Follow Up Grant AFC215-71: Advanced Low Noise Fan Array System

Initial Grant AFC215-21: Low Noise Efficient Rim Driven Auxiliary Ventilation Fans

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Focus of the proposed follow-on work: It is important to remark that the ThinGap motor dominated the noise from the VTQR fan, i.e. the fan aerodynamic noise is very low. In fact, the aerodynamic noise from the VTQR fan is estimated to be 28dB quieter than the Cincinnati fan. Thus, there are significant opportunities to further reduce the noise from the VTQR fan. In this follow-on project, we propose to implement three technologies to further improve the VTQR fan acoustic and aerodynamic performance.

1. Implement a fan array concept: The large single fan is replaced by an array of smaller fans. Since the noise from the multiple fans is uncorrelated, the multi-fan system will result in less noise than a single fan producing the same flow rate. Note the approach in this follow-up project is to have each fan in the array driven by an independent motor. This will eliminate the potential noise and complications of having a single motor drive all fans through a complex inter-fan transmission system. This concept was proposed in the initial AFC215-21 project. However, it was not pursued because the implementation of the coupling system between the center fan and the outer fans driven by it was deemed technically too risky.

2. Implement a multi-element blade: The speed of the fan cannot be reduced further with the current single airfoil technology to construct the blades. To further reduce the speed and noise, a multi-element airfoil is proposed to produce more lift at lower fan speeds and thus noise. This concept utilizes a a single airfoil to construct the blades is replaced by 2 smaller airfoils (multi-element blade). Using 3D printing technology, the fabrication of the multi-element blades is easily achieved. This approach is new and not used in AFC215-21 project.

3. Implement noise control of the motor. The electric motor dominated the fan noise mainly at high frequencies (> 4000 Hz). Thus, this noise source needs to be attenuated. So we propose to implement noise controls to the motors (or select quiet motors). This is also a new task not used in AFC215-21 project.

Specific Aims of Proposed Research:
The aim of the proposed research is to build upon the tools and findings of award number AFC215-21 to design and test a single quiet ventilation fan array unit to experimentally demonstrate > 25 dB noise reduction relative to the baseline Cincinnati fan and > 7.5 dB noise reduction relative to the VTQR fan demonstrator (two VTQR fans) while maintaining or increasing the volumetric flow rate [CFM]. To that end, the justification metric for success is illustrated in Figure 3 by the blue shaded region. In other words, the VTFA unit will be successful if its performance resides within this shaded area. The upper left corner (green diamond) point indicated the minimum performance expected. This effort significantly contributes to the improvement of the health of mine workers by reducing their exposure to high noise levels, i.e. preventing hearing loss. A noise reduction of > 25dB would imply that the fans will become one of the quietest sound sources in a mine operation.