A FINITE ELEMENT ANALYSIS OF VENTILATION SYSTEM IN THE TWO STROKE MARINE DIESEL ENGINE WORKSHOP

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Abstract

The study focused on to identify and determine the levels of thermal comfort and air ventilation in the workshop 2-stroke marine diesel engines, the Department of Marine Engineering, Ungku Omar Polytechnic. On site scientific measurement approaches have been carried out for data collection. Three-dimensional model of the workshop was analysed using finite element method. Experimental studies on the workshop building based on two elements IAQ; thermal (temperature) and indoor air quality (air movement). Experimental results obtain will be compare with Code of Practice for Indoor Air Quality 2010 and ASHRAE Standard 62.1 (2007): Ventilation and Acceptable Indoor Air Quality has stipulated details of minimum requirement with maximum limit for potential Indoor Air pollutant. The result showed that the local ventalition system in workshop could not reduce the surrounding temperature into ideal temperature according to ASHRAE Standard.

Keywords: Air Velocity, Ergonomic, Finite Element, Thermal Comfort.

1.0 Introduction

Indoor air quality in a hot and humid climate country is a new issue especially in Malaysia. Limited data is available on the general understanding about present indoor air quality of Asian regions especially for office buildings. It is also important that indoor air quality be given more attention and further studies be conducted to assess the indoor air quality. Besides, the office building in academic institution in Asian region can be very different from those in cool climate region. Investigation of air quality at office building may be useful to characterize and for subsequent implementation of corrective measures if necessary. In workshops 2-stroke marine diesel engines, perfect working conditions is one of the main factors determining the level of safety and comfort while working. Air quality in the workshop influenced by high temperature levels emitted from the combustion process in diesel engines. Ventilation plays an important role in providing comfortable working conditions and productive. There are three main factors affecting thermal comfort, the air temperature, air velocity and air humidity levels. Internal air flow in the workshops that are affected by air distribution system, the design of the building, the external environment, the presence or the activities of people in the workshop, and many other factors. Convenience factor is one of the key factors in technology heating, ventilation and air. The level of comfort is closely related to the control of temperature, humidity, air movement and heat radiation levels which interact with the residents. Odor, dust (particles), noise, vibration are other factors that can affect the discomfort. A heating, ventilation and air ambiance they are able to manage the factors within the limits set by the user, building regulations and consideration of better engineering. While not of environmental factors such as clothing and the level of human activity should also be considered.

According to The American Society of Heating, Refrigerating and Air-Conditioning Engineering, Inc. (ASHRAE, 1999) defines that the indoor air quality as air is allowed where there is no concentration of pollutants as dangerous as defined by the authorities and by a large majority (80% or more) of people exposed do not express dissatisfaction. When designing and analysing systems of heating, ventilation and air conditioning, engineers and scientists generally have a limited three tools to study the internal air flow patterns, analysis model, full scale or small scale model. Model analysis is usually limited by the need to facilitate the assumption and easy configuration. Full scale measurements can provide reliable data, but it is the most expensive and difficult (or mostly impossible) to implement. Extrapolation of the data of small-scale model to the actual size of the room or building is limited by the scale of difficulty. Finite element method seems a common and accessible method, but it also faces a number of challenges. For the use of finite element method for indoor air flow, the challenges include physical modelling of flow including turbulence, state boundary conditions are realistic, which represents the geometry of a complex and developing accurate and efficient numerical algorithms.In addition, indoor air quality study using is wider, because the simulation program is able to provide accurate information on factors that include the distribution of flow and focus. Some ventilation efficiency index has been proposed and studied with the help of finite element method. The use of finite element method to simulate environmental problems and the building has been in existence for over 20 years (Zhang et al., 2006). Finite element method is able to simulate the patterns of air flow, thermal comfort and indoor pollutant concentration distribution at low cost. This technique allows the depiction of environmental problems, and simulation that represents a powerful tool to motivate, guide and educate about the environment. Due to constraints in the experimental approach and improved performance and capabilities of today's computers, finite element method provides practical options for computing the airflow and pollutant distribution in buildings (Hayashi et al., 2002). A more practical approach is to allocate space in the room into a number of parts in volume or a virtual elements. Sub elements normally do not have a solid border; Instead, this border is a border open to allow gas to flow through the surface-bound (John et al., 2001).

However, this study focused on the effect of the changes taking place in the workshop 2-stroke marine diesel engines when applying a new ventilation system in the workshop. Modelling the workshops will be undertaken before the process is for the level of effort and the effort level after the process is done. The planned model has been used for numerical simulation. For the model workshop before the level of effort applied, the ventilation system is naturally where the level of the ceiling lattice spacing of 1m workshop is generated. As for the model after the level of effort on the run, there are a ventalition system that was introduced at the ceiling height of 2m workshop. There are two main door which is the main input elements in both models. The study was done by 2 height of 1.6m height from floor level and at a height level and the exhaust fan 1m and 2m from the ceiling level workshops. Current operating activities 2-stroke marine diesel engines, the heat and smoke generated in the combustion process is composed mainly of nitrogen, oxygen, carbon dioxide and water vapour with smaller quantities of carbon monoxide, oxides of sulfur and nitrogen, and hydrocarbon materials not burned. Previous studies about thermal comfort in a workshop for marine diesel engines 2-stroke Politeknik Ungku Omar was conducted by Shahril (2010). This review is mostly focused only thermal comfort and concluded that marine diesel engines in the workshop uncomfortable with day temperatures between 26 ° C to 32 ° C with carbon dioxide gas content at a high level. The study also concluded that the level of thermal comfort is very hot. This study is focused on a study to determine the level of thermal comfort through the measuring device and according to ASHRAE standards without considering any air flow pattern analysis or simulation, CFD and less focus on ventilation and indoor air parameters. According to previous studies, most studies of thermal comfort is based on the properties of indoor air flow. Therefore, the analysis of finite element simulation must be made to understand the relationship.

