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New approach to reducing water consumption in commercial kitchen hood

N Asmuin [1] **and M R Pairan** [2]
[1-2]Department Energy & Thermofluid Engineering, Faculty of Mechanical and Manufacturing Engineering, Universiti Tun Hussein Onn Malaysia (UTHM), Malaysia

E-mail: [1] norzela@uthm.edu.my, [2] uncle_sid@yahoo.com.my

Abstract. Water mist sprays are used in wide range of application. However it is depend to the spray characteristic to suit the particular application. The modern commercial kitchen hood ventilation system was adopted with the water mist nozzle technology as an additional tool to increase the filtration efficiency. However, low level of filtration effectiveness and high water consumption were the major problems among the Commercial Kitchen Ventilation expert. Therefore, this study aims to develop a new mist spray technology to replacing the conventional KSJB nozzle (KSJB is a nozzle's name). At the same time, an appropriate recommended location to install the nozzle in kitchen hood system was suggested. An extensive simulation works were carried out to observe the spray characteristics, ANSYS (FLUENT) was used for simulation wise. In the case of nozzle studies, nozzles were tested at 1 bar pressure of water and air. In comparison with conventional nozzles configuration, this new approach suggested nozzle configuration was reduce up to 50% of water consumption, which by adopted 3 numbers of nozzles instead of 6 numbers of nozzles in the commercial kitchen hood system. Therefore, this nozzle will be used in industry for their benefits of water consumption, filtration efficiency and reduced the safety limitations.

1. Introduction

The term "water mist" is refers to very fine particle of water sprays in which 99% of the volume of the spray is in drops with diameters less than 1000 microns and that remains suspended in air for an extended period of time [1]. The first finding of the application on water mist is during 1950's and 1960'S about water mist fire protection system [2]. This water mist system is rather cheap and effective system compared to available system such as conventional sprinklers and halon gaseous agent [3]. The principle of this system is by applied the high pressure to the water to generating very fine droplet of water and delivering them to the fire zone in fact due to its high specific heat and heat of vaporation coupled with the increases surface area allowing faster heat absorption [4]. Technically the mist system raised concerns due to the high pressures required to produce a fine spray, the potential for blocking of the small orifice nozzles and doubts the long-term ability to maintain the equipment [5].

Nowadays, Deflector atomizer was widely used as a tool to degreasing and washing application [6]. Commercial kitchen hood system were adopted this deflector nozzle concept as an additional tools in filtration system, this type of nozzle known as KSJB nozzle. Manufacturer implemented a water mist spray nozzle as an additional tool which used nontoxicity fluids (water) to be used in the kitchen area.

Since the nozzle is utilised in a premise, thus the nozzles which produces a fine mist spray in low pressure condition is a major factor in consideration. Halton Company has selected a nozzle which complies the concept of deflector atomizer. This nozzle functioned as the first stage filtration system to trap the plumes before it passes through the second stage filtration system.

As a conventional nozzle adheres to the concept of deflector wall, it's usually sprayed pointing downwards, causing the restricted in limitation of nozzle configuration. For conventional commercial kitchen hood ventilation system, 6 units of nozzle are required to ensure that entire surface of filter is fully covered. This configuration limitation will lead to water consumption issues. Therefore, it is required to discover an appropriate nozzle design and it's characteristic (water droplets size, water droplets velocity, spray angle and spray penetration) for new development of new mist spray. Thus this research applied low pressure of water and air to produce water mist by using external mixing technique to suitable used in industry sector.

2. Methodology

In this study, ANSYS software was used to simulate the nozzle in order to observing the spray pattern generated by the KSJB nozzle and new development nozzle. Simulation was conducted by using ANSYS fluent, the new development nozzle model and KSJB nozzle were constructed using SOLIDWORKS. Two types of fluids were used in this simulation and experiment which are water and air. Water and air temperature are set to 293K and 300K, the flow rate of the water for pressure 1bar was set as 0.00128 kg/s meanwhile for air pressure 1 bar the flow rate were set as 0.00087kg/s.

Figure 1 show the details of the KSJB nozzle and new development nozzle dimension. The computational domain of KSJB nozzle and new development water mist model were illustrated in Figure 2.

