CFD Validation With Goal To Optimally Mix Air Ions To Purify And Sterilize Building Air Conditioning

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Abstract

Air Ionization provides an excellent opportunity to improve indoor air quality (IAQ) for commercial buildings. Our ultimate goal is to develop guidelines based on a combined experimental and analytical approach for implementing air ionization (AirI) systems into commercial buildings, more specifically, buildings on the campus of the University of Tennessee, Knoxville (UTK). The guidelines target maximizing air ion exposure to contaminants, which in turn, provides the best opportunity to sterilize, purify and improve IAQ [Refs.1-2].

COMSOL Multiphysics software [main module and CFD module only, no other COMSOL features or products were used for this paper] is used to perform computational fluid dynamics (CFD) simulations to observe the airflow and resulting streamlines occurring in large-capacity air handler units (AHUs). The AHUs of interest undergo high Reynolds number (Re) flows that can exceed 1e5 and approach 1e6. The strength of these flows may force air ions to travel along the inner metal surface of the duct which would dissipate the ion-charge and render the ions neutral [Ref.4].

UTK MABE class members participated in a project to build a wind-tunnel test facility [the Air Ionization Test Facility (AITF), Fig.1] that produces flow similar to the AHU of interest, and is of sufficient length to produce fully-developed velocity profiles. In addition, class members have utilized COMSOL Multiphysics models of the AITF and produced results to benchmark against airflow and pressure drop measurements acquired from AITF. The tested wind tunnel had a 0.406 m (16-in diameter) cylindrical metal ducting capable of airflow Re ranging from 1.2e4 to 2.5e5. The AITF includes air blower speed control, and automated data acquisition measurements of air temperature, relative humidity, static pressure drops, and air velocity. The AITF also includes transparent flow visualization sections upstream and downstream of an air blender [Refs.3] which forces mixing of air [and ions if present] along the central axis of the cylindrical duct. Flow visualizations using smoke and sparks were also made to help characterize the turbulent flow patterns and potential ion travel.

UTK student teams, spanning a 4-yr teaching period, selected the AirI study for completion of their Senior Capstone design [Fig.2, Ref.5] Their challenge was to pursue a proof of concept of the airflow and

ion mixing question for completion of the ME core-curriculum Capstone class. COMSOL class-kit software licenses were provided by the Mechanical Aerospace and Biomedical Engineering (MABE) department for non-commercial use. Students learned CFD basics through COMSOL seminars, instructor support, and through the graphical user interface provided by COMSOL. Classes were designed to start with simple 2D problems, and gradually advance to a full 3D representation of the AITF for benchmarking the COMSOL CFD code. The results from the student COMSOL simulations were used to evaluate improvements in the design of the AITF and air blender, and data acquisition of tests going forward [Figs.3-4].

Reference

[1] Stephanie Licht et al., "Use of Bipolar Ionization for Disinfection within Airplanes". The Boeing Company, https://www.airora.com/wp-content/uploads/2022/09/boeing-use-of-bipolar-ionization-for-disinfection-within-airplanes-1.pdf

[2] Christina Jewett and Lauren Weber, "Boeing Tested Air Purifiers Like Those Widely Used in Schools. It Decided Not to Use Them in Planes.", https://kffhealthnews.org/news/article/boeing-tested-air-purifiers-like-those-widely-used-in-schools-it-decided-not-to-use-them-in-planes/, 6/8/2021.

[3] Dr. Mark Paval, Blender Products Inc., https://www.blenderproducts.com/, 16600 E 33rd Dr. Suite #30, Aurora, CO 80011, 833.526.7053 or 303.295.6111.

[4] Dr. Edward Sobek, Global Plasma Solutions, http://www.globalplasmasolutions.com/, Oak Ridge, TN.

