OPTIMIZATION OF BAG FILTER DESIGNS
(ON THE EXAMPLE OF CEMENT PLANTS IN THE FERGANA REGION OF THE REPUBLIC OF UZBEKISTAN)

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Abstract. Cement production is one of the most common man-made air pollutants. In this regard, the need for dust collection in this process is obvious. The article presents an analysis of the used structures of dust collection devices in the cement production of the Fergana region of the Republic of Uzbekistan. Methods of tissue filter regeneration are analyzed. The results of experimental studies on the state of synthetic fabric bag filters installed on air purifiers from dust and gas flows are presented. The choice of the standard size, design and the required number of fabric bag filters was made.

According to official data [1] currently, 22 cement plants in the Republic of Uzbekistan produce about 11 million tons of cement per year.

The development of the construction industry over the past 5 years has dramatically increased the demand for cement in both domestic and foreign markets. In this regard, the Government has set a goal to increase the volume of cement production to more than 20 million tons per year by 2025. This is planned to be achieved not by increasing the capacity of existing enterprises, but by building and commissioning new plants. So, in the Fergana region there are 6 plants with a capacity of 0.5 million tons per year each, which is 1,400 tons. per day, 4 plants of the same capacity are being built and are at the stage of commissioning. At the same time, they ensure 90% cleanliness of the surrounding air pool. There is a share of emissions, existing dust collectors need to be systematically improved and require energy and resource-saving developments.

We are conducting research to improve the standard sizes, weaving material design, design and optimal number of synthetic fabric bag filters themselves. Below is a detailed description of their work.

The minimum filtering surface of fabrics and the maximum service life of hoses are achieved by combining short filtration and regeneration cycles. However, if the efficiency of cleaning gases immediately after shaking is very low and the sediment is formed slowly, then a high initial speed is necessary to ensure the rapid formation of such a sediment. And then a long period of effective gas purification until the set value Δρ is reached. This method is often used when operating high-temperature synthetic filters that operate at low speeds and long filtration cycles.
The power consumption per fan, which is proportional to the aerodynamic drag of the filter, increases linearly with increasing intervals between regenerations, but the duration of the filtration cycle at this speed does not significantly affect the energy consumption, especially in conditions of low gas loads.

At certain values of intervals, a power-law dependence of the energy consumption on the filtration rate is observed.

The given experimental ratios were obtained when filtering cement dust in synthetic fabric filters.

After a certain period (from several tens to several hundred hours, depending on the operating conditions) of filter operation with alternating filtration and regeneration cycles, the residual amount of dust in the fabric is stabilized and corresponds to the so-called equilibrium dust content of the fabric and the residual resistance of the equilibrium dusty fabric. The values of these values depend on the type of filter material, the size and properties of dust particles, the relative humidity of gases, the method of regeneration, and other factors.

According to the device features and their classification, fabric filters differ in the following features:
- the shape of filter elements – bag filters;
- the presence of supporting devices in them – frame;
- at the location of the fan relative to the filter-suction;
- according to the method of tissue regeneration-shaken;
- by the presence and shape of the housing for placing filters-rectangular;
- by the number of sections in the installation – multi-section;
- the type of fabric used is synthetic.

The size of the sleeves is determined by design features and economic considerations. The higher the height of the sleeves, the larger their diameter is usually (this is done in order to reduce the wear of the fabric at the entrance to the sleeve). Table 1 shows the technical characteristics of the FR type filter units used at the Ferganacement LLC plant [2].

| Table 1 | Technical characteristics of FR type filters on OOO “Ferencement” |
|---------|---------------------------------------------------------------|
| Number of modules | 1 | 2 | 3 |
| Installations | Filter surface area, m² | 1320 | 1980 | 4620 |
| Number of sections in the module | 24 | 24 | 24 |
| Number of cells in the section | 65 | 65 | 65 |
| Length, L mm | 2000 | 3000 | 7000 |
| Diameter, d mm | 130 | 130 | 160 |
| Ratio of sleeve length to diameter | 15-1 | 23-1 | 46-1 |
| Filter material | Polypropylene synthetic fabric |
The number of filters in a complete installation: $24 \times 65 = 1560$ PCs., the total number of filters in three installations $3 \times 1560 = 4680$ PCs., the total area of the required fabric $7826$ m$^2$.

