inter.noise 2000
The 29th International Congress and Exhibition on Noise Control Engineering
27-30 August 2000, Nice, FRANCE

I-INCE Classification: 3.3

IMPROVEMENT OF SOUND INSULATION OF DOUBLE GLAZINGS BY USING WAVE GUIDE SYSTEMS WITHIN THE AIR SPACE

M. Rehfeld, B. Mottelet

Saint Gobain Glass CDI, B.P. 31, 60150, Thourotte, France

Tel.: +33 3 44 92 36 56 / Fax: +33 3 44 92 36 99 / Email: marc.rehfeld@cdi.saint-gobain.com

Keywords:
DOUBLE GLAZING, SOUND INSULATION, WAVE GUIDE, BUILDING

ABSTRACT
Normal way to improve the sound insulation of double glazings is to increase the thickness of one or the two glass components, or to use special highly damped laminated glasses. This leads to an increase of the weight which induces many problems of manipulation during construction or rehabilitation of buildings. The wave guide system allows an increase of acoustic performances by keeping the same glass components. It has first been put into evidence that the eigenmodes of the gas space cavity are increasing the coupling between the two glasses, and then creating a decrease of the sound insulation. The principle is to create a Helmoltz resonator which will disorganize these modes. The system is included within the spacer of the double glazing. It is compatible with all other requirements for a spacer. It has first been designed by simulation with I_DEAS vibroacoustics, and then prototypes have been realized and measurements done with the two reverberant rooms method following ISO 140. Improvement was between 3 and 5 dB for the global insulation, in function of the rating (Rw or Ra, tr), and of the glass components. Modelisation will be presented, as well as examples of realizations, and results.

1 - INTRODUCTION
The acoustic insulation of windows by using double glazing is now well known. Using double glazing like 4/12/4 for example (i. e. 2 glass panels 4 mm thick with 12 mm air space) is certainly better than using only one monolithic panel of 4 mm of glass. But to have a good acoustic insulation, it is necessary to use of double glazing with thicker or multi layered glass panels. The problem of those thick compositions of double glazing is the weight. The density of the glass is 2500 kg/m3 and very often the weight of a windows is above 50 kg. So our goal is to find how to increase the acoustic performance without increasing the weight of the double glazing, and at a low cost. In the context of the lightened glass without losing acoustic performance, Saint Gobain Glass has developed a new type of glass spacer with improved acoustic performance. This wave guide will now be presented, including its numerical optimization, its first experiments and the perspectives of using such a spacer in the double glazing.

2 - PRINCIPLE OF THE WAVE GUIDE
Firstly, in order to describe exactly how a double glazing is made, figure 1 shows two rectangular glass panels which are sealed and joined by a metallic spacer. This spacer has no acoustic performance, it only creates an air space between the two glasses for thermal reasons. The path of the noise inside a double glazing is quickly explained in figure 2. So if the structure (glass panels) must be kept, it is only possible to have some action on the air space. The idea is to disturb the pressure of the acoustic cavity of the double glazing to decrease the sound transmission to the second glass panel. To trap the acoustic waves inside the double glazing, some tubes on the boundaries of the panels are introduced in order to create a circulation of acoustic waves inside the air cavity at the periphery. By this mean a modal disorganization of the air cavity is created, which limits the vibro-acoustic coupling of the 2 panels. With this installation, the sound transmission through the double glazing is reduced.

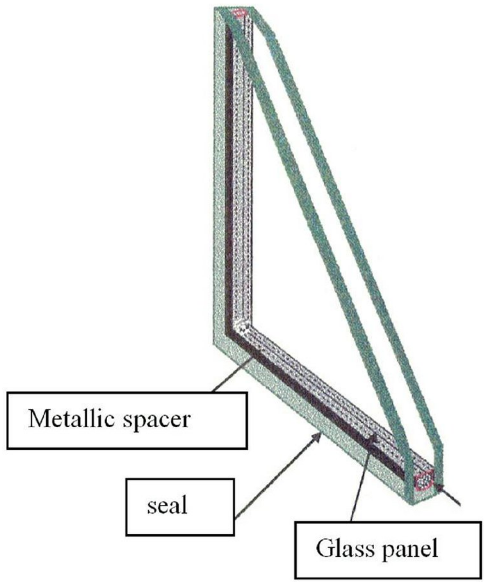

Figure 1: Details of a double glazing.

