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ANALYSIS OF THE ACCURACY, STIFFNESS, AND STABILITY OF ANTENNAS USING SIMULATION MODELING

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Abstract. *In the course of the work, the process of forming reflective shells and finding the position of grid elements after deformation was investigated. Fixation of the mesh nodes by the method of electric arc spraying. After that, a composite material such as polystyrene is applied to form reflective shells. The result of the work is the formation of the antenna array shell by electric arc spraying and the application of the composite material. Schematic of the mirror structure: spherical and cylindrical shells docked with a ring. The shell for the ring is a kind of elastic base that prevents its movement. The effect of the shell when considering the motion of the ring under the action of pulse pressure is taken into account by introducing contact forces of interaction, which are determined when solving the corresponding contact problems of the mating. The assessment of the stiffness-strength characteristics of antennas of solid and reinforced structures is graphically presented, and their stress-strain state is calculated under the action of wind load and gravity. The presented research examines offset antennas with the aim of unlocking their potential and improving their application in modern radio engineering systems. In the context of constant technological development and the growing need for communication, offset antennas are coming to the fore as an effective and innovative solution. The paper deals with the problem of local stability under load. It is important to study the corresponding problems under the influence of an edge dynamic load arising from vibrations of the antenna mirror and transmitted from the base. The dynamic stability of a mirror as a spherical segment bonded to a ring is investigated. For the sake of consistency, we assume that a cylindrical shell of finite length is attached to this ring (the case when the antenna mirror is made in the form of only one spherical shell will be treated as a special case). The presence of a cylindrical shell is associated with a design solution to protect the antenna from external influences, such as an incoming flow. The motion that occurs after the application of the pulse consists of axisymmetric vibrations and bending vibrations associated with the inevitable deviations of the pulse from a uniform one.*

Key words: *electric arc spraying, mesh, reinforced composite material, punch, mirror, antenna.*

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1. INTRODUCTION

The production of antenna systems and the manufacture of reflective surfaces is based on new technological and design ideas, the implementation of which requires appropriate scientific and technical support, and is possible in close cooperation between production and scientific potential. The technology of manufacturing mesh material shells can be used to produce axisymmetric and non-axisymmetric reflectors or individual elements of mirror antennas [1].

The paper considers the method of electric arc spraying for the production of antenna systems and the manufacture of reflective surfaces based on new technological and design ideas. The process of shell formation from mesh material is investigated. The complexity of describing the deformation process lies in the fact that the mesh behaves qualitatively differently when deformed than a sheet of solid material. This is due to its structure, in particular, the ability to rotate mutually perpendicular mesh wires relative to each other at the nodes. The design, production, and development of the mesh was carried out by scientists from Ukraine and abroad, which is reflected in [2, 3]. In Ukraine, production was carried out by the Saturn and Promin enterprises. As well as well-known foreign companies such as Siemens and Andrew.

The presented research examines offset antennas with the aim of unlocking their potential and improving their application in modern radio engineering systems.

In the context of continuous technological development and the growing need for communication, offset antennas are coming to the forefront as an effective and innovative solution.

Thanks to intensive research and development, offset antennas have gained significant recognition in the world of radio engineering in recent years. Their efficiency and unique characteristics have been thoroughly examined and researched, opening up wide prospects for their practical application to improve communication systems and ensure signal stability in a variety of environments. Offset antennas, which emerged as a response to the requirements of rapidly changing radio communications environments, play a key role in modern data transmission systems.

They have a high level of signal directivity and provide stable communication even in difficult weather conditions and electromagnetic interference. Confirmed results of experiments and practical applications show high reliability and stability of offset antennas even in critical conditions, which makes them promising for use in a variety of areas, from telecommunications and satellite communications to military equipment and scientific research.

The paper deals with the problem of local stability under load. It is important to study the corresponding problems under the influence of an edge dynamic load arising from vibrations of the antenna mirror and transmitted from the base.

The dynamic stability of a mirror as a spherical segment bonded to a ring is investigated. For the sake of consistency, we assume that a cylindrical shell of finite length is attached to this ring (the case when the antenna mirror is made in the form of only one spherical shell is treated as a special case).

The presence of a cylindrical shell is associated with a design solution to protect the antenna from external influences, such as an incoming flow. The motion that occurs after the application of the pulse consists of axisymmetric vibrations and bending vibrations associated with the inevitable deviations of the pulse from a uniform one.

