Part 5

DECREASE IN PHYSICAL FACTORS IMPACT FROM POWER OBJECTS ON ENVIRONMENT

5.3. Reduction of noise from power engineering equipment

5.3.2. Elimination of noise level caused by steam exhaust

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Operation of boilers is connected with the possibility of steam exhaust during blow-offs of boiler super-heaters, boiler kindling, popping of main pressure safety valves and super-heater safety valves, etc. Boiler steam exhaust to the atmosphere is the source of the most intensive noise impact of thermal power plants on the environment. For example, when steam is exhausted sound level increases at 30…40 dbA within a distance of several kilometers. Acoustic measurements show that at a distance of 1…15 km away from a boiler sound levels exceed not only an allowable, but also a maximum allowable sound level (110 dbA) at 6…28 dbA, therefore presence of operation and maintenance staff not equipped with means of personal protection is prohibited at the level of exhaust pipelines [1].

Elimination of noise level caused by steam-oxygen boiler blow-offs refers to the specific cases when special silences are required. The peculiarity is that steam-oxygen washing of internal surfaces of boilers performed prior to start-ups is connected with long-lasting exhaust of a large quantity of solid admixtures to the atmosphere together with steam.

Designing of high efficient steam silences is a complicated task due to high requirement posed on them, such as high acoustic efficiency, capability of operation at high temperatures of exhaust steam and critical pressure drops at the inlet and outlet of a silencer, lowest weight and dimensions, minimal hydraulic resistance of a silencer.

Main design principals of steam silencers for pressure safety valves, which are applied mostly often, are consequential increase of flow area, uniform speed distribution in a flow area, achievement of atmospheric pressure in a flow prior to the exhaust section. In this connection it should be noted that metal nets and porous materials with mesh diameter from 1 to 5 mm are recently spread for internal filling of silencers. Several patented solutions exist yielding noise elimination caused by steam exhaust while pressure safety valve popping or boiler blow-offs. Thus [2] describes a silencer designed by Polish scientists. In this silencer stream is directed to the system consisting of several hundred vertical tubes through a perforated expanding nozzle and is exhausted to the atmosphere also through a perforated expanding cone nozzle, covered with a lattice at the top. Authors of the patent declare noise decrease from 140…160 to 70…80 dbA using their design. Unfortunately information is not provided on test results of the above design, its weight, reliability characteristics, capability of application for high capacity units. In this patent authors also suggest an extremely interesting decision where silences of the above design are connected with a general collector. As it may be noted the described design appears to be a rather complicated system. Therefore this system is likely to act differently under different exhausted steam quality.

Most companies-manufactures of such equipment follow a more simple way, for example a Canadian company «Fluid Kinetics Corporation» [3] presents a silencer, consisting of several concentric perforated rings-lattices. The manufactures note that that the peculiarity of the silencer consists in a special methodic of lattice location and calculated sizes of exhaust holes, yielding creation of special hydro-dynamic effect for steam flow and use mutual damping of sound waves.

In a silencer of an American company «Penn Separator Corp.» steam is directed through the diffuser, which is a vertical cylindrical lattice, where steam transforms into hundreds of small reactive jets. The same process takes place in a second stage of the silencer. Moreover the second stage provides flow swirling yielding uniform gas exhaust to the atmosphere.

The well-known manufacturer of silences an American company «Glaunach» is committed to almost the same principles.

Figure 5.52 *a* shows designs of five types of silencers, and figure 5.52 *b*- their acoustic efficiency. Steam silencers may by of a dissipative, reactive and a combined type. Increase in acoustic efficiency results as a rule in increase of overall dimensions, weight and hydraulic resistance of a silencer. Weight of a silencer is within the range from 0,5 to 5 tons, maximum weight is limited by load on roof, pipelines, where silencer is installed, possibility of mounting at the roof of a boiler department. Acoustic efficiency of silencers, presented in fig. 5.52, is within the range of high sound frequencies of 20 to 43 dbA. It should be kept in mind that in steam silences with acoustic absorber (fig. 5.52 *a*, items 1-4) acoustic efficiency sharply decreases under moister, and at temperatures of below zero icing of such material may lead to destruction of a silencer, therefore silencers of another type are spread in our country.

