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Study the Velocity and Pressure Exerted in Front of the Filter Surface in the Kitchen Hood System by Using ANSYS

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Abstract. Commercial kitchen hood ventilation system is a device used to capture and filtered the plumes from cooking activities in the kitchen area. Nowadays, it is very popular in the industrial sector such as restaurant and hotel to provide hygiene food. This study focused at the KSA filter part which installed in the kitchen hood system, the purpose of this study is to identify the critical region which indicated by observing the velocity and pressure of plumes exerted at of KSA filter. It is important to know the critical location of the KSA filter in order to install the nozzle which will helps increase the filtration effectiveness. The ANSYS 16.1 (FLUENT) software as a tool used to simulate the kitchen hood systems which consist of KSA filter. The commercial kitchen hood system model has a dimension 700 mm width, 1600 mm length and 555 mm height. The system has two inlets and one outlet. The velocity of the plumes is set to be 0.235m/s and the velocity of the inlet capture jet is set to be 1.078m/s. The KSA filter is placed 45 degree from the y axis. The result shows the plumes has more tendency flowing pass through at the bottom part of KSA filter.

INTRODUCTION

A Professional Kitchen is a very challenging and demanding environment. Ventilation plays an important role in providing comfortable and productive working conditions and in securing contaminant removal [1]. Commercial Kitchen hood ventilation system is device used to filter the plumes during the cooking activities. The purpose of commercial kitchen hood system is to capture the heat plume rise up from the cooking equipment [2]. Nowadays, the use of the kitchen hood is very widespread and very popular in the industry especially hotels and restaurants. Each part in the kitchen hood has difference purpose and benefits such as energy efficiency, Indoor Environmental Quality (IEQ), security, and so the level of air purification [3]. Therefore, significance grease filter were used in modern kitchen hood to filtered unclean air. Grease filter is an important component in the kitchen hood, this because the efficiency of kitchen hood system depends on the type of filter being used. Grease filter is a device installed in the exhaust hood in any way to remove the oil from the air exhausted by the trap the grease [4]. The efficiency of commercial kitchen ventilation filtration system is measured based on how much the particles could capture by the filter [5].

METHODHOLOGY

ANSYS software is used to simulate flow characteristics in commercial kitchen hood system. The model was constructed by using Solid Works 2013 software which divided into four parts which are exhaust, supply, side panel and middle roof part. Total model size of Water Wash/Water Mist kitchen hood is 700mm length, 1600mm width and 553mm high.

Figure 1, illustrated the full model of Water wash/Water Mist kitchen hood system. The exhaust part has a dimension 598mm length x 598mm width x 553mm high and connected with the ducting system with

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has a the dimension 400mm length x 200mm width x 10mm high. The cyclonic KSA filter with a dimension 1966mm length x 330mm width x 48mm high is place 45 degree from y-axis. Pipe with the dimension 20mm diameter, 598mm length is connected to the water wash and water mist in front KSA filter. The fresh air supply from the ambient will pass through the inlet of the supply part which automatically connected to the side panel which has 140 holes and each hole has 10mm in diameter. Figure 2 shown illustrated the different between kitchen hood with capture jet technology and kitchen hood without capture jet technology.

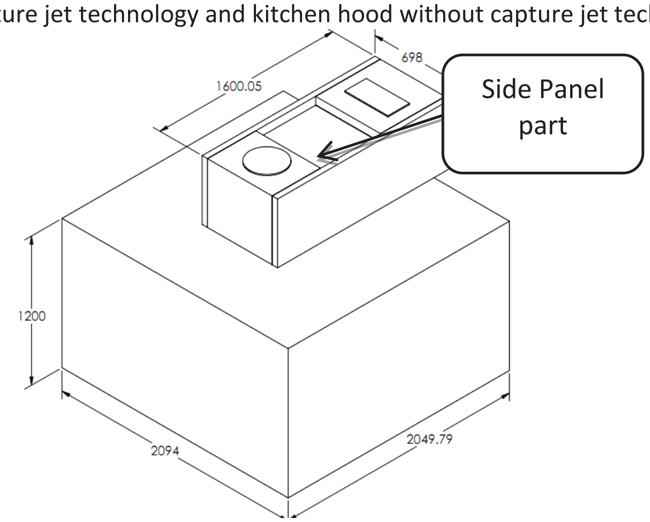

FIGURE 1. Full model of commercial kitchen hood system.

