Production of health-conscious alcoholic beverages

Analysis of Process Safety to Mitigate Personal Health Consequences

A Thesis Prospectus
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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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Introduction

Process safety and the protection of personal health are at the core of engineering. All engineering projects have goals, but those goals should better the lives of all people, or at a bare minimum, not affect them in a negative way. This is especially important for Chemical Engineers, as our processes can often have disastrous consequences from the perspective of individual heath, due to the chemicals used and the sheer scale of projects (Eames, 2019, pg.1). Personal health must be kept in mind, not only for the final goal of the project, but also the methods used to achieve that goal.

To address the aspect of better health through the final product, the technical project being pursued has the final goal of a healthy alternative to most other alcoholic beverages. Currently, the market for alcoholic beverages is flooded with highly sweetened low quality malt base liquors and mass batch beer (Grand View Research, 2022, pg.1). While this technical project does not address the inherent health issues that arise during alcohol consumption, it does greatly aim to minimize the other side effects (Gray, 2021, pg.1). This minimization of affects is especially important in the time after the Covid-19 pandemic, as the alcohol consumption uptick during the lockdowns has not subsided back to pre-covid levels (Winderl, 2021, pg.1). This investigation into healthier alternatives to the mass-produced alcoholic beverages must be pursued in order to give individuals a healthier beverage alternative.

After addressing health through better products in the technical project, the betterment of health through improved processes will be addressed through a social lens. This side of better health through superior process methods and safety will be investigated by researching an ethanol distillation related accident that ended in many deaths and injuries, as well as excessive property damage. The root problems in this case will allow us to better understand how to improve our processes to increase personal health and safety for not only workers but also people in the vicinity of our processes.

With a healthy beverage process designed and a safer unit operations perspective attained, a complete concept of process safety can be assembled. Together, both the technical project and STS research will allow for the overall processes to be better understood, and the personal health of all people to be considered.

Technical Project

Hard seltzer sales, such as White Claw, are growing at a much faster rate than beer sales, due to its popularity among Gen Z and Millenials who have established a drinking culture with seltzer brands. Trends such as the Smirnoff Ice challenge and colloquialisms such as "No laws when you're drinking Claws," contribute to the growing sales of canned seltzers and the expansion of product lines to include flavored seltzers (Allied Market Research, 2021, pg.1). The trending drink in correlation with the onset of the pandemic has further skyrocketed sales. The pandemic contributed to a heightened apprehension to consume alcohol in public spaces, such as bars and clubs, and generated a shift towards at-home drinking as well as online food and beverage shopping to avoid viral exposure. Thus, canned cocktails have high market potential and potential for growth due to its convenience and reminiscence of buying drinks at a bar. Furthermore, canned cocktails have largely marketed themselves to health-conscious populations and the gluten-free community who are shifting towards drinking low-alcohol fruit-flavored beverages (Ready To Drink Cocktails Market Size Report, 2022-2030, n.d.).

As people have grown accustomed to drinking canned cocktails in the comfort of their homes, there is a growing desire for more sophisticated liquor-based products that can offer a better-tasting cocktail adjacent beverage. Most common seltzers have a lingering aftertaste from the malt-base which many consumers find unsettling. Our product aims to improve the taste by using a distilled liquor base instead. While this change will increase production cost, many consumers would be willing to pay a premium to remove the unpleasant aftertaste, and our product will remain competitive. Additionally, in developing a liquor base there is broad versatility and a wide range of products that can be marketed from a more streamlined process. Different flavorings can be added to the liquor base and sold as different cocktails. We envision this product being consumed both at home and at formal events, where a more polished, mobile drink can replace live mixing of cocktails that may cause anxiety about the transmission of covid.

This Capstone project will design a unit-operations process to ferment and distill cane sugar-based liquor for implementation in low-calorie carbonated canned cocktails. Our initial step is to produce a high concentration of ethanol within our mash. The yield of ethanol produced will be kept around 10-15% purity, as too much ethanol would kill the yeast and prevent fermentation, while too little ethanol would result in slower overall fermentation. The ethanol mash will then be transported to scrubbing and filtering units to remove any impurities and eventually sent through a continuous feed distillation process (Holl, 2022). The ethanol mash will be injected into the distillation column and vaporize within the column and rise, eventually condensing as a concentrated ethanol product. The bottoms product will consist almost entirely of water and other byproducts due to their higher boiling points (*DISTILLATION OF MASH AND RECTIFICATION OF ALCOHOL*, n.d.).