[5] University of Tennessee, Tickle College of Engineering, Senior Design Showcase, https://design.utk.edu/senior-design-showcase/

Figures used in the abstract

Figure 1 : AITF wind tunnel north view showing instrumentation board , cabling, work table, and flow exhaust to UT Drive Services Building B outdoor exit.

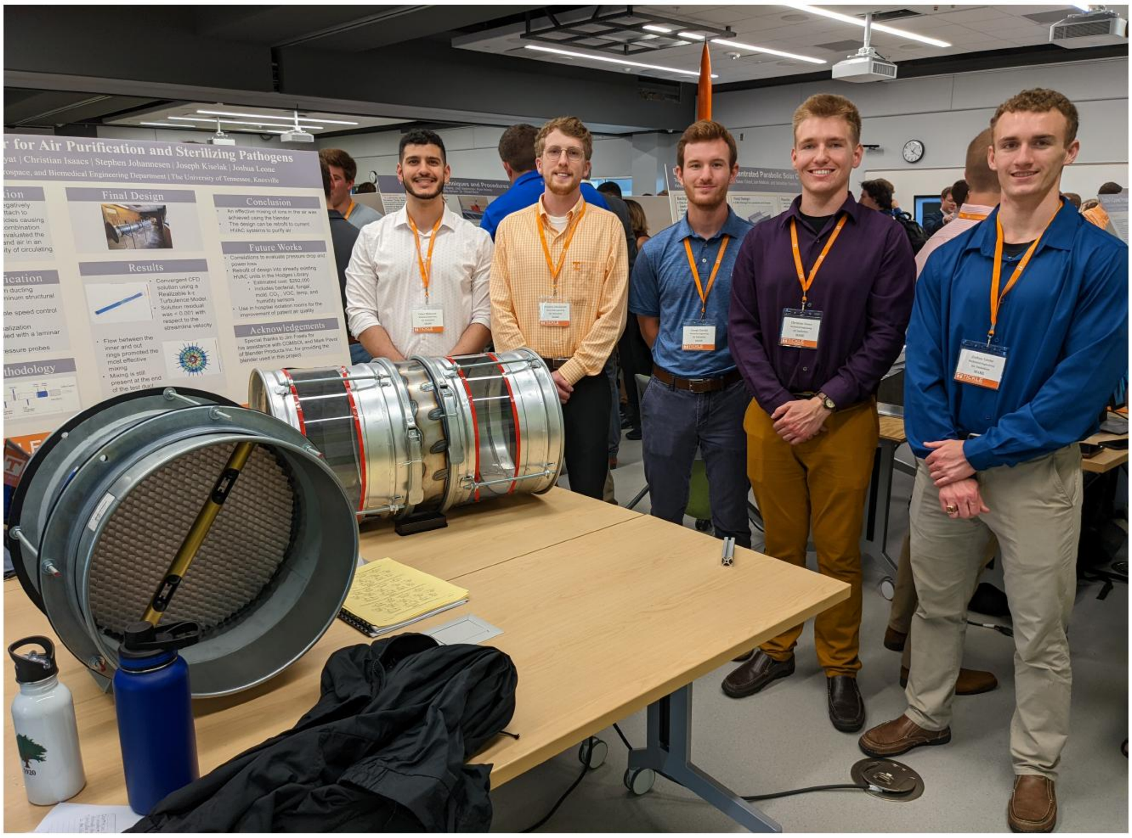

Figure 2 : ME-460 Class of Spring Semester 2022 presenting Air Ionization Project findings for the annual engineering showcase at new Zeanath Building.

