OPTIMIZE AIR VENTILATION ARRANGEMENT USING CFD MODEL TO MAINTAIN THE ENGINE ROOM TEMPERATURES OF AN 8000 DWT GENERAL CARGO

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ABSTRACT

Ship’s engine room temperature will increase when all machineries are running. To evaluate whether ventilation system already produces sufficient air circulation then its arrangement has been modelled and simulate precisely by using Computational Fluid Dynamic Methods. Ducting arrangement complete with mechanical air blower varies in three combinations to maintain air inside engine room below 48°C. simulation result shows that alternative-3 is the best system that it is capable of keeping air temperatures between 35°C and 45°C.

Keywords: General Cargo, HVAC, Ship Ducting system, Computational Fluid Dynamics,

INTRODUCTION

HVAC is an important system onboard a ship to maintain human comfort and equipment safety. Inside the engine room, ventilation system may not be designed to give comfortability zone to the engineers but it is mostly to keep the engine room space temperatures not over than limit which is mandatory by Class Rules, 45 Celcius degrees. To achieve the requirements, it is necessary to design a good ventilation system consist of blowers and their ducting system. Ventilation system in the engine room is unique and be designed specifically to fit a certain ship. Therefore, it is need to be customized to perform the best system so that the air circulation not excessively moreover it will not less than the required. Excessive ventilation will cause not only in-efficiency of electrical energy but also may generate noise and strong hot air circulation inside the engine room, the worst when the quantity and direction of the air circulation cannot be spread evenly. Some cases reported that the engine room condition is hotter than Class requirement may not be caused by too low blowers capacity power, but it was caused by mis-design of the blower placement and ducting arrangement.

Based on the above point of view, this paper will report a study results in varying five types of ducting arrangement in an 8000 DWT General Cargo. On the five possibly variations therefore it will evaluate to determine which the most optimal system in order to keep the engine room temperature under Class requirement. A modern tool called Computational Fluid Dynamics will be adopted to modelling the ventilation system and run the results to get data of the optimal ducting arrangement.

METODHOLOGY

Literature Review as a first step carried out to evaluate and review previous research works and industrial products may already be installed onboard a ship.

Secondly, the supporting technical data and formulation are collect to be used during performs mathematical model, logical program, and use for validating the simulation results in the end of the modeling works, this consist of:

- Calculation of heating and cooling loads. It can be done by using formulas published on Journal SNAME Buletin 4-16, article *calculation merchant ship heating ventilation and air conditioning design*.
- Modeling air circulation on ducting system by using program computer named as ICEM CFD. Model validated by manual calculations.
- CFD Simulation works carried out by several processes as follow:
  - Modeling engine room and determined the surrounding
  - *Running setup*, *meshing*, then *running simulation. Running setup* is carried out to enter data which will be analyzed by using *solver CFD*. The data is the results of the total heat calculations which is absorbed by the air on the engine room space. *Meshing* is a process to mark nodes that later will be analyzed also by *solver* CFD. The results of the *running simulation by post-CFD* are in the forms of animation, table, and graphical materials.

Finally, conclusion of the works can be done by comparing all five simulation alternatives then evaluate their technical performances based on the effectivity and efficiency during distribute the air circulation inside the engine room. The simulation results useful to determine the best ducting system for the *General Cargo* 8000 DWT.

RESULTS AND DISCUSSION

Heat loads calculation by using reference Journal SNAME buletin 4-16:

1. Heat loads produced by *Main Engine*

   Heat transmission calculate using this formula:

   $$Q = 0{,}02\ N_e \times g_c \times Q_f \quad (1)$$

   The result is, Q = 106656 kkal/hour = 123839.47 watt (123,84 KW)

2. Heat loads produced by *Auxiliary Engine*

   Using similar formula, the result is 9599.04 kkal/hour = 11145.552 watt (11,15 KW) PACSTAR General Cargo 8000 DWT use 2 units D/G, then = 22.30 KW.

3. Heat loads produced by powered electrical equipment formulated as:

   $$Q = 864 \times N \times [(1-\eta)/\eta] \quad (2)$$

   For example: the calculation of heat released by *Main Air Compressor*:

   Q = 1415 kkal/jam = 1643,02 watt (1.64 KW)

All machineries and equipment inside the engine room which are potentially contribute heat will be summarized on following Table 1.

