DESIGN OF AN INTELLIGENT CAR AIR CONDITIONING LOUVER FOR EFFICIENT COOLING OF CAR INTERIOR COMPARTMENT

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ABSTRACT

Keywords: car air conditioning, simulation, air conditioning louver

The increase of car usage in the current century seeks for more comfort in the car even the back passengers. Major characteristics passengers look for are the air flow from the louver. Louvers require to be adjusted manually by the front passengers and maybe dangerous for driver to adjust when they are only passenger in the car. Previous research found primarily improving or adjusting the components air supplies before entering the louvers. However, this still unable to direct the air flow to the desired locations. In this research, with the integration of Solidworks and Ansys Fluent application, I was able to simulate the situation of air flow occur in the car. By creating the body structure of a car, the cavity model was extracted along with the parallel position of the louver. Results were obtained and based on that, the louver is adjusted to fulfill desire location for one to four passengers respectively. As for the louvers, it is designed to be integrated with servo motor, microprocessor, and infrared sensors. As the infrared sensor triggered by the passenger through wearing the seat belt, the signal will send to the microprocessor and transfer desired output signals based on the completed simulations. Having the intelligent louver that auto-adjust based on the number of passengers a car removes the hectic for the passengers to adjust them manually.

ACKNOWLEDGEMENTS

The completion of this research could not have been possible without the assistance of many people. Their contributions are sincerely appreciated and gratefully acknowledged.

I would like to express my gratitude to my research supervisor, Dr. Mohd Nashrul Bin Mohd Zubir, Senior Lecturer of University of Malaya, Department of Mechanical Engineering, Faculty of Engineering, for giving me this opportunity to do research providing invaluable guidance throughout this research. He has taught me the methodology to carry out the research and to present the research works as clearly as possible.

I am also extremely grateful to my parents for their love, prayers, caring and sacrifices throughout the research under the pandemic heist. My special thanks go to my friend, Kosalishkwaran Ganesan for the support as well.

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For examples:

m/s	:	Meter per second
km/hr	:	Kilometer per hour
3D	:	Three dimensional
K	:	Kelvin

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CHAPTER 1: INTRODUCTION

In this 21st-century, we are currently living in the world full of advanced technology that allow man kinds to perform their work, including travels. The automotive industry is one of, if not the most important industries in the world to allow human to travel from one destination to another. Under automotive industry, cars became globally used by humankinds in the early 20th century. Now a days human depends on car for all our work whether it is small or big in scale. In fact, for some people cars have come to take on almost human characteristics.

For decades ever since the first car was created, additional feature and controls for driving, parking, and even passenger comfort, making them progressively more user friendly and complex at the same time. This includes in-car entertainment, cameras on all sides of the car, and air-conditioning.

Under air conditioning in the car, it now comes as standard in all newly produced cars and is one of the most important features have come to expect by the users. The air conditioning in cars now works under the same principles that was developed in the 1930s. The current way that the passenger to adjust the louver is in manual. Front passenger requires to adjust for themselves and for the passengers at the back seat if there are any. Certain times it may be dangerous for the driver to adjust during his/her drive on the road if he/she is the only passenger in the car. Adjusting the louver manually could be difficult sometimes as the passenger needs to adjust it several times. Thus, with the problem stated, in this research I will present the design of an intelligent car air condition louver for efficient cooling of car interior compartment.

In the research, I am simulating the air flow within the car interior compartment, for when the louver is not adjusted and what kind of adjustment should the intelligent louver be based on the number of passengers in the car.

CHAPTER 2: LITERATURE REVIEW

2.1 Automobile Air Conditioning System

The air conditioning system is the integration of a few components, compressors, condensers, filter dryer, expansion valve, evaporator, pressure switch, ventilation fan and condenser fan. The functionality of the automobile air conditioning system is to cool the passengers of a vehicle in hot weather.

There are two types of air conditioning systems. One which is the Nash integrated system and the other will be the automatic climate control. In Malaysia, often the car is using the Nash. It is the basic air conditioning system that we see. It is compact and easily serviceable with all its components installed under the hood or in the cowl area. Automatic climate control uses separate heating system and an engine-mounted compressor for additional function of warming up the car interior.

The idea of the automotive air conditioning was consolidated by the author, Nishant Agarwal and found it outweighs the current modes of conditioning in several ways. Automotive air conditioning system is beneficial and is much cheaper, overcomes most of the general air conditioners. [1]

2.2 Practical Studies on Car Air Conditioning Systems

Temperature in the car play in the major role in comforting the passengers in the car, it is defined as thermal comfort. From theoretical point of view, the author found that the operating principle of air conditioning and refrigeration systems are based on Carnot Cycle. Carnot cycle definition is the heat transfer from cold source to the hot source through energy input.

Under experimental research by the author, with experimental stand and Testo Smart Probes – VAC SET, he/she was able to measure data of the air flow in the air conditioning system. The stand that was created can be serve as a teaching stand for students.

The relative humidity decreases, and the temperature increases in the car interior, whereas when the fan being switched on, the temperature in the condenser decrease long with the car interior (to zero degree Celsius). [2]

2.3 Investigation on the Improvement of Car Air Conditioning System Performance using an Ejector

The author has conducted experiment whether the ejector that was installed as a secondary component along with separator, filter dryer, sight glass, and five hand valve units able to improve the air conditioning system performance. The main components consist of compressors, air-cooled condenser, thermostatic expansion valve, and finned evaporators. [3]

The results obtained, the ejectors increase refrigeration effect and coefficient of performance by 25% and 22% respectively. From my perspective, to have the ejector installed requires major dismantling.

2.4 Vehicle Interior Airflow Assembly

The four louvers from the front shares the same ventilation system. The author, Pamela Sue Greenwald designed the louver to have the capability of close and open the louvers based on the passengers present in the car seats. With the integration of sensing devices within the vehicle interior to the actuator, the air flow will travel towards desired louvers and remaining louvers will be closed.

When the sensing device detects close object for this case it is the human body, the door in the louver is opened thereby allowing the air to flow through these outlet members. This increases the airflow speed on the opened, due to the air was not distributed throughout on all four louvers as a normal air conditioning system in car would do. [4]

However, from my perspective, the louver still requires adjustments to satisfy the passengers.

2.5 Effect of Car Speed on Amount of Air Supplied by Ventilation System to the Space of Car Cabin

There are a few fundamentals were included by the author under the methodology of this research. The amount of air which is sucked by the main fan, the speed of air in front of the central air outlet, and the distribution ratio of air between all the louvers are constant.

It was found that at the maximum fan speed out from the louvers, it is at approximately 50km/h. With different fan speed, the difference with and without car speed of 90km/h varies. Maximum fan speed has the increase of 6% when the car is moving, and with minimum fan speed and difference is 18.3%. [5]

With the results and experiment present by the author, the supply air flow rate is strongly dependent on speed of the car at low speed. With such case, the research which I am conducting will be based on the maximum speed that can be provide by the car air conditioning system to neglect minimum changes that can be affected by the car speed.

2.6 Investigation of Air Conditioning Temperature Variation by Modifying the Structure of Passenger Car Using Computational Fluid Dynamics

Author, Krishnaswamy Haribabu from this journal proposed a different body structure for the Indian budget car, improving the air conditioning performance in the car. With the assistance of Ansys CFD application, the air distribution inside the cabin of the car was analyzed, without considering air vent in the car. With the new car structure model, the simulations clearly show an improvement in the air distribution. [6]

2.7 New Automotive Air Conditioning System Simulation Tool Developed in MATLAB/Simulink

The authors, Tibor Kiss and Lawrence Chaney described the new automotive air conditioning system simulation tool on the MATLAB/Simulink platform. It is consisting of two type of model, one which is the detailed cooling circuit and a relatively simple cabin model. With the finite volume formulation of the governing equations, it provides a very accurate preservation of refrigerant mass and energy balance. According to the authors, this model is suits for co-simulation with vehicle system analysis software and for development of air conditioning system controls, but it has not been demonstrated yet. [7]

2.8 Modelling and Analysis of Aut0matic Air Conditioning System using Support Vector Machine

This scientific paper is prepared by the authors, Srinivasan Santhosh, Perumal Sakthivel, Kadasari Rajaguru, Pandiyan Lakshmanan, and Balakrishnan Suresh Kumar. They proposed a novel technique to create model of automatic air conditioning system. The model is used to predict the system performance, utilizing SVM classifier. It consists of four inputs and three outputs; inputs are compressor speed, evaporator temperature, condenser temperature, and velocity. This technique predicts the cooling effect, evaporator input power and coefficient of performance. The authors tested the proposed technique with data obtained from the literature and analyzed with artificial neural network technique. It is evident that proposed technique is effectively become suitable alternative to predict the performance of automatic air conditioning system.

CHAPTER 3: OBJECTIVES

In this research, the objectives are:

1. To design a louver which would enable most suitable auto-adjustments based on the number of passengers in the car.
2. To conduct computational work to analyze the air distribution under the current and the adjust louvers direction of the whole interior of a car.

CHAPTER 4: METHODOLOGY

This chapter provides an outline of the research methodology. The research that I have done starts from drawing a 3D model of the vehicle, create cavity model of that, and perform simulation to identify the air flow from the louver towards the passengers. This involves in kinematic energy and thermal energy in the car interior. The simulation involves from one passenger up to four passengers in the car. The initial simulations will be when the louver is in standard position, whereby the direction is directly parallel with the car door. With those simulations, only then the louver is adjusted and performs another set of simulation to identify the angle is suitable for the passengers in the car.

4.1 3D Model of the Car

The first stage for the research, the 3D model of the car is based on the commonly used local product of Malaysia, the Perodua MyVi. I have used the SolidWorks 2018 to draw the simple car model a 1 to 1 scaling and 3D human model as the passenger. Figure below shows one of the 3D model which has one passenger (driver). Remaining figures will be attached under Appendix.

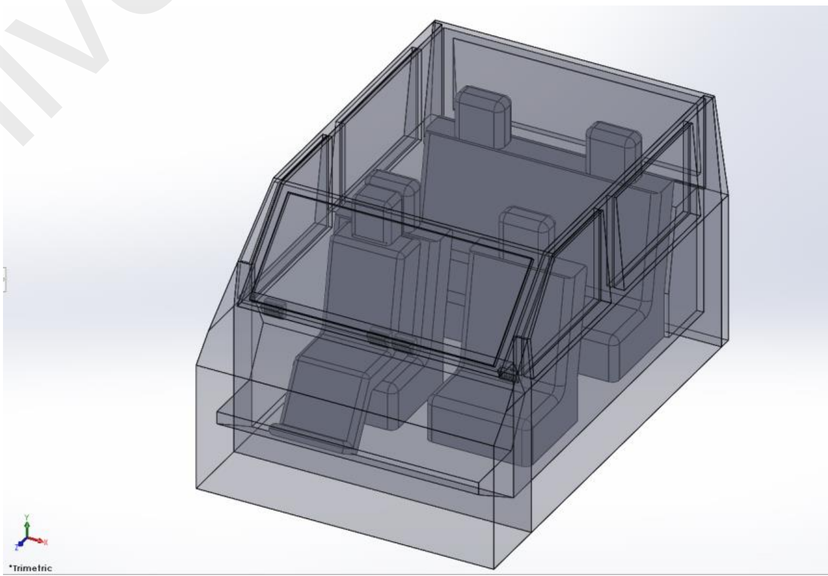

Figure 1: 3D model of the car with 1 passenger (isometric view)

The designed louver is in rectangular shape integrated with servo motor, microcontroller and infrared sensor that is attached onto the seatbelt which will be in front of the passenger's chest when they have the seat belt tied. Figure below shows the back view of the louver designed. It can rotate the louver blades horizontally and vertically reacting to the input from the infrared sensor.

