MAINTENANCE OF SAFETY OF WATER-COOLING TOWER CONSTRUCTIONS

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Abstract. The analysis of a condition of designs of the large-sized coolers SK-1200 is carried out. Critical areas of construction designs are specified: ferro-concrete inclined racks, areas of a mouth and lower part of a konfuzor. Influence of defects in the form of scratches on mechanical characteristics of the loaded thin-walled elements of the designs working in hostile environment is investigated. The technique of an expert assessment of safety of designs and constructions is offered. Devices are developed for prevention of destruction and strengthening of buildings and the constructions subject to essential corrosion wear.

Introduction

Modern designs and constructions perceive big mechanical loadings. Cooperating with environment, designs are exposed to corrosion wear. Deformations of elements of designs thus intensify corrosion process. In the course of corrosion wear there is a change of geometrical and mechanical characteristics. Protection against corrosion destruction of designs and constructions is an important problem of modern economy. Competent protection against corrosion allows to keep a design or a construction from destruction, to prevent a technogenic catastrophe and to solve environmental problems.

Some results of the analysis of a condition of designs of the large-sized coolers SK-1200 are given in work. Critical areas of construction designs are noted: a, b, c, d, e (fig. 1). Recommendations for restoration and strengthening of critical areas of designs [1-9] are made.

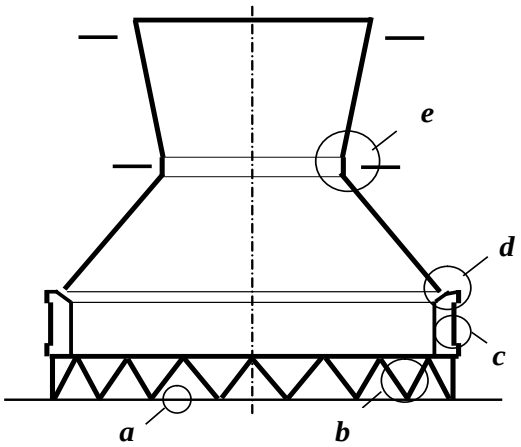

Fig. 1. Critical areas of designs of the cooler SK - 1200 critical areas of designs [1-9].

The cooler is a device for water cooling by atmospheric air in systems of turnaround water supply of the industrial enterprises and in air conditioning devices. At the petrochemical enterprises ventilyatorny coolers find application. Ventilyatornye coolers represent designs from reinforced concrete (inclined racks, a cylindrical part) and metal (a konfuzor, a mouth, a diffuzor and horizontal frames). Elements of a design perceive power loadings (weight, loadings from a wind and the fan) and are subject to intensive corrosion wear (the manufacturing atmosphere and cooled technological water).

Hostile environment negatively influences a condition of elements of designs, thus the kinetics of corrosion processes is influenced by level mechanical tension. Corrosion wear leads to reduction of section of elements of designs, decrease in mechanical characteristics of a material and according to, to increase in level of a gradient of tension. Big loadings and humidity, hostile environment and differences of temperatures, and also constructive imperfections result in considerable wear of construction designs and promote their destruction.

Condition of ferro-concrete designs of coolers

Loadings in a combination to aggression of the environment negatively influence a condition of ferro-concrete designs, there is a process of a loosening of concrete, there are micro and macro cracks, there are corrosion centers in fittings. As a result of it prochnostny properties of bearing ferro-concrete designs decrease.

Natural inspections of a condition of construction designs of coolers showed that inclined racks and a cylindrical part of the cooler have various degree of wear. Critical areas of ferro-concrete designs are areas b, c and d (fig. 1). Separate elements in these areas are in emergency or in an unsatisfactory condition.

Condition of metal designs of coolers

Hostile environment and big humidity negatively influence a condition of metal designs: the paint and varnish covering is broken, there are corrosion centers up to complete "corrosion" of some обечаек, edges, etc. All this leads to decrease in durability of bearing metal designs.

Natural inspections of a condition of construction designs of coolers showed that konfuzor elements in the field of the top ferro-concrete ring and elements of designs of a mouth are subject to the most intensive wear, that is critical areas of designs are areas d and e. On all circle on these elements there are through openings and essential utoneniye. Surfaces of the majority of edges and manacle rings are covered with a rust, especially top regiments of channels. Farm elements, inclined braces and elements (kerchiefs) of fastening of farms to panels are subject to wear also.

The main reasons for essential corrosion wear are: violation of a paint and varnish covering that promoted by hostile environment, humidity in the cooler, a sign-variable deformation field and operation time; existence of various superficial mechanical defects; high level of intensity of tension in some areas of the designs arising from variable wind and big weight loadings; depressurization of interpanel seams; existence of an internal air stream with the kapelnozhidky inclusions moving with rather high speed at the working fan; imperfection of the constructive and power scheme and irrational interposition of the next coolers, promoting growth of tension, and also dirt and moisture accumulation in separate parts of a design.

elements in these areas are in emergency or in an unsatisfactory condition.

