

Geodetic Determination Method of NPP Containment Deformations

Ibragim Gairabekov^a, Yuriy Zabaznov^b,
Magomed-Bashir Gayrabekov^c and Kheda Gagaeva^a

^aGrozny State Oil Technical University named after acad. M.D. Millionshchikov,
Grozny, RUSSIA;

^bRostov State University of Civil Engineering, Rostov-on-Don, RUSSIA;

^cSaint Petersburg National Research University of Information Technologies,
Mechanics and Optics, St. Petersburg, RUSSIA.

ABSTRACT

The paper covers the possibility of receiving of more complete information on the deformed condition of protective containment with the use of modern electronic geodetic measuring instruments in comparison with a method of the deformations' determination by the control instrumentation recommended by the relevant normative documents. There are given the results of geodetic determinations of the domical (top) and cylindrical parts of the Rostov NPP's second reactor building's protective containment's deformations during its tests on durability at increase and reduction of pressure inside the cover. Requirements for creation of mobile geodetic measuring system are developed.

KEYWORDS

Protective cover; measuring system; deformed condition; target points.

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Introduction

Matters of geodetic instruments and methods of measurements use for the solution of tasks at objects of nuclear power and other unique objects were lit in works earlier (Zharnikov & Fedorov, 1980; Zhilkin, 1981; Lobov & Andolenko, 1985; Nevolin & Tyshyuk, 1987; Nersesyan, 1990; Pimshin et al., 1999; Ruskov & Boglov, 1984; Slipenko & Ruskov, 1983; Ustavich & Kostina, 1983; Dimitrov & Tonkov, 1989; Ustavich, 2005; Storozhenko, 2004; Dyakov, 2009; Golygin & Shaimkulov, 2003; Kalinchenko & Uvarov, 2009; Fedoseyev, 1977; 2010).

The conducted researches of the protective containment (PC) deformation process at a pretension and testing for durability with use of modern electronic geodetic measuring instruments revealed a possibility of receiving a more complete information on its deformed condition in comparison with method of deformations determination by the control instrumentation, recommended by the relevant normative documents, consisting of the string sensors, which are built in a body of containment (Gairabekov

CORRESPONDENCE Ibragim Gairabekov ✉ ibragim.ggni@mail.ru

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et al., 2009; 2015a; 2015b; 2015c; Gairabekov & Zabaznov, 2010). Such control system of the deformed condition allows revealing deformations only on sites of PC's momentless zones.

Separate general recommendations of the geodetic works carrying out only at stages of the PC's construction and operation are provided in normative literature. However, geodetic works aren't provided by normative base at such responsible stages as pretension and testing for durability of PC before putting of the NPP's power unit into operation after completion of a construction or at prolongation of term of its operation (Xu, 2010; Bouziani & Benouar, 1996; Costachel, 1967). The containment is an important link in a security system of the NPP and development of geodetic technology of receipt of more complete information on its deformed condition at all stages of PC's functioning is an urgent scientific task.

Materials and Methods

The technology of geodetic provision of the NPP PC's geometry inspection has been approved on the Rostov NPP under construction. With the use of such technology works on definition of deformation characteristics of dome and cylindrical parts of PC of the Rostov NPP second reactor building during its tests for durability at increase and reduction of pressure inside the cover have been performed.

Development of diagnostic tools of a technical state of the NPP's PC in the period of their pretension, test and an exploitation is a complex task. Until today PC have been constructed and have been operated, the construction of which was developed in 70 years of the last century, and represent by themselves previously strained reinforced concrete building construction, which internal surface is made from sheet steel. The construction of the cover consists from several elements: bearing plate, cylindrical part, bearer, dome (fig. 1).

The plate represents by itself a horizontal reinforced concrete construction, which is overlapping of cellular structure of the reactor building's building up. The plate serves as a bearing of the cover's cylindrical part, and to all complex of the technological equipment located in a pressure-tight zone.

