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REVERVERATIONS* IN LARGE AREAS

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ABSTRACT
Reverberation is one of the most important physical phenomena related to distribution of sound in closed halls. The dependence between number of sound reflections (N) of the form, proportions and dimensions of industrial halls is determined on the basis of a theoretical model, and therefore the reverberation.

Reverberation is the presence of a gradually damping sound in an in-door hall after the cease of sound from the principal source. That phenomenon is observed in last closed areas, including processing plants, premises for repair of heavy-duty mechanization etc. Practically, it is established that in all the cases time for reverberation depends on a number of factors, primarily the size and shape of premise.

The time of reverberation is calculated by the formula of Airing–

$$T = -\frac{13.81}{N\ln(1-\alpha)}, s, \qquad (1)$$

where N is the number of reverberations for unit time;
α - average coefficient of sound adsorprion;

It is accepted that in the case of diffuse sound field, the average number of reflections 1s is:

$$N = \frac{cS}{4V}, \qquad (2)$$

where c is the speed of sound, m/s;
s – total area of inner walls of the premise, m^2;
V – volume of the premise, m^3.

We will consider the case of a point source, the model of which is similar enough to real conditions.

Premises in industrial buildings most often are of the shape of a rectangular parallelepiped, their inner walls are practically plain and sound reflecting.
Then (fig.1)

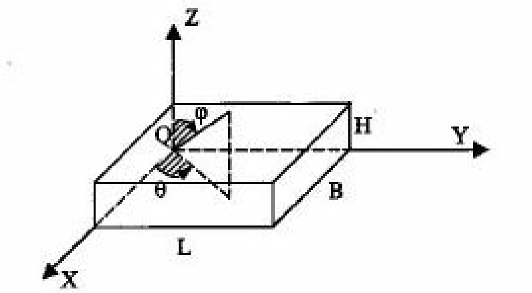

Figure 1.

V = B.L.H, m^3,
S = 2 (L.H + B.H + B.L), m^2,
where L, B and H are the lengths, width and height of the premise, m.

If in the point Q there is a non-directed sound source, the sound rays going out from that point with the speed c have the following projections of the vector of speed on the three axes (X, Y and Z in fig.1): c.sinφ.cosθ, c. sinφ.sinθ and c.cosφ. The angles θ and φ may be denoted as azimuth and positioned vertical angle in the generally accepted terminology..

Number of reverberations of the bundle of rays for 1s is:

$$N = \frac{c}{B}\sin\varphi.\cos\theta + \frac{c}{L}\sin\varphi\sin\theta + \frac{c}{H}\sin\varphi \qquad (3)$$

* From Latin reverberate – reflect

The total number of reverberations (from many bundles) is acquired by integration of (3) –

$$N_1 = \int_0^{\pi/2}\int_0^{\pi/2} \left(\frac{c}{B}\sin\varphi.\cos\theta + \frac{c}{L}\sin\varphi.\cos\theta + \frac{c}{H}\sin\alpha\right)\sin\varphi.d\varphi.d\theta =$$

$$= \frac{\pi c}{4}\cdot\frac{(L.H + B.H + B.L)}{B.L.H} = \frac{\pi.c}{8}\;\frac{S}{V}\cdot \qquad (4)$$

The formula (4), shows that in case the other conditions are equal (speed of sound and coefficient of sound adsorbsion), the number of reverberations is determined by the shape, proportions and sizes of the premise.

For example, for an industrial premise of dimensions 100x50x15m (V=75 000 m^3)

$$N_1 = \frac{\pi c}{8}\;\frac{S}{V} = \frac{\pi c}{8}\;\frac{14500}{75000} \approx 26 \text{ бр/s.} \qquad (5)$$

If the proportions are changed, however the volume is the same – for example L=200, B=37.5, H=10, number of reflections will be:

$$N_1 = \frac{\pi c}{8}\;\frac{19750}{75000} \approx 35 \qquad \text{бр/s} \qquad (6)$$

When one of the dimensions is significantly extended, for example (L) and the other two dimensions are approximately equal (B≈H) – a tunnel-like premise, the number of reverberations is as follows:

$$N_1 = \frac{\pi c}{8}\;\frac{2L.B + B^2}{L.B^2} \approx \frac{\pi c}{4\sqrt{P}}, \qquad reverb/s, \qquad (7)$$

where P is the cross section, m^2.

When the technological process involves industrial premises of inclined floor (fig. 2).

Then the boundaries within the integral (4) are changed (4)

$$N_1 = \int_0^{(n/2+\gamma)} \int_0^{n/2} \left(\frac{c}{B}\sin\varphi.\cos\theta + \frac{c}{L}\sin\varphi.\cos\theta + \frac{c}{H}\sin\alpha\right)\sin\varphi.d\varphi.d\theta \qquad (8)$$

If the angle of slope is 15^0 ($^1/_{12}\,\pi$), then

$$N_1 \approx \frac{\pi.c}{6}\;\frac{L.H + B.H + B.L}{L.B.H} = \frac{\pi.c}{6}\;\frac{S}{V}, rev./s$$

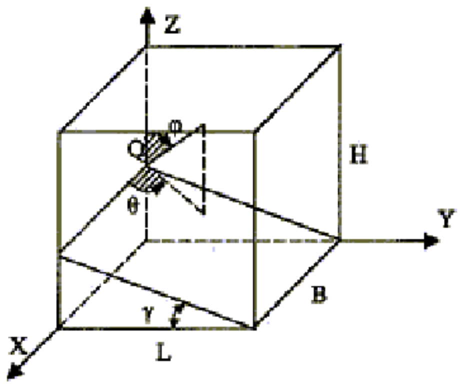

Figure 2.

In spite of the evident idealization of the accepted model, the investigations show that shape (proportions) of premises exert significant impact on the number of reflections of sound and therefore – reverberations.

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