A Study on the Rubber Dampers Which Have Been Managed Under Different Aging Environments

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Abstract. The aging is a main factor which could influence the rubber damper's properties of isolating vibration. In this paper, a kind of dampers which was managed under different aging environments were treated as the test structures. The dampers' property of isolating vibration was studied by experiment. The results showed that the dampers' propertied of isolating vibration changed visibly when they had gone through different aging environments. Those who have gone through radiation or some humidity-temperature aging environments turned softening, and their property of isolating vibration was better than before. Those who have gone through stress or other temperature aging environments turned stiffen, and their property of isolating vibration was worse than before. The result of this paper can be the reference of the change of the rubber damper that works in certain environment.

Introduction

During the start-up and the process of flying, the aircraft may work in a strong vibration environments. There must be a step to reduce the vibration when the level of the vibration surpass the tolerance limit of the airborne equipment. The rubber damper is a common and effective damper[1,2] which can protect the equipment from the oversized vibration or shock[3].

The rubber dampers have lots of advantages, such as light weight, small size, easy installation, easy processing, low price, etc[4]. Their type and material are diverse. But they have one thing in common, their stiffness is low, and they can reduce the natural frequency of the structure in order to achieve the purpose of vibration reduction.

The rubber dampers may work in a variety of environments, such as heat, humidity, radiation, stresses, etc. Lots of environments may accelerating aging of rubber materials, and cut down their performance. So, it is meaningful to study the characteristics of the rubber after different environment aging treatment. It can be consulted for choosing a suitable rubber dampers and avoiding the equipment endure oversized vibration.

In this paper, a certain kind of rubber dampers are treated as the research subjects. Their vibration response characteristics are researched through test methods. And the characteristic of the rubber dampers after different environment aging treatment are summarized. The result can be the reference to the choice of the rubber dampers.

Test Introduction

The appearance of the rubber dampers used in this test are seen in Fig.1. Upper and lower layers are steel, intermediate is rubber. All layers are glued together. The lower plate was fixed on the shaker. The response of the upper was measured. The environments that the rubber dampers have born are shown in Tab.1.

A random vibration test is carried out to study the rubber dampers' characteristic and the test level is shown in Tab.2 and Fig.2.

Tab.1 the aging treatment environments that the rubber dampers have born

number	environments
1#	normal atmospheric temperature，15d
2#	radiation， 15d
3#	65°C， 15d
4#	85°C， 15d
5#	105°C， 15d
6#	125°C， 15d
7#	65°C， 85%RH， 15d
8#	85°C， 85%RH， 15d
9#	stress， 30d

Tab.2 the test level

the spectrum			RMS
10Hz～50Hz	50Hz～1000Hz	1000Hz～2000Hz	[g]
3dB/oct	$W1=0.04g^2/Hz$	-6dB/oct	7.68
3dB/oct	$W2=0.08g^2/Hz$	-6dB/oct	10.86
3dB/oct	$W3=0.13g^2/Hz$	-6dB/oct	13.84

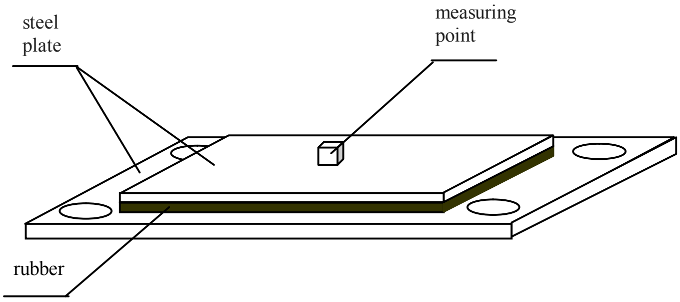

Fig.1 the rubber dampers structure

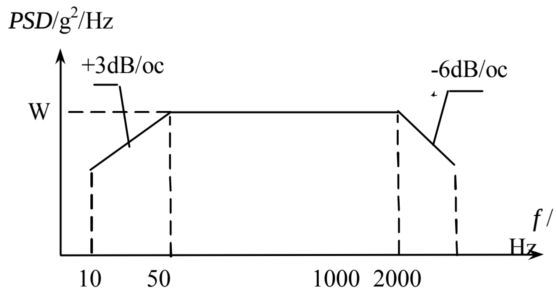

Fig.2 the spectrum shape of the test

Analysis of test results

The RMS of the response of the measuring points in different level test are shown in Tab.3. The RMS is different obviously. The 1st resonance frequencies are shown in Tab.4. The data shows that the dampers have different resonance frequencies. One thing must be explained that the mass of the upper layers of the dampers is small and the rubber thin, so the rubber damper can't bring about large displacement to reduce the vibration.

a) the characteristics of the rubber damper conserved in normal atmospheric temperature

The section headings are in boldface capital and lowercase letters. Second level headings are typed as part of the succeeding paragraph (like the subsection heading of this paragraph).

