AIR-CLENZ™ SYSTEMS

Novel Exhaled Air Capture and Purification System for Classrooms and Offices

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ABSTRACT

Most HVAC systems and air purifiers, regardless of how they clean air (HEPA filters, UVC, Ultrasound, etc.), create cross-room airflow patterns that can drag airborne pathogens with it, contaminating others in the room prior to the air being captured and cleaned. A patented exhaled air capture and air purification system has been developed and tested. This proprietary system can be integrated into or retrofit onto a computer monitor and a laptop. The novel system quickly captures exhaled air close to the user's face before the exhaled air disperses in the room air environment. Once captured, exhaled air, as well as other air in the room, is cleaned in an air purification chamber and then released back into the venue. All this is accomplished within 3-5 seconds for each exhaled air breath. The Computational Fluid Dynamics (CFD) model proved that nearly 100% of a user's exhaled aerosols and droplets are captured and cleaned by computer monitors and laptops equipped with the novel system.

METHODS

The CFD simulations were performed with the Siemens comprehensive multiphysics software Star-CCM+. The simulations used a 3D, segregated flow, steady-state approach with constant density air and gravity enabled. The RANS-equations with the K-Epsilon turbulence model were employed to solve the fluid flow. Aerosol and droplet particles (1-10 µm) were simulated by a Lagrangian methodology. The droplets were assumed to be spherical and subjected to pressure, drag, lift, and turbulent forces.

