Airborne Infection Isolation and Elimination Device (AIIED)

The Airborne Infection Isolation and Elimination Device (AIIED) developed by Care Health Meditech Developments Inc. and marketed under the trade name “AIIR”, enables local elimination of airborne infection in an open environment. This makes AIIED unique and different from other isolation and elimination devices. More details about the uniqueness will be discussed below after introducing the working principle of AIIED.

I. Working Principle

Figure 1a schematically shows the working principle of the AIIED, which involves airflow dynamics and multiphase flow physics. A suction pump connected to the hose creates and maintains a negative pressure (pressure lower than ambient pressure) inside the suction nozzle. Driven by the pressure inference, ambient air flows into the dome and then the suction inlet, forming a suction airflow. The suction airflow exists inside the dome (the optical “dome” shaped head) and also outside but close to the opening of the dome, with varied distributions of velocity and pressure. Velocity increases with location moving radially toward the center and also moving vertically upward to the suction inlet, whereas the pressure distribution is opposite. When AIIED is brought close to a source of airborne infection, such as the dental operation shown in Fig. 1b, the suction airflow field forces and facilitates the infection air and particles to follow the suction flow. In addition to directing the suction airflow, the dome geometry causes flow acceleration inside the dome, and the accelerate airflow provides constant drag force for droplets and particles to overcome gravity and continue to move toward the suction inlet. As a result, infection is removed before it spreads to the ambient. The suction power, orientation angle, and height can be adjusted to change the local suction airflow so that sufficient drag force can be produced to change the trajectory of droplets and particles to follow the suction flow.

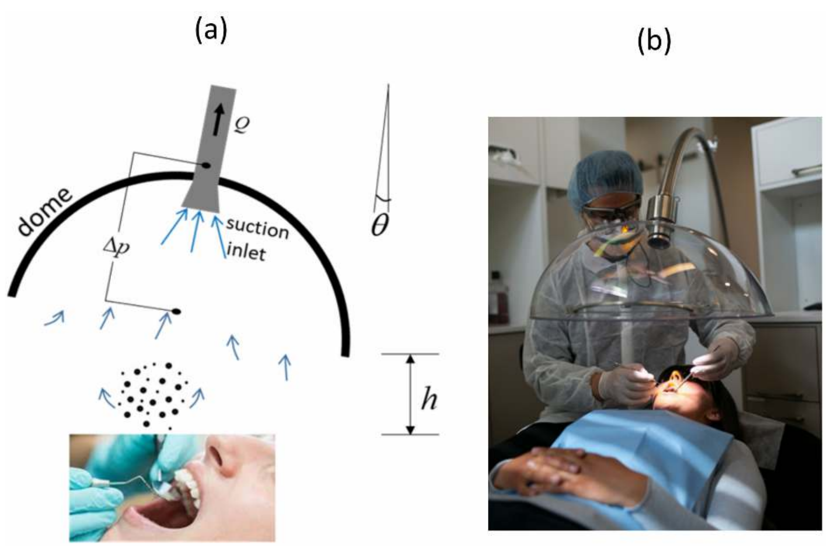

Figure 1: (a) Working principle of AIIED; (b) Application of AIIED.

II. Uniqueness of AIIED

Traditional suction devices terminate at intake orifice and do not incorporate the optical head unit (the dome) developed for AIIED. The detriment of which is that suction intake ends must be placed in close proximity to the source of the aerosol in order to be effective, as only the airflow close to the orifice can have sufficient velocity to produce enough drag force for capturing droplets and aerosols. This provides for ergonomic and patient comfort issues. Examination of Computational Fluid Dynamic models completed on AEIID provide indication that the "dome" shaped head unit of AEIID contains the low pressure required within the dome, allowing the negative pressure orifice to be moved further away from the patient (150-200mm) while retaining efficacy. This provides the healthcare worker with the ability to conduct procedures as they would normally and also increasing patient comfort as they are not in as close proximity to the suction intake.

III. Research & Development

Professor Sunny Li and his colleagues at UBCO conducting research and development of AIIED in order to develop future iterations of the device. The goal of this is to develop devices that can be used in various healthcare settings, both protecting the healthcare workers and other patients from known or unknown dangerous aerosolized particles while simultaneously reducing the need for Protective Equipment. The R&D team applies numerical simulation and experimental testing to investigate the complex fluid mechanics of airflow and multiphase flows involved in AIIED and to establish the relationship between AIIED performance and design parameters including dome design (size and geometry), suction inlet design, required suction power (negative pressure , flow rate), and positioning (orientation angle and height).

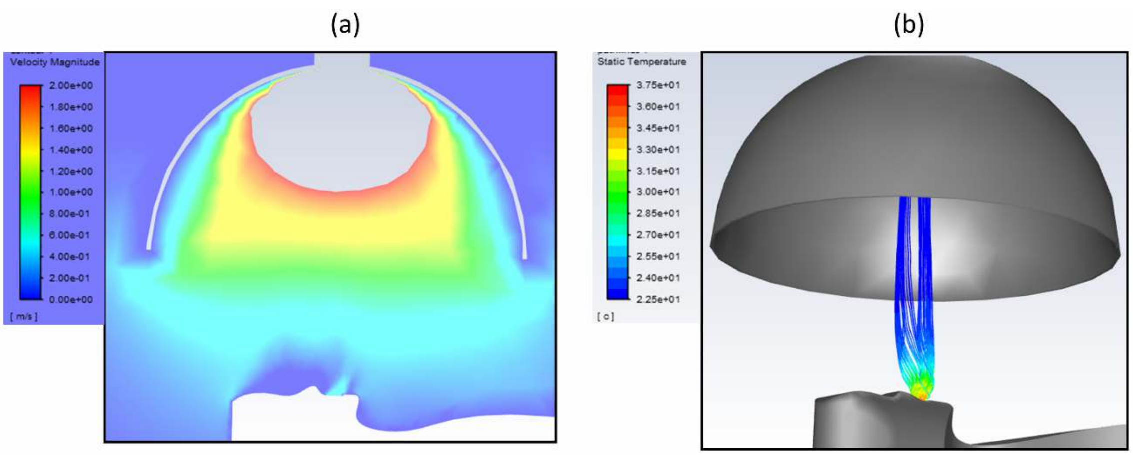

Figure 2: Preliminary CFD results of AIIED. (a) velocity distribution; (b) pathline of airflow representing breathing.

Two numerical simulation models based on computational fluid dynamics have and are being developed. Simu-AIIED-A simulates the airflow of a single AIIED as shown in Fig. 2. The suction of AIIED and the breathing of patient are simulated. Simu-AIIED-B simulates an entire dental room with AIIED installed. The model includes the suction of AIIED, the breathing and thermal-gravitational airflows from the patient and the doctor, and ambient airflow due to HVAC (heating, ventilation, air-conditioning).

For experimental testing, state-of-the-art flow diagnostics equipment including Particle Imaging Velocimetry and High-speed & High-resolution Shadowgraphy are used to study and test the flow dynamics of air, micro droplets, and particles in AIIED.