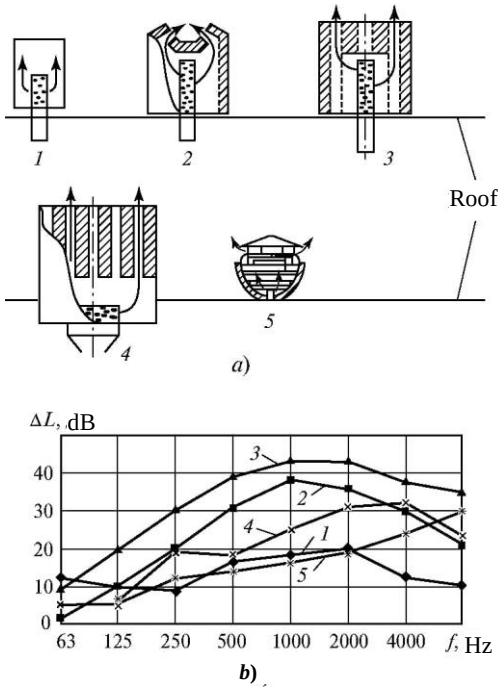

Fig. 5.52. Steam silencers:
a — designs *1 — 5*; *b* — silencer efficiency *1 — 5*; silencer weight *1 — 5*, t: *1* — 0,5; *2* — 1,0; *3* — 2.0; *4* — 5.0; *5* — 0,5

Design of YuzhVTI (fig. 5.52 *a*, item 5) provides noise reduction due to flow division and its fluent expansion is a silencer lattice. Silencer tests showed that its efficiency at the distance of 100…400 m makes 15…20 dvA. Silences are installed at thermal power plants of SC "Mosenergo" No 9, 25, 26, thermal power plant No 25 of Kievenergo, thermal power plant No 15 of SC Lenenergo, etc.

Silencer of GSH-200 type designed by Production unit "Krasny Kotelschik is similar to silencer 5, shown in fig. 5.52 *a*. Its peculiarity is use of additional acoustic absorber with electric heating. While damping of noise caused by moist steam acoustic absorber casing is connected to the electric energy source. At that moisture evaporates from the acoustic absorber and as a result its acoustic absorbing characteristics remain. Designed efficiency of the silencer is 30 dbA. In some cases silencers are required designed to answer special conditions. A tubular-type silencer was designed by scientific production unit for study and designing of power equipment named after I.I. Polzunov" for Mutnovsky geothermal power plant (ref. fig. 5.53).

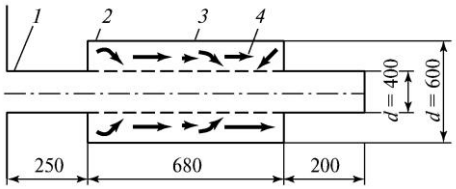

Fig. 5.53. Silencer for exhaust at Mutnovsky GeoPP:
1 — flange; *2* — casing; *3* — perforated outer surface; *4* — metal net

Length of a silencer is 680 mm. Three rectangular perforations of 200x5 mm are uniformly placed at a cylindrical surface of a tube at a distance of 20 mm from each other along a tube length on an inner and outer surfaces of a tube. Metal lattice is used as an acoustic absorber. Estimated efficiency of a silencer at the frequencies of 125, 250 and 1000 Hz makes consequently 14, 27 and 32 dbA. A silencer designed by Mosenergomontazh, VZPI and Souztechenergo is efficient for noise elimination under steam-oxygen blow-off of a boiler (fig. 5.54, *a*). Silencer consists of a cylindrical casing, where to the lower and upper parts steam polluted with blow-off admixtures is directed tangential. The flows are spinned to the opposite directions and divided by a separating disc. Technical water is injected inside the casing and to the steam supply pipeline through the collectors. Steam separated from the admixtures is exhausted to the atmosphere through the exhaust tube. Fig. 5.54, *b* shows sound levels measured at a distance from a silencer. The advantage of the silencer is low sound levels at steam flow of 300 t/hour, for example at a distance of 150 m sound level makes 68 dbA that is lower than a regulated level for the working areas. Efficiency of steam separation from the admixtures makes 88…99% depending on a load.

In Moscow state opened university (MSOU) a steam silencer shown in fig. 5.55 [4-6] was designed. A silencer is a construction consisting of four main elements, carrying certain operation functions.

- Expansion chamber *1*, consisting of throttling lattices, where steam expands and its flow speed considerably decreases.
- Casing *2* -cylindrical shell with rigid connections, providing damping of sound energy and expansion of steam flow in a self slowdown mode.
- Sound muffling chambers *3*, consisting of four sections of blades. Steam flow is spinned in each section to opposite directions, yielding damping of flow speed and energy. Inner and outer diaphragms provide uniform distribution of steam through the silencer cross-section.
- Distributor *4*, including a chamber filled with basalt fiber and distribution blades, directing steam flows to a designed direction.

Steam from the central channel passes spinning blades of four sections. In the first section steam is spinned contraclockwise, in the second- clock wise, in the third contraclockwise, etc. Therefore mutual slow down of steam flows and flow energy dispersion takes place, providing decrease of pressure drop at the exhaust and increase of acoustic suppression efficiency.