2.0 Methodology

The finite element method was used to investigate the patent of air flow or wind flow in the workshop 2 -stroke marine diesel engines. Since this method assumptions or value closest to the actual value, then the need to ensure that the data collected is valid and should be embraced by simulation program is used as a research tool. Confirmation of this can be done by comparing the results from the simulation software with ASHRAE standards and research for the ventilation in the workshop. To compare the results of the simulation software, the analysis of the thermal comfort and indoor air quality can be run with a comparison with the corresponding index for the ventilation system . Flow chart in Fig. 1 shows the methods of research using the simulation software.

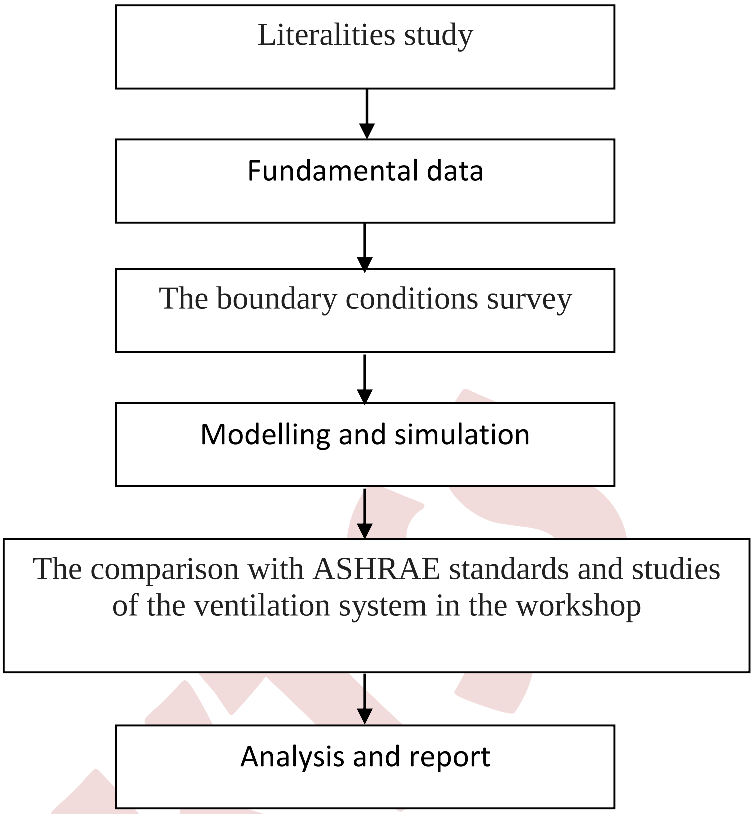

Fig 1 : Flowchart study

The study was conducted in workshop 2-stroke diesel engines. Activities carried out by the students in the workshop include the work of tracing pipe, measure the deflection of the shaft and measure the performance of the engine. When practical training conducted instructors and students will be directly exposed to a variety of free gas and noise resulting from the operation of some machinery or machinery to help when work on the operation of the engine and the air humidity and lighting environment that is acceptable to do the work. Therefore, students will often do the work of monitoring the temperature of the engine charger, blow through process, monitoring the upper cylinder lubrication will be performed by students. Internships run begins at 8:00 am and end at around 4.30 pm and run every week. But when the engine is operating, equipment or machinery to help the others will operate. With the situation will become warmer environment and noise levels will also increase which in turn will give the impression of discomfort to the occupants.

In this study , the measured parameters to assist in the analysis of the factors related to airflow and thermal comfort for students while doing practical work in the workshop were air temperature , globe temperature , air humidity and air velocity . In addition , the value of the level of noise generated by the main engine and auxiliary machinery was also measured and the lighting is measured in the vicinity of practical activities conducted. Other factors are also taken into account is the physical nature and experience in the marine field. Fig. 2 shows a flow chart of the method used to achieve the objectives.

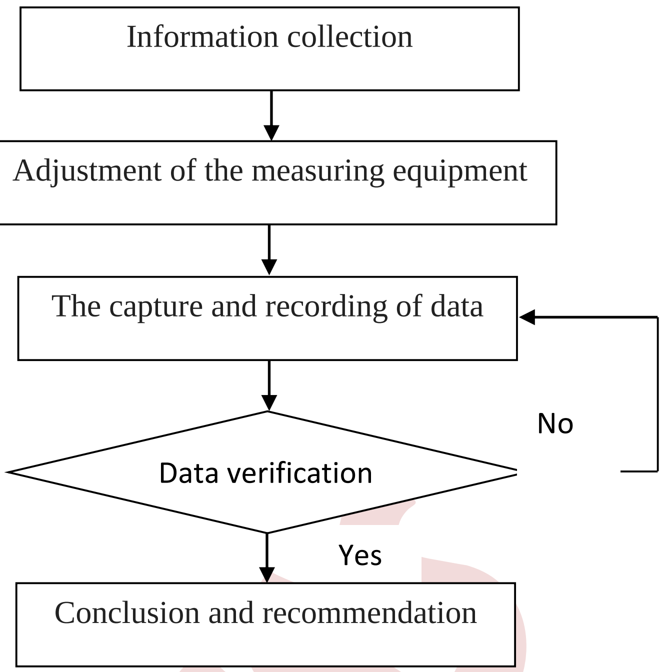

Fig. 2 : Flow chart study method

Before the actual study conducted, a preliminary study carried out for help and to determine the design of the study. Among the preparatory steps are conducting surveys at the beginning to workstation to identify the factors contributing to indoor air quality and noise in the workshop. A study to determine a point of reference to ensure proper placement measurement tool is the most strategic. Taking point location for data collection is referring to Table 1 to determine the minimum point of data collection points in the study. However, depending on the type and nature of the building, additional samples to be taken if it is deemed necessary

