

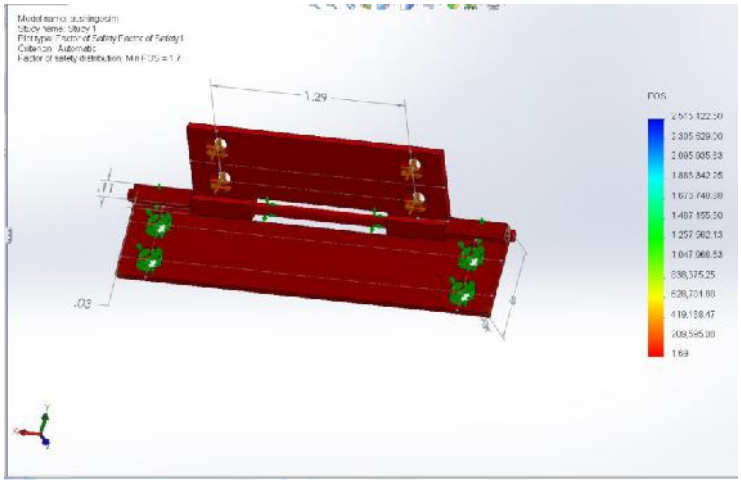

Figure 3: Cube Satellite 2U Deployable Factor of Safety

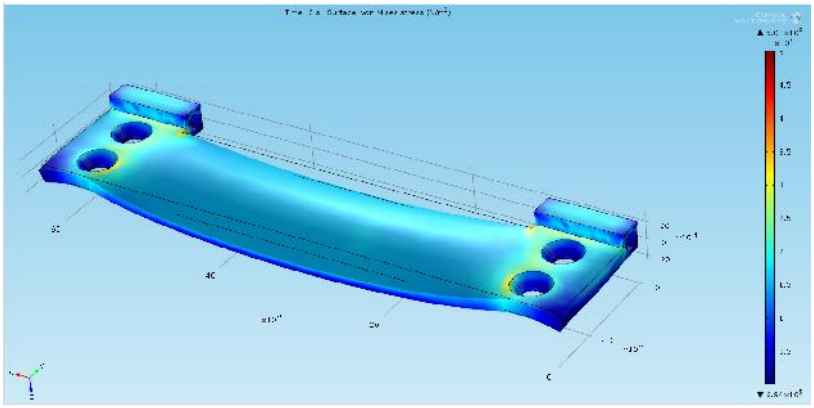

Figure 4: Thermal Stress of the Lower Hinge Part under temperature

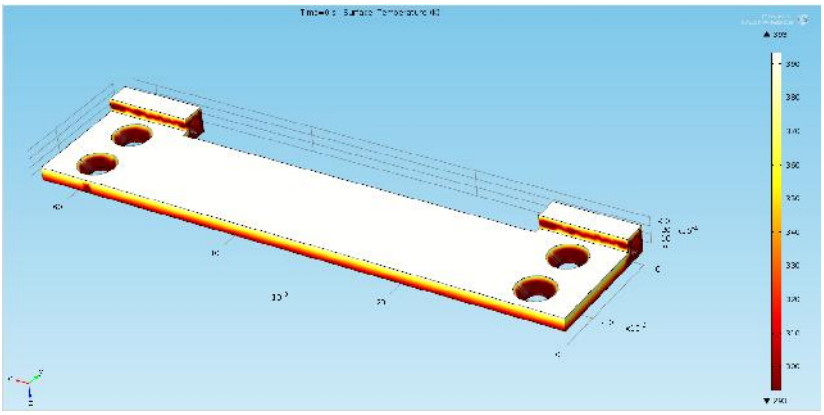

Figure 5: Temperature transfer around the part

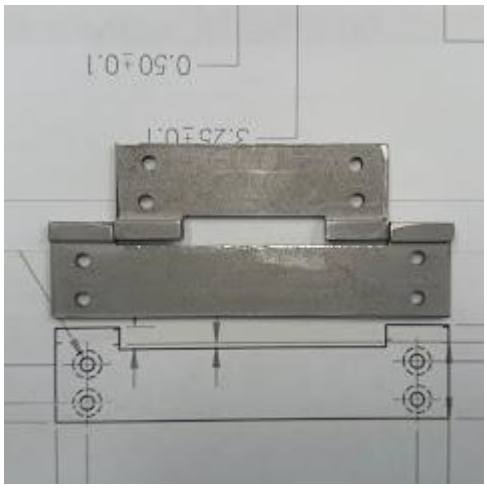

Figure 6: Steel Prototype set of hinges

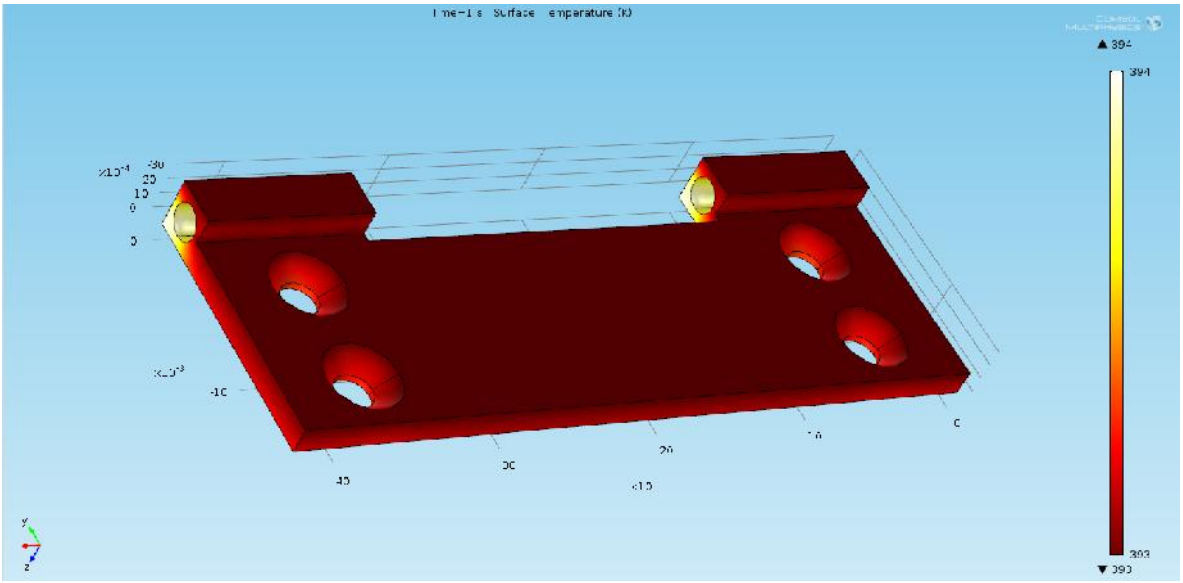

Figure 7: Temperature transfer around the Upper Hinge

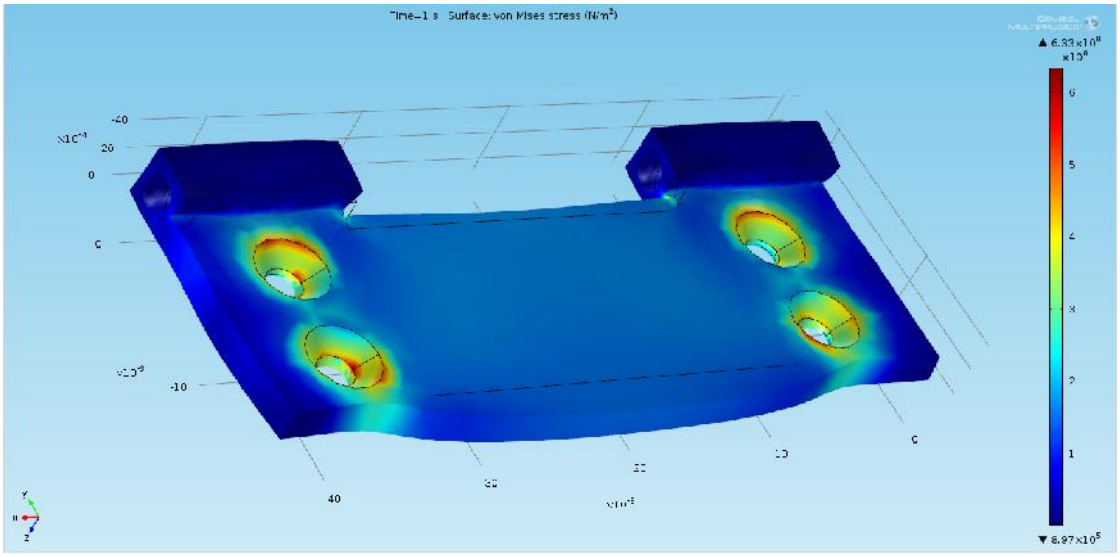

Figure 8: Thermal Stress of the part

The wing was created to be as small as possible, easier for the creation at the machine shop but without sacrificing strength to it. The stress analysis showed that the Yield Strength of the wing was of 55.1 MPa or 55,148,500 Pa to be exact (Figure 5). Analysing the wing with a force of 5N the displacement showed was approximately to 3.94mm. The factor of safety of it was 1.51 (Figure 7) that means that it holds 7.56N of force. According to the thermal stress analysis the temperature in the wing is almost the same on both sides due to it being very thin. Also, after applying heat the metal becomes more ductile, thus explaining why after applying the heat the Yield strength of the wing goes down to 1.03MPa.