Stiffening rings are installed in the sleeves to prevent their compression and facilitate the fallout of dust into the hopper during regeneration at certain distances. The sleeves are put on the pipes and sealed with clamps with screw clips. The pipes are provided with annular collars that prevent the sleeves from slipping off. Since this is where the fabric undergoes the most wear, this part of the sleeves is doubly reinforced and impregnated with latex.

Fastening of sleeves in sockets by the lower cast-iron tube of a lattice without branch pipes is carried out by thin spring rings from special steel which after additional covering with fabric are sewn into sleeves. To avoid flattening, the sleeves are put on wire frames.

The housings are made of sheet steel, and must be sealed to prevent cold air from being sucked in, which can cause condensation of water vapor, they are made hermetically.

The suction filter housings are designed for a vacuum of 3 kPa. Under special conditions, the design vacuum for housings increases to 10 kPa.

For inspection of hoses when servicing filters in sections, passages are arranged not only on the pipe grid, but also at the level of the suspension of the hoses. Each sleeve is accessible from the aisles, and the distance between the sleeves (at least 50 mm) provides a secure attachment and does not allow mutual friction. Service of hoses is carried out through hatches.

The disadvantages of the described filters include the complexity of changing bags and abrasion of the fabric on the frame.

Dust is removed unevenly along the length of the sleeve. Usually, more dust remains in the middle part of the hoses, which causes an uneven distribution of gas velocities and faster wear of those places where the regeneration process is more intense — in the upper and lower parts, depending on the method of shaking.

The minimum filtering surface of fabrics and the maximum service life of hoses are achieved by combining short filtration and regeneration cycles. However, if the efficiency of cleaning gases immediately after shaking is very low and the sediment is formed slowly, then a high initial speed is necessary to ensure the rapid formation of such a sediment. And then a long period of effective gas purification until the set value $\Delta \rho$ is reached. This method is often used when operating high-temperature synthetic filters that operate at low speeds and long filtration cycles [3].

According to numerous tests, the residual dust concentration after fabric filters is $40-60$ mg / m$^3$.

For an approximate calculation of the filtration area of a fabric filter with section-by-section regeneration, the total flow rate of dusty gases entering the fabric (taking into account air suction in the gas path from the dust source to the filter cloth) and the flow rate of purge gases or air coming from the regenerated section were determined.

Thus, it is practically established that in many cases the gas load and wear of the hoses primarily depend on the input concentration and size of dust particles, and often a large dust content and high dispersion cause the need to increase the size of the filter. Therefore, the calculation of the required surface of the fabric was based not on the accepted gas load, but on the amount of dust entering per unit of the fabric surface [4].

One of the main conditions for the normal operation of fabric filters is to maintain the required temperature of the cleaned gases at the inlet to the filter and inside it. At
temperatures higher than indicated in table 2, the service life of fabrics is sharply reduced, and at temperatures below the dew point, water vapor condensation is possible, accompanied by the formation of non-removable growths or almost complete loss of gas permeability of the fabric and increased corrosion of metal parts.

The gas temperature at the filter outlet should be 15-30°C above the dew point temperature. When the filter is operating under vacuum, measures must be taken to minimize the suction of atmospheric air in the housing. If necessary, the housing is covered with thermal insulation. Filters should be installed in warm areas of the room. If an additional amount of heat needs to be applied to the filter and this cannot be done by increasing the temperature of the gases in the process apparatus, then the dusty gas is additionally supplied with air heated by electric heaters, steam heat exchangers or by direct combustion of natural gas in this air. Installation of electric or steam heaters inside the enclosure is impractical due to the risk of steam leakage and dust on the heater surfaces.

The service life of fabrics varies depending on the conditions of use, the design of the device and the quality of its service. The average service life of the hoses is from 9 months to 2 years, although it can vary from a few weeks to 10 years. The quality of installation and maintenance of the sleeves and regeneration mechanisms has a great influence on these terms.

The economic effect is expected to be achieved from the research aimed at energy and resource conservation, the calculation of which will be published later.

References:

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