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| UNiversity of Canterbury |
| Generating Power for Remote Applications in Extreme Environments |
| Progress Report |
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| The following report documents the progress as at 3rd March 2011 for the final year project of Nathan Rich, an electrical engineering student at Canterbury University. The project is investigating generating power for remote applications in extreme environments. The extreme environment chosen is deep sea with the method of power generation being turbines utilizing the passing currents. The progress thus far has been the investigation of the environment and power generation method. The progress to come will be the design, build, and testing of the project. The design is aimed to be mostly completed at the end of term 2 with the build and testing happening during term 3. |

# Abstract

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# Project Overview

Around the world there are many extreme environments in which battery power is not suitable for powering devices due to the fact that one has to replace the battery when it runs out and the environment does not easily allow this. Thus the solution must be robust and reliable with minimal maintenance, if any at all.

The environments can have temperatures from -30 to 2000 ̊C with extremely high or low pressures. To build a device that can generate power for some application and withstand the harsh environment is the challenge of this project. Of benefit is the environment itself as high temperatures and pressures can be used to generate power because there is an abundance of it in the extreme environment.

In this project the extreme environment chosen is the deep sea environment. In the deep sea the temperature can range from 3 to 21 ̊C and the pressure increases 1 atmosphere per 10 metres of depth under water (Zabel, 2006). Thus the solution must be able to handle these temperatures and generate power.

The specific tasks of this project are to investigate an extreme environment finding a suitable way to power a device and then to design, build, and test the solution.

The goal upon completion is to have a working model of a device that can generate power while withstanding the pressure and temperature.

# Progress to Date

## Choosing an Extreme Environment

The first task in this project was to choose an extreme environment for the project to centre on. This was done by identifying extreme environments and the factors that make them extreme. The information was found by searching on the internet and the following table was made:

|  |  |
| --- | --- |
| Environment | Extreme Factors |
| Coal Mine | Heat, high pressure |
| Volcano | Heat, high pressure |
| Deep Sea | Cold, high pressure |
| High altitude | Cold, low pressure |

The extreme environment chosen was deep-sea which was chosen because of the student’s interest in the sea due to sporting activities such as surfing and the fact that tidal power generation is currently being developed in New Zealand. The deep sea environment was found to have temperature that can range from 3 to 21 ̊C and the pressure that increases 1 atmosphere per 10 metres of depth under water (Zabel, 2006).

## Choosing a Method of Power Generation

The next task was to choose a method of power generation. Once again research was done on the internet looking into the characteristics of the deep sea and trying to identify ways to exploit the environmental characteristics. Four different possible ways of generating power in the deep sea were considered and the following information was found.

### Pressure

High pressure is one of the extreme environmental elements of the deep sea for which this project was chosen. Thus it makes sense to try and exploit this characteristic as there is virtually no limit to its supply. In exploiting it one would of course have to think of any environmental impacts it might have.

From the research done it was found that to create energy from pressure one must obtain a differential however small. In the deep sea environment there is high pressure but it is not a differential. There were two ways that were thought of to obtain a differential; the first was by having two devices with one much deeper than the other, as it is known that the pressure increases the deeper down one is. Thus the two devices have different pressures and a differential is found. The disadvantage to this though is that the whole solution would have to be rather large and would therefore not be very helpful on moving objects and would be more prone to damage from sea creatures. The second way to create a differential was to use the undersea currents which would press against a plate creating a differential. This technology has in fact already been in use in the form of hydrophones and uses piezoelectric technology (Wilson, 2005).

### Temperature

Low temperature is the other environmental extreme of the deep sea and so it makes sense to try and exploit this also. However as with pressure, a differential in temperature is needed. The only way hypothesized to create such a differential was to once again have two devices at different depths so that different temperatures are found. However since this is the same solution as before, it has the same disadvantages.

### Chemical

It was briefly considered that the chemicals in the ocean could be used in a chemical reaction to create power for the application; however it was quickly found that this thought was naïve. The reason it is naïve is that the chemicals in the seawater are in a post-reacted state meaning that they will not react in any way for the project. If any chemical pair was not yet reacted they would react of their own accord in the seawater. The only way to force a chemical reaction then would be to bring another chemical to react with something in the seawater; however this option is actually a battery in an elementary sense and thus does not meet the design requirement.

### Kinetic

The solution of using the pressure of currents to create a pressure differential was the best solution found thus far, however the glaring problem was that the current would push the device very heavily when contacting the plate. Another solution that solves this problem is actually a lot simpler than the piezoelectric technology although not as exciting; a turbine. Using a turbine would allow water to flow through the device generating the power while not being pushed as much by the current.

The chosen method of power generation was thus turbines utilising the passing currents.

## Application

In designing any product there needs to be an application in mind. At this point there are a few applications that this product could be used for. Peter Gough’s Towfish has been suggested as a possible application however the intricacies of functioning with the Towfish are still being worked out. Another possible application are undersea robots; undersea robots are used in many applications from fixing deep sea oil spills to investigating untouched depths of the sea to recovering valuables from sunken ships. If a turbine could be attached to power such a robot then they would be able to stay underwater exploring for indefinite amounts of time. However the glaring problem with this is that power gained from a current going by is unlikely to be enough to allow the robot to swim against the current. One way around this might be to have the turbine recharge a battery pack by anchoring itself to the bottom during strong currents and then exploring when the battery is fully charged.

# Remaining Tasks

Now that the background work has been mostly finished the next step is to design the device which includes finding prices for parts. There are three areas that will need to be designed or bought; they are the turbine, a power converter, and an enclosure. The enclosure would be entirely mechanical, the power converter almost entirely electrical, and the turbine a combination of electrical and mechanical. The enclosure then will be the biggest challenge of the design phase as it needs to be custom-built to withstand the temperature and pressure. The design work is intended to be finished by the end of term 2.

After the design, the device will need to be built which will no doubt bring up many real world limitations and thus the device will have to be constantly redesigned.

The final part of the project will of course be to test the device and see what parts have worked and what parts have not to provide feedback on the work. The build and testing is planned to be done during term 3.

Term 1

Term 2

Term 3

Figure 1. Gantt Chart of Project

# Budget Summary

Thus far no components have been purchased.

To give an idea of cost the following table has been compiled with estimated costs.

|  |  |
| --- | --- |
| Component | Cost |
| DC-DC converter | $25.00 |
| Turbines x3 | $100.00 |
| Enclosure | $10.00 |
| Total | $135.00 |

Table 1. Component cost breakdown

# Conclusion

So far the project has been all background work so although there is not much tangible evidence to show for the work, a lot of knowledge has been gained that should aid a fast completion down the track. The extreme environment chosen is the deep sea with the method of power generation being turbines utilizing passing currents. The design work should mostly be completed by end of term 2 with the build and testing in term 3.

# References

[1] J.S. Wilson. (2005). *Sensor Technology Handbook* (Vol 1). Newnes.

[2] M. Zabel. (2006). *Marine Geochemistry*. Birkhäuser.