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HEAT TRANSFER ANALYSIS OF AN AIRCRAFT CABIN THERMAL TRANSIENT

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Abstract. This paper develops calculus methodology to obtain the heat transfer coefficients involved in the transient thermal analysis of a passenger's cabin using the lumped parameters method. The thermal load conditions had been analyzed for the aircraft on ground. The heat transfer coefficients were evaluated by one-dimensional thermal resistances approach and the heat exchange areas were determined for a typical short-range commercial aircrafts data. The following elements were considered in the heat transfer analysis: cabin floor, luggage compartment, seats, upper and lower fuselages and airflow inside the cabin. The time-dependent temperature behavior in each component was represented by an ordinary differential equation, resulting in a system that was solved by iterative methods. Results allow to foreseen the time to begin the operation of the aircraft air conditioning system before the passengers boarding to satisfy the client requirements. Comparing the results against the experimental data of a commercial aircraft, it is verified that the proposed model is consistent and is a useful tool for aircraft air-conditioning design.

Keywords*. Thermal numeric analysis, Transient heating, Thermal comfort, Commercial aircrafts, Aeronautical engineering.*

1. Introduction

The passengers' cabin is the "show window of the aircraft", and it is essential that it could offer to the passengers a pleasant environment during the trip. Although the comfort of the passengers inside the aircraft involves satisfaction with environmental characteristics as illumination, ergonomic, available space for luggage, entertainment, this study only focuses on the thermal analysis of some cabin components such as: the fuselage, floor, seat, cabin air and the luggage compartment.

Aircraft cabins are formed by metal plates, structure, thermal insulation, floor, windows and seats. These components possess different thermal properties varying according to the manufactured material.

The major factors that affect the cabin thermal conditions can be divided in external and internal disturbance factors. The external factors include the flight speed, aircraft altitude, atmospheric temperature, humidity, pressure, solar radiation and the conditions of the adjacent compartment spaces, for example, when the aircraft has passengers' classes divisions. The internal factors are mainly the heating sources such as: the thermal load of the avionics and electric equipment, and the heat released by human bodies (Fang, 1999).

The knowledge of the thermal characteristics as well as of the external and internal disturbances factors allows a transient analysis to determine the behavior of the temperature of the cabin components. The dynamic behavior of cabin air temperature is influenced by the dynamic of the cabin components. The environmental control systems shall maintain cabin thermal characteristics within specific values in order to minimize the number of thermally disatisfeid persons during transient and steady-state flight conditions. The passenger comfort is determined by adequate temperature, humidity, ventilation and pressure conditions provided by the aircraft Environmental Control System (ECS). As per ASHRAE 55-92 (ASHRAE, 1992), "thermal comfort is that condition in that a human being is satisfied with the thermal environment". ASHRAE 55-92 is a recommendation for buildings environment, ASHRAE is currently working on a recommendation for aircraft cabin environment.

The knowledge of the transient response of the cabin is important to permit the development of a stable air conditioning and temperature control system and to determine the cooling or heating capacity that would comply with client pull-down and warm-up requirements. The pull-down process determines the necessary time to reduce the cabin temperature and to obtain comfortable temperature values for the occupants, after long period under extreme solar radiation exposure. Otherwise, the warm-up process indicates the required time to raise the temperature levels, after exposition under environments with extremely low temperatures. These time-intervals must conform to client requirements and affect the aircraft availability and imposes performance requirements for the air conditioning system.

As higher is the aircraft availability, greater will be its competitiveness in the market, increasing its chances of purchase orders once it increases the tendency to maximize the operator profits.

Several works have been focused in the simulation of heat transfer process inside passenger's cabins. Fang (1999) developed a mathematical model of the cabin thermal transient processes using the finite differences method. The model considers the evolution of the temperature as a function of the time for components of the airplane cabin such as: floor, metal plates and windshield. Numerical results are compared with the experimental results and the predictions agree with the experimental data quite well. The verified computer simulation program has the functions of calculating static and transient cabin heat loads, simulating the transient thermal characteristics of aircraft cabins and providing the cabin thermal characteristic parameters for designing and evaluating aircraft environmental control systems.

In the thermal comfort evaluation performed by Turcio and Neto (2003) a mathematical model of the passenger's cabin is presented considering the thermal comfort index PMV (Predict Mean Vote). The authors developed two methodologies for the air conditioning system control. The first is based on the PMV as feedback signal of the controller. The second methodology considers that the feedback signal of the system is just the cabin temperature.

Zaparoli and Andrade (2003) proposed a mathematical model aiming to study the influence of the physical parameters in the air conditioning system and the cabin characteristics in the pull-down and warm-up processes. The cabin transient temperature is simulated applying the lumped parameters method in order to reduce the computational time spent in the problem solution.