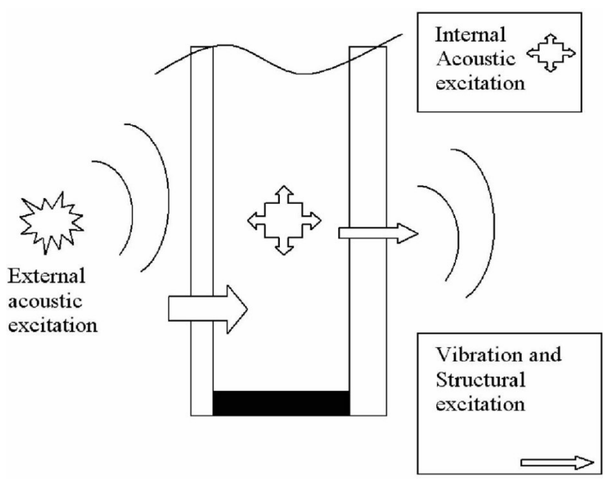

Figure 2: The path of the noise.

3 - OPTIMIZATION OF THE WAVE GUIDE BY USING SIMULATION

To define the wave guide properly, the number and the position of holes on the boundary of the double glazing must be chosen, in order to trap the acoustic waves. To do so, vibro-acoustic simulation is used. First the acoustic impedance is studied, to identify the most active acoustic modes on the response of the double glazing for an acoustic random excitation [1]. I-DEAS Vibro Acoustics is used to study the behavior of the double glazing (particularly the structure-fluid-structure coupling) and to optimize the geometry of the wave guide. Simulation allows to remark that it is more judicious to disturb acoustic modes where the pressure is equal to zero, that is on the lines that join the middle points of the four sides of the panel. The parameter to decide which configuration of double glazing with wave guide prototype is better than the other is the sound transmission loss (STL) and the global indicators $R_{A,tr}$ and R_w. (EN ISO 717). So after several numerical studies for different positions and number of holes, some tubes on the boundaries of glazing were integrated, as presented in figure 3. These tubes are like integrated Helmoltz resonators which are accorded on the half acoustic wave length of each side of the glazing. To increase the sound insulation, some acoustic absorbent material were also introduced inside the tubes.
To illustrate the action of the Saint Gobain wave guide on the acoustic behavior of the air cavity, figure 4 presents the repartition of the pressure for the cavity modes number 2 to 5 of a double glazing (dimensions: 1.48 m x 1.23 m, composition: 6 mm glass / 20mm air / 4 mm glass). The modes 2, 3 & 4 have zero pressure lines on the natural median lines of the rectangular panels: the wave guide can

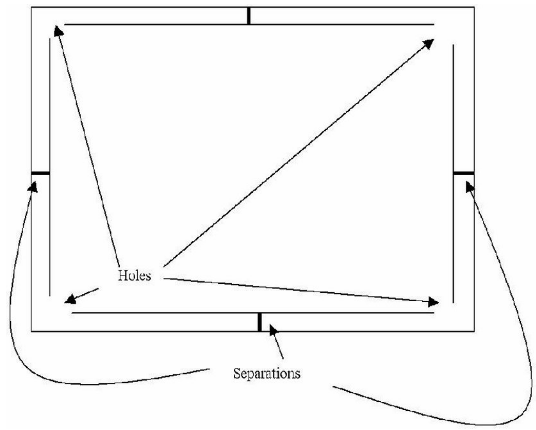

Figure 3: Section of the double glazing with the wave guide.

disturb the modes (0,1), (1,0) & (1,1); the mode 5 which can be named (0,2) cannot be disturbed. Figure 5 shows that the modes 2, 3 & 4 have been disturbed and that the maxima of pressure are localized now in the tubes and not in the visible surface of the glass. For the mode 5 it is stated that the guide is not active, the maxima are effectively on the visible glass surface which is the acoustic radiating surface.

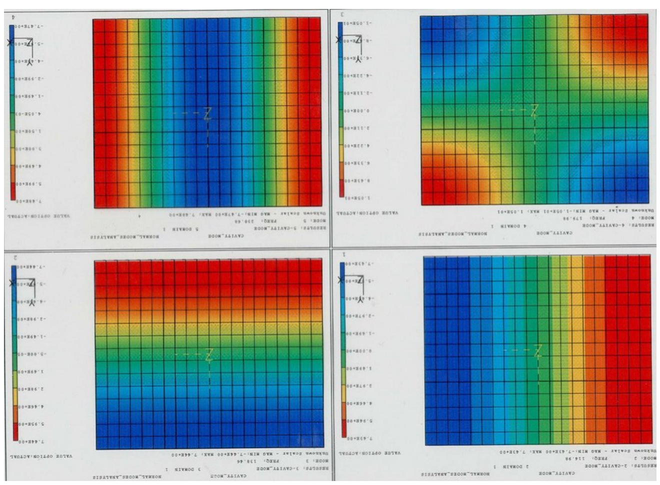

Figure 4: Cavity modes.

