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ASPECTS OF VENTILATION PRINCIPLES IN SHIPS MACHINERY ROOMS

Octavian Narcis Volintiru, Epikhin Aleksey I, Ionuţ Cristian Scurtu, Daniel Mărăşescu Ioniţă Florin, George Bălan

To maintain the air parameters in the rooms within the permissible or comfortable limits, the ventilation systems are designed to circulate the air in the rooms on board, usually without heat treatment or humidity. Ventilation systems consist of machines that provide the energy for air circulation (fans), main ducts connected to the suction and exhaust of the fans, branches and distribution components. For machinery spaces related to ships, ventilation systems are vital for the proper functioning of thermal engines used as propulsion systems. Gas turbines are heat engines used as propulsion systems usually for special ships.
Keywords: ventilation, flow, machinery, fan.

НЕКОТОРЫЕ АСПЕКТЫ ПРИНЦИПОВ ВЕНТИЛЯЦИИ СУДОВЫХ МАШИННЫХ ОТДЕЛЕНИЙ

Octavian Narcis Volintiru,
А.И. Епихин, кандидат технических наук, доцент
Ionuţ Cristian Scurtu,
Daniel Mărăşescu
Ioniţă Florin
George Bălan

Для поддержания параметров воздуха в помещениях в допустимых или комфортных пределах системы вентиляции предназначены для циркуляции воздуха в помещениях на борту, как правило, без термической обработки или увлажнения. Вентиляционные системы состоят из машин, обеспечивающих циркуляцию воздуха (вентиляторы), основных воздуховодов, соединенных с всасывающими и вытяжными вентиляторами, ответвлений и распределительных элементов. Для помещений машинного отделения, связанных с судами, системы вентиляции жизненно важны для правильного функционирования тепловых двигателей, используемых в качестве двигательных установок. Газовые турбины — это тепловые двигатели, используемые в качестве двигательных установок, как правило, для специальных судов.
Ключевые слова: вентиляция, поток, машины, вентилятор.

1. Introduction

Natural ventilation is based on the idea of free movement of air masses, the displacement being dictated either by the kinetic energy of the flowing air or by the difference in air density at different temperatures. Ventilated compartments have ventilation ducts that exit at the top (outlet to the atmosphere), are movable in the direction of the atmospheric air flow, and either introduce or remove air from the ventilated compartment. The kinetic energy of the air mass is transformed in the ventilation pipes into the static pressure difference, which is the basis of the air exchange in the rooms. Fans are used to move air in and out of the compartment when artificial ventilation is used. Regardless of the weather, these fans will provide ventilation when needed. The ventilation system ensures the transport of air used as replacement air or as a thermal agent (thermally processed or unprocessed).

Ventilation systems limit the concentrations of heat, humidity or toxic compounds in rooms. When the air is introduced unfiltered, the installation cannot guarantee the maintenance of some parameters below the level of the outdoor air parameters. [1]

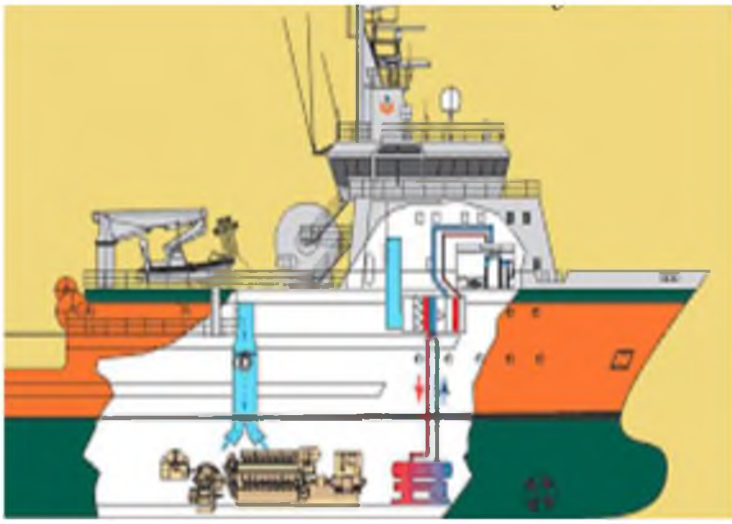

Figure 1. Machinery space ventilation system for the ship [1]

2. Ventilation system for ship machinery space

The following ventilation options are used, depending on the direction of air circulation and the type of phenomenon that degrades the air in the rooms:

• introduction ventilation;

• extraction ventilation;

