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Research paper

Modified Turning Vanes in Air Distribution System of HVAC for Thermodynamics Lab

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Abstract

The objective of our study is to develop a new design of turning vanes. We have developed two types of turning vanes, proposed turning vanes 1 and 2 which will then virtually install on thermodynamics laboratory. The result of the simulation was then compared with the conventional turning vanes 1 and 2. It was found that the proposed turning vanes 2 gave better results compared to the conventional turning vanes 2 with improvements of 43.5% in velocity distribution and 16.0% in pressure distribution respectively. The results showed that the best turning vanes was conventional turning vanes. As a conclusion, conventional turning vanes produce better result compared to proposed turning vanes when it virtually applied to the thermodynamics lab. It can be implied that conventional turning vanes produced better outlet velocity compared to the proposed turning vanes. Real experiment should be conducted to verify the numerical result.

Keywords: *Airflow; Duct; HVAC; Simulation, Vanes*

1. Introduction

Air distribution system consists of three major components which are air handling unit (AHU), ductwork system and components of heating, ventilation and air conditioning. Heating, ventilation and air conditioning (HVAC) system is a system used to heat or cool as well as ventilate residential, commercial or industrial buildings. In general, air distribution system is responsible to provide fresh outdoor air to dilute interior airborne contaminants such as odours from environments, volatile organic compounds (VOC's) which are emitted from interior furnishings and chemicals used for cleaning. Since air distribution system consists of many components and will consume large amount of energy, the components need to be installed with proper monitoring and maintenance. Proper installation and maintenance will lead to the efficient energy utilization [1]. The study of the ventilation system can be done either numerical or experimental [2]. The study in terms of numerical can be done by visualization of the flow where it is done using computational fluid dynamics software [3].

Turning vanes is not a new concept in HVAC industry as it reduced the pressure loss in ductwork of HVAC system. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) has set up guidelines about usage of turning vanes in the elbow of the bends. The function of turning vanes is to reduce the sudden impact of airflow to the wall of the duct [4]. Thus, making the airflow to be smoother when changing direction of the airflow. Furthermore, turning vanes not only used in HVAC industry but also in gas-turbine design where the called it as guide vanes which deliver similar purpose as turning vanes. Material of the guide vanes play important roles in term of its performance. The material of guide vanes also can cause more energy saving based the research of Junaidi [5]. Different angle of the inlet turning vanes would give different outlet result according to Cheng [6]. According to McFarlane [7], the installation of turning vanes is compulsory to the turning vanes when the air velocity is greater than 1000ft/m. However, the industry has misunderstood the installation of turning vanes on the return ducts and exhaust duct is not compulsory whereas the contractor understood the importance of turning vanes installation on the supply duct. Factors that affect the performance of the system when installation of turning vanes was done is the number of bends, the number or degrees in each bend and the amount of sag allowed between the supports joists [8]. Undersized and constricted ductwork are thought to be key culprits that lead to excess external static pressures in many systems [9]. To overcome the losses that occur on the duct, flexible duct can be used within the underfloor plenum so that it could deliver cool air [10]. Material of the ductwork play importance roles towards the air flow. The use of suitable material can cause the system to be more energy savings [11]. The objective of our research is to develop a new design of turning vanes, which would reduce the losses on the ductwork of thermodynamics lab of UNIMAS.

This paper conducted research to develop a new design of turning vanes. It will then enhance the flow in the ducting which will reduced the losses occur at the bend of the duct.

2. Materials and Methods

This study was conducted by using Computer Aided Design (CAD) software which is AutoCad in designing the turning vanes and the thermodynamics laboratory of UNIMAS. The use of Computational Fluid Dynamic (CFD) software which is Ansys as a method in simulating the air flow in the ductwork. The simulation was conducted on the 90◦ bend first before it is virtually applied towards the ductwork of thermodynamics laboratory.

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Figures 1 and 2 show several types of turning vanes that available in today's market, whereas Figures 3 and 4 were the proposed turning vanes for this study. The first proposed design of turning vanes have some longer inlet vanes and shorter outlet vanes, whereas for the second proposed turning vanes, it has longer vanes at the outlet and a shorter inlet vanes. The different in length of turning vanes will produced different result of the simulations.