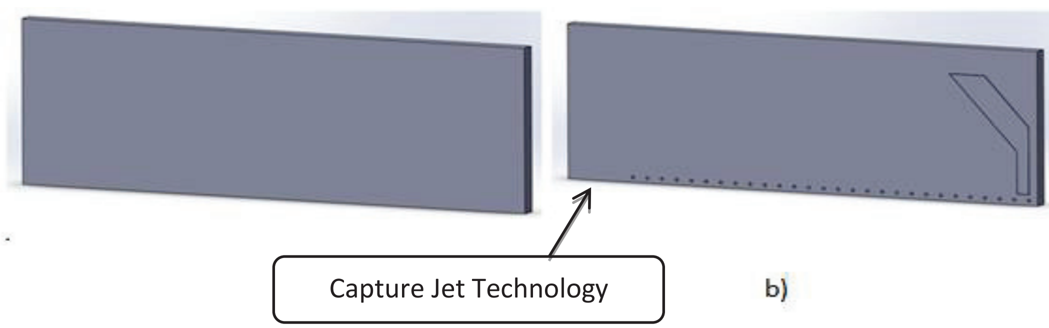

FIGURE 2. Side panel without capture jet technology and with capture jet technology

The computational domain consists of two inlets velocity and one outlet. The turbulent model for this simulation is Re-Normalization Group (RNG) k-ε. The RNG k-epsilon has been selected in this simulation because it suitable to study the flow characteristics in the kitchen hood and shown useful to analyse the interior of the region. Besides that, RNG k-epsilon has good moderately complex behaviour like impingement, separating flow, swirling flow and secondary flows.

The study focused at the KSA filter part. Nine horizontal lines and fifteen vertical lines were drawn just in front of the KSA filter in order to collect the data which pass through the line position which shows in figure 3 and figure 4.

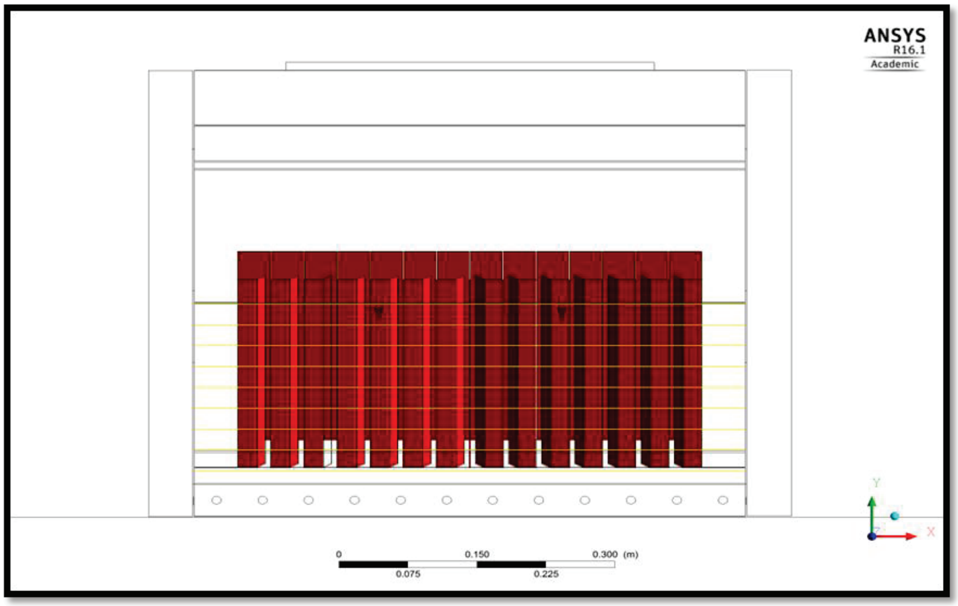

FIGURE 3. KSA filter with nine horizontal lines.