• mixed ventilation

The inlet ventilation variant is suitable for any similar compartments that do not generate hazardous gases or vapours, including cabins, saloons, machinery spaces and other similar spaces. In the engine compartments of the ships, can be found this ventilation type. By mixing the toxic compounds with the air flow introduced by the installation, the leaks allow the mixture to escape (fig. 3 a). In rooms with bad or strong smells, the extraction (exhaust) variation is commonly used (kitchen for food, kitchens, toilets, compartments for storing dirty laundry, etc.). In compartments with toxic emissions, the extraction ventilation method is also used (pump compartment, storage rooms, etc.). The facility's fan removes the contaminated air flow from the area, while the drains are used to fill the space with the air. The mixed variant, which is used in situations where the extraction or intake of air through leaks is insufficient, is a hybrid form between those with introduction and extraction. [2]

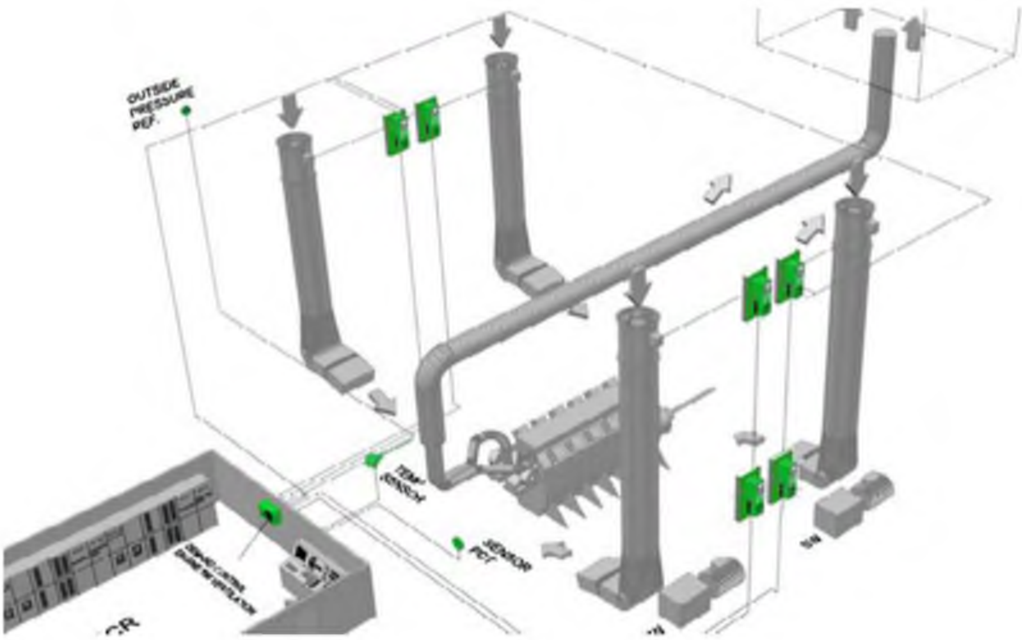

Figure 2. Machinery space ventilation system [3]

On a special vessel with a length of 150 [m], the following ventilation system is found in the machinery space for gas turbines used for propulsion:

- 2 x supply fan = 2 x 5.30 = 10.61 $\left[\frac{m^3}{s}\right]$
- 2 x exhaust fan = 2 x 7.56 = 15.13 $\left[\frac{m^3}{s}\right]$

The flow rate of the engine compartment air extraction fan is greater than the flow rate of the intake fan to ensure the extraction of gases and smoke from the compartment and to ensure the cooling of the exhaust galleries.

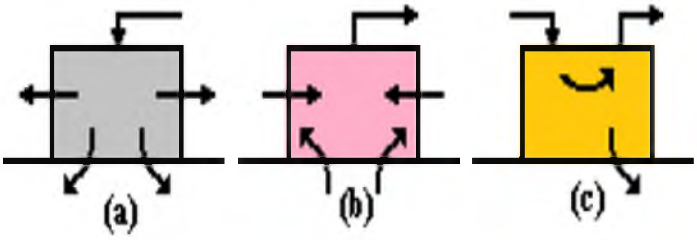

Figure 3. Ventilation type of machinery room [4]

3. Calculation of machinery spaces ventilation systems

3.1 Calculation of the ventilation requirement for the gas turbine machinery room

The engine compartment has 2 Rolls Royce Tyne RM1C type gas turbines.

