Welcome to my demonstration professors. Today I’ll be explaining and showing off some of the hard work I’ve done this year on my project. My project has been titled generating power in extreme environments for remote applications, which is a mouthful I know. But in slightly simpler terms it means powering a device without batteries.

Now this title leaves a lot to the imagination so the specific aims of my project were as follows: Investigate an extreme environment; Find a suitable way to power some device and design a solution for it; and the goal upon completion is to have a well thought out design that could be built and used in the real world.

So following the aims I investigated a number of extreme environments going by pressures and temperatures, that is I looked at environments with high pressures and temperature like underground mines, or high pressure but low temperature like the sky or water. In the end I chose the undersea environment simply because it personally interested me due to surfing.

So what I found out was that the sea cover approximately 75% of the earths surface and yet most of it remains unexplored and unknown due to the harsh conditions down there. For example there is no air for humans to breath, the pressure increases one atmosphere for every 10m down you go and the temperature declines rapidly with depth.

Thus a perfect application was an undersea explorer robot, a robot that could stay underwater for indefinite periods because it could generate its own power. The robot could send back images of what it find or information wirelessly.

Before this idea could really begin to take shape though, a method of power generation was needed, this of course is the key part of the project. I looked into four difference sources of power, pressure, temperature, chemical and kinetic. Pressure and temperature both required a differential and this was not easily obtained in the undersea environment without creating a very large system so I chucked that idea out, the chemical thought was very naïve in that all the chemicals underwater are in a post reacted state and will not react for the robot otherwise they would have done so already. The robot could of course bring down chemicals to start a reaction but this is actually a battery in an elementary sense. The last way then was kinetic, ie using the currents underwater; these could be harnessed in two ways, one by piezoelectric technology which is actually already in use in hydrophones or by turbine. I chose turbine as the piezoelectric requires a solid plate that when current hits would push the robot of course.

At this point it was important to make a more exact specification as the scope of the project was so very wide and unrealistic to finish by myself in one year: the specification, said that the robot must be able to withstand the undersea environment, ie the temperature, pressure, and salt water, while generating its own power. However with these simplification which would be rectified once the initial design was proven. The robot would have no turning, ie it only goes straight. No remote control, it just goes when power is given, idles otherwise and no video cameras or sediment testers.

So with the scope sufficiently narrows I was able to start work and I came up with the following design: this flow chart shows a very simple overview, with the turbine spinning the generator which passes power through a power converter to the motor to power the wheels.

So looking at each of these sections in more detail: we have the turbine. The amount of power given from the turbine is governed by the size of it, which is given by the following equation, and when the correct numbers a plugged in the diameter of the turbine is found to be 23.8 cm. I haven’t put it on the slide there but the efficiency I use in the equation is only 0.3 this is because the Betz limit says that the maximum possible with a turbine that is not shrouded is only 0.6.

Next up is the gearbox which will need to move the speed of the turbine which is only 124 rpm up to 2400rpm, this will require a ratio of about 19:1.

Following this the generator is a three phase delta wound permanent magnet generator that was chosen simply because it was already in the department. This generator was actually specified as a motor so I had to do significant testing to find its generating characteristics which are detailed later on.

The power converter then has to convert this three phase AC wave to a single phase DC wave for the output motors. So a three phase rectifier bridge is chosen to convert it following by some DC bus capacitance and a buck-boost converter to regulate the voltage output.

The output motors are once again chosen not on efficiency but just by what was on hand, they require 5V and 1A while running. And the plan is to parallel two to give 4WD drive while also decreasing resistance which we will see gives more power later.

The wheels that are powered are chosen to be tank tracks so that maximum traction is applied and so that the weight of the robot is spread evenly to reduce the chance of sinking in the soft sediment.

Other challenges that are specific to the environment are that of stopping water entering the electronics which requires a watertight seal but also the pressure, if the inside is air then the robot is likely to be crushed in deepwater whereas if the robot is filled with oil it will not compress and will also not conduct.

Finally the exterior of the robot is to be made entirely from plastic so as to stop rust.

And here we see the final design as illustrated.

Here we have the cost which is estimated to be $366 for the components, I say estimated because finding prices for the enclosure, tank tracks and oil was not realistic so they were estimated.

As I was saying earlier the generator only had motor characteristics with it thus I had to test it to see what I could expect to get. So I set up a test set and put a resistance on to model the load, I used three resistances, 0.5,1 and 5Ω and the different results are shown on the graph. What is clear is that for a lower resistance more power is produced. I should be noted that this is a single phase representation. After these tests I did open and short circuit tests to develop a single phase equivalent circuit which is shown here.

So the testing the generator gave us these three helpful points of information, the maximum output at 0.5Ω is 70W three phase, the speed required at 0.5Ω is 2400 rpm to get the 25W we require. And the voltage and current are 4.7V and 5.4A.

So although I have completed what I set out to do, if I was to build this robot I would need to do a few more steps, which would require me to build a bit and test a bit. I would need to build up the tank tracks and then find exactly what voltages and currents need to be supplied to the motor s to run them. Then I would need to choose the power converter and slowly build and test the device to ensure it all worked together. The final test would be done in a water tunnel to simulate a current and a success would be given by the robot moving against that current.

In conclusion the project was a success, the design was completed, future work has been detailed. The robot uses plastic to resist corrosion and oil to resist pressure