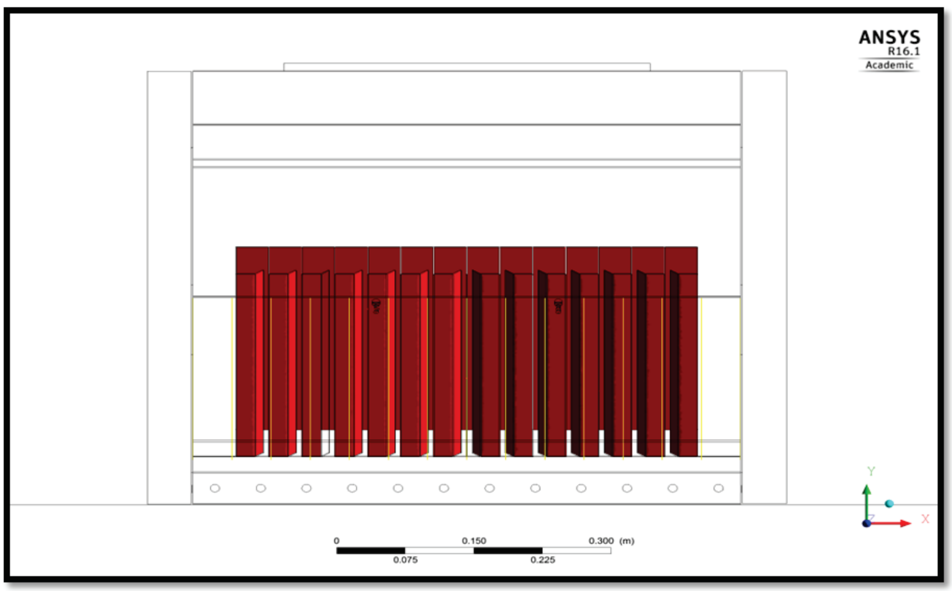

FIGURE 4. KSA filter with fifteen vertical lines.

RESULT

ANSYS 16.1 software (FLUENT) were used to simulate the flow characteristics in kitchen hood system. Based on figure 5, the figure shows the contour of pressure just front of the KSA filter. From the picture, it is clearly show that the bottom part of KSA filter exposed to the high pressure compared to the upper side of KSA filter.

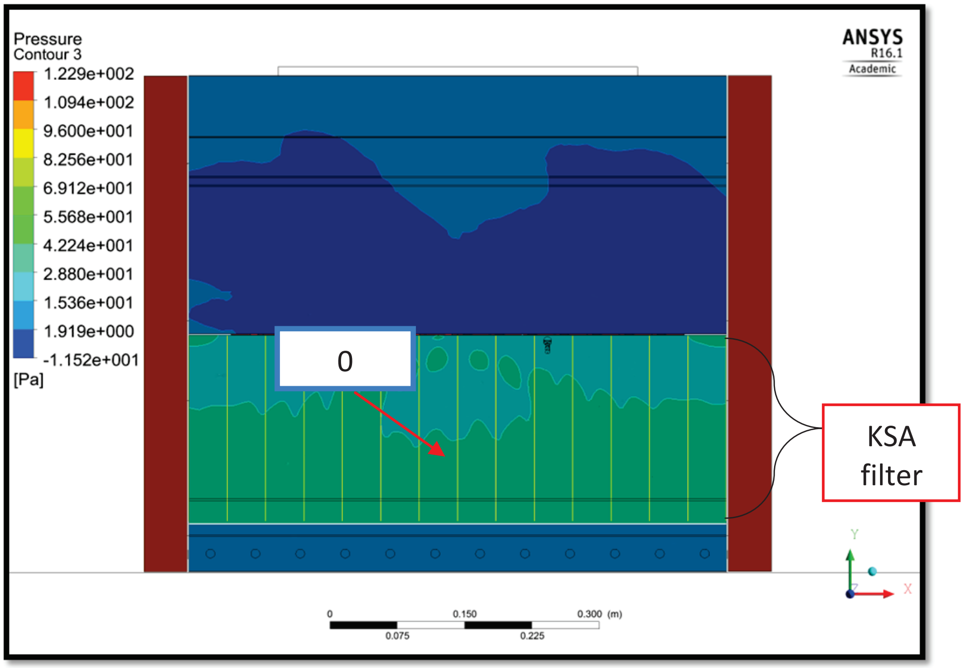

FIGURE 5. Pressure contour in front of KSA filter surface (vertical line)

The KSA filter then divided into fifteen vertical straight lines to get the average pressure exerted in vertical line just in front of the filter. The distance between lines to line is 4.3cm and point 0 start at the middle of the filter. The result then plotted in the graph. Figure 6 shows the average pressure versus distance.