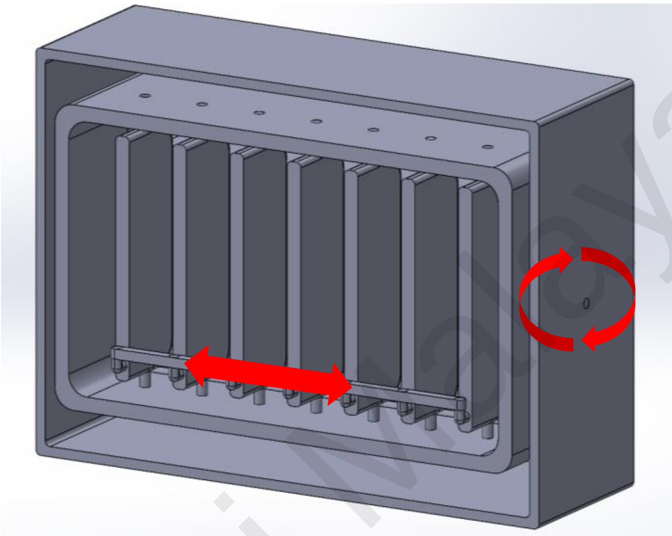

Figure 2: 3D model of louver (isometric view)

4.2 Creation of Cavity Model of the 3D Car Model

To perform simulations for this research, cavity modeling method is used to extract the model whatever if inside the car interior. We are studying the fluid in the car and simulate it in Ansys application. Thus, the cavity model is extracted based on the drawn 3D model of the car.

A cavity 3D model is the model structure of an object whatever it is inside it. A simple example would be water bottle filled with water. The bottle is the body structure whereas the water inside the bottle is called as the cavity model. With Solidworks, I was able to extract the cavity model from the initially drawn 3D model of the car.

Below are the steps of creating the cavity 3D model or so called the car interior fluid 3D model:

4.2.1 Create Part File

Using Solidworks 2018, a part file was inserted as a component for the 3D model assembly as shown in the figure below. The purposes of the part file is to combine all the assembly as a single component only then the cavity would be able to extract out from it.

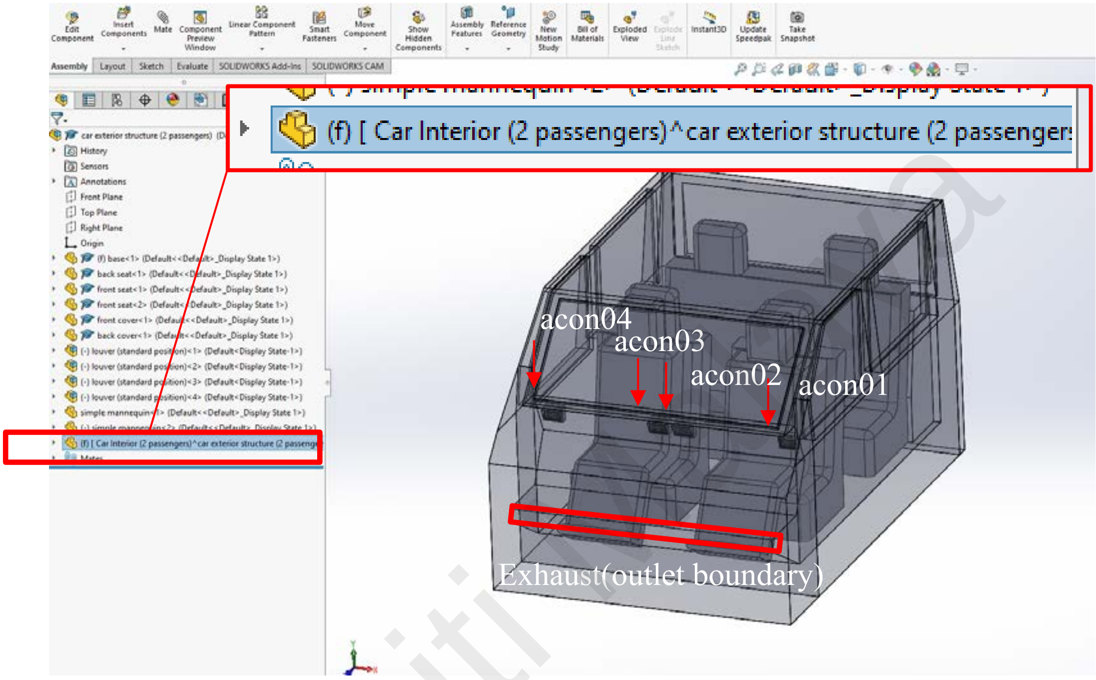

Figure 3: Louver named selection and part file creations

The louver from left to right is named as acon04, acon03, acon02, and acon01. The outlet boundary (exhaust) is named as output01.

4.2.2 Create Join Features in the Part File

For that component that is just added, Join feature is used to combine the model assembly as one complete model. Join is used when in an assembly mode. Two or more parts can be joined to create a new part. The JOIN operation removes surfaces that invade each other's space and merges the part bodies into single solid volume. This allows the system to identify the car seats and the passenger model are within the car interior when perform the cavity modeling.

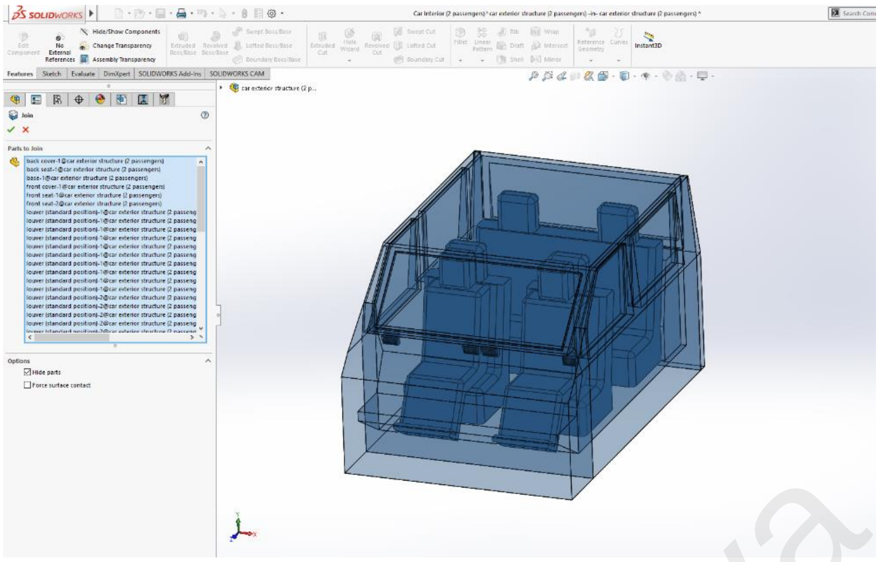

Figure 4: Combination of part assembly into 1 part file

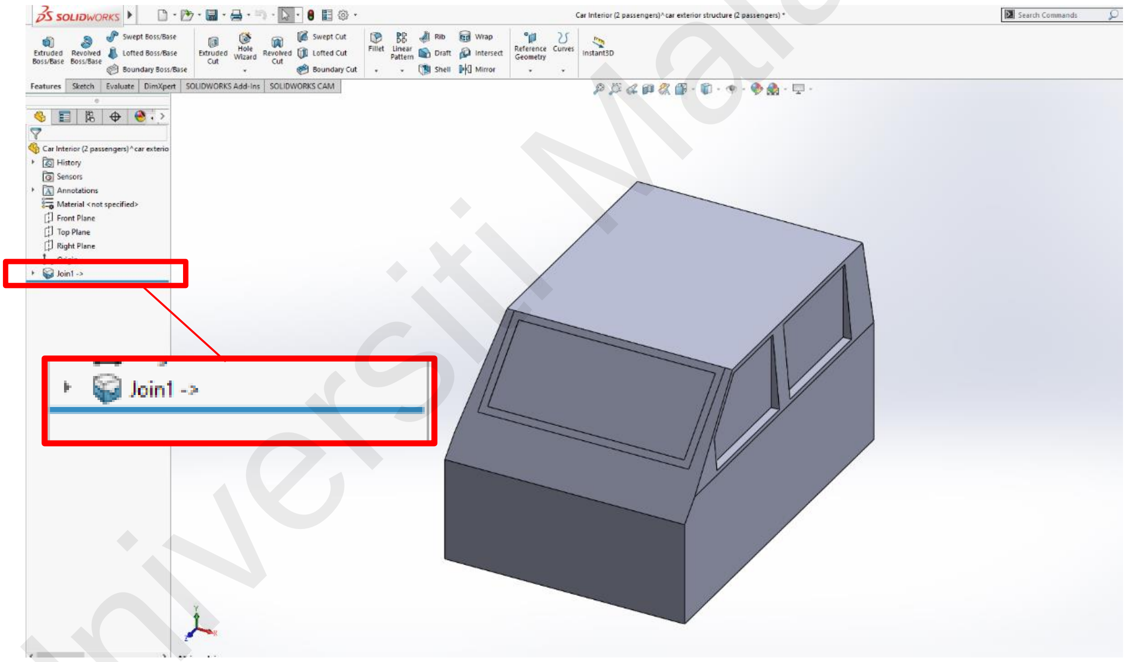

Figure 5: Part file created as a single assembly (isometric view)

4.2.3 Extrude model within the 3D car model

After Join model is completed, a 3D model is extruded based on the car interior's structure with the *Up To Body* extrusion feature provided in Solidworks itself. A 3D model of the car interior is then extracted and saved as IGS file format for simulation purposes as shown below.