The data in Tab.4 shows that the 1st resonance frequency of 1# specimen decrease with the raising of the testing level. The 1st resonance frequency is 622.5Hz in level W1, while it is 387.5Hz in level W3. This is a typical soft nonlinear characteristic[5]. The data in Tab.3 shows that the magnification ratio to the incentives decrease with the raising of the test level. The reason is that the rubber layer can produce lager displacement and can consume more energy.

b) the characteristics of the rubber damper conserved in radiation environment.

The responses of 1# and 2# specimen are contrasted in Fig.3 and Tab.4. In the same test level, the 1st resonance frequency of 2# specimen is lower than that of 1#. This phenomenon is explained that the rubber turns soft in radiation. So the damper's stiffness is lower. The data in Tab.3 shows that the vibration damping effect of 2# specimen is better than that of 1# in lower testing level(level W1 and W2) and their vibration damping effect is roughly the same in higher level. The curves in Fig.3 show that the response of 2# specimen is lower than that of 1# at low frequencies (lower than 900Hz). The response of 2# specimen is higher than that of 1# at high frequencies (higher than 900Hz).

Tab.3 the RMS of the response

Number	Level W1		Level W2		Level W3	
	RMS [g]	magnification ratio	RMS [g]	magnificati on ratio	RMS [g]	magnification ratio
1#	13.15	1.71	16.79	1.55	16.97	1.23
2#	11.05	1.44	14.13	1.30	17.01	1.23
3#	11.21	1.46	14.08	1.30	16.70	1.21
4#	12.09	1.57	16.24	1.50	20.32	1.47
5#	9.66	1.26	13.09	1.21	16.37	1.18
6#	19.28	2.51	24.57	2.26	29.66	2.14
7#	8.81	1.15	11.78	1.08	14.23	1.03
8#	8.71	1.13	12.25	1.13	15.77	1.14
9#	13.69	1.78	16.98	1.56	20.11	1.45

Tab.4 the 1st resonance frequencies of the response

Number	the 1st resonance frequency [Hz]		
	Level W1	Level W2	Level W3
1#	622.5	590.0	477.5
2#	572.5	482.5	457.5
3#	485.0	485.0	457.5
4#	772.5	752.5	742.5
5#	612.5	607.5	605.0
6#	912.5	912.5	912.5
7#	437.5	412.5	407.5
8#	482.5	477.5	457.5
9#	757.5	637.5	605.0

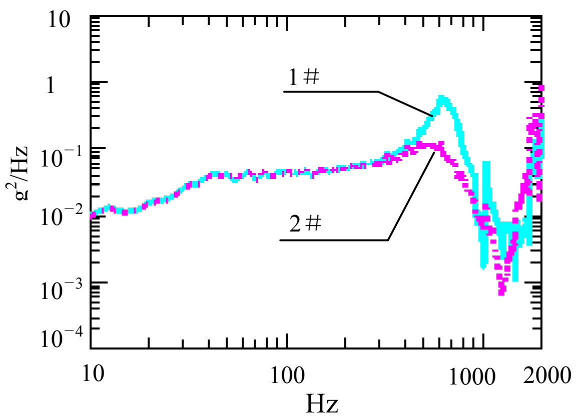

Fig.3 the responses of 1# and 2#

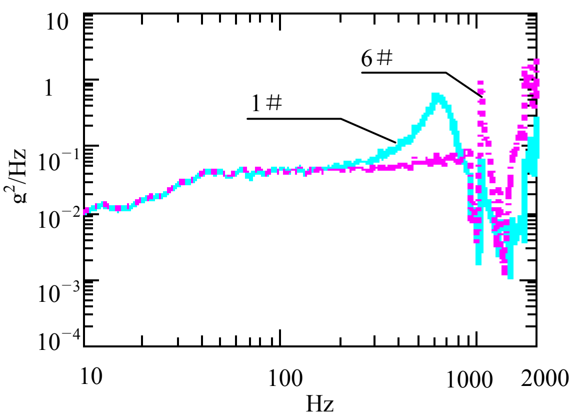

Fig.4 the responses of 1# and 6#

c) the characteristics of the rubber damper conserved in heat or humidity environment

3#、4#、5#、6#、7#、8# specimen are the rubber damper treated in heat or humidity. The data in Tab.3 and Tab.4 shows that the vibration damping efficiency are in the order of 7#、8#、5#、3#、4#、6#. The 1st resonance frequencies are in the order of 7#、8#、3#、5#、4#、6#.

