DSF PERFORMANCE EXCHANGING SKINS

F. Lembo[1], F. Marino[2], G. Lacava[3]

T. 1.

ABSTRACT

This study defines a computational algorithm to calculate and evaluate termical performances of a double skin façade (DSF). The definition of the algorithm, expressed in the unit Simulink of Matlab, has been obtained through: the physical-mathematical treatment of the air stream model and the thermal model; the solution of differential equations through the routine writing in Simulink; the simulations to evaluate the constructive parameters of DSF.

The first simulations have been made in order to evaluate the ideal depth of a single cell of DSF [Lembo et al. 2007], placing a single tempered glass on the outer skin and a double glazing filled with argon on the interior skin.

In the new simulations the outside glazing has been exchanged for the internal double glazing (that is placing double glazing filled with argon on the outer skin and a single tempered glass on the interior skin). Analysing results we can say that efficiency of preheating η has increased up to 5.6% in winter, while solar factor g has increased up to 70% in summer. Simulations has just demonstrated that we have no improvement changing the position of glazing with respect to the first simulations because the solar factor g increases a lot and the efficiency of preheating η increases a little.

KEYWORD

DSF, Simulations, Simulink, exchanging skins.

[1] University of Basilicata, Potenza, Faculty of Engineering, Italy, filiberto.lembo@unibas.it
[2] University of Basilicata, Potenza, Faculty of Engineering, Italy, francesco.marino@unibas.it
[3] University of Basilicata, Potenza, Faculty of Engineering, Italy, giusy.lacava@yahoo.it

1. INTRODUCTION

Nowadays consciousness as for ambient pollution and demand for transparent façades carries out research towards the minimization of energy consumption and location of new solutions to increase thermal performances of buildings. These researches have introduced new concepts, among these double skin façades (DSF), if correctly planned, respond adequately reducing thermic increase in summer and improving thermic performances in winter. In this document there are results of simulations to optimize performances of a double skin façade.

2. DEFINITION OF DOUBLE ENVELOPE SYSTEM

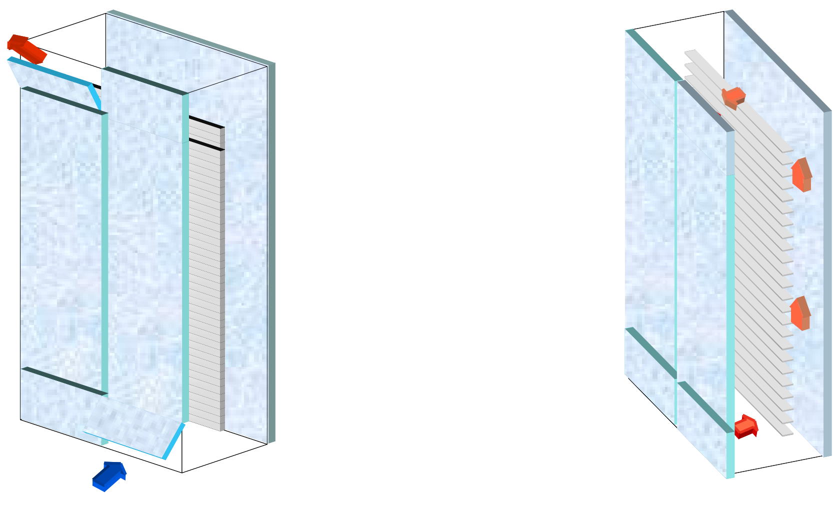
Two glass skins parted with an air corridor which acts as insulation against outer temperature, wind and noise form double skin façades. The DSF exploit passively solar energy realizing a splitting of vertical closing and creating an air gap between external and internal frontier; hot air tends to go up in this cavity, replacing cold air in its place trough a stack effect guaranteed for baffles positioned at the bottom and at the top of double skin façade (DSF).

Intervening with restrain on air displacements caused by a difference of temperature and/or pressure, it is possible to manage climatic conditions and façade's performances at any period of the year, reducing in this way the hardships due to solar irradiation in summer and thermal losses in winter

2.1. DSF working according to season

DSF's working is different according to season:
During summer period baffles are open so that the difference of temperature between air inside cavity and external one allows hot air to go up, as a result of its lower density, permitting cold air entry from basic baffle; Venetian blinds are closed to obstruct direct entry of sun radiation, heat accumulated between glass sheet and Venetian blinds is removed through natural night ventilation as shown in 'Fig. 1a'.

During winter period baffles are closed and Venetian blinds are inclined at sixty degrees (60°) to permit the entry of sun radiation and consequently store of heat inside cavity. Moderate air speed and positive thermal gradients inside cavity allow air to exchange heat with internal surfaces realizing a raise in temperature near internal windows as shown in 'Fig. 1b'.



