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 International Conference on Science and Technology 2019 Journal of Physics: Conference Series 1569 (2020) 032039 IOP Publishing doi:10.1088/1742-6596/1569/3/032039 1 Evaluation of Air Side Characteristics Performance of Finned Tube Evaporator I D M C Santosa*, ING Suta Waisnawa, P W Sunu, IW Temaja Mechanical Engineering Department, Politeknik Negeri Bali, Jalan Kampus Bukit Jimbaran, Kuta Selatan, Badung-80364, Bali, Indonesia *corresponding email: idmcsantosa@pnb.ac.id Abstract. 3 Improvement of Refrigeration system performance should be supported by increasing efficiency of its components. Mainly, two components must have excellent performance are condenser and evaporator. In this study examined a finned tube heat exchanger for evaporator application, furthermore research goal is aimed to enhance the evaporator designs in order to get higher efficiency and effectiveness of the heat exchanger. The effects of distance of fin, shape and size of the fin and combination of tube, will be investigated deeply and the heat transfer coefficient is going to examine using U-LMTD method based on some parameters of heat. This paper

is still focus on design CFD model to comply the research purpose. The results were found that geometry design and meshing already compatible to get reasonable post processing results. Analysis of the air velocity vector in the heat exchanger showed good agreement toward references. Vortex and turbulence occurs in side are of the tubes and wake or stagnant flow seems in the behind tubes. The next examine is going to concern with model validation toward experimental results and investigated heat transfer coefficient in details. 1. Introduction In recent years, refrigeration system development is focusing on efficiency improvement and environmental friendly encouragement. Both development are including components innovation and leads to natural material such as natural refrigerant [1, 2]. However, natural refrigerant is certainly very good for the environment but at the moment still has several of weaknesses, especially in terms of safety and efficiency of the system, so component improvement still more profitable to be conducted [3]. Previous studies showed that in refrigeration system using exergy analysis, losses occurred mainly at condenser, evaporator, compressor and expansion valve with percentages of 30%, 25%, 25%, and 20% , respectively [4, 5]. It means that condenser and evaporator are urgent to be improved to get significantly higher coefficient of performance of the refrigeration system. Especially, in refrigerator medium temperature which use for fresh vegetables and fruits storage, evaporator can be designed to maintain the humidity by reducing condensation of air in storage room [6]. So, evaporator becomes very important to be examined in detail. Computer simulation, such as Computational Fluid Dynamic (CFD) has been implemented widely for heat exchanger simulation. Where, the simulation can analyse the flow and temperature deeply instead of measurement and instrument method and become good solution of expensive and complex experimental methods [7, 8]. In addition, with a valid CFD modelling, the analysis will be more flexible and highly specific data obtained. With precision simulation, heat exchanger design optimization can be conducted in depth. So, this study is aimed to design the evaporator of refrigerator

2 medium temperature system for fresh fruits and vegetables. Optimum performance of evaporator 2 will be able to keep reasonable humidity and temperature according to standard storage needed. Furthermore, it also urgent to build an effective evaporator modelling with the CFD program. The results of the study will contribute very important to the development and improvement of the efficiency of the medium temperature refrigerator system. With the obtaining of an efficient evaporator then 15 the Coefficient of Performance (COP) system increases significantly. While the development of CFD simulation is done with the development of fluid mechanics and thermodynamics formulas, so that it can contribute to the knowledge development. 2. Research method This research is carried out by establishing or creating a simulated modelling with the Computational Fluid Dynamics (CFD) which will be validated with the results of an experiment that is simultaneously implemented in this research. With CFD can be investigated and analysed in each small segment of the evaporator and also obtained data from a very difficult location in heat exchangers to be obtained with an experiment method. 2.1. Modelling procedures This research was designed with the development adopted from the CFD modelling procedures, with some modification in order to get suitable step for finned 2 and tube heat exchanger. The three step design consideration are Pre-processor, Solver and Post Processor. The step is shown in Figure 1. The Pre-processor is covering designing geometry, meshing and determining the problem that will be solved. Solver consists of setting the physical completeness for the problem that want to solve and determine the modelling method that is closest to theory. And the third is the post processor analysis of the results of the modelling, analysis based on contour, plotting and vector. Figure 1. Modelling procedures 2.2. Input boundary condition Boundaries condition were set up with same real data, working fluid including air and Refrigerant (R22) properties retrieved from EES (Engineering Equation Solver) [9]. Fin and tube material are aluminium and cooper, respectively with the thermo-physical properties of copper and aluminium are obtained from the FLUENT database [10]. Air