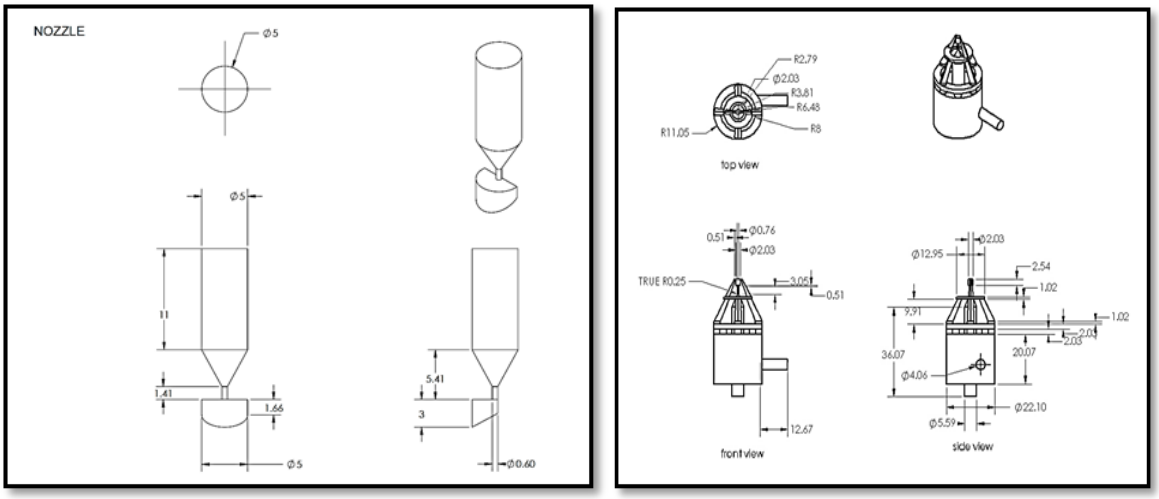

Figure 1. Computational domain new development nozzle

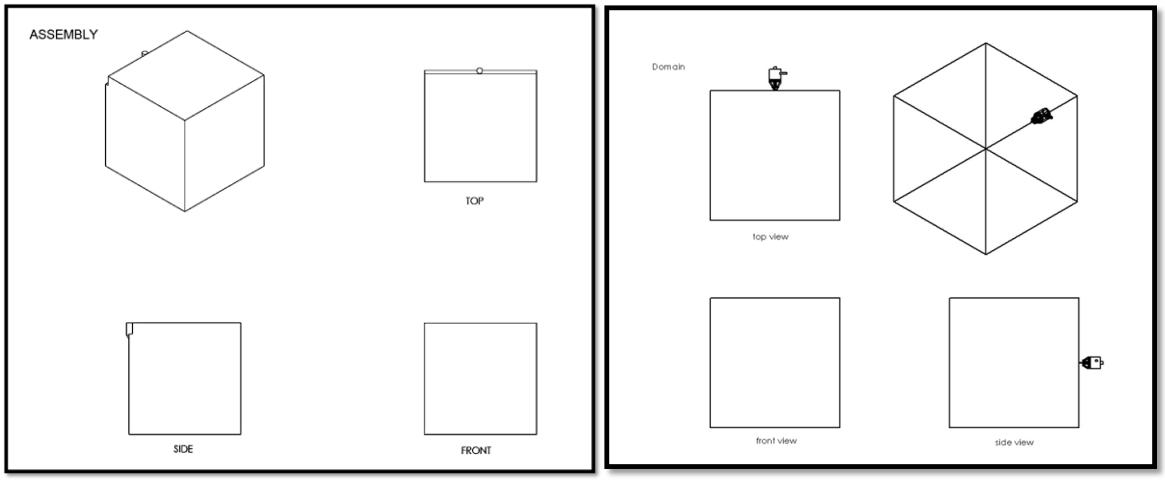

Figure 2. Computational domain new development nozzle

To run this simulation few boundary condition have to apply to the model. For the KSJB nozzle has only one inlet which is water inlet meanwhile for new development nozzle, it consist of two inlets which are water inlet and air inlet. Table 1 and Table 2 indicate the boundary condition details for KSJB nozzle and new development nozzle.

Table 1. Boundary conditions and numerical setup for KSJB nozzle

Item	Physical Properties		
General Condition	Steady State Incompressible Non radiation Multiphase		
Turbulence Model	k-epsilon realizable		
Boundary Condition	Water inlet	Water flow rate	0.00128 kg/s
	Air inlet	Air flow rate	0
	outlet	Pressure (Kpa)	0

Table 2. Boundary conditions and numerical setup for water mist nozzle

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3. Result

Figure 3 show the velocity contour of KSJB nozzle, based on the velocity contour, the KSJB nozzle produce flat spray pattern. The highest velocity of water was at the tip of the nozzle and obviously when the water flowing to the surrounding, the velocity of water becomes slow and widely spreading. This phenomenon happened because of the relation between the impingement between liquid with the wall. It was observed that after water with high velocity flowing out through the small nozzle orifice; it strikes the nozzle wall, thus its result the change of velocity and direction of water. The spray penetration angle of this type of spray is 125 degree with short penetration distance and this type of spray has limited configuration which is it has to spray pointing to the downwards direction.