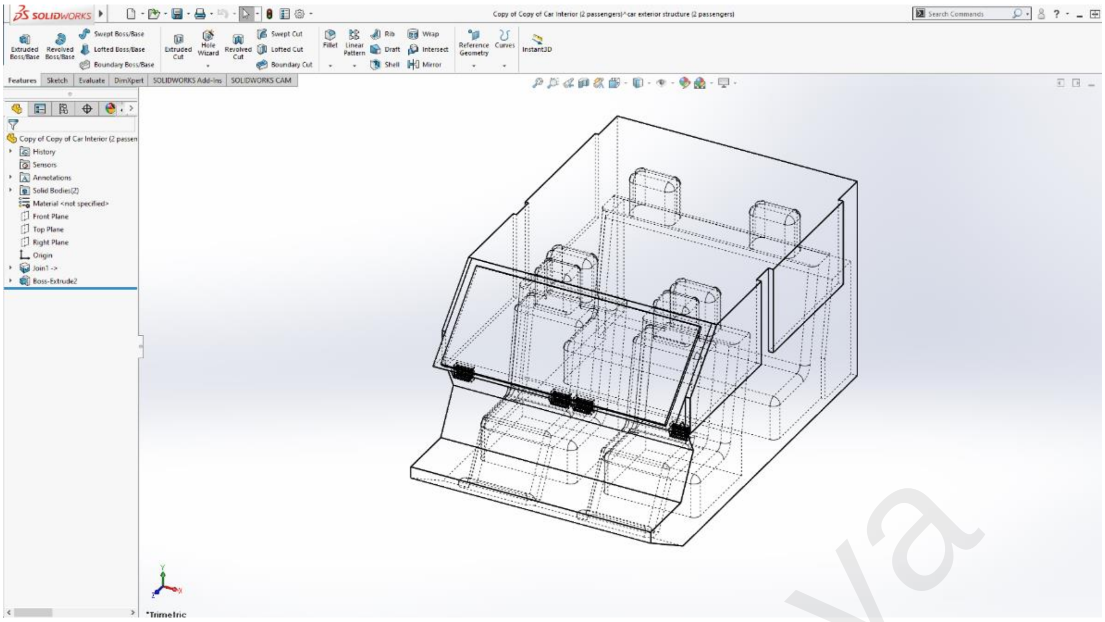

Figure 6: Extrude 3D model as cavity model for the simulation (1 passenger)

4.3 Perform Simulation Study

The Simulation Study for this research is to understand and identify the resultant air flow from the louver towards the car interior. There are eight complete simulations in this research and details of iteration tables will be attached under Appendix. The Ansys Workbench 19.0 was used to perform the simulation. The steps are as follows:

4.3.1 Select Analysis System and Insert Geometry

Under Ansys WorkBench 19.0, Fluid Flow (Fluent) was selected as the analysis system as the research involves in kinetic energy and thermal energy of air in the car interior. Below figure shows the WorkBench set up and the detail of the body is marked as fluid:

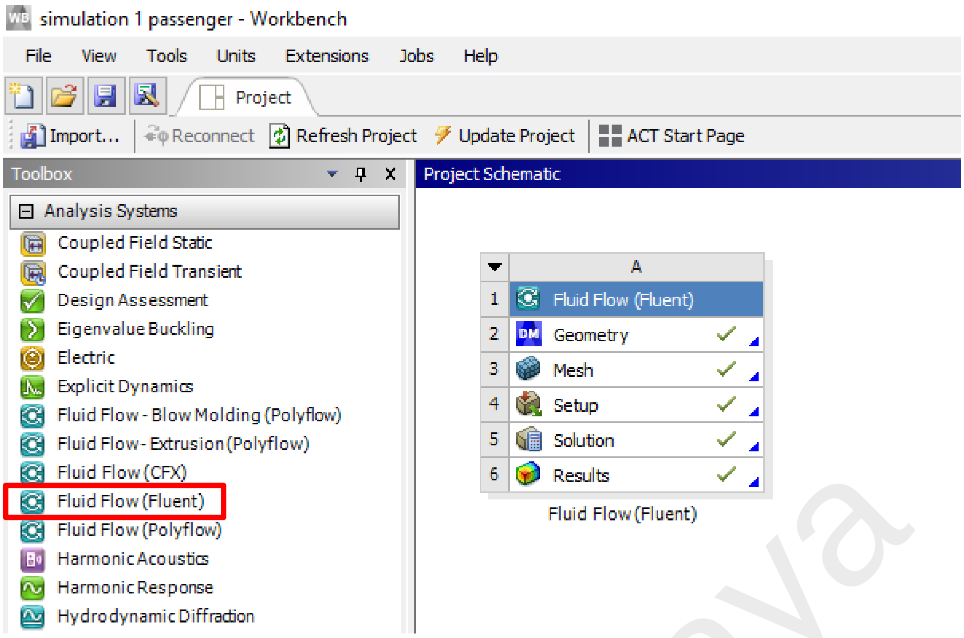

Figure 7: Project schematic is selected as fluid flow (fluent)

The reason behind choosing the Fluid Flow (Fluent) is that the research requires to study on the fluid flow, in this research it would be the air flow distribution in the car model. Under Geometry tab, insert the cavity model that is prepared and change the details of body from solid to fluid.

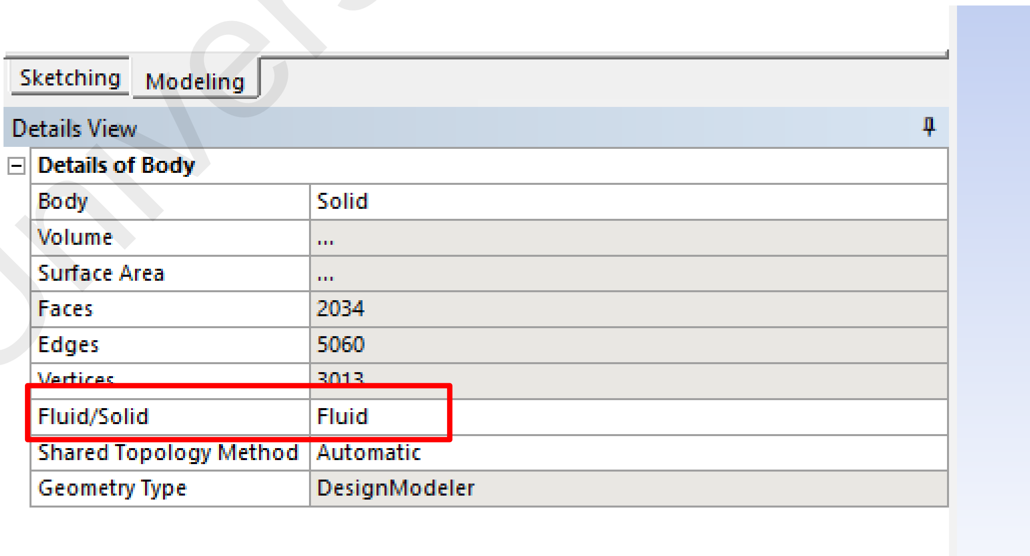

Figure 8: Details of the Body is selected as fluid

4.3.2 General Mesh Set Up for all Four Simulations

For all four/eight of the simulations, the 3D model mesh was generated with identical set up to act as the constant variable for the simulations. Smoothing tab is changes to high to increase the mesh size and thus much accurate results will be obtained. The inlet velocity from the louver surface is labelled as well for the manipulating variable later in the simulations:

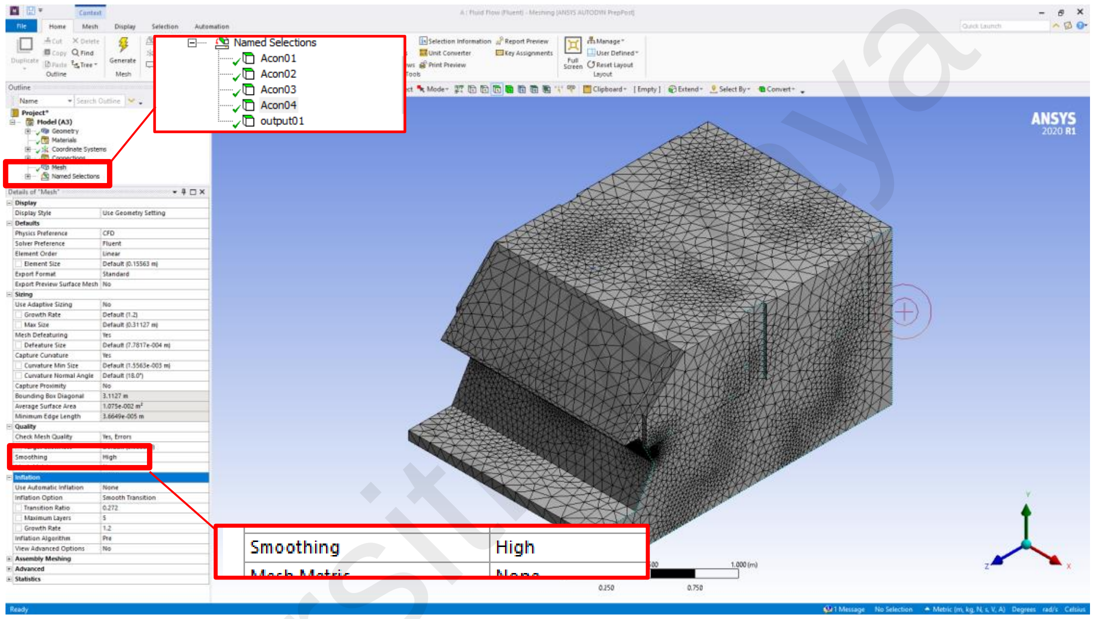

Figure 9: General mesh set up prior to simulation

4.3.3 General Set Up for Fluent Launcher

After the meshing has been generated, Fluent Launcher as known as the simulation program is set up as follows for all the simulations.

Depending on the capability of the processor in the computer, the solver processes was set as 4 to reduce time taken for each simulation iterations. Ansys Fluent's parallel solver allows you to compute a solution by using multiple processes that may be executing on the same computer, or on different computers in a network. Increasing the number of solver will reduce the turnaround time for the solution.

Double precision is selected as well as it is significant if tiny relative differences are significant. Examples where you would expect double precision to make a difference are natural convection (especially modelled with the fully compressible option); meshes with a large difference between the largest and smallest elements sizes; larges geometries with small but significant features; flows with large pressure/velocity/temperature variation etc. In conclusion, double precision is always more accurate, but does run slower and takes up more memory.

Figure 10: General Fleunt Launcher set up

4.3.4 Simulation General Conditions Set Up

Under the simulation, the materials selected was air with being as standard output from the louver, and velocity inlet from louver of 5 m/s as average. Primary objective of this research is to study the air distribution flow from the louver in the car. Thus, the initial assumptions made was to only focus the airflow coming out from the louver only and defines the airflow out results to be direct proportional to the inlet velocity from the louver.

The number of iterations was 100 and iteration data for each simulation is recorded under Appendix. The number of iterations of 100 was selected after studying the user guide of Ansys Fluent.

At low speeds, combustion couples to the fluid flow through density. The Lagrangian PDF transport algorithm has random fluctuation in the density field, which turn cause fluctuations in the flow fields. For steady state flows, statistical fluctuations are decrease by averaging over several previous iterations in the Run Calculation task page. By increasing the Iterations in Average, fluctuations are smoothed out and residual level off at smaller values. It is recommended by Ansys User Guide that minimum of 50 iterations in average is set until the steady state solution is obtained. Thus, a number of 75 iterations was selected to further secure the steady flow of residual without any fluctuation, obtaining more accurate results in the simulations.