Table 1: The minimum number of sampling points suggested for assessing indoor air quality[1]

Total floor area (Equip with EVAC system) m^2	The minimum number of data collection point
< 3,000	1 per $500m^2$
3,000 < 5,000	8
5,000 < 10,000	12
10,000 < 15,000	15
15,000 < 20,000	18
20,000 < 30,000	21
≥ 30,000	1 per $1,200m^2$

Physical measurements in workshop studies are needed to explain the effects that affect indoor air quality and air velocity. The parameters measured using Thermal Comfort Tool Multi-station (TCM), "Casella CEL633-B Sound Level Meter" and "Advance Sense Toxic

Gas Monitoring System. Thermal Comfort Tool measurement Multi-station (TCM) is placed at a suitable location in the workshop adjacent to the area of research activities carried out for accurate data but certainly not interfere with or obstruct the process of practical activities. Fig. 3 shows the sealing tool measurement "Thermal Comfort Multi-station (TCM)" as used in this study. The study was conducted on a day where there are practical activities involving study workshops, and installed on time as early as 8.30 am to 4.00 pm. Although activity internship ended around 1.00 pm, the measuring equipment is allowed to continue to make measurements to observe changes in the parameters measured. The Thermal Comfort Multi-station (TCM) is recording data for time period with the same frequency for each reading interval of 5 minutes. During measurement, Thermal Comfort equipment Multi-station (TCM) are connected to notebooks and meter box to enable it to record accurate readings.

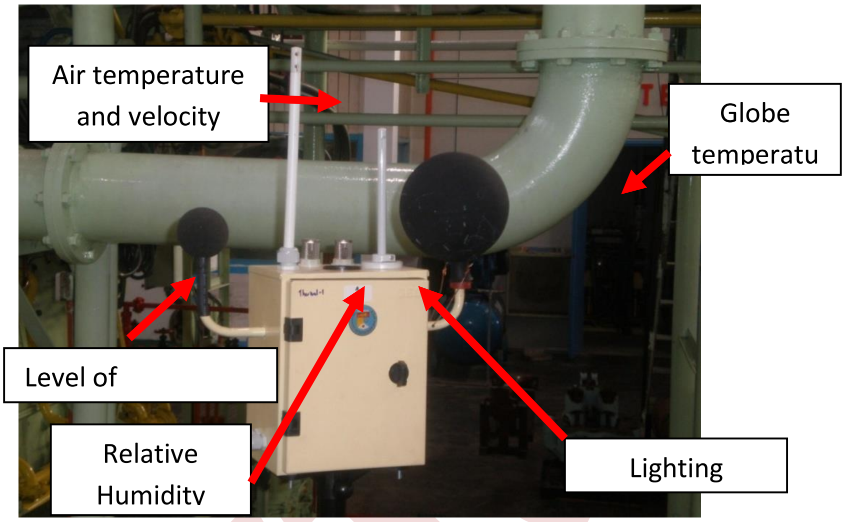

Fig. 3 : *Thermal Comfort Multi-station (TCM)* with the measures parameter.

This study is using a simulation software for modeling and simulate the heat distribution and air flow on the workshop. The simulation software is a computer software that allows the modeling and simulation of fluid flow, heat and mass transfer in complex geometries . It is characterized by high flexibility when performing grafting or meshing process which is a process that is crucial in the analysis of complex geometric shapes. The structure of the program shown in Fig. 4.

