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THE INFLUENCE OF WALL RESONANCES ON THE LEVITATION OF OBJECTS IN A SINGLE-AXIS ACOUSTIC PROCESSING CHAMBER

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16. ABSTRACT

Instabilities have apparently been observed in high-temperature, single-axis acoustic processing chambers. It is hypothesized that at certain temperatures strong wall resonances are generated within the processing chamber itself and that these transverse resonances are sufficient to disrupt the levitation "well." This investigation indicates that, if these wall resonances do exist in the processing chamber, they are apparently not strong enough to cause instabilities in the levitation well.

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TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

INTRODUCTION

A sample of gallia/calcia/silica glass was lost from the levitation "well" of the single-axis acoustic system in the SPAR VI sounding rocket flight [1]. Observation of the flight film indicated that an instability may have developed in the levitation well. It has been hypothesized that the acoustic field may have induced a radial resonant condition sufficient to disrupt the levitation well when the processing chamber reached certain temperatures. A partial simulation of this phenomenon was performed by varying the dimensions of a processing chamber at room temperature in order to simulate the temperature variation effect on the wavelength of sound in the processing medium. At certain wall separations a resonance condition was established and the effect on the levitation well noted.

APPARATUS

The experimental apparatus is shown schematically in Figure 1. A St. Clair sound generator with a stepped driver of 3.5 cm head diameter is used as the acoustic source. A levitation node is formed by interfering the sound field with a 2.0 cm^2 reflector. Measurements taken with B&K sound pressure equipment included axial sound pressure distributions between driver and reflector for resonance and antiresonance conditions as shown in Figure 2 (a,b). The sound pressure was measured radially from the common levitation node to the wall of the processing chamber. The walls were positioned at three different separations corresponding to possible resonance conditions of 3, 4, and 5 times the wavelength of the axial sound pressure distribution (λ = 2.256 cm), as shown in Figures 3 (a,b,c) and 4 (a,b,c). The dimensions include the actual dimensions of the SPAR VI processing chamber (10.8 cm × 10.8 cm × 11.4 cm) [2]. Also, any fluctuations of the sound pressure level in the levitation node resulting in instabilities in a sample being levitated were noted as the wall separation of the processing chamber was constantly varied.

AXIAL SOUND FIELD

In the resonance condition the levitation node is one quarter of a wavelength below the reflector. This is verified by the data in Figure 2a. If the reflector is moved by one quarter of a wavelength to the antiresonance condition, the worst case of a typical off-resonance condition, the levitation node is also located one quarter of a wavelength below the reflector. This is confirmed by the data in Figure 2b. These figures indicate that for typical resonance and typical nonresonance conditions a strong interference well is formed one quarter of a wavelength below the reflector. It should be noted that this is the levitation well used in the SPAR VI single-axis acoustic furnace.

RADIAL SOUND FIELD AND WALL RESONANCES

It was observed that as the wall separation was varied from a separation of 3, 4, and 5 times the wavelength of the axial sound field, the radial sound field remained virtually undisturbed [see Fig. 3 (a,b,c) for typical results]. It was also observed that as the wall separation was varied constantly, no fluctuation in sound pressure occurred in the interference node, and no unusual instabilities occurred in a sample being levitated in the node. It may be deduced that this type of single-axis sound source does not generate strong wall resonances. Another factor contributing to the absence of strong wall resonances is that there is minimal sound reflection at the walls because the high-temperature zirconia has a high absorption coefficient ($\alpha \approx 0.7$) [3].[1]

CONCLUSIONS

This experiment was a partial simulation of the phenomena occurring in high-temperature, acoustic suspension furnaces. It was hypothesized that at certain temperatures strong resonances could be generated between the walls. The data show that varying the transverse wall separation by 3, 4, and 5 times the wavelength of the axial sound field appeared to have no effect on the levitation node immediately under the reflector. Based on these experiments and results from other high-temperature investigations, these resonances, if indeed they do exist, do not appear sufficiently intense to disrupt the levitation wells of high-temperature, single-axis acoustic processing chambers.

