PROPFAN NOISE REDUCTION USING BLADE SWEEP

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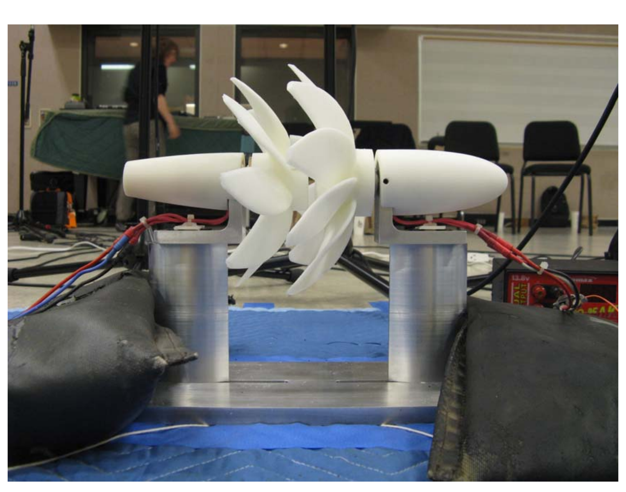
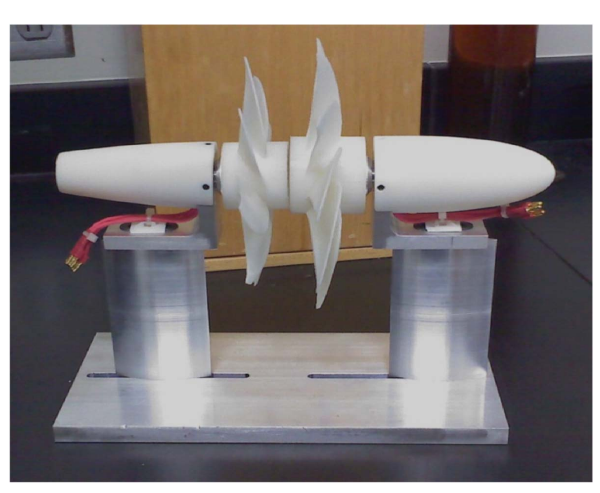
INTRODUCTION

With the price of fuel rising worldwide, airlines are looking for ways to increase efficiency and profits. The Propfan, or Unducted Fan (UDF), is an alternative to standard jet engines that could improve fuel efficiency up to 35%. Propfans are like two sets of ordinary propeller blades placed back to back that rotate in opposite directions. However it is this very design that creates the biggest drawback for propfans; noise emission. If noise emission and vibration problems could be solved, the propfan could have an important role in making the airline business more efficient and hopefully less expensive to the passengers. In an attempt to reduce noise, we swept the rotor blades back like the wings of a supersonic jet. In theory, this would reduce the strength of the vortices coming off the tips of the blades and reduce the interaction between the fore and aft blades, thus reducing the noise and vibrations.

