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EFFICIENCY STUDY ON THE AIR CONDITIONING SYSTEM ONBOARD A PASSENGER SHIP

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Abstract: In the conditions of normal operation of ships, due to the release of heat from various machines and people, the increase in humidity as well as due to various releases of gases from on-board systems or goods being transported, the air in the rooms it degrades, requiring its replacement and processing. In the following we will present the issue associated with ensuring the comfort parameters on board ships, a matter regulated by international provisions on ensuring living conditions for crews - International Code for Safety Management and Pollution Prevention (ISM Code).

Key words: HVAC, ship, cabin, efficiency, analysis.

1. INTRODUCTION

The artificial microclimate installations have the role of thermally and humid-thermically processing the air, so that inside the naval compartments the corresponding state parameters are maintained:

- comfort conditions in living rooms;
- storage conditions of the goods;
- operation of machines and units.

Artificial microclimate installations include: ventilation installations; heating installations; cooling installations; conditioning (complex processing) installations.

The ventilation installations have the role of realizing the air circulation, without a homeothermic processing, eliminating the releases of heat, noxious gases (noxious) and of the humidity.

The heating and cooling installations perform the thermal treatment of the air in the living compartments.

Air conditioning systems ensure:

- for surface vessels: complex homeothermic processing of the air so that its state parameters are maintained at the comfort values automatically;
- for ships with watertight compartments and submarines: in addition to the parameters it achieves for surface ships, it also ensures a processing of the chemical composition to complete the oxygen consumed and the retention of carbon dioxide released on board.

The efficiency of the operation of ventilation, heating or air-cooling installations depends on the processes that take place in the rooms served, as well as on the meteorological conditions of the external environment. In this way, the meaning of the processing on the installation is dictated by the season, taking into account the extreme situations, corresponding to the summer and winter seasons.

The profitability of choosing one or more groups of installations on the ship is determined according to the operating conditions of the various rooms, the volume of labour incorporated in the installations, the location, closely correlated with the problems of size and weight, noise, etc. Therefore, artificial microclimate installations must meet the following basic conditions:

- to maintain in the rooms the optimal air parameters, avoiding the existence of dead areas where there is no air circulation;
- not to cause harmful air currents;
- not to make noise above the normal limit;
- not to allow gas and dust to enter from one room to another;
- to be reliable, with weights, dimensions and minimum energy consumption.

The normal conditions of comfort of the navigating personnel on board the ships, the keeping of the cargo in good condition and the normal operation of the aggregates, depend on the temperature, humidity, speed and chemical composition of the air. The determination of the air parameters in the living rooms is made on the basis of the physiological and hygienic-sanitary norms, taking into account the specific navigation conditions (small volume of the rooms, different climatic conditions, navigation area, etc.). In the case of rooms intended for machines and units, the determination of air parameters is done, on the one hand, according to their functional parameters, and on the other hand, to ensure the working conditions for the crew.

The parameters of the outdoor air are prescribed for different periods of the year and for different navigation

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areas, the recommended values having a statistical character.

For naval air conditioning systems, the calculation and operation parameters are provided in the standards. In the preliminary calculations and in the design, other norms will be considered, such as the conditions of increased comfort for the passenger ships or the operating conditions for cars, units and devices, etc.

2. HVAC SYSTEMS USED ONBOARD SHIPS

The role of ventilation, heating and air conditioning systems is to process the air so that living conditions for crew and passengers are maintained in the ship's spaces, storage of goods and ammunition in the case of military ships and operation of equipment in optimal conditions.

Heating is the process by which the temperature of the air in the compartments is raised from a heat source or by the introduction of hot air. The ventilation system circulates the air, eliminating heat, noxious substances, water vapor and smoke without processing the humid-thermal air.

The air conditioning system performs a complex air processing (heating, cooling, humidification, drying) to achieve comfort and working parameters. In the case of submarines and military ships with watertight compartments, the air conditioning system replenishes the oxygen consumed and retains the carbon dioxide retained on board.

The basic design considerations for HVAC systems for marine applications are similar to those for onshore systems, except those marine systems must meet several requirements. Here are some of them:

- The space for equipment, pipes and components is smaller;

- A ship is mobile and solar heating can affect any external walled compartment above the water line;

- The ship can withstand extreme weather conditions during a day;

- HVAC systems must withstand the corrosive action of seawater and salt air;

- HVAC systems must be capable of normal and efficient operation in severe conditions of ship movement;

- HVAC systems must have a high degree of reliability as supply and intervention at sea are low and the ship must carry spare parts and tools with it;

- Enclosed spaces on the ship are small and noise and vibration transmitted through the ship structure and air must be minimized;

- The design of HVAC systems must prevent water from entering the ship in bad weather;

- The position of the openings through which the air intake and the evacuation from the ship are made are critical due to the small space available, the protection at the water entrance in the ship and the minimization of the air routes that cross the corridors for passengers and crew;

- An HVAC system must achieve satisfactory performance in compartments with a multitude of functions: living compartments, bathrooms, warehouses, compartments with propulsion equipment and electric generators, compartments with electrical and electronic equipment, etc.;

- Smoke control and fire safety are critical due to the limited fire-fighting and rescue conditions.