The purpose of the present study is to develop a calculus methodology to determine the heat transfer coefficients considering physical parameters of the aircraft such as material, aircrafts partitions and areas. The cabin model will be based on the analysis carried out by Zaparoli and Andrade (2003) resulting in the evolution of the temperature behavior during the pull-down and warm-up processes. By this way, it will be possible to analyze the influence of heat transfer coefficients in the cabin time-dependence temperature.

2. Cabin mathematical model

A fuselage transversal section with width enough to accommodate three passengers is considered in the cabin model. The cross section airflow is assumed well mixed permitting a good heat exchange with the aircraft partitions, as shown in Fig. (1).

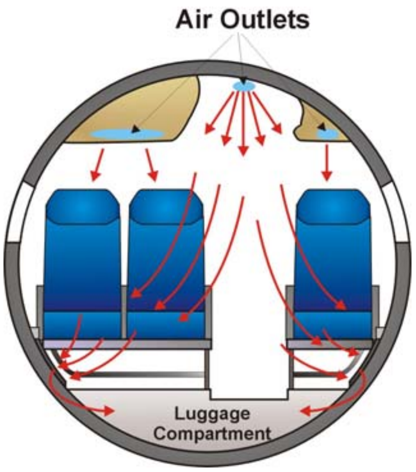

Figure 1. Cabin cross section airflow.

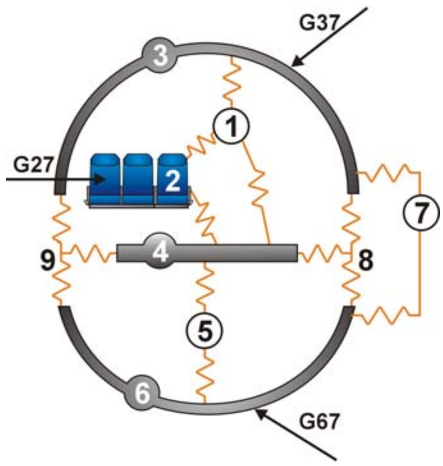

Figure 2. Cabin cross section thermal model.

The main cabin parts that have great influence in the heat exchange processes are: the fuselage (upper and lower), the cabin air, the passenger's seat, the luggage compartment air, and the cabin floor. Adopting the one-dimensional heat transfer hypothesis and using the lumped parameters method, a transient heat transfer process can be represented by the thermal resistances model, illustrated in Fig. (2).

Table 1 – Cabin sub-domains and heat exchange interfaces.

Cabin sub-domains	Description	Heat exchange with
1	Cabin air	2 , 3 , 4
2	Seat	1 , 4
3	Upper fuselage	1 , 7 , 8 , 9
4	Floor	1 , 2 , 5 , 8 , 9
5	Luggage compartment	4 , 6
6	Lower fuselage	5 , 7 , 8 , 9

The nodes 8 and 9 represent the right and left joints among upper fuselage wall, floor and lower fuselage wall. The cabin sub-domains interactions and the environmental conditions (solar radiation) where the heat exchange occurs are also schematized. These characteristics are shown in Tab. (1).

Considering the recommendations and equations proposed by SAE (1989) and Incropera (1998) and applying mass and energy balances in the sub-domain control volumes above described, the following system of linear ordinary differential equations is obtained:

$$m_1 c_{p1} \frac{dT_1}{dt} = NU_{12}A_{12}(T_2 - T_1) + U_{13}A_{13}(T_3 - T_1) + U_{14}A_{14}(T_4 - T_1) + \dot{m}_{in} c_{p1}(T_{in} - T_1) + E_1 \tag{1}$$

$$m_2 c_{p2} \frac{dT_2}{dt} = NU_{12}A_{12}(T_1 - T_2) + NU_{24}A_{24}(T_4 - T_2) + \alpha_2 G_{27} A_{27} \tag{2}$$

$$m_3 c_{p3} \frac{dT_3}{dt} = U_{13}A_{13}(T_1 - T_3) + U_{37}A_{37}(T_7 - T_3) + U_{38}A_{38}(T_8 - T_3) + U_{39}A_{39}(T_9 - T_3) + (\alpha_3 G_{37})(A_{37}\beta) \tag{3}$$

$$\begin{aligned} m_4 c_{p4} \frac{dT_4}{dt} &= U_{14}A_{14}(T_1 - T_4) + NU_{24}A_{24}(T_2 - T_4) + U_{45}A_{45}(T_5 - T_4) + U_{48}A_{48}(T_8 - T_4) \\ &+ U_{49}A_{49}(T_9 - T_4) \end{aligned} \tag{4}$$

$$m_5 c_{p5} \frac{dT_5}{dt} = U_{45}A_{45}(T_4 - T_5) + U_{56}A_{56}(T_6 - T_5) + \dot{m}_{in} c_{p5}(T_1 - T_5) + E_5 \tag{5}$$

$$m_6 c_{p6} \frac{dT_6}{dt} = U_{56}A_{56}(T_5 - T_6) + U_{67}A_{67}(T_7 - T_6) + U_{68}A_{68}(T_8 - T_6) + U_{69}A_{69}(T_9 - T_6) + \alpha_6 G_{67} A_{67} \tag{6}$$

$$T_8 = T_9 \tag{7}$$

$$T_9 = \frac{U_{39}A_{39}T_3 + U_{49}A_{49}T_4 + U_{69}A_{69}T_6}{U_{39}A_{39} + U_{49}A_{49} + U_{69}A_{69}} \tag{8}$$

where:

