Consideration Regarding Maritime Ship Engine Room Ventilation System

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ABSTRACT

The work has been done on the study of bibliography and experience in the operation of the doctoral students in the field of comercial ships whit different type of main engines and auxiliary engines.Air circulation in the engine compartment must ensure air quality breathing air for the crew members and, the amount of air for thermal process development machines and power plants on ships in all the machinery spaces.

Keywords:

Ventilated air flow, ventilated air pressure, power drive fans, determining the temperature of the supercharge air, terms of reference for the environment.

1. INTRODUCTION

The paper highlighted that rules of ship classification societies concerning the main design and functional parameters of gas turbine integrated in naval propulsion systems, their design and construction, and a brief overview of the role of companies classification.

2. ENGINE ROOM AIR FLOW DETERMINATION

2.1 Specific Air Flow for Gas Exchange:

$$d_{asg} = m_{air_t} \cdot \alpha_{sg} \cdot C_s \left[\tfrac{kgair}{kWh} \right] \quad (1)$$

Where;

m_{air_t} — theoretical air mass needed for burn of one fuel kilogram

α_{sg} — excess air coefficient for gas exchange

C_s — specific fuel consumption

As per REF [4] **specific air flow needed for ventilation is:**

$$d_{av} = (1.5 \div 2) \cdot d_{sg} \left[\tfrac{kgair}{kWh} \right] \quad (2)$$

2.2 Mass Air Flow for Ventilation:

$$C_{av} = (1.5 \div 2) \cdot d_{sg} \cdot P_e \left[\tfrac{kgair}{h} \right] \quad (3) \text{ where;}$$

P_e -The effective power of the thermal engine propulsion of the vessel

2.3 Volumetric Air Flow for Ventilation:

$$\dot{V}_{av} = (1.5 \div 2) \tfrac{d_{asg}}{\rho_{air}} \cdot P_e \left[\tfrac{m_{air}^3}{h} \right] \quad (4)$$

Where: $\rho_{air} \left[\tfrac{kgair}{m^3} \right]$ is the compressor inlet air density

$$\rho_{air} = \tfrac{P_0}{RT_0} \left[\tfrac{kgair}{m^3} \right] \quad (5)$$

For:

$$P_0 = 100 \tfrac{kN}{m^2} \quad ; R_{air} = 0.286 \tfrac{KJ}{Kg \cdot grd}$$

$$T_0 = 318 \, K \, ; \, \rho_{air} = 1.0995 \tfrac{Kg_{air}}{m^3}$$

Relation (4) becomes:

$$\dot{V}_{av} = \left(\tfrac{1.5 \div 2}{1.0995} \right) \cdot d_{asg} \cdot P_e \left[\tfrac{m_{air}^3}{h} \right] \quad (6)$$

3. FANS POWER DRIVE CALCULATION

3.1. Discharge Pressure of the Fan in Engine Room:

Measurement units for pressure

$$1 \, [bar] = 100 \left[\tfrac{kN}{m^2} \right] = 10\,200 \, [mmH_2O]$$

As per REF [4] $\Delta P_{ref} = 60 \div 80 \; mmH_2O$

Result: Absolute Pressure

$$P_{ref} = 10\,250 \div 10\,280 \, [mmH_2O]$$

Or

$$P_{ref} = 100.58 \div 100.78 \left[\frac{kN}{m^2}\right]$$

Relation (6) becomes:

$$\dot{V}_{av} = (1.36 \div 1.82) \cdot m_{air_t} \cdot \alpha_{sg} \cdot c_g \cdot \frac{P_e}{3600} \left[\frac{m^3}{s}\right] \quad (7)$$

3.1 The Drive Power of The Fan:

$$P_{ant_v} = \frac{\dot{V}_{av} \Delta p_{ref}}{\eta_v} [kW] \qquad (8)$$

Where: $\eta_v = 0.7 \div 0.8$ **is mechanical efficiency of the fan**

Numerical application:

$$\dot{V}_{av} = 1 \left[\frac{m^3}{s}\right] ; \Delta P_{ref} = 0.78 \left[\frac{kN}{m^2}\right] ; \eta_v = 0.7$$

Result:

From relation (7) actual engine power is:

$$P_{em} = 3\,600 \cdot \dot{V}_{av} \cdot \frac{1}{1.5} \cdot \frac{1}{m_{air_t}} \cdot \frac{1}{\alpha_{sg}} \cdot \frac{1}{c_g} [kW] \quad (9)$$

So,

$$P_{em} = \frac{3\,600}{1.5} \cdot \frac{1}{13.5} \cdot \frac{1}{3} \cdot \frac{1}{0.175} = 340\ [kW]$$

**Table 1.The Debt and The Drive Power of The Fan**

P_{em} [kW]	P_{ant_v}/fan			Nr. of fans
	$\alpha = 2.5$	[kW]	$\alpha = 3$	[kW]	
1000	2.45	1.35	2.94	1.62	2
2000	4.90	3.03	5.88	3.64	2
5000	12.24	6.69	14.7	8.025	2
10 000	24.51	6.695	29.41	8.035	4
20 000	49.02	13.47	58.83	16.17	4
50 000	122.55	22.50	147.06	27.00	6
70 000	171.56	31.45	205.88	37.74	6
80 000	196.07	35.94	235.29	43.13	6
	$\dot{V}_{av}\left[\frac{m^3}{s}\right]$		$\dot{V}_{av}\left[\frac{m^3}{s}\right]$		

Table 2.The Debt and the Drive Power of The Fan

P_{em} [kW]	P_{ant_v}/fan		P_{ant_v}/fan		Nr. of fans
	$\alpha = 4$	[kW]	$\alpha = 5$	[kW]	
1000	3.91	2.15	4.88	2.64	2
2000	7.84	4.31	9.775	5.38	2
5000	19.61	10.78	24.44	13.48	2
10 000	39.22	10.78	48.88	13.48	4
20 000	78.43	21.57	97.75	26.96	4
50 000	196.08	35.93	244.38	44.91	6
70 000	274.51	50.33	342.38	63.00	6
80 000	313.73	57.52	391.00	72.00	6
	$\dot{V}_{av}\left[\frac{m^3}{s}\right]$		$\dot{V}_{av}\left[\frac{m^3}{s}\right]$		

Comparison of Table 1 And 2 Values And Fig.1 Values for Engine Powered At 50000KW:

a) As per calculation from table 1 and 2, fans power drive in engine compartments are between values of 135 and respectively 270 [kW]

b) From Fig.1, for power drive at 200÷270 [kW], we have exchange gas coefficient α between 4÷5, so appropriately whit tables1 and 2 and graph Fig.1 values.
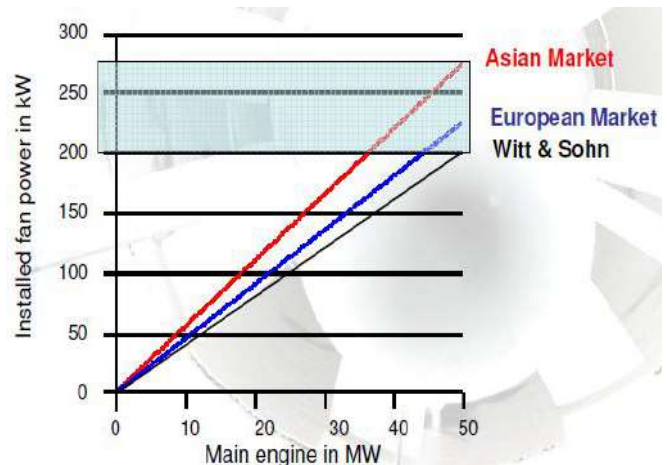
Fig.1 Installed engine room fan power as a function of main engine size [5]

4. STANDARD REFERENCE CONDITIONS

a) Terms of reference for the contracting of thermal machines that allow naval facilities require maintenance of appropriate temperatures in the engine department for crew activities, and starting and safe operation of thermal machines.

