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TECHNIQUE OF AN ESTIMATION OF SOUND ABSORBING CHARACTERISTICS OF THE PROCESS EQUIPMENT PLACED INSIDE INDUSTRIAL PREMISES

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Abstract: The process equipment, placed in manufacturing buildings, essentially influences the process of formation of reflected noise fields of rooms. The presence of the equipment results in reduction of an average length of free path of sound beams and change of average factors of a sound absorption of a room. In the end it has an influence on distribution of sound-levels pressure. The report deals with the technique of an estimation of average factors of a sound absorption inside the premises with the equipment based on use of method of ray tracing.

As it is known [1, 2], the process equipment, placed in an industrial room, in an essential measure reduces the average length of free run of sound rays and changes the average factor of a sound absorption of a room. It is noticed, that the change of a sound absorption in conditions of real industrial rooms appears considerably large, than it can be at the account of an additional sound absorption brought into a room at installation of the equipment and determined as $\alpha_{eq}S_{eq}$, where α_{eq} and S_{eq} factors of a sound absorption and the total area of surfaces of the equipment.

Now there is no enough reliable technique of an estimation of the specified changes and analysis of the influence on them of space-planning and acoustic parameters of rooms, characteristics of the equipment and other factors.

The development of such technique is possible on the basis of use of a method of ray tracing. The method enables to make mathematical modeling of processes of distribution of sound rays in view of the sound-proof characteristics of surfaces of rooms, equipment and character of reflection of a sound from them. On the basis of a method of ray tracing we developed the computer program allowing to make accounts of average length of free run of sound rays and to define the time of reverberation in rooms with the equipment.

Received item of information about average length of free run of rays and time of reverberation enables to define an average factor of a sound absorption of a room, using well known Airing's formula as

$$T_{\text{scat}} = \frac{0.041 l_{\text{scat}}}{-\ln(1-\alpha_{av}^{\text{sett}})} . \qquad (1)$$

In the formula (1) l_{scat} – the average length of free run of rays in a room with scatterers, determined in the program with use of a technique which is taking into account the power importance of rays [2]; T_{scat} – time of reverberation in a room with scatterers, calculated in the program on recession of levels of sound pressure of the reflected noise after cancellation of a source; $\alpha_{av}^{\text{sett}}$ – settlement average factor of a sound absorption in a room with scatterers.

The accounts of average length of free run l_{scat}, time of reverberation T_{scat} and average factor of a sound absorption $\alpha_{av}^{\text{sett}}$ were made in proportional, long and flat rooms. Below as an example settlement data are given, received for a flat room with the sizes 36 × 36 × 6 m.

The accounts were carried out at accommodation of 9, 25, 49 and 81 scatterers in a room, having the sizes 1.5 × 1.5 × 1.5 m. Distances between sides of next scatterers were accepted equal to 2.0 m. The subjects were stirred symmetrically concerning the center of the room and at 81 scatterers in regular intervals filled in all area of a floor. The factors of a sound absorption of walls α_{woll} and floor α_{flow} were accepted equal 0.10, and surfaces of scatterers α_{eq} equal 0.05. Factor of a sound absorption of a ceiling α_{ceil} changed from 0.10 to 0.60. As the presence of scatterers considerably raises a degree of accident of directions of the reflected sound rays, the reflection of a sound from all surfaces was accepted diffusive. The source of noise was placed also at the center of a room and radiated energy in regular intervals in sphere. The settlement point, in which the account was made $\alpha_{av}^{\text{sett}}$, settled down near to the center of a rooms above the scatterers. For each variant the ways of 1000 rays were retraced, let out by a source. Accounts were repeated in all cases not less than 7 times. The estimation was made with confidential probability 0.95.

The diagrams of change of average lengths of free run l_{scat} and time of reverberation T_{scat} in a flat room are given in a fig. 1 and 2. Received results of accounts $\alpha_{av}^{\text{sett}}$ are given in the table. In the table the meanings of average factors of a sound absorption of surfaces of rooms are given also, determined as

$$\alpha_{av} = \frac{\sum \alpha_i S_i + \alpha_{eq} S_{eq}}{S_{\text{gen}}}, \quad (2)$$

where $\alpha_i S_i$ – factors of a sound absorption and area of surfaces of protections; S_{gen} – general area of surfaces of protections and equipment.

