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ENVIRONMENT PROTECTION

Influence of Wind on Seepage of Gases through the Shell of Smoke Stacks

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Abstract—The effect of wind on the distribution of static pressure at the outer surface of thermal power station smoke stacks is considered. It is shown that the wind velocity and direction are the main factors influencing on the seepage of gases through the shell of smoke stacks when no excess static pressure is exerted from the side of flue gases. A procedure for determining the wind influence zone on the seepage processes in smoke stacks is proposed. This procedure supplements the previously adopted approach for estimating the operating modes of smoke stacks taking the influence of wind into account. The proposed procedure is used for determining if seepage of flue gases is possible and for finding the wind influence lower boundary for different operating conditions. The described procedure can be used in designing new smoke stacks and in repairing and retrofitting existing ones, and also in developing new techniques for revealing through flaws in smoke stack shells during their examination by means of an infrared imager. As an example, the results from infrared flaw detection of a smoke stack are presented, which testify that a change occur in the direction of seepage processes taking place in a reinforced-concrete shell when a change occurs in the wind effect pattern.

Keywords: smoke stack, construction joint, wind velocity, pressure difference, seepage of gases

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Safe operation of modern thermal power stations (TPSs) depends to a significant extent on how reliably the totality of its main and auxiliary equipment operates [1, 2]. Smoke stacks are an important link in the technological process through which heat and electricity are generated, and the technical state of these structures is of quite essential importance for securing stable operation of the power-generating equipment at a TPS.

As is well known from experience, the structural elements of smoke stacks (lining, heat insulation, water proofing, and the bearing reinforced-concrete shell) undergo changes in the course of their long-term operation, which lead to degradation of their functional properties. Depending on the kind of fuel fired in the TPS boilers, gas purification method, and the temperature and humidity parameters of flue gases, as well as the type and quality of materials used during the construction of smoke stacks, both lining and the bearing reinforced-concrete shell undergo different kinds of mechanical and corrosion damage. Such phenomena are mainly due to first, poor quality of construction, also due to the use of substandard materials and, second, inconsistency between the designs of smoke stacks and conditions of their operation.

Speaking about the design features of the reinforced-concrete smoke stacks that are in operation at existing TPSs, we should bear in mind that the majority of these stacks were put in operation in the period from the late 1940s to the early 1980s, and their reinforced-concrete structures were erected with the use of lift-and-progressive shuttering. One natural and characteristic feature of this construction method is that the structure contains construction joints. If a construction joint is made with deviations from the standard technology, the stack will have degraded tightness due to the occurrence of a system of voids and leaky places, which leads to seepage of flue gases and facilitates escape of condensate to outside the stack. Another defect that is usually observed in the joint zone along with this structural imperfectness is that the concreting section contains low-density popcorn concrete in its lower part. Not only does such concrete lead to degraded tightness of the shell, but it also has degraded strength, poorer freeze-thaw durability, and increased water permeability. Smoke stacks erected with the above-mentioned defects are not leaktight structures for the conditions under which they operate.

In analyzing all unfavorable factors affecting the smoke stack gas-removing shaft, including those influencing the seepage processes, special attention should be paid to the external wind effect, which unfortunately is not duly taken into account in designing, nor does it properly considered during the subsequent operation, monitoring, and development of