THEORETICAL RESEARCH ON THERMAL MODELING OF A HIGH POWER AUDIO DEVICE

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ABSTRACT :*This paper aims at analyzing the mechanism of heat transfer and consequently a thermal analysis. Data obtained provides a starting point in choosing solutions constructrive, mechanical and electrichal dynamic audio device prototype .A comprehensive approach allows optimization of device based on our maximum eficianta developed model and finite element analysis program using coupling possibilities in different conditions*.

Keywords: magnet, speaker, transducer

1.INTRODUCTION

Most speakers today are products of "electrodynamic" or "permanent dynamic." Schematic representation of such a speaker is shown in Figure 1

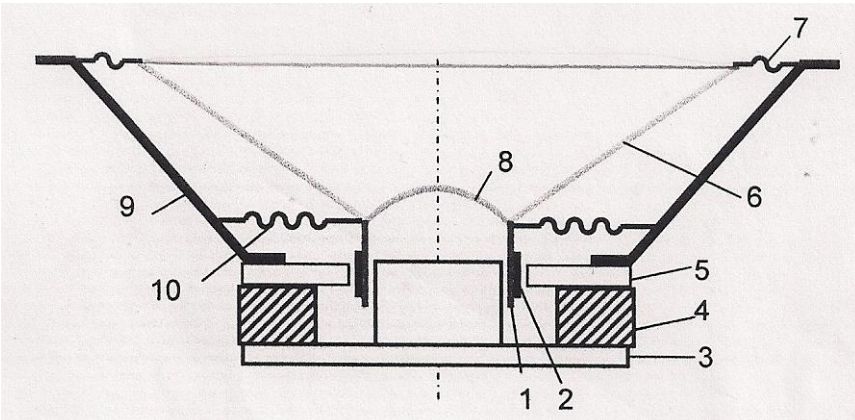

Fig. 1.*Schematically representation of a permanent dynamic audio device :1-coil support, 2-coil, three-board back, 4-permanent magnet, front plate 5, 6-cone membrane, 7-membrane suspension, 8-capacde dust; 9-chassis (frame), 10-centering membrane*

The speaker is basically a transformer (transducer) of electrical energy in the acoustic energy passing through mecanica.Numai a small amount of energy used is converted into acoustic energy, the rest being lost in part by the heating effect of electric current, partly by eddy currents and partly by friction in mechanical system. The audio device applications is that a circuit with concentrated parameters as in Fig.2

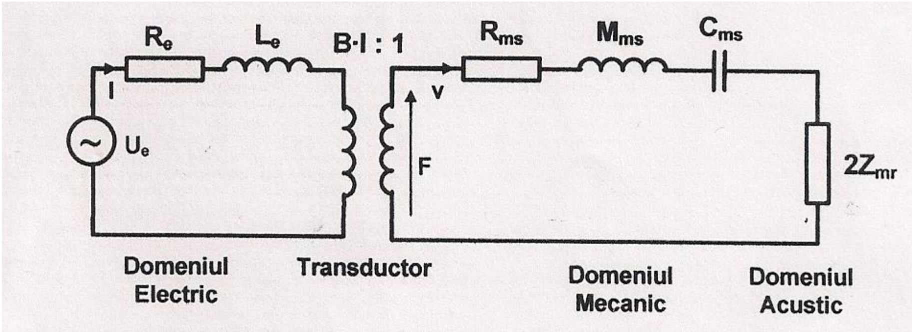

Fig.2. *Equivalent circuit with concentrated parameters of the speaker transducer*

Where : U is the the voltage supply control for audio device ; R_e is the electric resistence ; L_e is the inductance of mobile coil ; R_{ms} – equivalent resistence of the losses of the mobile sistem ;C_{ms} – equivalent capacitance losses ; Z_{mr} – acoustic radiation impedance of the vibrating piston corresponds to one side of the membrane

The transducer is represented as a transformer with transformation ratio B· l :1 from electrical to the mechanical ,where B is the magnetic induction and l is the length of the conductor coil. It can make a formal equivalence between the electric and the acoustic , the mechanical force and speed is corresponding to voltage and current. This equivalent circuit can be used both in electrical engineering and in the sound, depending on the intended purpose. The electrical circuit can be used to determine the frequency behavior of the speaker (resonance frequency) and the mechanical (acoustic) can be used to determine the total radiated power or sound pressure.

Total radiated power is the power dissipated in the environment acoustic radiator.

Based on Figure .2, radiated power is $2 \cdot R_{mr} \cdot v^2$,with R_{mr}, the radiation resistance.

There are two requirements for the new speaker:

1.) Mobile equipment to suport the developed high power

2.) Acoustic efficiency of the speaker to be high.

Thermal analysis seeks to define the limits of power for the prototype to be built. Electric power is applied to the mobile coil. Terem dissipation is concentrated in the narrow air gap of magnetic circuit .Adhesives used to fix the coil support on the membrane, and the permanent magnet ,wire insulation are the most susceptible to overheating.

2.. MODELING THERMAL DEVICE AUDIO

Electrical energy is transmitted to mobile coil. Most energy is used for heating coil, some energy is transformed into mechanical energy, of which a fraction is converted into acoustic energy. If energy transfer by radiation is neglected, energy transfer coil surrounding air that circulate through the air gap. Thermal energy is then transmitted to bodies in contact with hot air, bodies found in the region of flow, thus warm the magnet and pole piece.