The cover's cylindrical part is made from reinforced concrete. In this construction are applied two types of reinforcing. The first is made from nonprestressed reinforcement. The second is made by cables of prestressing cover's system (PCS), kicked a pig into the channels executed from the plastic pipes established in the course of construction in a cover body. The internal surface of a pressure-tight part is made from sheet steel by thickness 8 mm. Besides, constructive elements of the cover are the consoles, which are built in by one end into its body and are intended for installation in a containment of the lifting machines and other type of the equipment.

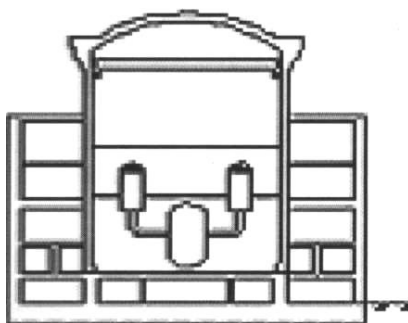


Figure 1. The construction of prestressed containment

The constructive solution of the bearer and the constructive solution of the dome part are analogous to that, which are applied in a cylindrical part (fig. 2). Elements of the prestressed cover's system are installed on the bearer.

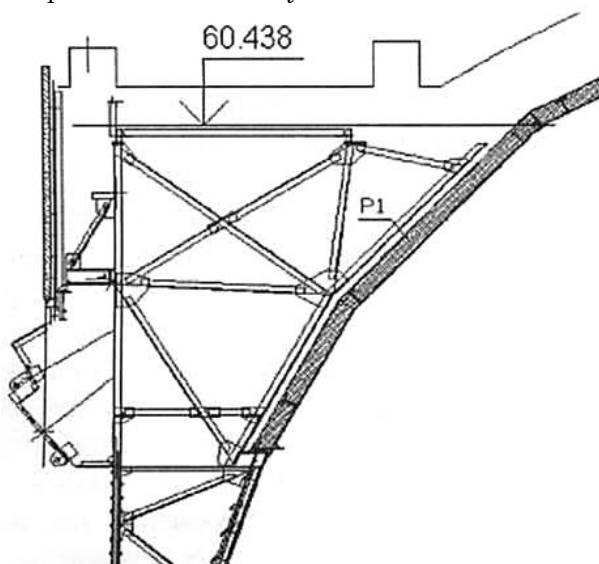


Figure 2. Connection assembly of the cover's cylindrical part and dome

The system of a pretension in a cylindrical part is executed according to the helical scheme of an arrangement of reinforcement cables and orthogonal loop in dome (Fig.3).

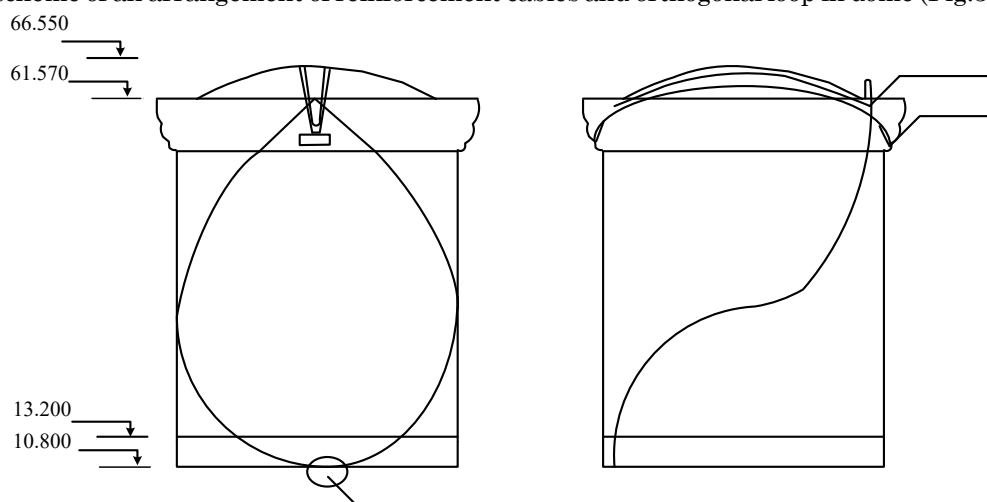


Figure 3. The scheme of an arrangement of ropes in cylindrical and dome parts of a protective cover