(a) **(b)**

Figure 1. Double skin façade's working

2.2. Typologies of double skin façades

Double skin façade's typologies are different according to cavity's physical characteristics and they can be classified into four systems:

Full-surface systems where outside skin is completely parted from building not being either horizontal or vertical partitions between two skins. The cavity develops along all envelope surface and cavity's ventilation is guaranteed by baffles placed at the bottom and at the top of building (Fig. 2);

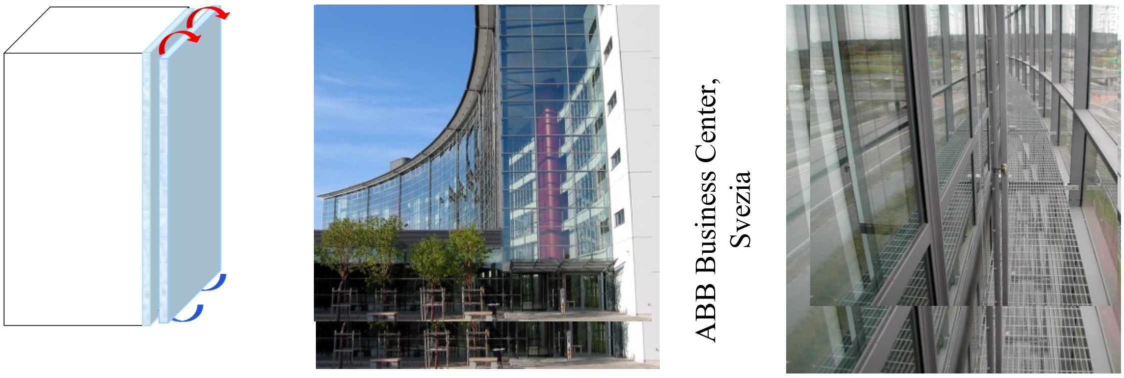


Figure 2. Full-surface systems

Horizontal-channel systems where is generated a longitudinal channel cavity corresponding to building's width and gap's height; every ditch module has got a baffle for air input /output (Fig. 3);

Figure 3. Horizontal-channel systems

Cell systems with vertical well where is generated an alternation of modules up to gap and a vertical duct which extends in height along more floors. Every module is provided with baffles for air input and with lateral openings for air ejection into channel, which will provide for air escape (Fig. 4);

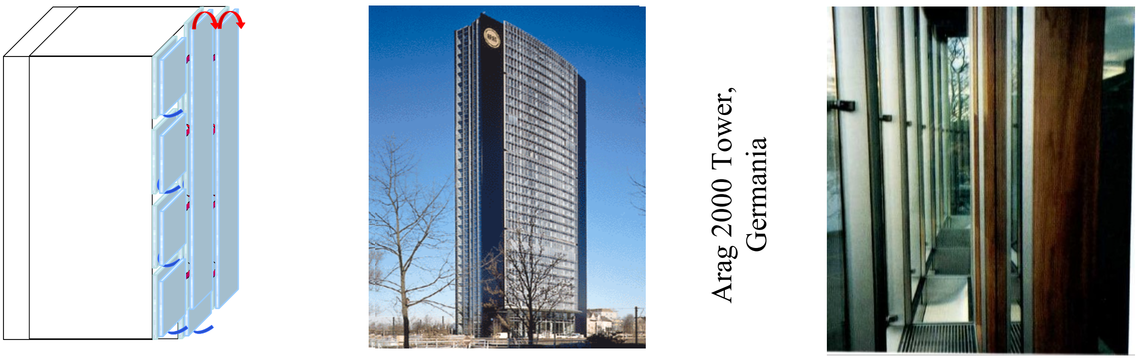


Figure 4. Cell System with vertical well

Single cells systems are constituted of aggregation of glazed cells with vertical partitions in correspondence with every stanchion and horizontal baffles in correspondence with ceilings. Every cell is endowed with own baffles for air input/output with independent cavities (Fig. 5);

Figure 5. Single cells systems

3. PHYSICAL-MATHEMATICAL MODELLING

Thermal performances of a double skin façade (DSF) have been translated by means of physical-mathematical modelling constituted of interaction between two subsystems:

- Airflow model;
- Thermal model;

These patterns, widely described in the document "*Double skin façades: definition of an ideal depth for cavities",*'according to [Lembo et al. 2007]', have been introduced into Simulink in order to carry out simulations.