Figure below shows the set up for the boundaries in the simulation: (figure cont. on next page)

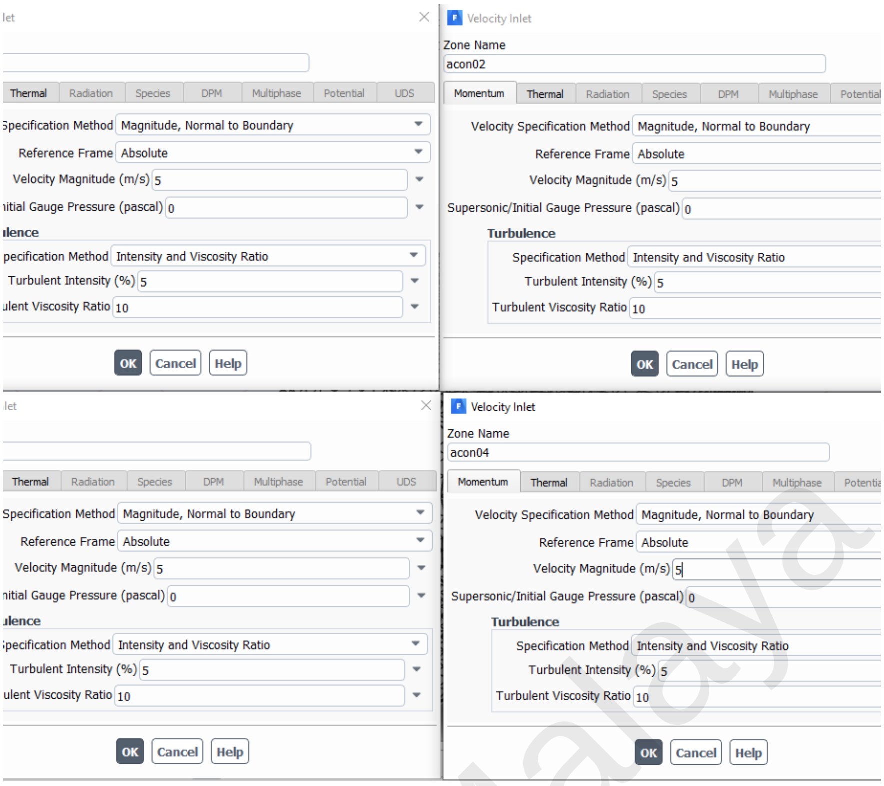

Figure 11: Simulation general condition/boundaries set up

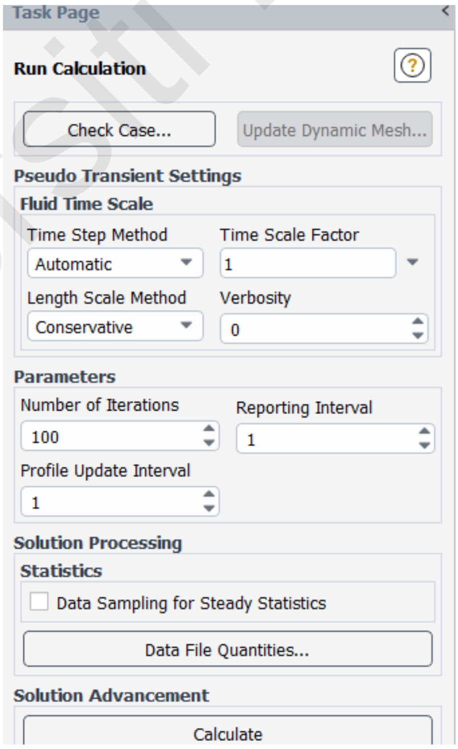

Figure 12: Run Calculation task page set up

4.3.5 Generate Diagrams of Simulations

The streamline known as the air flow movement is generated to study on how to adjust the louver that will benefit from one passenger up to four passengers, respectively. Iteration graph has been plotted and generated as well.

CHAPTER 5: RESULTS AND DISCUSSIONS

The simulation results are shown as figures for each one to four passengers as below.

At the end of each solver iteration, the residual sum for each of the conserved variables is computed and stored, thus recording the convergence history. This history is also saved in the data file. The residual sum is defined below. On a computer with infinite precision, these residuals will go to zero as the solution converges. On an actual computer, the residuals decay to some small value ("round-off") and then stop changing ("level out"). Double-precision residuals can drop up to twelve orders of magnitude. By default, residual values for all relevant variables are printed in the console after each iteration. The plotted graph is shown in the next chapter.

5.1 Simulation Results for One Passenger (The Driver)

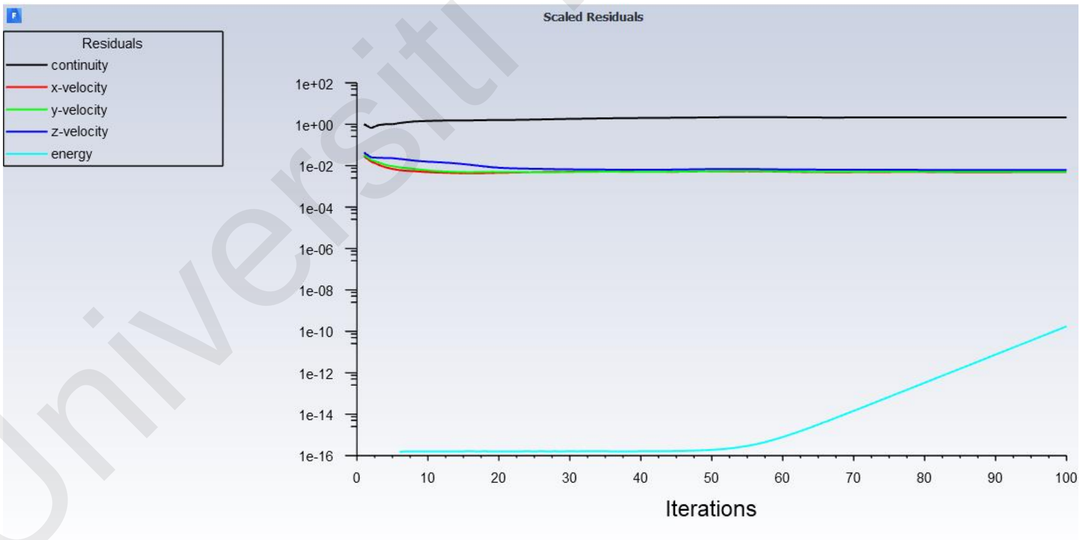

Figure 13: Residual graph for simulation of 1 passenger (standard louver position)

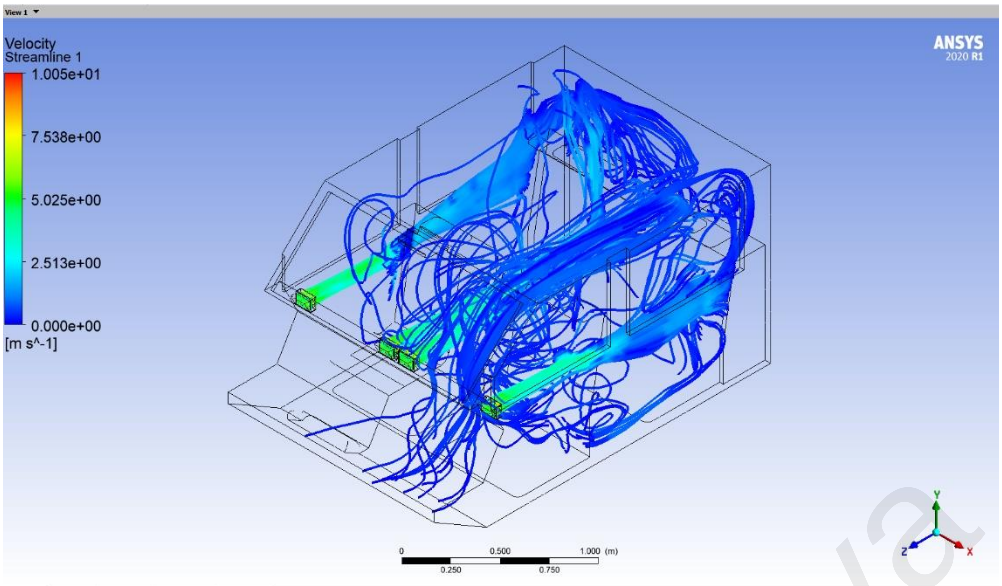

Figure 14: Velocity Streamline of simulation for 1 passenger (standard louver position)

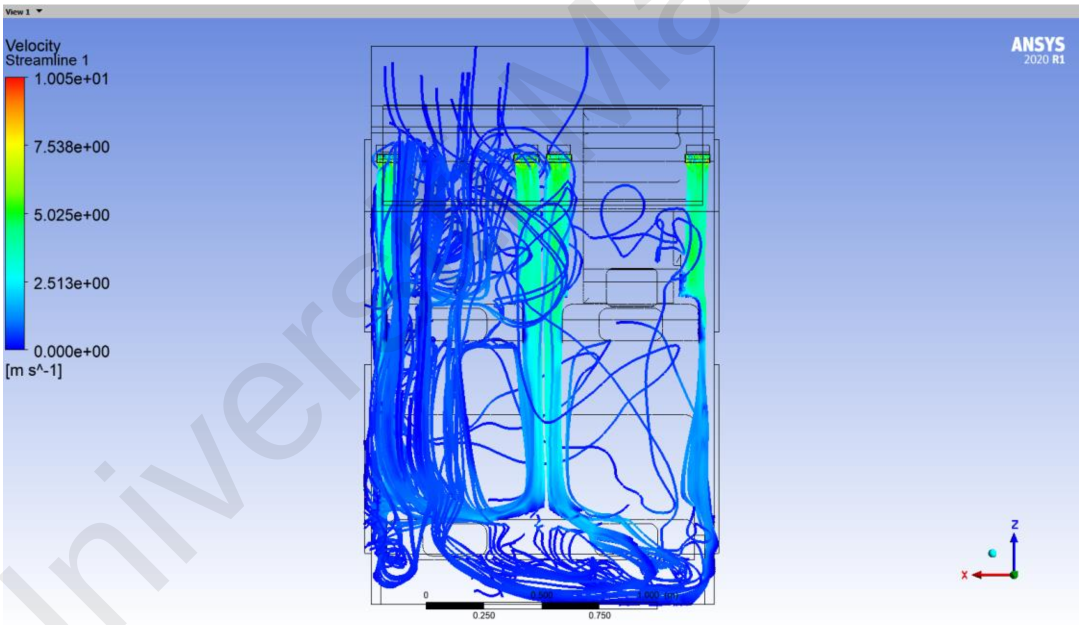

Figure 15: Velocity Stramline of simulation for 1 passenger (standard louver position) (top view)

Based on Figure 14 & 15, the airflow flows hit to the sides of the front passenger's seat and distributed in a random manner after hitting the rear section of the car. In this situation, the louver position was not projecting the air flow towards the only passenger in the driver's seat.

5.2 Simulation Results for Two Passengers (Front Passengers)

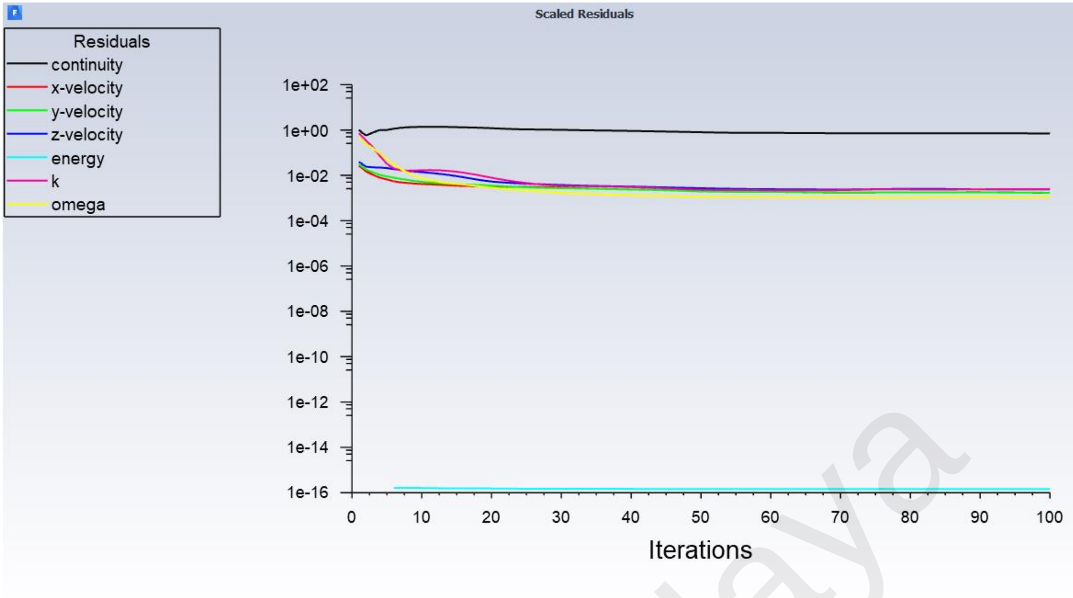

Figure 16: Residual graph for simulation of 2 passengers (standard louver position)