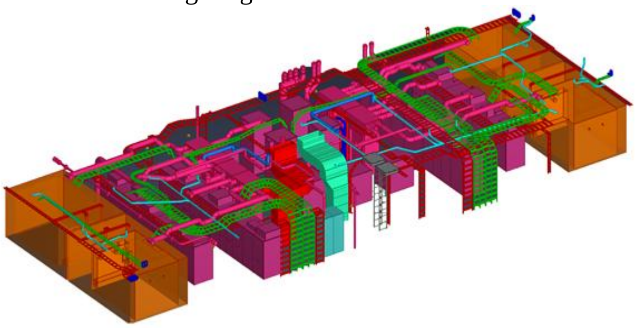

Figure 1 Detailed diagram of an HVAC system on board a passenger ship

In the case of military ships, in addition to the above requirements, there are others given by their specificity:

- Systems and equipment must be designed to withstand shocks and vibrations that occur in combat conditions;

- Due to the complexity of systems on military ships, the space for HVAC systems is smaller;

- Weight is a critical parameter and therefore HVAC systems on military ships are designed with minimum weight;

- Military ships have compartments with a high density of equipment that generates a high thermal load but which varies greatly. HVAC systems must be able to pick up thermal load peaks;

- HVAC systems must contain modules with standardized components that can be easily replaced in combat or emergency conditions;

- Unlike projects on merchant ships, systems on military ships must operate continuously even in the face of combat damage;

- In order to operate even under the conditions of a backup energy source, the HVAC system is divided into modules so that the vital compartments benefit from services continuously and in non-vital compartments the services can be temporarily suspended;

- The hydraulic balance of the distribution networks must be ensured in all operating conditions, even when certain routes are suspended.

It is the responsibility of the HVAC specialist engineer to develop systems that meet the required parameters.

The air conditioning system has become a common system for marine applications due to the comfort requirements required by crew and passengers. In

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general, one can talk about the comfort of people in a room if the following factors are taken into account:

- personnel factors:
  o the type of work performed inside the rooms;
  a clothes worn by staff.
- environmental factors:
  o air temperature and humidity;
  an air speed;
  o temperature of the surrounding walls, ceiling and floor;
  o the influence of the sun through the windows;
  o radiation from lighting fixtures and other heat sources.

The air conditioning systems have as applications:

- systems to ensure human comfort and living conditions for animals;
- systems that ensure the operation of electrical and electronic equipment and appliances;
- systems for storing goods and ammunition.

The designer of the air conditioning system takes into account the criteria related to the outdoor climate and the indoor climate. The design of the air conditioning system begins with the analysis of the temperature and relative humidity of the external environment, which means knowing the navigation routes of the ship. Exterior conditions influence the air parameters in the interior of the ship. Exterior conditions are different day and night. To establish the external conditions, maps with all regions of the world are used, which contain the average values of temperature and humidity. With regard to the indoor climate, the requirements of the crew and passengers must first be taken into account. Other factors that influence the indoor climate are:

- heat from the sun;
- heat transfer through walls;
- the degree of occupation of the space;
- heat from cars and electrical equipment.

Because the air in the ship's spaces becomes contaminated with bacteria, viruses, smoke, water vapor, carbon dioxide, dust, etc. it must be replaced with clean air. Nowadays the volume of supply air is estimated at 30-35 [m3 / h] for one person in smoke-free spaces and 45-50 [m3 / h] in smoke-free areas. The amount of air supplied to a volume depends on that volume. For example, the volume of air supplied to a ship's cabin in one hour is 6-10 times the cabin volume, which means 6-10 shifts per hour.

If the space is ventilated, the outside air must be heated or cooled separately and mixed with the recirculated air to reach the desired temperature. There are areas that need to be given more attention to fresh air supply and exhaust air. It is advisable to divide the spaces into smoking areas and non-smoking areas. Smoking areas are supplied with more fresh air than non-smoking areas to achieve the same result. The evacuation capacity at smoking areas will also be higher.

Sanitary, public or private spaces are provided with separate evacuation. Medical facilities such as hospitals, consulting rooms, etc. where sick people receive care, they have ventilation facilities separate from the facilities for the other spaces.

Laundries have hot spots represented by boilers, washing machines, irons, etc. The amount of air supplied and the amount of air evacuated must remove heat and humidity in order for these parameters to be within certain limits.

Cargo spaces are supplied with air to remove generated odors, water vapor, heat, etc. The amount of air supplied depends on the cargo carried by the ship.

It is important to create a depression in the ventilation of kitchens (the air pressure in the kitchen must be lower than in the surrounding spaces). This prevents the spread of kitchen odors in other compartments of the ship. If the kitchen has a separate space for cooking meat, a temperature below 16 ° C will be kept here.

