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Development of Plate Fin Heat Exchanger Using Solidwork Toward IR 4.0.

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Abstract: Nowadays, heat exchangers are important used in the industry no matter the small or large industry, heat transfer system which are used for internal heat transfer between two or more fluids at different temperatures. HPL Technologies one of the companies was facing the problem in designing the fin plate heat exchanger to provide a higher efficiency of heat exchanger for HVAC system. In this study was successfully develop heat exchanger model differentiate diameter and size of hole tube and then simulate by solid work software. The heat exchanger model was examined the body structure at 450psi of pressure at three diameter of hole tube of fin plate heat exchanger is 10.10 mm,13.35 mm, and 16.60 mm. The results show the different size of diameter give different impact because the larger the diameter of the hole tube give larger the surface area. Therefore, the larger of diameter give more efficiency of heat exchanger compare small of diameter hole tube. This development of fin plate heat exchanger towards IR4.0 successfully useful as basic information and parameter to HPL Technologies in designing for heating, ventilation, and air conditioning systems (HVAC) applications.

Keywords: Develop, Different Diameter, Finite Element Analysis

1. Introduction

Heat exchangers are heat transfer devices for two more fluids at different temperatures. The heat exchanger is used for many different applications, including generations, chemical processes, food, electronics, environmental engineering, heat recovery, manufacturing, cooling and space. For example, automotive radiators, condensers, evaporators, air preheaters, and oil coolers are familiar to us daily. Heat exchangers can be categorized in many ways. [1]

A part of the heat exchanger technology has been used in heating, ventilation and air conditioning systems (HVAC). HVAC system is a major achievement in the construction of mechanical systems that provide occupants with thermal comfort and indoor air quality. HVAC systems can be classified according to multiple zones, location, and distribution as central and local systems. Primary HVAC equipment includes heating, ventilation, and air conditioning equipment. Central HVAC systems are in

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a central equipment room away from buildings and provide air conditioned by a supply ductwork system. Central HVAC systems include all-air and all-water systems. Two systems such as heating and cooling panels and water heat pumps should be considered central. Local HVAC systems were located inside or adjacent to the conditioned area and no ductwork requirement. Local systems include local air conditioning, local heating, local ventilation, and split systems. The principle of HVAC is that the indoor environment retains optimum temperature and air circulation [2]

Plate Fin Heat Exchange (PFHE) is one of the heat exchange types of corrugated fins in which the three-sided and rectangular cross sections or spacers are typically sandwiched between parallel plates. Often fins are included in a flat tube with rounded corners known as a shaped tube that eliminates the need for side bars. If fluid or fluid changes on the other side, the separation plate is usually replaced with or without an insert or web by a flat tube. [3] The objective for this study is to list the important parameter of fin plate heat exchanger, to develop heat exchanger by control all dimension using equation, global variable, and configuration table, and to evaluate three size of diameter fin plate heat exchanger which is 10.10 mm, 13.35 mm, 16.60 mm.

To achieve the objective of this research, there are some guidelines that will be used as a research scope such as need to follow the HPL Technologies standard dimension to develop plate fin heat exchanger, based on information given by HPL Technologies, the length FPHE between 500 mm to 1699 mm doesn't require center of frame. Table 2 shows the number of frame center required based on the length FPHE.

Table 2: The number of frame center required based on the length FPHE

Length of FPHE (mm)	Center of Frame (pcs)
1700 – 2600	1
2601 – 3600	2
3601 – 4800	3
4801 - 6000	4

Next, the scope of this project which is change the number of tube base on the height and wide heat exchanger and use the same thickness for body plate heat exchanger which is 3 mm.

2. Materials and Methods

2.1 Need Analysis

For this study, Heat exchangers are machines that transfer heat at various temperatures between two additional liquids. Thermal exchangers are used in numerous applications including generations, chemical, food, electronics, environmental engineering, heat recovery, manufacturing, air conditioning, cooling, and space. [1]There are, have many types of heat exchangers which is tubular heat exchangers, double pipe heat exchangers, shell and tube heat exchangers, spiral tube heat exchangers, gasketed heat exchangers, plate fin heat exchanger, tubular fin heat exchangers, spiral plate heat exchangers, lamella heat exchangers. [4]

Based on discussion with manufacturer (HPL Technologies) [5], to develop the plate fin tube heat exchangers. There are three sizes of tube usually been in industry with standard size dimensional between tubes are shown in Figure 1, Figure 2, and Figure 3. Based on discussion, the manufacture required to develop Plate tube fin heat exchanger using solid works, the manufacturer require to create the equation, global variable, and design table to control the dimension of plate tube fin heat exchangers.

To less time for develop heat exchanger, HPL Technologies require only change the data at design table for example, change the data for height, the number of vertical tube automatically change and follow the parameter. For wide heat exchanger, change the data at design table and automatically the number of horizontal tube change follow the parameter.

For the length, change the data at design table and center frame must follow the parameter (<1699=0, 1700-2600=1, 2601-3600=2, 3601-4800=3, 4001-6000=4) [5] and the number of fin also change follow by 10psc/in. The benefit of this project can develop plate fin tube heat exchanger very easy because just change the data at the design table. After done change the data and get the desired size, easy to convert drawing to CNC machine for cutting purpose. This project also helps to engineer to submit project and drawing early to client. If the drawing, cutting process, and assembly process done early and increasing customer demand.