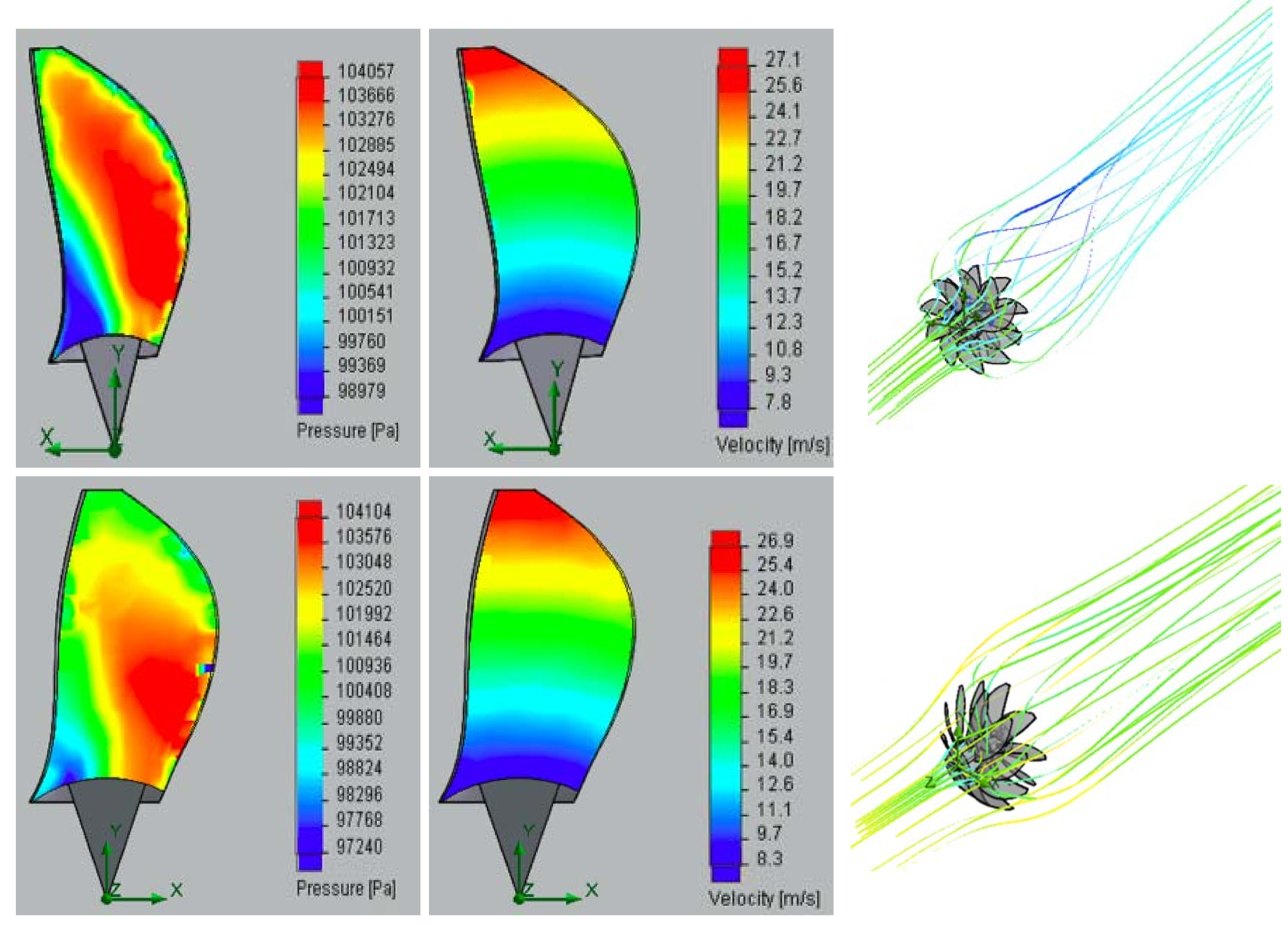




SWEPT BLADE DESIGN VS. UNSWEPT DESIGN

CFD ANALYSIS

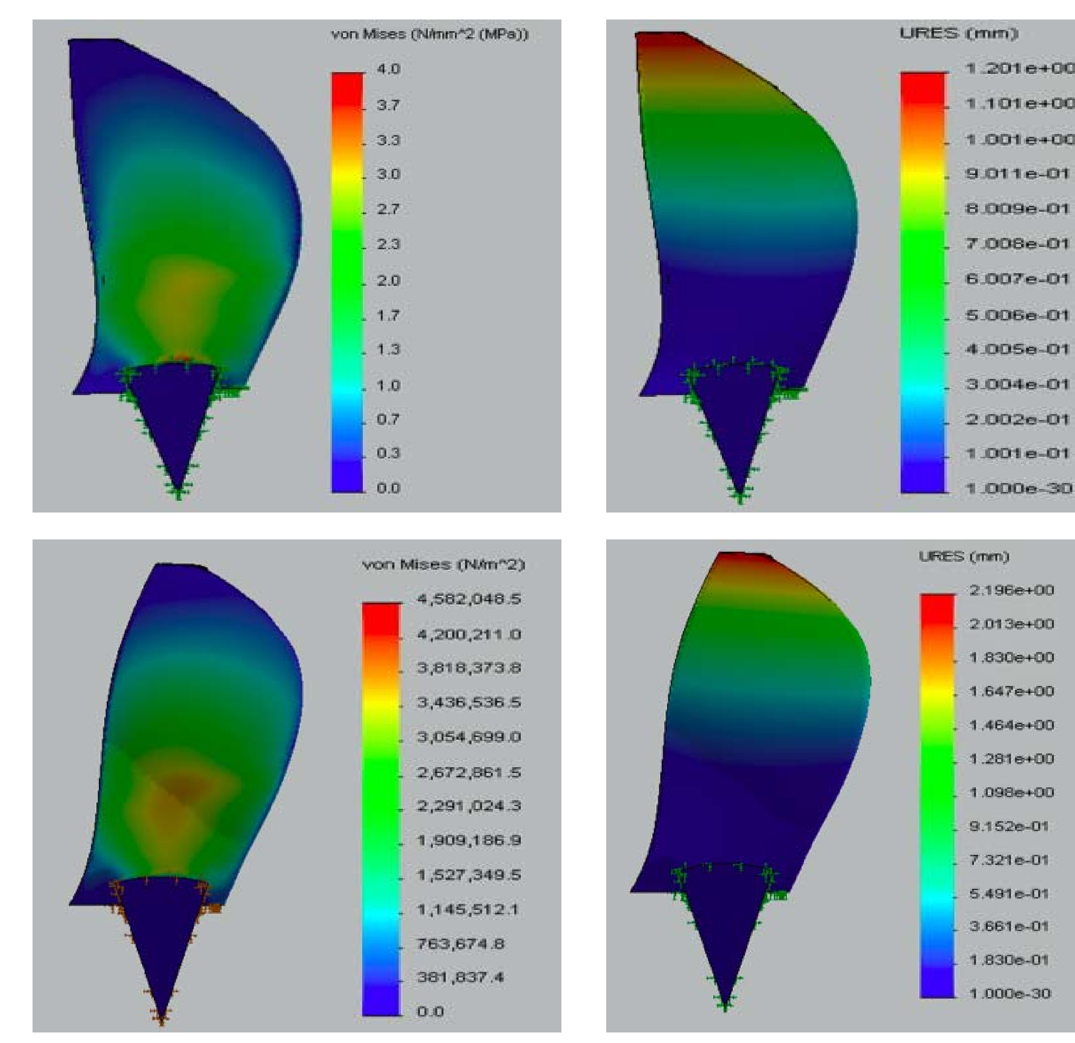
Using SolidWorks Flow Simulation, Computational Fluid Dynamics was run on to find the pressure distribution, tip velocity, and visual streamlines. In the simulation, the blades were run at 3000 rpm with an incoming air velocity of Mach 0.2 (~70 m/s or 155 m.p.h) @ STP. We began with 20 variations of severity of sweep and iterated down to the design with the smoothest pressure distribution, the lowest tip speed, and the smoothest flow behind the blades in hopes it would reduce the noise emission.



Pressure Distribution, Velocity Distribution, and Streamlines for Baseline (top) and Swept (bottom) designs

FEA (STRUCTURAL ANALYSIS)