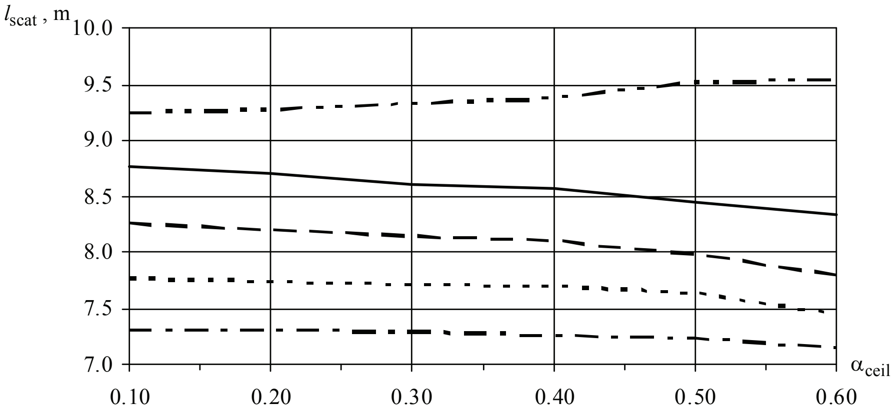

Fig. 1 Changes of average length of free run of sound rays in a flat room depending on a sound absorption of a ceiling and a quantity of the scatterers:
——— 9 scat., – – – – 25 scat., ··············· 49 scat.,
— · — · 81 scat., — · · — without scat

From the data of the tables it is visible, that the designed factors $\alpha_{av}^{\text{sett}}$ can essentially distinct from α_{av}. Thus the size of divergences depends on quantity of scatterers and sound-proof characteristics of a ceiling. In rooms without sound-proof facing scatterers increase a sound absorption of a room, and on the contrary, at large sound absorption of a ceiling they reduce it. It is well visible from results of accounts $\alpha_{\text{ceil}}^{\text{sett}}$, received in view of size $\alpha_{av}^{\text{sett}}$, considering thus, that α_{wall}, α_{flow} and α_{eq} remain constant.

In the whole results of accounts received for proportional, long and flat rooms, show, that the scatterers in rooms without sound-proof facing increase average factors of a sound absorption $\alpha_{av}^{\text{sett}}$ in comparison with α_{av}, determined on the formula (2), on 10…12 % in flat rooms and on 15…20 % in long and proportional rooms. In rooms with an effective sound absorption of a ceiling ($\alpha_{\text{ceil}} \geq 0.5$) the scatterers reduce $\alpha_{\text{ceil}}^{\text{sett}}$. It is the most brightly shown in flat rooms. The sizes $\alpha_{\text{ceil}}^{\text{sett}}$ are decreasing in comparison with α_{ceil} on 7…14 %. Obviously, the given reduction is connected to faster degeneration of rays falling on sound-proof surfaces of a ceiling, than rays extending between the equipment, walls and floor.

It is necessary to note, that the results of accounts $\alpha_{\text{ceil}}^{\text{sett}}$ differ from α_{av}^{rec}, received in industrial rooms experimentally with the use of a method of reverberation (see, for example, [1]). It is firstly connected with the fact that in technique of definition α_{av}^{rec} Airing's formula is used as

$$T_{\text{scat}} = \frac{0.164V}{-S_{\text{gen}} \ln(1-\alpha_{av}^{\text{rec}})}, \qquad (3)$$

where V – volume the room.

In formula (3) the reduction of average length of free run of rays is not taken into account at the expense of presence of the equipment in a room. Most essentially distinctions $\alpha_{\text{ceil}}^{\text{sett}}$ and α_{av}^{rec} are shown in long and flat rooms, in which at accommodation of the equipment changes of sizes l_{scat} and T_{scat} are most significant (see fig. 1 and 2)

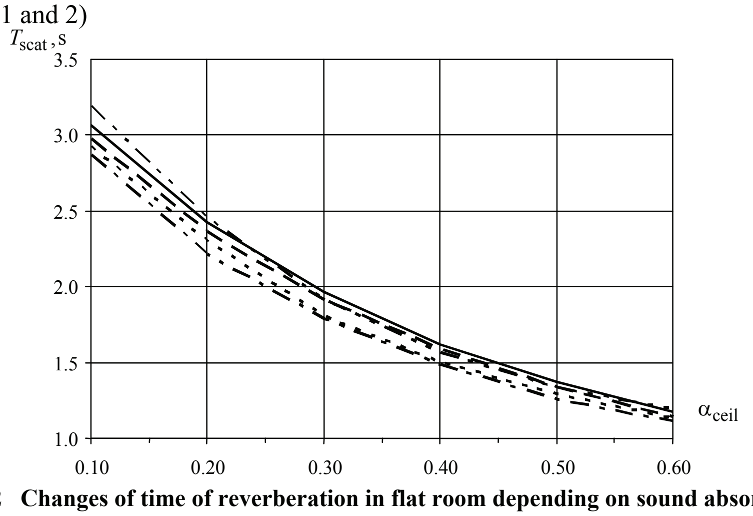

Fig. 2 Changes of time of reverberation in flat room depending on sound absorption of a ceiling and quantity of scatterers:

9 scat., 25 scat., 49 scat.,
81 scat., without scat

In the whole the results of modeling of formation processes of the reflected field on the basis of a rays tracing method enable to consider that the offered technique of an estimation of average factors of a sound absorption of rooms with the equipment will allow to take into account more objectively the influence on their size of space-planning and acoustic parameters of rooms, characteristics of the equipment, disseminating a sound, and other factors, meaningful for distribution of the reflected energy.