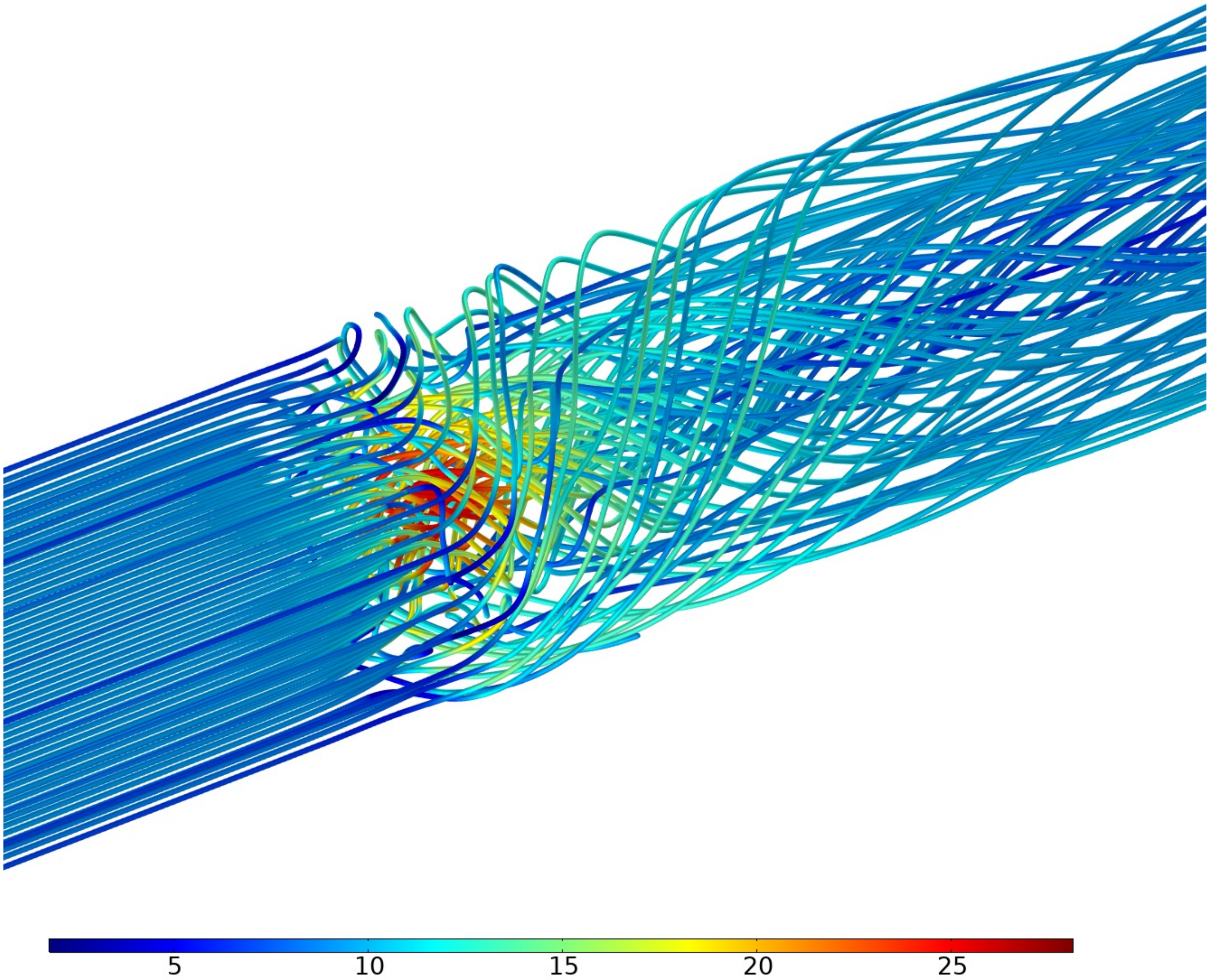

Figure 3 : AITF velocity streamlines zoom, Re=2.3085e5, inlet conditions {V_in, T_in, rho_in, mu_in} = {8.6961, 20.147[degC], 1.2040, 1.821284e-5}, k-e turbulence.