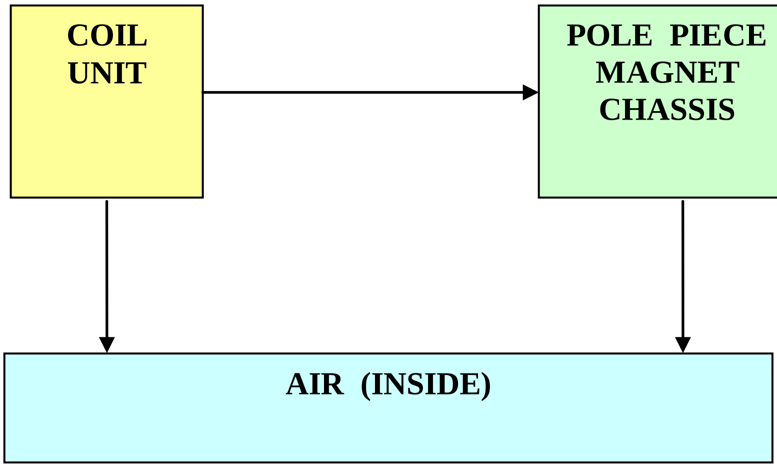

Fig.3.*Simplified cooling model of speaker*

It uses concentrated parameters model in figure 2.

Heating speaker is due to the resistors of the scheme. Losses due to friction in the system is neglected . Heat is generated in the coil which transmits the ambient air. A coil support with high thermal conductivity can prevent rising hot spots in windings and removes heat from the air gap. Airflow partially transmits heat to the permanent magnet pole piece and the channel forming flow. Hence heat is removed by convection or radiation to the environment.Based on the simplified thermal model described above ,the thermal equivalent circuit (for stationary thermal regime) is presented in figure 4 .

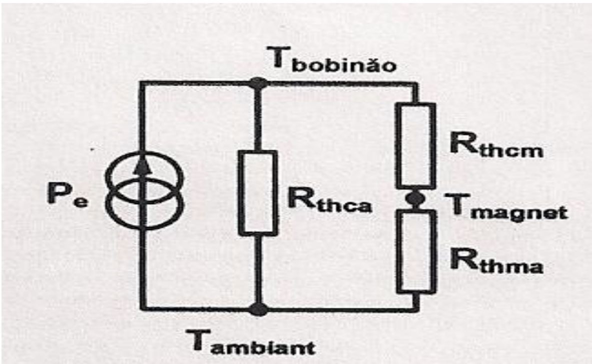

Fig.4. *Simplified thermal modelul of speaker*.

The concentrated parameters model from figure 2, determine the heat resistance of the speaker schedule. A major contribution to heating has Rms. Losses due to friction in the system and the air surrounding the coil are neglected .The heat is generated and transmitted to ambient air.

A coil support with high thermal conductivity can help to avoid the ' hot spots' in the windings and helps remove heat from the air gap.

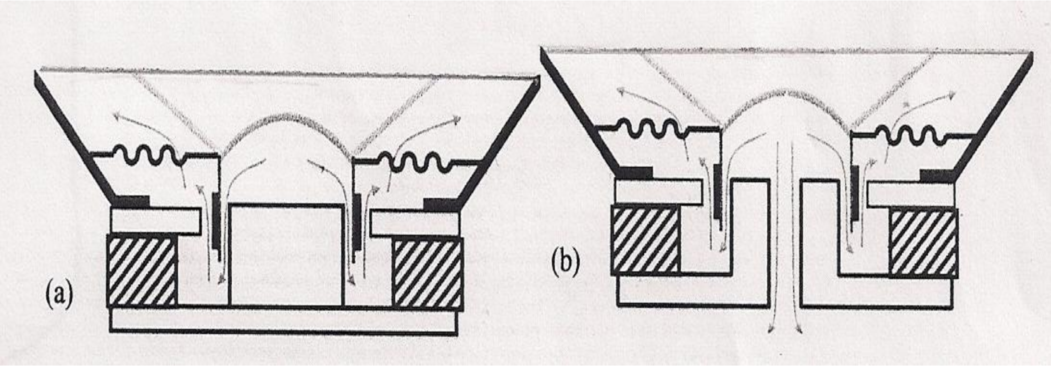

Fig.5. *The air flow circulating in the air gap (a) classical, (b) leg "ventilated"*

For low frequencies, the high-powered, some manufacturers made a pole piece ventilation channel, see fig. 5 (b) as a supplementary heat in the exhaust. But this solution reduces air velocity in the coil, the air gap, so be well analyzed before being applied
Analysis using finite element modeling can complement optimizing constructive solution.

There are some problems in modeling finite element diffuser structure, most problems resulting from the cooling the air gap mechanism .
Computational Fluid Dynamics, (CFD) require a finer mesh in areas with high gradient of temperature and usually require more memory and computing time. CFD analysis result will be presented as temperature, air velocity and temperature of solid zones .

Boundary conditions are imposed in the area of fluid flow. Solid surface areas, usually normal speeds are zero and the domain boundaries are prescribed zero speed or require temperatures known. Effects due to natural convection (buoyancy) can be taken into account by specifying a value of gravitational acceleration ($g = 9.8 m/s^2$)

Moving areas will be modeled with a relative velocity of the fluid turbulence inducing factor in the equation. In determining whether flow should be estimated Reynolds number:
$Re = (\nu \cdot \rho \cdot L) / \mu$ (1)
with ν air velocity, air density ρ, length L characteristic and dynamic viscosity μ.

For an estimated average amplitude A = 5 mm ,the relative speed for harmonic oscillation frequency of 100 Hz is $2 \cdot \pi \cdot f \cdot A = 3.14 m / s$, which corresponds to the actual 2.22 m / s

If you consider the flow channel width of 2 mm (the value of L in this case is 4 mm) and for proper air ρ = 1006 kg/m3, μ = 1.873 · 10-5Kg / m · s get a Reynolds number of 240.

The critical Re number is about 2200. In this case, the result indicates a laminar flow. The turbulent flow will turn algorithm for moving areas.

CONCLUTIONS

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