Reverse Engineering of Toro Snowblower

Group #6 11/28/2024
Owen Marsden
Abdul Hayye
Jacob Baldwin
Paul Poleon Jr
Benjamin Thomas

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Executive Summary:

This project focused on analyzing and improving a Toro CCR Powerlite snowthrower through systematic disassembly and evaluation of its key subsystems. The team conducted a thorough examination of the machine's components, including the auger-belt system, pull cord-engine system, and chute function. Through this analysis, three significant improvements were identified: converting to battery power from gas, implementing a convertible design to allow rototiller functionality in non-winter months, and enhancing repairability for owners in line with the "right to repair" movement. These proposed modifications address multiple GSEE (Global, Societal, Economic, and Environmental) factors while maintaining or improving functionality. The improvements can be quantified through metrics such as usage hours, maintenance cost reductions, and emissions measurements. Despite challenging weather conditions during disassembly, the team successfully completed their analysis and developed practical recommendations that would make snow throwers more versatile, environmentally friendly, and user-serviceable.

Introduction:

The group sought out to analyze an older Toro CCR Powerlite snowthrower that one of the members had sitting in their garage. The choice to analyse the snowthrower was based on the fact that it was sufficiently complex to explore multiple subsystems yet common in use to the point where the members were familiar with its basic functionality. The snowthrower can mainly be represented as taking energy, user inputs, and mechanical processes to function. In regards to the energy usage, the snow thrower takes gasoline into its fuel tank and then disperses that fuel to the engine. The biggest user inputs were utilizing the handle to guide the snow thrower along some desired path, altering the auger and chute to shoot the snow to the ideal location, and pulling the pull cord to put the gasoline to the engine. Most importantly, the snow thrower is rich in internal mechanical processes. As mentioned previously, the snow thrower consists of the auger-belt subsystem that the group analyzed, the pull cord-engine subsystem that the group analyzed, and the chute function which the group briefly explored. The snowthrower was provided by Abdul Hayye and the analysis predominately took place at the residence of Paul Poleon Jr himself. The main purpose of this project was to collaborate with other engineering students to attempt to apply the engineering method in the real world. Specifically, the group sought out to analyse the snowthrower’s subsystems, explore the individual parts and their functions, and report the findings in a timely and effective manner.

Methodology:

Throughout the process of completing this analysis of the snowthrower, there was a necessary dissection process to be completed.To complete this disassembly process, many different tools needed to be used including mainly screwdrivers and wrenches. The group greatly benefited from Paul's handy tool collection as well as a part catalog found online as it meant that there was no element of 'going in blind'. During the disassembly process, it was made clear that many components of the snowthrower fall into a series of subsystems with the main three being the hull, the internal operation components, and the engine components. It was useful to break apart this large system of components into smaller subsystems as it allowed for an easier time analyzing the components. The disassembly process consisted predominantly of unscrewing bolts and pulling the individual parts apart. For the analysis, the group chose to analyze the auger, the recoil starter, and the engine. These parts were chosen due to the plentiful mechanical implications they have. The group was able to relate each part to their own respective equations which we learned in class. For example, the auger spins rapidly against the snow and ice, meaning it needs to withstand the stress that it's put under when in contact with the ice. On the contrary, the recoil starter had to do with rotational kinetic energy because it relies on the pull cord which is essentially a string wrapped into a circle. In addition, the engine primarily has to do with doing work - making it most important to know how efficient the engine is.

Results and Discussion:

Throughout this process of dissecting this snow thrower, the group encountered numerous different struggles that led to members thinking that there must be a better way to design some elements of the snow thrower to make it more efficient for individual customers. It was very clear that many of the components that the group did end up disassembling were not meant to be disassembled for repair by the consumer of the product, thus it is more and more evident that one way that this product could be better would be to increase the ability to disassemble and repair parts of the snowthrower with tools that anyone would have around the house. This would lead to the customer being more inclined to purchase this product at a higher price point as the consumer knows they would be able to repair it themselves rather than having to buy a new snow thrower if any component were to break. This would make it more economically viable for the company as the company would be able to sell the snow throwers at a higher cost and higher frequency. The main GSEE factor that would be considered with this improvement would be the S, societal factor, mainly due to the fact that this change would empower consumers with a choice to repair rather than replace. In addition, this change would allow for an increased access to repairs for more rural communities that don't have shops to make more advanced repairs and, instead, promote consumers to repair the parts themselves with the gaggle of tools available to them. A way to quantify this advancement in the snow thrower would be the percentage of owners that can service the item themselves per unit sold.