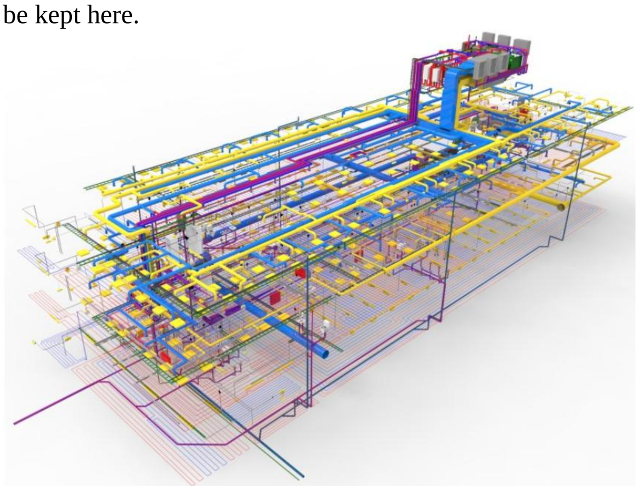

Figure 2 Pipping diagram of an air conditioning system fitted on board a passenger ship serving several decks

Engine rooms/engine compartments require special attention. Current engines are compact and generate a large amount of heat. Engine heat loss data is provided by the engine manufacturer. It is important that the temperature in the car compartment is controlled, values of 50 ° C or more affect the health of the staff. In addition to the heat dissipation, the ventilation system in the engine compartment also provides the necessary air for the operation of the main engine and auxiliary engines.

The air in the rooms in the process of processing to meet the requirements of comfort and operation is heated, cooled, dried or humidified. These transformations can be made on the basis of wet air diagrams, the most widely used of which is the diagram drawn by Moeller.

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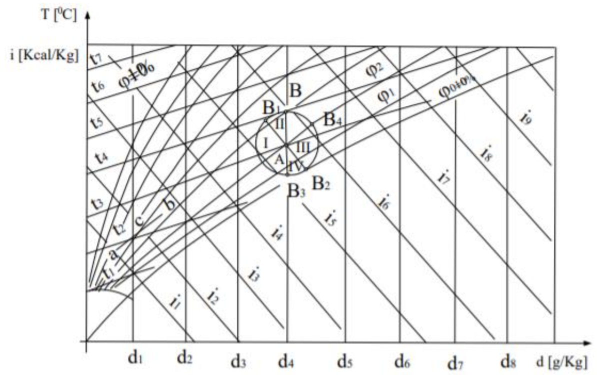

Figure 3 Moeller diagram

In this diagram, the total enthalpy of humid air ($\boldsymbol{i}$) is drawn in order and the moisture content ($\boldsymbol{d}$) in the abscissa. The relative humidity curve $\boldsymbol{\varphi_0} = \mathbf{100}\%$ is called the saturation limit curve because it separates the domain of unsaturated moist air from the fog domain (supersaturated air). This curve connects the saturated humidity points $\boldsymbol{d}_{\text{saturation}}$ for different temperatures. Above the saturation limit curve $\boldsymbol{\varphi_0}$ are the relative humidity curves $\boldsymbol{\varphi} < \mathbf{100}\%$, drawn to the vaporization isotherm. The isotherms are denoted in the diagram by $\boldsymbol{t_1}$, $\boldsymbol{t_2}$… $\boldsymbol{t_7}$. Any point in the humid air diagram corresponds to four state parameters: $\boldsymbol{t}$ - temperature, $\boldsymbol{\varphi}$ - relative humidity, $\boldsymbol{i}$ - enthalpy, $\boldsymbol{d}$ - moisture content.

With this diagram you can characterize the state of the air in a room knowing only two of these parameters. Any wet-thermal process that produces the transformation of the initial state characterized by these two parameters into a final state, by exchange of heat and humidity, can be studied with the Moeller diagram. We assume that in a room we have the temperature $\boldsymbol{t_A}$ (measured with a thermometer) and the humidity $\boldsymbol{\varphi_A}$ (measured with a psychrometer). These state parameters correspond to point $\boldsymbol{A}$ in the diagram. If the state parameters of the point $\boldsymbol{A}$ change as a result of a thermal process with heat release without changing the absolute humidity, reaching the point $\boldsymbol{B}$ ($\boldsymbol{t_B}$, $\boldsymbol{\varphi_B}$), the segment $\boldsymbol{AB}$ in the humid air diagram represents a moist thermal process. The coefficient of the humid thermal transformation is defined $\boldsymbol{\epsilon}$ the ratio between the enthalpy variation and the humidity variation ($\boldsymbol{\epsilon} = \Delta\boldsymbol{i}/\Delta\boldsymbol{d}$) or the ratio between the sum of the heat flows entering the process and the sum of the humidity releases ($\boldsymbol{\epsilon} = \sum \boldsymbol{i}\ \boldsymbol{\Phi i}/\sum \boldsymbol{i}\ \mathbf{d}\boldsymbol{i}$).

The ship's spaces must be heated or cooled for a day or a year. The thermal load may vary for the whole vessel or for part of it. Changes in the air characteristics are made in the treatment unit. There are two basic systems, one centralized with a main piping from which branches that supply air to all spaces of the ship and a decentralized system that contains several treatment units that serve the areas where the ship is divided. Air conditioning systems can provide treated air to large spaces such as lounges, dining rooms, passenger ship docks or a small group of cabins such as dry goods vessels.

Air conditioning is provided to each space to meet the maximum comfort requirements. A mixture of outside air and recirculated air is filtered and conditioned (preheated, dehumidified and cooled if necessary) in a central station and distributed to the individual heaters in the spaces served. The automatic dampers on the fresh and recirculated air supply are controlled by two sensors mounted on the piping, one for the heating cycle and one for the cooling cycle. The master thermostat records the outside air temperature. It is recommended that the terminal heater (from the cab) be with hot water or electric heating as it allows a finer adjustment of the temperature than in the case of steam.