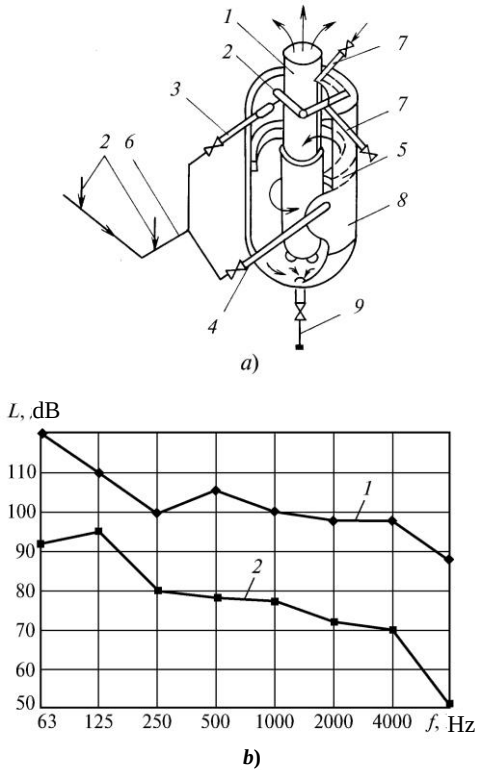

Fig. 5.54. Steam silencers for steam-oxygen start-up cleaning of internal surfaces of boilers. Designed by Mosenergomontazh — VZPI — Souztechenergo:
a — design: *1* — exhaust tube; *2* — collector for water injection; *3* — upper steam supply; *4* — low steam supply; *5* — separating disc; *6* — steam pipeline; *7* — pipelines for water injection; *8* — casing; *9* — discharge channel; *b* — sound kevel at a distance of 50 m away from a silencer: *1* — before water injection; *2* — after water injection

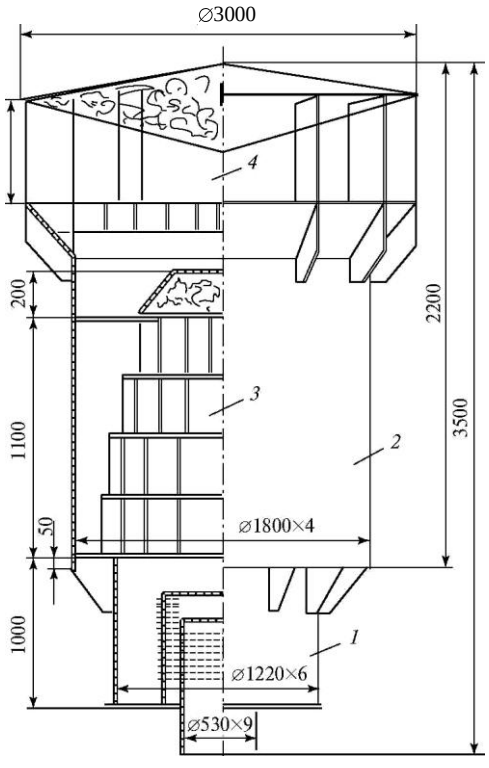

Fig. 5.55. Silencer design in Moscow state opened university

Dimensions of the silencer are: height – 3500 mm, diameter- 1800 mm. Such silencers are installed at thermal power plant No 23 of SC "Mosenergo". Tests of a steam exhaust system showed that noise at a distance of 10 m away from a silencer under the first mode of pressure safety valve popping decreased from 131 to 110 dbA, pressure in the collector prior to a silencer was 0,05 MPa, temperature difference at end exhaust pipes in the area of a heating shunt pipe made 80 °C.

At the second mode of popping when two pressure safety valves operated simultaneously, noise at a distance of 10 m away from a silencer was 118 dbA, pressure in the collector rose to 0,08 MPa, and temperature before silencer up to 290 °C , temperature difference between the forth and first pipe made 70 °C.

Noise pressure levels at a distance of 120 m away from a silencer were decreased to 74…81 dbA for geometric mean frequency 63…4000 Hz. Silencer weight is 750 kg.

In 2005 scientists of Moscow power engineering institute designed and implemented a silencer for steam exhaust (fig. 5.56) consisting a multy stage casing 1, consisting of coaxial shells 2, forming silencer stages. The first stage of the casing is connected with two pipelines 3 and is divided by screen 4 into parts in a quantity equal to a number of blow-off pipelines, each having a drainage pipe 5 for collected condensate discharge.