Below I will mention same international standards in ship and ship equipment building and design:

ISO 3046-1:2002(E) and ISO 15550:2002(E):
ISO ambient reference conditions:
Barometric pressure: 1000 mbar
Turbocharger intake temperature: $25°C$
Charge air coolant temperature: $25°C$
Relative humidity: 30%

IACS M28 (1978):
Tropical ambient reference conditions
Barometric pressure: 1000 mbar
Air temperature: $45°C$
Sea water temperature: $32°C$
Relative humidity: 60%

Winter ambient reference conditions
Barometric pressure: 1000 mbar
Turbocharger intake temperature: $10°C$
Cooling water temperature (minimum for lubricating oil cooler): $10°C$
Relative humidity: 60%

b). Reference conditions for other spaces on board of Ship regulated by:
ISO 7547, Shipbuilding – Air-conditioning and ventilation of accommodation spaces on board ships– Design conditions and basis of calculations
ISO 8862, Air-conditioning and ventilation of machinery control rooms on board ships – Design conditions and basis of calculations

ISO 8864, Shipbuilding – Air conditioning and ventilation of wheelhouse on board ships – Design conditions and basis of calculations

ISO 9785, Ships and marine technology – Ventilation of cargo spaces where vehicles with internal combustion are driven

ISO 9943, Shipbuilding – Ventilation and air treatment of galleys and pantries with cooking appliances

As per reference [9] the following conditions shall be met with regard to permanent workplaces:

- Engine room maximal temperature must be below 35^0C
- Engine control room temperature mus be below 28^0C or less becouse of electronic equipment and in both situation, maximal 7^0C diference temperture below outside summer temperature.
- Work shop maximal temperature no more than 33^0C, and maximal de 5^0C below summer outside temperature.
- Inlet air speed betewen 0,1m/s and 0,5m/s .

5. ENGINE ROOM VENTILATION

To maintain an acceptable engine running and optimal functioning smoothly and all equipment, special attention must be paid to the ventilation system in engine room and engine intake air used by engines [7]. Suction intakes for engine room air must be positioned and designed so as to prevent entry into the ventilation system exhaust gas, rain water, rainfall, dust and sprayed seawater. The amount of air required to be delivered to the engine room ventilation system is calculated, started from the total amount of energy flow from aggregates in engine room.

To be determined amount energy flow, all heat sources should be considered , such as : motors (main and auxiliary) , piping exhaust gas , generators , electrical systems , boilers or donkey boiler , boilers , steam piping , condensing the steam heated fuel tanks etc.

Figure 2 presents a simple ventilation engine room where the fan sucks air from the outside, you enter through manifolds of air in the engine targeted to aggregate, then the excess air and warm air is discharged through the chimney engine room to the atmosphere.

Air ventilation system in the engine room is provided with several independent fans. It is preferable that these fans have more speed. The ventilation can be controlled depending on outside air temperature and the heat generated in the engine room. For example, when making repairs to the main engine, it has stopped preheating system.
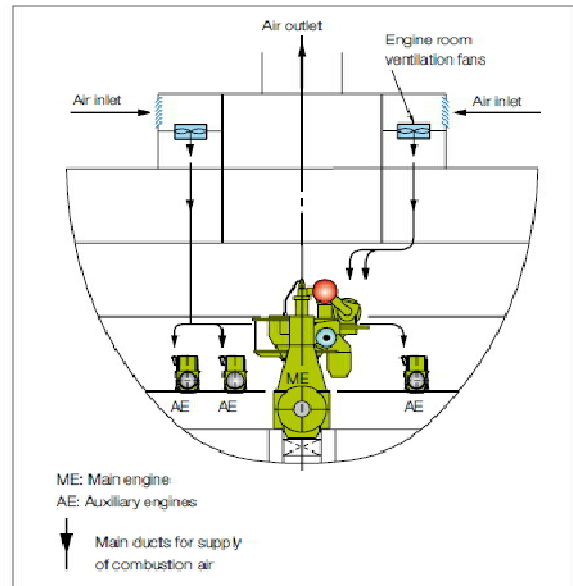

Fig.2. Machinery spaces ventilation system [8]

The air introduced into the engine room ventilation should be distributed in a balanced manner taking into account the amount of air supply points, and the points of discharge in the air. Usually basket ship engine room serves for evacuation of most of the hot air. At the same time, the outdoor fans may be used.

A good method is to use in areas with significant heat sources such as compartment dividers, a proper ventilation system, with introductory and air extraction. Excessive temperature in the engine room should be avoided throughout the operation of the ship. A decrease in temperature must also be avoided, especially during maintenance. In winter conditions, with very low temperatures preheat systems should be used. As a heating agent, thermal oil can be used in or glycol mixture in water to avoid freezing plants. If steam is used in the heating system of the vessel shall be provided a preheating secondary.