The air ducts are made of galvanized steel sheet or aluminum sheet. It can be circular or rectangular. In general, circular tubing is cheaper than rectangular tubing.

3. MAIN PARAMETERS OF THE HVAC SYSTEM FITTED ONBOARD PASSENGER SHIP

In the operation of air conditioners, the compressor is one of the elements with a major role in regulating the temperature in a room. In a traditional system, it goes through two states: functioning at maximum capacity or stagnation. In other words, this type of compressor will work at maximum capacity, from the moment of start-up, until the moment when the temperature in the room reaches the desired level, when it closes. This is the periodic start and stop of the compressor and is, in fact, responsible for the high consumption of electrical energy.

The compressor operates at a variable speed, which allows a suitable consumption of energy to meet the needs of the temperature in the room. Thus, it does not stop, only the speed of the function of the function is adjusted automatically according to the needs. In an inverted air conditioning system, the compressor operates at maximum capacity until the temperature is brought to an optimum level, after which the speed is reduced.

Any change in temperature in the cabin is automatically detected by existing sensors, and this adjustment can be done by a slight increase in function, without any increase in function. At the first sight, a continuous operation of the compressor, would be considered responsible for a high energy consumption, but which generates, with a real, high consumption. The main advantages of the inverter technology are the following:

- Decrease in electricity consumption - Through INVÈRTER technology the repeated start and stop of the compressor is avoided, which generates a high energy consumption. The additional financial effort to purchase

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an air conditioner with investment is soon recovered due to significantly diminished costs;

- Quite operation conditions - represents a considerable advantage for passenger vessels;

- Increased reliability over time - Due to the fact that repeated starts and stops are avoided, the mechanisms and parts of the interior are much less required in one condition than the other.

On the heating part, the heat pump switches and inverts the refrigeration circuit, so that the evaporator becomes a condenser and the condenser becomes a vaporizer. The circuit is similar, with the mention that now the indoor unit is giving off heat to the condenser, and on the outside, it is taking off the heat of the vaporizer.

For the purpose of this study a HVAC system onboard a passenger ship is being considered as operating after a cycle without subcooling and with the following area,

- refrigerant: R134a;
- refrigerating power: Q_C = 340.9 [kW];
- vaporization temperature: t_0 = 8 [0C];
- air temperature: tf '= 15 ^{0}C, tf " = 17 [$_0$C];
- air temperature at the entrance to the subcooler: t_a '= 25 ^{0}C, t_a "= 35 [^{0}C];
- condenser temperature: t_C = 55 [^{0}C];
- subcooling temperature: Δt_{sr} = 0 [^{0}C];
- overheating temperature: $\Delta_{tsî}$ = 5 [^{0}C];

Analogically, the parameters of the cooling agent in the vaporizer are established as:

- t^0 = 8 ^{0}C → T_0 = 281.15 [^{0}K];
- p_0 = 1,641 [bar];

The parameters of the agent in the condenser are established as:

- t_C = 55 ^{0}C → TC = 328.15 [^{0}K]
- p_C = 10.98 [bar]

4. EFFICIENCY STUDY ON THE HVAC SYSTEM

In this chapter a simulation of the passenger's ship HVAC system is being presented. This HVAC system supports three identical passenger cabins, the difference between these cabins consisting in the fact that the pipping of the HVAC system is fitted in three different configurations, this simulating the conditions existing on real passenger ships.

All engineering simulations begin with the establishment of geometry to symbolize the aspect, whether it is a powerful aspect of a structural evaluation or a quantum of a fluid. The engineer is at the disposal of the geometry which was created in a CAD system (laptop-assisted layout), which builds the geometry from zero. ANSYS Design Modeler is a generating method the cabin geometry which will be simulated further on in ANSYS. The geometry of the cabin on board the ship is created using the software ANSYS Design Modeler, which is a special concept for the creation and modeling of the geometry. In technical simulations, geometry consists of information that is not currently necessary for simulations. Only the physics involved will be included, simulating such a version completely similar to the geometry of the cabin on board the ship. The figure below suggests the geometry created for the ship's cabin and the way in which the air conditioning pipes are arranged in the room. Thus, the stable dimensions for the room are:

- Height: 4 meters;
- Width: 3.65 meters;
- Length: 6 meters.

The duct that directs the air conditioning in the cabin has the following dimensions:

- Length: 0.5 meters;
- Width: 1.5 meters;
- Height: 0.65 meters.

