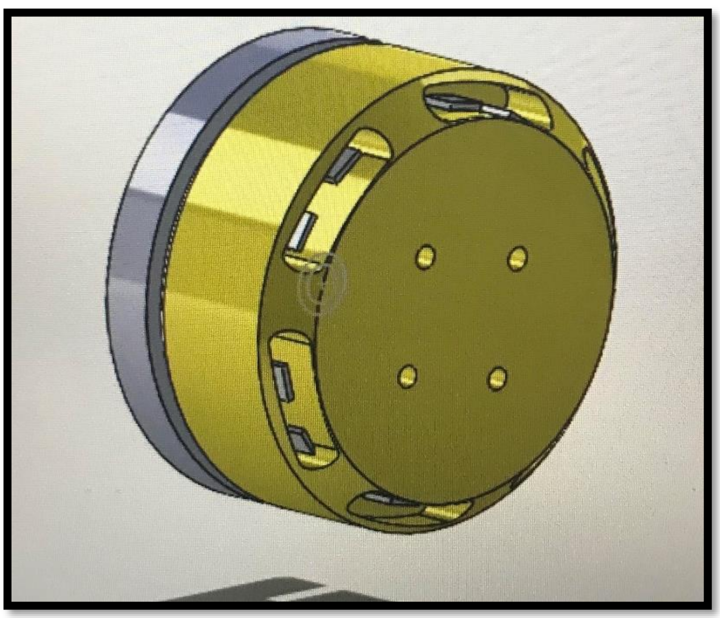
Northern Arizona University | College of Engineering, Informatics, and Applied Sciences

Postmortem Analysis

August 23, 2021

CWC 3D Generator Team: 007

ME 486C: Section 001



Introduction

The following report summarizes the overall performance of the CWC 3D printed generator capstone project heading into the second semester of the two-part course. Technical questions are answered that bring up specific positive and negative lessons taken away from the first semester. The project performance heading into the second semester is improved by understanding the faults as well as successes of the team's overall collaborative efforts made in the initial 16 weeks of design development. This report is split into two sections, the first of which elaborates upon the project successes made and how these can be continued moving forward. The second section includes the areas lacking in the team's performance so far. These are detailed and then reflected upon in terms of opportunities for further improvement. Understanding the overarching weak points and stronger areas of the team will help improve the working dynamic as the project progresses into a finalized generator design from the first semester's contributions and development of fundamental design breakthroughs.

Contributors to Project Success

The team's purpose, outlined in the charter, expresses the demand for a non-commercial, small-scale wind turbine generator that integrates seamlessly with the design of the Collegiate Wind Competition model. The project takes on designing and 3D printing elements of a generator capable of meeting the output of current outsourced generator models used by the CWC teams. The goal is to render a design that not only performs at the necessary standard, but also cuts down on costs and time associated with outsourcing. Our team has successfully narrowed down a final model to be further enhanced in the second semester that can be used in future CWC events. We have found a cheaper alternative approach in which the final design materials will be made primarily from a 3D printer with several components such as magnets and copper wire found locally and online. The team's purpose will be fulfilled once the final model features adequate power and mounting capabilities specific to a small-scale turbine. The stakeholders for the project include Professor Willy and the CWC team. The CWC team has provided our team with several resources regarding their commercial generators for comparison and influence in our final design. Our team kept in close contact with the stakeholders to ensure proper communication for design updates and budgetary information. Our team has successfully tested and produced two generator prototypes with our goal to test 1-3 at least. Both generators have different building processes and performances. The generators were compared to find the best features for our final design with the most crucial feature to have mounting capabilities relative to the CWC model turbine. Manufacturing the two prototypes has increased our knowledge and speed of production that will be vital for building and testing our final model. Lastly, once the 3D files are finalized for the printing of our final model, future capstone teams can have a reference for their generator.

In the continual search for the optimal micro wind turbine generator design, the project's overall welfare going into the second semester depends on positive attributes taken from the first semester of project performance. The team's ability to meet, brainstorm, and develop ideas weekly was crucial to product development. The questions raised for each client meeting were proven to be impertinent to the pathways chosen throughout the first semester and initial iterations of the generator design. For every deadline, the team's time management skills were adequate for achieving realistic goals even throughout the close scope of weekly deliverables. Instances when time management may have swayed, the team's open communication allowed for meeting and conducting long intervals of work time to accomplish set goals. This was a positive attribute because scheduling conflicts could be worked around, and no singular project development deliverable was unachievable to the standards set by the team charter goals. Furthermore, the budgeting of the project has gone smoothly with multiple transactions made and materials gathered for the initial prototype designs. Using the current first semester planning in terms of generator materials and necessary components, the final design in the second semester will be set. As of the first semester, experimentation with the quality of the 3D printable components has been successful in setting constructive guidelines for smoother surfaces and strength; as proven through prototype testing.

Experimentation with input programming to improve the final product performance was immensely helpful in the first-semester design evaluation. Being that multiple prototypes were built; the declaration of the final design proposal was made even more accurate through simulative testing. Although this final design is still in CAD form, the preliminary stages of the tweaks made to improve product quality through the program were a majorly positive attribute of the project thus far. Since building the initial two prototypes the overall cost of the project so far is in the correct range to successfully build a final design and even create multiple iterations.

A tool that contributed positively to the development of the project was an application called MotorCAD which is a modeling and analysis tool powered by ANSYS. This tool was able to contribute positively to the project due to the near-infinite designs that can be created and analyzed to help develop a motor that meets or exceeds the design and customer requirements. A method that the team took to accomplish this was creating multiple different motor styles and analyzing them without changing parameters so that a basis of performance based on the style of the motor can be determined. Once the team determined which motor style performed the best (the outer rotor design), parameters were changed, and materials were selected to start designing a motor to meet requirements. A couple of motor styles were printed and then tested using a dynamometer over the summer which the team was then able to see the real-world performance instead of FEA.