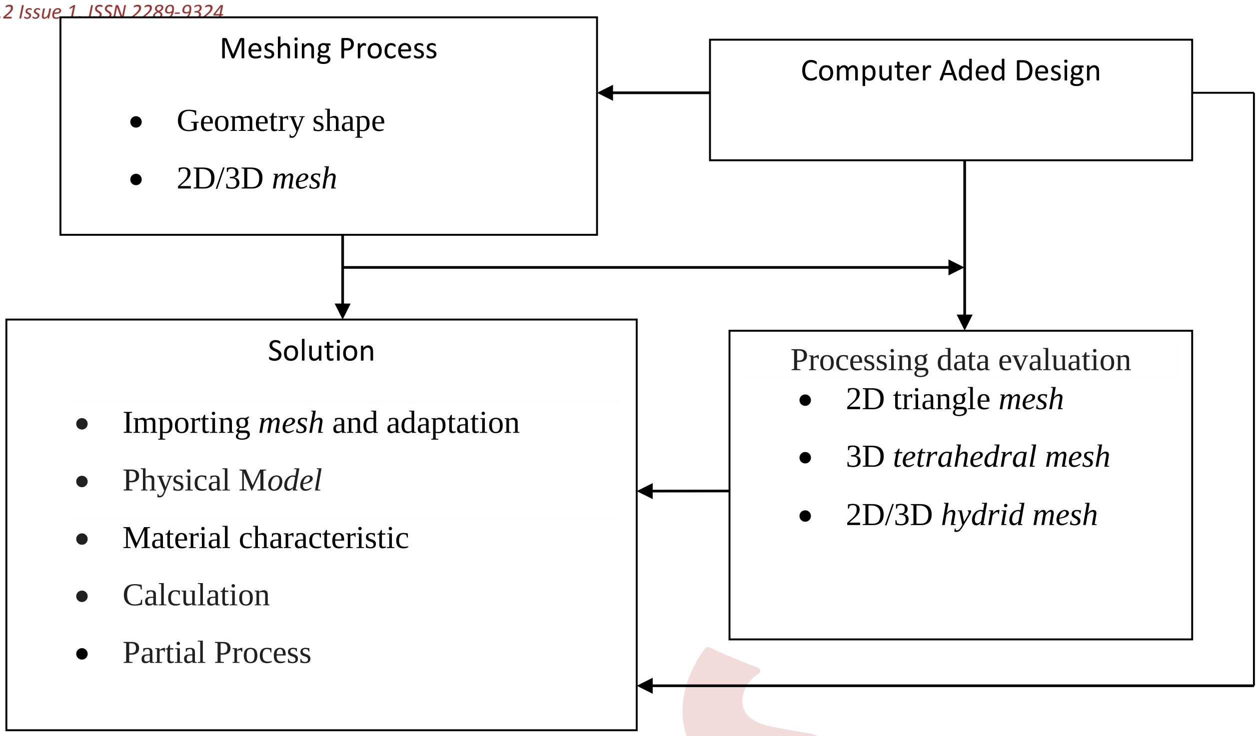

Fig. 4 : Structure software

Workshop model of the 2 stroke marine diesel engine is illustrated in Fig. 4. This model is a model diagram that has been used for Finite Element Method simulation. There are only two doors for ventilation in the model which uses push air into the concept . The length , width and height of the model is 21m x 1m to 8m height of the building is . Size fan exhaust is 1.5m x 1.5m . Both doors are 2m long and 2m wide.

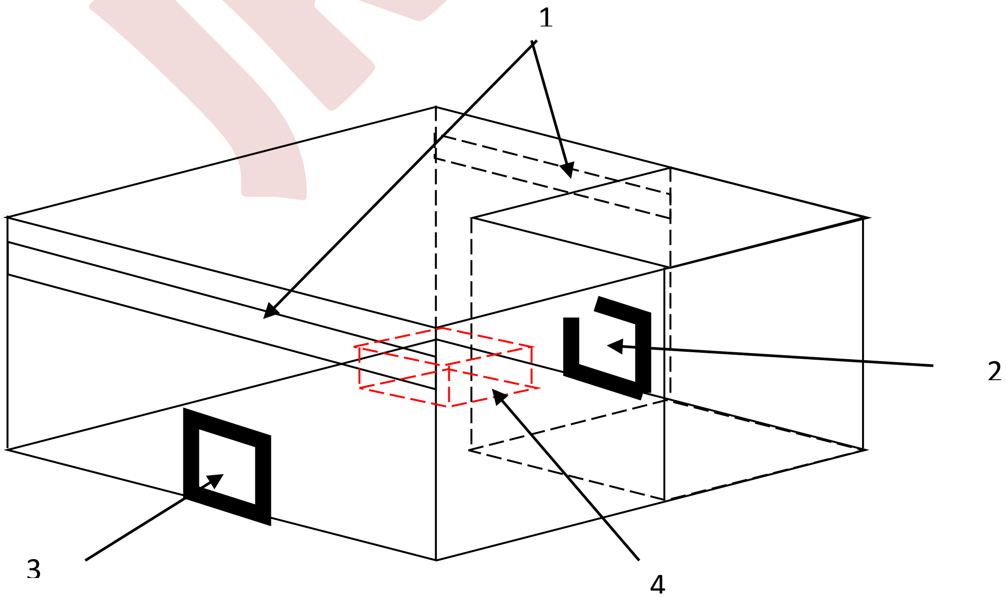

Fig. 4 : Sketch of a computerized simulation model analysis, lattice window (1), door 1 (2), door 2 (3) and heat source (4)

3.0 Discussion and finding

The 2 Stroke Marine Diesel Workshop is using natural ventilation system for the air to enter through the workshop entrance and going out through the window on the top (window lattice) walls of the workshop . This model is based on the comparison of results obtained with the standards issued by ASHRAE (Table 2) .

Table 2 : ASHRAE Standard[1]

No.	Parameter	ASHRAE Standard
1.	Temperature	20°C - 27°C
2.	Wind velocity	> 0.2 m/s

3.1 Simulation of heat flow with natural ventilation system in the workshop, y = 1.6m height from the floor in the XZ plane

The 3-dimensional model of 2-stroke diesel engine workshop has been developed to study heat flow generated from heat sources (2-stroke diesel engine) and air flow through the existing ventilation system which uses flow naturally. 2-dimensional model is able to present a clear and convincing data. The use of color can give a contour graphically direction of heat flow in the engine workshop 2-stroke marine diesel. The simulation program has been used to study and see how the flow of heat in the engine workshop 2-stroke marine diesel by using existing ventilation system. Fig. 5 shows the heat flow diagram represented by the contour colors show the flow of heat from the heat source 2-stroke diesel marine engines to the workshop environment.