Influence of mechanical defects on properties of the loaded thin-walled elements of designs in an excited environment

Special danger to the loaded designs is represented by cases when two and more sources of destruction, for example, concentrators of pressure + corrosion take place. Some results of researches of influence of defects in the form of scratches on mechanical characteristics of thin-walled elements of the designs working under loading in an excited environment are more low

resulted. Aspects of the experimentally-theoretical approach are stated, in particular, in works [5-7,11-13]. For the developed way and equipment DMK-1 the patent of the Russian Federation for inventions [11] is taken out. Working out is included in the Report of the Russian Academy of Sciences for 2006 [14], and also awarded by the Silver medal and the Diploma on 35th International Salon "Geneva-2007" [15].

Samples by thickness of a material h_0=0,6 mm and diameter of working part D =110 mm, with defects in the form of scratches have been considered, in particular. Scratches about 0,02 mm were put by depth in the form of a rectangular grid. The various step has been considered. Samples were tested under the pressure of 0,2 MPas within 888 hours. As an excited environment the solution гипохлорит sodium was used. Owing to impossibility of maintenance of full hermetic sealing, pressure fell a little, regular feed to 0,2 MPas therefore was spent. For comparison of results two samples with scratches were exposed to excited environment influence, and other two samples with scratches and one sample without scratches weren't exposed to corrosion deterioration: the sample №1 (scratches with step of 25 mm without an excited environment), the sample №2 (scratches with step of 25 mm with an excited environment), the sample №3 (scratches with step of 10 mm with an excited environment), the sample №4 (scratches with step of 10 mm without an excited environment), the sample №5 (free of defects). The schedule of change of deflections on time is presented on fig. 2. Modules of elasticity E of samples have been defined at small deformations – during the initial moment of test when elastic deformation of samples (table 1) takes place.

Table 1

Elasticity module	Sample 1	Sample 4	Sample 5
E, MPa	149000	133300	200000

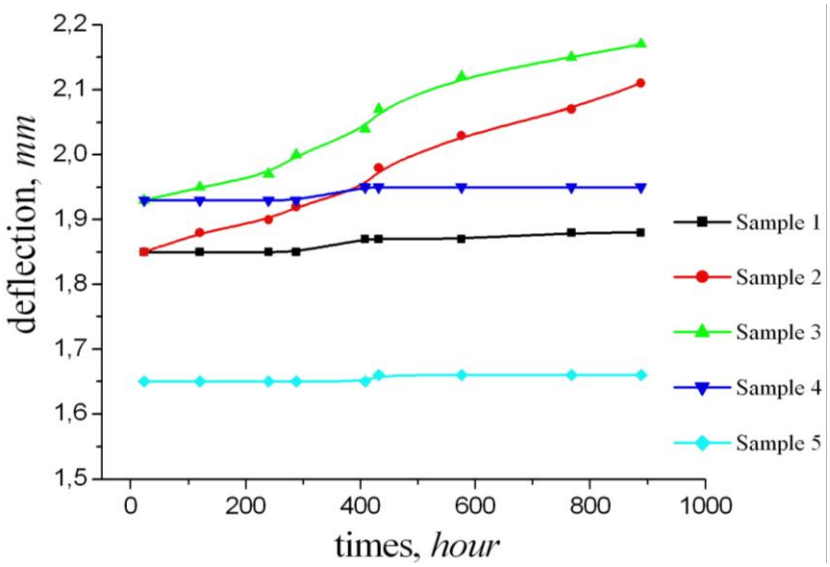

Fig. 2. Deflection change on time

It is established that mechanical defects accelerate process of corrosion wear and influence mechanical characteristics of a material. For a membrane with defects the conditional module of elasticity at the end of test made for a grid with a step of 25 mm – 26836 MPas, and for a grid with a step of 10 mm – 24249 MPas.

The analysis intense the deformed condition

For the analysis intense the deformed condition of a metal part of a design of the large-sized cooler the spline option of a method of final elements [16-20] is used. The method is based on synthesis of idea of preliminary parametrization of a median surface of a cover and a method of final elements. Geometrical parameters of a design are set in cylindrical system of coordinates. Plastic deformations are considered according to the deformation theory of plasticity.

Calculations for definition of the of system a diffuzor - a mouth - a konfuzor initial (to wear) and a real design (taking into account wear of elements) the cooler being under the influence of a body weight and wind loading are carried out. Intensity change tension of σ_i on circular coordinate of θ around a mouth joint with a diffuzor (horizontal section) is presented on fig. 3.