Normally, the intake air is taken from the engine room, passed through the filter to the blower unit of supercharger. This reduces the risk of engine use in cold or contaminated air. It is important that the intake air is dust, sea water, smoke etc., free. Under normal circumstances, intake air temperature boost unit should be kept between 15 and 35ºC. Temporarily, for short periods of time, it supported a maximum of 45ºC [7]

Intake air must be pumped several independent fans with a capacity greater than the amount required air consumption. The amount required air mass specified in the technical data is calculated for a temperature of 25 ° C ambient airs. Calculating the air density corresponding to a temperature of 30ºC or higher, turn the volume flow mass flow.

Preferably, for better flexibility, the fans must be driven by electric motors in 2 speed stages (or variable speed) . Thus, by simple manual control, fan speed is linked to main engine load. In ships with several main engines, it is preferable that each engine has its own fan air intake necessary. In this way, the amount of air can be adapted to the number of engines under operation.

The air intake must enter the engine room through a manifold located as close to the suction blower supercharger unit and be routed directly to suction. The same must be insured and other consumers of air in the compartment, such as internal combustion engines, boilers, gas turbines, etc. At the end manifolds for air at the exit to users must be mounted flaps controlling the direction and amount of air. If necessary, the air manifold can be connected by a flexible connector directly to the turbocharger. In this case, to protect the turbocharger, manifold air must be provided on an additional air filter.

In extreme cold, the air supply system must be provided for heating the air. Also, fans are turned off during engine starting and engine air required is taken from the engine room. After starting, the air introduced by the ventilation system must be combined with that of the engine or the heater so as to maintain the minimum required inlet air temperature. In the situation mentioned, extremely cold air coming from the ventilation system should be so directed as to not come directly to the engine; he must first heat in the engine room .

In tropical regions, particularly in areas with high humidity, it condenses into air coolers [7].

The motors are equipped with a short drain pipe to the condensate collector air and air cooler. The amount of condensate can be estimated and controlled using the diagram in Figure 3
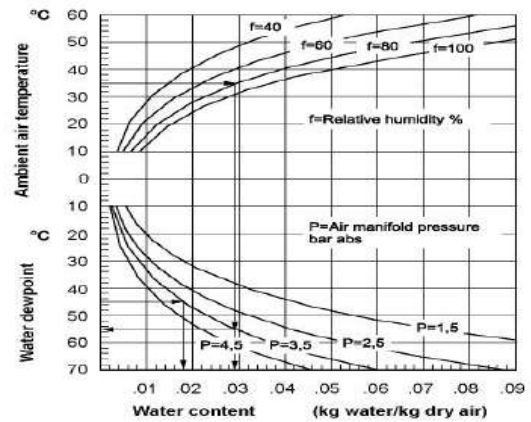
Fig.3 The condensation in cooler air [7].

Example:

At a temperature of 35 ° C ambient temperature and 80% relative humidity, the water content in the air is 0.029 kg water / kg dry air. If the pressure in the manifold air is of 2.5 bar (3.5 bar absolute pressure), the dew point will be 55 ° C . If the temperature in the collector the air is only 45 ° C, the air will contain only 0.018 kg water / kg dry air. The difference of 0,011kg water / kg dry air (0.029 - 0.018), therefore, the amount of condensate produced in the system.

6. CONCLUSIONS:

The main air flow inlet in engine room space are destinated for main engine good operating;

Ventilation air syetem must drive the air flow to this directions:
 - supercharging unit inlet at propulsion main engine;
 - supercharging unit inlet at auxiliary thermal engines;
 - steam boiler ventilators inlet burners;
 - air compressor inlet and gas turbine power plant;

Extraction and introduction fan must be provided for area of injectors testing bench and purifiers cleaning areas;

To optimize the energy consumption required for air entrainment fans must take into account the burden of thermal propulsion machine works, namely the number of engines to run simultaneously, the number of steam boilers burners in operation simultaneously.

Ambient conditions require adjusting the air flow which ventilates the engine room and supply the necessary air for engines, and engine room air temperature regulation.

In addition to paragraph 5, to increase the density of the supercharging air, air cooling is used at constant pressure, and depending on its moisture content, the air coolers must be purged from time to time by using a manual or automation systems.

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