In this simulation analysis, the main heat source are from the main diesel engine with the surrounding temperature in the workshop are at the constant room temperature. By considering the outside temperature of the workshop is also constant, there is no external temperature source from the workshop wall and roof in the simulation. In this simulation study, the limits of the border were identified and taken into account. The study starts at a height limit of 1.6m high levels indicate an average worker in the workshop 2-stroke diesel marine engines. The height limit is important to represent the heat received by workers and students when they make such activity during marine diesel engines, 2-stroke operation. It also shows the level of reception and the release of heat from the heat source of the heat engine 2-stroke marine diesel. (Fig. 5)

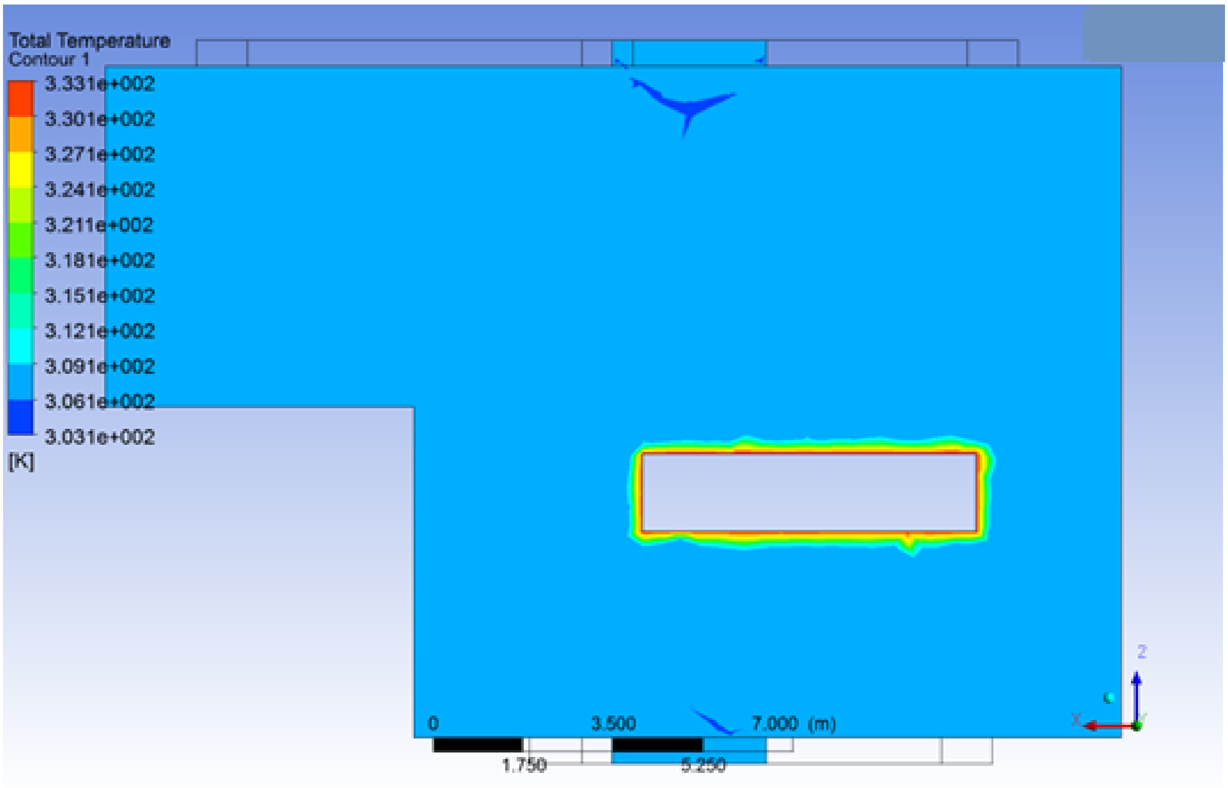

Fig. 5 : Heat distribution contour at plane x=0m, z=0m, y=1.6m from workshop floor.

Fig. 5 shows the contours of the temperature distribution on the wall, the heat source (diesel engine) and the air in the workshop. To study the thermal comfort in the workshop analysis of heat distribution is taken at a height of 1.6m (average high of Asian people). Fig. 5 shows that the temperature is slightly higher near sources of heat (1m from source of heat) and 1.6m above the floor. There are significant variations in temperature in the work area with the highest temperature are about 333.1K (59.95 ° C) and an average of 312k (38.9 ° C) on the other side the workshop. This is due to the high heat in the area. However there is a small area in front of the experienced minimum temperatures of 303K (29.9 ° C). This is because the region is a major route of entry of air from outside into the garage.

3.2 Simulation of heat flow naturally in the workshop , the height of 1m from the ceiling in the XZ plane

The height of 1m from workshop ceilings have also been taken or about 7m from the workshop floor . Had this height represents the movement of heat at the casement lattice which also is an important element in the natural ventilation system. Casement lattice is an outflow of primary air and heat inside the workshop, by studying the simulation at this height is important for assessing the effectiveness of air flow system than it is in helping the movement and controlling the heat in workshop. The uses of contour colors can give a clear picture and the right data to assess the movement of the air at the height of casement lattice. (Fig. 6)

