Jordi Parra Porcar
Master in Numerical Methods in Engineering
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A CFD ANALYSIS OF A LATERAL VENTILATED DOUBLE SKIN FACADE WITH VENETIAN BLINDS

Extended Abstract

Energy consumption in buildings is responsible about 40% of the total amount of energy in the European Union; these ones require energy in order to provide: heating, cooling, illumination, hot water and sometimes also ventilation to the indoor occupants. A continuous effort is carried out for reducing the energetic expenses of these constructions with the aim of achieves a sustainable performance following the current European Union law in this field. The building façade plays an important role in relation to the abovementioned due its direct contact with the surrounding environment and in particular with its interaction with the solar radiation. The façade design must be developed taking in account the following energetic factors: heat circulation, heat storage and the reuse of energy. The idea of using large double glazing areas as a building envelope has to be assessed. Glazing surfaces are separated by an air chamber to achieve an insulation effect, protecting the indoor of heat loses and noise pollution as well as allowing natural light to pass through the façade resulting in an increase of the occupants comfort. Likewise, the particular aesthetics of this kind of construction carries an important weight in the decision of providing a building with this architectural solution. These sorts of façades are given the name of DSF (Double Skin Façades). Nowadays, the use of DSF is a broad practice and in consequence, a wide variety of possible configurations have been described. In relation to the space between the two glazing surfaces, it is built with a separation of 20cm to 2 meters. Several factors are analysed to develop the most efficient building construction.

The DSF concept was firstly studied in the early XIX century by the hand of a sweedish-french architect called Le Corbusier, he named this kind of system “the neutralizing wall”. He included a heating/cooling piping system between two walls, further on his design was selected for doing several projects. The next advance in relation to the neutralizing wall was purposed by Harvey Bryan, who stated that the system originally invented by Le Corbusier was feasible concerning to the energetic matter whether the piping system was replaced by incoming solar radiation. The aforementioned implied a change in terms of selecting materials during the façade design in order to allow the solar radiation get into the building with the result of energy savings. From that moment several DSF designs have been made.

In order to implement a properly DSF, the correct design of the façade before the construction of the building will prevent catastrophic results such as overheating and a sort of greenhouse effect. If paying attention the configuration of this sort of construction we notice why this warm up phenomenon is caused; so by means of the installation of a second glass in front of the conventional one an air channel is created. If is taken into account a façade in whose air chamber there are not air openings for the air to be able to circulate, it would be talking of a very efficient insolating barrier between both glazing surfaces; this effect is shown through a parameter which measures the resistance created in a building façade due to the materials which compose it, the R-value.

Gratia and de Herde [1] proved that the implantation of a DSF in a building decreases the amounts of energy used to heat the building but increase the energy for cooling. These authors studied a building with and without a DSF system to come to the aforementioned results.

Previous studies carried out in the line of research of the present study [2, 3, 4] determined the most efficient manner of ventilating the air cavity and, concluded that the most suitable method of ventilation is a sort of horizontal forced ventilation. The authors stated that using a ten times lesser mass flow rate by the comparison to the vertical ventilation case, it was possible to get a reduction about 25% on the total solar load entering the building. In the study immediately precedent it was assessed a viable way of performing an upper-crossed horizontal ventilation. An alternative to the broadly used fans was presented taking advantage the appliance of the Coandă effect [5, 6] by using nozzles. The mechanical features that the use of Nozzles instead of fans is offering are promising by showing that is possible to get economical savings in respect to the employment of fans. Going further on the implementation of a DSF, the effect of including a fenestration system within the air cavity it’s been also a reason of research. The effects of placing a VB system in front of the interior glass of a DSF have been studied [7].

The general aim of the present work is to carry out a parametrical analysis of the VB in order to obtain the optimal design configuration; this is done facing the fact of minimizing the solar load gains passing through the DSF. According to the abovementioned key parameters must be chosen both geometrical and physicals, as well as its range of variation. Regarding to better understanding the behaviour of all the transport mechanism involved in the study, for each flow conditions expressed a dimensionless analysis has been made of all the equations constituting the heat transfer phenomena.

The dimensional analysis allows us to identify the problem as a sort of conduction/radiation phenomenon within the solid and a convective flow in both turbulent and laminar regime depending on the velocity of the income mass flow. Prior to realize the CAD design intended to be used in the CFD program, some construction parameters such as material and its thickness as well as the total slat length, regarding to the production stage must be properly selected.

Concerning to an appropriate spatial discretization a mesh density independence test was carried out based in the elements length (Le). Three different measures were tested proving the solution is independent of the elements quantity. The DSF model considered to carry out all the CFD simulations has the same dimensions as the used in the preceding stage of the presented line of researching but as distinction from this one, inside the air channel of the actual model has been fitted a system of VB. Likewise for conducting the simulations boundary conditions are imposed such as: mass flow inlet, both optical and physical properties of the air as well as its temperature as well as the incoming solar load (radiation) accounting for the geographical location.

Simulations for both, the natural and forced convection cases have been conducted in a transient state covering 24 continuous hours of flow and operation time of the façade. A time step of 10 minutes was selected (quite below the usual time step used for these kind of simulations, 1h) in order to guarantee the solutions to be solved by minimizing the error associated with the time step Δt in the moment of integrating numerically the obtained results. Likewise, the key point of the numerical model is the Turbulence model and Wall treatment RNG k – epsilon with logarithmic wall treatment accounting for full Buoyancy Effects.

With the purpose of quantifying the VB effect over the incoming heat flux, a parametrical study was carried out of the constructive parameters variation (finishes and geometry) and operative (mass flow rate) that were susceptible of having a certain effect in the thermal performing of the façade.

In addition, a base case with the expected worst operating conditions has been also fixed in order to quantify all the consequent improvements.

Through the parametrical study can be concluded that the variation on the radiative parameters (absorptivity and emissivity) play an important role on the problem, and not only variation on the value of physical parameters is important but also in the geometrical ones as the slat to window ratio and the slat dimensionless parameter (related with the thickness).

The mass flow rate through the Coandă Nozzle as it was studied but previous research of CDIF members has turned out to play a certain role, mainly due to the increasing on the velocity of heat removal by active recirculations within the channel.

Relevant bibliography

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