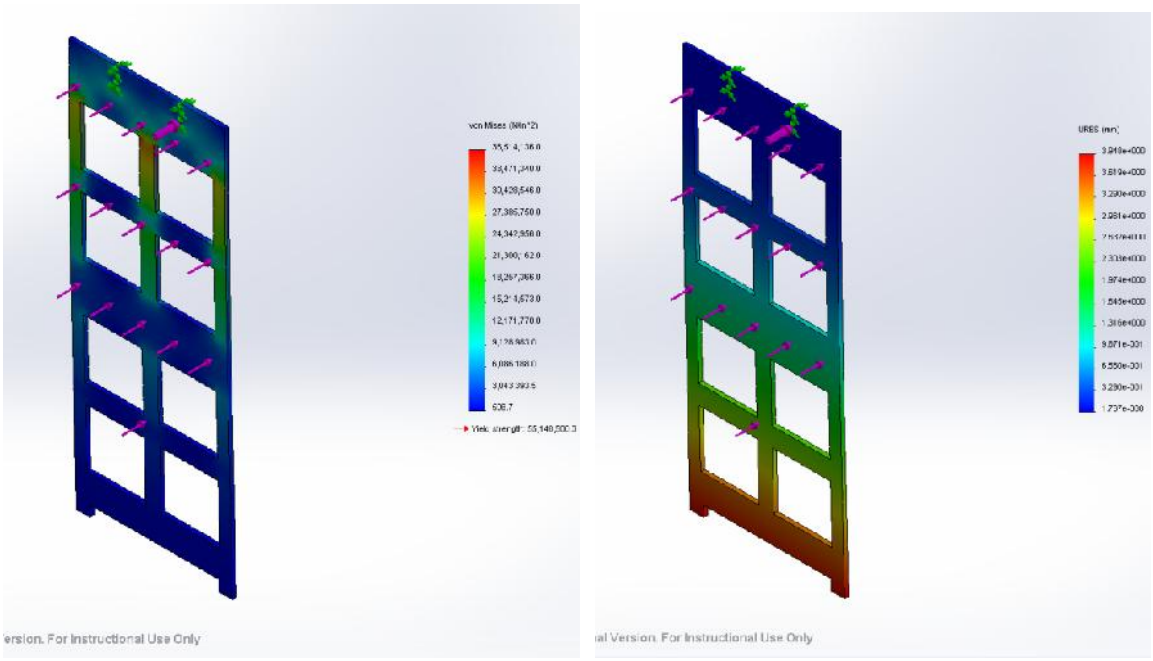

Figure 9: Stress (left) and Displacement (right) Analysis for the Cube Sat Wing

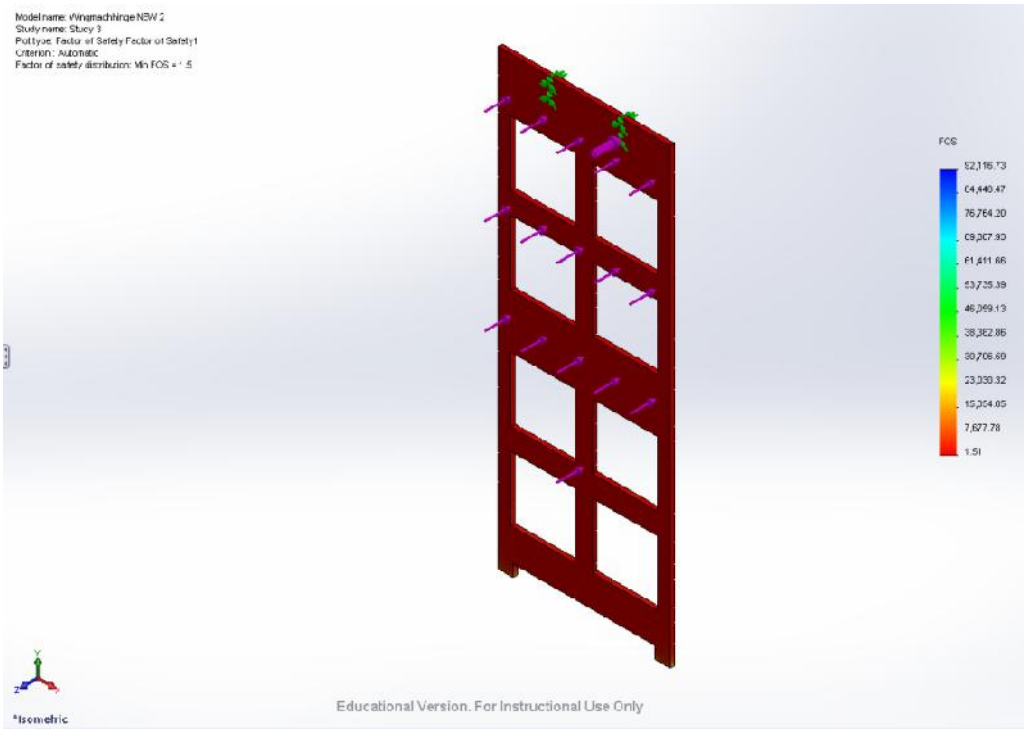

Figure 10: Factor of Safety for the Cube Sat Wing

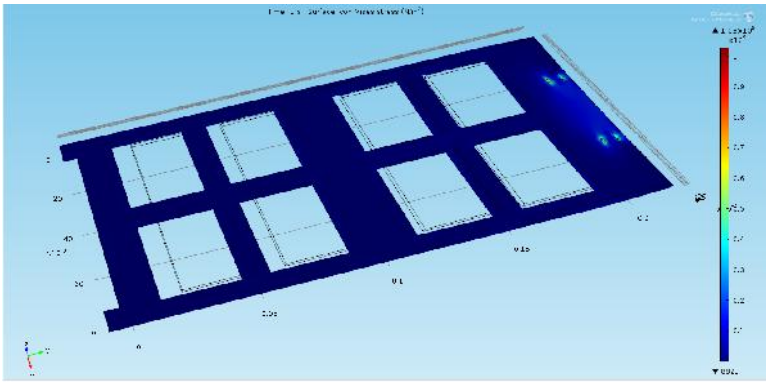

Figure 11: Thermal Stress in the wing

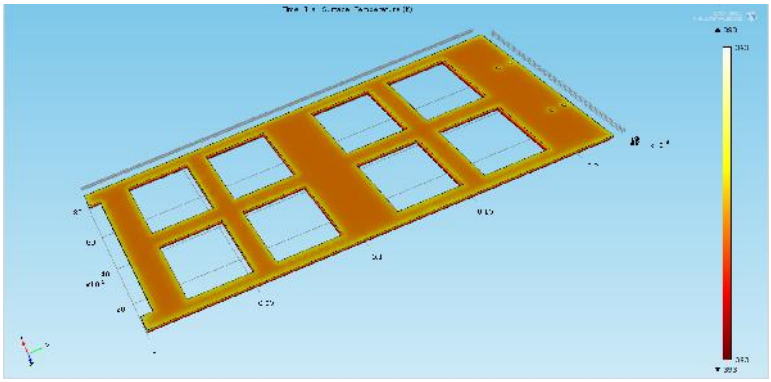

Figure 12: Temperature in the top of the wing

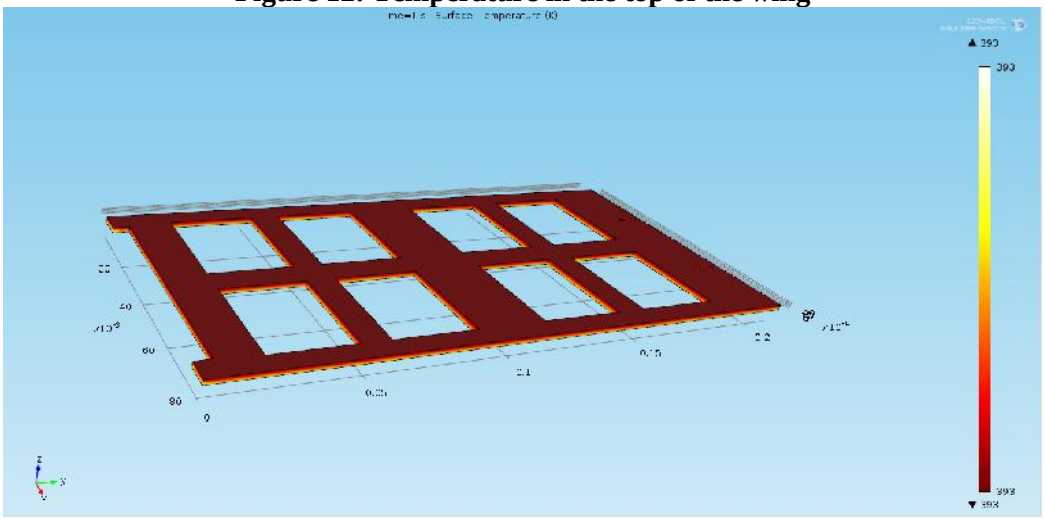

Figure 13: Temperature in the bottom of the wing

For the mechanism, there will be 4 torsion springs with a pre-load force needed to open the wing in the earth atmosphere. It will be from McMaster.com, Part number 9271K701. The stiffness of the spring will be .00275 lb*in or .000311N*m. currently, the spring haven't been studied at all because the missing of small properties by the distributor.

Figure 14: Torsion Spring

4. CONCLUSION

Tolerances were the biggest issue of this internship. Designs has to be remade thinking in the possibilities of complying with the tolerances that were required by this type of project and the machining capabilities of the university's machine shop. It was determined that as long as rounded shapes are avoided the tolerances can be meet by the CNC machine. A prototype of the hinge was