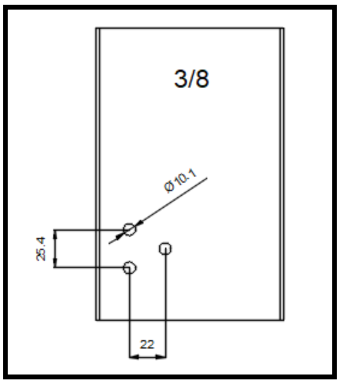


Figure 1: the dimensional for 10.1mm diameter of tube. [5]

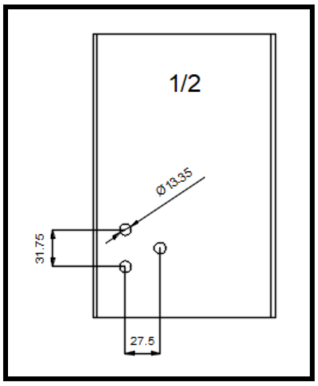


Figure 2: the dimensional for 13.35mm diameter of tube. [5]

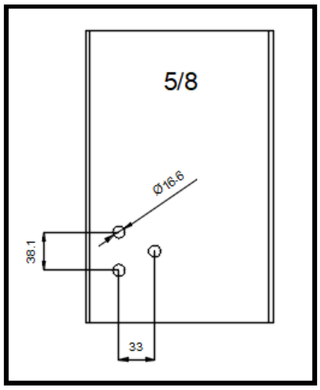
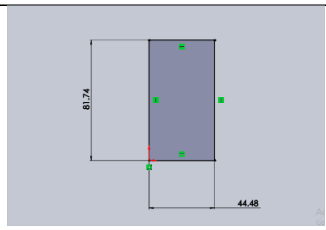
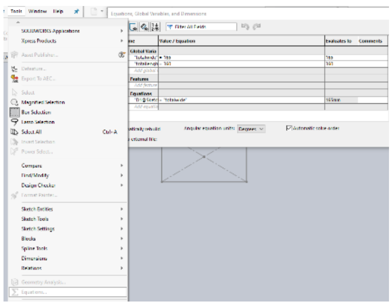


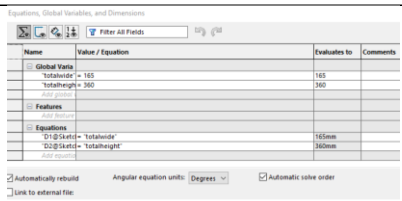
Figure 3: the dimensional for 16.6mm diameter of tube. [5]

2.2 Procedure of Develop Tube Fin Plate Heat Exchanger

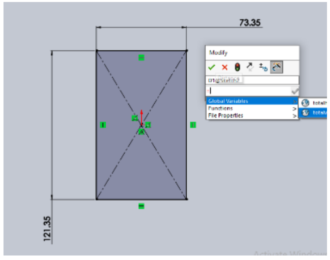
Based on the requirement of HPL Technologies company, this section provided the step how to develop of FPHE controlled by design table. Table 1 shows procedure to development of center frame condition and hole tube condition for FPHE controlled by design table.

Table 3: procedure to development of center frame condition

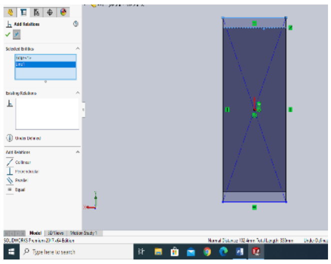
Instruction	Figures
Open the Solid Works Software and select the part and press OK. I. Choose the front plane, sketch, and give dimension the rectangular.	
II. Go to tools and select “equation”, add the global variable. • Totalwide • Totallenght III. After adding global variables, the equation will automatically be generated in the table Equation, Global Variables, and Dimensions.	



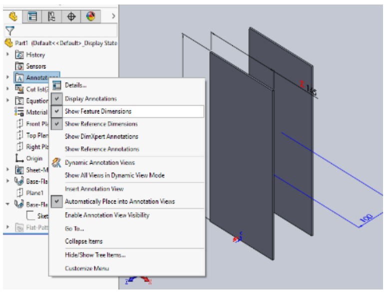
IV. Link dimension of rectangular with global variable.



V. For the length with equation, Global Variable and the Dimensions table. Need to go the features and select the reference geometry, choose the plane and add the plane to the first reference. After the reference plane has already been added, the rectangular pattern needs to be sketched and the relationship added follows the previous rectangular pattern.
   - Collinear relation



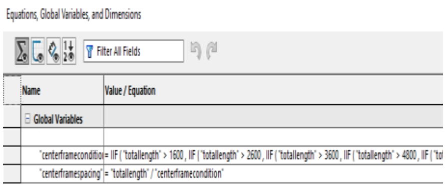
VI. Go to the annotation and select the show feature dimensions. Edit the dimension plane to "totallenght" same step with step 3, 4, 5.



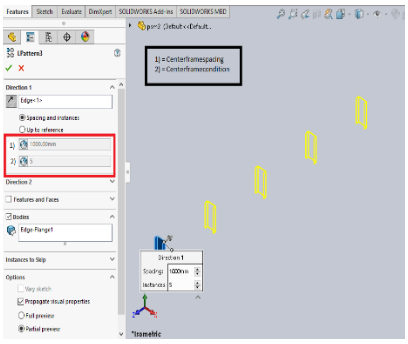
VII. To follow the scope of this project. You need to refer to the parameter table for the condition of the center frame.

You need to create a simple formula and coding that is "centerframecondition" and "centerframespacing" in the Equation, Global Variable, and Dimensions tables.

- Centerfarmecondition = IIF ("totallength" > 1600 , IIF ("totallength" > 2600 , IIF ("totallength" > 3600 , IIF ("totallength" > 4800 , IIF ("totallength" > 6000 , 5 , 5), 4), 3), 2), 1)
- Centerframespacing = totallenght/Centerfarmecondition



After already add simple coding and simple formula at the Equation, Global Variable, and Dimensions table. Need to add a center frame with a linear pattern. Go to the features and choose linear pattern