T_i	= thermal circuit node temperature;
m_i	= cabin sub-domain mass;
c_{pi}	= cabin sub-domain constant pressure specific heat;
$U_{ij} = U_{ji}$	= global heat transfer coefficient between i node and j node;
$A_{ij} = A_{ji}$	= heat transfer area between i node and j node;
N	= passenger number seats in each fuselage cross section;
$\dot{m}_{in}$	= input mass flow rate to the cabin and under floor compartments;
T_{in}	= input temperature cabin air;
E_i	= electric energy dissipated inside the cabin;
G_{i7}	= direct solar irradiation to the sub-domain i;
α_i	= i - sub-domain absorptivity;
β	= ratio of the projected area of the fuselage to the total area.

3. Global heat transfer coefficients evaluation

Equations (1) to (8) were defined as a function of the global heat transfer coefficients (U_{ii}). In these coefficients, all interactions between each sub-domain are considered. The coefficients are determined based on the material thermal properties of the respective sub-domains and the correspondent heat transfer area. Generally, the coefficient values are collected by experimental tests. The present study proposes a methodology to calculate the global heat transfer coefficients, applying the thermal resistance model to define an equivalent thermal circuit between each adjacent sub-domain. The heat transfer mechanism will be considered one-dimensional to facilitate and accelerate the global coefficients calculation, without compromising solution quality.

3.1 Upper fuselage coefficients – U_{13} and U_{37}

The coefficients U_{13} and U_{37} are calculated carrying on the interaction between the upper cabin fuselage (sub-domain 3) with the cabin internal air and external environmental conditions, respectively. The upper fuselage is composed by materials such as metal plates, shear clip, U beam, acoustic and thermal insulations, air layer and internal furnishing as shown in Fig. (3).

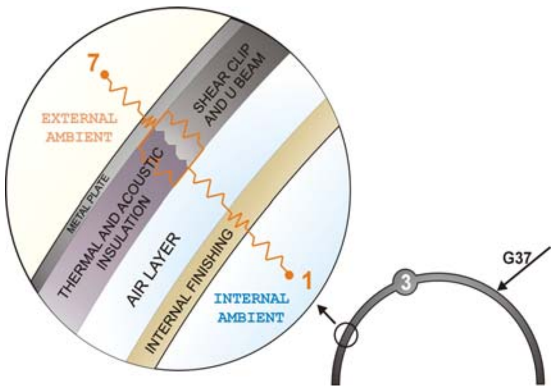

Figure 3. Thermal model of U_{13} and U_{37} coefficients.

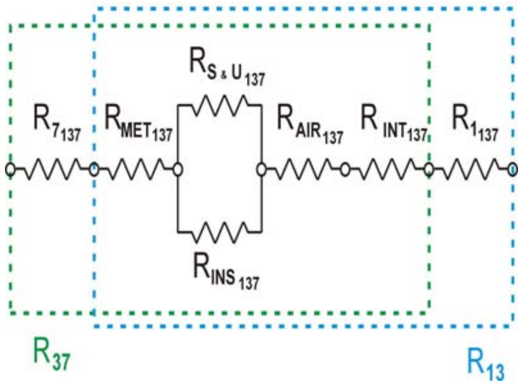

Figure 4. Thermal resistances of 1-3-7 sub-domains.

Assuming that the predominant heat transfer direction for the sub-domains 1 and 7 is perpendicular to the tangent of the internal and external surfaces, it is verified that the heat conduction occurs throughout the fuselage thickness, except in the air layer that separates the internal refining from the insulation, shear-clip and U beam, where the convection heat transfer is assumed. Due to the aircraft large dimensions, the solution is obtained by the plane wall model approximation (one-dimensional). Consequently, the thermal resistance circuit involving 1-3-7 sub-domains is shown in Fig. (4). The equivalent thermal resistance (R) and the global heat transfer coefficients (U) are given by:

$$R_{13} = \left(\frac{1}{h_{1_{137}} A_{13}}\right) + \left(\frac{L_{INT_{137}}}{k_{INT_{137}} A_{13}}\right) + \left(\frac{1}{h_{AIR_{137}} A_{13}}\right) + \left(\frac{\dfrac{L_{S\&U_{137}}}{k_{S\&U_{137}} A_{S\&U_{137}}} \cdot \dfrac{L_{INS_{137}}}{k_{INS_{137}} A_{INS_{137}}}}{\dfrac{L_{S\&U_{137}}}{k_{S\&U_{137}} A_{S\&U_{137}}} + \dfrac{L_{INS_{137}}}{k_{INS_{137}} A_{INS_{137}}}}\right) + \left(\frac{L_{MET_{137}}}{k_{MET_{137}} A_{13}}\right) \tag{9}$$