2. EXPERIMENTAL METHODS

The main design and technological ideas that are implemented in antenna systems are: preservation of the basic principles of aviation technologies in the production of antennas and with the exclusion of technological processes of the influence of subjective factors on product quality; optimization of structures according to the criteria of stiffness-accuracy-mass; use without slipway assembly and adjustment of antennas at facilities; use of vector diffraction methods in optimizing the electrodynamic characteristics of the antenna system at the design stage [4]; position control system

Selecting the type of antenna. Let's consider the main possible types of antennas and identify their advantages and disadvantages.

Let's take a closer look at the most suitable type of antenna for radar – a single-mirror parabolic antenna. Mirrored parabolic antennas can be prime focus and offset.

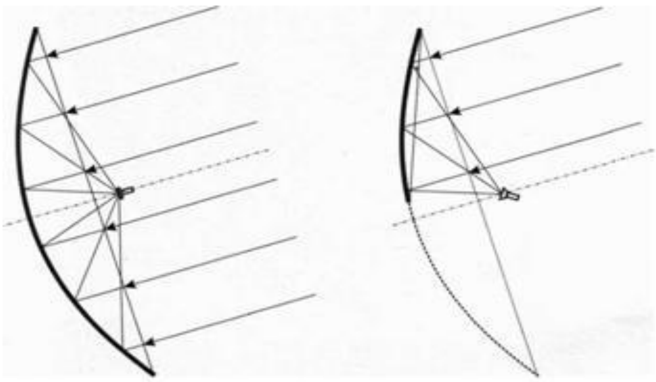
Direct-focus antennas are also called axisymmetric antennas. The mirror of a direct-focus antenna is a paraboloid of rotation, the antenna is round, its geometric axis coincides with the electrical axis. The converter is placed on the same axis, which is usually attached to the edges of the reflector with three or four racks.

An offset antenna is a cutout of a paraboloid. As a rule, the notch is formed by the intersection of a paraboloid and a cylinder, the axes of which are parallel. Thus, the mirror of the offset antenna has the shape of an ellipse, and the direction of the electric axis of the antenna differs from the direction of the geometric axis of the mirror by a certain angle. As a rule, the electric axis is 20...30 degrees higher than the geometric axis [6].

The geometry of the direct-focus and offset antennas is shown in Fig. 1.

Both antennas have their advantages and disadvantages. A direct-focus antenna uses the mirror area more efficiently. An offset antenna has the same effective area as a direct-focus antenna with a diameter equal to the size of the offset antenna along the minor axis. In other words, to get the effective area of an offset antenna, you need to multiply its physical area by the cosine of the angle between the electrical and geometric axes. In typical antennas, the physical area is utilized by 86–90%.

On the other hand, in a direct-focus antenna, part of the surface is obscured by the converter and its mounting elements, while in an offset antenna it is not. Therefore, antennas of small diameter, up to 1.5 meters, in which the converter can cover more than 10% of the area, are usually made offset, and large antennas are more often direct-focus [7].



(1) (2)

Figure 1. Geometry of direct-focus (1) and offset antennas (2)

Figure 2. Exterior view of a direct-focus parabolic antenna

Since the diameter of the antenna will be more than 1.5 m to ensure a given gain, and the converter will not cover more than 10% of the antenna area, we will choose a single-mirror parabolic antenna type – direct-focus.

Parabolic antennas have recently been increasingly used in space and radio relay communication lines. In 1888, the famous German physicist H. Hertz first used a parabolic cylinder as a focusing device in his experiments in microwave optics.

Mirrored parabolic antennas are the most common type of directional antennas in the centimeter, decimeter, and partially meter wave bands [8, 9].

The widespread use of mirror antennas is explained by the simplicity and lightness of the design, the ability to form a wide variety of radiation patterns, high efficiency, low noise temperature, and a large frequency overlap. Some types of mirror antennas can provide a fairly fast beam swing in a significant sector of angles.

Mirrored antennas are also the most common type of antenna in space communications and radio astronomy, and it is with the help of mirrored antennas that giant antenna systems with an effective surface area measured in thousands of square meters are currently being implemented.

The appearance of the design of the direct-focus parabolic antenna is shown in Fig. 2.

The main elements of a parabolic antenna are a metal reflector (mirror) having the shape of one of the parabolic surfaces, an irradiator with mounting elements placed in the focus of such a surface, and a feeder F (Fig. 3).