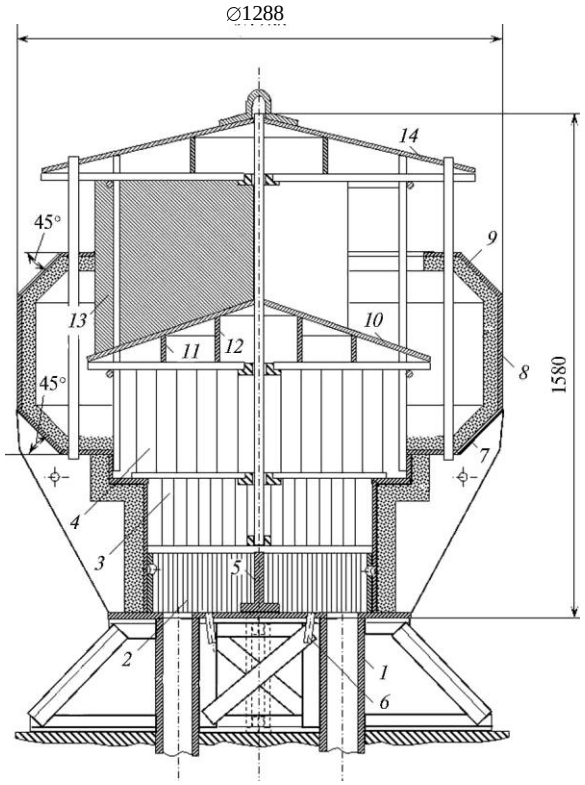

Fig. 5.56. Stem silencer of MPUI design

Each silencer stage includes a winded net 6, providing fluent steam flow expansion. At the exhaust of the last silencer stage a conic sound baffle 7 is located, equipped with cylindrical shells 8 for noise decrease at low frequencies. At the outer side of a sound baffle there are directing screens 9 to decrease aerodynamic resistance if the silencer. The last stage of the silencer is provided with a silencing chamber 10, where inner surface is covered with an acoustic absorbent 11.

All silencer stages are covered outside with the acoustic absorbent 12, reliably protected against blowing out by a perforated metal sheet *13*. Acoustic absorbent is nonhydroscopic. At the silencing chamber exhaust there is a roof 14 to prevent atmospheric downfalls inside a silencer.

Silences (fig. 5.57) are installed and are in a successful operation at Saransk Thermal power plant No 2 of SC "Mordov generating company and at Novolipetsk metallurgic works.

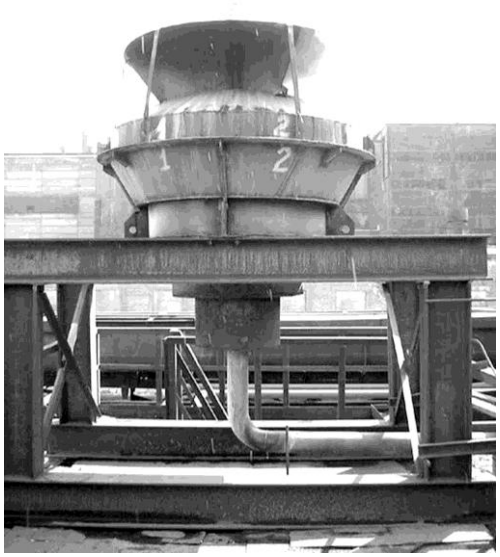

Fig. 5.57. Steam silencer of MPEI design, installed at Novolipetsk metallurgic works

Efficiency of the MPEI silencer estimated using results of measurements at a distance of 15 m at Saransk thermal power plant No 2 makes 9,4…31,4 dbA of sound pressure level and for all regulated geometric mean frequency or sound level -27 dbA.

It should be noted that efficiency of the suggested silencer may be increased up to 45 dbA and more but is limited with weight and dimension characteristics.

In 2006 MPEI steam exhaust silencers of another type were tested at Novolipetsk metallurgic works. The tests showed efficiency of 37 dbA. Results of the tests at Saransk thermal power plant No 2 and Novolipetsk metallurgic works are appropriately registered. Comparison of different silencer designs is performed using coefficient of steam silencer design sophistication

$$T = M/(D\Delta L), \qquad (5.9)$$

where M — weight of a silencer, kg; D — steam flow through the silencer, t/h; ΔL — silencer efficiency, dbA [10]. It is seen that the coefficient for the silencer of an MPEI design calculated using (5.9.) is 0,07, that is one of the best values within known native and foreign silencers (table 5.19).

The developed silencer design is protected with a utility patent [11].

Steam silencer of an MPEI design may by used with other boilers having different parameters and flow rates of steam.

Table 5.19. **Efficiency of silences of different types**

Boiler characteristics			Silencer characteristics			Company, country
p, MPa	T_{steam}, °C	*D*, t/hour	Δ*L*, dbA	*M*, kg	*T*, kg • hour /(t • dbA)	
9,5	510	32	40	3170	2,48	«Tangshan», Chaina [10]
17,6	540	75	35	1000	0,38	Japan [10]
3,8	329	90	28	4820	1,91	USA [10]
10,0	540	60	41	218	0,09	«Zhanjiang», China [10]
13,3	550	150	30	500	0,11	YuzhVTI, Soviet Union [9]
13,3	550	154,4	27	300	0,07	Moscow power engineering institute, Russia [8]