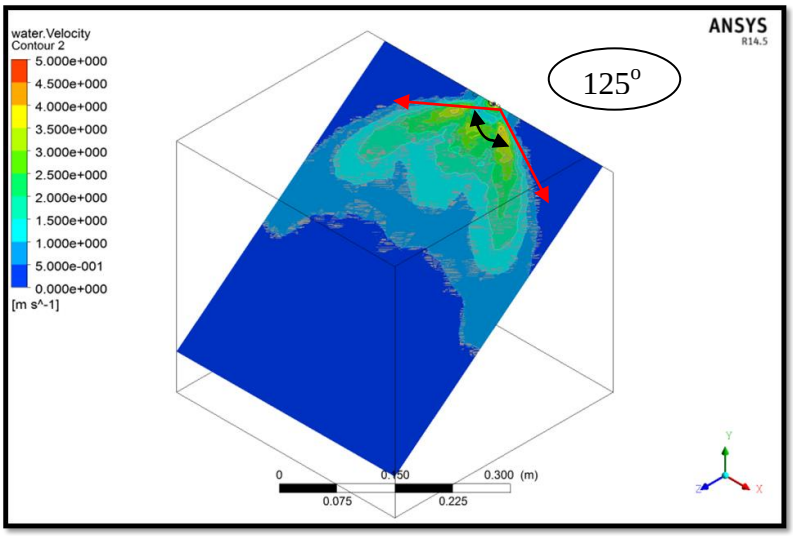

Figure 3. velocity contour of KSJB nozzle

In a real condition, there were 6 numbers of KSJB nozzle is required in order to fully cover the entire filter surface. The KSJB nozzle were placed at the top of the KSA filter and spray pointing to the downwards direction as shown in in Figure 4. The problem of this configuration is the water consumption issue. Thus to overcome this issue, new development nozzle were develop in order to replacing the conventional nozzle to reducing the water consumption.

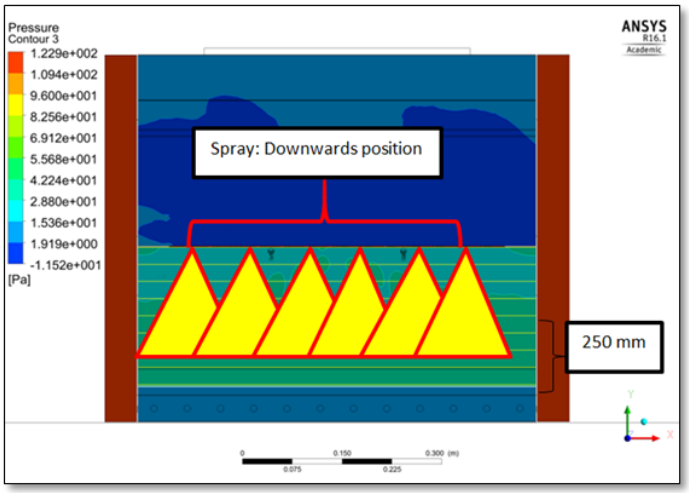

Figure 4. Conventional position of KSJB nozzle in commercial kitchen hood system

Figure 5 shows the water velocity contour generated by the new development mist spray; this new development nozzle has the advantage and disadvantage compared to the KSJB nozzle which follows the deflector atomiser concept. Since this new development nozzle utilise the external mixing technique, it produce jetting effect which helps to increase the air velocity which will push the water droplet move a way further from the orifice, this phenomenon resulted the effect to the spray penetration length. Even though it has smaller spray penetration angle which is 32 degree, it has a advantages on spray penetration length, this type of spray able to penetrate more than 750mm, by this penetration advantage, it was suggested to install only 3 number of new development nozzle horizontally to fully cover the entire filter surface which has the 1000mm length and 330mm height dimension. The recommendation location was illustrated in Figure 6.