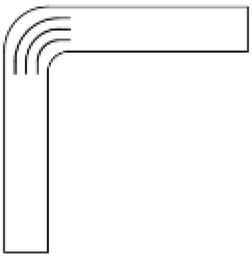

Figure 1: Conventional turning vanes 1

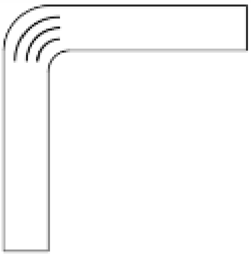

Figure 2: Conventional turning vanes 2

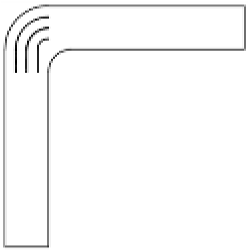

Figure 3: Proposed turning vanes 1

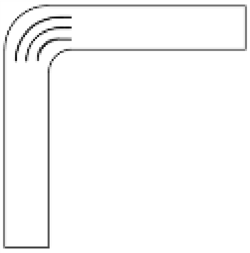

Figure 4: Proposed turning vanes 2

3. Results and discussion

For the first conventional design, the radius of the turning vanes was a bit longer at both turning vanes end. As for the second conventional design, the radius of the turning vanes was set to be the same with the radius of the bend. Two new designs of turning vanes were proposed in this study. For the first proposed turning vanes, the radius of the turning vanes was the same with the radius of the bend, but the length of the turning vanes at the first end was extended. The second proposed design was that the radius of the turning vanes was the same with the radius of the bend but the length of the turning vanes on the second end was extended. Based on simulation results, having different length of turning vanes had affected the air velocity behaviour and had improved the distribution of the air velocity.

Figure 5 shows that the comparison of turning vanes in terms of average pressure. The average pressure at the centre of the bend for conventional turning vanes design 1 was 2.131 Pa. For conventional turning vanes design 2, the average pressure at the centre of the bend was 1.029 Pa which was slightly lower as compared to the pressure at bend for conventional turning vanes design 1. The average pressure at the centre bend for the proposed turning vanes design 1 was 5.299 Pa meanwhile the average pressure for proposed turning vanes design 2 was 1.225 Pa.

The average pressure for the proposed design 1 was higher compared to other design which is 5.299 Pa. The reason why this occurred was because there was a part at the bend which was at the inlet of the turning vanes was having high pressure and has low pressure near the wall of the bend. Furthermore, the high pressure will cause noise which will discomfort the users.

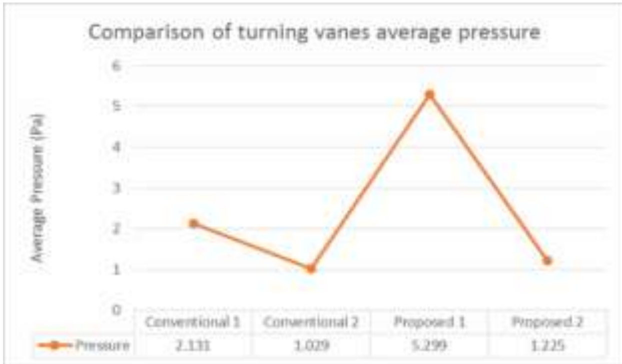

Figure 5: Comparison of turning vanes in terms of average pressure

The conventional turning vanes design 2 had resulted in the lowest average pressure at the center of the bend which was 1.029 Pa. Though it had the lowest pressure, the distributions of the pressure and the average pressure value contradict with each other. It can be seen on the result where there was high pressure zone at the corner of the bend and at the turning vanes. For the proposed turning vanes design 2, the average pressure at the center of the bend was 1.225 Pa which was near to the value of average pressure obtained by installing conventional turning vanes design 2. Furthermore, the distributions of pressure for the proposed turning vanes design 2 was more uniform as compared to other designs where there was a slight pressure increased at the corner of the bend and the turning vanes. This was due to the length effect of the turning vanes towards the distributions of the pressure.

Figure 6 shows the comparison between the average velocities in the ductwork. For the first and second conventional design, the average velocity at the bend were 2.204 m/s and 2.533 m/s respectively. The average velocity for the first proposed turning vanes was 2.507 m/s and as for the second proposed turning vanes the velocity was 4.481 m/s. The implementation of turning vanes in thermodynamics laboratory was discussed and comparison of results obtained by simulations are made with the published data. This simulation was conducted so that the result can be compared with the result of simulation with the installed turning vanes in the duct system.