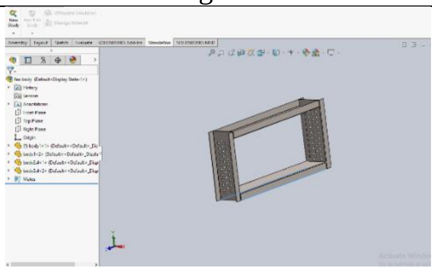
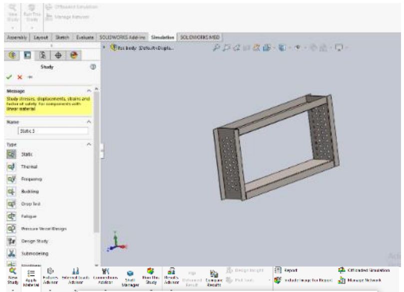
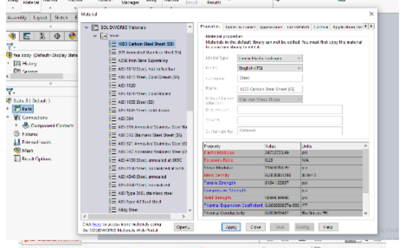
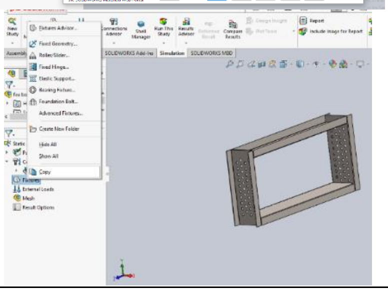


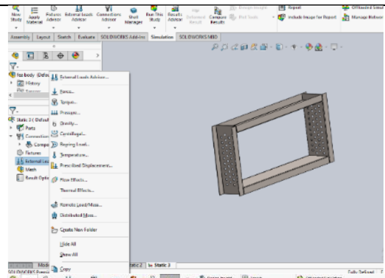
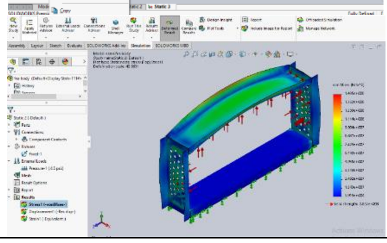
2.3 Finite Element Analysis (FEA)

In FEA, there are several steps to run the simulations such as designing, modelling, material used, boundary condition, meshing generation and result. The FEA is a method to facilitate an experiment to be performed in simulation to obtain the desired data. In mathematical terms, FEA is a numerical technique of solving the problem described by a set of partial differential equations. The finite element method is commonly used in many engineering disciplines. In mechanical engineering, FEA is widely used for solving structural, vibration and thermal problem. Using FEA, easily to analyze any shape, use various ways to idealize geometry and produce results with the desired accuracy [6]. In FEA there are several steps to run simulations such as design and modelling, defined material used, boundary condition, meshing generation and result. [7]

Therefore, static analysis study function was selected in this simulation and had been carried out to get the maximum value of stress, displacement and strain for this fin plate heat exchanger after applied the pressure which is 450 psi. This section, Table 4 show the procedure/step to running FEA analysis of FPHE in solidwork software.

Table 4: procedure to running FEA analysis of FPHE

Instruction	Figures
I. Press the simulation select the new study and choose the static analysis.	 
II. Identify the material of frame of FPHE, select the part and apply material (for this simulation the material used is carbon steel. Carbon steel have height value of yield strength.	
III. After done to select the material, need to define the located to applied fixture and choose the fixed geometry.	

IV. Next, identify the external load and identify the place to apply the pressure 450psi. This section choose the pressure as the external load.	
V. After done step I to step IV, select the run this study and result for FEA analysis done. This section show the stress analysis, displacement, and strain.	

3. Results and Discussion

In this chapter, the result successfully achieved the objectives of this research study by using Solidworks® Software to control the parameter which is total length, total wide, and total height of fin plate heat exchanger using design table. This project was followed the parameters of fin plate heat exchangers and the information given by manufacturer HPL Technologies Sdn Bhd. In this study, the relationship between dimensions name, global variable and design table was successfully examined. Furthermore, to control the fin plate heat exchanger with design table need to understand about the global variable to linking with dimensions name and global variable link with design table.

3.1 Types of Parameter Fin Plate Heat Exchanger

Development of fin plate heat exchanger (FPHE) need to identify the parameter involved and understand the important parameter that may affect the changes of FPHE physical. The Design of FPHE controlled by equation, global variable, and design table. The Important parameter consist with center frame condition, parameter of tube condition, and parameter of fin plate condition.

3.2 Develop Fin Plate Heat Exchanger by Equations, Global Variables, and Design Table

The objective of this project is to develop FPHE that can be controlled by equation, global variables and design table. The formula needs to be created and corded in the global variable table as to control the changes of center frame condition, hole tube condition, and fin plate condition. The following section present the result of the fin plate heat exchanger control by equation, global variable, and design table.

3.2.1 Center Frame Condition

Based on information given by HPL Technologies, the length FPHE between 500 mm to 1699mm doesn't require center of frame. Table 5 shows the number of frame center required based on the length FPHE.

Table 5: The number of frame center required based on the length FPHE

Length of FPHE (mm)	Center of Frame (pcs)
1700 – 2600	1
2601 – 3600	2
3601 – 4800	3
4801 - 6000	4

The number center frame is automatically added if length of FPHE is changes according to Table 5. The Function of center frame is to support the overall frame of FPHE and as a splitter. [7] This changes have been established using the solidwork by relation between corded at global variable table, linear pattern at model of FPHE, and controlled by design table. Figure 3.1 to figure 3.5 shows the result of center frame condition, if the overall length of the FPHE changes.

