Difference in function of anti-vibration rubber due to changing condition

Hideki Hiratsuka, Kuroi Naoto, Koshiro Fuke

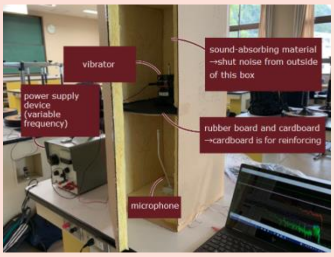
1st grade, Science Course, Hyogo Prefectural Kobe High School

Background and Purpose

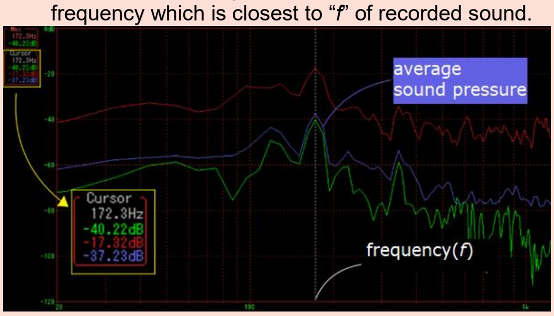
When one of us noticed the lack of noise on a train, he became interested in noise reduction. Then he researched it, and he found that train uses tire waste, or rubber, for that train`s floor. In addition, he learned the effectiveness of anti-vibration rubber changes by condition, and we started to examine that condition deeply.

Method

We used this system →



1. Send a particular frequency (f) of alternating current to the vibrator and make vibration
2. Record the above vibration as a sound through 2 natural rubber boards (<u>smooth one</u>:10mm thickness, <u>grooved one</u>:10mm~3mm thickness)
3. Measure the average of sound pressure for 4 seconds in the frequency which is closest to "f" of recorded sound.



4. Define as

$$\frac{measured\ \ value\ \ with\ \ rubber}{measured\ \ value\ \ without\ \ rubber} = vibration\ \ transmissibility$$

Hypothesis

※formula of vibration transmissibility

$$Tr = \left|\frac{1}{1-\left(f/_{fn}\right)^2}\right|$$

$$fn = \frac{1}{2\pi}\sqrt{\frac{Kg}{L}}$$

- Tr vibration transmissibility
- f frequency
- fn natural frequency
- K spring constant
- L mass(constant)
- g gravitational acceleration(constant)

According to previous research, "K" gets smaller as temperature rise
⇒ "fn" similarly gets smaller

$0<\left(f/_{fn}\right)^2<1$	$f<fn$	$Tr>1$	Vibration is amplified
$1<\left(f/_{fn}\right)^2<2$	$fn<f<\sqrt{2}fn$	$Tr>1$	Vibration is amplified
$2<\left(f/_{fn}\right)^2$	$\sqrt{2}fn<f$	$Tr<1$	Vibration is isolated

From formula of vibration transmissibility,
Higher temperature/Large frequency → higher effectiveness

From shape of anti-vibration rubber on the market,
Grooved one has more effectiveness than smooth one

Result

<u>Result is as shown in the table and graph below.</u>

Change of vibration transmissibility by temperature and frequency in each shape

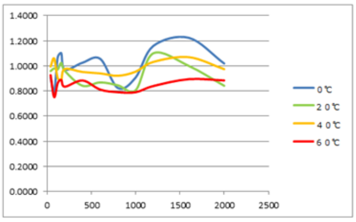
smooth

frequency (Hz)	temperature(℃) 0	20	40	60
40	0.908	0.958	0.994	0.926
80	0.792	0.980	1.059	0.751
120	1.067	0.971	0.903	0.863
160	1.102	1.024	0.888	0.889
200	0.970	0.961	0.975	0.834
400	1.025	0.842	0.951	0.884
600	1.056	0.869	0.940	0.812
800	0.823	0.845	0.921	0.790
1000	0.907	0.806	0.954	0.790
1200	1.159	1.100	1.031	0.840
1600	1.224	1.000	1.069	0.894
2000	1.019	0.842	0.974	0.884

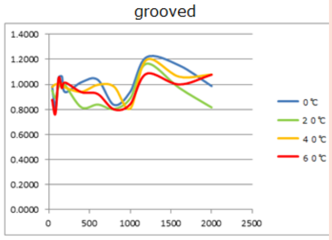
grooved

frequency (Hz)	temperature(℃) 0	20	40	60
40	0.983	0.951	0.979	0.877
80	0.815	0.893	1.000	0.764
120	1.054	0.983	1.000	1.052
160	1.064	0.991	1.006	0.971
200	0.938	0.993	0.975	1.015
400	1.017	0.816	0.941	0.938
600	1.038	0.840	0.997	0.924
800	0.837	0.803	0.983	0.801
1000	0.941	0.889	0.807	0.842
1200	1.217	1.166	1.197	1.085
1600	1.153	0.973	1.062	1.000
2000	0.987	0.816	1.079	1.078

smooth



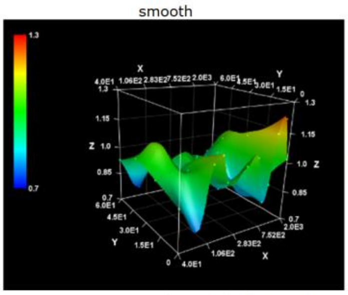
grooved



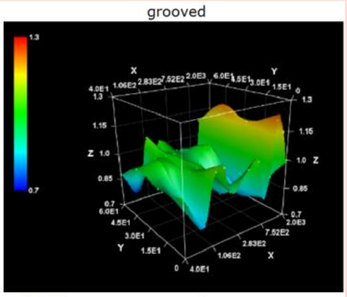
change of vibration transmissibility by frequency in each shape and temperature

Below one is the graph which plot value from the table above
(X:frequency Y:temperature Z:vibration transmissibility)

smooth



grooved



Change of vibration transmissibility by temperature and frequency in each shape (third dimension)

Consideration

<shape> Little difference in each temperature but result of grooved board was more unstable than a smooth one
→because of thickness…?

<temperature> Except for the low frequency about grooved board, the effect tends to get higher as temperature gets higher

<frequency> The frequency around 120Hz seems to be natural frequency
We expected the effect gets higher as frequency gets higher, however, the transmissibility amplified once again at around 1200Hz

⇒<issue>Making rubber board same thickness taking grooves into consideration

Examine the transmissibility in low frequency, high temperature, grooved board (contrary to the tendency ――the higher temperature the higher effectiveness)

Researching the transmissibility amplified around 1200Hz

References

"Property and application anti-vibration rubber " Takeru Okada
"Anti-vibration rubber" Yuji Kobayashi
"Anti-vibration rubber" NOK Co.Ltd