3.1. Simulations and Results

Practical application of calculation algorithm, obtained through characterization of airflow and thermal model with relating differential equations which characterize them, has been effected for the typology of single cell DSF, situated in a Mediterranean climate (into simulations have been introduced the maximum values of either summer or winter temperatures during 24 hours, which middle values are 23,08 °C in summer and -1.14 °C);

The simulations, 'according to [Lembo et al. 2007]', out have permitted to define ideal DSF's depth fixing cell dimensions, baffles height, the position of the venetian blinds in the cavity and arranging a safety tempered glazing on the external skin and a double glazing filled with argon on the internal skin, have demonstrated the ideal cavities, for either summer or winter period, are: not accessible cavities: 20 and 30 cm, accessible cavities: 60 cm;

New simulations have been carried out changing the position of glazing: a double glazing filled with argon on the external skin and a tempered glazing on the internal skin, with the same climatic and geometrical conditions as the previous ones, and determining efficiency factors of a DSF, distinguishable for season: for winter season we calculate efficiency of preheating η, which represents capacity of DSF to preheat air inside cavity:

$$\eta = \frac{\theta_{c2} - \theta_0}{\theta_{room} - \theta_0} \tag{1}$$

While for summer season we value solar factor g, which represents heat quantity which arrives inside building unit:

$$g = \frac{DT \cdot q_{sun} + \alpha_i \cdot \left(\theta_{surface} - \theta_{inside}\right)}{q_{sun}} \tag{2}$$

Summary results of these simulations can be described during summer period by range of solar factor g in function of depth as shown in 'Fig. 6', while during winter period the results of simulations are described by efficiency range in function of depth as shown in in 'Fig. 7'.

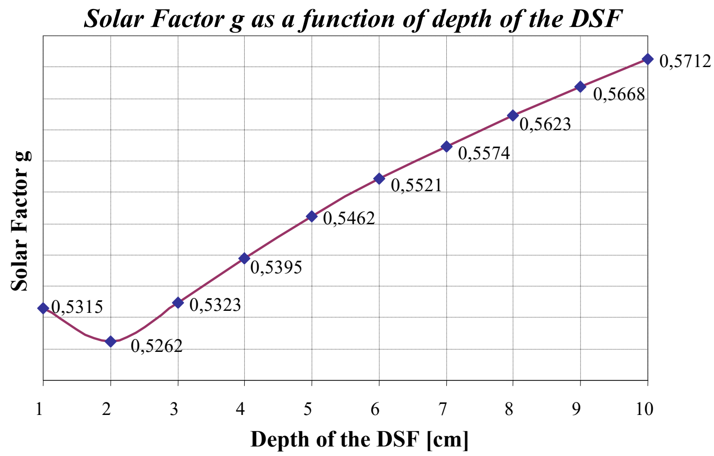


Figure 6. Results of simulations

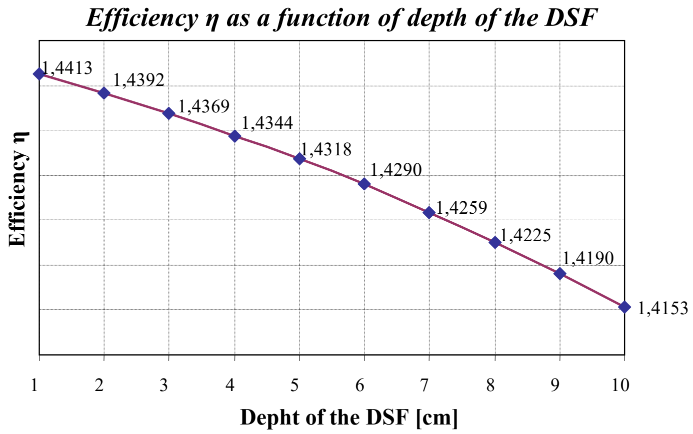


Figure 7. Results of simulations

Comparative graphics between simulations are reported here, 'according to [Lembo et al. 2007]', and recents ones; the Figure 8 highlights a considerable increase of solar factor g in new simulations, which represents a worsening in summer time; while the Figure 9 shows a very low increase of preheating efficiency in recent simulations with respect to first ones, which represent a minimal improvement in the winter time.