Based on the figure 6, the graph indicated the average pressure in straight vertical line versus distance. Based on the figure, it shows that the higher average pressure exerted at the middle part of the KSA filter. It shows that the higher plumes flowing through this position. The average pressure decreased from 0 to 4, however the average pressure suddenly increased again from 4 to 7 before in going down at point 8. The behavior of the graph from distance 0 t0 7 and 0 to -7 has almost similar pattern.

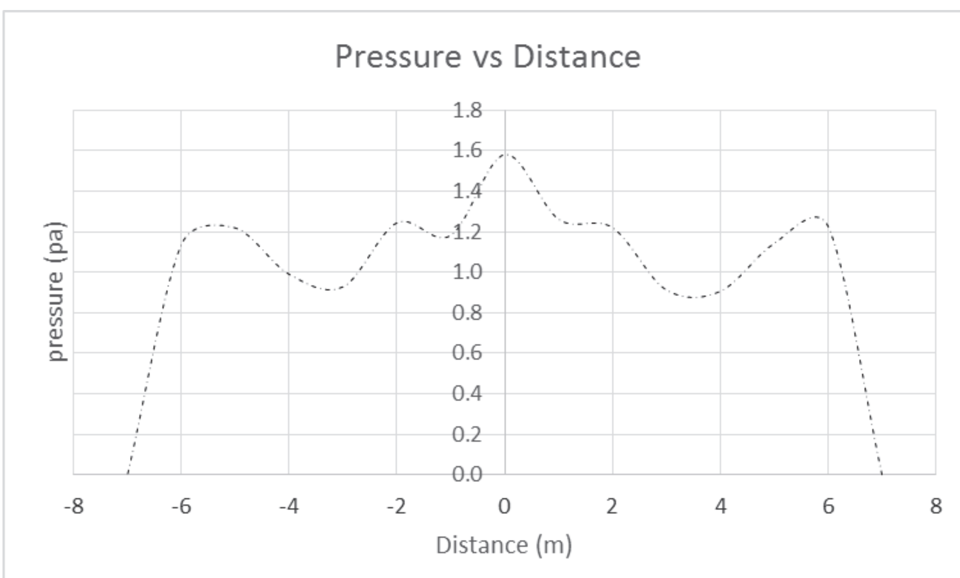

FIGURE 6. Average pressure versus distance in front of KSA filter surface (vertical line)

Figure 7 and figure 8 shows the air velocity contour and the graph of plumes velocity flowing through the KSA filter. As can be seen on the contour in figure 7 its shows that there are uniform velocities occur at the middle part of the filter, thus it indicates there are lots of plumes flowing through this region. Referring on the graph in figure 8, the result shows that the lowers average velocity happened at the center of the KSA filter, however the average velocity increasing start from point 1 until 4 before its suddenly decreasing from point 5 the return to increasing from point 6 to 7. The behavior of the graph from distance 0 t0 7 and 0 to -7 has almost similar pattern

The graph from figure 6 and figure 8 give good argument, since its true when the velocity is low thus the pressure will high. The phenomenon higher average velocity and lowest velocity happened at certain point especially at point 0 is because of when there are a lot of plumes flowing at the certain point it will stuck to enter the KSA holes vane, thus it cause the velocity getting slower meanwhile the pressure increased, as can be seen in velocity contour in figure 7, the uniform velocity contour happened at the point 0, thus it cause the pressure at this region increased.