velocity is 1.8 - 2 m/s and refrigerant mass flow rate was calculated using heat balance equation depend on the refrigeration system. The temperature input of refrigerant is 0 oC.

8 International Conference on Science and Technology 2019 Journal of Physics: Conference Series 1569 (2020) 032039 IOP Publishing doi:10.1088/1742-6596/1569/3/032039 3 2.3. Turbulence model Reynolds number indicates the turbulent or laminar regime flow. However inside heat exchanger especially in between fins and tubes air flow should be naturally complex. Several researcher using fin collar diameter (Dc) since this diameter is contact to the air flow directly. With staggered tube arrangement can effect most of the turbulence in the fin gap [11-13]. Wang [14] found correlation of fin geometry correlation with Reynolds Number depend on the collar diameter (Dc) as a characteristic length Basically, flows with Re < 2000 are considered laminar, while Re > 4000 indicates turbulent regime. So, the refrigerant flow is turbulent, whereas the air flow can be calculated as laminar flow. However, the studies found concerning to 2 finned tube heat exchangers to recommend that the realizable k-ε model chosen since it was predicting more good agreement toward experimental data [15]. In addition, previous studies have assessed the 16 performance of turbulence models for several of finned tube heat exchanger cases. The k-ε turbulence models have been most generally used, showed acceptable validation deviation toward experimental results. The others studies apply k-omega standard and SST, but the choice is according to the design finned tube heat exchanger being examined [16]. Sun [17] was also using the realizable k-ε turbulence model, and obtained the errors were found to be in the range of 4.7-13.2%, towards experimental results. Based on those explanations, in this study the realizable k-ε model has been chosen for turbulence model however more deeply will asses with experimental result which will be built focus for model validation. 3. Results and discussions Figure 2 (a) and (b) show consideration geometry model and meshing. Individual segments of the entire heat exchanger are observed as representations of the

evaporator's performance. It is impossible to model the entire evaporator due to the large number of fins that are complex and therefore required a huge computer capacity, this will cause an ineffective computing system. Engineering geometry design to get enough modelling to be accessible with fluent.

(a) (b) Figure 2. Geometry model (a) and meshing (b) 3.1. Geometry and meshing consideration This Model is designed to get 11 heat transfer coefficient of heat exchanger by U-LMTD method. 12 Heat transfer coefficient is a crucial parameter for assessing heat exchanger performance, and this model is High grid density Medium grid density Air flow in fin gap Refrigerant in Refrigerant out Wavy Fin Tubes