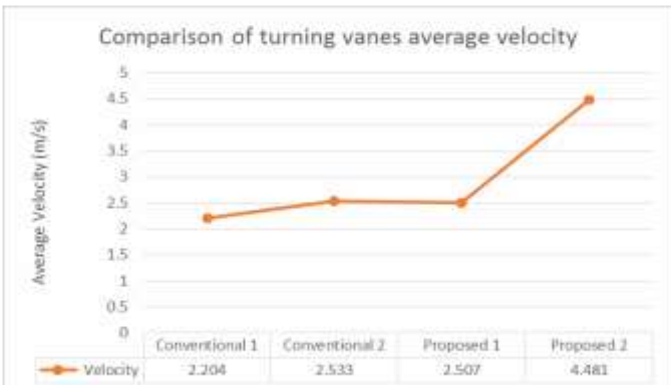

Figure 6: Comparison of turning vanes in terms of average velocity

Figures 7 and 8 shows that the velocity profile of the conventional turning vanes 2 and proposed turning vanes 2. By using the function calculator on the Ansys software itself, the average velocity can be determined which is 2.533m/s and 4.481m/s for conventional turning vanes 2 and proposed turning vanes 2.

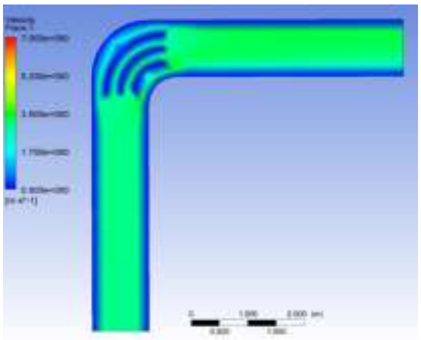

Figure 7: Average velocity profile for conventional turning vanes 2

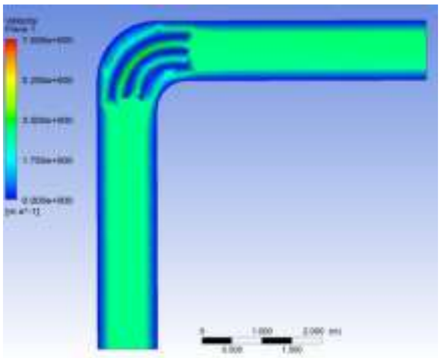

Figure 8: Average velocity profile for proposed turning vanes 2

The implementation of turning vanes in thermodynamics laboratory was discussed and comparison of results obtained by simulations are made with the published data. This simulation was conducted so that the result can be compared with the result of simulation with the installed turning vanes in the duct system.

Three types of simulations were conducted which were when there were no turning vanes, with conventional turning vanes and with proposed turning vanes in the duct systems. The conventional turning vanes design that was chosen was the conventional turning vanes design 2 while for the proposed turning vanes design that proposed turning vanes design 2 was chosen. The reason why those designs were chosen was because of both designs had shown positive results in the simulations with a single bend.

Table 1 shows that the comparison between the applications of turning vanes in which when there are no turning vanes applied on the ductwork and when conventional and proposed turning vanes applied on the ductwork. There is an increase on the average outlet velocity of the ductwork of thermodynamics laboratory. However, when compare between conventional and proposed turning vanes, the conventional produce better outlet velocity. Whereas for average velocity and pressure on the ductwork of thermodynamics laboratory, the results appear to be same.

Table 1: Comparison between the applications of turning vanes

	Without turning vanes	Conventional design of turning vanes	Proposed design of turning vanes
Average Outlet Velocity (m/s)	8.99	10.14	10.10
Average Velocity (m/s)	10.67	10.98	10.99
Average Pressure (Pa)	65.14	82.37	82.37

Figures 9, 10 and 11 show the velocity profile of the ductwork when there are no turning vanes applied and when there is conventional and proposed turning vanes applied. As can be seen from the figures, when turning vanes is applied, the flow behavior on the end of the duct was uniform compared when there are no turning vanes. Meanwhile, when compare between conventional and proposed turning vanes, the uniformity at the end of duct reduced with the use of proposed turning vanes.