Table 1. Beban Panas Peralatan

No	Nama Peralatan	n	η	Beban Panas	
				kkal/jam	watt
1	*Main Air Compressor*	1	0.9	1415	1643.02
2	*Cooling Sea Water Pump*	1	0.9	2380	2763.26
3	*Jacket cooling Freash Water Pump*	1	0.9	1415	1643.02

4	*T/C Lub Oil Pump*	1	0.9	193	224.05
5	*M/E Lubricating Oil Pump*	2	0.9	2830	3286.04
6	*Fuel Oil Booster Pump*	2	0.9	193	224.05
7	*Fire & G.S Pump*	1	0.9	2380	2763.26
8	*Bilge & Ballast Pump*	1	0.9	2380	2763.26
9	*Sanitary & Ref. M. Cooling Water Pump*	1	0.85	1532	1779.20
10	*Sea Water Service Pump*	1	0.9	1930	2240.48
11	*Freash Water Pump*	1	0.85	449	521.90
12	*Boiler Water Feed Pump*	2	0.85	1124	1304.75
13	FO *Transfer Pump*	1	0.85	1124	1304.75
14	DO *Transfer Pump*	1	0.85	306	355.84
15	*Bilge Pump*	1	0.85	82	94.89
16	*Bilge Sludge Pump*	1	0.85	306	355.84
17	*Ejector Pump*	1	0.85	102	118.61

CFD Modelling and Simulation

CFD simulation are objected to evaluate and analyze the quantity of air supply and their velocity which enter into the engine room space through several variation of designed ducting system. This works simulates under two steps, firstly make five variation of ducting models then after validate the model, secondly, simulate each of them combined with the model of the engine room space.

On ducting models, the simulation carried out to get output values in the form of air velocity in both ends of the system by inputing data of *mass flow rate* (Q) which it is already known as blower capacity of 900 m^3/min or 54000 m^3/hour. The simulation done for five variations of air ducting models with different combination of arrangements. The simulation results of the ducting model can be shown below:

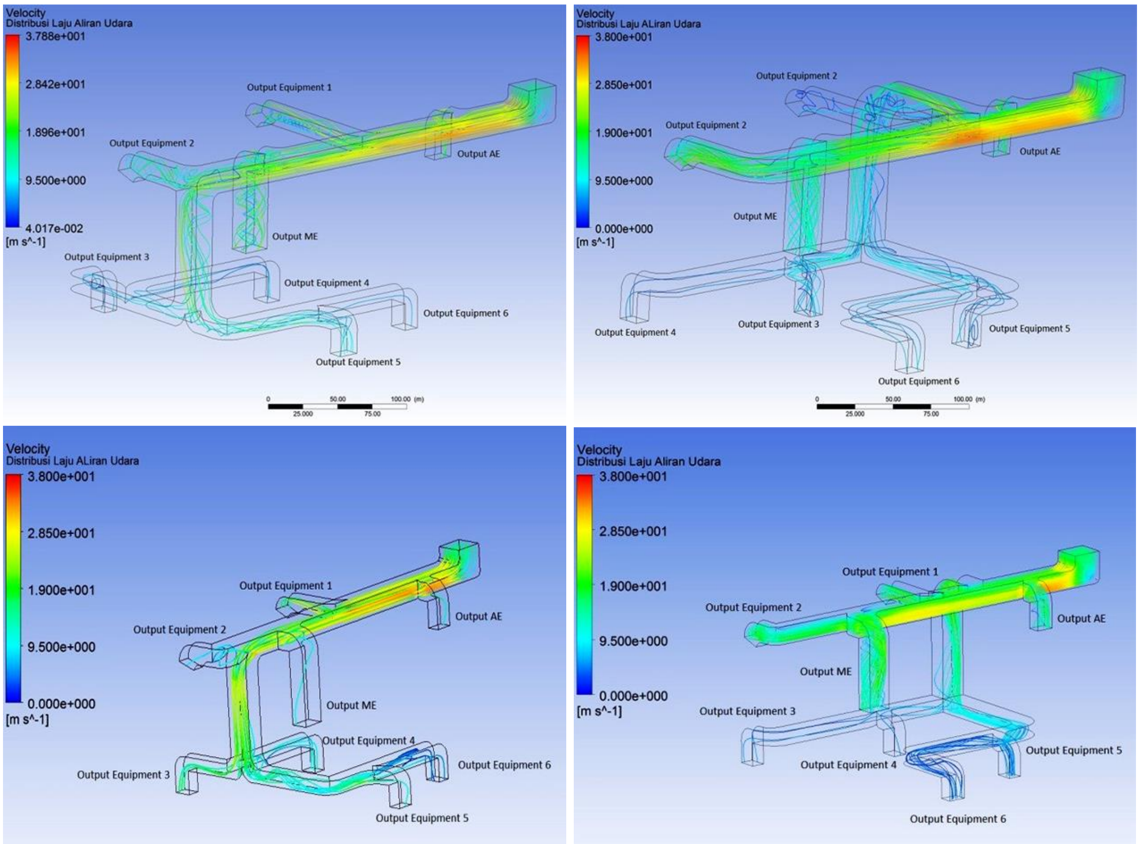

Figure1. Air speed simulation for *ducting* var-1, var-2, var-3, var-4, and var-5

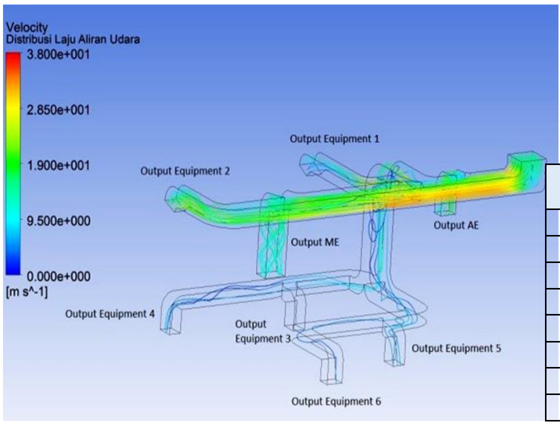

Table 2. Results of *velocity* delivered by every single *output ducting*

Lokasi	**Kecepatan Udara (m/s)**				
	Var-1	**Var-2**	**Var-3**	**Var-4**	**Var-5**
Output AE	10,95	10,13	6,61	9,63	11,37
Output ME	11,90	10,97	6,16	10,13	10,10
Output Equip 1	10,00	2,62	10,01	9,60	6,22
Output Equip 2	7,69	6,71	6,19	9,34	9,17
Output Equip 3	5,80	4,57	8,24	2,13	2,65
Output Equip 4	4,02	2,77	8,07	3,32	3,52
Output Equip 5	3,70	3,88	8,15	3,22	3,42
Output Equip 6	2,50	4,55	3,10	2,32	2,68

Modeling Engine Room Space

For each data, the simulation was carried out five times by increasing 25% minimum heat loads in every step. The simulation result can be shown below:

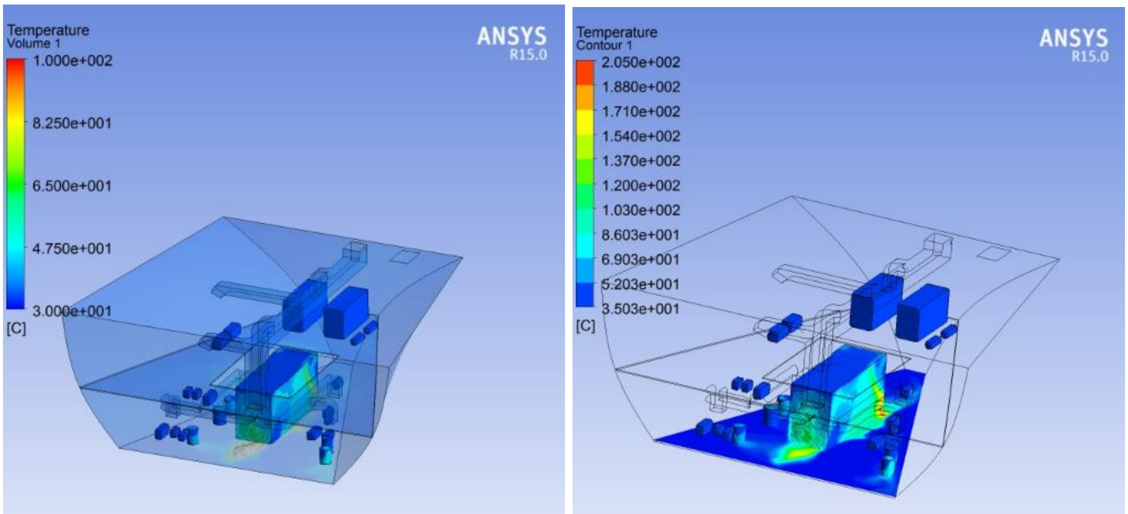

Figure 2. Temperature inside engine room (left), Heat at level height 1 meter (right)

The lowest engine room temperature is about 35°C and the highest at 48°C. Table 3 shows the complete data for five alternative systems.

Tabel 3. Hasil temperature ruangan untuk seluruh variasi

Ducting Var	Variasi *input* daya *main engine*				
	1851,66	1782,23	1712,79	1643,35	1573,91
1	35-46°C	35-46°C	35-45°C	35-45°C	35-45°C
2	35-46°C	35-45°C	35-45°C	35-44°C	35-44°C
3	35-45°C	35-45°C	35-45°C	35-44°C	35-44°C
4	35-48°C	35-47°C	35-46°C	35-45°C	35-45°C
5	35-47°C	35-46°C	35-45°C	35-45°C	35-44°C

The temperature condition at level height of 1 meter from the floor deck is also simulated. Minimum result of 35°C and maximum of 98°C were noted. Simulate the level height of 2 meters from engine room floor show the temperature from 35°C to 78°C. And at level height of 3 meters, near *engine* have temperature from 35°C to 65°C.

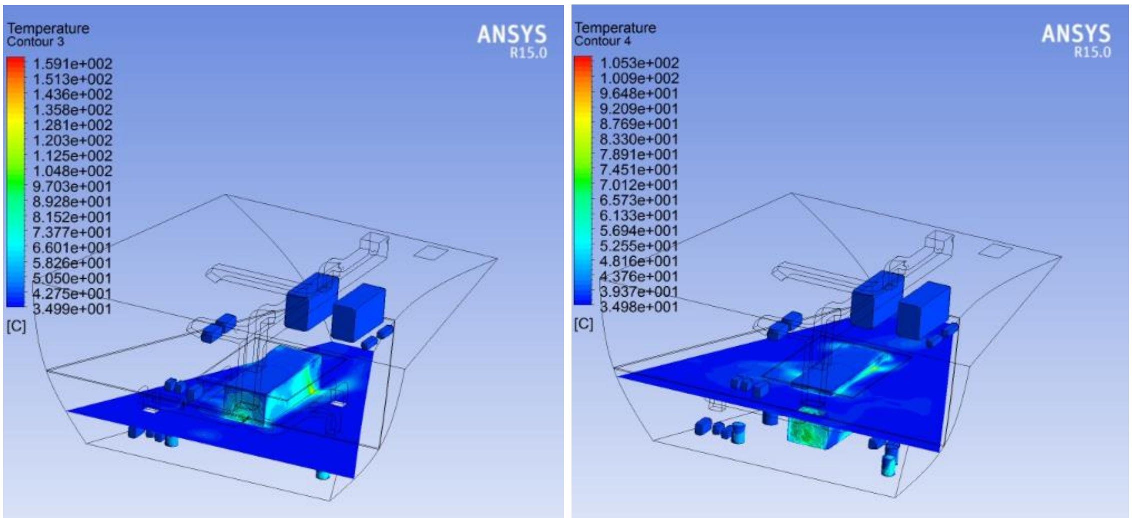

Figure 3. Heat at level height of 2 meter (left), Heat at level height of 3 meter (right)