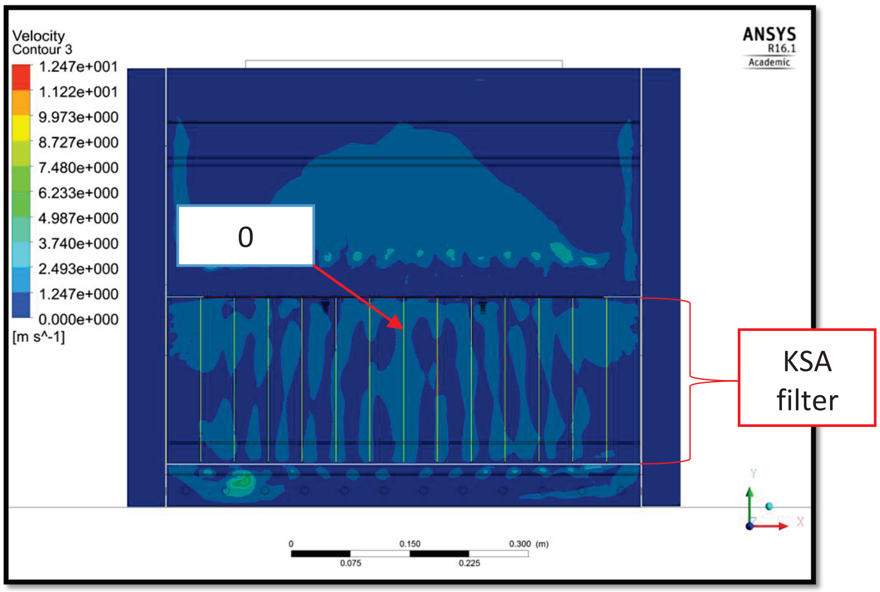

FIGURE 7. average velocity contour in front of KSA filter surface (vertical line)

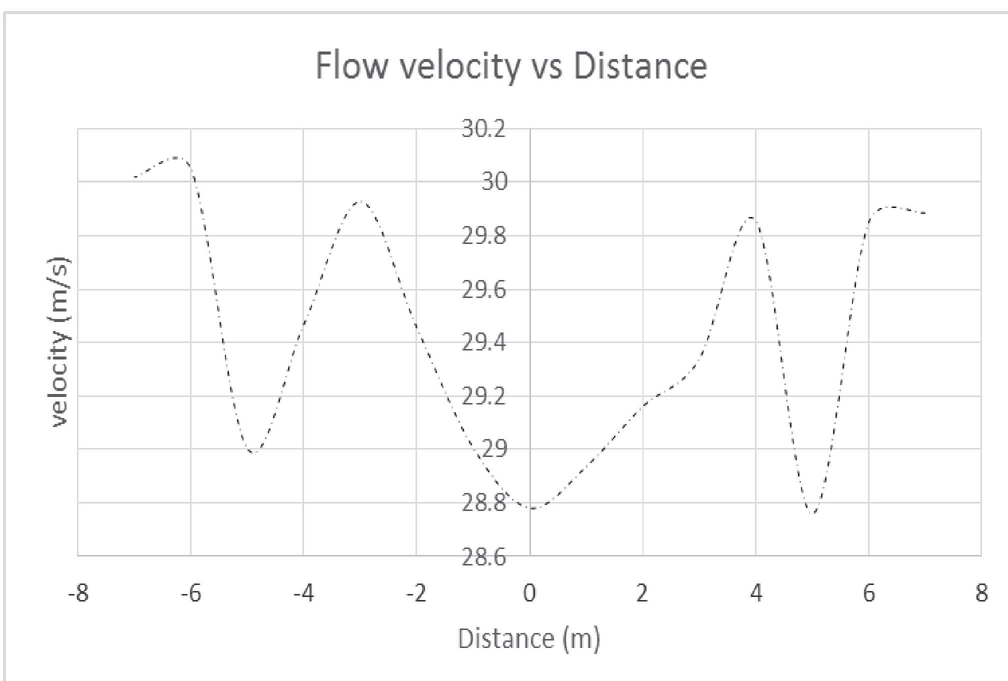

FIGURE 8. average velocity vs distance in front of KSA filter surface (vertical line)

This section discusses the average velocity and average pressure as previous result but in different way of analysis which will be analyze by horizontal line. As shown in figure 9 it show the velocity contour exerts the in front of KSA filter. Point 0 is start at the middle of KSA filter, the upper side start from point 0 until 4 meanwhile lower side start from point 0 to -4. The distance between lines to line is 5cm.

