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Introduction – Château de Nemo

Technical aspects and ideas of engineering are the primary concentration of engineering education, however, in industry, engineering practice is composed of other non-technical aspects in addition to the above. The ability to manufacture and market, along with overall product safety are some of the major decision process involved when designing a product. In addition to these aspects, ethics and environmental impact of a product are significant factors of product design and must be studied in detail to ensure a safe and ethically acceptable product.

The objective of this senior design project is to successfully design and implement an automatic aquarium controller that is capable of monitoring the pH of the water and changing the water level as required. The controller will also be able to control an automatic feeder and a heating system along with a day-light simulator.

The aquarium settings may be input to the system using either a keypad control mounted on the actual aquarium itself or through a personal computer (PC) connected to the internet. An associated program will be developed to allow the user to access their fish tank and control it through the internet using the Ethernet port on the chosen Rabbit Processor.

All components connected to the I/O relay module (heater, lights, etc.) are external to the system, and thus optional. These are the responsibility of the user and therefore will not be discussed in detail when studying the environmental and ethical issues related to Château de Nemo.

According to The Institute of Electrical and Electronics Engineers (IEEE), engineers must "accept responsibility in making engineering decisions consistent with the safety, health and welfare of the public, and to disclose promptly factors that might endanger the public or the environment."[i] Through the remainder of this document, the above statement will be addressed through a thorough discussion of environmental and ethical impact analysis of Château de Nemo.

Ethical Impact Analysis

In order to realize a design and bring it to market, it is important for any product to undergo an ethical impact analysis. Through this analysis, a product's performance and limitations are tested in different operating conditions, issues such as warning labels and user documentation are studied, and a list of safety mechanisms that ensure user safety is developed and implemented.

Operating Environment & Testing

Château de Nemo should be able to operate as advertised. In order to achieve this, it will be necessary and mandatory for the manufacturer to test this device under different operating conditions that will allow the manufacturer to track and analyze the performance of the device under test. If the device does not function adequately (meet advertised performance) under cases of exposure to water, extreme temperatures, or other known conditions, it is the responsibility of the manufacturer to document these conditions and try to rectify the device so it does function as advertised. Proper operation as advertised in this case is defined as the device successfully satisfying the project success criteria defined in the initial project proposal as follows:

1. Detect the level of pH and Ammonium in the water and change water accordingly.
2. Feed fish through an automatic feeder controlled by a Real Time Clock (RTC) on the microcontroller.
3. Monitor temperature of tank and activate heater when necessary.
4. Simulate daylight through tank tube connected to a RTC.
5. Communicate with user through Ethernet port.

The primary concern with regard to the device is proper operation in the case of water. Since the device will be in close proximity to the water at all times, it is very important that the packaging be water-proof and extensively tested around water. Successful operation will allow the device to operate in cases where there may be residue or small droplets of water on the casing; however, if water does enter the hardware under the casing the device should be shut off. As a secondary measure, it is important that the

entire system be safe around water, and thus opto- isolaters are installed to safeguard the system.

Another concern with the device is temperature. Château de Nemo should be able to operate as advertised in normal to humid conditions. Normal operating conditions will be at room temperature (~ 25 ºC); however, due to the device being mounted alongside lighting and other equipment that may release heat during operation, temperatures may rise. To address this issue, the operating sheets for all components related to the system can be checked and in addition, the microcontroller chosen (Rabbit 3000) allows a wide operating temperature range of -40 ºC to 70 ºC.[ii] Testing, in the case of temperature, could be carried out at actual operating temperatures, in a cold refrigerator for extremely low temperatures, and in a heated room to ensure device will operate as advertised in regions of high temperatures.

The mechanical robustness and fragility of the device must also be taken into consideration. The casing should be such that it can accommodate for minor shocks since the device will be mounted on the tank and thus may encounter the rare case of being moved around. If the soldering is not done well, then the device will not be able to handle occasional movement or reinstallation to another area of the tank if required. To reduce the possibility of the above failure, simple measures such as proper soldering, casing and framing can avoid if not eliminate the possibility of failure due to fragility.

Lastly, taking the surroundings of the device into consideration, it is necessary to study how the system would control water levels to ensure excess water would not cause damage to the surroundings of the tank. In order to this the device is installed with IR detectors at different levels alongside the tank. If the water level reaches an IR receiver marked as a critical water level, the microcontroller is pre-programmed to stop all activity and alarm the user through and LED. Testing of the IR receivers can take place in an isolated environment, where no electrical equipment is nearby, and rubber mats are installed for safety of testers.

Reliability Analysis

This section looks at the reliability of the device and takes into consideration the warnings and safety mechanisms that must be outlined on the device itself in addition to the user manual.

