Problems of tank roofs resistance to corrosive attacks

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Abstract. Nowadays, there are many types of roofing designed for steel vertical tanks. Their working properties are also quite different. The paper considers technical solutions of tank roofs constructed for storage of liquid aggressive liquids of oil type and the like. It describes a new technology which is being actively introduced at Russian enterprises at the moment. According to this new method, load-bearing structures are installed above roof flashing sheets, thus protecting them from direct contact with an aggressive environment. It ensures corrosion resistance and, consequently, durability of the tank stationary roof. To reduce the risk of corrosion damage it is necessary to increase metal thickness. The researchers suggest using stainless steel instead of regular carbon steel. In this case, steel sheets thickness can also be lessened thus making it possible to reduce loads on underlying constructions. The proposed solution of the units fastening the tank roof elements also simplifies construction inspection activities.

1 Introduction

Oil industry significantly contributes to the country's budget, being the object of close attention for designers, technologists and economists [1]. Particular attention is paid to tanks and pipelines design. Tendency to increase the number and size of reservoirs leads to an increase in the level of responsibility and danger of these structures [2]. Their design requires the following: they should provide safe product storage, be simple to manufacture and installation, and have a low metal content. Modern roofs are installed in accordance with international and local legislation of oil and gas industry, as well as the latest European and international standards: API 650 and Eurocode 1. They can be used in any climatic conditions within -50 to + 90 ° C temperatures, taking into account necessary requirements [3].

Special attention should be paid to the characteristic drawbacks of metal structures of tanks roofs, which can be found during their operation, namely:

tendency to structural elements corrosion damage under the influence of gas-air environment of the stored product, which is due to the presence of a frame on the inner surface of the roofs and crevice corrosion sources;

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possible pyrophoric deposits formation, as well as fall and deposition of corrosion products on the reservoir bottom and wall;

roof hermiticity break resulting from the flow through corrosion damage formation.

In the process of operation, various defects and damages occur, corrosion being the most common - 30% of the total amount (Figure 1). Corrosion is a natural phenomenon, defined as destruction of substances, usually metals, or degradation of their properties due to environmental influences. Like other natural phenomena, such as serious natural disasters, corrosion can cause dangerous and costly damage [4,5].

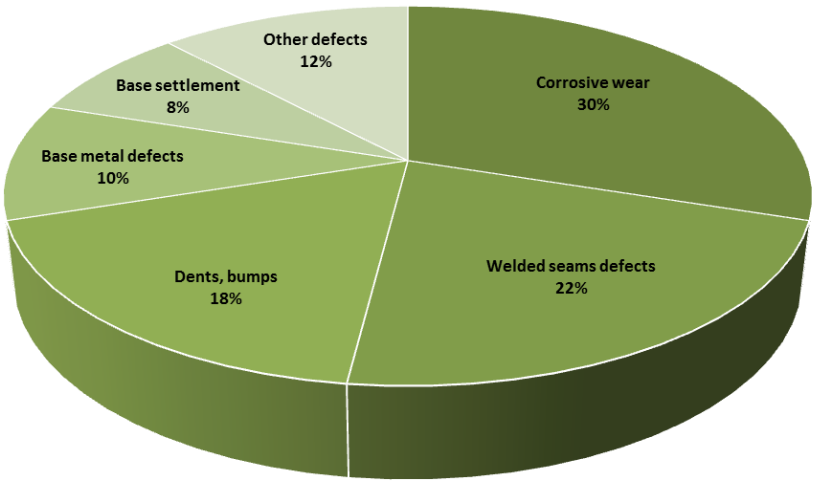

Fig. 1. Roof defects and damages

Corrosion inside the reservoirs depends mainly on the frequency of filling with petroleum products, chemical composition of petroleum products, and the presence of water in the fuel. The speed and nature of corrosion process are more pronounced on the inner surface of the tanks at the places of separation of the two media; for example, oil - bottom water, petroleum product - steam-air mixture. The intensity of corrosion is affected by moisture and ambient temperature, as well as steel corrosion resistance from which the tank is made of. The main cause of oil products losses is evaporation - a sharp disparity between the properties of petroleum products, equipment and tanks construction.

The type of corrosive destruction of the inner surface of the roof, as well as of the upper part of the wall, is the contact with the vapor-air mixture, which contains a large number of different aggressive components. When using breathing valves, this inevitably leads to the moist air ingress into the reservoir, which can lead to corrosion. In the same way, metal can deteriorate because of the sulfuric air emissions of the stored substance. Corrosion eventually results from condensation, which appears after the effects of fumes on the inside of the roof and all open elements inside the tank. The intensity of corrosion processes in this case depends on the stored petroleum product, as well as on air humidity and composition, which is sucked into the tank through the branch pipes in the roof. Today, a large number of technical roofing solutions are known for steel vertical tanks, which have proven themselves in the process of operation in different ways. Depending on the location and conditions of reservoirs, various methods and techniques for assembling and installing roofs can be used.

2 Materials and methods

The tank roof, which is in constant contact with vapor-air mixture, can be protected only with the help of special expensive coatings, the application of which presents considerable technological complexity and requires periodic recovery. Moreover, when designing the construction, elements thickness required by the calculation should be increased by the amount of allowance for corrosion. [6] In general, in order to reduce corrosion damage risk of metal structures that are capable of damaging the tank, a system of measures should be provided, including the application of protective coatings and (or) increasing the thickness of steel structures sheets of tank (allowances for corrosion), which take into account the possible loss of elements thickness due to corrosion. At the same time, the minimum thickness of elements made of carbon steel is 5 - 6 mm, excluding the allowance for corrosion (Table 1). The value of the allowance for corrosion is established on the basis of the rate of metal structures corrosion damage, which is determined by the degree of medium aggressiveness:

Table 1. Nominal thicknesses of structural elements of frame roofs.