FIGURE 1.
CFD VELOCITY VECTOR ANALYSIS OF EXHALED AIR

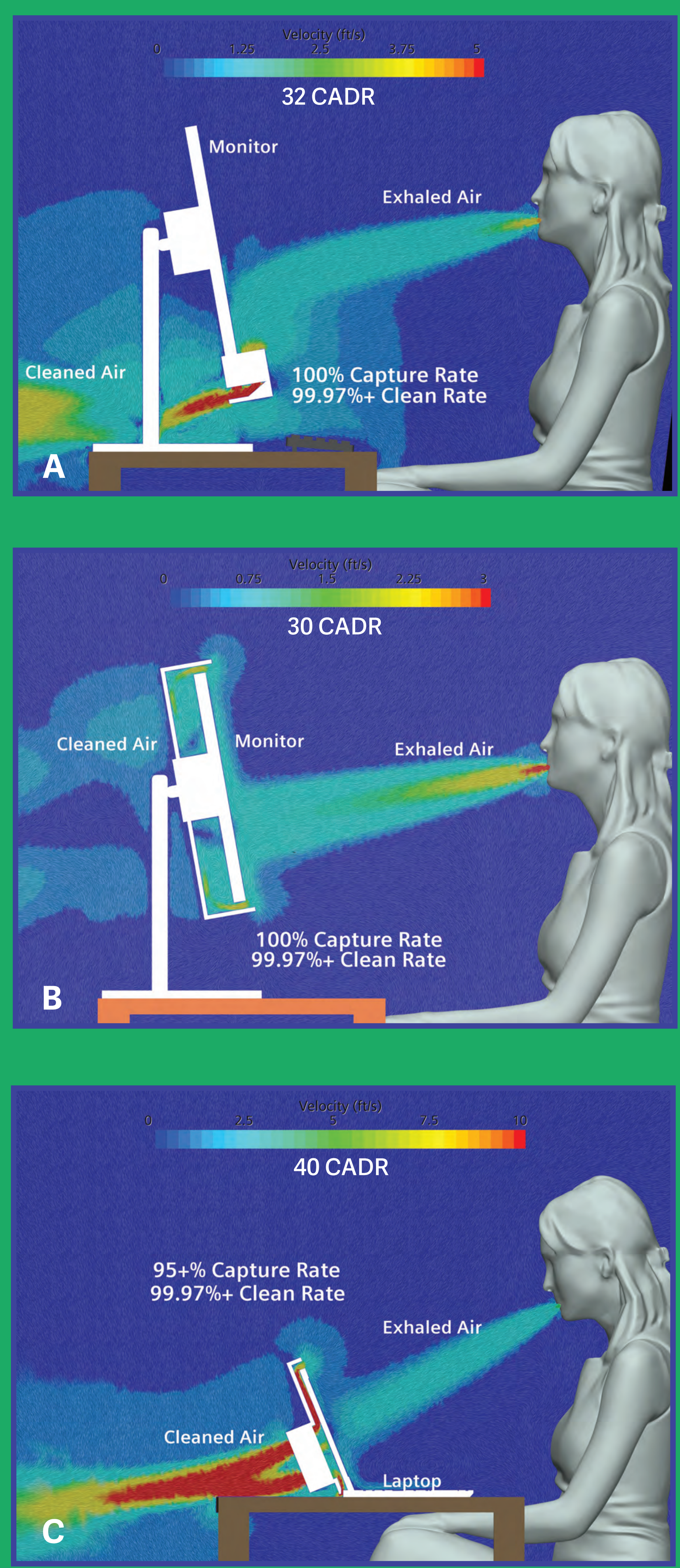

FIGURE 1. CFD velocity vector analysis of exhaled air towards (A) a monitor with attached air-purification-system, (B) a monitor with an integrated air-purification-system, and (C) a laptop with attached air-purification-system.

FIGURE 2.
COUGH DROPLETS **WITHOUT** AIR-CLENZ — COUGH DROPLETS **WITH** AIR-CLENZ

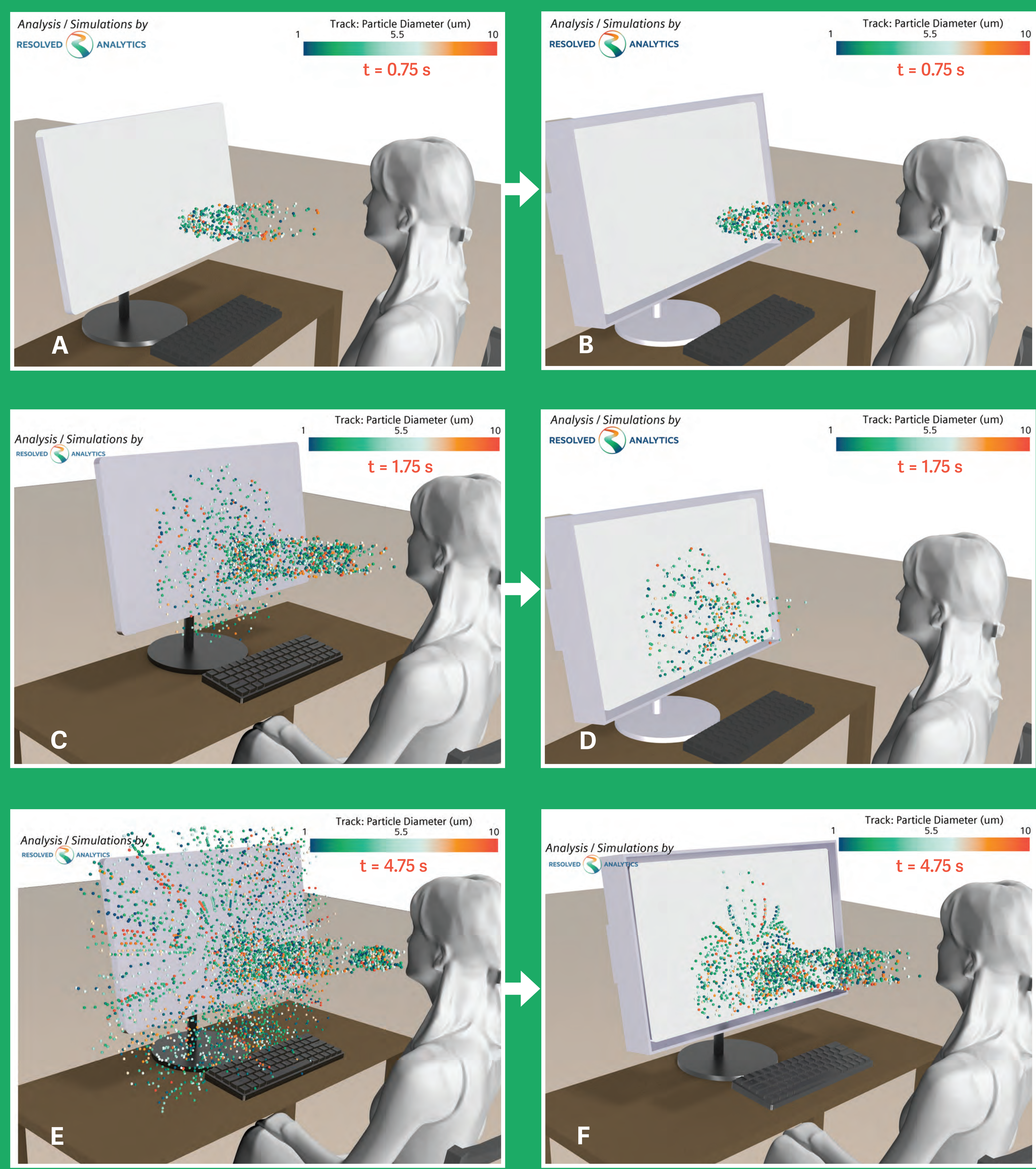

FIGURE 2. CFD simulation results of cough particles without the air-purification system (left images – A, C, E) and the same cough particles with the proprietary integrated air-purification system (right images – B, D, F).

