inter•noise 96
25th Anniversary Congress – Liverpool
INCE: 13

SIMULATION OF WAYSIDE TIME-DEPENDENT NOISE LEVEL ON SHINKANSEN AND ANALYSIS OF NOISE SOURCES FOR THEIR CONTRIBUTION TO THE NOISE LEVEL

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1. INTRODUCTION

This paper describes sound simulation method of time-dependent fluctuation noise level and contributions to noise of the current collecting system and the others sources as revealed through it on Tokaido Shinkansen.

2. SIMULATION METHOD

In order to simulate time-dependent fluctuating noise level, the trainset must be resolved into various sound sources. Fig.1 indicates assignment of noise sources in a trainset, for an example, 300 series trainset. While pantograph and rail/wheel are taken as point sources, on the other hand aerodynamic noise source from the surface of carbody are taken as a line source. Analyzing the wayside noise special directive microphone is used together with non-directive one. This directive microphone is useful to estimate the contribution of each sound source. The validity of the magnitude of each noise source in power estimation is ascertained in terms of the time-dependent noise level waveform between simulation and measurement. Provided that level recorder is first-order time delay system,

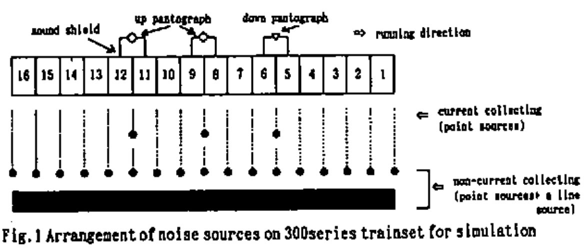

Fig.1 Arrangement of noise sources on 300series trainset for simulation

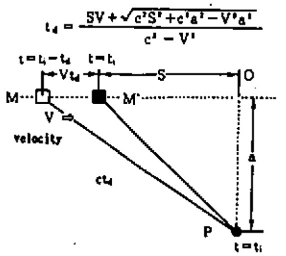

Fig.2 Positional relation between noise source and noise receiving point

Dependence of peak level on time constant (dB)

time const.(sec)	peak value	differ-ence
0.0	71.04	0.0
0.005	70.95	0.09
0.035	69.30	1.74
0.065	67.97	3.07
0.100	66.81	4.23
0.125	66.14	4.90

SPL = PWL − 20log (r) − 11
= 110 − 20log (25) − 11
= 71.04 (dB)

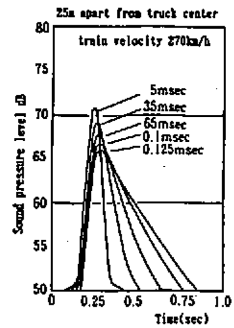

Fig.3 Dependence of peak level on time constant as registered by level recorder

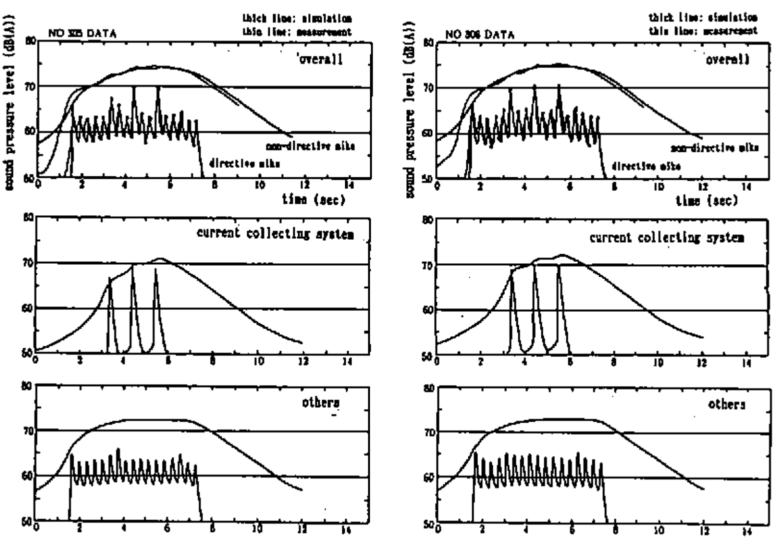

Fig.4 Noise level simulation, divided into noise from current collecting system and that from the other sources

Then, impulse response function is shown, as follows:

$$h(t) = \exp(-t/T_c)/T_c \quad t \geq 0, \qquad = 0 \quad t < 0.$$

Layout of moving source and receive point is illustrated in fig.2. According to geometric relations and so on, next equations are gained:

$$w_i(t) = 10^{\frac{L_i(t)}{10}} \cdot p_0^{\,2} \quad \cdots\cdots$$

$$W(t) = \sum_{i=1}^{n} K(\theta) \cdot w_i(t) \quad \cdots\cdots$$

$$W'(t) = \int_{-\infty}^{t} W(\tau) \cdot h(t-\tau)\, d\tau$$

$w_i(t)$:power level of point source
p_0 :minimum audible sound pressure level
$L_i(t)$:sound pressure level of one point source
$W(t)$:power sum of point sources
$K(\theta)$:coefficient of directivity
$W'(t)$:power sum after processing the response function

$PLEV(t) = 10 LOG_{10}(W'(t)/p_0^2)$ PLEV(t) :sound pressure level by calculation

After these procedures, sound power level at reference point is gained. Generally, this sound power level is strongly affected by time constant of level recorder. This influence is indicated fig.3. Time constant value should be determined to enable proper estimation by taking into account the distance attenuation. For this reason we adopt 65msec as a time constant in absence of spark noise. Of course, as for non-directive microphone one second is used.