Constructive element	Nominal thicknesses of elements, mm	
	with the bottom frame	with the upper frame
Frame - Carbon steel - Stainless steel	 4,0+Δ*tcr* 3,0	 4,0 3,0
Roof decking: - Carbon steel - Stainless steel	 4,0+Δ*tcr* 1,5	 4,0 2,0
Note: Δtcr - allowance for corrosion of roof elements.		

Thus, there is a necessity to use cross-sections more than it is required by calculation, which significantly increases structure weight and its cost. If the roof is designed with the upper frame arrangement relative to the deck, the corrosion allowance can be ignored. Such design is a non-standard solution for Russian tank building and provides increased corrosion resistance of the roof by creating a smooth internal surface on the side of the stored product and its vapors [7]. When using stainless steel (for example, 12H18N10T) as a deck instead of carbon steel 09G2C, traditionally used for the tanks construction, the thickness can be significantly reduced [8]. This structure consists of a central panel, a deck 1, a tie-bar 3, radial shields with radial beams of rigidity 2, which are connected together by ring stiffeners 4. The ring stiffeners and the deck are located with a gap in relation to each other and are interconnected by means of discrete vertical connections with overlays. U-shaped brackets are attached to the ends of the radial beams, which, when mounted, are fixed on the central panel with the help of bolted connections. The other ends of the radial beams of adjacent radial shields are joined together in the area of their attachment to the tie-bar through the sheet element (Figure 2). The deck can be made of stainless steel, and the remaining parts are made of carbon steel.

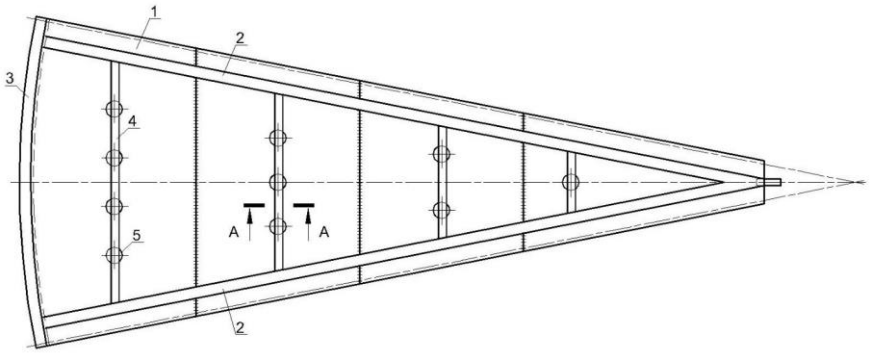

Fig. 2. Radial panel.

The tie bar of the fixed roof consists of the parts included in the design of the radial panels and the tie bars inserts that connect the tie bars parts to the assembly during installation.

When assembling the fixed roof of the tank, the overlapping radial joint of the decks, adjacent radial panels and the connection of the radial beams with the ring inserts, which are the continuation of the ring stiffeners, are welded. In the joints of the radial panels with the central panel, between the radial angles of the radial beams, the U-shaped brackets are fixed, which are fixed during the installation with bolted connections through oval holes with radial bosses on the central panel. Radial beams of stiffness of adjacent radial panels are connected by their ends to each other in the zone of fastening of these ends to the tie bar by means of a sheet element, the first and second parts of which are welded to the corresponding horizontal shelves of the radial strength bars, and the third part is welded to the corresponding sides of the vertical shelves of the beams (Figure 3).

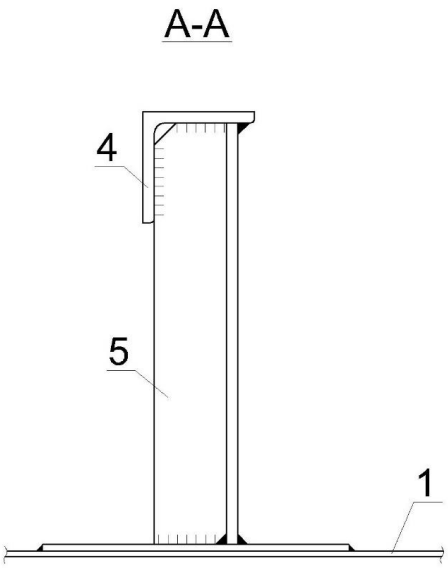

Fig. 3. Section A-A.

3 Conclusions

Corrosion not only reduces the service life of the tank equipment, but also directly affects industrial safety during its operation. Its impact inside and outside the roof leads to expensive repairs and long downtime. The given fixed tank roof, aggressive liquids vapor come into contact mainly with the deck and with the inner side of the elements of the central panel. Thus, the corrosion resistance and durability of the fixed roof of the tank is ensured. The structural design of the attachment points of the radial beams of stiffness to the central panel and to the tie bar provides higher reliability of the fixed roof due to the increase in rigidity of the attachment points. Moreover, the inspection of the structure is facilitated (there is no need to stop the technological process), and, if necessary, the strengthening measures are simplified.

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