The model realized in the mentioned program is presented in the figure below:

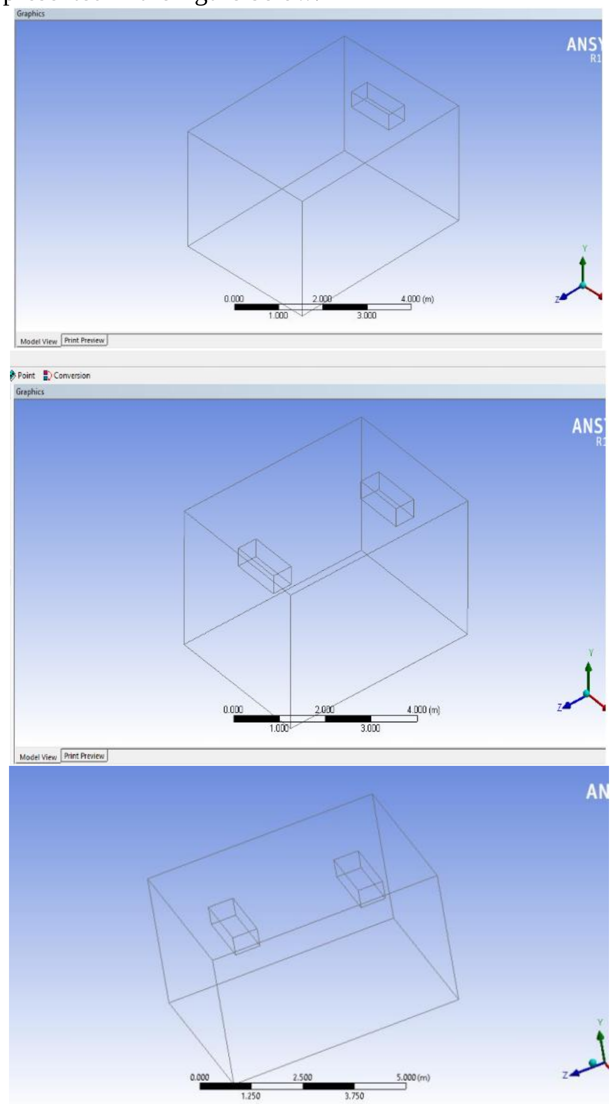

Figure 4 Geometric model of the cabin with air conditioning ducts for the air conditioning system

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One of the complex and enduring events of CFD simulation is the meshing of the computational domain. It is also called that the discretisation or the generating process of geometrical elements that simulate the surface and shape of the simulated object. Analytical solutions to the Navier-Stokes equations exist only for the simplest flows under ideal conditions, in the case of simulations of thermodynamic processes. In order to obtain a solution for real flows, a numerical approach has to be taken by which the equations are replaced with algebraic approximations that can be solved using a numerical method by applying the discretization of governing equations which implies the dividing process of the spatial domain in small finite elements in order to shape volumes using a discrete element of meshing or mass. Pre-set equations are integrated into each volume of control, so that the relevant quantity (mass, momentum, energy, etc.) can be preserved in a single volume.

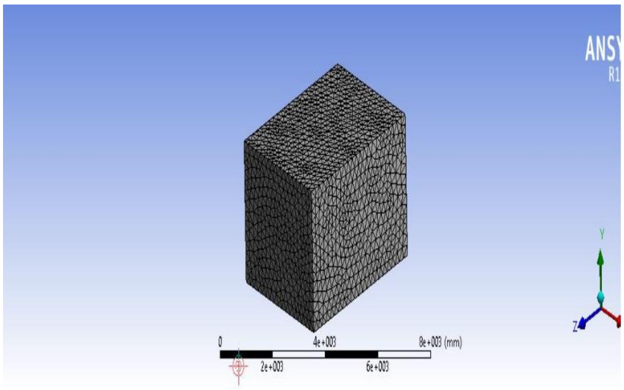


Figure 5 Cabin meshing using triangular elements

The method of discretization in finite volumes takes into account the points that form a set of volumes called cells. Methods with finite elements use sub volumes called elements that have nodes in which variables are defined. The variable values of dependencies, such as temperature, pressure, speed, etc. will be described for each element in the part. The quality of the CFD result strongly depends on the quality of the nodes.

As part of the simulation of the main parameters monitored and analysed:

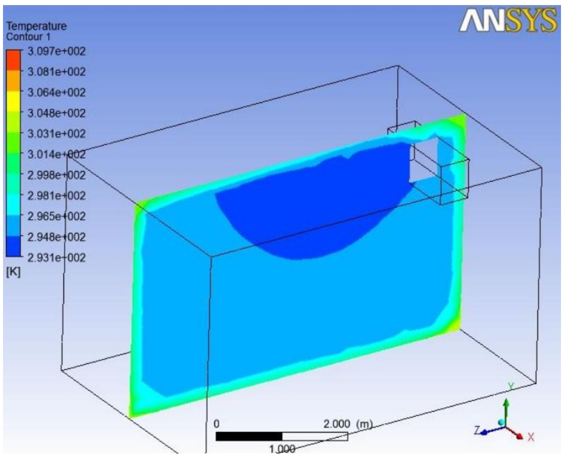
- Temperature - distribution of temperature in the three-dimensional panel of the cabin;
- Density - rate of mass of the air per unit of volume;
- Viscosity - consistency of the air in the conditions of internal friction;
- Specific heat - this is the necessary heat for the unit of mass to increase the temperature in the cabin with a degree Celsius;
- Thermal conductivity - the degree to which a certain material transfers heat, calculated as the ratio of heat flow to the temperature of the temperature.