The reinforcement rope consists from 456 in parallel laid high-strength stabilized wires by diameter 5 mm from the carbon steel 5B1400-P1 State Standard 7348-81. The reinforcement rope has two anchor loops at the ends. Originally one of them is formed by winding of a wire on thimble, another - on the bushing of leader. By means of the leader the rope is installed into the channel of a protective cover. After the mounting of a rope the leader is replaced by the second thimble and the tension is made. The beginning of works on a tension of PCS is started after 90 days term after achievement of 100% designed durability of concrete. Works on a tension of the



reinforcement ropes include the works on installation of reinforcement ropes in duct tubes and process of their tension. (Lifting) jacks DG-650/1200 are used at the work. The developing effort forms: 800 t at tension of rope, 900 t at supporter.

Continuous monitoring of all systems' work including a protective cover is conducted during operation of the NPP. Serviceability of a protective cover is determined by compliance of the actual parameters with design requirements, such as geometrical parameters compliance, quality of material, pretension level, etc.

The control of their current parameters is carried out at assessment (evaluation) of the protective covers' technical state in the process of their pretension, tests and later on at an operation stage. As it was mentioned already, the regular in-house automated system is used for control and assessment of the cover's physic mechanical characteristics. However, the experience of such systems' operation has shown that their use is connected with certain shortcomings, for example transducers failure, change (modification) or their parameters misfit to calibration characteristics, etc. Owing to getting of firsthand information on condition of the investigated object isn't provided. Thereby the creation of the backup portable instrumentation management system, intended for control of the PC's geometrical parameters and provided for the increase of information acquisition's objectivity on the cover's physic mechanical characteristics, as a result of it the increase of the technical state value's reliability and, eventually, increase in safety of operation of PC, is warrantable (righteous).

Results and Discussion

The analysis of the containment's construction elements' work at its pretension and test has shown that at these stages work of PC's constructive parts is various. Therefore, at first, it is necessary to consider these features at design of measuring system. Secondly, it is necessary to consider features of each constructive part's work (taken) separately and zones' specificity of their arrangement. Thirdly, it is necessary to consider a specific form of PC's parts.

Proceeding from the listed conditions the following requirements to creation of mobile geodetic measuring system (MGMS) are defined.

The object is investigated by means of the discretely distributed points' coordination on his surfaces, which are situated in the most informative zones.

Control of points' position is carried out with an accuracy (precision) providing reliable determination of result.

Target points are defined in unified system of coordinates.

Control is carried out taking into account pretension programs, test and a monitoring by technical state of an object during operation.

The following central tasks, the solution of which it is necessary to provide at creation of MGMS, are resulted (followed) from the listed requirements.

Creation of geodetic basis in conditional system of object's coordinates, which provides all studied PC zones in the process of their control by stationary initial data.

Distribution of target investigated points taking into account an arrangement of the studied object's deformational zones and their placement in the places providing a reliable definition and value of required deformation parameters.

Selection of methods, means and measuring systems guaranteeing obtaining of given accuracy for the subsequent appropriate reflection of deformation characteristics of an investigated object.

Development of the joint interpretation's system of object's deformation characteristics with assessment of the given deformation process and the PC physical mechanical properties' general characteristics.

The cover's studied elements are the domical and cylindrical parts, at the same time target points are located at their internal and external surfaces. The bearing plate and bearer are practically not deformed at the effect of the PCS forces on the cover's construction elements. At the same time the PCS specified effects are directed to pretension of cylindrical and domical parts, just they, having taken (received) loadings, change a form, i.e. are deformed. At that zones of cylindrical part's direct contiguity to the bearing plate and bearer, and a domical part to the bearer undergo minimum travels, are moment zones. The zones located between minimum relocatable and relocatable as much as possible, are transitional (transitive), and zones with the established maximum travels are momentless. Distribution of deformation zones by the PC's constructive elements in a graphic look is presented in fig. 4.