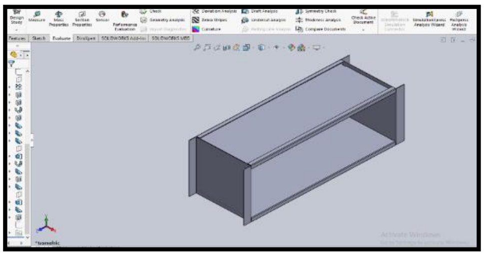


Figure 4: no have center frame if the total length is 1000 mm

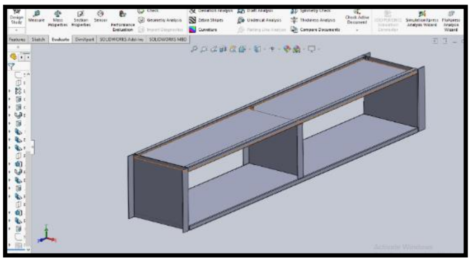


Figure 5: the number of center frame is 1pcs, if the total length is 2000 mm

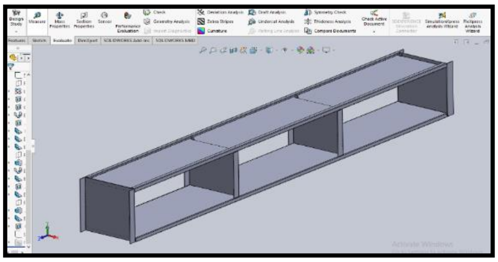


Figure 6: the number of center frame is 2pcs if the total length is 3000 mm

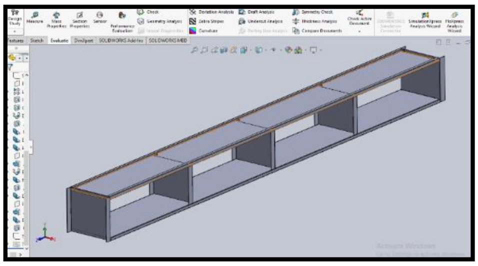


Figure 7: the number of center frame is 3pcs if the total length is 4000 mm

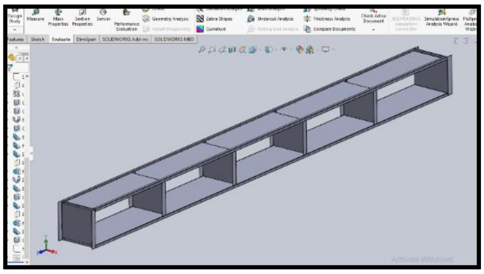


Figure 8: the number of center frame is 4 if the total length is 5000 mm

From the result, the relationship between center frame and length is influence by manipulation factor of length. The increasing of length of FPHE, the increasing of center of frame as well. This result shows that the function of the central frame to support the resulting force when the cooling process takes place in the FPHE and the function of center frame as a splitter for fin plate of FPHE. [8]

4.2.2 Holes Tube Condition

The development of holes tube condition requires understanding of the basic of dimension between hole and body of FPHE. There are 3 types of holes for FPHE based on information provided by HPL Technologies. The hole size consists with 10.10 mm, for development of hole at FPHE need to identify the vertical dimension and horizontal dimension. For the vertical dimension the distance between body and hole which is 25.00 mm for the row 1 and for the row 2 the distance between body and hole is 37.70 mm. The distance between hole and hole for vertical dimension is 25.40 mm. The horizontal dimension the distance between body and hole which is 25.00 mm and the distance between hole and hole is 22.00 mm show the Figure 9 to Figure 11 show the detail dimension about hole size which is 10.10 mm.

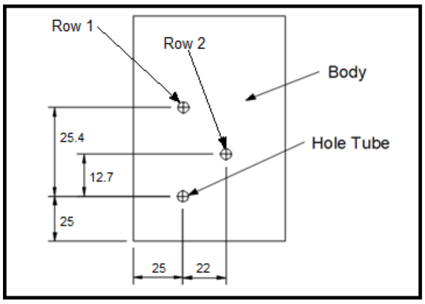


Figure 9: show the side of 10.10 mm FPHE

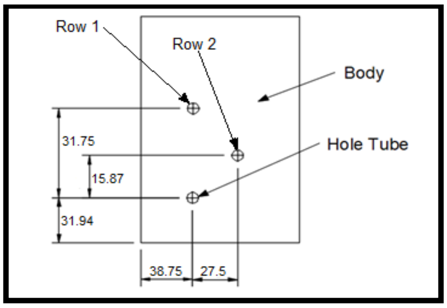


Figure 10: show the side of 13.35 mm FPHE

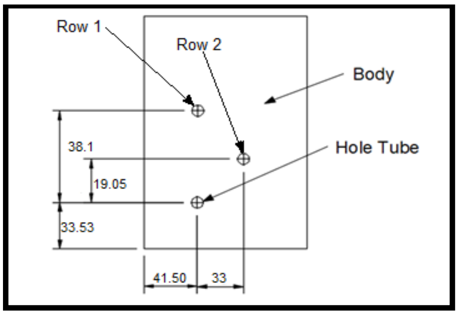


Figure 11: show the side of 16.60 mm FPHE

Therefore, for the hole size which is 13.35 mm. The distance between body and hole is 31.94 mm for the row 1 and for the row 2 the distance is 47.81 mm. The distance between hole and hole which is 31.75 mm. For the horizontal dimension, the distance between hole and body which is 38.75mm and the distance between hole and hole is 27.50 mm. Figure 10 show the detail dimension about hole size which is 13.35 mm. Besides that, for the hole tube size which is 16.60 mm the distance between body and hole is 33.53 mm for the row 1 and for the row 2 the distance is 52.58 mm. The distance between hole and hole which is 38.10 mm. For the horizontal dimension, the distance between hole and body which is 41.50 mm and the distance between hole and hole is 33.00 mm. Figure 11 show the detail dimension about hole size which is 16.60 mm. To develop fin plate heat exchanger control by design table, need to understand about dimension affected for fin plate heat exchanger. For this section to control holes tube condition, the dimension affected which is total wide and total height.

The range of total wide dimension start from 72.00 mm – 314.00 mm and the range of total height dimension start from 302.00 mm – 1600.00 mm. The observation for this section, if the total wide and height increased the number of hole tube also increased for example the number of wide is 116.00 mm the number of hole tubes is 3 columns and the total of height is 302.00 mm the number of hole tube is 10 rows, if the value of total wide which is 270.00 mm the number of hole tube is 10 columns and if the value of total height is 708.00 mm the number of hole tube which is 26 rows. The Figure 12 to Figure 14 show the number of hole tube if the number of total wide and total height was increased for the hole size which is 10.10 mm.