The characteristics of the gas turbines are as follows:

- Nominal power: 2 x 4500 = 9000 [kW];
- Specific fuel consumption: 0.260 $\left[\frac{Kg}{kWh}\right]$;


Figure 4. Marine Tyne gas turbine [5]

3.2 Calculation of the specific air flow required for gas exchange

$$d_{asg} = m_{tsg} \cdot \alpha_{sg} \cdot C_e \left[\frac{Kgair}{kWh}\right] \quad (1)$$

where:

m_{tsg}=14.2 $\left[\frac{Kgaer}{Kgcomb}\right]$,- the theoretical mass of air for burning 1 Kg of fuel;

α_{sg} = 1.8 - excess air coefficient for gas exchange;

C_e = 0.260 $\left[\frac{Kgcomb}{kWh}\right]$,- specific fuel consumption;

$$d_{asg} = 14.2 \cdot 1.8 \cdot 0.260 = 6.64 \left[\frac{Kgair}{kWh}\right] \quad (2)$$

3.3 Calculation of the specific air flow required for ventilation

$$d_{av} = (1.5 \ldots 2) \cdot d_{asg} = 2 \cdot 6.64 = 13.29 \left[\frac{Kgair}{kWh}\right] \quad (3)$$

3.4 Calculation of the mass flow of air required for ventilation

$$C_{av} = (1.5 \ldots 2) \cdot d_{asg} \cdot P_e = 2 \cdot 6.64 \cdot 9000 = 119620.8 \left[\frac{Kgair}{h}\right] \quad (4)$$

3.5 Calculation of the volume flow of air required for ventilation

$$V_{av} = (1.5 \ldots 2) \cdot \frac{d_{asg}}{\rho_a} \cdot P_e = 2 \cdot \frac{6.64}{1.099} \cdot 9000 = 108845.1 \left[\frac{m^3_{air}}{h}\right] \quad (5)$$

3.6 Calculation of the power at the fan shaft

Units of measure for engine compartment fan discharge pressure:

$$1[bar] = 100 \left[\frac{kN}{m^2}\right] = 10200[\text{mmH2O}] \quad (6)$$

For low pressure fans we have the following pressure drop:

$$\Delta P_{ref} = 60 \dots 80[\text{mmH2O}] \quad (7)$$

We will have absolute pressure:

$$P_{ref} = 10260 \dots 10280[\text{mmH2O}] \quad (8)$$

or

$$P_{ref} = 100.58 \dots 100.78 \left[\frac{\text{kN}}{\text{m}^2}\right] \quad (9)$$

The equation will become:

$$V_{av} = (1.36 \dots 1.82) \cdot m_{air} \cdot \alpha_{sg} \cdot C_e \cdot \frac{P_e}{3600} \left[\frac{\text{m}^3_{\text{air}}}{\text{s}}\right] \quad (10)$$

Fan shaft power

$$P_{antv} = \frac{V_{av} \cdot \Delta p_{ref}}{\eta_v} [\text{kW}] \quad (11)$$

where:

η_v – the mechanical efficiency of the fan;

Numerical application for calculating fan shaft power:

$$V_{av} = 2 \left[\frac{\text{m}^3_{\text{air}}}{\text{s}}\right] \quad (12)$$

$$\Delta P_{ref} = 0.78 \left[\frac{\text{kN}}{\text{m}^2}\right] \quad (13)$$

$$\eta_v = 0.7 \quad (14)$$

$$P_{shaft} = 3600 \cdot V_{av} \cdot \frac{1}{1{,}5} \cdot \frac{1}{m_{aer}} \cdot \frac{1}{u_{aer}} \cdot \frac{1}{C_e} [\text{kW}] \quad (15)$$

$$P_{shaft} = \frac{3600}{1.5} \cdot \frac{2}{14.2} \cdot \frac{1}{1.8} \cdot \frac{1}{0.260} [\text{kW}] \quad (16)$$

$$P_{shaft} = 23.88\ [\text{kW}] = 24[\text{kW}] \quad (17)$$

There may be several fans in the engine compartment.

For the machine compartment studied we will take 4 fans x 6 [kW] each. [6]

Figure 5. Axial fan [7]

4. Conclusions

The ventilation systems have the role of thermally processing the air, so that inside the naval compartments the corresponding state parameters are maintained: the comfort conditions in the living compartments and the safe operation of the machines and aggregates. The operation at nominal parameters of the aggregates depends on the conditions of temperature, humidity, speed and physical composition of the air. In the case of rooms intended for machines and aggregates, the determination of the air parameters is done to ensure the working conditions both for the crew and for the operation of the machines at nominal parameters. In order to eliminate the thermal flows from the machine compartments, it is necessary to calculate the air flow required to evacuate the heat flow from the respective compartment. For machinery spaces, the extraction flow rate is greater than the air intake capacity in order to ensure the extraction of smoke and gases from the compartments and to cool the gas exhaust paths. The algorithm for the dimensioning of the ventilation installation for the machinery compartment took into account the power installed on each aggregate existing in the reference compartment. The main heat is dissipated by the 2 turbines with a power of 4500 [kW] each. The algorithm for dimensioning the ventilation installation for the gas turbine compartment followed:

- Calculation of the specific air flow required for gas exchange;
- Calculation of the specific air flow required for ventilation;
- Calculation of the mass flow of air required for ventilation;
- Calculation of the volume flow of air required for ventilation;
- Calculation of the power at the fan shaft.

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