$$U_{13} = \frac{1}{R_{13} A_{13}} \tag{10}$$

$$R_{37} = \left(\frac{L_{INT_{137}}}{k_{INT_{137}} A_{37}}\right) + \left(\frac{1}{h_{AIR_{137}} A_{37}}\right) + \left(\frac{\dfrac{L_{S\&U_{137}}}{k_{S\&U_{137}} A_{S\&U_{137}}} \cdot \dfrac{L_{INS_{137}}}{k_{INS_{137}} A_{INS_{137}}}}{\dfrac{L_{S\&U_{137}}}{k_{S\&U_{137}} A_{S\&U_{137}}} + \dfrac{L_{INS_{137}}}{k_{INS_{137}} A_{INS_{137}}}}\right) + \left(\frac{L_{MET_{137}}}{k_{MET_{137}} A_{37}}\right) + \left(\frac{1}{h_{7_{137}} A_{37}}\right) \tag{11}$$

$$U_{37} = \frac{1}{R_{37} A_{37}} \tag{12}$$

Where:

$A_{13} = A_{37} = A_{S\&U_{137}} + A_{INS_{137}}$;

$_{S\&U_{137}}$ refers to shear clip and “U” beam of sub-domains 1-3-7;

$_{INS_{137}}$ refers to insulation of sub-domains 1-3-7;

$_{MET_{137}}$ refers to metal plate of sub-domains 1-3-7;

$_{INT_{137}}$ refers to the internal finishing of sub-domains 1-3-7;

$_{AIR137}$ refers to the air layer of sub-domains 1-3-7;

L indicates the wall thickness;

k indicates the wall thermal conductivity;

h the heat transfer coefficient between the upper fuselage and the external ambient.

3.2 Seat coefficients – U_{12} and U_{24}

The heat transfer coefficient U_{12} involves the heat exchange between the passengers' seats and the cabin internal air. The seats are typically constituted by foam padding, which is an important material because it is in contact with the body surface of the passengers, and a metallic structure that guarantees seat stiffness.

In sub-domain 2, the heat transfer mechanisms occur by conduction inside the seat and there is convection with the cabin internal air, as shown in the Fig. (5). The equivalent thermal resistance is illustrated in Fig. (6) and is determined using Eq. (13). The heat transfer coefficient for the 1-2 sub-domains is calculated by Eq. (14).

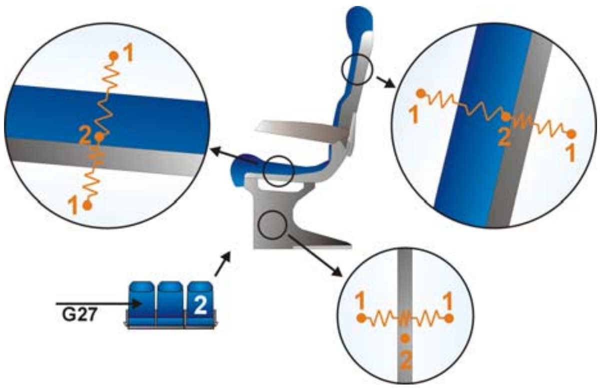

Figure 5. Thermal model of U_{12} coefficient.

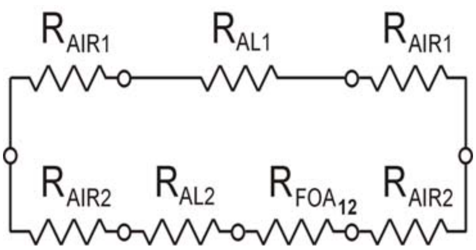

Figure 6. Thermal resistances of 1-2 sub-domains.

$$R_{12}=\frac{\left(\left(\frac{1}{h_{AIR1}A_{AIR1}}\right)+\left(\frac{L_{AL1}}{k_{AL1}A_{AIR1}}\right)+\left(\frac{1}{h_{AIR1}A_{AIR1}}\right)\right)\cdot\left(\left(\frac{1}{h_{AIR2}A_{AIR2}}\right)+\left(\frac{L_{AL2}}{k_{AL2}A_{AIR2}}\right)+\left(\frac{L_{FOA_{12}}}{k_{FOA_{12}}A_{AIR2}}\right)+\left(\frac{1}{h_{AIR2}A_{AIR2}}\right)\right)}{\left(\left(\frac{1}{h_{AIR1}A_{AIR1}}\right)+\left(\frac{L_{AL1}}{k_{AL1}A_{AIR1}}\right)+\left(\frac{1}{h_{AIR1}A_{AIR1}}\right)\right)+\left(\left(\frac{1}{h_{AIR2}A_{AIR2}}\right)+\left(\frac{L_{AL2}}{k_{AL2}A_{AIR2}}\right)+\left(\frac{L_{FOA_{12}}}{k_{FOA_{12}}A_{AIR2}}\right)+\left(\frac{1}{h_{AIR2}A_{AIR2}}\right)\right)} \quad (13)$$

$$U_{12}=\frac{1}{R_{12}A_{12}} \quad (14)$$

Where:

$A_{12}=A_{AIR1}+A_{AIR2}$;

$_{AIR}$ refers to internal air;

$_{AL}$ refers to aluminum structure;

$_{FOAM}$ refers to the seat foam;

L indicates the wall thickness;

k indicates the wall thermal conductivity;

h the heat transfer coefficient between the seat and the internal ambient.

The heat transfer coefficient U_{24} represents the interaction between the seat and the cabin floor. The sub-domain 4 is constituted by floor plates and acoustic and thermal insulations. It is assumed that one-dimensional conduction is the only process of heat transfer in the sub-domains. The global heat transfer coefficient is given by Eq. (15). The thermal model and equivalent thermal resistance are shown in Fig. (7) and Fig. (8), respectively.

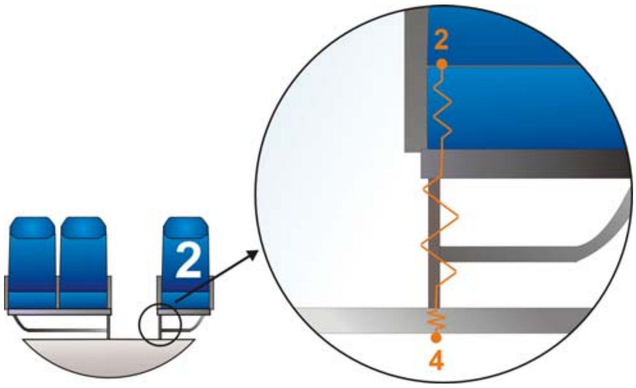

Figure 7. Thermal model of U_{24} coefficient.

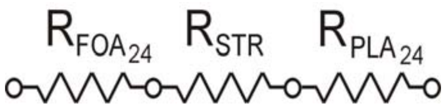

Figure 8. Thermal resistances of 2-4 sub-domains.

$$U_{24} = \frac{1}{R_{24}A_{24}} = \frac{1}{\left[\left(\frac{L_{FOA_{24}}}{k_{FOA_{24}}A_{24}}\right) + \left(\frac{L_{STR}}{k_{STR}A_{24}}\right) + \left(\frac{L_{PLA_{24}}}{k_{PLA_{24}}A_{24}}\right)\right] \cdot A_{24}} \tag{15}$$

Where:

$_{PLA}$ refers to floor plate;
$_{STR}$ refers to aluminum structure;
$_{FOAM}$ refers to the seat foam;
L indicates the wall thickness;
k indicates the wall thermal conductivity;

3.3 Other global coefficient values

The same process listed above was applied to each global heat transfer coefficient presented in Eq. (1) to Eq. (8). The correspondent thermal model and equivalent thermal resistance for the remaining U_{ij} coefficients are shown in the following Fig. (9) to Fig. (18).

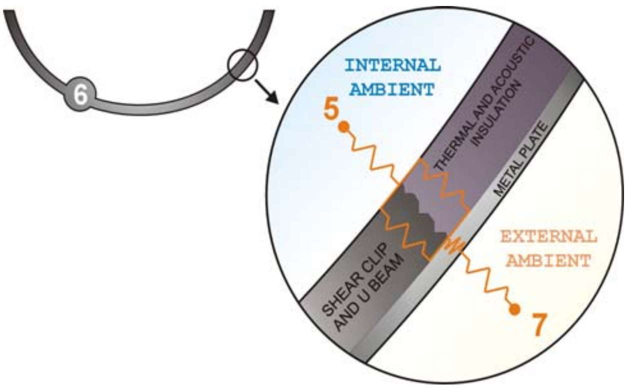

Figure 9. Thermal model of U_{56} and U_{67} coefficients.

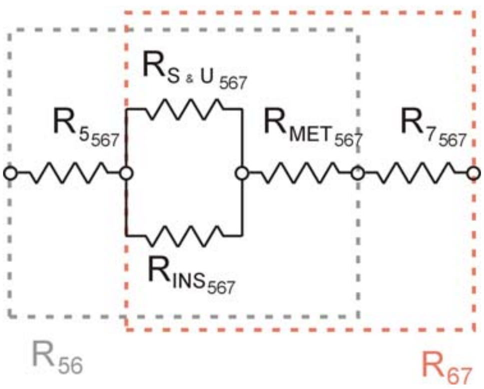

Figure 10. Thermal resistances of 5-6-7 sub-domains.