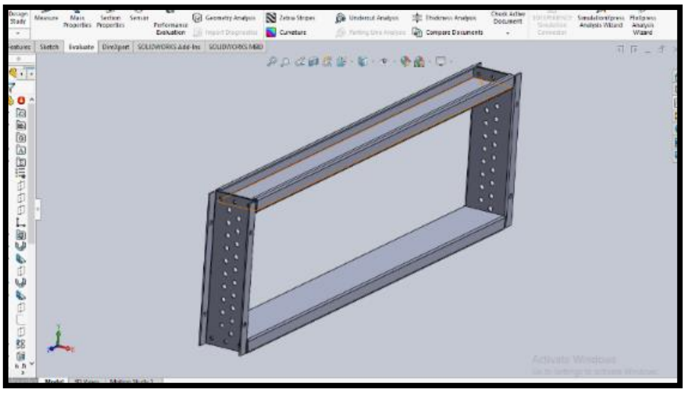


Figure 12: the holes tube condition if the total length is 1000 mm, total wide is 94 mm, and total height is 302 mm

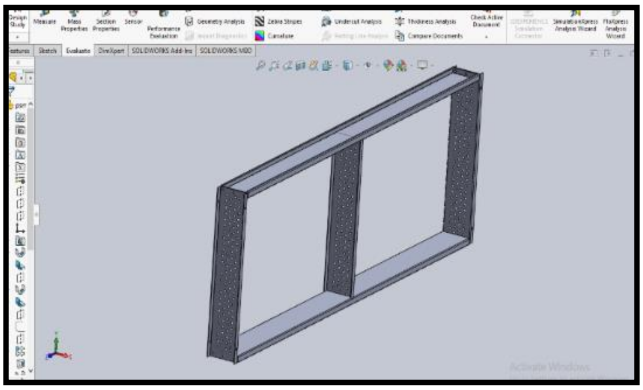


Figure 13: the holes tube condition if the total and total length is 2000 mm, total wide is 138 mm, and total height is 709 mm.

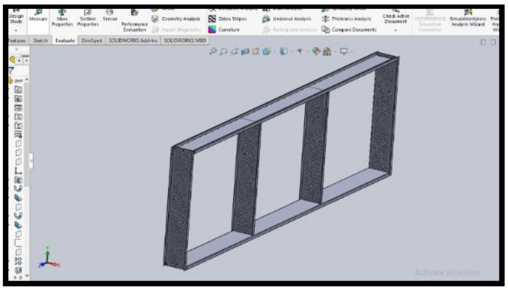


Figure 14: the holes tube condition if the total length is 3000 mm, total wide is 182 mm, and total height is 937 mm

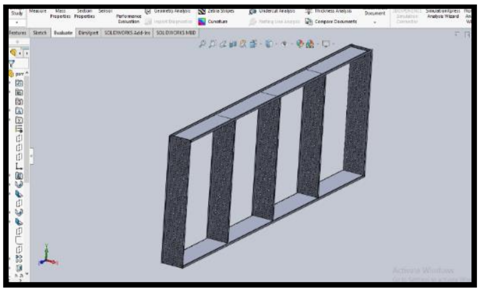


Figure 15: the holes tube condition if the total length is 4000 mm, total wide is 270 mm, total height is 1318 mm

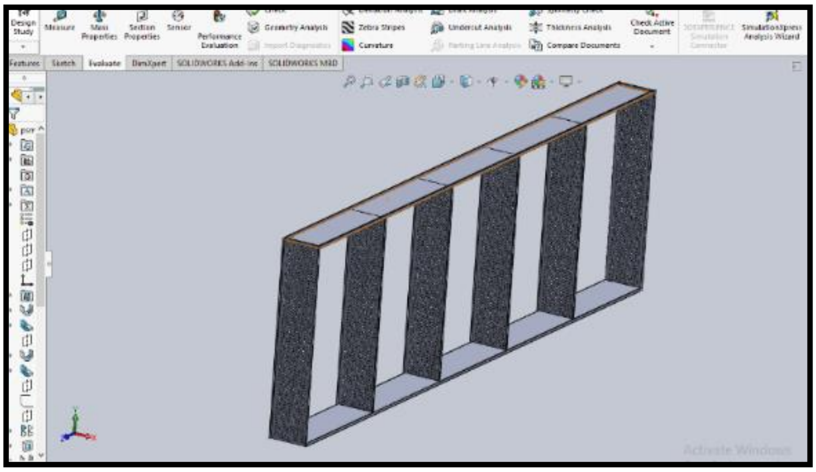


Figure 16: the holes tube condition if the total length is 5000 mm, total wide is 314 mm, and total height is 1598 mm

4.2.3 Fin Plate Condition

To develop of fin plate must follow the standard which is a tube fin tube exchanger having falt with 400 fin / m (10 fins / in) has a surface area density of about 720 m^2 / m^3 (220ft^2/ft^3). [4] The number of fin depend on the total of length such as, the numbers of fin plate is 400 pieces if the total of length which is 1016 mm. The Observation for this section, if the total of length increased the number of fin plate also increased. The function of fin plate is that uses plates and finned chambers to transfer heat between fluids. It is often categorized as a compact heat exchanger to emphasize its relatively high heat transfer surface area to volume ratio. The Figures 17 to Figure 21 shown the numbers of fin plate parallel with the total of length.