It is essential for the device to provide accurate and precise information since the product is directly associated with monitoring and maintaining living conditions for live organisms. With regard to this, all system components are selected and verified such that they provide detailed readings that are as accurate as possible keeping a low cost product in mind. Since temperature and pH levels are the two of the most important environment variables being studied, devices to monitor these parameters were carefully selected. The temperature sensor used is a Maxim DS18S20 that measures temperatures in the range of -55 C – 125 C with accuracy of 0.5 C.[iii] The pH meter used is Checker, and measures between 0 to 14 pH, with resolution of 0.1 pH and came with a calibration unit.[iv] This ensures reliable and accurate readings. Also the calibration unit allows the user to re-calibrate the device if needed.

Again, since we are dealing with live organisms, it is essential that all warnings are taken seriously, and ensure these warning labels will be placed appropriately. Firstly, the I/O relay module will have a warning label associated with each input port (light, heater, etc.) that warns the user of maximum power requirements and fatalities from using equipment outside these boundaries. A warning label will also be placed on the pH meter warning the user that the electrode may corrode after extensive use and should be frequently monitored and changed if required to ensure proper readings. Lastly, to ensure overall safety from any electrical related injuries, a warning label will be placed on the casing of the device, warning the user not to attempt disassembling the casing for any reason.

Safety is a serious issue, and thus to ensure safety of both the operator and the fish in the tank, along with warnings on several components, the user's manual will also reflect these warnings in bold text to ensure full safety measures are practiced by the manufacturer before the release of the product.

Environmental Impact Analysis

Today, along with a successful launch of any product come many responsibilities, one of which is ensuring sustainable environment. The National Science Board (NSB) believes "within the broad portfolio of science and engineering … the environment is emerging as a vigorous, essential and central focus … it is the prime target for increased research."[v] To further illustrate the increasing importance towards a sustainable and engineering friendly environment, the National Academy of Engineering (NAE) "has conducted a serious of industrial ecology workshops and related studies … all with the aim of illuminating the relationship between technology, economic growth and the environment."[vi] Through this section we look at the following processes with relation to Château de Nemo and analyze the environmental impact of each:

1. Manufacture
2. Packaging
3. Normal Use
4. Recycling/Disposal

Manufacture

The environmental effects of manufacturing are largely common amongst many products. The major and the most critical impact during the manufacturing stage is the printing of a circuit board. The printing of circuit board produces complex and hazardous waste products which may in some cases be simply disposed, however, in other cases need to be carefully disposed or recycled.[vii] Once the PCB is created using copper plating on plastic followed by the use of harsh chemicals to etch off the copper, solder is applied, involving lead, and a large amount of waste products (hazardous) are generated. These waste products such as industrial waste-water re-flow oil, acids used for cleaning equipment, and copper sulfate crystals must be properly disposed.[viii]

While waste products such as water and re-flow oil may simply need to be disposed in a environmental friendly method, copper can at times be reclaimed and reused from the etchant, allowing more productivity, less cost and ensuring a sustainable environment.[ix]

Packaging

The device is not extremely fragile or large, therefore minimal packaging is required. The device will be packed in a cardboard box, which can be easily recycled or re-used. Also, the device will be packed in bubble wraps and Styrofoam to handle movements during shipping and handling. Again, both these packaging materials can be easily reused and recycled. Another measure that could be taken is when distributor shipments are made. Shipments can be made in reusable packaging. This involves transport packaging in forms of "wood metal, or plastic pallets and containers that can be used multiple times … they are designed and built to last for many years of use and replace one-time or limited-use pallets and boxes."[x]

Normal Use

During normal operation of the device, the environment is not harmed in any way. This is because minimal power is required to run the device and therefore no harmful products are released into the environment.

Recycling/ Disposal

The disposal of the device brings forth many concerns with relation to the environment and its sustainability. The primary concern is disposal of the circuit board. The circuit board contains significant amounts of lead, which can be harmful to the environment, and thus disposal through means of a landfill are not allowed. Other methods of disposal involve disassembling the boards, crushing and melting these boards to separate and recover the lead. Other more expensive methods, involve lead-free soldering, which would have to be considered at the time of manufacture and would greatly reduce disposal issues.[xi]

Another issue with environment friendly disposal techniques is the proper disposal of liquid crystal displays (LCD's). Improper disposal of LCD's can be very harmful to the environment, they contaminate water and very difficult to biodegrade. It is possible and highly recommended that they be recycled or properly disposed through the means of a hazardous-waste incinerator.[xii] Another widely used concept is one where a notice on the LCD display recommends the return of a display to the manufacturer at the

end of its life, so that the manufacturer can then properly dispose the item in cases where it may be hard for a consumer to get access to proper disposal facilities.

Since Château de Nemo does not use any batteries, or other products that may cause disposal problems, it is a fairly environmental friendly product that is easy to use and dispose at the end of its life cycle.

Conclusion

Environmental friendly and ethical designs are some of the most successful designs today in an industry that largely supports environmental research and healthy manufacturing and safety procedures associated with products. There are many ethical and environmental issues related to Château de Nemo. The major issues are thoroughly discussed in this document and proper implementation of these ideas will ensure that the device is safe, more reliable, and environmental friendly, thus ensuring that it meets the safety and environmental standards put forth by organizations such as the IEEE, NSB, and the NAE.

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