Fig.4 indicate comparison between simulation and measurement. Upper one indicates directive microphone pressure level and non-directive one for simulation and measurement, respectively. There is not much difference between the two. The center and lower ones also indicate time-dependent sound pressure levels exclusively containing current collection sources or others sources . These charts concern 300 series trainsets which generate the least noise of all trainsets in operation. Through these analyses,on Tokaido Shinkansen the contributions to the overall noise of the current collecting system or non-current collecting system are revealed as shown in fig.6. For reference, fig.5 indicates types of trainsets in operation on Tokaido Shinkansen.

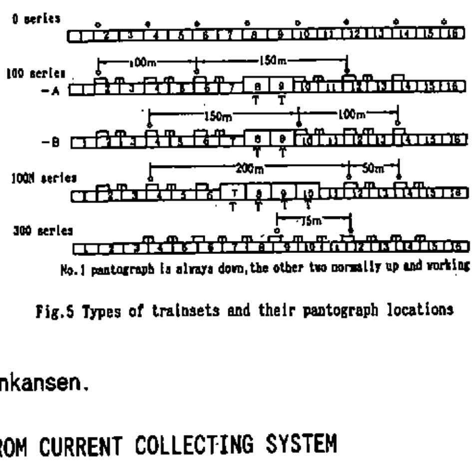

Fig.5 Types of trainsets and their pantograph locations

3. NOISE LEVEL FROM CURRENT COLLECTING SYSTEM

Fig.7 indicates the sound pressure level due to a single current collecting system. The noise levels of current collecting system of 0 ,100,300 series cars are shown. Assuming that the higher level of 0 series is 0 dB(A), one of 100 series is -9~-8dB(A) at 220km/h and one of 300 series is -7~-6 dB(A) at 250km/h. The No.1 pantograph of 100 series car is -5dB(A) which is a little higher than rear-located pantograph. The reason why level of 0 series car scattered over a large extent is that it contains spark sound. Fig. 8 also indicates overall sound pressure level for various trainsets.

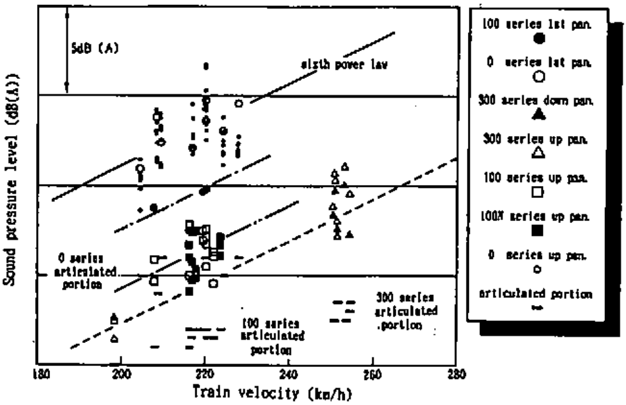

Fig.7 Level of noise from a single current collecting system in various cars

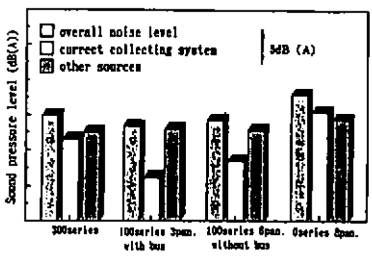

Fig.6 Contribution of current collecting system to the overall noise

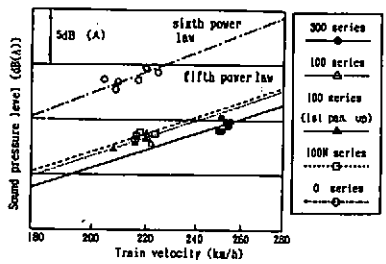

Fig.8 Wayside noise level of various types trainsets

4. CONCLUSIONS

Through the simulation and field measurement of wayside noise, conclusions are gained as follows.

(1)Good accordance is seen between simulation and measurement of wayside noise.

(2)Comparing the noise level from current collecting system with the one from others, as for 300 series trainset they are almost equal. On the other hand, as for 100 series trainset those of other sources are larger than that of a current collecting system by 7 dB(A).

(3)The position of No.1 pantograph, which is down for 300 series trainset, a relatively high peak of noise level can be recognized. this is caused by aerodynamic noise from sound shield around pantograph.

References

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