A second possible revision was rendered when it was realized that the snow thrower can only be used during the winter months of the year. To combat this low usage during times of the year that snow isn't on the ground, attachments can be made to switch out the auger for a different device to allow for the snow thrower to not just be a snow thrower. This leads to the snow thrower not only being a snow thrower used during winter months but now also a rototiller to be used in the spring and summer to help with gardening. This advancement would fall under nearly all of the GSEE factors as looking at each factor separately it can be seen that the advancement would help in all areas. Firstly looking at Global, it is possible to see that this advancement would lead to increased utility for different global markets and seasons. Secondly, when looking at the Societal factor, it is easy to realize that this advancement fits into the societal factor as it allows the snow thrower to be more affordably accessed as both snow removal and gardening equipment. In other words, purchasing one expensive machine that functions as a snow thrower and tiller could be less expensive than buying a snow thrower and tiller separately. Looking at this advancement from a purely economical standpoint, it is clear that this advancement is fundamentally about maximizing the financial value and utility of this single piece of equipment by allowing it to serve multiple purposes through the year. This is vital as it reduces the total cost of ownership since the user of this snow thrower only needs to buy and maintain one machine rather than two separate machines. This finally leads to the Environmental factor of this advancement which is that as it is only one machine rather than two that are necessary now it means that there is a decrease in the manufacturing of separate machines which means a reduced resource consumption. This revision would be quantifiable by utilization rate as right now the snow thrower is only utilized for 3-4 months with this revision it would be presumed that it would have a higher than 100% increase to 7-8 months that it can be used in the year.

Leading to the third and final revision to this design the most applicable revision would be the revision that changes the fundamental principles of the snow thrower, that being that the snow thrower uses gas as its primary fuel source, the change that group 6 is presenting would be that the snow thrower would be more economically and environmentally friendly if it was instead battery powered rather than gas-powered. The switch from gas to battery power eliminates direct emissions and could reduce operating noise significantly compared to traditional gas engines. From a Global perspective, this design aligns with international environmental standards and can be adapted for various markets with different power grid capabilities. Economically, battery operation reduces fuel costs by what can be assumed to be in the couple hundreds annually based on average usage. Environmentally, the elimination of gas engines reduces carbon emissions exponentially while preventing potential fuel spills. Societally, the reduced noise levels create a more neighbor-friendly solution that can be operated at flexible hours without disturbing the community. Making the switch to battery-powered snow throwers offers clear advantages. These machines run quietly, allowing for snow removal at any hour without disturbing neighbors, while helping the environment by eliminating exhaust fumes. The savings come from never needing to buy gas, along with reduced maintenance since there's no

need for oil changes or spark plug replacements. The simple operation makes this technology accessible to everyone. It's a practical solution that benefits both users and the environment. The success of this switch can be measured through comprehensive performance metrics including noise level readings, emissions reduction calculations, and long-term maintenance cost comparisons between gas and battery models.

Making modern snow throwers more user-friendly and versatile represents a significant step forward in outdoor power equipment. Converting to battery power creates a quieter, cleaner operation while eliminating gas costs and reducing maintenance needs. The ability to transform into a rototiller during warmer months maximizes the value of the investment, turning a seasonal tool into a year-round workhorse. Adding right-to-repair features empowers owners to maintain and fix their machines, reducing repair costs and extending equipment life. Success metrics for these improvements can be tracked through maintenance cost reductions, increased usage hours across seasons, and overall cost savings compared to purchasing and maintaining separate machines. Together, these advancements create a more sustainable, economical, and practical solution for property maintenance throughout the year. These changes fit well with what people want today - equipment that's better for the environment, tools that can do multiple jobs, and machines that owners can fix themselves. By combining battery power, convertible design, and repair-friendly features, snow throwers become more useful and practical for everyday people.

Conclusions:

Overall, the project went just about as expected - a mess through and through. That being said, many things were learned throughout this highly experimental process. With the plentiful and uniquely talented minds that went into this project, everyone played a highly specialized role that could really only be fulfilled by its designated person. It was agreed upon fairly quickly by the group that Abdul Hayye's prized snow thrower would be easy pickings for the task of disassembling and analyzing its parts, perchance. After which, the group designated roles to everyone and decided to use the prime location of Paul Poleon Junior's residency, as it would turn out to be the most convenient estate for the task at hand. Through Paul's shed, the group was able to gather every single tool that could possibly be necessary for the project. With the efficiency of four young, bright, engineer-tuned minds, the disassembling was able to be completed within just a single session of the project, albeit not without some hiccups along the way. The dissection could have gone a little smoother if the group had decided to use a power tool from the get-go, which sped up the process exponentially. It would also have benefitted the group to be in conditions that were ever so slightly warmer, as the blistering cold and downpour would cause movements to be a little sluggish at times. However, it was decided that neither snow nor rain nor sleet nor hail shall keep this snow thrower from being completely taken apart that night. During the operation, the group attempted to take as many pictures as possible and took care to keep track of all disassembled parts. Looking back on it, the parts should have been

placed inside upon finishing with them, as the violent gusts were detrimental to the overall progress and caused issues left, right, and even center! It was an unfortunate time and god was against us, but luckily productivity was gushing from the pores, so the group persevered. After that, the group planned to meet and make sure everything was in order, and planned to analyze the parts. This section of the project went fairly smoothly, but with it came a lot of educated guesses regarding names of parts and attempting to figure out what they did. The group ended up doing a good job and didn't run into any major roadblocks here, as the connections and bonds that were forming between the group had made our synergy and overall chemistry just simply electric. This continued for the rest of the project, and collaboration had then become childsplay.