manufactured in steel to test the precision of the machine and the machine shop technician abilities. Almost all the dimensions were inside the .1mm tolerance but the ones that were not the machine shop technician explained how the technique can be improved in order to avoid those errors.

Aluminum 6061 would be the material used given that it has high yield strength while being lightweight and high temperature resistant (temperatures in the thermosphere at 380km range between -50 degrees Celsius and 150 degrees Celsius). The parts for the preparation of the full assembly are still not finished on the moment of the preparation of this paper. Torsions springs are on the way and the shaft is being assessed for the manufacturing.

ACKNOWLEDGMENT

We give our thanks to all the people that in one or other way helped us to complete this internship. First of all, Dr. Hien B. Vo to take us and lead us to perform this project. Dr. Amaury Malave for the help us solve our concerns and doubts any time that we need; to Brenda Liz Morales for pushing us to work in an Aerospace Engineering extracurricular project. To the machine shop technicians, to let us use all their equipment and creating the parts needed to complete the design.

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"Cubist Movement". *Space News*. 2012-08-13. p. 30. "*When professors Jordi Puig-Suari of California Polytechnic State University and Bob Twiggs of Stanford University invented the cubesat, they never imagined that the tiny satellites would be adopted by universities, companies and government agencies around the world. They simply wanted to design a spacecraft with capabilities similar toSputnik that graduate student could design, build, test and operate. For size, the professors settled on a 10-centimeter cube because it was large enough to accommodate a basic communications payload, solar panels and a battery.*"

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APENDIX

Failure Design

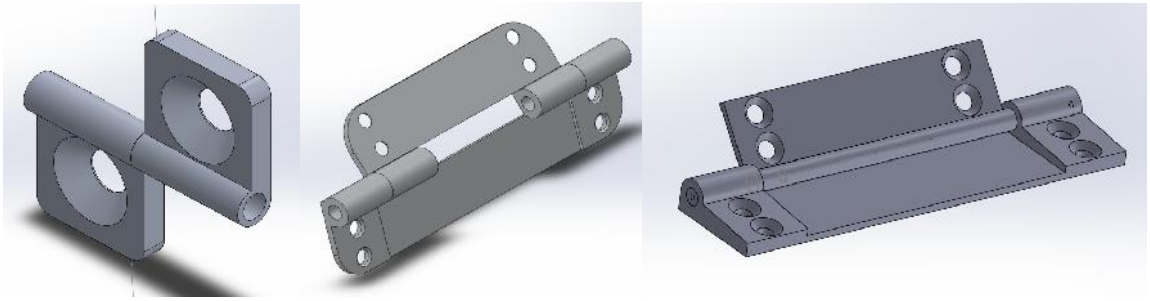

Figure 15: Failed Hinges Designs

The Simple hinge design (Left Side) wasn't able to create because of its smallest dimensions. The Shaved/Curved (Center) of hinge was the best option and strongest one but the tolerances of the curved shaved didn't give way to create it in the machine shop with the equipment we have. Finally, the staggered (right side) hinge is the most stable at the opening but at the same time the difference of dimensions between all the surfaces make it the weakest one.

