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A Review on Muffler with Resonator Configuration to Reduce Low Frequency Noise

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Abstract: High noise levels occur during exhaust noise from vehicle engines and impression of noise from surrounding. The sound waves strikes on the surface of the tube shaped fairing and couples with the methods of the system causing vibration. In this way the issue of noise inside the fairing has turned out to be much progressively essential. Nowadays, Resonators are used widely to reduce low frequency noise of engine exhaust. Resonator has unique characteristic of attenuate noise without any absorptive material, which make it highly useful for automobile, aerospace and some other industrial application. Newly designed resonator array have been utilized to acquire broad band transmission loss in the generally low frequency scope of exhaust system. The transmission loss qualities are controlled by the acoustics impedance attributes of the resonators. In the paper, review study has been done for comparison between the transmission losses of silencer of the engine using resonators with different configuration. In this study, suggestion is made on the basis of improved noise attenuation performance of the resonator at low frequency with limited space. Also comparative study of transmission characteristics has been done on the basis of acoustics impedance characteristics of resonators.

Key words: *Acoustics, Resonator, Transmission loss, Exhaust system*

Introduction

Investigation of sound transmission has constantly played an essential job in various applications, for example, aviation, car, building architecture household appliances and so forth. One of the critical uses of sound transmission examine is vehicle silencer where both sound and heat insulation assume a vital job in the design.

A noise filter device, usually called silencer or muffler, performs silencing work through sound dissipation, reflection, or combination of both elements. The dissipative silencer consists of acoustically absorptive material lined on the silencer wall. The acoustic liner will act as a sound absorber which converts considerable amount of the sound energy coming in contact with it into heat. While the reflective silencer does not depend on any dissipative material to absorb noise, it consists of well-defined geometrically tubular structure which reflects substantial part of the incident acoustic energy back to the source; hence the sound will be reduced.

Nowadays, many types of resonators are used, with Helmholtz resonator and quarter wave tube being the most popular ones. These resonators are applied to abate noise in pipes, industrial application, automotive noise, and even in home installed heating, ventilation, and air conditioning (HVAC) systems. One of the most common uses of resonator is to suppress noise from automobiles, especially in the intake and exhaust systems. In almost all vehicles, resonator is applied to reduce the duct's noise. Compared to dissipative muffler, resonators have the advantages of not depending on fibrous liner, which may be costly and insufficiently durable due to high operating temperature and exposure to unburnt carbon particles that might deteriorate its dissipative performance.

In the present paper, we attempt to review the research that has been done on resonators and muffler configurations basing on previously published data. The purpose of this paper is to understand how resonator types, geometry, modifications, and arrangements may affect its attenuation capabilities, and to propose area for study and improvement that needs to be explored in the future.

2. Helmholtz Resonators

In applied acoustics, Helmholtz resonators are mostly utilized. [1] Essentially a Helmholtz resonator is a cavity of moderately vast volume associated with the outside space through a tight neck opening. The Helmholtz resonator having the normal for capacity to ingest sound influxes of a specific frequency called resonant frequency. In practical applications, decide the full frequency as definitely as could reasonably be expected, since an off base design can diminish efficiency of the hardware impressively.

In this comparative examination, the impact of different plan parameters, for example, cavity radius, neck radius, cavity length and neck length, on sound transmission sound transmission loss of HRs has been considered and recommend best parameters for structure. [2]

These resonators offers valuable acoustic structure alternatives when there are a few requirements to be viewed as, for example, space impediments, design particulars, materials accessible and so on. For sound protection on level surfaces, for example, windows, Helmholtz Resonators should be typical to the sound waves pressure. In this relative investigation, the impact of different plan parameters, for example, neck span, neck length, pit sweep and depression length on sound transmission loss of HRs has been considered and recommend best parameters for design. [2]

Literature Review

Crucial inspiration driving this overview contemplates is to give a succinct outline of both establishment and late work on acoustic gadgets used for active and passive noise control applications. Noise control gadgets have been comprehensively used for active and passive noise control of sound from various types of structures. Vibration safeguards have been commonly used for control of vibrations and resulting transmitted commotion from structures. The vibration absorbers gadget takes a shot at the rule of single mass-spring framework having one full recurrence which can be tuned by changing the framework parameters. The resonant frequency of the absorbers is adjusted close to the typical common frequency of either the driving or the structure frequency. The early structures for vibration safeguard include the commence of the bleeding edge gadgets which are astoundingly profitable and incredible and are comprehensively used for passive control of sound and vibration. [3]

In this literature review survey, the upgrade for the acoustic transmission loss of a duct by including some Helmholtz resonators is examined about. Thusly, the count of the transmission loss of a channel in an unyielding divider by modifying the condition dictated by Wilson and Soroka Approximation to the diffraction of sound by a circuitous hole in a resolute mass of restricted thickness. It's relating estimation and both the calculation of improved transmission loss of a duct by including band-pass channels, and estimation of its included transmission loss. The results of this examination shows, decided transmission loss of a channel in an inflexible unbending divider with its related estimation is exceptionally extraordinary at frequencies more than 200 Hz, and the improvement of pretty much 28 dB on the transmission loss of the grasped pipe at the frequency where the related transmission misfortune is to be upgraded can similarly be gained when some appropriate Helmholtz resonators are incorporated. [4,5]

A modernized technique utilizing EXRSIL and FORTRAN was utilized. They directed a streamlining method that changes muffler part lengths to accomplish least transmission loss over a predetermined frequency range. The outcomes demonstrated that three-stage extension chamber muffler together for the exhaust pipe-Y-connector for consolidating the exhast gases from all barrels decreased the exhaust noise and no critical engine execution loss.[6]