1. Approximation derived from Table XIII of Reference 3; for example, glass ($\alpha = 0.2$).

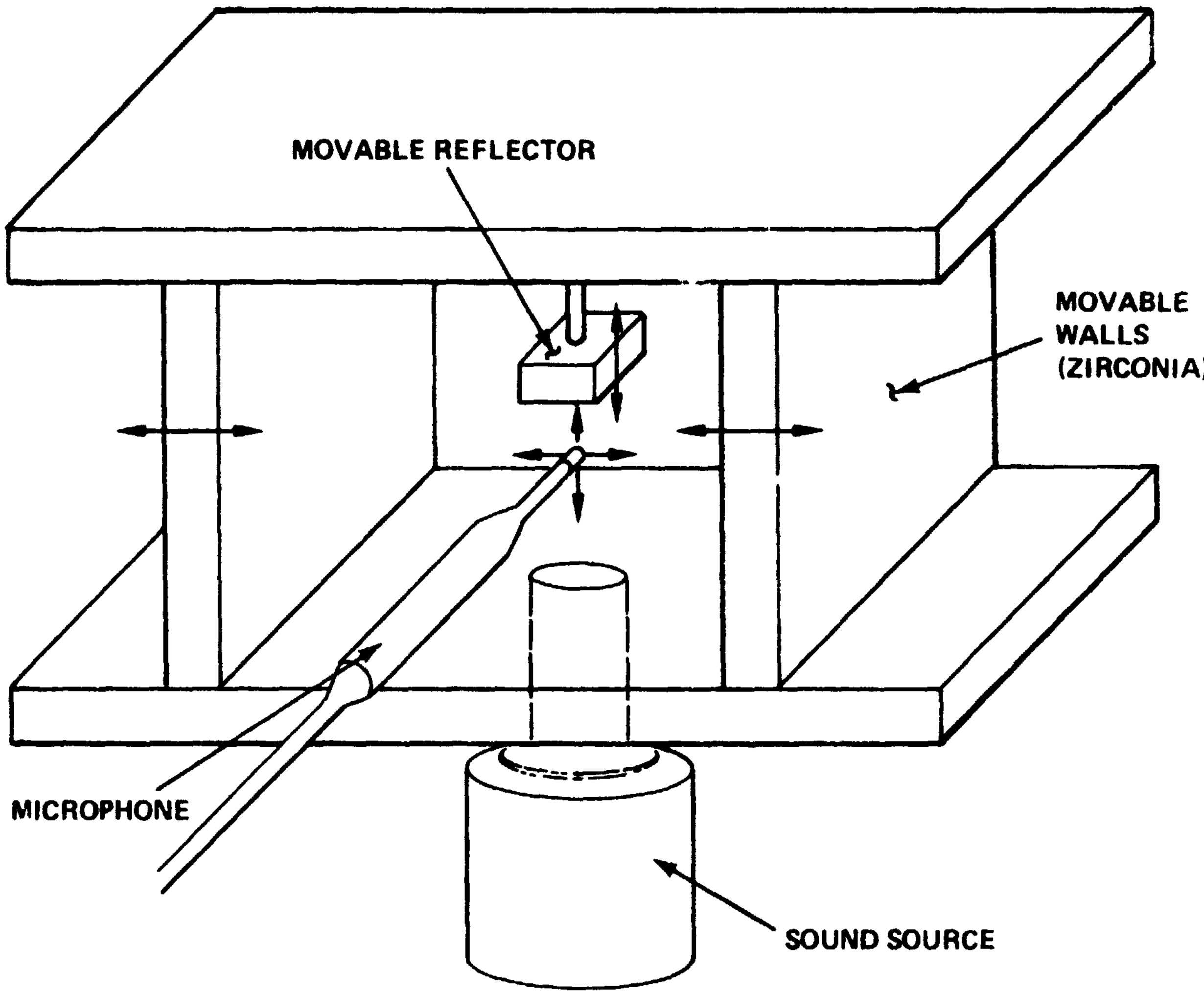
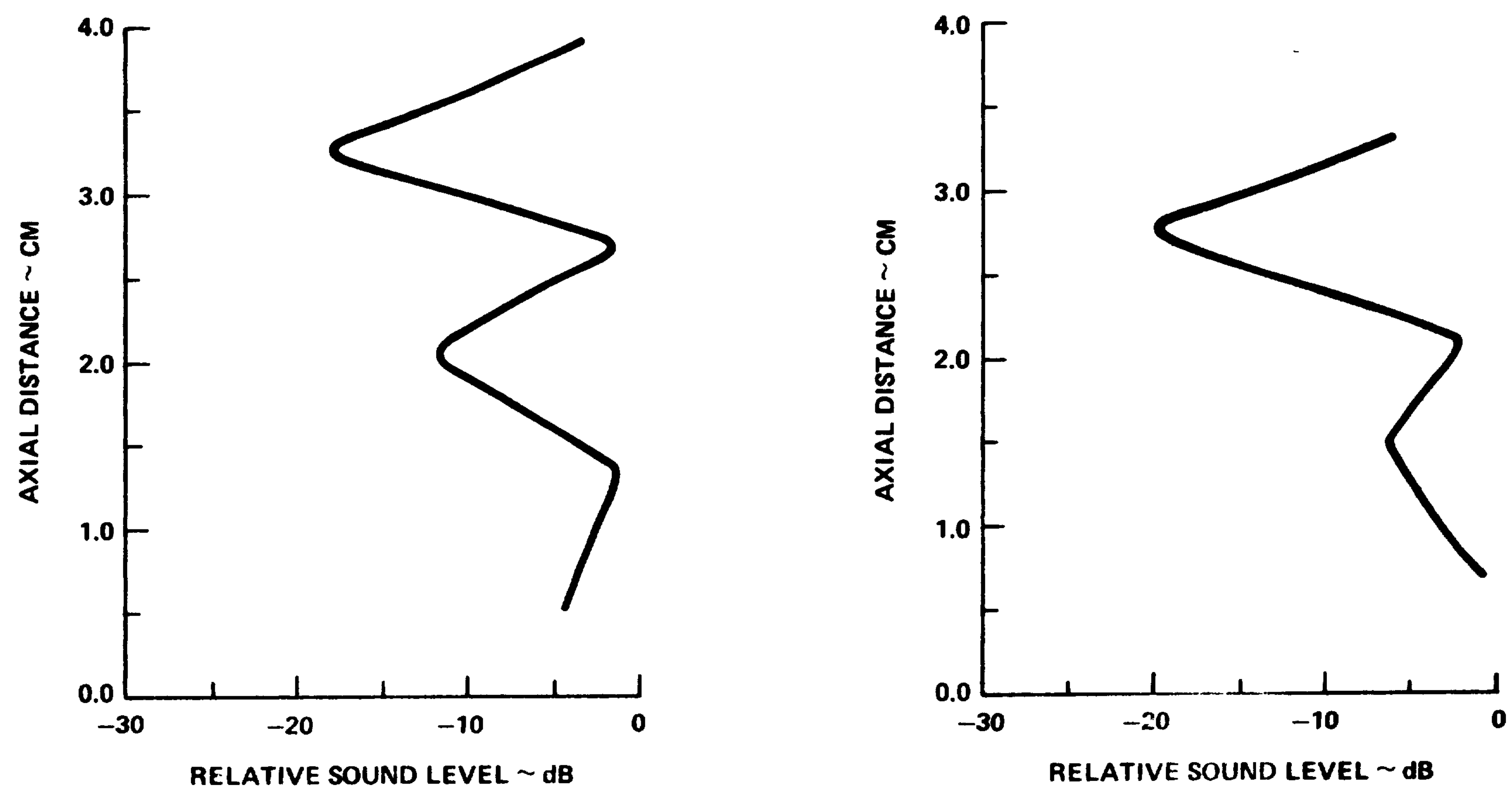