Tabel 4. Temperature near *engine* taken from 1 meter of level height from floor

Ducting Var	Variasi *input* daya *main engine*				
	1851,66	1782,23	1712,79	1643,35	1573,91
1	35-86°C	35-80°C	35-75°C	35-71°C	35-69°C
2	35-74°C	35-70°C	35-68°C	35-67°C	35-65°C
3	35-68°C	35-65°C	35-62°C	35-60°C	35-56°C
4	35-98°C	35-96°C	35-95°C	35-94°C	35-94°C
5	35-98°C	35-98°C	35-94°C	35-90°C	35-86°C

Tabel 5. Temperature near *engine* taken from 2 meters of level height from floor

Ducting Var	Variasi *input* daya *main engine*				
	1851,66	1782,23	1712,79	1643,35	1573,91
1	35-70°C	35-65°C	35-63°C	35-60°C	35-57°C
2	35-62°C	35-60°C	35-58°C	35-56°C	35-54°C
3	35-56°C	35-54°C	35-53°C	35-52°C	35-50°C
4	35-78°C	35-75°C	35-70°C	35-68°C	35-66°C
5	35-74°C	35-70°C	35-69°C	35-65°C	35-62°C

Tabel 6. Temperature near *engine* taken from 3 meters of level height from floor

Ducting Var	Variasi *input* daya *main engine*				
	1851,66	1782,23	1712,79	1643,35	1573,91
1	35-57°C	35-55°C	35-52°C	35-50°C	35-47°C
2	35-54°C	35-52°C	35-52°C	35-50°C	35-48°C
3	35-52°C	35-52°C	35-50°C	35-49°C	35-48°C
4	35-62°C	35-60°C	35-58°C	35-55°C	35-54°C
5	35-65°C	35-63°C	35-59°C	35-56°C	35-54°C

The air flow velocity and its distribution inside the engine room also simulated for five variation systems. Figure 4 (left) shows the air velocity flowing on the inside of the engine room. Figure 4 (right) shows the air distribution inside the ducting system. Combined both the simulation results, direct us to capable of understanding how the important of the ducting arrangement influences the performances of ventilation system. Variation var-3 shows the most effective model in order to maintain the engine room temperatures.

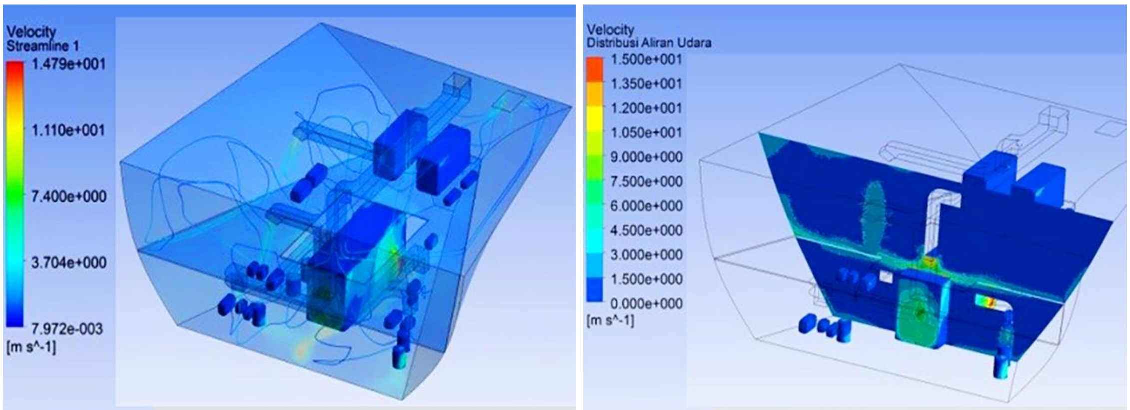

Figure 4. Air velocity on engine room (left), Air distribution on ducting system (right)

CONCLUSION

Based on the simulation results, the existing ducting system operated mechanically capable of maintain the engine room temperature under 48°C. Optimizing the existing system by applying Model Ducting Var-3 moreover capable of keep engine room temperatures between 35°C to 45°C.

In conclusion, some problems in engine room overheating may not always caused by insufficient power of the mechanical blowers but more caused by bad distributions of air flows. The problem possibly be corrected by re-design the ducting arrangements. Modern tools such as CFD contribute powerful help.

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