RESULTS AND DISCUSSION

In this study, CFD modeling enable us to predict the fate of respiratory particles exhaled from the monitor (laptop) user during different expiratory events, such as breathing, coughing, and sneezing. CFD results show that most of the expiratory particles ranging 1-10 µm hit the computer monitor or laptop screen, which are approx. 50 cm from the user's mouth and nose. Results for the velocity vectors for a breathing event and air-purification-system-enabled desktop monitor and laptop are shown in Figure 1; examples for a coughing event and a monitor without and with the novel system is in Figure 2. The simulations showed >95% capture rate in all cases of enabled monitors and laptops and for all respiratory events. The velocity vectors for the enabled monitors and laptops given in Figure 1 are dependent on the CADR value. The difference between a non-enabled monitor and a patented exhaled air capture and purification system-enabled monitor for a single cough event from the user is presented in Figure 2. After the exhaled particles impact the surface of the non-enabled monitor, the particles slide and/or bounce off in all directions and then mix into the room air. However, when the monitor is equipped with the novel system, the monitor screen re-directs the particles to the air suction intake that surrounds the monitor, where they are pulled into the air purification chamber located at the back of the monitor and are isolated as the captured air passes through a HEPA-13 filter. The cleaned air, free from most of the exhaled particles with 99.97% efficiency, is then returned into the room.

CONCLUSIONS

Airborne transmission of respiratory pathogens is a major concern, especially in indoor environments with multiple occupants, such as shared offices, call centers, classrooms, etc. The long survival times of smaller respiratory particles in the air makes them a high risk for cross-infections in enclosed environments with multiple occupants. The enabled monitors and laptops presented in this study quickly capture exhaled air from users, clean it, and return purified air back into the room in 3-5 seconds. CFD modeling show the patented air-purification system is highly efficient and effective: it captures >95% of exhaled particles and filters them with minimum efficiency of 99.97%. The enabled monitors and laptops quickly capture the exhaled air from the users, clean it, and the purified air is back into the room in 3-5 sec. This is a cost-effective and viable solution to reduce airborne-transmitted diseases in indoor venues.

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For Everyone Who Breathes™

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REFERENCES

BLUM, R., BROACH, A., FRENCH, R., Exhaled air purification unit and system for indoor multi-person venues or environments, US patent 11,324,850; Additional US and Foreign Patents Pending

ALLEN J.G., AND IBRAHIM A.M. 2021. Indoor Air Changes and Potential Implications for SARS-CoV-2 Transmission, JAMA, 325(20): 2112-2113.

ALLEN J. G., MACNAUGHTON P., SATISH U., SANTANAM S., VALLARINO J., AND SPENGLER J.D. 2015. Associations of Cognitive Function Scores with Carbon Dioxide, Ventilation, and Volatile Organic Compound Exposures in Office Workers: A Controlled Exposure Study of Green and Conventional Office Environments, Environmental Health Perspectives, volume 124, number 6, 805.

AI Z.T. AND MELIKOV A.K. 2018. Airborne spread of expiratory droplet nuclei between the occupants of indoor environments: A review, Indoor Air. 28:500–524.

BAKE B., LARSSON P., LJUNGKVIST G., LJUNGSTRÖM E. AND OLIN A-C. 2019., Exhaled particles and small airways, Respiratory Research 20:8

BASU S. 2021. Computational characterization of inhaled droplet transport to the nasopharynx, Scientific Reports, 11:6652

GUPTA J.K., LIN C.H. AND CHEN Q. 2010. Characterizing exhaled airflow from breathing and talking, Indoor Air 2010; 20: 31–39

MADAS B.G., FURI P., FARKAS A., NAGU A., CZITROVSZKY A., BALÁSHÁZY I., SCHAY G.G. AND HORVÁTH A. 2020. Deposition distribution of the new coronavirus (SARS-CoV-2) in the human airways upon exposure to cough-generated droplets and aerosol particles, Scientific Reports, 10:22430.

WANG C.C., PRATNER K.A., SZNITMAN J., JIMENEZ J.L., LAKDAWALA S.S., TUFEKCI Z. AND MARR L.C. 2021. Airborne transmission of respiratory viruses, Science 373, eabd9149