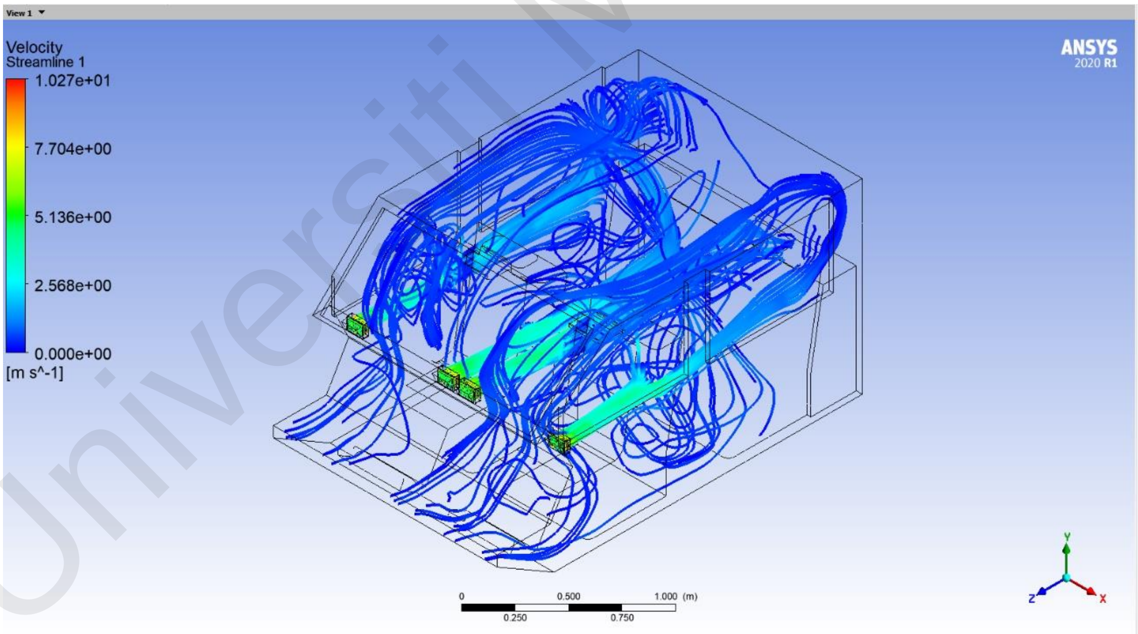

Figure 17: Velocity streamline of simulation for 2 passengers (standard louver position)

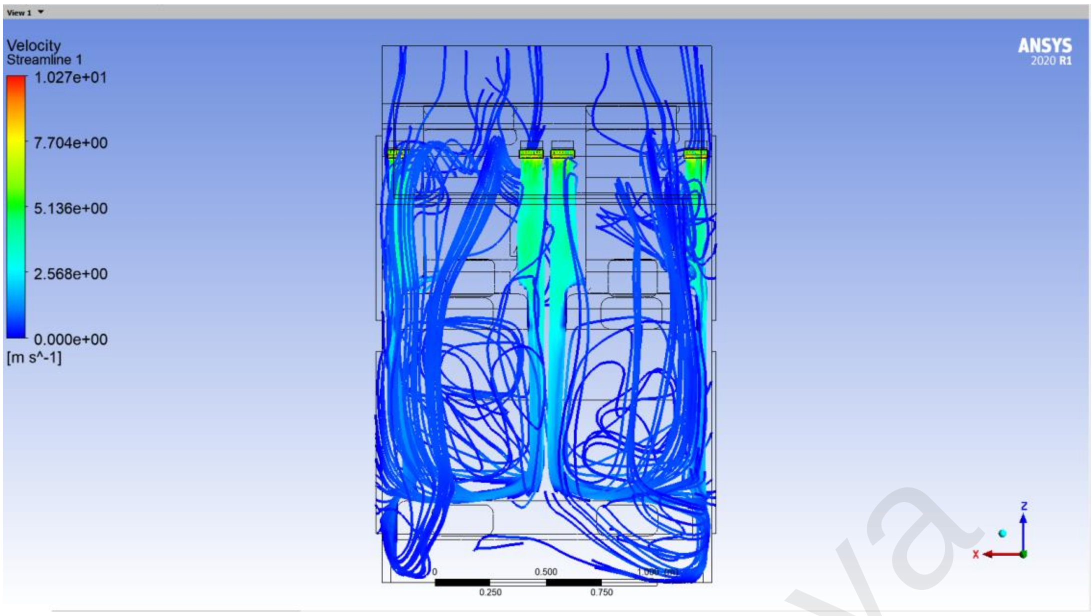

Figure 18: Velocity streamline of simulation for 2 passengers (standard louver position) (top view)

In Figure 17 & 18, the air flow has the same situation as the simulation for the one passenger. The air flow projects and hit to the sides of the two front seats. The flow is then projects in a random manner after hitting the rear sides of the car. In this situation, the louver position also unable to projects the airflow directly towards the two passengers in the front.

5.3 Simulation Results for Three Passengers

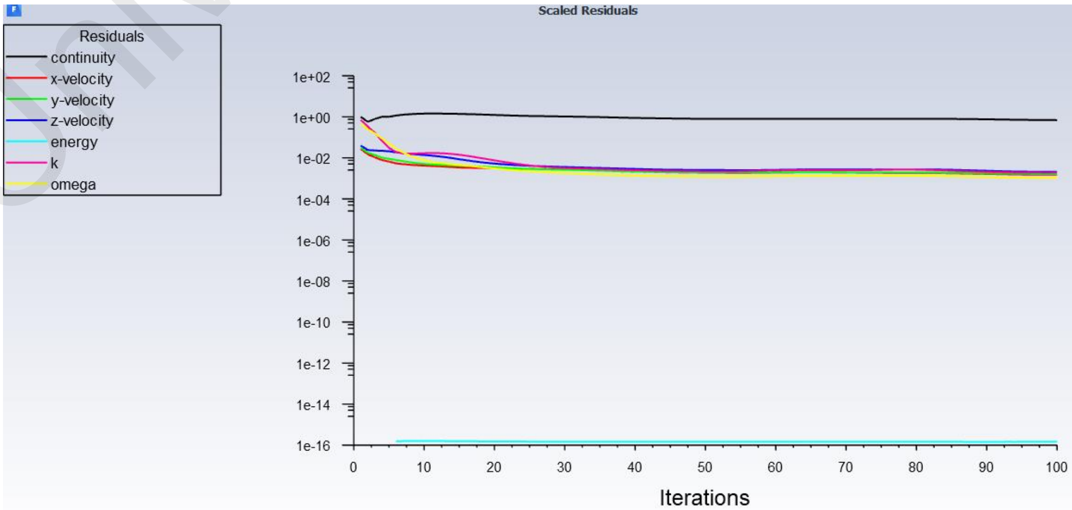

Figure 19: Residual graph for simulation of 3 passengers (standard louver position)

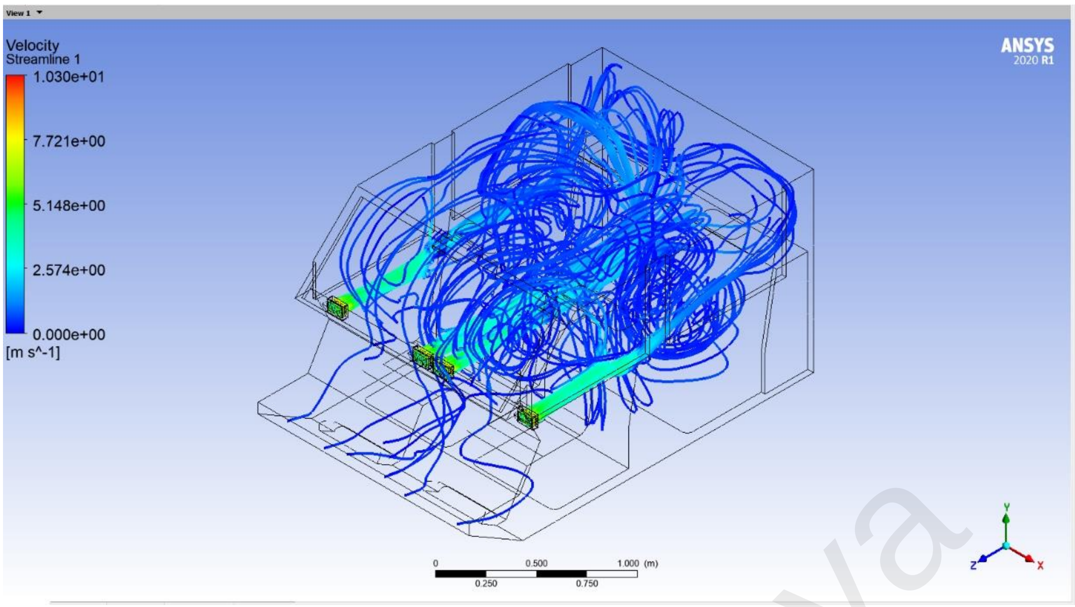

Figure 20: Velocity streamline of simulation for 3 passengers (standard louver position)

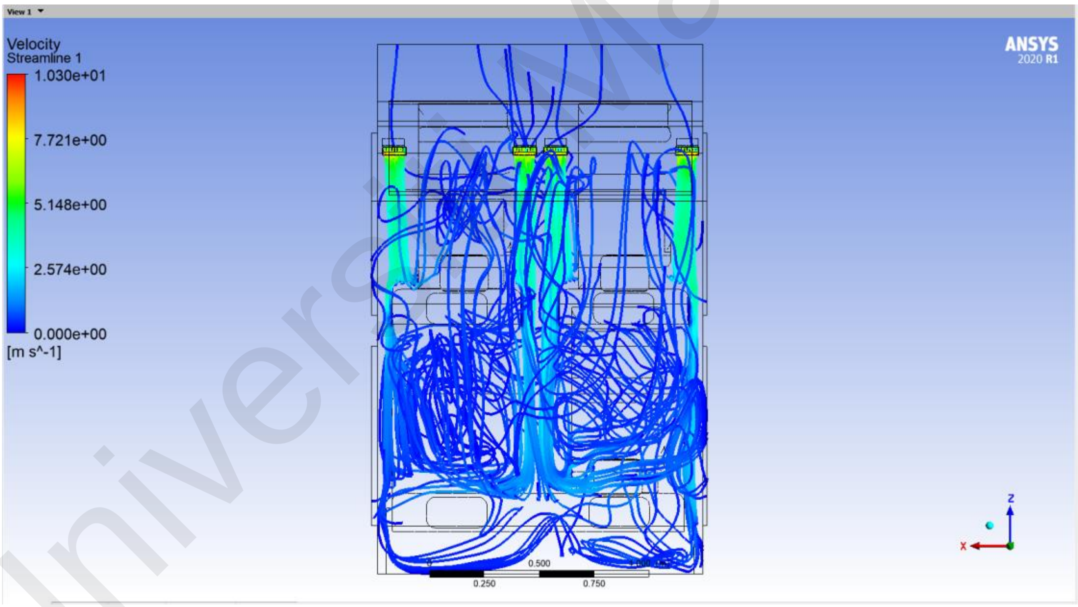

Figure 21: Velocity streamline of simulation for 3 passengers (standard louver position) (top view)

In Figure 20 & 21, the air flow projects the same manner as the simulation for one and two passengers. However, the third passenger at the back seat was able to receive an airflow on the passenger's arms and shoulder. Further adjustments on the louvers are required as it does not projects air flow to the two passengers at the front seat.

