Thesis Project Portfolio

Design of a Modular Cloud Chamber with an Internal Clock Mechanism

(Technical Report)

Investigating the Impact of the Nuclear Stigma: Encouraging a More Productive Discourse

(STS Research Paper)

An Undergraduate Thesis

Presented to the Faculty of the School of Engineering and Applied Science

University of Virginia • Charlottesville, Virginia

In Fulfillment of the Requirements for the Degree

Bachelor of Science, School of Engineering

Julian Lee

Fall, 2023

Department of Mechanical and Aerospace Engineering

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Sociotechnical Synthesis

(Executive Summary)

Nuclear Power and Subatomic Particles: Making Them Visible

"Nuclear" is a scary word. No matter the context (like energy, weaponry, or radiation), people are often fearful of nuclear things. My technical project focuses on the design of a clock within a cloud chamber, which is a type of particle detector used for visualizing ionizing radiation. The clock was implemented to provide an opportunity to exercise more complex mechanical engineering design in addition to the visually appealing cloud chamber. The cloud chamber is a clear box containing a fog-like vapor that makes moving charged particles (including subatomic ones from atomic nuclei) stand out to the naked eye. My STS research was born from my experience working at a nuclear power company, where I analyzed a new cooling system for the control rods of a nuclear reactor. The safety training, documentation, and people there all implicitly acknowledged a public bias against nuclear power. In both projects, I aimed to make something visible: in the case of the cloud chamber, I make ionizing radiation visible in a neat science demonstration and timekeeper. In my STS research, I make the biases and stigma surrounding nuclear power visible, in the hopes of making the topic more approachable.

My technical project is a unique blend of mechanical engineering and design for aesthetics. My capstone project group designed and built a cloud chamber (powered by an electric rolled ice cream machine) with an analog clock mechanism inside. The machine constrained our cloud chamber assembly physically and was used to make our project long-lasting and reusable (as well as provide a fun way to make ice cream). Cloud chambers require a very low temperature at the bottom (usually below -30 °C) to produce an alcohol vapor used to

make moving charged particles visible via condensation. Typically, people use dry ice, but we used an ice cream machine for longevity and reusability. Some of our other major design considerations were how the cloud chamber must be sealed, how isopropyl alcohol can be corrosive and flammable, and how the clock can be visually appealing. We had to power an analog clock with sensitive components like electronics outside the actual chamber, while minimizing alcohol vapor leakage. Our solution was to transmit mechanical power through two aluminum shafts entering the chamber through airtight ports with an external, acrylic gearbox and stepper motor system. These powered acrylic ring gears control the clock hands inside the chamber. Figure 1 below shows a CAD model view of the gear and clock system within the cloud chamber. This project provided me with valuable experience in designing for both functionality and aesthetics and can be used as a potential science demonstration at the University in the future.

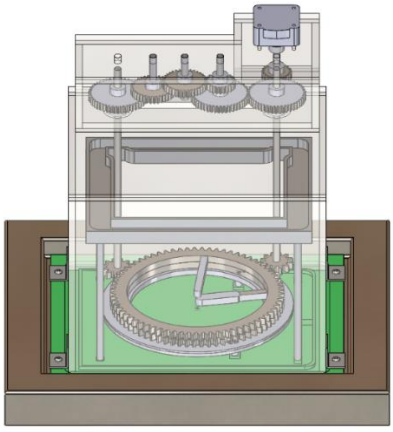

Figure 1. CAD model of the cloud chamber assembly. The ring gears allow the clock hands to be easily visible from many angles (created by the author).

In my STS research, I analyzed several case studies to characterize the "nuclear stigma" surrounding nuclear power. The nuclear stigma causes people to be wary of nuclear power or prevents them from even discussing it properly. I argue that the implicit nuclear stigma must be made explicit to promote a more productive discourse about nuclear power. I believe that nuclear

power is a great energy source; others might disagree, but it's important to at least discuss the topic and its potential use, or else a potentially economical, safe, and clean energy source might be wasted. I analyzed several cases to better understand how the stigma affects peoples' thoughts, behaviors, and perceptions regarding nuclear power. While each scenario was different, I found specific ways in how the stigma biases people against nuclear power. One striking result from the Chinese villages showed that there, where they did not have an entrenched stigma against nuclear power, residents were much fairer in their consideration of nuclear power. In British towns, proximity to nuclear power plants created an underlying atmosphere of risk normalization and fear. From my results, I conclude that eliminating the nuclear stigma is likely not possible, but simply being aware of it will greatly improve impartiality and discourse about the subject, benefiting everyone. Like my technical project, my STS research resulted in new understandings of nuclear power-related subjects.

Both projects taught me the value of broadening one's knowledge to truly be an active, engaged engineer. The cloud chamber and clock may look visually intriguing, but without knowledge of its workings, it lacks a perspective that allows you to admire its simplicity and beauty. It is designed to demonstrate and educate others about its working scientific principles to freely and openly disseminate knowledge. My STS research broadened my own perspective during my research about the opposition to nuclear power. As someone who likely has a deeper knowledge of the technical aspects and safety features in nuclear power plants than most, I was positively biased towards it while most are the opposite. I gained a new understanding of nuclear opposition during the process of researching how others might gain new perspectives. Together, these insights showcase how in engineering, providing information and ensuring a fair treatment of all factors is both fulfilling and the ethically responsible path to take.