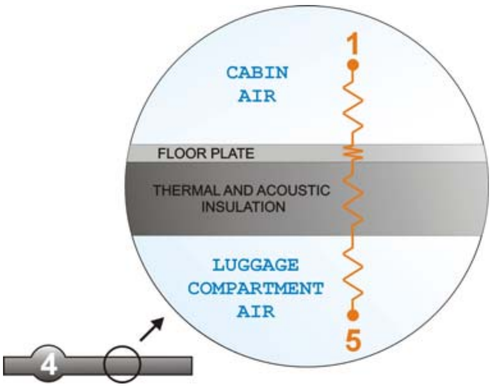

Figure 11. Thermal model of U_{14} and U_{45} coefficients.

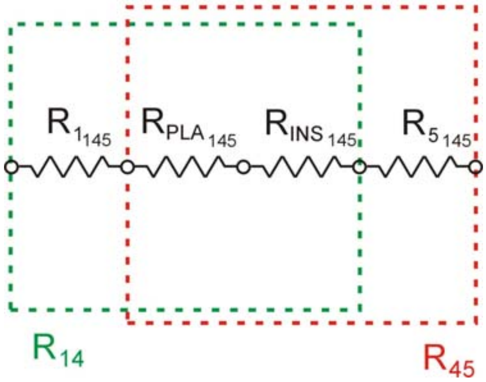

Figure 12. Thermal resistances of 1-4-5 sub-domains.

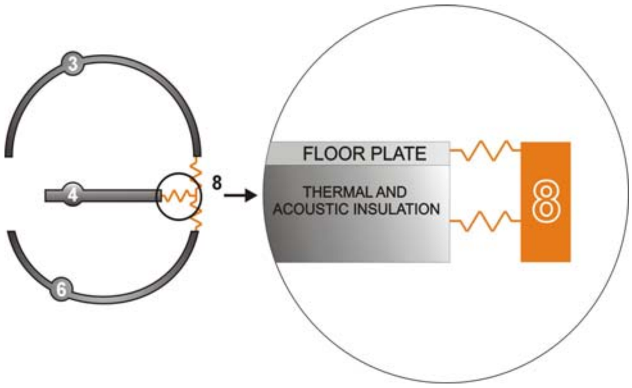

Figure 13. Thermal model of U_{48} and U_{49} coefficients.

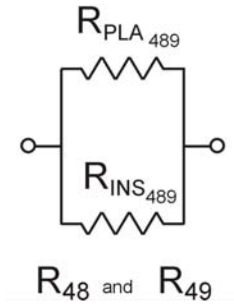

Figure 14. Thermal resistances of 4-8-9 sub-domains.

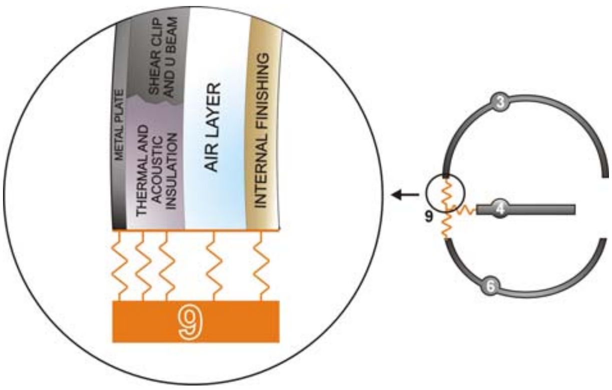

Figure 15. Thermal model of U_{38} and U_{39} coefficients.

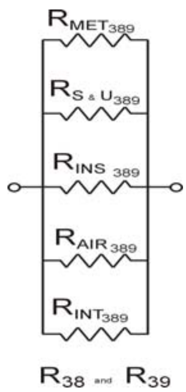

Figure 16. Thermal resistances of 3-8-9 sub-domains.

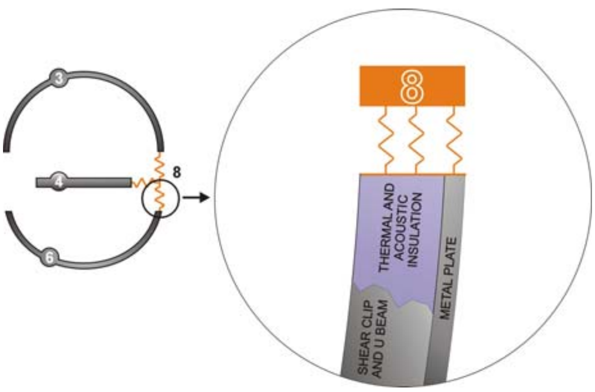

Figure 17.Thermal model of U_{68} and U_{69} coefficients.