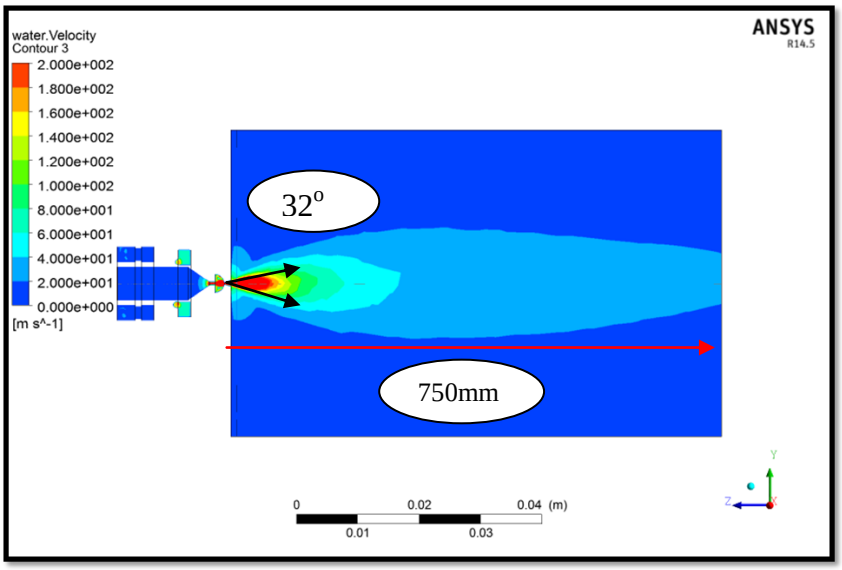

Figure 5. velocity contour for new development nozzle

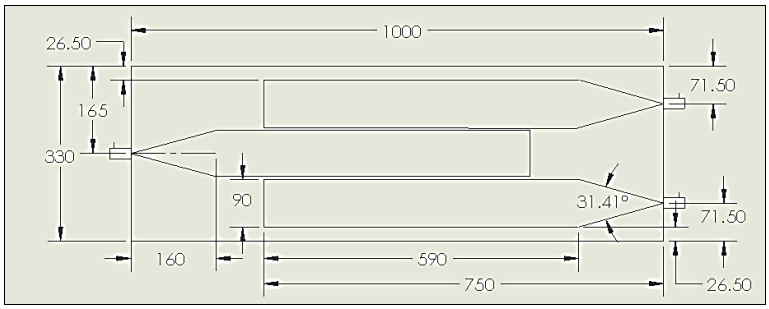

Figure 6. The recommendation nozzle configuration of new development nozzle

Other advantage of this new development spray is the spray performance, in term of water droplets size, under optimum condition which is at 1 bar pressure water and air, this type of nozzle able to produce very fine water droplets size which is below than 2 micron as shown in Figure 7. This become the additional advantage of this nozzle which expected to increase the filtration efficiency of the CKV system since the combination of the KSJB nozzle and KSA filter fails to trap particles size less than 2.5 micron.

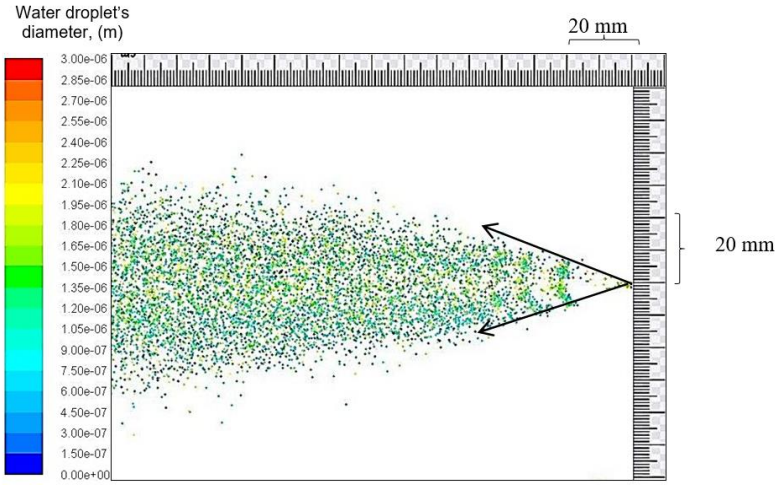

Figure 7. Water droplets diameter generated by new development nozzle

4. Conclusions

As a conclusion, since the nozzle has the ability to penetrate more than 750mm, the suggested locations to install the nozzle were at the side of the KSA filter which the nozzle will be spraying horizontally. There were 3 pieces of nozzle were suggested to install in the system in order to the spray pattern will cover the entire surface. By installing the new nozzle following this configuration water consumption reduced to 50% compared to the previous nozzle. The advantages of placing the nozzle at the side of the kitchen hood was to form a streamline which was generated by the water droplet are not parallel with the streamline generated by the plumes. This method was expected to increase the collision between the water droplet and the contaminant.

5. Future Scope

This study is for the future scope to implement the new development mist spray to the commercial kitchen hood system as a tool to traps the small particles. It is very important to know the physical characteristic of the new development nozzle.

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