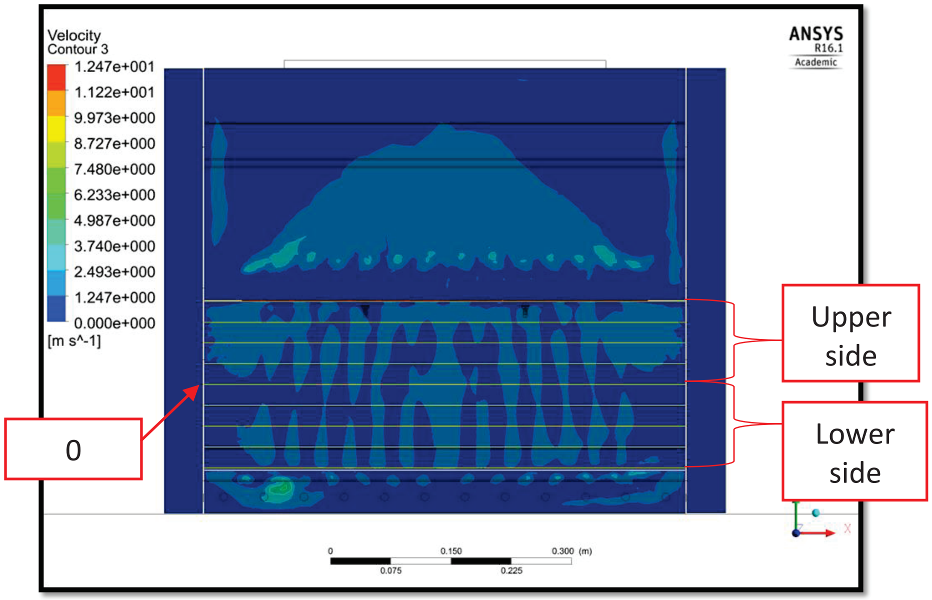

FIGURE 9. Average velocity contour in front of KSA filter surface (horizontal line)

Based on the graph in figure 10, the graph indicates the average velocity versus distance in horizontal line. Based on the graph the average velocity at the lower side of the KSA filter is lower compare to the upper side of the KSA filter. The maximum average velocity and minimum average velocity for upper side are at the point 3 which is 1.2m/s and at point 4 which 0.2m/s meanwhile the maximum average velocity and minimum average velocity for lower side is at point -3 which is 0.8m/s and point -4 which is 0.5 m/s.

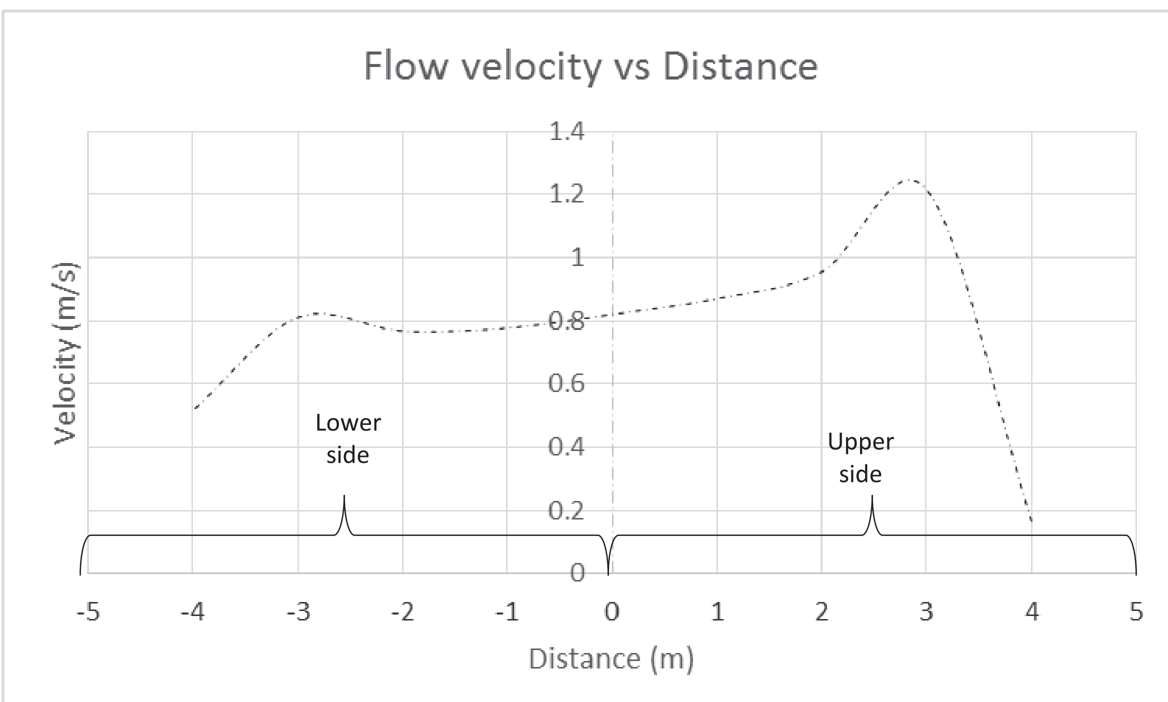

FIGURE 10. Average velocity versus distance in front of KSA filter surface (horizontal line)

Figure 11 show how the horizontal line was placed just in front of the KSA filter to get the average value of the pressure.