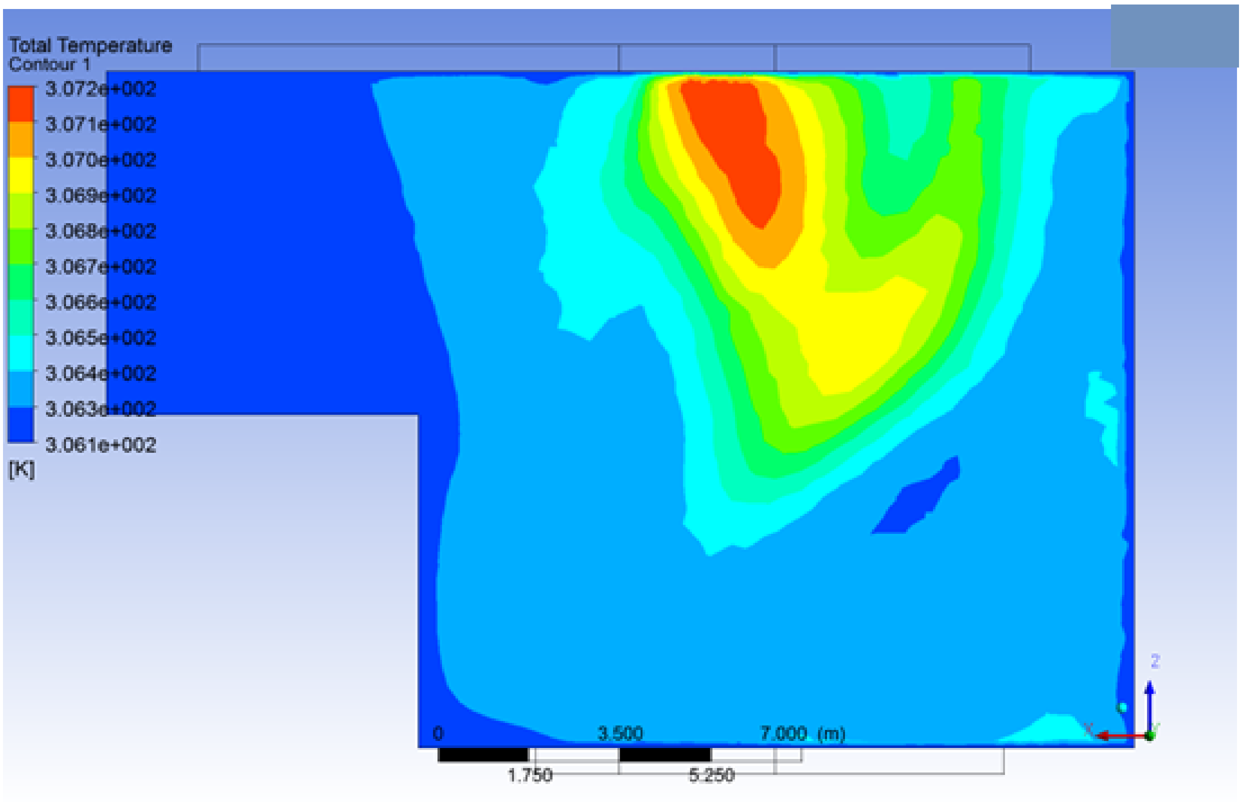

Fig. 6 : Heat distribution contour at plane x=0m, z=0m, y=7m from workshop floor.

3.3 Flow simulation of natural air ventilation in the workshop , y = 1.6m height from the floor to the XZ plane

The ventilation system in the engine workshop 2-stroke marine diesel is designed to assist the movement of air in order to ensure clean air in the workshop conveyed to the 2-stroke diesel marine engines of all time, this is because the combustion of marine diesel engines, 2-stroke can produce toxic gases besides carbon in the vicinity of a 2-stroke diesel marine engines. Exposure to toxic gases and carbon could contribute to discomfort and illness to workers and students who conduct activities in the vicinity of marine diesel engine workshop 2-stroke. In addition, a system of ventilation in the workshop 2-stroke diesel marine engine is intended to assist heat flow result from marine diesel engines, 2-stroke during the operation. An efficient of heat flow is able to bring in fresh air and convenient to the engine workshop 2-stroke marine diesel and warm air flows out of the workshop. The use infinite element method simulation program was conducted at the height limit of 1.6m from floor level to evaluate the air movement by using the existing ventilation system naturally. Use color contour can give a good picture of how fast the movement of air in the engine workshop 2-stroke marine diesel. (Fig. 7)