4 - CONFRONTATION WITH EXPERIMENTS

By simulation several glass compositions have been studied (different glass thickness, different air space thickness and different dimensions of the panel surface) and it has been stated that the wave guide behaves properly with monolithic and multi-layered panels, and with an air space larger than 16 mm. Figure 6 shows the compared numerical STL of a double glazing (6 mm glass / 20 mm air / 4 mm glass) in the frequency range [30, 400] Hz. By calculation the R_w value of the double glazing with the optimized wave guide is improved of 2dB and the $R_{A,tr}$ value of 3.5 dB. By experiments in the acoustic laboratory, with the two reverberant rooms method where the tested glazing is excited by a diffuse sound field, a difference of 2.5 dB for the global indicator $R_{A,tr}$ between the 2 configurations of double glazings was obtained. Figure 7 illustrates the measured STL for the double glazing 6/20/4 without and with wave guide. So experiments have confirmed the predictions of simulations.

5 - CONCLUSIONS AND PERSPECTIVES

Our target is reached on two points:

- the correlation between simulations and experiments is good, our vibro-acoustic models are relevant, and

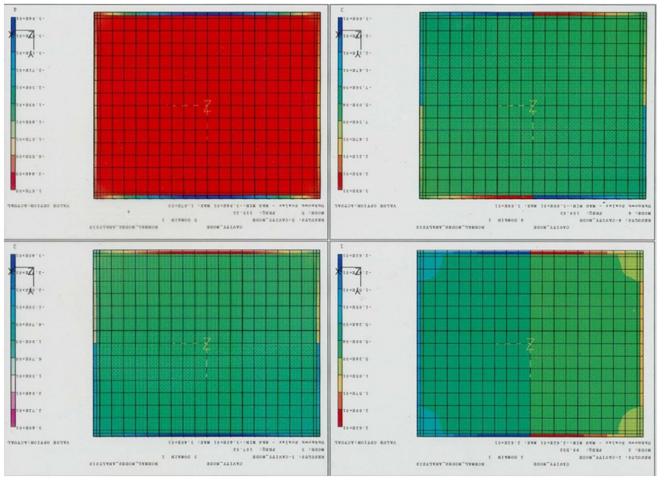

Figure 5: Cavity modes with wave guide.

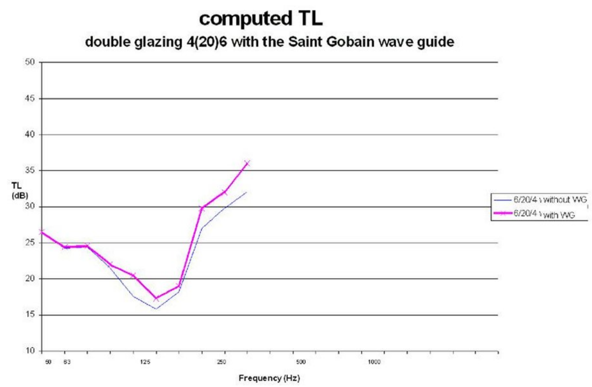

Figure 6: Compared computed TL.

- thanks to the calculation a way, that is a new air spacer, has been found to increase the acoustic performance of double glazing without increasing its weight. The added cost of the wave guide is acceptable and compatible with the increase of performance.

Moreover this new glass spacer which is patented by Saint Gobain Glass works properly with both double glazing with low acoustic performance like 2 monolithic glass panels of 6 mm and 4 mm thickness and double glazing with high acoustic performance like 2 multi-layered glass panels with specific acoustic interlayer.
Now the industrialization of the fabrication of this new glass spacer and the validation of all the other functions (thermal, moisture, mechanical, ... characteristics) are to be done, in order to put it on the market during next year.

REFERENCES

1. **B. Appert-Mottelet**, Dimensionnement du guide d'onde des systèmes de double vitrage, *STRACO*, 1996

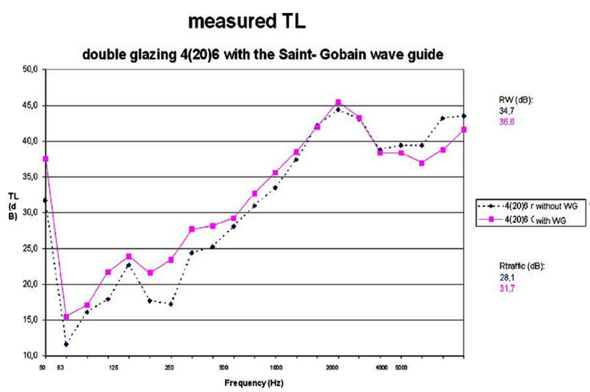

Figure 7: Compared measured TL.