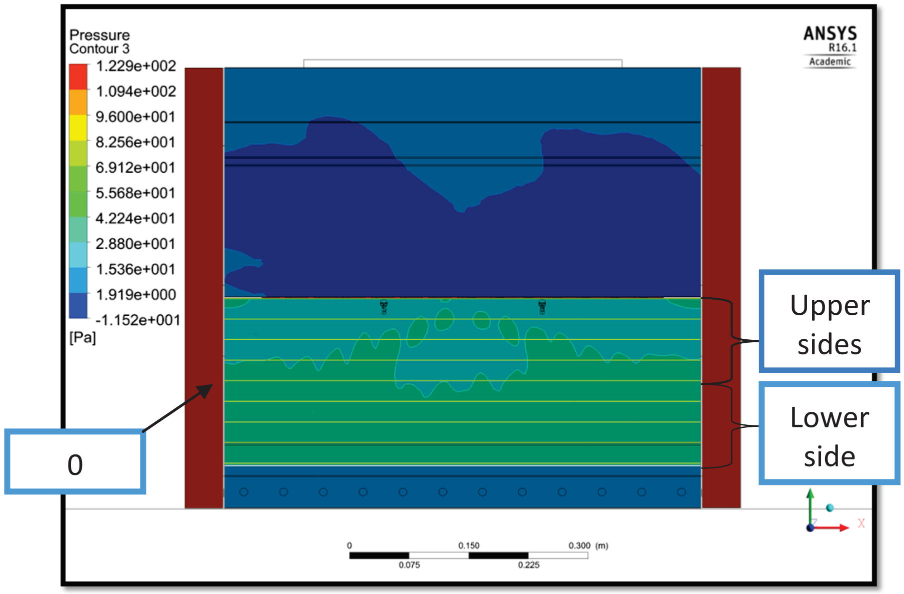

FIGURE 11. Pressure contour in front of KSA filter surface (horizontal line)

Figure 12 represent the data which collected from the simulation result. Based on the graph plotted in the figure 12, it shows that the lower side of the filter has the higher average pressure. The maximum average pressure exerted at point -4 which is 32 Pascal, the minimum average pressure exerted at point 4 which is 27 Pascal. The high pressure happened at lower side because of at lower side region, there are lots of flows are trying to pass through the KSA filter. This phenomenon happened because of the pipe bar used for supple water to KSJB nozzle be an obstacle to the flow, thus once the flow pass through the CKV system, it will collide with the pipe bar, this collision cause the change of direction and magnitude to the flow. As can be seen in the figure 13 and figure 14, once the flow hit the bar wall, it will separated into two direction, one will pass through the upper bar, one another will flowing below pipe bar, however because the space under the pipe bar is too small, most of the plumes flowing below the pipe bar.

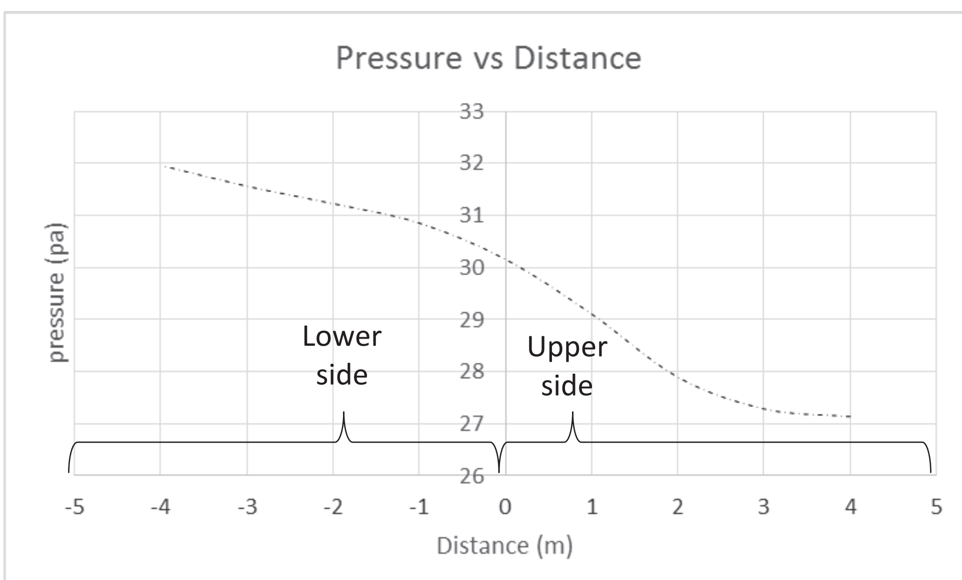

FIGURE 12. Average pressure vs distance in front of KSA filter surface (horizontal line)