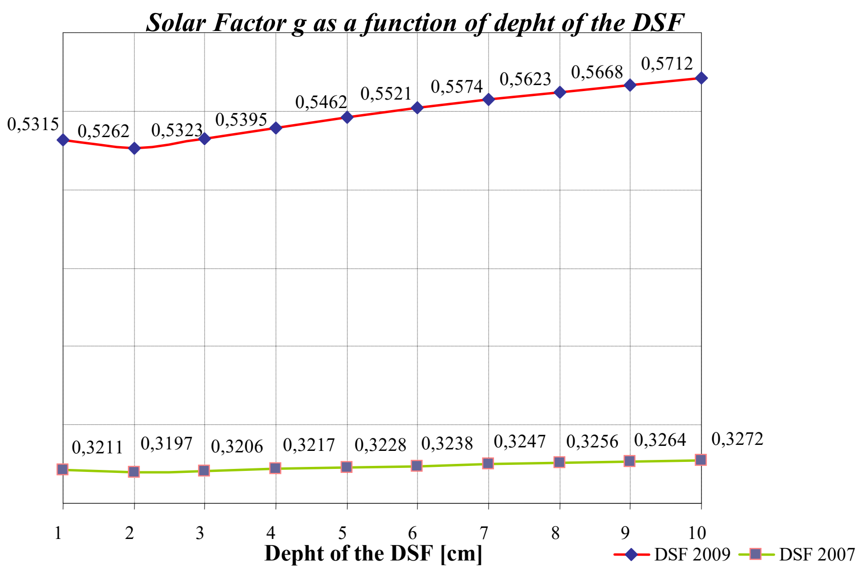


Figure 8. Results of simulations

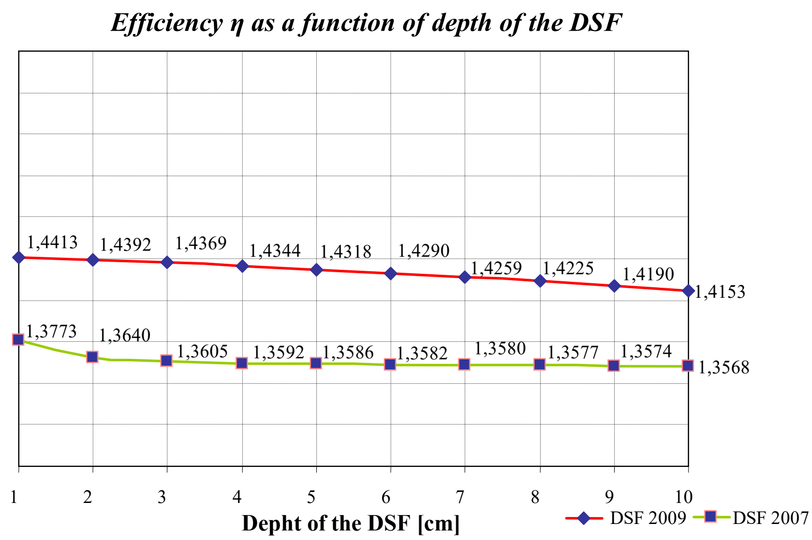


Figure 9. Results of simulations

New simulations demonstrate a considerable increase of solar factor g in summer time, in Table 1 the value of this factor for the ideal cavities are summarized, ‘according to [Lembo et al. 2007]’.

Table 1. Increase of solar factor g

Ideal Depht	*Solar Factor 2007*	*Solar Factor 2009*	*Percent [%]*
20 cm	0.3197	0.5262	+65
30 cm	0.3206	0.5323	+66
60 cm	0.3238	0.5521	+70

In winter new simulations have demonstrated a very low increase of preheating efficiency η, in Table 2 these values for ideal cavities and the very low increase of efficiency are summarized.

Table 2. Increase of preheating efficiency η

Ideal Depht	*Efficiency 2007*	*Efficiency 2009*	*Percent* [%]
20 cm	1.3640	1.4392	+5.5
30 cm	1.3605	1.4369	+5.6
60 cm	1.3582	1.4290	+5

For the Mediterranean climate, setting a double glazing filled with argon on the external skin and a tempered glazing on the internal skin, we can conclude that changing the position of glazing involves a greater overheating in summer and no benefits in winter

REFERENCES

Lembo F, Marino F. & Lacava G. 2007, 'Double skin façade: definition of an ideal depth for cavities', 4th International Research Symposium (SCRI), Salford, Manchester, 26 27 March, pp. 147–160.

Stec W. 2006, '*Symbiosis of double skin façade and indoor climate installation*', Delf University of Technology, The Netherlands, 14 16 January.

Loncour X., Deneyer A. & Flamant G. 2004, '*Les Doubles Façades Ventilées'*, Centre Scientifique & Technique de la Construction - Département Physique du Bâtiment Climat intérieur & Equipements, s.l., 7 14 October.

Di Maio F., Van Paassen A.H.C. (s.d.), '*Modelling the Air Infiltration in the Second Skin Façade'*, Laboratory for Refrigeration Engineering and Indoor Climate Technology - Delft University of Technology, The Netherlands.

Van Paassen A.H.C., Stec W. 2000, '*Innovation in Ventilation Technology- Controlled Double Skin Façade for Preheating Ventilation'*, Laboratory for Refrigeration Engineering and Indoor Climate Technology-Delft University of Technology, The Netherlands, September.

Van Paassen A.H.C., Stec W. (s.d.), '*Defining the Performance of the Double Skin Façade with the use of the Simulation Model'*, Energy in Built Environment - TU Delft, The Netherlands.