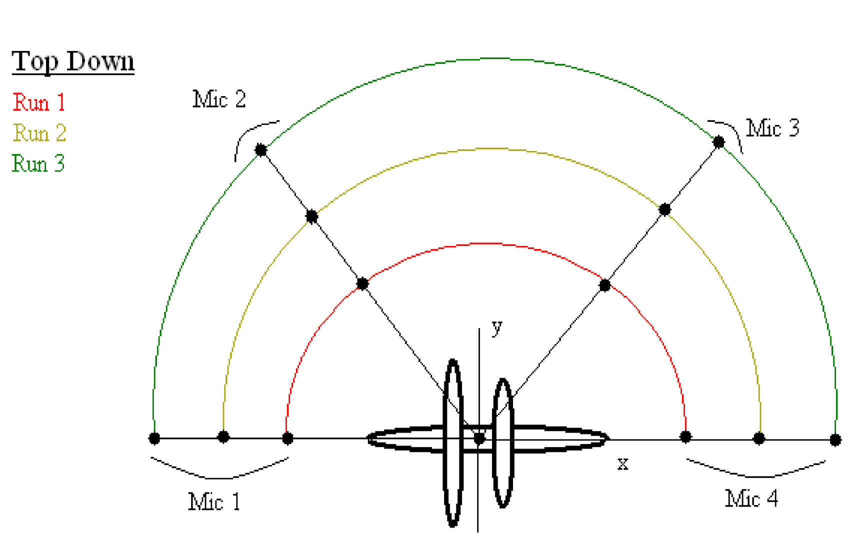
The aerodynamic forces obtained from CFD were imported into SolidWorks Simulation to run structural analysis to ensure the blades would not break during the acoustic testing. The construction material was ABS P400 Plastic; the material used by the Dimension 1200 SST 3-D Printer. Additional physical structural testing was carried out with a printed test blade to verify computer simulation results.