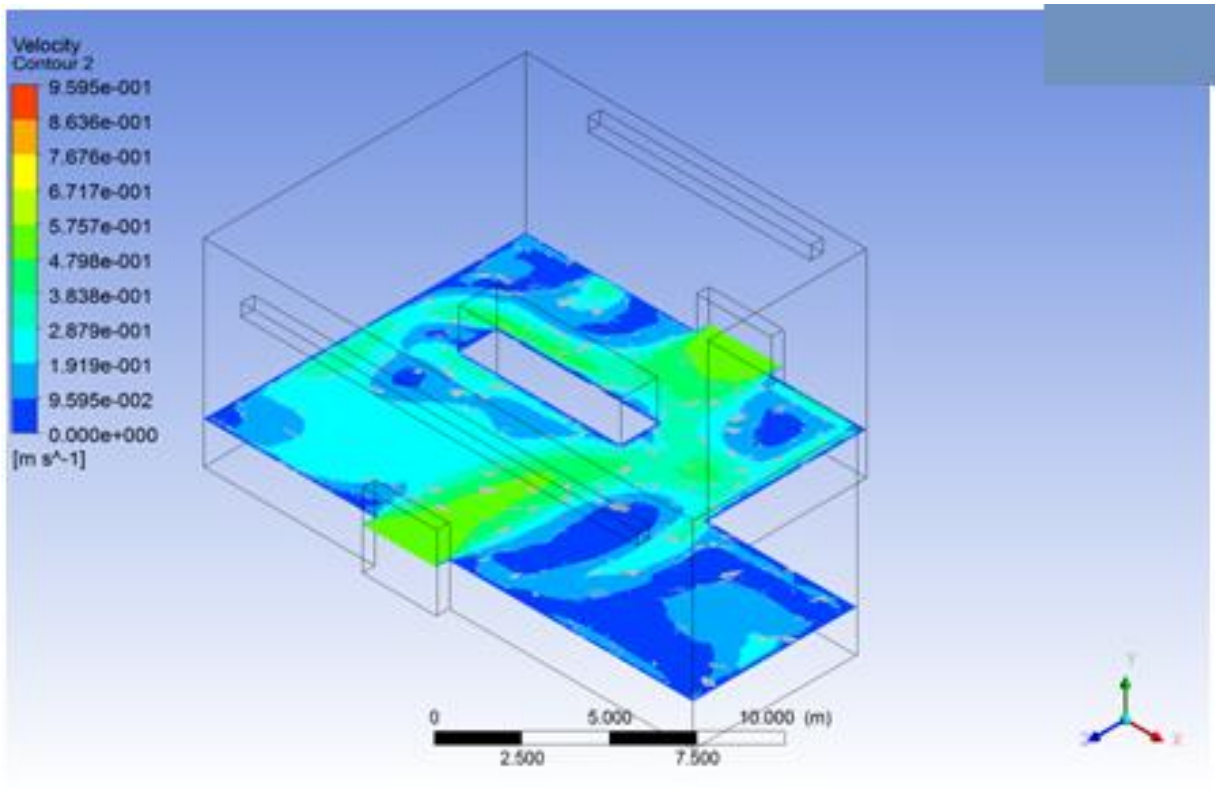

Fig. 7 : Air flow contour at plane x=0m, z=0m, y=1.6m from workshop floor

Fig. 7 shows contours of the velocity of air movement inside the workshop at the height y = 1.6m, shows that there are almost no movement of air velocity minimum 0.095ms-1 while the maximum velocity is 0.480ms-1.

3.4 Natural ventilation air flow simulation in the workshop , the height of 1m from the ceiling in the XZ plane

With the 1m height from the ceiling, the lattice window predetermined positions in Finite Element method simulation program for the movement of air in the vicinity lattice window height . There are two results of the data in the form of contour color and vector direction of air movement and air velocity at the height of the lattice windows. (Fig. 8 and Fig. 9)