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 designed to allow investigation of heat transfer coefficient on air side, refrigerant and overall/total on each segment. This geometry model of evaporator considers air flow, refrigerant mass flow, fin wall and tube wall simultaneously, 11 as shown in Figure 2 (a). Fin is a wavy type fin made of aluminium, copper tube arrangement is staggered. Figure 2 (b) shows the meshing on this model which uses a tetrahedral type with three different number of cell densities. Analysis of the meshing sensitivity is done in connection with model convergence. It uses a rough grid (1.2 million cells) and a medium (3.2 million cells), minimum residuals convergence of 10-4 for continuity, 10-7 for energy, 10-3 for x, Y and Z, 10-3 for K and 10-2 for ε, while a fine grid is obtained having a consecutive residue of 10-5, 10-8, 10-6, 10-4 and 10-4. Highly satisfying residue is obtained from a smooth grid. However, this smoother grid also requires longer computing time. The mesh with high grid density is used in all areas where high-temperature gradients, which occur on the fin collar and nearby ambient heat sources. 3.2. Air side flow characteristics evaluation Figure 3 shows the air velocity vector on the 2 heat exchanger with a colour depicting the speed magnitude, with the air inlet speed of 1.8 m/s. It can be seen that due to the turbulence effect around the pipeline, causes the speed to increase after the air reaches the pipeline and there is a vortex around the pipe. The flow characteristic in heat exchanger flow is strongly influenced by the presence of cylinder pipes and fins. The fluid flow between the adjacent fins and around the pipe results is very complex in nature. In order to explain this phenomenon, in Figure 3 also presents the characteristics of the flow in each evaporator line. Each line has a stagnant formation on the back of the pipeline. Larger stagnant areas happen on row-2. The problem 12 of heat transfer on heat exchangers is strongly related to the flow structure [17]. On each line, a better vortex can afford a better turbulence of the air flow [18] and larger vortex can generate higher heat transfer performance [19]. Figure 3. Air flow characteristics in fin gap Above explanation condition (vortex and stagnant) also called flow mal-distribution. This is other main problem in term of heat transfer coefficient of 2 finned tube heat exchangers. Maldistribution also occurs when air is not evenly contact all of segments of fin and collar. In evaporator case, the considered causes of mal-distribution are the liquid/vapour distribution and the airflow Detail-B first row Detail-A second row Air IN flow Stagnant area Vortex/turbulence area Air OFF flow

8 International Conference on Science and Technology 2019 14 Journal of Physics: Conference Series 1569 (2020) 032039 IOP Publishing doi:10.1088/1742-6596/1569/3/032039 5 distribution. Kaern [20] introduced an innovation solution control of individual channel superheat. It is found 4 that the interlaced evaporator is better at flow mal-distribution than the face split evaporator. The better flow mal-distribution effect to the 7% increase of overall UA-Value and 1.6%-2.4% on COP of the refrigeration system. However in this study mal-distribution is going to investigate related to the optimum wavy design of the fins. 4. Conclusion The modelling of a finned tube-type heat exchanger with CFD is highly relevant and profitable compared with the experiment method. This is mainly in terms of speed of time, cost effectiveness, and the modelling can investigate the temperature and flow characteristics of working fluid of

the heat exchanger. This should be very difficult to be investigated by experimental method since some places is very difficult to install measuring instruments, in the area between the fin and pipe, for example. This modelling is also possible to analyse each segment on a finned tube-type heat exchanger. Air flow vectors in fins and pipes indicate the presence of turbulence flows and also there is a stagnant flow area. The higher the turbulence or vortex of airflow between the fin and the pipe, the higher the intensity of the heat transfer. In subsequent studies, the temperature input will be done on the refrigerant and continued to be validated against experiment results where the own equipment will be built in the Bali State Polytechnic refrigeration Laboratory. Thus this model can be further increased its accuracy in order to investigate heat transfer coefficient of evaporator with U-LMTD method. It also will be investigated air side heat transfer coefficient with various innovation design. This will be conditioned according to the work of the evaporator that is prone to frost, so that the fin gap becomes very important to be investigated deeply to avoid the blockages when the frost occurs. 5. References [1] Santosa I D M C, Sudirman and Waisnawa I G N S 2018 Performance analysis of transcritical CO2 refrigeration system for supermarket application Int. J. of GEOMATE 15 70 - 75. [2] Santosa I D M C, Sudirman, Waisnawa IGNS, Sunu PW and Temaja IW 2018 Simulation of transcritical CO2 refrigeration system with booster hot gas bypass in tropical climate J. Phys.: Conf. Ser. 953 012044. [3] Santosa I D M C, Gowreesunker B L, Tassou S A, Tsamos K M and Ge Y 2017 Investigations into air and refrigerant side heat transfer coefficients of finned-tube CO2 gas coolers. Int. J. of Heat and Mass Transfer 107 168–180. [4] Choi J M, Kim Y, and Lee M 2010 Air side heat transfer coefficients of discrete plate finned-tube heat exchangers with large fin pitch. Appl.Thermal Eng. 30 174 – 180. [5] Tao Y B, He Y L and Tao WQ 2010 Exergic analysis of transcritical CO2 residential airconditioning system based on experimental data Appl. Energy 87 3065-3072. [6] ASHRAE.2014 ASHRAE Handbook of Refrigeration. ASHRAE, Inc., Atlanta, 749 pgs. [7] Yaïci W, Ghorab M and Entchev E 2014 3D CFD analysis of the effect of inlet air flow mal distribution on the fluid flow and heat transfer performances of plate-fin-and-tube laminar heat exchangers Int. J.