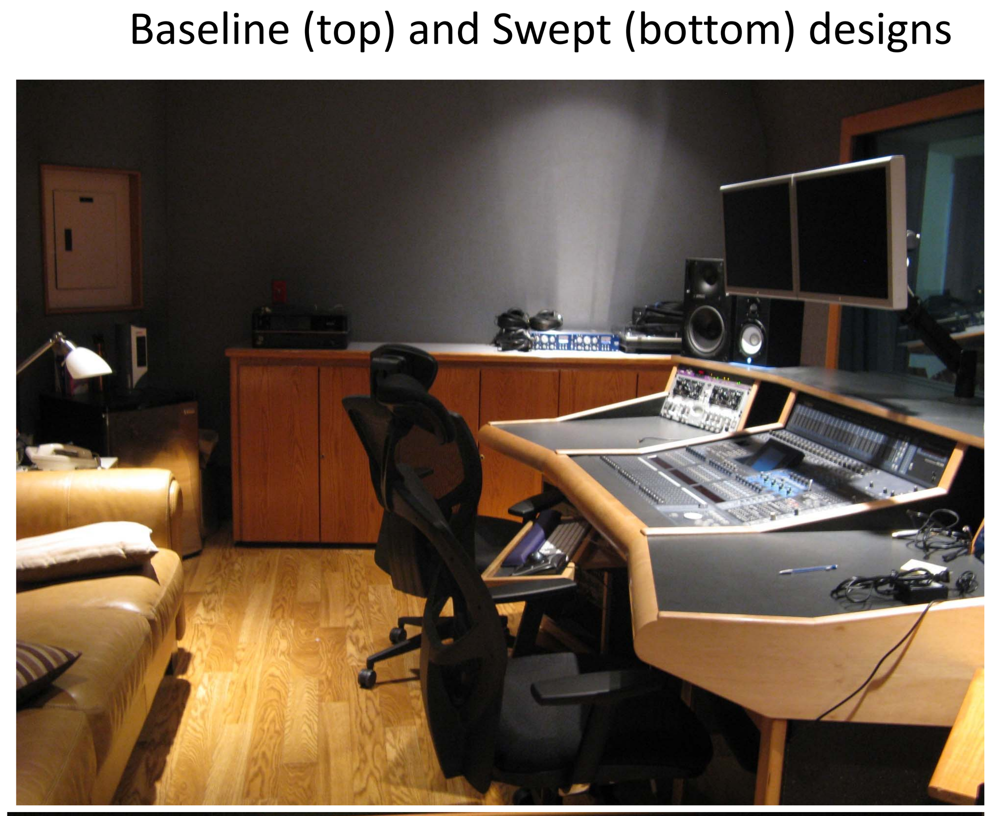


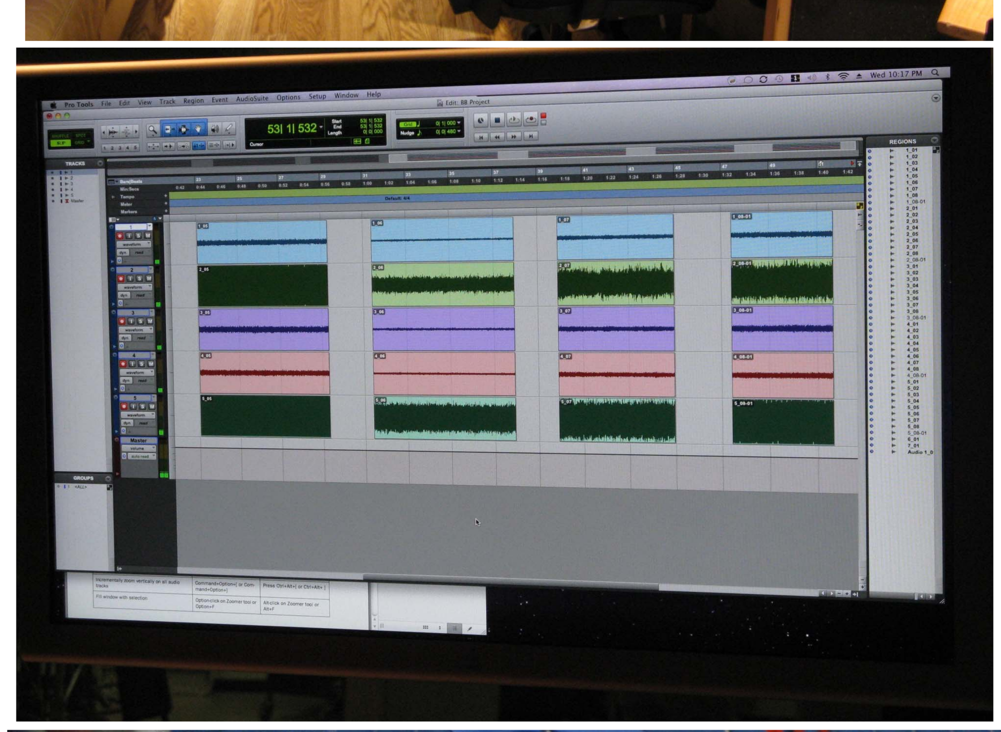
Stress Distribution and Deformation for Baseline (top) and Swept (bottom) design