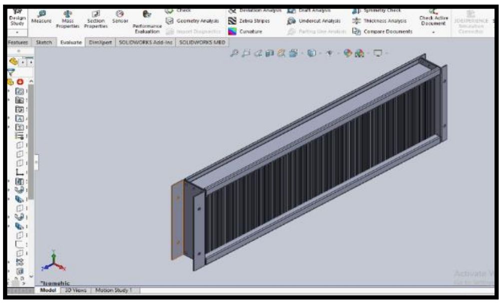


Figure 17: 395pcs of fin plate, if the total Length is 1000 mm, total wide is 94 mm, and total height is 302 mm

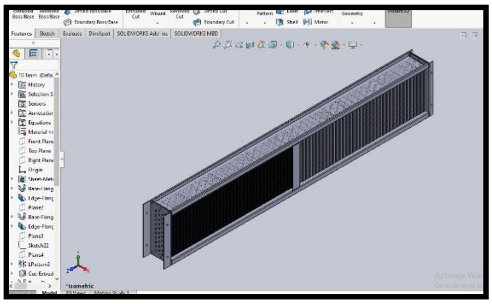


Figure 18: 8.5pcs of fin plate if the total length is 2000 mm, total wide is 138 mm, and total height is 709 mm

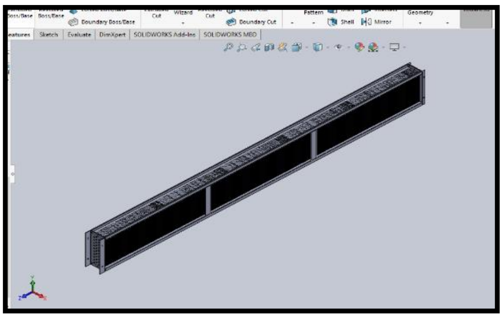


Figure 19: 1280pcs of fin plate, if the total length is 3000mm, total wide is 182mm, and total height is 937 mm

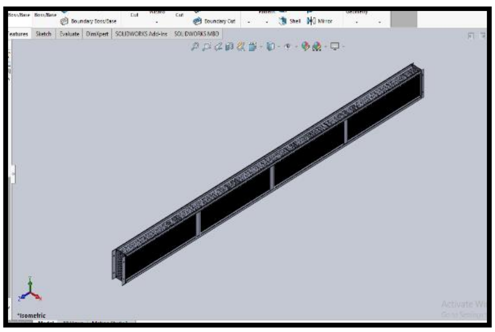


Figure 20: 1595pcs of fin plate, if the total length is 4000 mm, total wide is 270 mm, and and total height is 1318 mm

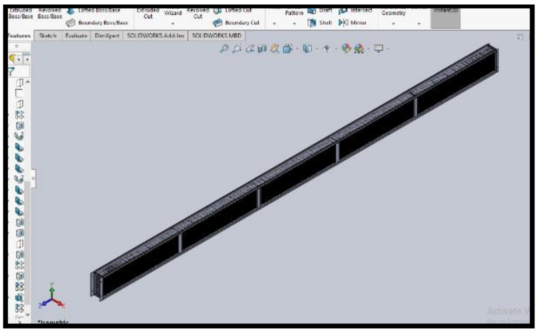


Figure 21: 1995pcs of fin plate, if the total length is 5000 mm, total wide is 314 mm, and total height is 1598 mm

3.3 Develop three size of diameter plate fin heat exchanger which is 10.1mm, 13.35mm, 16.6mm

Based on the HPL Technologies, the company provided 3 types of diameter hole tube which is 10.10 mm, 13.35 mm, and 16.6mm. [5] This section shows the result have three types of diameter of hole tube in Solidwork software, shown in figure 4.19 to figure 4.21. The figure shows the different size of dimension for 3 types of fin plate heat exchanger. The HPL Technologies provided 3 types of diameter of hole tube because, different diameter of sizes hole tube effects on heat transfer effectiveness. Based on the theory, the large of hole tube can give more efficiency of heat transfer compare than small of hole tube. [11]

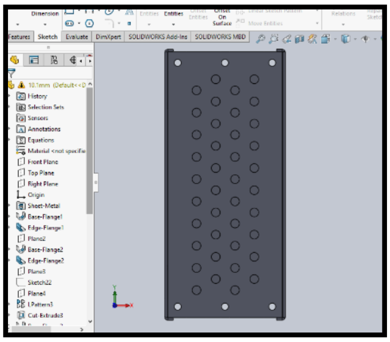


Figure 22: The 10.1mm size of diameter of hole

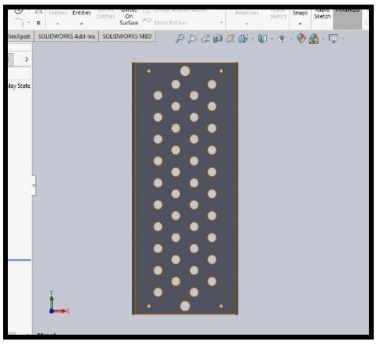


Figure 23 The 13.35 mm size of diameter of hole

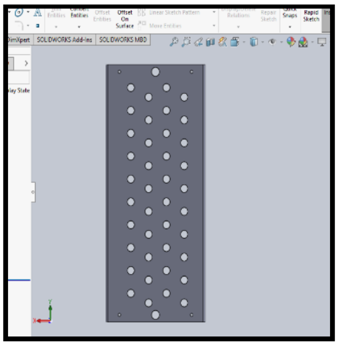


Figure 24: The 16.6mm size of diameter of hole

3.4 Finite Elements Analysis (FEA) for FPHE

Based on the HPL Technologies, before submitting the fin plate heat exchanger to customer need to do test which coil leak test for make sure the product not failed and can running perfectly. This section to analysis the fin plate heat exchanger to know the maximum stress, maximum displacement, and maximum strain after applied the pressure is 450 psi. There are 2 types of (FEA) for this section which is body of FPHE analysis and body + fin plate + hole tube analysis.

3.4.1 Stress Von Mises Analysis Result for Body

Figure 25 to Figure 27 show the von mises stress diagram, the value of yield strength is 2.827e 008. The maximum value von mises stress is located at the center of heat exchanger. This section used the stress analysis because before submitting to customer, HPL Technologies need to test the heat exchanger applied the 450 psi to check the body of FPHE field or not. This is because when the external load or pressure was applied at all surfaces of frame. The pressure cannot fully transfer to the bottom frame due to fix point at button frame. Therefore, the reaction between internal pressures will create high von mises stress value at top frame.

