Discussion/Conclusion

Section IV: Discussion

The objective of this study was to determine whether penguin wings, pterodactyl wings, and bat wings produced more energy for the amount of sound they emit. The sound measurements that were recorded were insignificant, and no clear ties as to which airfoil was quieter was able to be made. The main factor behind this was the noise from the fan itself (measuring over 90 dB), and the mechanical noise from the apparatus. While mechanical noise has been solved with modern day wind turbines, the overall stand and apparatus constructed were made with household materials. Adding on, the sound from the blades was also majorly scaled down. Overall, the sound measurements this project sought to identify were “lost in noise”. However, this doesn’t mean an approximation of power can be judged. Hoen et al. in 2023 found that there is a correlation between the angular speed of a wind turbine, and tip speed. Tip speed was also correlated with the sound produced by the blades, and therefore the faster the blades moved, the more sound they made.The same principle applies for the blades tested in this experiment. Based on that information, for the first wind speed the bat wing would have made more sound, while generating the second most amount of energy. For the second wind speed, the standard wind turbine blade would have made the most noise while generating the second most energy. For the third wind speed, the control would have generated the most noise while generating the most power.

The differences in speed were a result of mainly different surface areas and masses (correlating with moment of inertia). The penguin wing rotated at the lowest angular velocity while generating the most energy for the first wind speed, followed by the bat wing. The same occurred with the second wind speed. Therefore, in lower wind speeds the penguin wing would both likely be quiet and generate more power. As for the bat wing, more analysis is required to determine its specific noise production to determine whether the design would be quiet, and one where the mass was increased. Therefore, designs such as the penguin wing that have a greater surface area, have been shown to generate lots of power, and have large surface areas may be better suited for areas with lower to middle range wind speeds. Such areas can be found in northwestern states, such as Idaho, Oregon, and Wyoming (*NOAA Climate.gov*., n.d.).

Throughout the course of this project, several limitations were encountered. The first occurred with the initial proof of concept design. It was determined that the hub's surface area was too big in comparison to the length of the blades, resulting in its failure. To overcome this problem, the hub was made smaller, and the blades were lengthed, and were functional after these changes were made. The next major limitation occurred when trying to obtain data from a wind tunnel. The apparatus was too large for the wind tunnel, leaving a millimeter of space between the blades, wall, floor and ceiling. As a result, similar effects occurred as when the Betz limit was reached. When the Betz limit is reached at roughly 59% efficiency (of the wind turbine), the air starts stalling and blocking incoming air. As a result, the efficiency of wind turbines can't surpass 59.3% (Betz Limit and a Wind Turbines Coefficient of Power, n.d.).

A similar result occurred when testing in the wind tunnel. There was no room for the airstream to move by, overall blocking laminar flow. As a result, the air blocked the incoming air, resulting in the turbine to not work.

The next major limitation occurred with the photogate. The photogate was recording total distances (in revolutions) when the turbine was spinning, at factors that were off by roughly ten. To overcome this problem, troubleshooting was conducted with the photogate. It was rotated once to see if it recorded a single revolution. Initially, when a complete revolution was completed it recorded 0.1 revolutions. The process of troubleshooting was reported, until the photogate was consistently accurate. It was likely that the photogate needed to be calibrated. The next problem the photogate caused was a block in the laminar flow of the airstream. It was in front/slightly to the side of the wind turbine to measure how many times each blade broke its laser. To do this, it had to be in the way. A method to mitigate this in the future would be to connect the axle and hub, then have the back of this ale connect to a wheel, and have the photogate measure the RPM of the wheel.

The final limitation that was incurred was the lack of sound measurements because of the noise of the mechanical components and the fan. To mitigate this problem in the future, the blades would be put in a simulation where the sound could be calculated.

Future Research

Further studies should look into the economic and environmental benefits of implementing wind turbine blades with larger surface areas and greater masses. The justification was provided by the results from the penguin wing, having a larger surface area, and greater overall mass. Further studies should also include the simulations testing for sound and power for each wing/blade, determining if it's more efficient to use these types of blades. Finally, more research should be conducted testing the different pitch angles, determining at what pitch angle each blade is most efficient to optimize power generation.

Section V: Conclusion

The purpose of this study was to determine if biological airfoils could increase their power emission to sound emission ratio. To do this, pterodactyl wings, bat wings and penguin wings were examined, and tested as wind turbine blades. The different wings were located online, scaled to be the same length, and attached to a 3D designed hub in TinkerCAD. They were printed with PLA filament. A stand was constructed using sheet metal, nuts, bolts, and screws. Each different 3D print was placed on a screw allowing it to rotate freely. Each blade was tested under three different fan power levels, initially measuring sound while measuring RPM and angular acceleration. The power generated by each blade was calculated using torque and angular velocity. It was found that the penguin wing generated more power than the standard wind turbine blade under the first two fan power levels. The increased power with the decreased angular velocity was the result of a greater mass and greater surface area. Overall, wind turbine blades with greater masses and surface areas should be further investigated, providing a way to optimize the energy obtained from the wind in lower wind speed areas, taking another step towards a clean and renewable world.