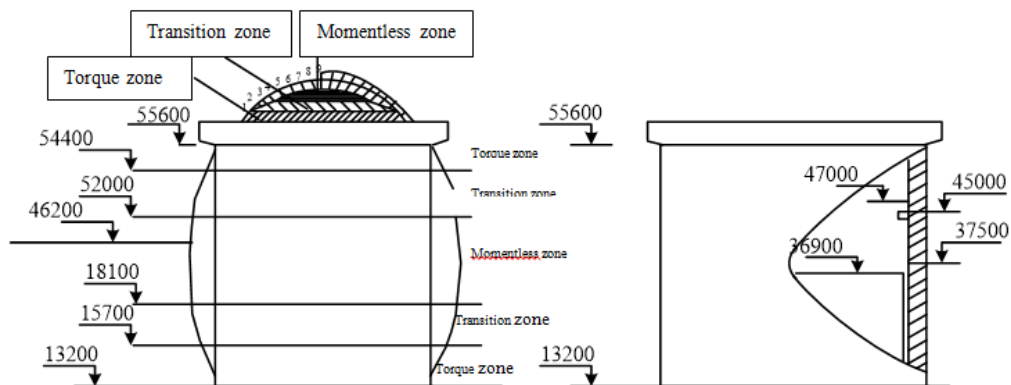


Figure 4. Distribution of deformation zones at PC's construction elements

Momentless zones, which in this case are the most informative, receive the largest travels at reduction of the cover by the PCS system. In these zones radial core armature undergoes deformations of tension that can lead to stratification of the cover's wall. Therefore, realization of travels' measurements has to be carried out on the studied points located at internal and external surfaces diametrically oppositely relative to each other (fig. 5, 6).

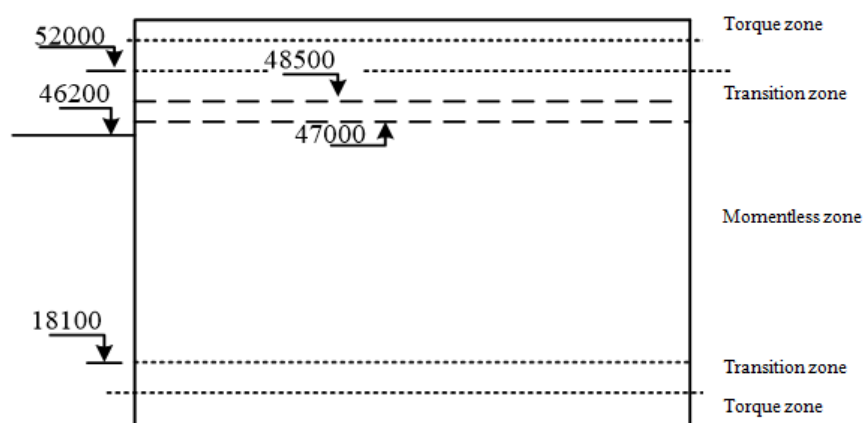


Figure 5. Distribution of target points on the PC's cylindrical part



The initial cycle of measurements is carried out before the reduction process, the last cycle of measurements is carried out at the end of the cover's endurance (relaxation)'s period before its tests.

At test of the cover on technical conditions of works' execution, target points are placed only on external surface of the PC's construction elements.

Marking on the set sections of the target points' construction is carried out in such a way that on a dome of protective cover the points are placed and marked on the axled and semi-quarter directions. And they are placed in a moment zone, a zone of a direct contiguity to bearer, with a pitch equal to about a half of thickness of this building construction, in our case to a half of the protective cover's thickness (it is 600 mm), such intervals fixed by points on each of the directions are marked two. In a transition zone the points are placed with the pitch equal approximately to the thickness of a building construction, in our case it is 1200 mm, such intervals fixed by points on each of the directions are marked two. In a momentless zone are placed points with the pitch equal to two or more thicknesses of a building construction, in our case 2500-3000 mm, thus all remained parts of controllable directions. On an external cylindrical part of the protective cover target points are placed in the vertical sections coinciding with axial sections, with a step of their distribution analogous to a dome part also having counted from bearer. At that, the first cycle of measurements is the cycle executed after a cover's relaxation after its reduction. The last cycle of measurements is carried out after the end of tests and in end of the calculated period of the cover's relaxation.