The maximum value of von mises stress for 10.1mm which is 1.485e+ 008 N/m^2, the maximum value of von mises stress for 13.35 mm which is 2.698e+008 N/m^2, and the maximum value of von mises stress for 16.60 mm which is 2.801e+oo8 N/m^2 at quiet high at body of heat exchanger. Based on the 3 types of FPHE, the best design is 10.10 mm because show the lowest maximum value of von mises stress compare with 13.35 mm and 16.60 mm. The FEA analysis, show the result which is not field because the value of yield strength highest than value of maximum stress. The Hencky theory, that a ductile material starts to yield at a location when the von mises stress becomes equal to the stress limit. In most cases, the yield strength is used as the stress limit. [10]

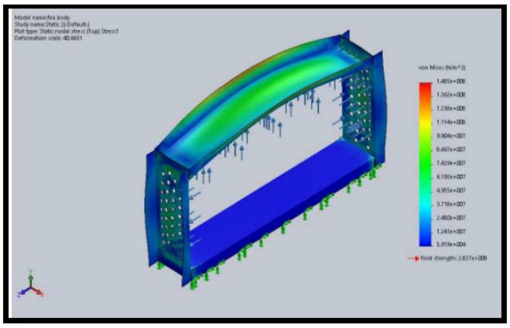


Figure 25: von mises stress value for 10.1 mm body frame heat exchanges for simulation

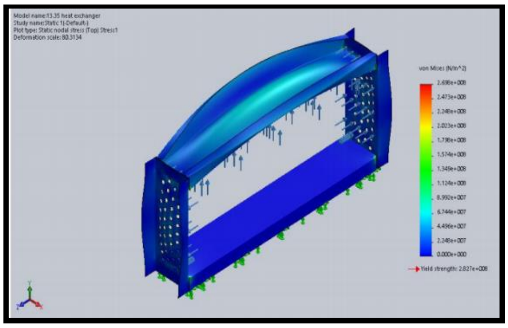


Figure 26: von mises stress value for 13.35 mm body frame heat exchanges for simulation

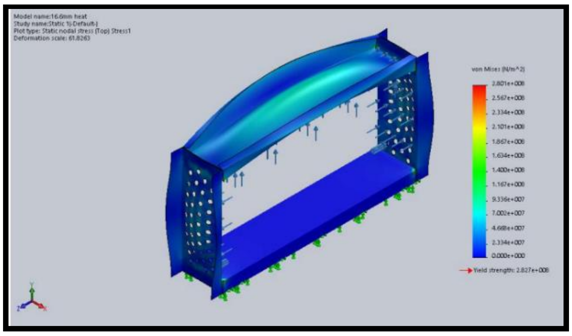


Figure 27: von mises stress value for 16.6 mm body frame heat exchanges for simulation

4. Conclusion

In conclusion, this study was carried out to fulfil the objectives that has been set out to increase the efficiency to develop fin plate heat exchanger using Solidwork software. Therefore, to develop fin plate heat exchanger must apply the important parameters for fin plate heat exchanger. In addition, among the important and influential parameters to develop a fin plate heat exchanger which are, the total length, total width and total height of the fin plate heat exchanger. The results show the fin plate heat exchanger control by equations, global variables, and design tables. This was influencing the efficiency of heat exchanger results also supported by the structural analysis by Finite Element Analysis (FEA) using SolidWorks Software 2017. The fin plate heat exchanger model successfully developed and simulate the body structure at the 450psi of pressure at three diameter of hole tube of fin plate heat exchanger is 10.1mm,13.35mm, and 16.6mm. The results show the different size of diameter give different impact because the larger the diameter of the hole tube give larger the surface area. Therefore, the larger of diameter give more efficiency of heat exchanger compare small of diameter hole tube. This development of fin plate heat exchanger towards IR4.0 successfully useful as basic information and parameter to HPL Technologies in designing for heating, ventilation, and air conditioning systems (HVAC) applications.

The Benefits of this project which is expected to provide information about types of heat exchanger and provide about plate fin heat exchanger design, this project help the engineer easy to design the plate fin heat exchanger because just change the dimension at configuration table also increase the efficiency and improve the productivity.

After all of the process that has been done from develop of FPHE and analysis using FEA simulation in solidwork software the result obtained are reasonable for the objective and scope, but still there is a lot of things that can be done and improved in this study. To enhance this study, further improvement can be taken by the following considering and following recommendations:

I. Improve the FEA simulation by compare the result with other simulation software such as ANSYS.
II. Improve the design of fin plate heat exchanger, add the tube in the FPHE
III. Improve the simulation used the Computational fluid dynamics (CFD) for analysis efficiency of heat transfer between tube and fin plate.