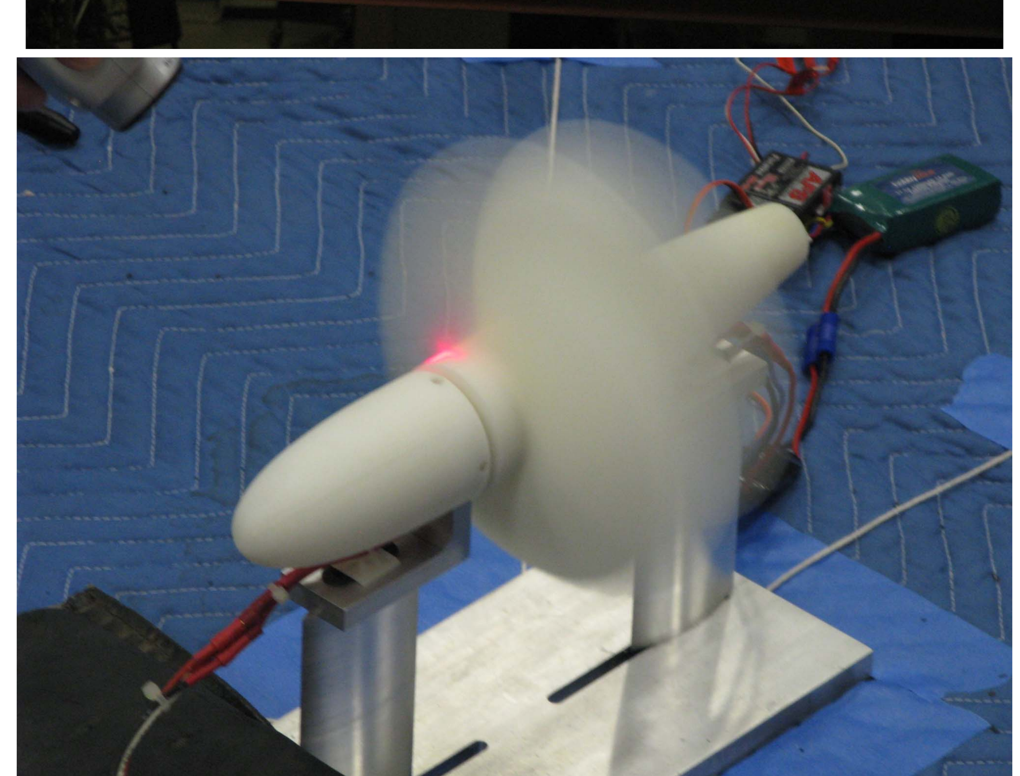
TESTING

Once the blade structural integrity was verified, the propfan was ready for acoustic testing. Testing was carried out at Azusa Pacific University in their sound recording facilities. An array of microphones and sound pressure level (SPL) meters were set up around the propfan to record and measure noise levels. All of the members stood inside the isolated control room with the audio engineer except the test conductor. The test conductor stood outside with the propfan to manually measure the RPM's with a laser tachometer. Once the RPM's were set via remote control, sound data samples were taken. Tests were run on both the baseline and swept designs at 3000, 4000, and 5000 RPM's with microphones at 20 in, 40 in, and 60 in.



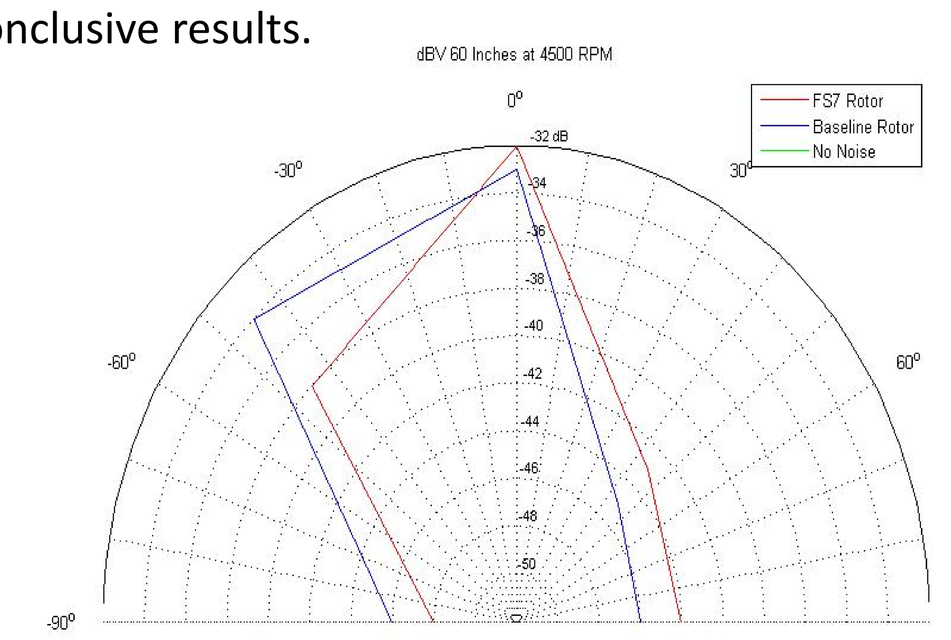






RESULTS

The results showed that noise emission was reduced for the swept blade design in only a few cases with most tests being very similar if not slightly better for the unswept blade design. There were a few factors that may have caused this. One was that there was an audible vibration in the r/c motors caused by overheating for the swept blade test but not the unswept blade test. Another issue was that the swept blades had to be thickened more than the unswept blades to ensure structural integrity. One of if not both of these may have lead to inconclusive results.



Polar Plot of results at 60 in @ 4500 (max) RPM

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