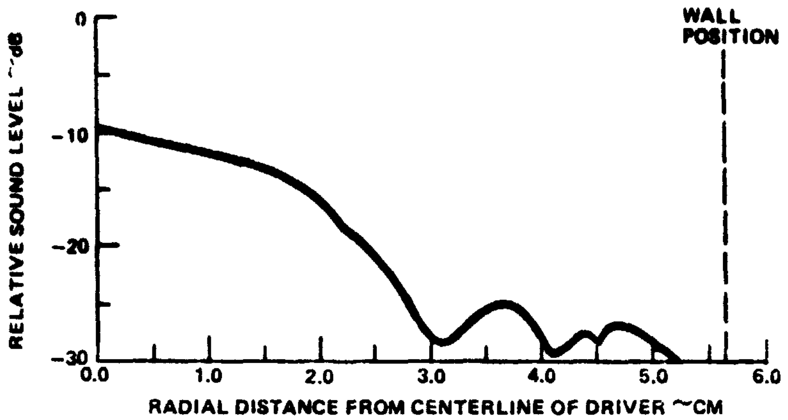
Figure 1. Simulated acoustic processing chamber.



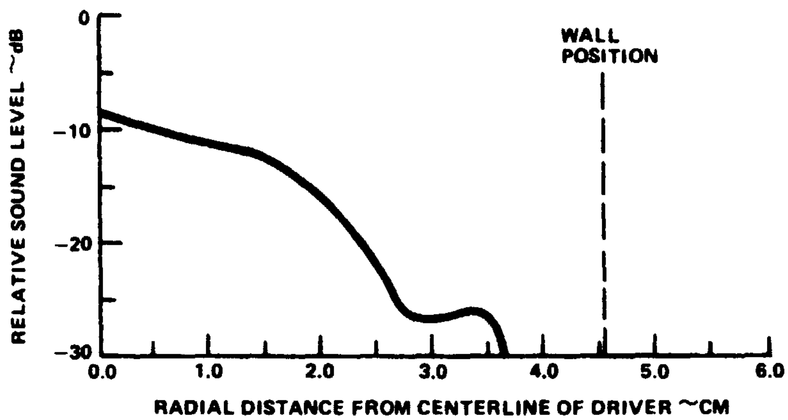
A. AXIAL DISTANCE ABOVE DRIVER VERSUS RELATIVE SOUND LEVEL FOR RESONANCE CASE

B. AXIAL DISTANCE ABOVE DRIVER VERSUS RELATIVE SOUND LEVEL FOR ANTIRESONANCE CASE

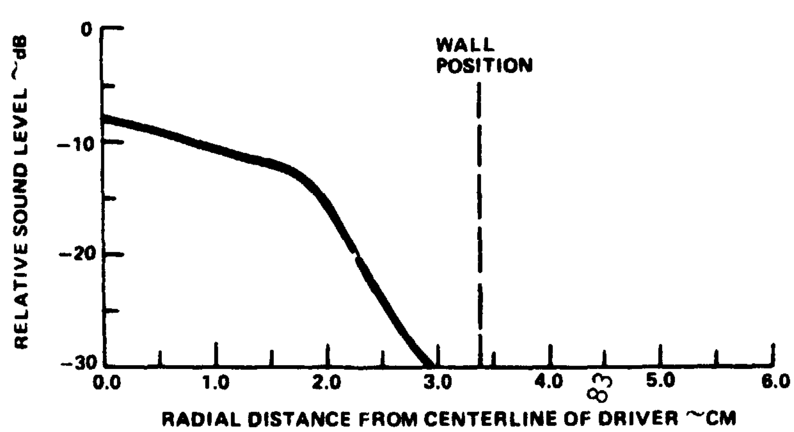
Figure 2. Axial distance versus relative sound level.



A. RELATIVE SOUND LEVEL VERSUS RADIAL DISTANCE FOR A WALL SEPARATION OF 5λ IN THE ANTIRESONANCE CASE.



B. RELATIVE SOUND LEVEL VERSUS RADIAL DISTANCE FOR A WALL SEPARATION OF 4 λ IN THE ANTIRESONANCE CASE



C. RELATIVE SOUND LEVEL VERSUS RADIAL DISTANCE FOR A WALL SEPARATION OF 3 λ IN THE ANTIRESONANCE CASE

Figure 3. Relative sound level versus radial distance in antiresonance case.

REFERENCES

1. Happe, Ralph A.: Containerless Processing of Glass, Experiment 74-42. SPAR VI Experiment Report, Contract No. NAS8-32023, 1980.

2. Acoustic Levitator Status Review Meeting, Marshall Space Flight Center/Intersonics, June 30, 1980.

3. Morse, Philip M.: Vibration and Sound, McGraw-Hill Book Company, Inc., 1948, p. 452.

APPROVAL

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The information is this report has been reviewed for technical content. Review of any information concerning Department of Defense or nuclear energy activities or programs has been made by the MSFC Security Classification Officer. This report, in its entirety, has been determined to be unclassified.

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