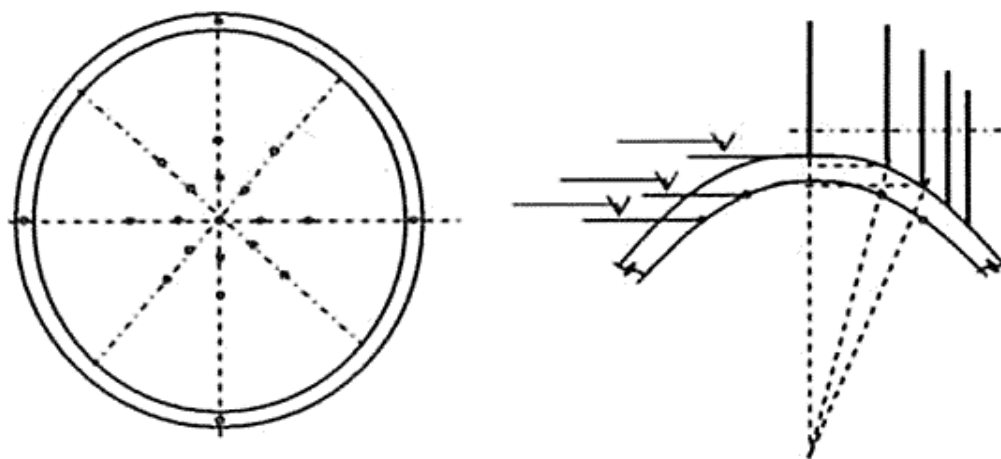


Figure 6. Distribution of target points on a dome part of PC

The state (form, condition, aspect) of an inspection method of the studied points' position is determined by conditions of the measurements' execution, and in particular, by a form and an arrangement of the protective cover's construction parts. So, the spatial tacheometry method is used as a basic for control of the PC's internal form carried out in the reactor hall premises. A method of a spatial tacheometry for a cylindrical part and a method of geometrical levelling for a domical part and for bearer are used for control of the form of PC's external surfaces.

Equipment like the high-precision electronic tacheometer or a laser tracker is used for the realization of the spacial tacheometry method as measuring instrument. The stationary geodetic basis in the form of special points with a possibility of antideflexion mounting of reflectors on them is formed at realization of the given



method at a prestage. Points of a geodetic basis are defined in system of PC's construction axes. Coordination of the studied points and points of a geodetic basis is carried out and coordinates of points of the current cycle in a system of the protective cover's construction axes are calculated in each subsequent cycle. First-order numerical levels are used as a measuring instrument for realization of the geometrical levelling's method. These measuring instruments provide getting of information on tall position of the studied points discretely distributed on surfaces of the studied object at each inspection stage.

Conclusion

Thus, realization of the described the protective cover's geometrical parameters' inspection's system allows to estimate objectively technical state of PC in the process of their pretension, tests and further at an operational stage that provides increase in nuclear safety of the APP.

Disclosure statement

No potential conflict of interest was reported by the authors.

Notes on contributors

Ibragim Gairabekov, PhD, head of the department Geodesy and land cadaster at the Grozny State Oil Technical University named after acad. M.D. Millionshchikov, Grozny, Chechen Republic.

Yuriy Zabaznov, PhD, professor of the department Construction productions at the Rostov State University of Civil Engineering, Rostov-on-Don, Russia.

Magomed-Bashir Gayrabekov, student at the Saint Petersburg National Research University of Information Technologies, Mechanics and Optics, St. Petersburg, Russia.

Kheda Gagaeva, assistant at the department Geodesy and land cadaster of the Grozny State Oil Technical University named after acad. M.D. Millionshchikov, Grozny, Chechen Republic.

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