Acknowledgement

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Appendix A

Table show the corded of diameter tube 10.1 mm for FPHE

GLOBAL VARIABLE	VALUE
"centerframecondition"	= IIF ("totallength" > 1600 , IIF ("totallength" > 2600 , IIF ("totallength" > 3600 , IIF ("totallength" > 4800 , IIF ("totallength" > 6000 , 5 , 5) , 4) , 3) , 2) , 1)
"totalwide1conditon"	= IIF ("totalwide1" > 71 , IIF ("totalwide1" > 115 , IIF ("totalwide1" > 159 , IIF ("totalwide1" > 203 , IIF ("totalwide1" > 247 , IIF ("totalwide1" > 291 , 6 , 5) , 4) , 3) , 2) , 1) , 0)
"totalwide2condition"	= IIF ("totalwide2" > 93 , IIF ("totalwide2" > 137 , IIF ("totalwide2" > 181 , IIF ("totalwide2" > 225 , IIF ("totalwide2" > 269 , IIF ("totalwide2" > 313 , 6 , 5) , 4) , 3) , 2) , 1) , 0)
"totalheightcondition"	= IIF ("totalheight" > 301 , IIF ("totalheight" > 326 , IIF ("totalheight" > 351 , IIF ("totalheight" > 377 , IIF ("totalheight" > 402 , IIF ("totalheight" > 428 , IIF ("totalheight" > 453 , IIF ("totalheight" > 478 , IIF ("totalheight" > 504 , IIF ("totalheight" > 529 , IIF ("totalheight" > 555 , IIF ("totalheight" > 580 , IIF ("totalheight" > 605 , IIF ("totalheight" > 631 , IIF ("totalheight" > 656 , IIF ("totalheight" > 682 , IIF ("totalheight" > 707 , IIF ("totalheight" > 732 , IIF ("totalheight" > 758 , IIF ("totalheight" > 783 , IIF ("totalheight" > 809 , IIF ("totalheight" > 834 , IIF ("totalheight" > 859 , IIF ("totalheight" > 885 , IIF ("totalheight" > 910 , IIF ("totalheight" > 936 , IIF ("totalheight" > 961 , IIF ("totalheight" > 986 , IIF ("totalheight" > 1012 , IIF ("totalheight" > 1037 , IIF ("totalheight" > 1063 , IIF ("totalheight" > 1088 , IIF ("totalheight" > 1113 , IIF ("totalheight" > 1139 , IIF ("totalheight" > 1164 , IIF ("totalheight" > 1190 , IIF ("totalheight" > 1215 , IIF ("totalheight" > 1240 , IIF ("totalheight" > 1266 , IIF ("totalheight" > 1291 , IIF ("totalheight" > 1317 , IIF ("totalheight" > 1342 , IIF ("totalheight" > 1367 , IIF ("totalheight" > 1393 , IIF ("totalheight" > 1418 , IIF ("totalheight" > 1444 , IIF ("totalheight" > 1469 , IIF ("totalheight" > 1494 , IIF ("totalheight" > 1520 , IIF ("totalheight"

	> 1545 , IIF ("totalheight" > 1571 , IIF ("totalheight" > 1596 , IIF ("totalheight" > 1621 , IIF ("totalheight" > 1647 , IIF ("totalheight" > 1672 , IIF ("totalheight" > 1698 , IIF ("totalheight" > 1723 , IIF ("totalheight" > 1748 , 67 , 66) , 65) , 64) , 63) , 62) , 61) , 60) , 59) , 58) , 57) , 56) , 55) , 54) , 53) , 52) , 51) , 50) , 49) , 48) , 47) , 46) , 45) , 44) , 43) , 42) , 41) , 40) , 39) , 38) , 37) , 36) , 35) , 34) , 33) , 32) , 31) , 30) , 29) , 28) , 27) , 26) , 25) , 24) , 23) , 22) , 21) , 20) , 19) , 18) , 17) , 16) , 15) , 14) , 13) , 12) , 11) , 10) , 9)
"spacingholeheight"	= 25.4
"fincondition"	= iif ("totallength" > 304 , iif ("totallength" > 330 , iif ("totallength" > 355. , iif ("totallength" > 381 , iif ("totallength" > 406 , iif ("totallength" > 431 , iif ("totallength" > 457 , iif ("totallength" > 482 , iif ("totallength" > 508 , iif ("totallength" > 533 , iif ("totallength" > 558 , iif ("totallength" > 584 , iif ("totallength" > 609 , iif ("totallength" > 635 , iif ("totallength" > 660 , iif ("totallength" > 685 , iif ("totallength" > 711 , iif ("totallength" > 736 , iif ("totallength" > 762 , iif ("totallength" > 787 , iif ("totallength" > 812 , iif ("totallength" > 837 , iif ("totallength" > 862 , iif ("totallength" > 887 , iif ("totallength" > 912 , iif ("totallength" > 937 , iif ("totallength" > 962 , iif ("totallength" > 987 , iif ("totallength" > 1012 , iif ("totallength" > 1037 , iif ("totallength" > 1062 , iif ("totallength" > 1087 , iif ("totallength" > 1112 , iif ("totallength" > 1137 , iif ("totallength" > 1167 , iif ("totallength" > 1187 , iif ("totallength" > 1212 , iif ("totallength" > "totallength" > 2312 , iif ("totallength" > 2337 , iif ("totallength" > 3362 , iif ("totallength" > 3387 , iif ("totallength" > 3412 , iif ("totallength" > 3437 , iif ("totallength" > 3462 , iif ("totallength" > 3487 , iif ("totallength" > 3512 , iif ("totallength, 1100) , 1090) , 1080) , 1070) , 1060) , 1050) , 1040) , 1030) , 1020) , 1010) , 1000) , 990) , 980) , 970) , 960) , 950) , 940) , 930) , 920) , 910) , 900) , 890) , 880) , 870) , 860) , 850) , 840) , 830) , 820) , 810) , 800) , 790) , 780) , 770) , 760) , 750) , 740) , 730) , 720) , 710) , 700) , 690) , 680) , 670) , 660) , 650) , 640) , 630) , 620) , 610) , 600) , 590) , 580) , 570) , 560) , 550) , 540) , 530) , 520) , 510) , 500) , 490) , 480) , 470) , 460) , 450) , 440) , 430) , 420) , 410) , 400) , 390) , 380) , 370) , 360) , 350) , 340) , 330) , 320) , 310) , 300) , 290) , 280) , 270) , 260) , 250) , 240) , 230) , 220) , 210) , 200) , 190) , 180) , 170) , 160) , 150) , 140) , 130) , 120) , 110)

Table show the equation of diameter tube10.1mm for FPHE

EQUATION	
"D1@Plane2"	= "totallength"
"D7@Edge-Flange1"	= "thickness1"
"D7@Edge-Flange2"	= "thickness2"
"D1@Sketch1"	= "totalheight"
"D2@Sketch1"	= "totalwide1"
"D3@LPattern3"	= "centerframespacing"
"D1@LPattern3"	= "centerframecondition"
"D1@Sketch25"	= "thickness3"
"D2@Sketch25"	= "thickness4"
"D3@Sketch72"	= "centerbolt1"

"D8@Sketch72"	= "centerbolt2"
"D12@Sketch72"	= "centerbolt1"
"D3@LPattern10"	= "finspacing"
"D1@LPattern10"	= "fincondition"

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