Reduction of MRI Scanner Acoustic Noise using a Micro-perforated Panel Absorber

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Introduction

MRI scanner noise has long been a concern for patient health and patient safety [1]. Depending on scanner main magnetic field strength and the type of imaging sequences being used sound levels within a scanner can be as high as 123-132 dB(A). The trend toward higher background magnetic field strength is worsening the noise problem. Work has been done to characterize the acoustic noise in the scanner bore. Various measures have also been investigated to attenuate the noise. However, these measures are either extremely costly or only modestly successful. We have studied the possibility of implementing a micro-perforated panel absorber in the MRI bore to reduce the acoustic noise. This paper presents some of our findings using computational analysis.

Methods and Results

Acoustic characteristics of a micro-perforated panel absorber were first described using Maa's theory [2,3]. A solid model of the absorber for an MRI scanner bore was developed for this study (Figure 1). Acoustic impedance functions and absorption coefficient functions of an absorber with various design parameters were calculated using MATLAB. Referring to Figure 2 and 3, a micro-perforated panel absorber can be designed for wide band absorption (absorber 1) or narrow band absorption (absorber 2 and 3). Figures 4, 5 and 6 show the change of absorption coefficient relative to the diameter of the hole (d), to the thickness of the plate (t) and to the thickness of the air gap (D) respectively, with all other parameters unchanged. Boundary Element Method (BEM) analysis was carried out with LMS Virtual.Lab Acoustics to compute the sound field in the scanner bore for the above mentioned three absorbers. Figures 7, 8 and 9 show that these absorbers significantly reduce the sound pressure levels in a wide frequency range and at all locations along the duct centerline.

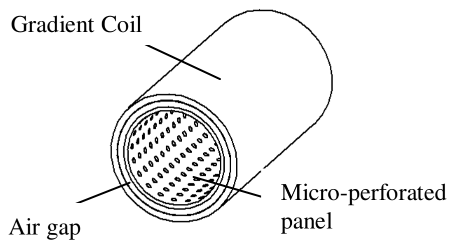

Fig. 1. Solid model of the absorber

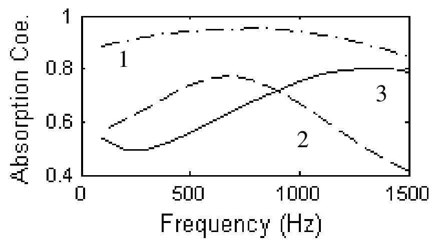

Fig. 2. Absorption coefficient functions

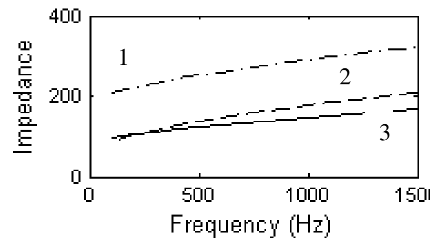

Fig. 3. Impedance functions

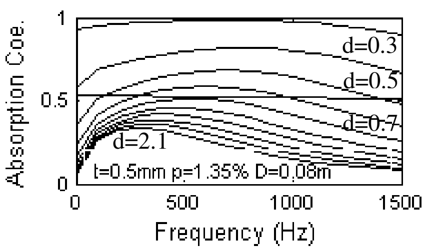

Fig. 4. Absorption coefficient vs. hole diameter

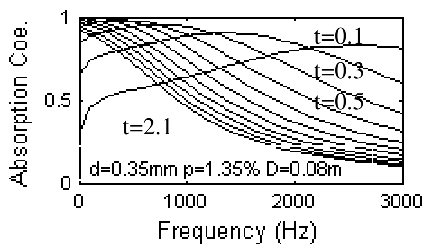

Fig. 5. Abs. coeff. vs. plate thickness

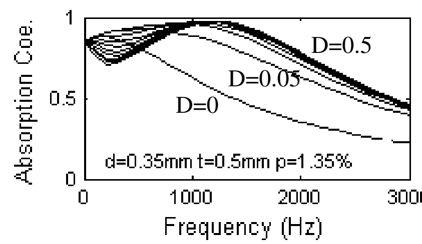

Fig. 6. Abs. coeff. vs. air gap thickness

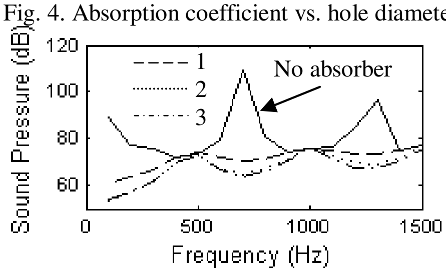

Fig. 7. SPL at the isocenter

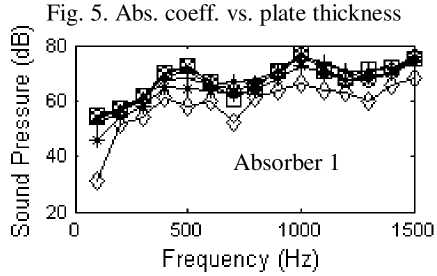

Fig. 8. SPL at 11 points along the centerline

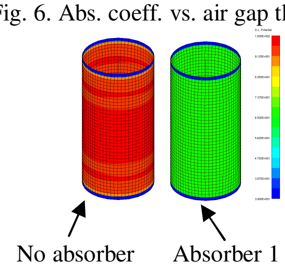

Fig. 9. Acoustic mode of 700Hz in the duct

Conclusions

The BEM Simulation results show that a micro-perforated panel absorber can significantly reduce MRI noise in the scanner bore. The impedance function of the absorber can be used for predicting the sound attenuation effect of the absorber. However, the absorption coefficient functions calculated according to Maa's theory do not reflect the absorbing effect of a micro-perforated panel absorber in a cylindrical duct such as an MRI scanner bore because the expression of impedance of air gap in Maa's theory is based on the assumption of plane waves. A new absorption coefficient function for cylindrical micro-perforated panel absorbers needs to be developed based on Maa's general theory.

References

[1] Quirk ME, Letendre AJ, Ciottone RA, Lingley JF. Anxiety in patients undergoing MR imaging. *Radiology* 170, 463-466 (1989). [2] Maa DY. Theory and design of micro-perforated panel sound-absorbing constructions. *Scientia Sinica* XVIII (1), 55–71 (1975). [9] Maa DY. Potential of microperforated panel absorber. *J Acoust Soc Am* 104 (5), 2861–2866 (1998).