Proceedings of the Canadian Society for Mechanical Engineering International Congress 2021
CSME Congress 2021
June 27-30, 2021, Charlottetown, PE, Canada

DEVELOPMENT OF A FULL-SCALE HUMAN COUGH SIMULATOR

Peter Daginis[1*], Franco Berruti[2], Eric Savory[1]
[1]Department of Mechanical & Materials Engineering, University of Western Ontario, London, Canada
[2]Department of Chemical & Biochemical Engineering, University of Western Ontario, London, Canada
*pdaginis@uwo.com

ABSTRACT

The COVID-19 pandemic has caused countless illness and death among those infected while disrupting the global economy. Thus, it is of great interest to further investigate the mechanism of spread of such illnesses. Viruses such as Influenza and Coronaviruses are known to spread primarily through droplets which are aerosolized during violent expiratory events such as coughing. Human coughs have been measured extensively using techniques ranging from spirometry to particle image velocimetry (PIV). Previous research has quantified parameters such as peak velocity, expired volume, cough duration, temperature, and equivalent mouth diameters. The current work investigates flow characteristics of a 1:4.75 scale human cough simulator apparatus using hot-wire anemometry (HWA), and in the future, PIV. With real cough data provided by the literature, and data obtained through HWA and PIV from the small-scale apparatus, the apparatus will be scaled up to a typical human mouth diameter of 21.7 mm. A similar scaled-down apparatus is currently under biosafety (BS) review to be tested in a BSL3 lab where COVID-19 is to be aerosolized in a 30x30x90 cm chamber in order to investigate the viability of the virus in various environmental conditions and its deposition and survivability on different material surfaces. Allowing the aerosolized virus to transport and then deposit on a surface is more realistic than directly placing droplets containing the virus on the material using a pipette.

The apparatus has 4 main components: a 75 cm^3 gas cylinder, a solenoid valve, a tee where liquid is added for aerosolization, and a nozzle with a diameter of D = 4.6 mm. Current experiments vary the pressure in the cylinder ranging from 3.45 to 241.31 kPa (0.5 to 35 psi), as well as solenoid opening time from 50 to 1000 ms. Velocity measurements are then made with an HWA probe sampling at 1000 Hz at distances varying from 2D to 200D on the jet centreline. A pressure transducer sampled at 1000 Hz is used to monitor the pressure drop in the cylinder as it empties. PIV measurements will be done to obtain the characteristics of the flow field. Currently the apparatus produces a realistic cough velocity (15-25 m/s) when the cylinder pressure is 3.45 kPa, yielding a velocity of 18 m/s. The current testing methodology will be applied to the human-scale apparatus which should produce coughs with similar velocities, duration, and droplet size distribution to those of a human cough.