Table

Influence of the equipment on a sound absorption of a flat room

Quantity of scatterers	l_{scat}, m	Factors of sound absorption			Time of reverberation T_{scat}, s	Settlement factors of a sound absorption		
		α_{wall}, α_{flow}	α_{eq}	α_{ceil}		α_{av}	α_{av}^{sett}	α_{ceil}^{sett}
9	8.763	0.1	0.05	0.1	3.064	0.099	0.111	0.133
	8.703			0.2	2.426	0.135	0.137	0.204
	8.609			0.3	1.965	0.172	0.164	0.280
	8.560			0.4	1.625	0.208	0.194	0.361
	8.445			0.5	1.372	0.245	0.223	0.440
	8.339			0.6	1.175	0.282	0.252	0.520
25	8.267	0.1	0.05	0.1	2.975	0.096	0.108	0.133
	8.210			0.2	2.364	0.131	0.133	0.204
	8.143			0.3	1.913	0.167	0.160	0.282
	8.100			0.4	1.596	0.202	0.188	0.360
	7.990			0.5	1.336	0.237	0.217	0.444
	7.804			0.6	1.141	0.272	0.245	0.521
49	7.762	0.1	0.05	0.1	2.923	0.093	0.103	0.131
	7.732			0.2	2.299	0.126	0.129	0.208
	7.707			0.3	1.810	0.159	0.160	0.302
	7.691			0.4	1.505	0.193	0.189	0.389
	7.635			0.5	1.296	0.226	0.215	0.466
	7.453			0.6	1.133	0.259	0.236	0.531
81	7.310	0.1	0.05	0.1	2.874	0.089	0.099	0.131
	7.305			0.2	2.214	0.120	0.127	0.221
	7.289			0.3	1.788	0.151	0.154	0.311
	7.258			0.4	1.484	0.182	0.182	0.399
	7.233			0.5	1.255	0.213	0.210	0.491
	7.143			0.6	1.111	0.244	0.232	0.561

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Методика оценки звукопоглощающих характеристик технологического оборудования, размещаемого в производственных помещениях

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Ключевые слова и фразы: время реверберации; коэффициент звукопоглощения; производственные помещения; средняя длина свободного пробега звуковых лучей.

Аннотация: Размещаемое в производственных зданиях технологическое оборудование существенно влияет на процесс формирования отраженных шумовых полей помещений. Наличие оборудования приводит к уменьшению средней длины свободного пробега звуковых лучей и к изменению средних коэффициентов звукопоглощения помещения. В конечном итоге это оказывает влияние на распределение уровней звукового давления. В статье рассматривается методика оценки средних коэффициентов звукопоглощения в помещениях с оборудованием, основанная на использовании метода прослеживания лучей.

Methodik der Einschätzung der schallabsorbierenden Charakteristiken der technologischen in den Produktionsräumen aufgestellten Einrichtung

Zusammenfassung: Die technologische in den Produktionsgebäuden aufgestellte Einrichtung beeinflusst den Prozeß der Formierung der abgespiegelten Lärmfelder von den Räumen wesentlich. Das Vorhandensein der Einrichtung führt zur Verkleinerung der mittleren Länge des freien Laufes der Schallstrahlen und zur Veränderung der mittleren Koeffiziente der Schallabsorption des Raumes auf. Es wirkt auf die Einteilung des Niveaus des Schalldruckes ein. Im Bericht wird die auf der Benutzung der Methode des Strahlentrackings gegründete Methodik der Einschätzung der mittleren Koeffiziente der Schallabsorption in den Räumen mit der Einrichtung betrachtet.

Méthode d’évaluation des caractéristiques absorbant le bruit de l’équipement technologique placé dans les locaux industriels

Résumé: L’équipement technologique placé dans les locaux industriels influence beaucoup sur le processus de la formation des champs sonores réflétés. La présence de l’équipement conduit à la diminution de l’onde moyenne du parcours libre des rayons sonores et au changement des coefficients moyens de l’absorbtion du bruit dans les locaux. Finalement cela influence sur la répartition des niveaux de la pression sonore. Dans le rapport est examinée la méthode de l’évaluation des coefficients moyens de l’absorbtion du bruit dans les locaux avec l’équipement qui est fondée sur l’emploi de la méthode du contrôle des rayons.