Acoustic Performance of Absorptive Foam in a Gradient Coil Insert in a 4T MRI

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Introduction

Acoustic noise generated by MRI scanners has a tendency to raise stress levels in patients undertaking the scanning. MRI acoustic noise may even lead to temporary or permanent shifts in the hearing threshold for patients [1]. This noise is mainly caused by the vibration of the gradient coil system due to the Lorentz forces generated by the interaction of electrical current in the conductors in the gradient coil and the main static magnetic field. An analytical model for the acoustical radiation of gradient coils showed that the application of acoustically absorptive materials to cover the inside surface of gradient coils can reduce the acoustic resonance inside the scanner effectively [2]. To validate the results obtained by the analytical model, experiments to investigate the sound field inside a gradient coil insert in a 4T MRI scanner with and without acoustical absorptive foams were conducted. The measurement and analysis results are shown in this paper.

Experiments and Results

Acoustic measurements were conducted in a 4 Tesla Varian / Siemens Unity INOVA whole-body MRI system. The gradient coil insert (0.68 m in length and 0.24 m in inner diameter) used in the experiment with the absorptive foam is shown in Figure 1. Foam layers of half inch and one inch in thickness were used to cover the inner surface of the insert wall. The spatial sound fields for these two cases are compared with the acoustic response when no absorptive materials were applied to the insert. A G.R.A.S 40AF microphone and National Instrument PXI system were used to collect the acoustic response signals. The sound field inside the duct is assumed symmetrical to the isocenter because the velocity distribution of the insert inner wall is symmetric about the center plane due to the symmetry of the gradient coil windings. Therefore only a half of sound field inside the insert was measured. The measurement points were distributed on the center line and on a cylindrical plane of 0.1 m in diameter. The spacing of these points along the axial direction was 0.04 m and 30 degree circumferentially (see Figure 2.).

Figure 1. The gradient insert with the absorptive foam

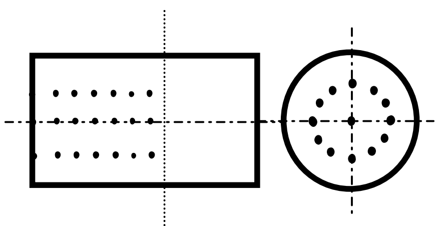

Figure 2. Measurement point arrangement

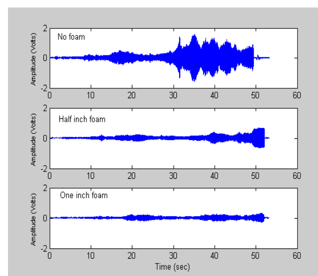

Figure 3. Sound pressure at at the isocenter

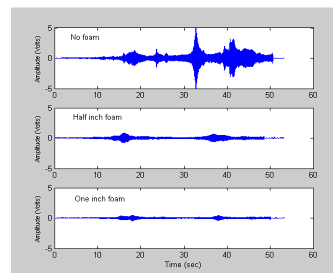

Figure 4. Sound pressure at the point r = 5 cm

A swept sinusoidal input from 100 Hz to 3000 Hz was used as the excitation signal. The sound pressures (absolute values shown in Volts) at the isocenter and the point $r = 5\ cm, \theta = 0$ for rigid wall (no foam), half inch and one inch absorptive foams covering wall are shown in Figure 3 and Figure 4 respectively. The horizontal axis shows the sampling time (in second) and the vertical axis represents the sound pressure values. It is obvious that the noise was significantly reduced after the absorptive foams had been put into the insert. The sound pressure levels Lp (dB) (with a reference of 20 micro pascal) of all measurement points were averaged from 100 Hz to 3000 Hz. The results show that the noise was attenuated by 7 dB and 11.3 dB when the insert wall was covered by half inch and one inch foam layers respectively, compared with no foam.

Conclusions

The sound fields of a gradient coil insert in a 4T scanner with and without acoustical absorptive foams were measured. The experimental results show that the application of acoustically absorptive materials to cover the inside surface of gradient coils can reduce the acoustic resonance inside the insert effectively. It also validates the conclusion based on the simulation results in Ref.[2].

References

[1]. Brumment RE, Talbot GM, Charuhas P. Radiology 1988; **169**:539-540. [2] .Shao W and Mechefske CK. "Acoustic Analysis of Gradient coils of A MRI Scanner". *Concepts in Magnetic Resonance, Part B: Magnetic Resonance Engineering,* Accepted and will be published in January 2005.