Compared with 1# specimen, the damping efficiency of 3#、4#、5#、7#、8# specimen are better and that of 6# is worse. The responses of 1# and 6# specimen are compared in Fig.4. The 1st resonance frequency of 6# specimen is higher than that of 1#. This phenomenon is explained that the ubber turns hard in high temperature. The responses of 1# and 7# specimen are compared in Fig.5. The response of 7# specimen is lower than that of 1# in almost all frequencies.

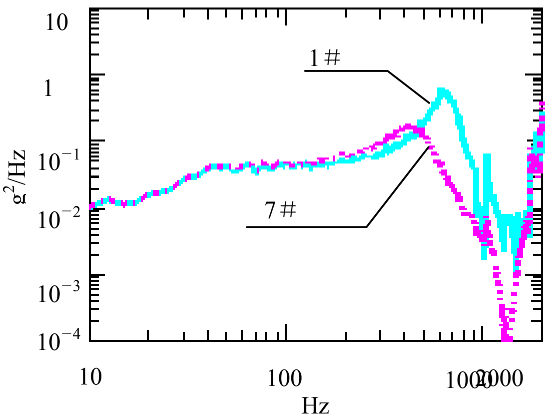

Fig.5 the responses of 1# and 7#

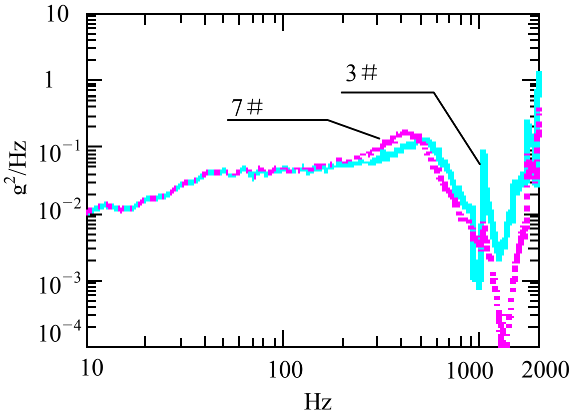

Fig.6 the responses of 3# and 7#

The dampers' appearances show that 3# and 4# specimen are normal, 5# specimen is sticky, and the surface of 6# specimen has been carbonized and has no flexibility. This is explained that in the same time, higher temperature can faster the aging of the rubber. In the different levels of aging, the rubber has different stiffness and damping efficiency . However, there is no a linear relationship between the damping efficiency and the temperature.

The aging treatment environments in Tab.1 shows that 3# and 7# have experienced the same temperature environment. The difference is that 7# has experienced humidity environment during the same period. The responses of 3# and 7# are contrasted in Fig.6. The curves in Fig.6 show that the 1st resonance frequency of 7# is lower and the response in high frequency is also lower. The contrasting result of 4# and 8# shows the same law. So it can be inferred that compared with separate temperature environments, wet - thermal complex environment can soften the rubber material, and enhance its damping efficiency.

d) the characteristics of the rubber damper conserved in stress environment.

Compare the data about 1# and 9# specimen in Tab.3 and Tab.4, it can be seen that the 1st resonance frequency of 9# specimen is higher than that of 1# in all testing level. The responses of 1# and 9# specimen are contrasted in Fig.7. It shows that stress environment can make the material hardens. Excited by the same source the response of 9# specimen is higher than the that of 1#. The damping efficiency of 9# specimen is lower than that of 1#.

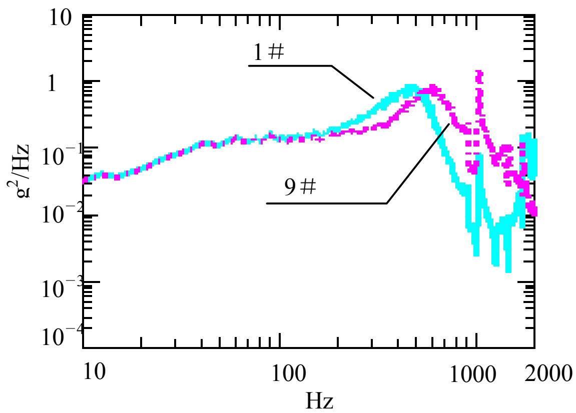

Fig.7 the responses of 1# and 9#

Conclusion

In this paper, the damping characteristics of the rubber dampers that have been managed under different aging environments. The results show that 1st resonance frequencies of all specimens decrease with the raising of the testing level. And their damping efficiency increase with the raising of the test level. The rubber dampers that conserved in radiation environment will be harden and their damping efficiency will be lower. Proper humidity, thermal environment can make the rubber dampers soft, and increasing their damping efficiency. But if the temperature is too high, the dampers will be harden, and their damping efficiency will decrease. The stress environment can make the dampers harden, and their damping efficiency will decrease.

This paper discussed the influence of the rubber aging from the aspect of damping efficiency. In actual using, rubber aging can also make the damper fragile and short-lived. All these should also be considered when using.

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