Considering the performance of the team, using Microsoft teams to share documents and conduct meetings was the most essential tool that contributed positively to the team's performance. Another tool that the team used to stay on track was a Gantt chart which outlined the teams' milestones and gave a visual representation of the semester. Although the team was not always following the exact preplanned track, this tool was useful to the success of the team's first part of capstone. A method that the team used to keep up to date with these tools was to meet on regularly scheduled days and times where there were no conflicts for any member. This allowed for efficient communication between the team members as well as a collaboration so that staying on track with scheduling and the timeline for the team stayed true.

Opportunities/Areas for Improvement

Throughout the course of the project, our team faced many challenges, some of which negatively impacted performance. Unfortunately, although not a part of our team's design, the two constructed prototype generators performed far below the necessary operating standard needed to comply with the customer requirements for the project outcome. Over the summer some initial testing of the two generator designs built proved this accusation made in the first semester. This outcome was not very promising and needs further revision as well as more testing of the current outsourced generator models available on the market. Although these testing models were built up to the specifications listed by each design, the product output was below average, proving that the final design needs further development. This includes the wiring configurations and overall structural design. Furthermore, there was only time during the first semester to finish two models, this was somewhat of a negative aspect due to the inability to create a full three models. This was primarily due to the wait times on part orders and the inability to meet as a team enough to overcome the issues that arise with building a design based on minimal reference instructions. Even though, as previously mentioned, all project deliverables were met, more advanced prototypes would have set our team in a better position moving forward. Another area of project performance that proved to be difficult was communication. Project development is often hindered by long periods between team questions and a lack of responses. As a result, not all material submitted upheld the initial standards the team hoped to achieve.

Meeting times were discussed in the team charter and were followed loosely on the times mentioned in the document. The meetings were used to present the main agenda of every week with each group member assigned to one or more individual and group tasks. A few barriers mentioned in the charter document included miscommunication, time management, and time zone differences amongst group members. The coping strategy for miscommunication was to allow 24 hours or more notice if a group member was unable to attend a meeting or complete a group assignment. This strategy was used effectively and helped keep every member up to date. The coping strategy for time management was to attend every meeting to understand and follow up on current and previous tasks presented by the group and individually. This coping strategy was used effectively, however, there were multiple instances where project tasks were considered too close to the delivery times of the capstone class. The same strategies were applied for the time zone difference with group members giving a 24-hour notice and attending every meeting to stay current with the group's weekly agenda.

One problem that the team encountered from the team functional side was having the team split up into two separate sections of capstone. This led to less time that the team was able to spend together and work on the project during class time. Presentations had to be recorded in some instances when team member(s) were not able to attend the other section to present. Having one of the team members in a different state also made building and communication more difficult than expected, especially during the building and 3D printing phase of the motor. Another problem that the team encountered was 3D printer issues where the printer being used was not able to print consistently. This issue caused the team to fall slightly behind schedule in the first part of capstone by only being able to build two out of the three planned motors. To correct this issue, at the time the prints were outsourced to the maker lab in the campus library. A more permanent fix was made by acquiring a higher quality printer that can print better, more reliably, faster, and with the ability to print more exotic materials. When building the motors used for benchmarking, getting the correct parts promptly proved more difficult with lead times stretching a week or two out. The team tried to counteract this lead time by printing the motor while waiting, however, due to printing issues the efficiency of doing this was not perfect and led to some time still wasted.

Another problem that the team encountered was the ability to test the 3D-printed motors effectively. This problem was caused by the CWC team who started a semester prior. Since their capstone ended the same semester that this project started and had to prepare for competition, the dynamometers were used by them for the whole semester. This led to this team having to wait until the dynamometer was picked up during the summer and the testing of the motors until the entire team was back in town.

Team performance can be improved in three fundamental areas. These three areas are meetings' efficiency and efficacy, working pace, and proper documentation. To improve the efficiency and efficacy of meetings, the team can meet in person to prevent technical difficulties such as bad internet connection and different time zones of members. In addition, keeping up with an agenda will allow the team to stay focused. The working pace of the project was as slow as it could be last semester. Three actions can be implemented to increase the working pace. First, by managing time efficiently during and after the meetings, we could make more progress on the design of the motor. Second, ordering parts through the school as soon as possible to decrease the waiting period. The third and last action will be starting 3D printing parts as soon as possible, as well as having two machines instead of one working on 3D printing parts for the generator. Finally, the team's performance could be improved by implementing proper documentation. So far, all work done has been uploaded to MS teams. However, one must navigate through many folders to find the documentation sought after. To decrease searching time or getting lost between documents all new documents will be saved under the "2nd-semester" folder, under this folder, there will be another folder corresponding to different topics.

The process of prototyping generators granted three important technical lessons for the team. The first technical lesson learned was 3D printing usable components. Since the project required 3D printing, the team obtained a 3D printer to practice and build two print two motor bodies for the prototypes. The second technical lesson was the ability to use the software MotorCAD. This software was used to create a simulation base design working from our CAD design and known input parameters. The final technical lesson obtained was the skills to properly solder wires and electrical components together. This was developed through practice, and the team's ability to follow different generator wiring configurations. Our team has ascertained a much higher level of detailed understanding of generator modeling, configurations, as well as what to achieve heading into the finalization of a successful micro wind turbine 3D printed design.