As ethanol is continuously distilled, the alcohol percentage/purity will increase with a goal of 90% purity. Fruit flavorings will be purchased and combined with the purified ethanol, water, stevia, and preservatives (sodium citrate) to create a product of 4-7% ABV (alcohol by volume).

Once thoroughly combined, the drink will then be carbonated with food-grade carbon dioxide and sent to canning. We intend to sell 3-4 flavors in a mixed pack of 12 canned cocktails. The general outline of the entire process is seen in Figure 1.

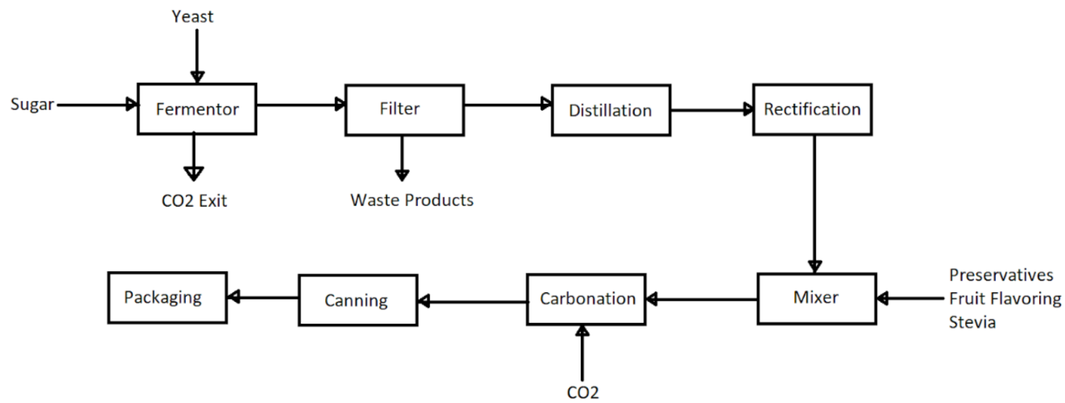

Figure 1. General Process Flow Diagram of Creating Canned Cocktails

Process Modeling and Calculation Methods

Our group will follow previous literature and current plant designs to help guide our design process. The project will be advised by Eric Anderson, Professor at the University of Virginia. We will model our fermentation process using MatLab and Excel and will switch to Aspen v11 Plus for distillation. This modeling will begin with the introduction of sugar for our fermentation process and finish with our ready-to-drink canned cocktail. All inputs, outputs, side products, byproducts, and waste will be considered and properly accounted for so no stream or material is without a source and sink. This modeling will include factors such as scale, size of plant, and cost of operation, ingredients, and disposal. Additionally, to accompany our process modeling we will also consider and report all safety hazards or risks associated with our plant and the chemicals involved. Our team will write a Design Basis Memorandum in the Fall of 2022 and finish the technical design in Spring of 2023.

STS Project

On the date of January 15, 1919, a flood fell upon the North End of Boston, Massachusetts. The flood originated from a Molasses storage tank owned by the Purity Distilling Company (Cavanaugh, 2019, pg.1), which burst just after 12:30 PM and flooded the streets. The tank, constructed to hold the molasses before distillation, released an estimated 2.3 million gallons of molasses creating a 25-foot-tall wave, destroying everything in its path. While killing 21 people and injuring 150 (McCann, 2016, pg.1), the wave also demolished the surrounding buildings and landscape. After the initial flooding, the cold Boston weather effectively froze the molasses, burying victims' bodies under a molasses glaze. It took hundreds of men many months to dig the bodies out and to clear the destruction, which totaled an equivalent of $127,000,000 today. This accident ushered in a great change in structure construction legal requirements (Cavanaugh, 2019, pg.1), which were developed so that an engineer was always involved.

The failure of this storage tank is often attributed to a combination of the conditions of the day the disaster occurred and the impending alcohol (Cavanaugh, 2019, pg.1). While these both played an important role in the disasters occurrence, they pale in comparison to the lazy construction of the tank and the unsafe practices used by the business. To elaborate, the conditions and prohibition do not account for the building overseers lack of engineering experience that led to unsafe tank being (The Boston Globe, 2016, pg.1). Along with the lack of experience, the tank was constructed from subpar metal (McCann, 2016, pg.1), likely to save cost, which also contributed to its later failure. These are much larger in the grand scheme, as they are the basis of the tank failure, while the conditions on the day merely exacerbated these factors. The natural and economic actors played an immediate role in the flood, but should we not delve into the social and conceptual actors, we will never truly find the root cause of similar incidents.