5.4 Simulation Results for Four Passengers

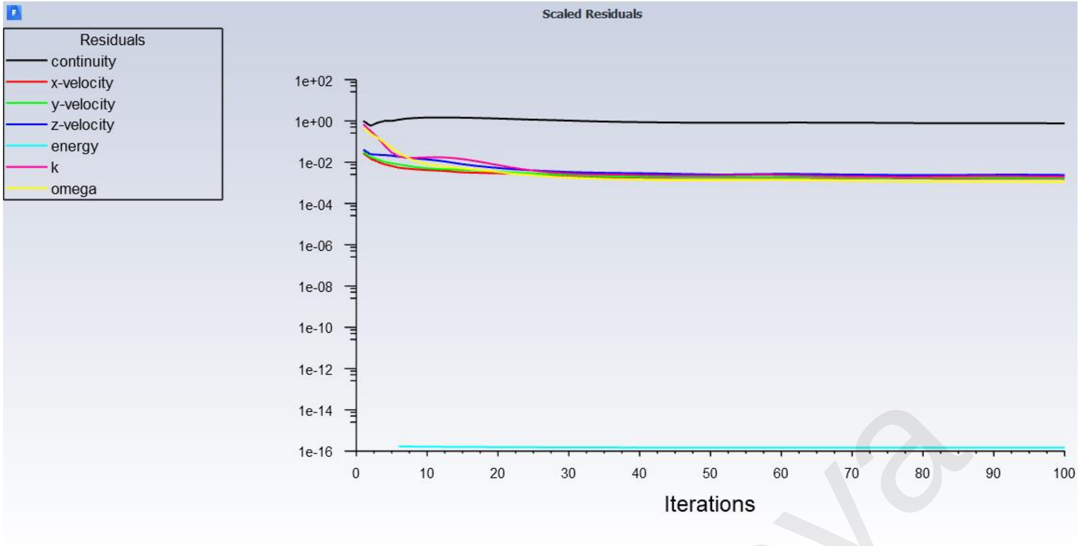

Figure 22: Residual graph for simulation of 4 passengers (standard louver position)

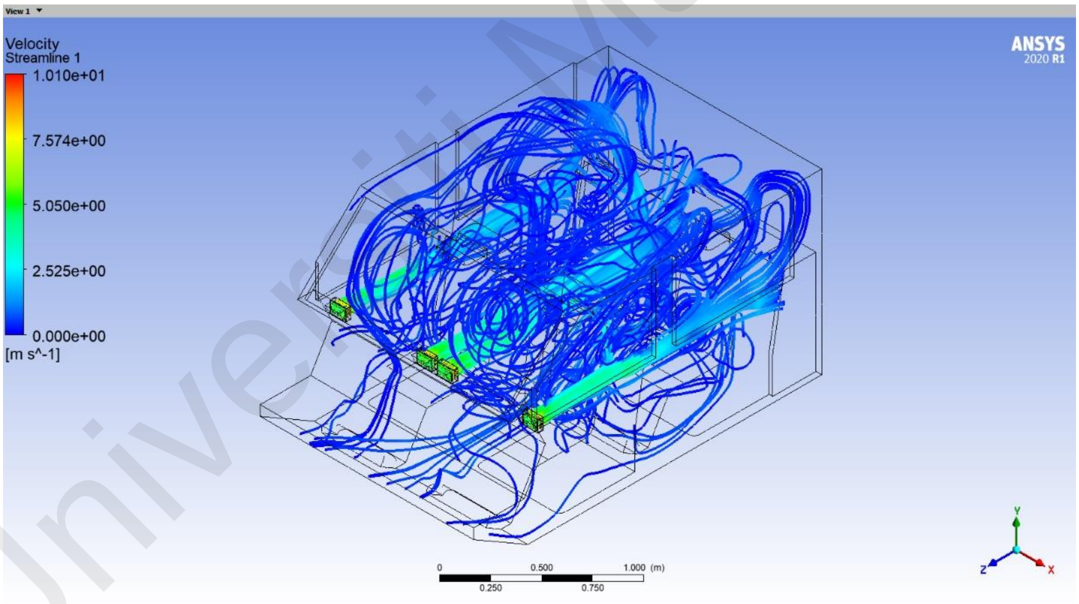

Figure 23: Velocity streamline of simulation for 4 passengers (standard louver position)

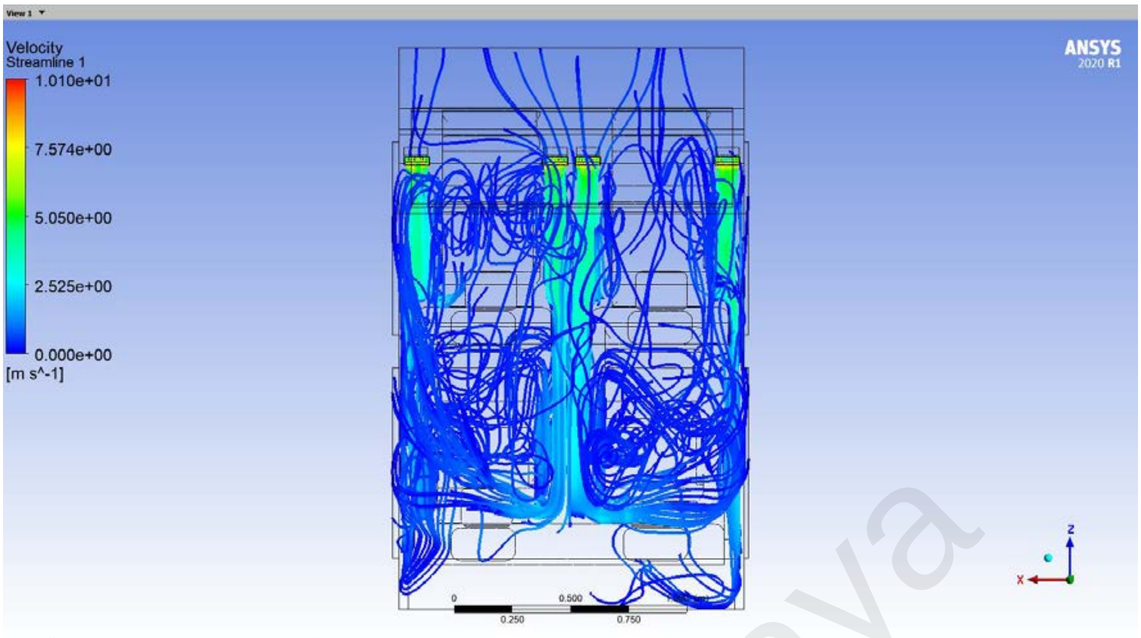

Figure 24: Velocity streamline of simulation for 4 passengers (standard louver position) (top view)

In Figure 23 & 24, the velocity streamline known as air flow projects the same as the simulation for one to three passengers. The air flow hits to the sides of the front seats and projects it to the passengers at the back seats. The louvers position satisfies most of the passengers mainly the rear seats.

5.5 Discussions

Based on the Results that obtained from the simulation, the airflow was unable to project directly towards the passengers as expected in a real-life situation. However, is case on simulation for four passengers, the louvers position projects the airflow almost evenly. It projects towards the passengers in the back seat and circulates to the front passengers. Thus, adjustments require to be made louver's direction for different number of passengers in the vehicle except for the 4 passengers due the flow is distributed evenly when the louvers are in the standard position.

5.5.1 Simulation results for 1 passenger with adjusted louver

For the 1 passenger, since the closest louvers to the passenger in the driver seat would be acon04 and acon03, I have adjusted louver acon04 30 degrees towards the right, acon03 30 degree towards the left, both facing the direction towards the passenger at the driver's seat. The simulation is shown as follows:

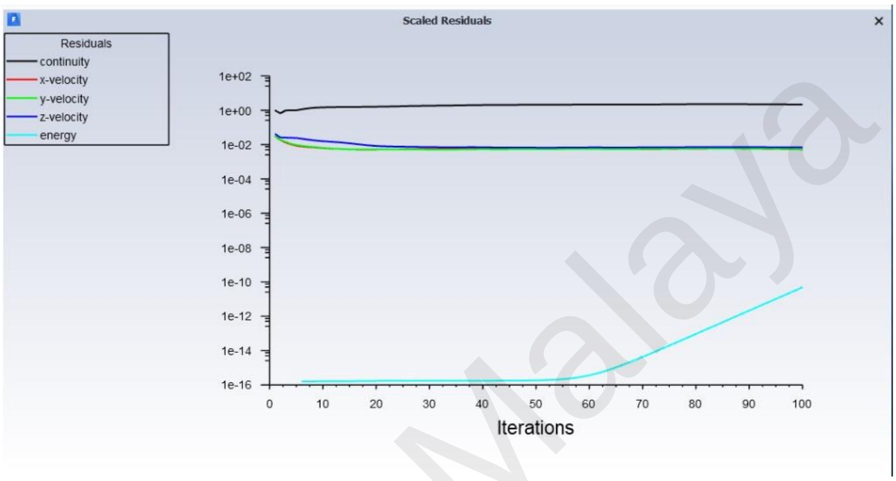

Figure 25: Residual graph for simulation of 1 passenger (adjusted louver position)

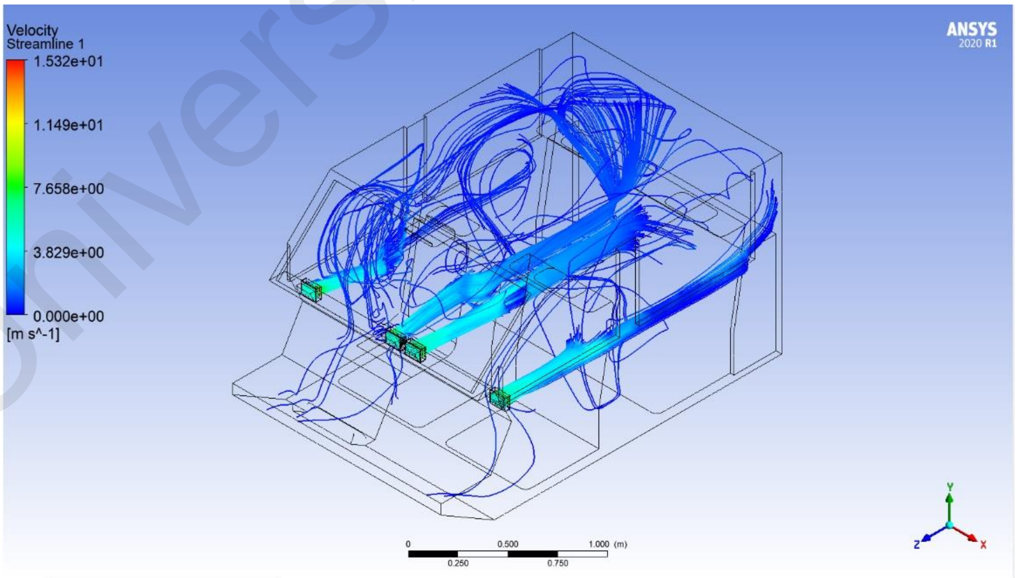

Figure 26: Velocity streamline of simulation for 1 passenger (adjusted louver position)

In Figure 26, the air flow from louver acon04 and acon03 projects directly towards the one passenger in the driver's seat, whereas the air flow from louver acon01 and acon02 projects the same, small amount hit the side of the front seat and remaining projects towards the back seat.