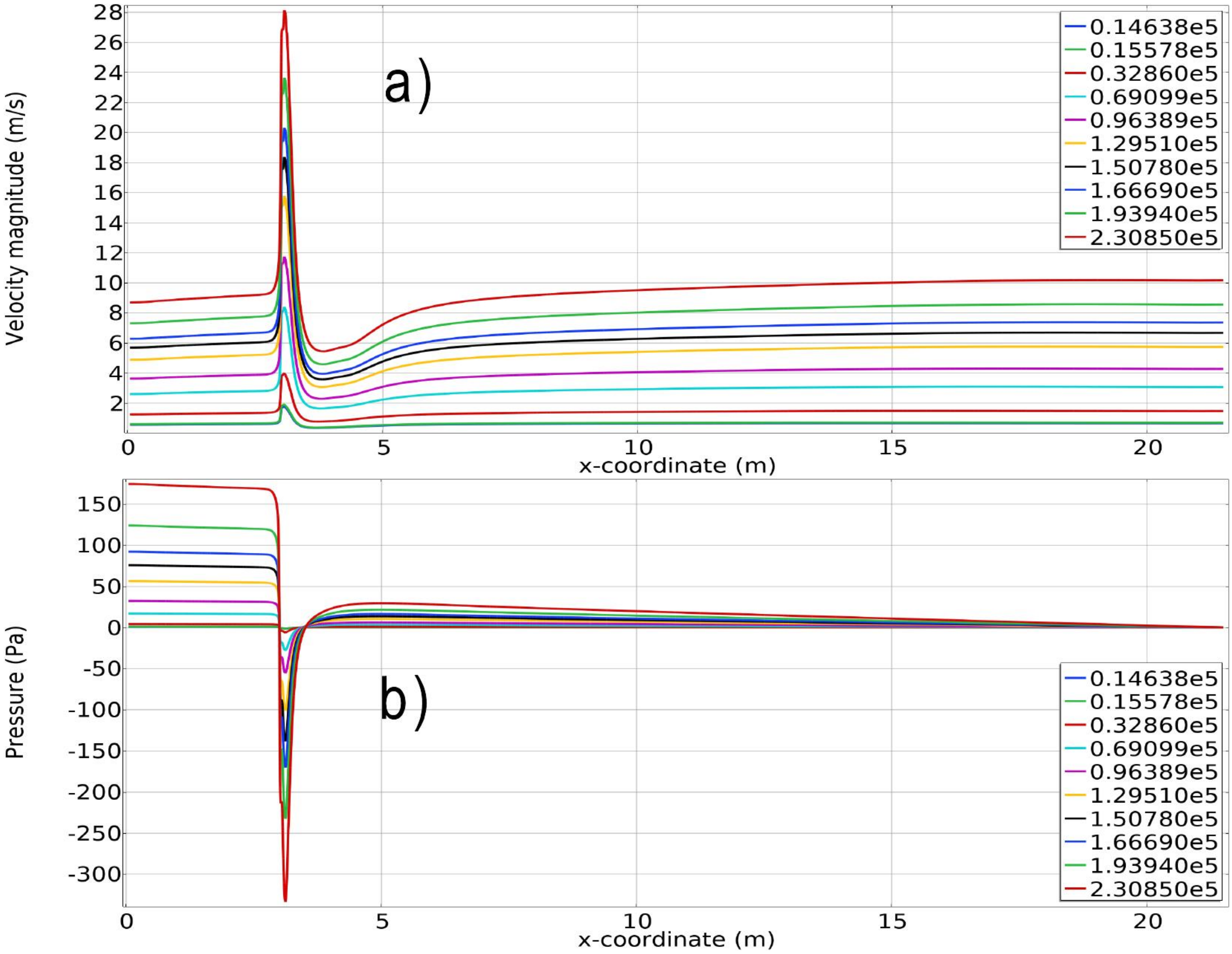

Figure 4 : AITF COMSOL simulations, cut centerline plots, test variations on Reynolds number and inlet conditions: a) top, velocity (m/s), b) bottom, pressure (Pa).