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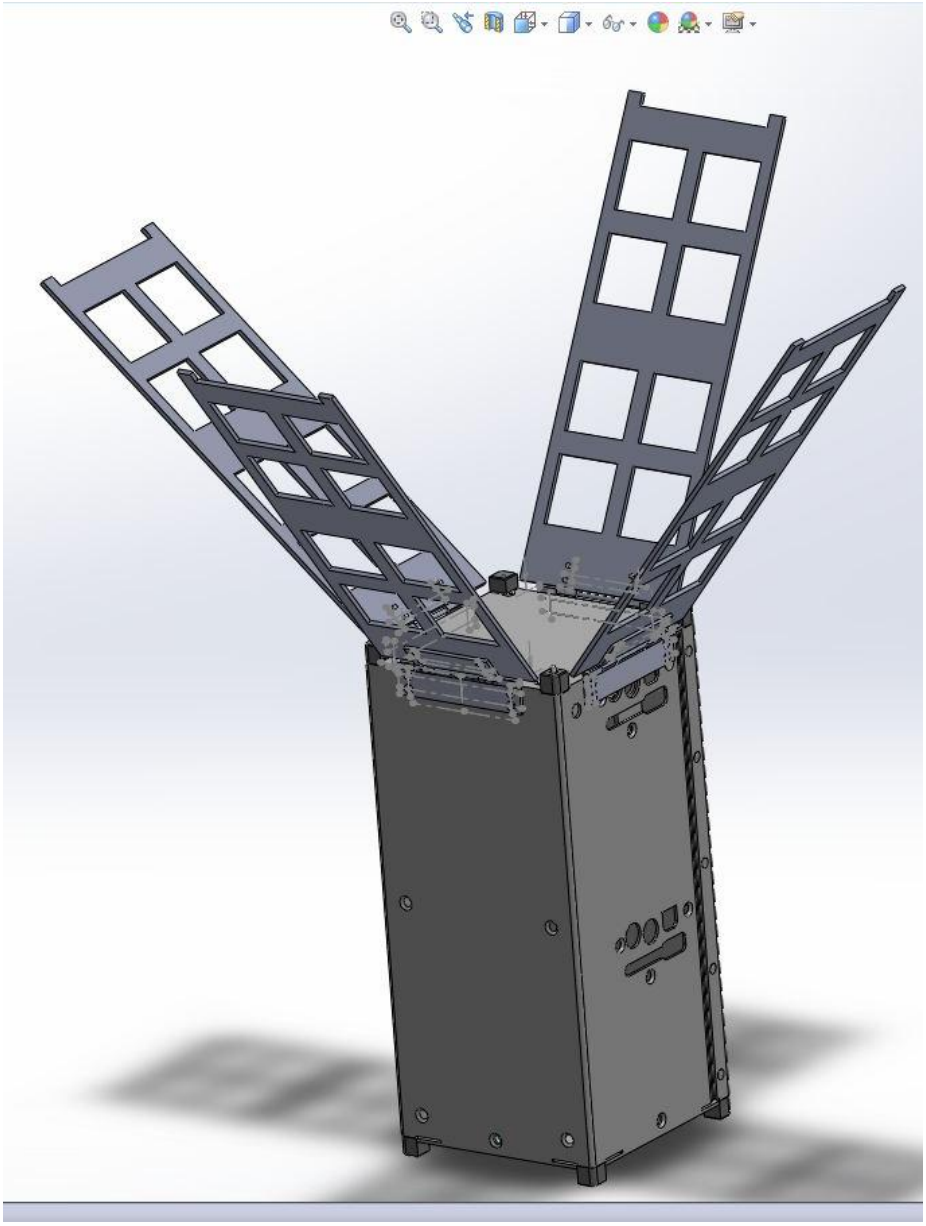

Figure 16: Full Assembly of the Deployable system

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