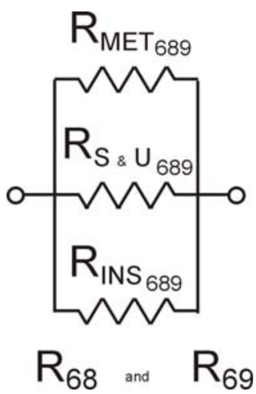

Figure 18. Thermal resistances of 6-8-9 sub-domains.

4. Solution methodology

The temperature time-evolution for each cabin sub-domain is mathematically modeled by the first-order ordinary differential equation system, Eq. (1) to Eq. (8) applying the lumped parameter method. An evaluation of the heat transfer areas for a typical commercial aircraft was performed resulting in the data presented in Tab. (2). The sub-domains material properties (mass and specific heat) are also listed in Tab. (2).

Table 2 – Mass, heat exchange area, specific heat and global coefficient values.

MASS (kg)	**AREA** (m^2)	**GLOBAL COEFFICIENT** $(W/m^2 \cdot K)$
$m_1 = 3.2547$	$A_{12} = 6.2524 \cdot 10^{-1}$	$U_{12} = 2.1327$
$m_2 = 6.2806$	$A_{13} = 4.0391$	$U_{13} = 1.8526$
$m_3 = 5.5053 \cdot 10$	$A_{14} = 1.3968$	$U_{14} = 8.0439 \cdot 10^{-1}$
$m_4 = 2.3423 \cdot 10$	$A_{24} = 9.2 \cdot 10^{-3}$	$U_{24} = 2.0824$
$m_5 = 4.7892 \cdot 10^{-1}$	$A_{37} = 4.0391$	$U_{37} = 2.0012$
$m_6 = 9.2401$	$A_{38} = 5.9096 \cdot 10^{-2}$	$U_{38} = 2.0979$
SPECIFIC HEAT $(J/kg \cdot K)$	$A_{39} = 5.9096 \cdot 10^{-2}$	$U_{39} = 2.0979$
$c_{p1} = 1.007 \cdot 10^3$	$A_{45} = 1.3968$	$U_{45} = 8.0439 \cdot 10^{-1}$
$c_{p2} = 1.0027 \cdot 10^3$	$A_{48} = 4.7244 \cdot 10^{-2}$	$U_{48} = 6.8302 \cdot 10^{-2}$
$c_{p3} = 8.8036 \cdot 10^2$	$A_{49} = 4.7244 \cdot 10^{-2}$	$U_{49} = 6.8302 \cdot 10^{-2}$
$c_{p4} = 9.2228 \cdot 10^2$	$A_{56} = 1.6009$	$U_{56} = 7.3727$
$c_{p5} = 1.007 \cdot 10^3$	$A_{67} = 1.6009$	$U_{67} = 1.0466 \cdot 10$
$c_{p6} = 8.8210 \cdot 10^2$	$A_{68} = 4.9647 \cdot 10^{-2}$	$U_{68} = 5.4682$
	$A_{69} = 4.9647 \cdot 10^{-2}$	$U_{69} = 5.4682$

Applying the methodology described in the previous section, each global heat transfer coefficient was determined and are also presented in Tab. (2). Once all the coefficients are known, the ordinary differential equation system was solved using a fourth-order Runge-Kutta numerical scheme. The program is implemented in the Matlab software language. By this way, the transient thermal behavior is obtained for each cabin sub-domain shown in Fig. (2).

5. Results

Numerical simulations were performed considering a typical pull-down process, characterized by the cooling of a heat-soaked aircraft prior to passenger loading. Both cool-down and warm-up time intervals of less than 30 minutes are usually specified by the certifications requirements.

Table 3 – Initial temperature conditions- Pull-Down.

Cabin Sub-domains	**Description**	**Initial Temperature**
1	Cabin air	$T_1 = 35^o C$
2	Seat	$T_2 = 35^o C$
3	Upper Fuselage	$T_3 = 85^o C$
4	Floor	$T_4 = 35^o C$
5	Luggage compartment air	$T_5 = 35^o C$
6	Lower Fuselage	$T_6 = 35^o C$
7	Ambient air	$T_7 = 29^o C$

To simulate the pull-down transient process, the cabin heating and cooling thermal loads at ground conditions must be evaluated. The following data is based on experimental tests of a typical commercial aircraft with an input mass flow of $\dot{m}_{in} = 0.026\ \mathrm{kg/s}$, that is, the value obtained by the division of the total input mass flow by the cross section length of the fuselage. The initial temperatures of the sub-domains are presented in Tab. (3).

Other assumptions are:

- The input mass flow temperature is $T_{in} = 1.0^oC$;
- As this condition is before the passengers boarding, it is assumed that there is no electrical dissipation inside the cabin. Therefore, $E_1 = 0$ and $E_5 = 0$;
- The upper fuselage solar irradiation is $G_{37} = 600\ W/m^2$. Considering that the cabin windows are closed, there is no solar irradiation in the seats ($G_{27} = 0$). The lower fuselage does not absorb heat by irradiation, so $G_{67} = 0$.