of Heat and Mass Transfer 74 490–500. [8] Kumar A, Joshi J B, Nayak A K and Vijayan P K 2016 3D CFD simulations of air cooled condenser-II: Natural draft around a single finned tube kept in a small chimney Int. J. of Heat and Mass Transfer 92 507–522. [9] F-Chart Software EES (engineering equation solver) 2017.. [10] ANSYS FLUENT User's guide.2017. Release 13.0, p. 699. [11] Pu H, Ding G, Ma X, Hu H and Gao Y 2009 Effects of biofouling on air-side heat transfer and pressure drop for finned tube heat exchangers Int. J. of Refrigeration 32 1032-1040. [12] Pongsoi P, Pikulkajorn S and Wongwises S 2012 Experimental study on the air-side performance of a multipass parallel and counter cross-flow L-footed spiral fin-and-tube heat exchanger Heat Transfer Eng. 33 1251–1263. [13] Yun R, Kim Y B and Kim Y C 2009 Air side heat transfer characteristics of plate finned tube heat exchangers with slit fin configuration under wet conditions Appl. Thermal Eng. 29 3014 – 3020.

International Conference on Science and Technology 2019 Journal of Physics: Conference Series 1569 (2020) 032039 IOP Publishing doi:10.1088/1742-6596/1569/3/032039 6

[14] Wang C C, Tao W H and Chang C J 1999 An investigation of the airside performance of the slit fin-and-tube heat exchangers Int. J. of Refrigeration 22 595-630. [15] Santosa I D M C 2015 Optimisation gas coolers for CO2 refrigeration application Brunel University London. [16] Bhutta M M A B, Hayat N, Bashir M H and Khan AR 2012 CFD applications in various heat exchangers design: A review. Appl. Thermal Eng. 32 1 –12. [17] Sun L and Zhang C L 2014 Evaluation of elliptical finned-tube heat exchanger performance using CFD and response surface methodology Int. J. of Thermal Sci. 75 45-53. [18] Tahseen A, Ishak M and Rahman M M 2015 An overview on thermal and fluid flow characteristics in a plain plate finned and un-finned tube banks heat exchanger Renewable and Sustainable Energy Rev. 43 363-380. [19] Ameel B, Degroote J, Huisseune H, Vierendeels J and Paepe M D 2014 Interaction effects between parameters in a vortex generator and louvered fin compact heat exchanger Int. J.of Heat and Mass Transfer 77 247–256. [20] Kærn M R, Elmegaard

B and Larsen L F S 2013 Comparison of fin-and- tube [4] interlaced and face split evaporators with flow mal-distribution and compensation Int. J. of Refrigeration 36 203214.

Acknowledgments The author thanked the highest to the Directorate of [10] Research and Community Service (DRPM), Directorate General of the Research and Development of the Ministry of Research, Technology and higher education, for the financing Given with the number DIPA: SP DIPA-042.06.1.401516/2019. Thanks also to all members and research assistants in the Mechanical Engineering Department of Bali State Polytechnic and finally, to Research Centre (P3M) Bali State Polytechnic for their excellent administrative support.

Sources

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