Radial Analysis of Fine Sprays Using Phase Doppler Anemometry (PDA)

J.A. Stewart*, G.G. Nasr, M. Burby and A. Nourian
School of Computing, Science and Engineering
University of Salford
Salford, Manchester M5 4WT, UK

Abstract

A mobile fine spray unit, utilising a Spill Return Atomiser (SRA) has been developed for the purpose of decontamination within healthcare environments. The unit must be able to spray uniformly onto any given surface, providing 'mist like' coverage. Any uneven coating would jeopardise the efficiency of delivering the decontaminant fluid. Thus it is pertinent to understand and analyse the characteristics of the spray at various radial and downstream locations within the full cone patternation produced by the SRA.

PDA equipment was used to acquire Sauter Mean Diameter (SMD), droplet velocity and mass flux data at set radial positions across the spray and at various distances downstream of the atomiser. The results provided a comprehensive analysis of the spray and were used to determine the most effective coating distance to achieve 'mist like' coverage for delivering a decontaminant fluid.

Introduction

Hospital Acquires Infections (HAI's) are a major problem for worldwide. Inefficient cleanliness and hygiene practice has lead to a steep rise in infection rates, with subsequent increases in HAI associated illnesses and fatalities. MRSA (Methicillin Resistant Staphylococcus Aureus) has become synonymous with these problems as the appearance of organisms resistant to antibiotics has, in some cases lead to patient mortality. Other similar infections includes VRSA (Vancomycin Resistant Staphylococcus Aureus) and Clostridium Difficile. A mobile fine spray system has been developed [1-2], producing droplet sizes 15 μm<D_{32}<25 μm. This is achieved by providing an effective and efficient delivery system for specified disinfectant agents, which have been proven to kill infection-causing organisms.

The Spray Research Group cooperated with relevant industries in collaboration with a major international company [3] in developing a portable surface coating disinfection system, which uses a high-pressure, spill-return atomiser [4]. The main aim of this investigation is to utilise the spill-return atomiser, which can produce similar spray patterns and surface coverage to the existing ultrasonic system. Furthermore, despite the requirement of a mains power supply, neither compressed air canisters nor a pressurised liquid reservoir would be required. Thus the system will be more cost effective and it is as efficient as an ultrasonic system.

Materials and Methods

To obtain radial positions throughout the flow the atomiser mounting trolley is traversed horizontally relative to the beams with the transmission optics fixed. The radial positions were situated at 15mm intervals from the centre of the atomiser orifice. Taking into account the estimated cone angle of the spray, the outer boundaries on the left and right peripheries of the radial scale were set at 60mm. A vertical traverse was constructed in order to record radial plots with each atomiser configuration at various downstream distances (150, 300 mm, 500 mm and 700 mm). To ensure precision, readings taken to the left of centre were given a minus (-) prefix.

Results and Discussion

The processing of the PDA data from radial positions across the spray and at different downstream distances, provided basic understanding with regards to main spray properties (i.e. drop velocity, SMD and drop liquid volume flux) and thus the spray patternation across a single radial plane. The examination of the experimental findings together with the iso-contours, show that the structure of the spray is closely axis-symmetric and there is relative uniformity across the spray, with regard to velocity and SMD, although drop volume flux across the sprays does vary for different geometrical design such as exit orifice diameter and the spill sizes. The atomiser has a maximum velocity along the centreline and as expected this is the region of lowest SMD.

* Corresponding author: j.a.stewart@pgr.salford.ac.uk

Acknowledgement

The author wishes to thank other co-authors Professor G. Nasr, Dr M. Burby and Mr A. Nourian for their input. The author would also like to thank Professor A. Yule for his advice and guidance.

Nomenclature

v droplet velocity
D_{32} Sauter Mean Diameter

Subscripts
$_{\mu m}$ Microns

Prefixes
- Left of geometric centre of spray

Acronyms
SMD Sauter Mean Diameter
CFD Computational Fluid Dynamics
PDA Phase Doppler Anemometry
HAI Hospital Acquired Infection
MRSA Methicillin Resistant Staphylococcus Aureus
VRSA Vancomycin Resistant Staphylococcus Aureus

References

[1] Nasr G.G., and Yule A.J., Spray device, Patent, WO 2008/075063 A1, 26 June 2008
[2] Nasr G.G., Yule A.J., Lloyd S.E., 'The Characterisation of the Spray from a New Design of a Spill Return Swirl Atomiser', ILASS-Europe 2007.
[3] www.hughes-safety-showers.co.uk (accessed Sept. 2009).
[4] Nasr G.G., Yule A.J., Stewart J.A., Whitehead A., Hughes T., A New fine spray spill-return swirl atomiser, Journal of Mechanical Engineering Science, Proceedings of Institution of Mechanical Engineers Part C,submitted Nov. 2009.
[5] Burby, M.L and Nasr, G.G. 'Spray characterisation and performance tests for an ultrasonic atomizer in the decontamination process', ICLASS, Kyoto, Japan, Aug.27-Sept.1, 2006.
[6] Stewart J.A., Nasr G.G., M.L.Burby, Fine Spray for Disinfection Purposes within Healthcare Environments, 11th Triennial International Annual Conference on Liquid Atomization and Spray Systems, ICLASS, Vail, Colorado, USA, July 2009