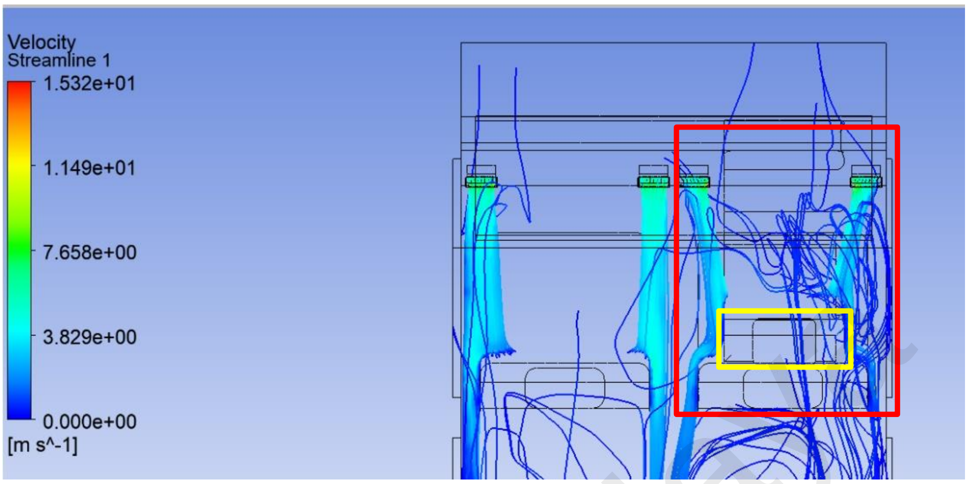

Figure 27: Velocity streamline of simulation for 1 passenger (top view) (adjusted louver position)

In Figure 27, we can clearly see that on the right which is the one passenger was able to receive significant amount of airflow towards him/her. The passenger is highlighted in yellow. Thus, this concludes the adjustment of the louvers was successful.

5.5.2 Simulation results for 2 passengers with adjusted louvers

After inspections on the simulation results before adjusting the louver, louver acon04 and acon02 must be adjusted 30 degrees towards the right; louver acon03 and acon01 must be adjusted to 30 degrees towards the left to satisfy the 2 front passengers in the car. The results are shown as follows:

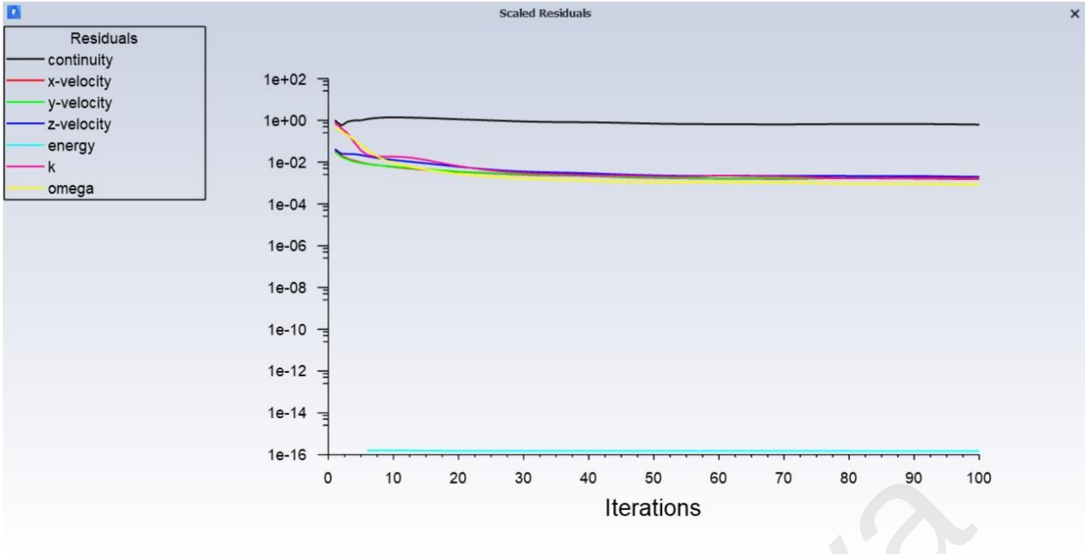

Figure 28: Residual graph for simulation of 2 passengers (adjusted louver position)

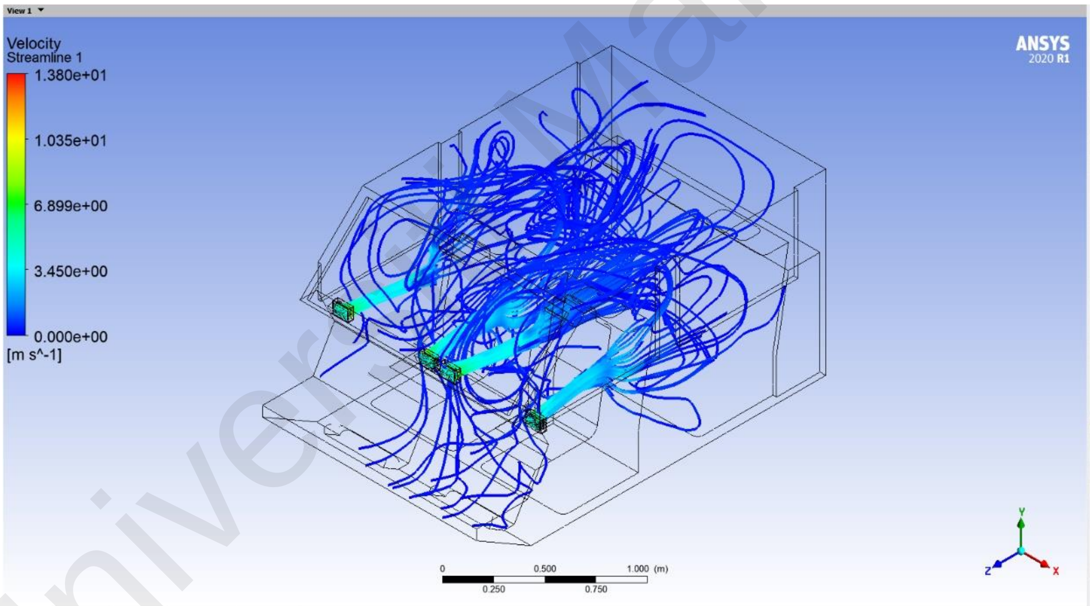

Figure 29: Velocity streamline of simulation for 2 passengers (adjusted louver position)

In Figure 29, the louvers adjustment successfully projects the airflow towards the two passengers. The louver acon04 and acon03 project the airflow directly towards the passenger in the driver's seat on the left whereas the louver acon02 and acon01 projects the airflow directly towards the second passengers on the right.

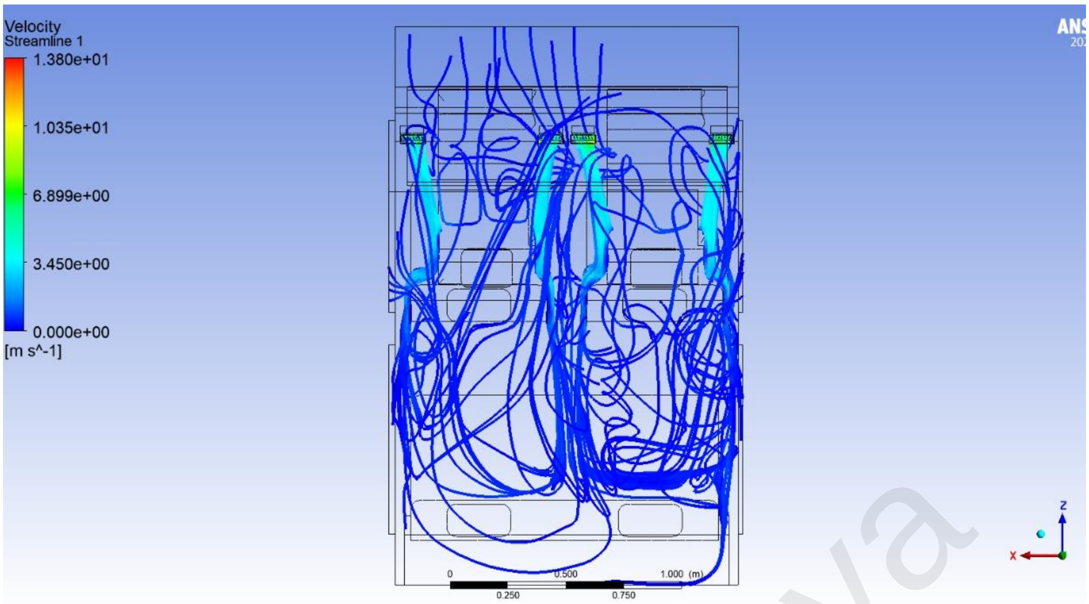

Figure 30: Velocity streamline of simulation for 2 passengers (adjusted louver position) (top view)

In Figure 30, with the top view, we able to observe the projection of air towards both passengers. The airflow is then going to the sides of the passengers and projects towards the back seats.

5.5.3 Simulation results for 3 passengers with adjusted louvers

For 3 passengers, louver acon04 remains in standard position to satisfy the 3rd passengers at the back seat. The louver acon03, acon02, and acon01 are all adjusted in an angle of 30 degrees towards the left. The initial simulation for 3 passengers, the 3rd passenger is positioned right behind the driver's seat. The results are as follows:

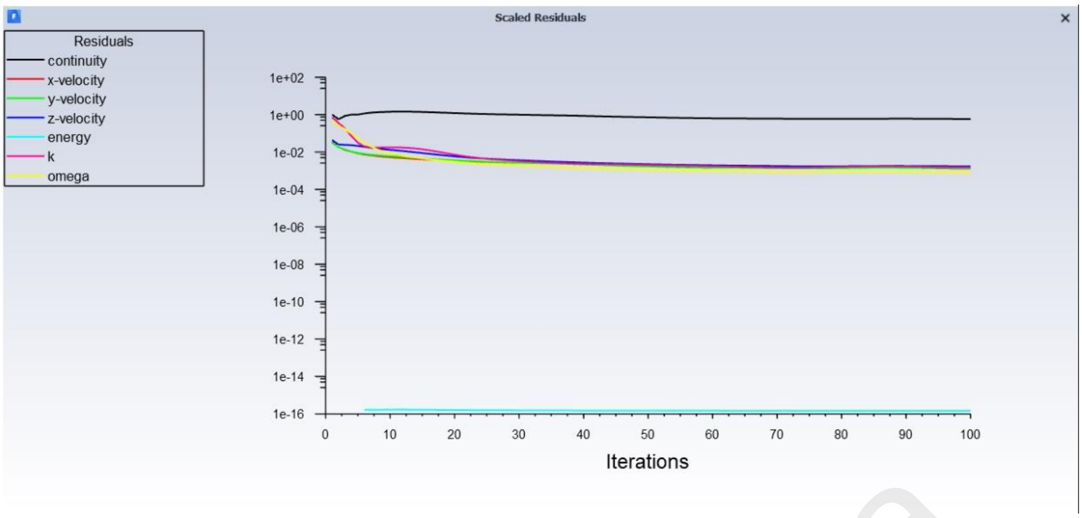

Figure 31: Residual graph for simulation of 3 passengers (adjusted louver position)

