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Rapid Sample Insertion/Extraction Systems for Gamma Irradiation

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The Rapid Sample Insertion/Extraction System for Gamma Irradiation, otherwise known as the “rabbit” system, was a four-week long project which included many different aspects such as coding an Arduino, building PVC piping, and 3-D printing the “rabbit” capsules. The “rabbit” system is a system of PVC piping that allows a quick and efficient transfer of materials into and out of one of the irradiation chambers in the Gamma Irradiation Facility (GIF) with the use of a 3-D printed “rabbit.” This “rabbit” encapsulates material to be irradiated and carries it from a position outside of the irradiation chamber to the basket inside of the chamber. The main purpose of this system is to save time and provide more exact data without any delays that normally occur when a person has to enter the chamber, retrieve data, and then analyze the data. This system should take measurements and retrieve the data instantaneously. The way in which the “rabbit” is sent through the PVC piping is with an advanced bi-directional, high-throughput pneumatic system, or a shop vacuum cleaner. When the vacuum is set to blow or suck then the “rabbit” will be pulled or pushed through the PVC piping to its intended destination and will hit sensors along the sides of the tubing when it reaches the end of the piping. These sensors tell the Arduino that the “rabbit” is finished moving throughout the tubing and stops a timer. Another timer is used to see how long the “rabbit” is being irradiated so when the “rabbit” reaches the sensors in the basket in the irradiation chamber another timer is started and it ends when the sensors no longer detect the “rabbit,” which means that it has begun its journey back to the starting point. These times, as well as the temperatures, are the data necessary for the project and must be extremely accurate.

The “rabbit” will be installed in a chamber in the GIF, which is a building in Sandia National Laboratories where nuclear radiation environments are simulated to test components and materials. This project could be used in Sandia National Laboratories to aid in testing for electrical-component hardness, material-properties, physical and chemical processes, radiation certification of satellite and weapons system electronics, dosimetry, and radiation damage to name a few.

My work on this project included design of the “rabbit,” which had to be small and have curved edges to fit through turns in the PVC piping. The “rabbit” was tested using 3-D printed parts but when finished should be made with metal to be conductive to aid with measurements of irradiation time. Although the rabbit had to be small, it could not be too small because it needed to fit objects inside of it for irradiation and it needed to provide adequate cross-sectional area to be pushed and pulled by air currents. I also had to design the circuit and write

the code for the Arduino, which had some challenges as well. I tested two different temperature sensors for the Arduino before choosing the most accurate one, and I also spent a long period of time researching and ensuring that I understood the Real Time Clock. After much research and redesigning, the Arduino was finalized. The next issue was that the TLDs, or the objects that needed to be irradiated, should not break in their travel within the "rabbit." Using cushioning to slow down the "rabbit" was initially attempted, however, many objects that could be used for cushioning would not survive irradiation. Next, I designed different ways that the tubing could be redesigned to slow down an object, such as releasing more air out the sides and adding contact points to slow the "rabbit" down. However, the releasing of air did not seem to slow the "rabbit" down much, and the contact points ripped the "rabbit" apart. The next thing to try was redesigning the "rabbit" so that the TLDs would not move around much. I tried many different designs that I then 3-D printed and tested. There were many failures including when the compartments in the "rabbit" were broken from impacts in the tubing. Eventually thick enough walls and simple designs proved the most effective in this. Therefore, the testing that had to be repeatedly performed for this project was all to achieve several goals including slowing down the "rabbit" speed, ensuring that the "rabbit" and the objects inside of the "rabbit" were not ruined from impacts, and field testing the Arduino code to ensure that it works perfectly each time.

The different parts that were used in this project included an Arduino Uno with its LEDs, LCD, temperature sensors, Real Time Clocks (RTC), etc. Also, PVC piping, a shop-vacuum, and a 3-D printer were utilized. Using the Arduino software download, the time, temperature, and location of the "rabbit" were printed out on the LCD on the Arduino Uno. CoolTerm4 was also used to store the data from the Arduino in a document instead of printing information on the LCD screen or in the Serial Monitor of the Arduino. Also, Tinkercad.com was used to make a circuit and the associated code for the Arduino online to test it before the parts were shipped. Tinkercad was also used to design objects to 3-D print as well as to design the Arduino Uno circuitry before building it on the board.

The results of this experiment were that the "rabbit" system could be utilized to provide more accurate and reliable data and to conduct temperature and time readings throughout the process. The improvements that could be made to further improve the "rabbit" system include cushioning or slowing down the rabbit as much as possible to avoid destroying the parts of the "rabbit" or the TLDs inside of it.

There were many learning experiences during this project but one of the most important was constant testing and retesting, troubleshooting and debugging, throwing out old ideas and trying new ideas. This lesson is important to learn now since it will be an essential part of being in an engineering career in the future. Engineering is not about getting things right on the first time, or even the hundredth time, but is instead about constantly finding ways to improve an experiment or a system. This project was an excellent learning experience for me

and also helped Sandia National Laboratories with a small system that could save time and give more accurate results when irradiating objects in the GIF.

Sources Used Throughout the Project

- http://www.instructables.com/id/Setup-for-DS3231-AlarmTimer-Function/
- https://playground.arduino.cc/Code/Stopwatch
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