Computer simulations offer an interesting opportunity to validate related aspects of ventilation, smoke movement, natural airflow, and thermal comfort. The obtained results indicate that different values are obtained for the same cabin dimensions (4 m X 3,65 m X 6 m), depending on the positioning of the air conditioning duct, all simulations being made considering that the temperature in the cabin is 40 ^{0}C, which is higher than the comfort temperature due to the stagnant area of the flow in the back of the chamber.

The three configurations used for the study and the dimensions of the room were the same during the analysis, as follows:

- In case no. 1 the cabin has the specified dimensions, but the air conditioning duct is fitted at a 3 m height above the floor of the cabin, while room temperature is 37 ^{0C}C and the air temperature in the duct at the entrance point of the air conditioning flow is 20 ^{0}C. The temperature of the cabin wall with effect from the temperature of the medium is used in the research is 40 ° C;
- In case no. 2, the conditioning air duct is divided here into two parts: each duct is used at an air flow velocity of 0.39 m/s. Both ducts are placed one in front of the other on the side of the cabin. The first pipe is placed at 3 meters from the base on the left side of the cabin and the second pipe is placed at 3 meters above the base on the right side. The temperature of the cabin is 310 ^{0}K (37 °C) and the temperature of the air at the point of entry of the pipe is 293 K (20 °C), while the speed of the air along both pipes. The temperature of the chamber used in the research is 40 ° C;
- In case no. 3, the pipeline is divided into two parts, each pipeline has an air flow velocity of 0.39 m/s. Both ducts are placed on the roof of the cabin. The thickness of the wall is used for the chamber is 3 cm and the temperature of the cable is 310 ^{0}K (37 °C), and the temperature of the air at the point of the pipe is 29 °C of 0.39 m/s. The temperature of the cabin wall used in the research is 40 °C.

In the figures below are presented the results of the simulation for the other three cases, being also indicated the parameters on which the simulation was concentrated:



a.Temperature varations

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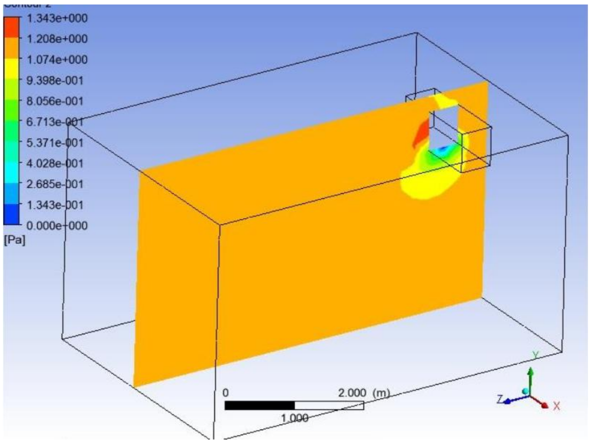
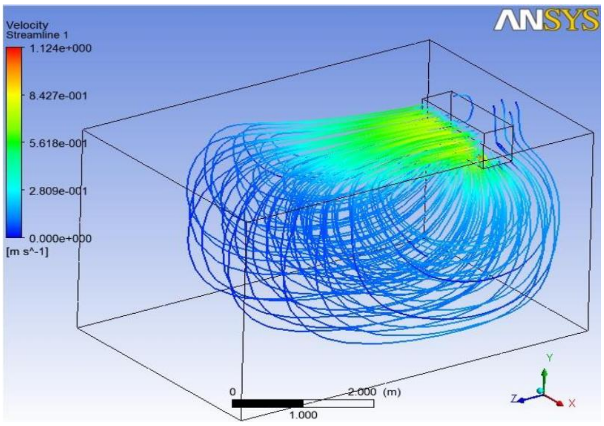
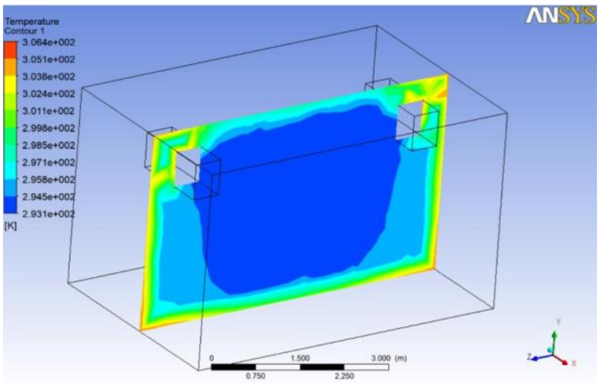