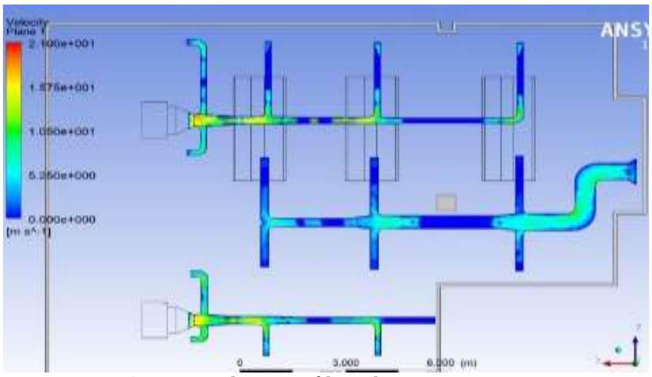

Figure 9: Velocity profile without turning vanes

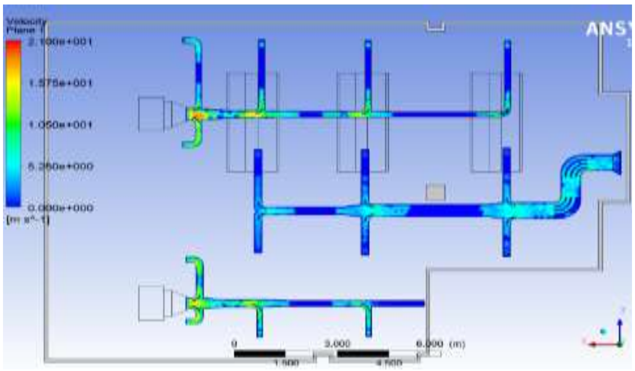

Figure 10: Velocity profile with conventional turning vanes

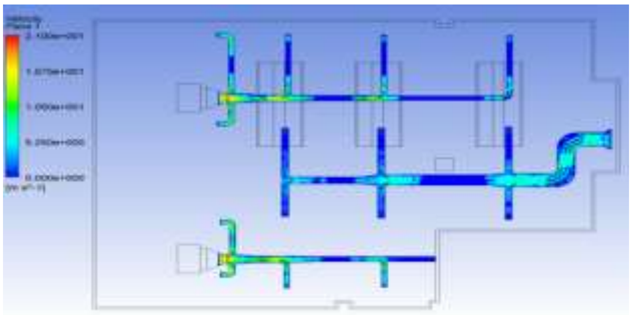

Figure 11: Velocity profile with proposed turning vanes

4. Conclusion

As a conclusion, conventional turning vanes produce better result compared to proposed turning vanes when it virtually applied to the thermodynamics lab. In which conventional turning vanes produced better outlet velocity compared to the proposed turning vanes. A real experiment on the design of turning vanes should be put into consideration to compare the results between simulations and experiment. Another recommendation is designing new duct systems in terms of the inner shape of the duct. Furthermore, the use of different computational fluid dynamics software should be take into consideration where the comparison between the two software can be done. This study can be continued to analyse whether the thickness of turning vanes will affect the flow of the air.

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References

[1] Air Distribution Systems, ENERGY STAR® Building Manual, 2008.

[2] M.P. Wan, C.Y. Chao, Numerical and experimental study of velocity and temperature characteristics in a ventilated enclosure with underfloor ventilation systems, Indoor Air, 15, (2005), 342,355.

[3] J.J. Martinez-Almansa, A. Fernandez-Gutierrez, L. Parras, C.D. Pino, Numerical and experimental study of a HVAC wall diffuser, Building and Environment, 80, (2014), 1-10.

[4] S.W. Comstock, M.S. Owen, H.E. Kennedy, N.F. Thysell, ASHRAE Handbook, 2008.

[5] M.A.R. Junaidi, N.B.V. Laksmi Kumari, M. Abdul Samad, G.M. Sayeed Ahmed, CFD simulation to enhance the efficiency of centrifugal pump by application of inner guide vanes, Material Today: Proceedings, 2, 4, (2015), 2073-2082.

[6] L.W. Cheng, L. Wei, W. Lei, B. Sunden, V. Chernoray, C. Arroyo, H. Abrahamsson, Experimental and numerical investigation of outlet guide vane and end wall heat transfer with various inlet flow angles, International Journal of Heat and Mass Transfer, 95, (2016), 355-367.

[7] D. McFarlane, Top ten reasons building HVAC systems do not perform as intended health care facilities measuring isolation room pressure.

[8] F. Memarzadeh, A. Manning, Z. Jiang, Energy efficient laboratory design: A novel approach to improve indoor air quality and thermal comfort, American Biological Safety Association, 12, 3, 2007, 145-158.

[9] B. Stephens, The impacts of duct design on life cycle costs of central residential heating and air-conditioning systems, Energy and Buildings, 82, (2014), 563-579.

[10] W. Pasut, F. Bauman, M.D. Carli, The use of ducts to improve the control of supply air temperature rise in UFAD systems: CFD and lab study, Applied Energy, 134, (2014), 490-498.

[11] A. Fontanini, M.G. Olsen, B. Ganapathysubramanian, Thermal comparison between ceiling diffusers and fabric ductwork diffusers for green buildings, Energy and Buildings, 43, 11, (2011), 2973-3987.