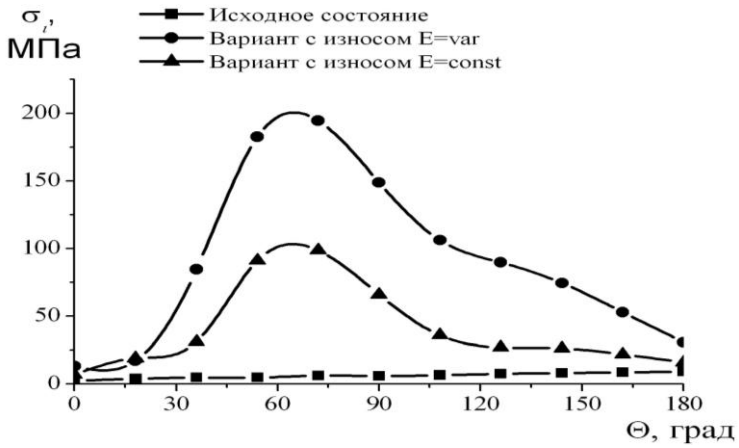

Fig. 3. Change of intensity of pressure σ_i from θ

The analysis of the received results of calculation of the VAT shows that change of the module of elasticity in some areas of a design leads to significant increase in intensity of tension, and increase of tension promotes decrease in bearing ability of designs and further increase in corrosion in this area.

Expert assessment of safety of designs, constructions

In use designs and constructions, in particular coolers, the assessment of their safety in a mode of continuous monitoring is required. Thus there is a need of receiving by certain criteria not only qualitative, but also quantitative characteristics of safety. It would allow to estimate:

- degree of a deterioration of designs and constructions;
- sequence of the objects, demanding performance capital and maintenance;
- expediency of further operation of considered object etc.

It is possible to determine characteristics of safety, in particular, by a way of carrying out an expert assessment [8]. The expert assessment of safety of designs and constructions can be executed, using dimensionless factors of safety of k_i $0 \le k_i \le 1$. The factor of safety represents the relation (significant) indicators with the same name playing important role in ensuring of safe functioning of objects:

$$k_i = \frac{S_i}{S_0} \tag{1}$$

where S_i – the current (actual) value of an indicator; S_0 – accepted from the point of view of ensuring full safety (standard) value of an indicator. $S_i \le S_0$ thus is accepted.

In the absence of regulations at the choice of values of significant indicators at calculation of factor of safety extreme values of indicators undertake:

(significant) indicators with the same name playing important role in ensuring of safe functioning of objects:

$$k_i = \frac{S_{\min}}{S_{\max}} \tag{2}$$

The factor of safety can be estimated also on degree of wear of elements of system, thus, the above wear degree, the is less than k_i. In particular, as integrated factors of safety of inclined racks of coolers on degree of their wear the sizes presented in table 2 are accepted. Degree of wear of elements is defined on stages of inspection and, if necessary, after predesigns intense deformed состояния.объектов:

Table 2

Degree of wear of an element	Value of integrated factor of safety of an element
Not above I	1,00
II	0,75
III	0,50
IV	0,25
The rack is completely destroyed	0,00

According to inspection of a number of coolers expert estimates are received. In particular, results of an expert assessment of a basic part of the coolers B8-2A1 and B9-1A3 are given in table 3.

Table 3

Safety indicators	cooling tower B8-2A1	cooling tower B9-1A3
$\sum_{i=1}^{42} k_{oi}$	28,00	16,75
$k_o = \left(\sum_{i=1}^{42} k_{oi} \right) / 42$	0,67	0,40

Apparently from table 3, estimated safety of a basic part of saltern B9-1A3 much more (in 1,675 times) below estimated safety of a basic part of saltern B8-2A1. Under this data it is easy to estimate degree of a deterioration of a basic part of a saltern and it is easy to establish sequence of restoration of the salterns, demanding performance capital and operating repair.

Some recommendations about strengthening of designs

Devices were developed for strengthening and the prevention of destruction weakened and defective sites of buildings and constructions of a round form in respect of, in particular, large-sized ventilyatorny coolers. On development patents for the invention of the Russian Federation [21-24] are received.

The basic system according to the patent [21] is established for strengthening of the falling cooler B11/A3 (fig. 4) and recommended for strengthening of other coolers SK-1200. The basic system for strengthening of industrial buildings includes a framework from basic elements and

elements of communications. The framework is executed in the form of the truncated cone and consists of the ravnoraspolozhenny inclined basic elements which have been rigidly connected by elements of communication in the horizontal plane. Adjacent basic elements are established

Fig. 4. Basic system for cooler SK-1200 strengthening

symmetrically to each other and rigidly connected by the top ends with each other, and their bottom ends are rigidly connected to the bottom ends of the subsequent next basic elements.

