CWC2020 Turbine Team

Postmortem

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Introduction

The purpose of this report is to reflect on the team's ability to follow the guidelines set by the Team Charter, as well as the team's overall performance and progress. The team will be discussing how well they completed goals and state the positives and negatives that arose during their completion. This analysis will also review aspects of project performance, tools and practices used, ways to improve performance, and technical lessons the team learned. Through this reflection the team hopes to avoid the difficulties that were faced last semester to ensure a more productive second half of the project.

Contributors to Project Success

In the Team Charter, the purpose stated was to learn as much as possible about wind energy collection and the components that make up a wind turbine. The team has completed this purpose and is continuing to work towards it because some members wish to follow this career path. This success is what the Department of Energy (DOE) and National Renewable Energy Laboratory (NREL) hoped for in the creation of the Collegiate Wind Competition (CWC). Also, within the Team Charter, were the goals set forth by the team, which include the use of technical tools such as MATLAB and SolidWorks, machining of parts, and the construction of a functional prototype. The team met all these goals. MATLAB was used to analyze aerodynamic properties for the selection of airfoils and the overall creation of the turbine blades. SolidWorks was used to analyze systems such as the stresses that will be seen on the tower and base plate of the turbine. SolidWorks helped the team create a visual representation of sub-systems that could be modified as new developments and ideas came up in research. The team used the machine shop to create the final prototype presented at the end of last semester. The prototyping that was done was not as functional as the team had hoped to have by that time, but it did display some critical components and ideas. These ideas include the slide on nacelle cover, two level design with braking system on the lower level, and the rough idea of the yaw system.

At the beginning of the fall semester, the team collaborated on and signed a team charter that provided a guideline of the goals, purpose and ways to cope with potential barriers the team might face when embarking on this project. Ground rules provided the team with codes that needed to be followed if this project were to be considered a success. Parts of the ground rules that the team followed very well include meeting every Wednesday at 5:30pm with our client David Willy, giving the team at least a 24-hour notice prior to the meeting if they were not attending, and respecting the opinions and ideas of other students. One item that could have been improved was the communication between the different groups of engineers working on the project, because occasionally there were schedule and conflict errors. There were also aspects relating to project performance that the team did not account for, such as shipping delays and the quality of products that were purchased.

The most positive aspects of the wind turbine project have been design, team effort, and product quality. From the beginning, the team has had a clear image for what the final design of the project will be and have worked hard towards that goal. Although blade design is not completed at this time, the team has dedicated more than 100 hours into understanding the theory behind the subject, learning new programs, and working on finalizing a design. Very detailed and high-quality SolidWorks part and assembly files have also been created for the theoretical final design. From these files, two prototypes have been created.

Opportunities for Improvement

Throughout the duration of the first semester, the team faced many problems mainly due to time management. While it was understandable that all members of the team had other classes to maintain, it appeared the team was always completing objectives last minute. A possible cause of this was miscommunication with the Engineering Front Desk and technical errors. When the team ordered their first motor, they were informed that it was delivered ten days after the actual delivery date, delaying dynamometer testing. This caused the team to rush with assembly, resulting in flaws on the mounting bracket to the dynamometer. Unfortunately, this was not the only instance. After discovering that the first motor purchased produced too much power for what was needed, a second motor was purchased. This new motor was first shipped to a different school, delaying the shipping time significantly. Once this issue was resolved, the new motor was lost with no one at the Engineering Front Desk knew where it was. After making numerous calls and emails with no resolution, members of the team went to the front office only to discover the motor was there and correctly labeled. Another problem that the team faced was with the quality of the products purchased. Learning the hard way, the team brought the first motor into the machine shop. After manually experiencing more difficulty in the cogging torque, it was discovered that the magnets attracted metal shards making it harder for the motor to turn. Thinking that it could be cleaned and rebuilt, the team then stripped the two screws that held the motor together and in consequence, could not take the motor apart to clean it. Another thing that the team saw problems with was with dynamometer testing. With the help of a computer science student from the Energy Club, an Arduino and code was supposed to help the team collect data during testing but after burning two Arduino modules and having the code not work with the third, manual data was collected instead. The torque transducer located on the dynamometer connected to the driving motor also failed to work with the team, restricting exact torque measurements to be taken for the various generating motors being tested. The team faced many obstacles with time management and product quality but with the start of the new semester and new motor, the team hopes to improve upon the methods used in the first semester.