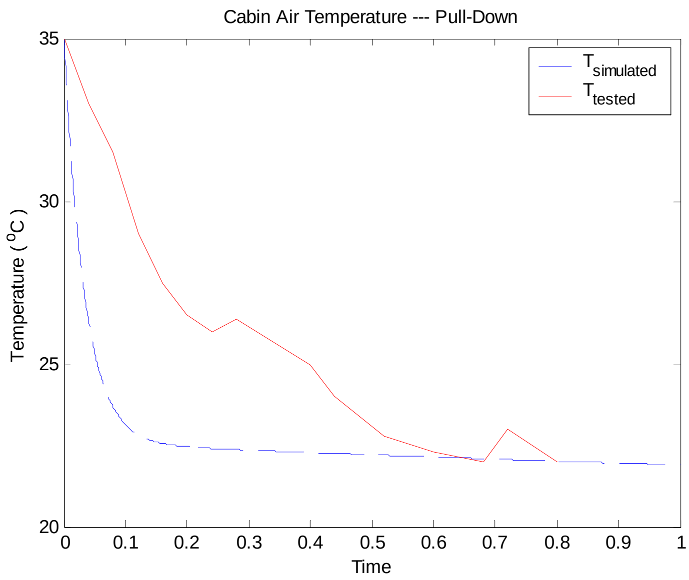

Figure 19. Simulation and experimental results.

Figure (19) shows the cabin air temperature time-evolution obtained numerically and experimentally. The steady-state values present a good agreement. Major differences verified between the experimental and numerical cabin air response can be attributed to the thermometer thermal delay. Numerical results exhibit a deeper decrease in comparison with the measured ones, but both these results nearly approximate the same value satisfying the comfort temperature after large time-interval.

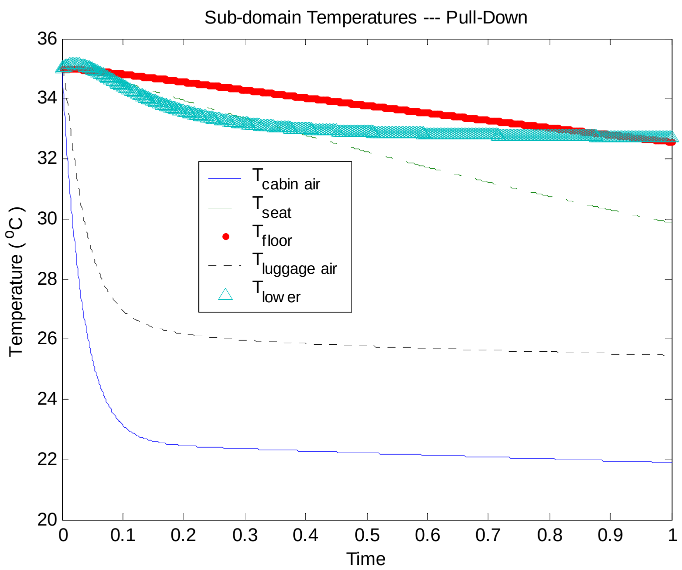

Figure 20. Sub-domain temperatures.

Five sub-domains thermal behaviors are presented in Fig. (20): cabin air, passenger's seat, cabin floor, luggage compartment air and lower fuselage. The cabin air temperature (sub-domain 1) fast reaches an adequate value around 22^0C for instant 0.6 of the dimensionless time. The decrease of the temperature values occurred in this time-interval would fulfill typical requirements of cabin pull-down process for commercial aircrafts.

The temperature time-variation shows that cabin air and the luggage compartment air are the first cabin sub-domains that achieve the steady-state condition. Other cabin partitions need a larger time-interval to reach a stabilized temperature level. Fig (20) also shows that the lower fuselage temperature slightly increases for the initial pull-down time-interval and soon afterwards it starts to decreases. This small temperature peak occurs due to the fact that started the cooling process, the lower fuselage later receives heat form the upper fuselage (T_3 = 85^oC). The air cabin temperature in 0.4 of time has a value below 25^oC, which is recommendable to improve the passengers' thermal comfort. On 0.6 of time, the aircraft cabin air has a temperature of 22^oC cabin confirming to achieve the usual values required for the cabin cooling certification requirements.

6. Conclusions

At the present work, the transient thermal response of an aircraft cabin was numerically simulated applying the lumped parameter method. A methodology solution was proposed to determine the global heat transfer coefficients to evaluate the heat transfer mechanisms between different cabin sub-domains. It was verified that the simplified model captured well the time-temperature variation in the cabin sub-domains with a good agreement with the experimental results of a typical commercial aircraft. The lumped parameters approach allied with the one-dimensional thermal resistance model had demonstrated an efficiency reducing of the computational time, keeping a good results quality and allowing to analyze the influence of the physical parameters in the temperature time-evolution.

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