Based on the information gathered, I argue that the improper construction and negligent levels of maintenance in conjunction with the molasses properties and weather were the causes of the Purity Distilling tank disaster. Actor Network Theory (Cressman, 2009, pg.1-5) looks to label a network builder, identified by their recruitment of both human and non-human actors in order to reach an overarching goal. In a process called translation, actors are assigned roles and formed into a cohesive actor network in order to be studied. Using the concepts of ANT and actor translation, I will identify the network structure of the Purity Distillation Tank disaster to grasp how human and non-human actors must be understood to prevent large scale industrial disasters such as this. To accomplish this goal, I will use primary sources as well as post-accident studies in order to fully identify the root cause of the tank rupture and analyze the actor conditions that immediately led to the disaster. This ANT facilitated root cause analysis will further the goal of understanding problems through a broad social lens and increase the safety of all processes for the betterment of all people.

Conclusion

With the goal of greater overall personal health, both the final product and the processes used to create said product must be understood and improved. The technical project will allow us to prioritize personal health through better final products, as the beverage produced will be a much better option than what is currently available. Improving the health of society through the goods consumed benefits everyone and should be pursued in other areas as well. The STS project researched has shown that not only do we need to improve our process, but we need to do it in a professional and honest manner if we want to improve individual health. What use would it be to produce a health-conscious product if the process used to make it was detrimental to workers health? With the combination of improved final products and safer processes, the goal of greater overall personal health can be achieved.

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References

Amy Marturana Winderl, C. P. T. (2021, September 23). *If the pandemic changed your drinking habits, you're not alone*. SELF. Retrieved October 27, 2022, from https://www.self.com/story/pandemic-drinking-habits

BEng(Hons), J. S. (n.d.). *Best yeast for making vodka*. Headlands Distilling Co. Retrieved October 26, 2022, from https://headlands.com.au/best-yeast-for-making-vodka/

The Boston Globe. (2016, November 24). *Slow as molasses? sweet but deadly 1919 disaster explained*. Boston.com. Retrieved October 26, 2022, from https://www.boston.com/news/history/2016/11/24/slow-as-molasses-sweet-but-deadly-1919-disaster-explained/

BTS Engineering. (n.d.). Retrieved October 26, 2022, from https://bts.net.ua/eng/news/peregonka-brazhki-i-rektifikatsiya-spirta-eng/

Cavanaugh, R. (2019, January 14). *Great Molasses Flood at 100: How Boston Disaster Made Us Safer*. Time. Retrieved October 26, 2022, from https://time.com/5500592/boston-great-molasses-flood-100/

Cressman, Darryl (2009) A Brief Overview of Actor-Network Theory: Punctualization, Heterogeneous Engineering & Translation, Simon Fraser University, Retrieved November 7, 2022

Eames, P. (2019). *The basis of safety*. The Chemical Engineer. Retrieved October 27, 2022, from https://www.thechemicalengineer.com/features/the-basis-of-safety/

Gray, J. (2021, April 22). *How hard seltzer became the Alcohol Industry's Party trick*. The Business of Business. Retrieved October 26, 2022, from https://www.businessofbusiness.com/articles/history-of-hard-seltzer-white-claw-truly-bud-light-cacti-comparison-travis-scott-constellation/

Holl, J. (2022, February 28). *A simple guide to how hard Seltzer is made*. Wine Enthusiast. Retrieved October 26, 2022, from https://www.winemag.com/2022/03/01/hard-seltzer-definition-guide/

McCann, E. (2016, November 26). *Solving a mystery behind the deadly 'tsunami of Molasses' of 1919*. The New York Times. Retrieved October 26, 2022, from https://www.nytimes.com/2016/11/26/science/boston-molasses-flood-science.html

P, A. (n.d.). *Alcoholic beverages market size and share: Industry Analysis, 2025*. Allied Market Research. Retrieved October 27, 2022, from https://www.alliedmarketresearch.com/alcoholic-beverages-market

Patel, A. (n.d.). *How is hard seltzer made? production process explained*. Production Process Explained. Retrieved October 26, 2022, from https://drinktinto.com/blogs/wine-wisdom/how-is-hard-seltzer-made

Ready to drink Cocktails Market Size Report, 2022-2030. Ready To Drink Cocktails Market Size Report, 2022-2030. (n.d.). Retrieved October 26, 2022, from https://www.grandviewresearch.com/industry-analysis/ready-to-drink-cocktails-market