Transmission loss of a reactive and dissipative mufflers obtained using an analytical one-dimensional solution, thus boundary element method validated. They discussed various techniques to determine Transmission loss. It was found that an excellent results were found between experimental and boundary element method.[7]

Amiya et. al. have done both test and numerical examinations for passive mufflers. A multi domain boundary component method functions as a numerically for modelling such mufflers and predicting the transmission loss. To effectively join perforates and sound engrossing materials in boundary element models, tests were led to decide the perforate exchange impedance and the propagation constant. Transmission loss of a responsive and dissipative muffeler got utilizing a scientific one-dimensional arrangement, therefore boundary element technique validated. They examined different strategies to decide transmission loss. It was discovered that an incredible outcomes were found among exploratory and boundary element method.[7]

Lamancousa structured an flexible pit of the Helmholtz resonator to substitute for improvement chamber silencers in vehicles. Two sorts of modifiable game plan of the pit volume were considered. In the fundamental gadget, the volume was continually changed by extending or reducing the length of the hole through a moveable barrel inside the pit.

In the second kind of gadget, separate volumes were used; that is, the volume of the chamber was parceled into a couple of sub-volumes, which could be closed off. Using the techniques portrayed in the earlier, it was possible to achieve either a constant or discrete assortment of volume of the resonator as shown by the resentful banner of the engine. In these devices, it was settled that expansion adversities of more than 30 dB were practiced by controlling the always factor volume of the resonator. It should be seen that Krause et al. moreover likely inquired about the effect of alterations of the volume and the neck of a Helmholtz resonator on weakening of the attenuation of source in vehicle tailpipes. [8]

Matsuhisa et al. inspected the results of the variable volume of a resonator by using a removable barrel inside the chamber. The resonator was associated with a pipe in the method for a side branch and the adjustment of the volume of the resonator was guided by connection with the time of the sound weight in the course, in regard to that in the resounding cavity. The gathering of the resonator was controlled to keep up a reliable stage qualification of ninety degrees. Using this technique, hostile to reverberation of the channel resonator framework was practiced. In this examination, three sensors were utilized to measure and take a gander at the sound load in different positions. One receiver was used to check the excitation frequency, one was used to evaluate the weight in the pipe, and the staying one measured the weight in the cavity. It was found in this examination that the usage of a movable resonator produces diminishes in sound weight up to 30 dB for a speaker driven structure and 20 dB for a fan-driven framework. [9]

McDonald et al performed tonal noise control by using a variable Helmholtz resonator, similar to that used in the examinations of Matsuhisa et al.[10] The stage distinction between the weight and the resonator pit in the conduit framework was used to oversee change of the volume of the cavity and the length of resonator neck, to achieve sound decline. [11]

Selamet et. al. demonstrated that the individual elements of a Helmholtz resonator can assume an incredible job in assurance of the full frequency and the transmission loss attributes. An expansion of the proportion of the length size of the volume to the measurement diminishes the overwhelming resonant frequency. This marvel is like the consequence of utilizing a compelling length, which incorporates an amendment length. Tests show closeness with the analytical expression and numerical simulation.[12]

DeBedout et al. investigated an adaptable Helmholtz resonator, which enhanced its execution as shown by changes in biological conditions and excitation frequency. It was found that decline in sound weight up to 30 dB could be practiced through a blend of a variable resonator and an appropriately controlled calculation. For the occurrence of this adaptable commotion control gadgets, the control figuring is clear and the adequacy of the method is redesigned. Besides, with the tunable Helmholtz resonator, it is possible to achieve perfect reductions of sound in light of changing environmental conditions and excitation frequency.[13]

Tang et. al. investigated the effects of the decline and length of the resonator neck on the characteristics of a Helmholtz resonator. It was analyzed that a development of the diminished length prompts upgrade of sound decline and an extension of the whole volume results in extended limit concerning sound ingestion of the Helmholtz resonator. These tests exhibited that sound choking by methods for the Helmholtz resonator of past what half could be practiced by changing the length of the diminished neck, diverged from the untapered neck. The development of the reverberating repeat is with respect to the diminished length and is reduced by developing the opening volume at a settled slope of the diminished zone. Additionally, this examination showed that the resonating repeat is with respect to the inclination of the diminished fragment at enduring volume of the Helmholtz resonation chamber. [14]

Han et. al. looked into sound decline by methods for picked Helmholtz resonator. The full frequencies of the Helmholtz resonator were evaluated by examinations and a logical strategy, while changing the geometrical parts of the Helmholtz resonator, including the neck cross-sectional region, the length of the neck, and the measure of the volume. [15]

Hannink et. al. connected cylinder resonator for the decrease of sound radiation and sound transmission. He explored the appropriateness of this strategy to create and approve proficient models for the forecast of sound radiation by and sound transmission through boards with cylinder resonators. [16]

Rahman et. al. designed and facricated a silencer for engine exhaust noise. They studied muffling effect of traditional silencer with cylinder resonator. With respect to qualities of the silencer utilizing resonators, Anderson, considered the impact of stream when a single side branch Helmholtz resonator is joined to a roundabout conduit. [17, 18]

Conclusion

In this literature study found noteworthy decision about the resonator measurements, transmission loss and resonance frequency. The individual elements of a Helmholtz resonator can assume an incredible job in assurance of the resonant frequency and the transmission loss attributes. An expansion of the proportion of the length size of the volume to the diameter diminishes the prevalent resonant frequency. The resonant frequency is relative to the slop of the decreased segment at steady volume of the Helmholtz resonance chamber. . It increases with increase in tapered length and decreases with expanding the cavity volume at a fixed slope of the tapered section. Tube resonator is also applicable for the reduction of sound radiation and sound transmission.

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