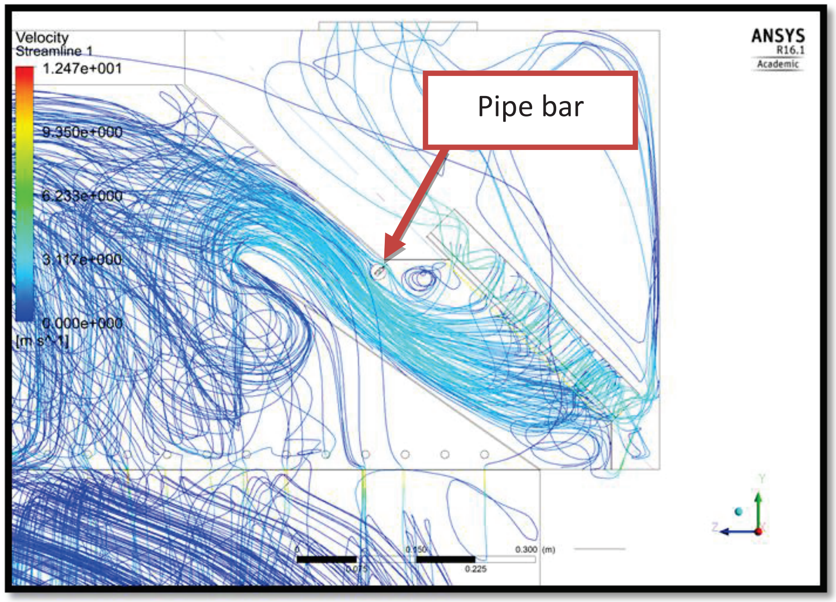

FIGURE 13. Velocity streamline of plumes in commercial kitchen hood system (CKV)

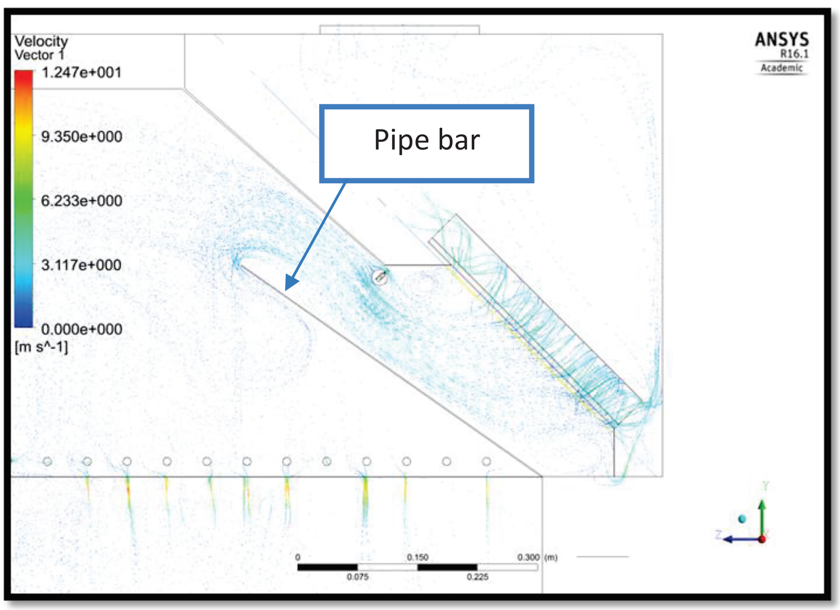

FIGURE 14. Velocity vector of plumes in commercial kitchen hood (CKV).

CONCLUSIONS

Based on the simulation result, the plumes have more tendencies to pass through at the middle and at the lower side of the KSA filter compared to the upper side of the KSA filter. It means, at the middle and at lower side region of KSA filter, there will be a more plumes will pass through this location. The result gives a hint and an idea to select the best location to install the nozzle. As collusion, the more attention will be paid to the lower side region and at the middle of filter in vertical position in order to increase the filtration effectiveness.

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 suitable location in order to increase the filtration effectiveness while reduce the water consumption.

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