b. Pressure generated by the air conditioning duct

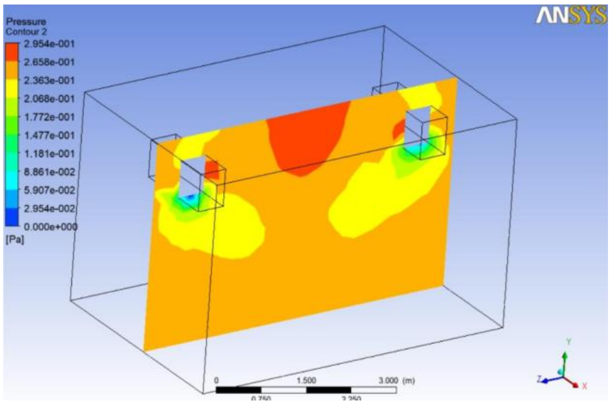


c. Air conditioning flow curves

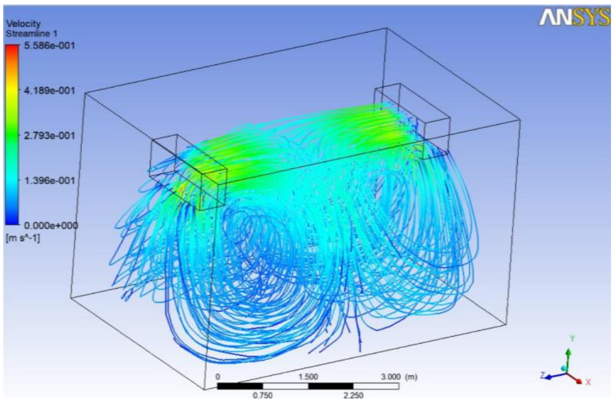
Figure 6 Case no.1 simulations



a.Temperature varations

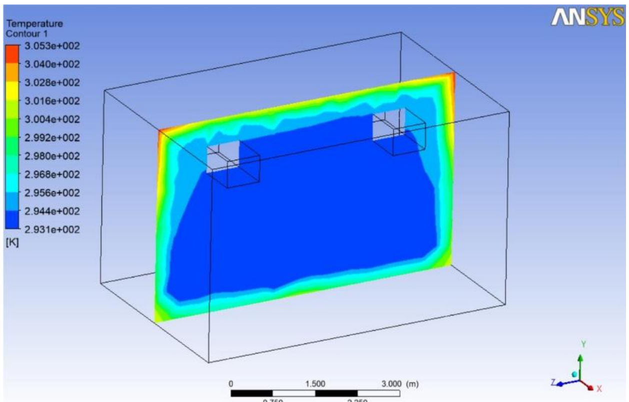


b.Pressure generated by the air conditioning duct



c.Air conditioning flow curves

Figure 7 Case no.2 simulations



a.Temperature varations

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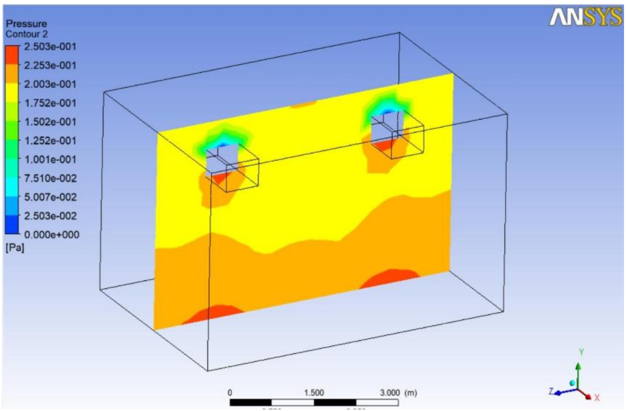
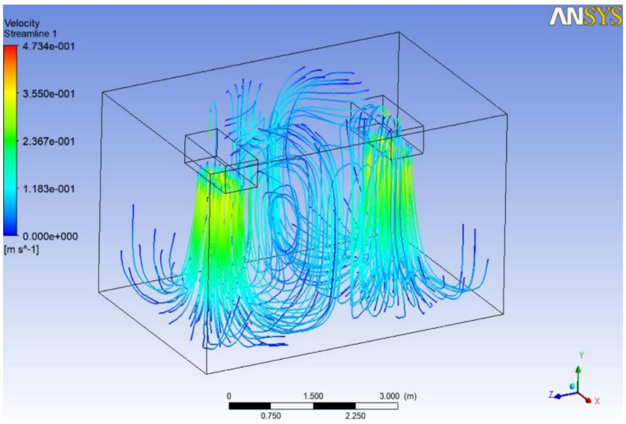


b.Pressure generated by the air conditioning duct



c.Air conditioning flow curves

Figure 8 Case no.3 simulations

The simulation results are presented graphically below:

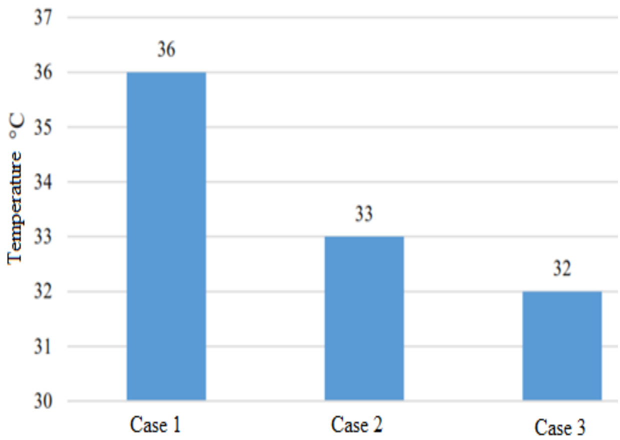


Figure 9 Temperature analysis results

According to the graph above, it was concluded that in case 1, the minimum cooling temperature after an interval of operation is 36 ^{0}C. In case 2 the double pipe used, arranged one in front of the other, led to the attainment of a minimum temperature of 33 ^{0}C, this being recorded somewhere in the middle of the chamber. In case 3, with the double channel used for air flow, but the mass flow rate of the air kept constant, the minimum temperature reached 32 ^{0}C, after the period of operation. Thus, according to the study, it was found that case 3, a double-pipe cabin with air conditioning, but the same mass flow, is a more efficient arrangement for a very short time system.