The team had used numerous tools to try and ensure a positive project during the Fall semester. The team has used many tools to accomplish many goals thus far. The team used a Gantt chart, Blackbox model, FMEA, and the required website, which have not positively helped or accomplished anything for the team. These like many other deliverables just took away time the team could have been using towards prototypes and or the final design. There seemed to be a lot of time given away to deliverables instead of allowing teams to build. Now, the team did use many tools that allowed for positive performance such as the resource of professors and the Energy Club to complete motor selection and blade development. The Energy Club received a grant which allowed them to rebuild NAU's dynamometer. The dynamometer allowed the team to test three motors, which helped in properly selecting a motor for the turbine. Testing will be completed on this motor once the final modifications and improvements are finished to the dynamometer. QBlade, SolidWorks, and MATLAB are the three programs being used thus far. SolidWorks has allowed the team to build a full CAD of the turbine and manufacture components in the machine shop for the turbine and the dynamometer. QBlade and MATLAB are currently being used to finish up the blade and airfoil design. MATLAB created the basic conditions to start making the blades. While QBlade is creating a 3D model that will be then downloaded to SolidWorks. Once the blades are in SolidWorks, the team will begin making additions to the blade that will attach them to the hub.

Through the fall semester the team completed all tasks and assignments with little issues. The three biggest problems encountered where lack of finishing assigned tasks before a due date though a set date

to review was agreed upon, unequal distribution of work completed throughout teammates, and lack of communication overall. Many assignments throughout the ME476 class consisted of writing papers about our project and or presenting with power points. Our team consistently failed at avoiding procrastination when it came to these assignments which led to lack of overall performance and outcome. Though many assignments where completed for this course consisting of teamwork and individual papers, extra time on assignments such as sub system designs and manufacturing prototypes was not equally distributed due to procrastination as well. This led to an inconsistent understanding of the overall design between teammates. Overall communication was not as strong as it should have been considering the team met multiple times a week. At times tasks were assigned and not completed, work was picked up by other teammates in order to get them done. There was an obvious lack of understanding across team members that this course required extracurricular work to be completed without being told to. Often excuses came with incompletion which ultimately is due to lack of communication and commitment proven by unassigned tasks being completed by only certain members.

Multiple actions can be taken in order to resolve these problems and improve the overall performance of the team. For one, following an organized “Gantt Chart” and using this tool without procrastination can be very useful. If a team member is committed, they can take the time to visit professors for help or other sources in order to complete an assigned task on time without excuses. No organizational tool will work without commitment of getting tasks completed no matter the difficulty which is why following this specific tool is what will help the most. There are many assignments specific to the project without a set due date which every team member is responsible for. If a Gantt Chart is created intelligently and followed by the team, this semester will flow much smoother for every member when relating to knowledge of the project and experience gained.

Through the construction of the turbine, the team has tackled new subjects and topics. Their knowledge of the components of a wind turbine, both electrical and mechanical have expanded tremendously. Primarily in the understanding of aerodynamics and motor behavior. After extensive reading of the Wind Energy Explained textbook, the team learned the aspects that affect wind turbine blade design. These aspects include airfoil selection, blade geometry and twist, wind speeds, and motor torque. The team needed to learn advanced coding techniques because calculating blade geometry is an iterative process. As for the motor, after 3 weeks of extracurricular lectures, taught by Professor Willy, the team has expanded their understanding of how every component of the motor effects the performance and behavior during operation. The team also learned the constraints for the motor through these lectures with Professor Willy. These constraints were based on size, Kv rating, and low cogging torque, which is determined using the pole and magnet pairs. The team conducted performance testing of the motors with a dynamometer to show the power curves and performance of the motor under loading. What then came to the attention of the team is that the operating and cut in torque of each motor widely varies. It also proved that the motor the team believed to give the best performance was not going to work for the necessary application. Through testing, the team found it more effective to buy various versions of the same part. This way testing can be done to find which performs best and then return the unwanted components. And finally, after research and selection of multiple solutions the team must move to testing of a given part to fully understand and anticipate the operation of the part in the final prototype.

Conclusion

Conclusively, the trials and struggles of the team till thus point has been nothing short of a learning experience. As a collective, the team has failed on several points, only to bounce back and find a solution to a problem that may not have been within our original scope. The project has had many difficulties that the team has had to overcome and perceiver through. However, this is to be expected in the professional workplace. The ability to tackle systematic problems with the aid of the engineering community has been beneficial for the team's learning experience. As each member progresses into the conclusion of this project, they will continue to gain valuable knowledge and experience for their possible future in the wind energy industry.