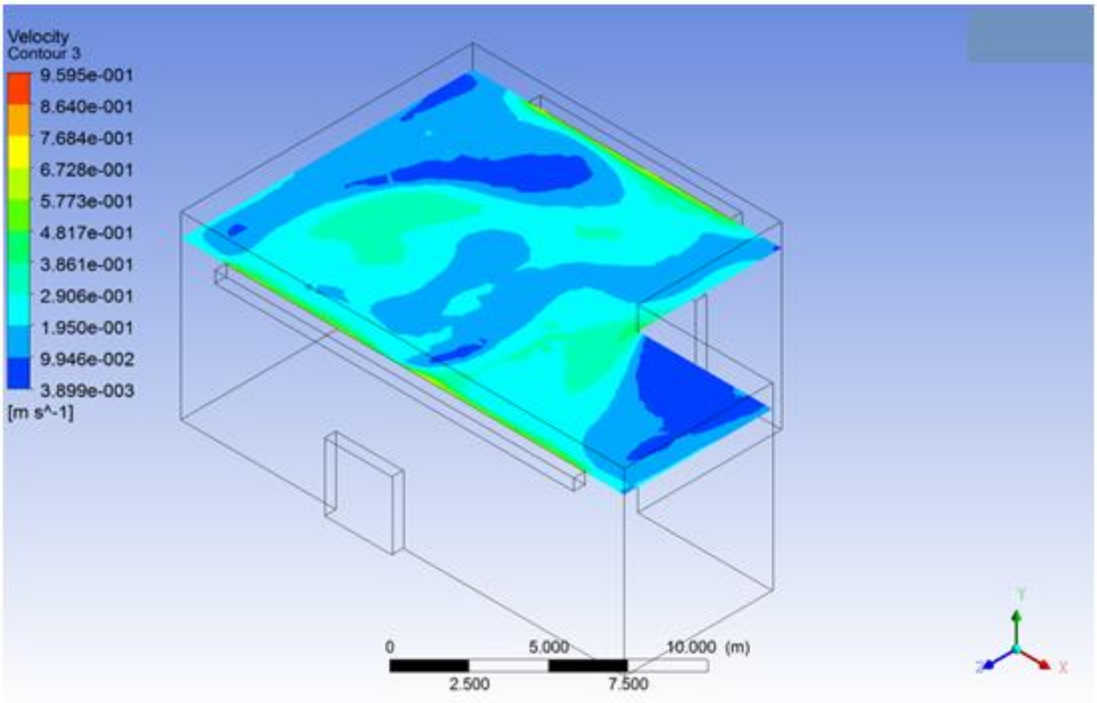

Fig. 8 : Air flow contour at plane x=0m, z=0m, y=7m from workshop floor

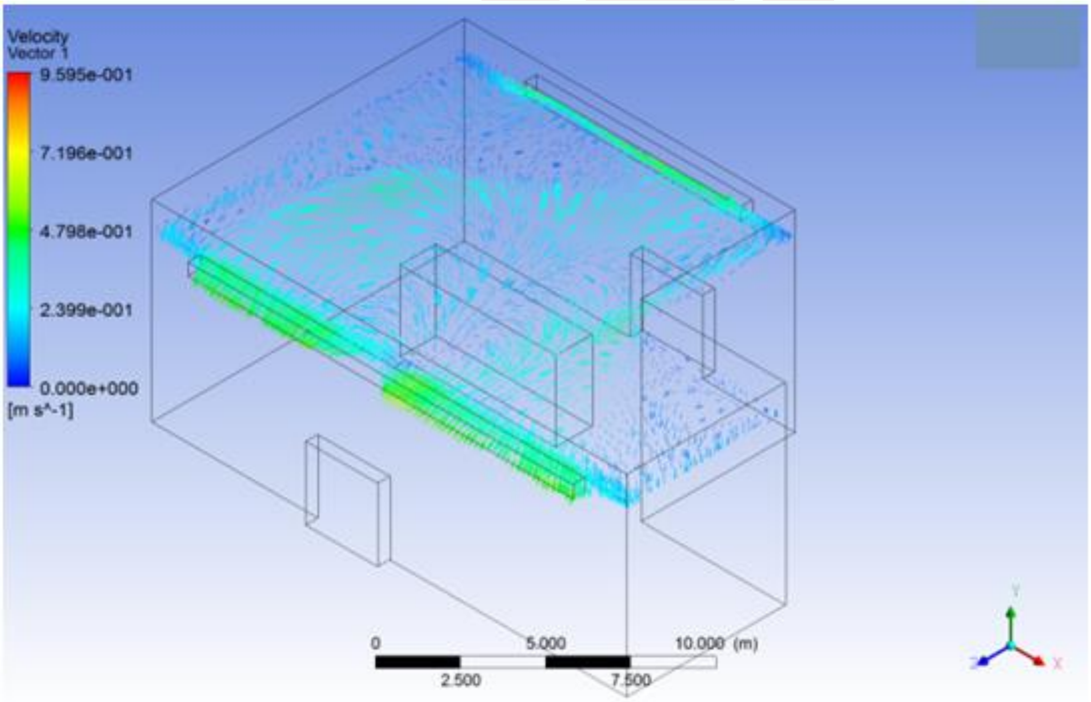

Fig. 9 : Air flow vector at plane x=0m, z=0m, y=7m from workshop floor

Fig. 7 and Fig. 8 shows the contour and the direction of the velocity vector the air at the height of 1m from the ceiling or floor level of 7m from the XZ plane, y = 7m. In this study, the consideration for the air flow in the main outlet and had been taken into account in the study. It shows that there are areas that have minimal air movement with minimum air velocity of 0.099ms-1 while the ideal air movement that applies only to the main air outlet air velocity of

0.768ms-1. However the temperature distribution is also found that the variation in temperature between 307K (33.9 ° C) and 306K (32.9 ° C).

3.5 Comparison from the data taken from the simulation with the ASHRE Standard

Revenue from data obtained through simulation program is then able to make a comparison and evaluation of the differences that apply to the distribution of heat . The difference is in the maximum value recorded in the engine workshop 2 -stroke marine diesel . The purpose of this assessment is to see the heat flow occurs at the existing ventilation system.

Table 3 : Comparison of the temperature distribution in the workshop with ASHRE Standard.

Location	Natural ventilation system (Temperature)	Differences the average value with ASHRAE Standard (27°C)
1. Breathing level : 1.6 m from floor (x-z,y=1.6m plane)	Maximum value : 333K (59.95 ºC) Average value: **312K (38.85 ºC)**	**11.85 ºC**
2. Lattice window level: 7 m from floor (x-z,y=7m plane)	Maximum value: 307K (33.95 ºC) Average value: **306K (32.85 ºC)**	**5.85 ºC**

The comparison of the results of the simulation analysis of the movement of air velocity between existing ventilation system with the ASHRAE Standard to be viewed in table 4. This distinction is intended to assess the effectiveness of ventilation systems and superbly integrated effort than the existing ventilation system. Comparative analysis of the simulations obtained with ASHRAE standards are meant to see the impact that can be had from the ventilation system in the effort to thermal comfort level in the engine workshop 2 -stroke marine diesel engine. A comparison will be undertaken refer to the ASHRAE standard air flow in the workshop is more than 0.2m / s to gain maximum value from existing ventilation system and ventilation system was at the level of effort .

Table 4 : Comparison of the air flow distribution with the natural ventilation systen in the workshop with ASHRAE Standard.

Location	Natural ventilation system (Air flow)	Differences the average value with ASHRAE Standard (> 0.2 m/s)
1. Breathing level : 1.6 m from floor (x-z,y=1.6m plane)	Maximum value : **0.480 ms^{-1}** Average value: **312K (38.85 ºC)**	**11.85 ºC**
2. Lattice window level: 7 m from floor (x-z,y=7m plane)	Maximum value: 307K (33.95 ºC) Average value: **306K (32.85 ºC)**	**5.85 ºC**

4.0 Summary

Finite element method simulation were carried out on a model representing two-stroke diesel marine engine workshop. By using this method, we can observe and compare the changes to the distribution of temperature and air flow conditions in the workshop when it is equipped with a natural ventilation system. The results of observations show that the temperature distribution for the workshop is still beyond the range of the level of thermal comfort guidelines specified by ASHRAE. However the simulation of models have also been developed for the use of the future study on to new ventilation system which have an impact on the flow conditions and reduce heat to a minimum internal temperature. For this study, we can conclude that, the natural ventilation system is has less impact on the circulation of the air flow and contribute minimum heat flow distribution in the workshop. This type of ventilation system is not safe in the confine space or in the space where machinery producing a harm full gases. A new ventilation system need to be propose in the future to help a better air circulation and heat displacement in the workshop.

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