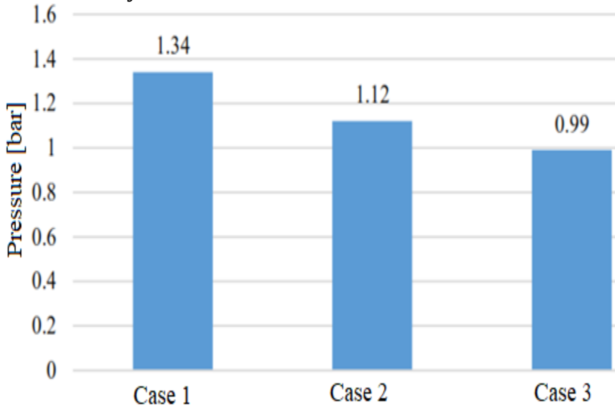


Figure 10 Pressure analysis results

According to the graph above, it is found that in case 1 the cabin has a high pressure inside, compared to others, while in case 3 the cabin has a minimum pressure in front of the other chambers. Therefore, a better circulation of the cooled air in the case is shown.

The way in which the percentage of air volume evolves, as reported in the ambient temperature of the cabin, is presented below:

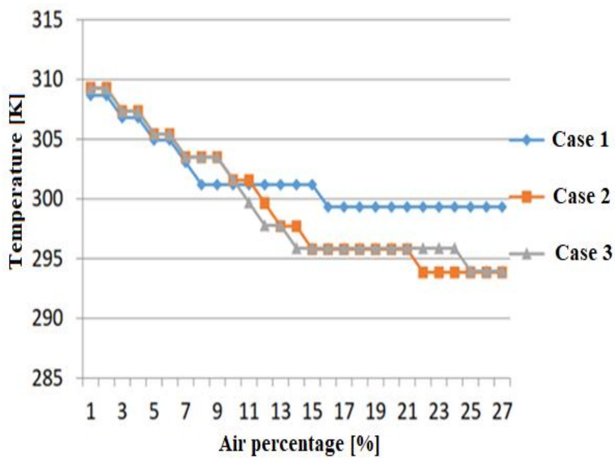


Figure 11 The evolution air percentage reported to the evolution of temperature decrease for the three cases

5. CONCLUSIONS

Cruise ships offer the opportunity to make a special trip, from trips around the world or in unique places to travel among tropical islands. If at the beginning of the twentieth century cruise tourism was exclusively a luxury tourism and the prerogative of those with very high incomes, today the possibility to make a cruise can be, somewhat, within the reach of anyone. Thus, the choice of the cruise as a holiday destination was burdened by some prejudices: the very high cost, the risks of a sea voyage, the lack of freedom of movement on the ship, the predominant type of tourists present on cruise ships (old, rich, eccentric) etc.

The evolution of the cruise sector in recent years (the replacement of fleets with state-of-the-art vessels, with much increased comfort and safety, the massive renovation of interiors and the addition of new services) have demolished, one by one, these suspicions. In addition, even those prone to seasickness will feel ashore, as ships are equipped with stabilizer systems that reduce the balance almost completely. Compared to traditional holidays, cruising offers some clear advantages, the most obvious of which is the change of scenery every day. At the same time, it allows you to travel long distances and visit in record time places with an extremely diverse nature, culture and civilization.

In order to attract new categories of tourists and to satisfy their most varied tastes, cruises offer them all the services of a five-star hotel: swimming pool, state-of-the-art health treatments and fitness programs, whirlpools, sauna, Turkish bath, shows, bars, restaurants and discos, as well as the prompt and friendly service of the flight attendants. Wheelchair access areas are also available on most vessels, including cabins, showers, special lifts and special health services that can be provided if reservations are made in advance. All these services, which are normally paid separately and in addition to the basic package, are included in the cabin price.

There are no more class I and class II, all services on board being the same for all passengers, the only difference being depending on the floor where the cabins are located and the presence or absence of windows or balcony (a last-minute innovation, which makes some ships real floating hotels). Cruises are not seasonal vacations; there is practically no "dead season" except for destinations like the North Sea, Alaska or South America. Cruises are made in the Mediterranean all year round, as well as in the Caribbean, except in September and October, when there are tropical storms.

Air conditioning systems have played a crucial role in the development of this industry because it has created the necessary conditions to achieve the level of comfort specific to the demands of tourists who prefer such trips.

This simulation is useful for analysing the efficiency of this installation. In this sense, a cabin was imagined for which three variants of installation of the pipe that delivers the air conditioning in the respective area were established. In the first case the cabin was provided with a single pipe, while in the other two cases the cabin was provided with two pipes, arranged in different variants. Using the program design module, the geometry and construction parameters of the cabin were established and the air conditioning ducts were positioned. The main monitored air parameters were temperature, pressure and volumetric percentage. The study allowed to choose the most efficient variant of supplying the cabin with air conditioning in the context of reaching the fastest cooling time of the respective room, an essential criterion for these systems.

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