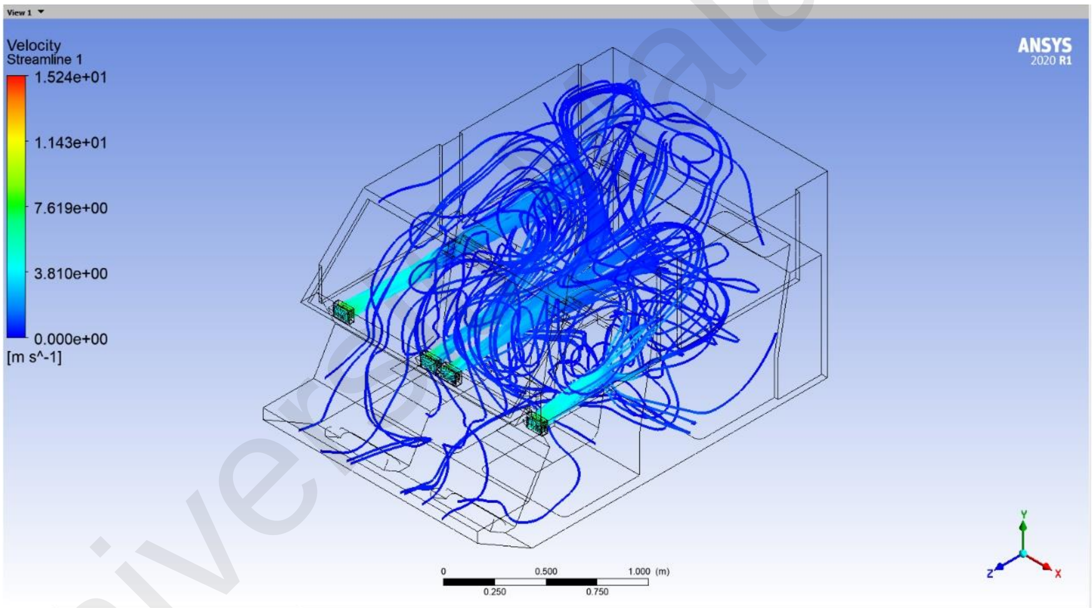

Figure 32: Velocity streamline of simulation for 3 passengers (adjusted louver position)

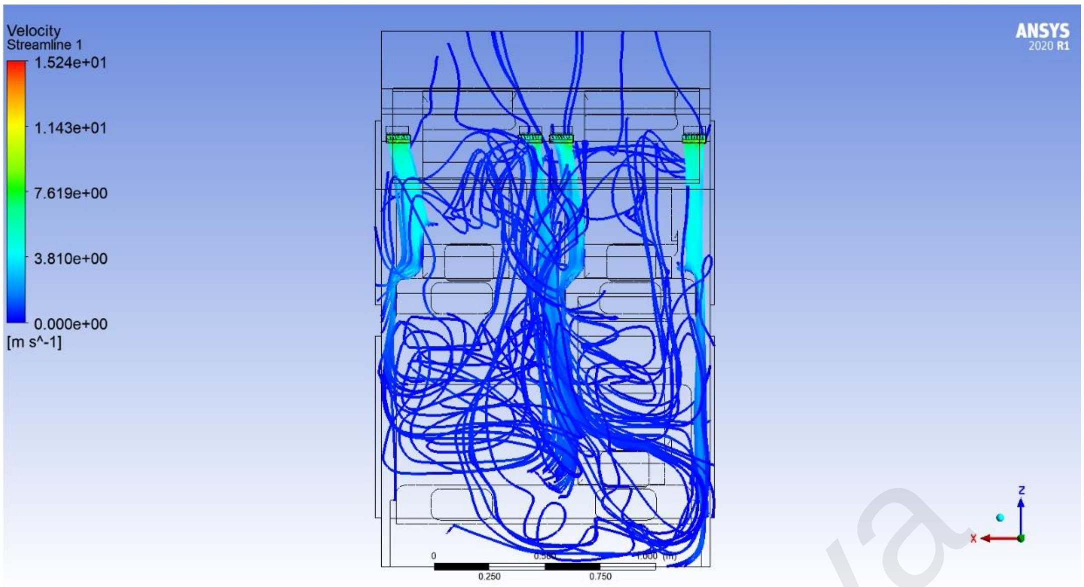

Figure 33: Velocity streamline of simulation for 3 passengers (adjusted louver position)

In Figure 32 & 33, the airflow from louver acon01 is hitting the passenger on the right; the airflow from louver acon02 projects directly towards the back seat passenger; the airflow from louver acon03 projects directly towards the front passenger in the driver's seat on the right; and airflow from louver acon04 projects directly to the back seat, giving the circulation through the right side of the car and hits the passenger at the back seat.

5.6 Table of simulation results before and after adjusting the louvers

Table 1: Simulation results summary of before and after louvers adjustments

Number of Passengers	Simulation without changing louvers position	Simulation with louvers position adjusted
One passenger (driver's seat)	Airflow projects to the sides of front passenger seats, minimal airflow collides onto the sides of the front seat. No impact on the passenger.	Airflow projects to the passengers from the adjusted louvers, bounces off then collides to the rear of car interior.
Two passengers (front seats)	Airflow project to the sides of front passenger seats, minimal airflow collides onto the sides of the front seat. No impact on both passengers.	Air flows from louver and project directly towards the two passengers, bounces off and flows to the rear of the car interior.
Three passengers (front seats and back seat on the left)	Air flows to the sides of front seats, minimal airflow collides onto the sides of the front seat. Passenger at the back seat receives the minimal amount of airflow	Airflow from acon01 and acon03 project directly towards the two front passengers; airflow from acon02 and acon04 projects to the back seats, directly collides onto the passenger at the back seat.
Four passengers	Air flows to the sides of front seats, then collides to the passengers at the back, circulating in the car interior back to the front.	No changes made as the louvers position evenly satisfies four passengers in the car.

CHAPTER 6: SCHEMATIC DIAGRAM OF THE INTELLIGENT LOUVER

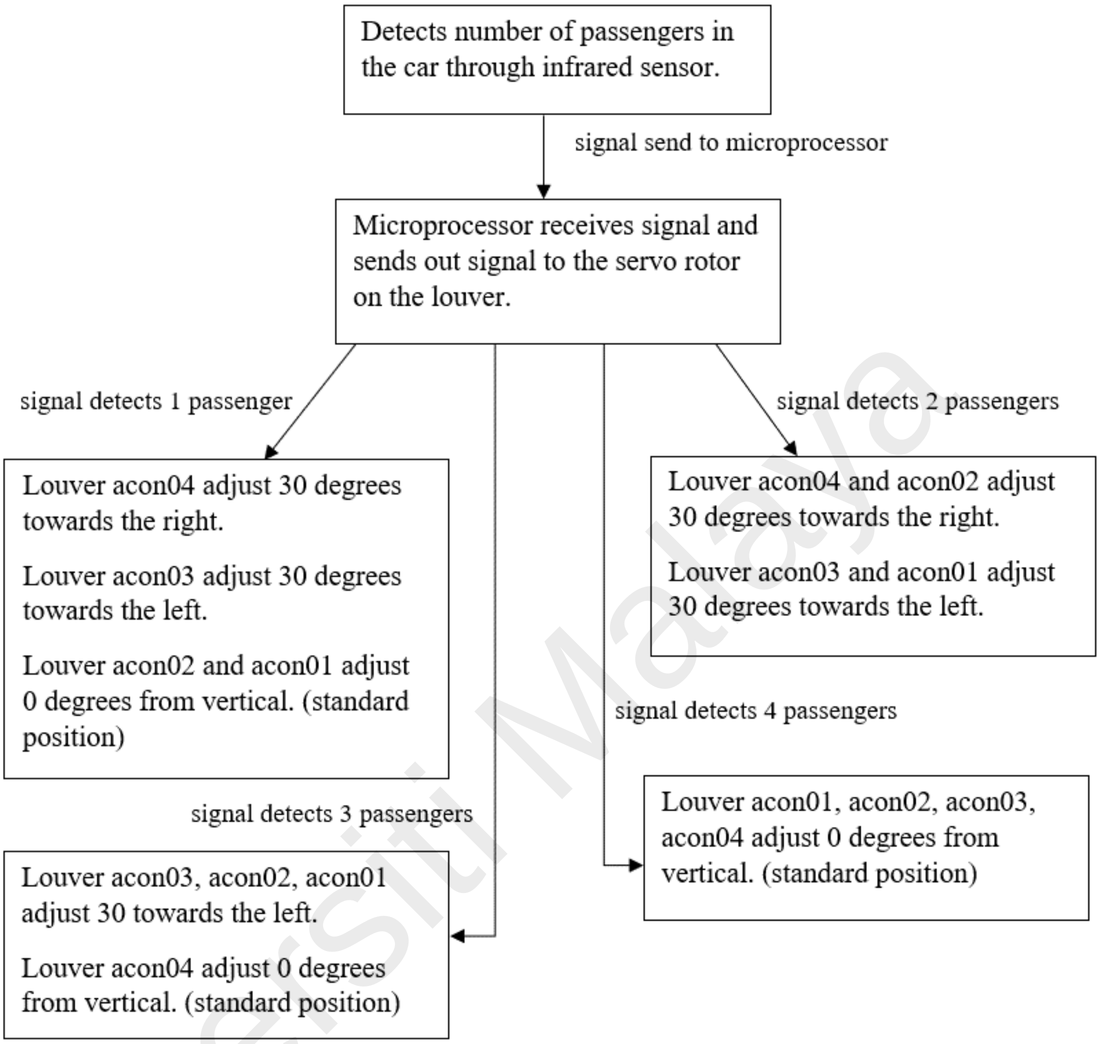

Figure 34: Schematic diagram of intelligent louver control

Figure 30 shows the schematic diagram of how the louver will interact with the assistance from infrared sensors and servo motor integrated to a microprocessor. On the seat belts on each passenger's seat, the infrared sensors are attached so that when the passenger ties up the belt, the infrared sensor will be in the chest area on the passenger, retrieve signal and sends to the microprocessor. The microprocessor is programmed to identify the number of input signal received from the infrared sensors and sends out command to rotate the servo motor on each louver.

CHAPTER 7: CONCLUSION

When the sensor detects one passenger on the driver's seat, the louver acon04 adjust 30 degrees towards the right facing the passenger; louver acon03 adjust 30 degrees towards the left. The adjustment is done by rotating the servo motor that is attached to the louver blades. Louver acon02 and acon01 remain 0 degrees from vertical direction (standard position).

When two sensors at the front passenger seats are triggered, louver acon04 and acon02 will rotate 30 degrees towards the right, whereas louver acon03 and acon01 adjust 30 degrees towards the left from the vertical direction. For 3 signal inputs from the sensors, louver acon03, acon02 and acon01 rotate 30 degrees towards the left, allowing the air from louver flows directly towards the three passengers as shown in the simulation.

Lastly, for when all four passengers occupied the seats, all four louvers will remain zero degrees from vertical direction, projecting airflow and circulate in the car.

In conclusion, having the intelligent louver that auto-adjust based on the number of passengers a car removes the hectic for the passengers to adjust them manually. With the integration of the microprocessor and sensors, passengers only have to tight their seat belts and the louvers will do their job, adjusting to satisfy passengers needs of airflow.

Future directions for this research would be build the prototype louver model and install into the car. The real-life experiment maybe differs to the simulations results shown as it has many uncertain variables involve in the experimentation.

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