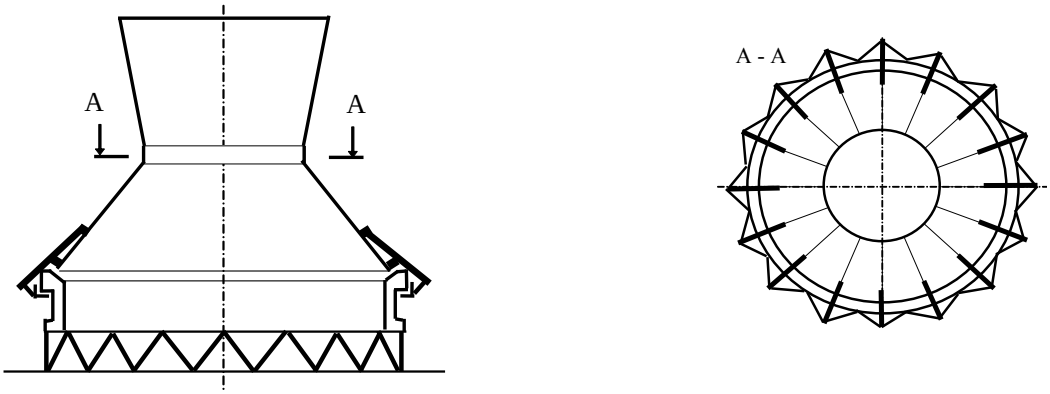

Fig. 5. The scheme of strengthening of the ventilyatorny cooler SK-1200 in the field of a konfuzor support on the top ferro-concrete ring

The scheme of strengthening of the cooler SK-1200 in the field of a konfuzor support on the top ferro-concrete ring (fig. 5) includes the inclined beams located in the radial directions of a konfuzor

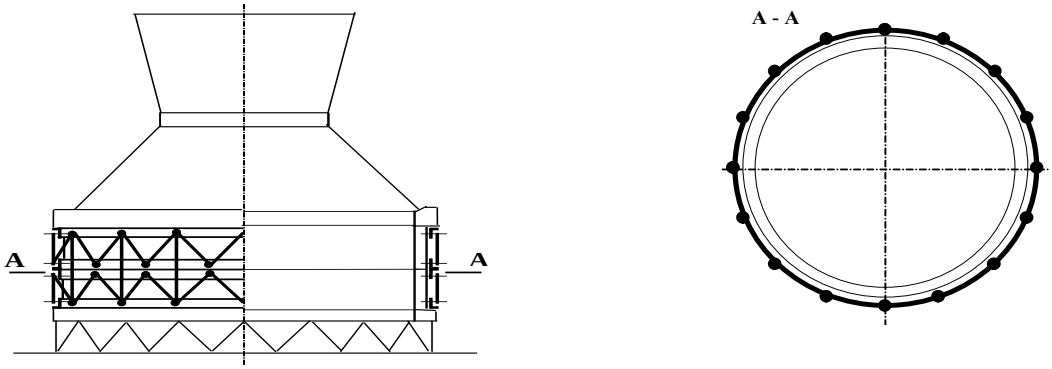

Fig. 6. The scheme of strengthening of the cooler SK-1200 in cylindrical area of a ferro-concrete part of a design

and attached by the top ends to bearing elements of a design and leaning on a basic ring [22].

In option on [23] device on [22] includes also surrounding bandage which is pulling together the top ferro-concrete ring of the cooler. The scheme of strengthening of the cooler SK-1200 in cylindrical area of a ferro-concrete part of a design (fig. 6) includes a strengthening framework in the form of the vertical racks connected by horizontal belts of rigidity, and inclined braces [24]. Thus cells of an obrazuyemy lattice can be executed different structure.

Summary

1. Special danger to the loaded designs is represented by cases when two and more sources of destruction, for example, concentrators of tension + corrosion take place.
2. Defects accelerate corrosion wear and influence mechanical characteristics of a material.
3. The maximum tension is observed in the field of fastening of a metal part to a ferro-concrete part and around a mouth; in zones of utoneniye and near openings there are plastic deformations.
4. After 15-20 years of operation of coolers carrying out major maintenance is required.
5. Devices of strengthening of buildings and the constructions providing rational transfer of efforts to support both allowing to increase durability and seismic stability are developed, and also to prevent destruction being in operation of buildings and constructions, including coolers SK 1200.
6. Development is awarded by Medals and Diplomas of the International Salons and Forums: Silver medals on Bryussel-Evrika-2004, Geneva-2005 and Archimedes-2009 Salons, and also a medal of the International forum "High technologies of the XXI century" – «W of XXI-2005», Moscow.

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