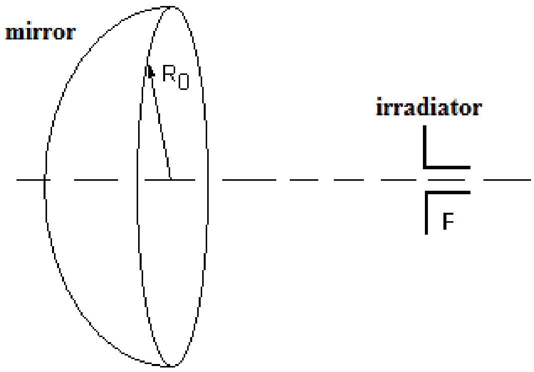


Figure 3. Rotational paraboloid excited by a weakly directed irradiator

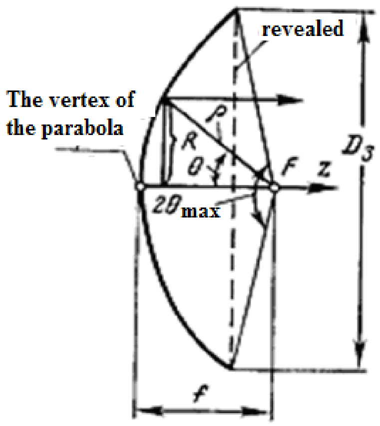


Figure 4. Parabolic antenna opening

The rotational paraboloid is excited by a weakly directed irradiator (e.g., a horn) placed in focus and converts the spherical wavefront into a flat one. The antenna's irradiator is designed so that almost all of the energy it emits is directed toward the reflector. Upon reaching the reflector, the electromagnetic waves excite high-frequency currents on its surface, which create their own electromagnetic fields.

Parabolic antennas utilize the optical properties of radio waves. The geometric properties of the parabola are such that the rays directed from the focus and reflected from the parabola become parallel to the parabola axis (Fig. 4), so that the path length from the focus to the parabola and then to the opening line passing through the parabola edges is the same for any angle.

Thus, an in-phase surface is formed in the opening of the parabolic antenna and the antenna radiation is sharply directed [10].

In the Cartesian coordinate system, the paraboloid of rotation is defined by the equation (the origin coincides with the vertex of the paraboloid) $x^2 + y^2 = 4fz$.

The diameter of the opening of the paraboloid D_3 and its focal length f are related by the relation [11]:

$$D_3 = 4f \cdot tg\left(\frac{\theta_{\max}}{2}\right),$$

where $2 \cdot \theta_{\max}$ – is the opening angle of the paraboloid (Fig. 4).

Selecting the type of mirror, irradiator, and pathway that channels energy to the irradiator.

Firstly, as mentioned above, since the antenna diameter will be larger than 1.5 m to ensure the specified gain, and the converter will not cover more than 10% of the antenna area, we will choose a single-mirror parabolic antenna type – direct-focus.

Second, the operating frequency of the antenna is $f_p = 3,6GGz$ (wavelength $\lambda = c / f = 83,33mm$). Thus, it is better to use a rectangular waveguide with a transition to a coaxial one as a feeder path, since circular waveguides are not used due to their polarization instability [12].

Thirdly, it is necessary to obtain a radiation pattern (RP) in which the width of the main lobe at half-power is equal in the E- and H-planes and is characterized by a high degree of directivity, i.e., a needle-shaped RP. Therefore, a paraboloid of rotation should be chosen as a mirror, which is easier to manufacture than a parabolic cylinder. At the same time, the antenna irradiator should have a DS in the form of a body of rotation and the ability to connect to the waveguide path.

In this case, a waveguide-horn irradiator will be the best, due to its simple design, relative ease of obtaining the desired DS shape and good range. The easiest way to ensure the same DS in both planes is to use an irradiator in the form of an open end of a circular waveguide with a conical horn placed at its end. However, in this case, a smooth or stepwise transition from a rectangular waveguide to a circular one will be necessary, which is performed in the immediate vicinity of the horn. To preserve the symmetry of the field distribution in the opening, we will use a supporting rod in the design, it is a copy of the feeder path and is symmetrical to it relative to the paraboloid axis, while increasing the strength of the irradiator mounting.

Another option for obtaining an irradiator DS that is the same in both planes is to use a pyramidal horn with carefully selected dimensions of the sides of the rectangular opening. In this case, no transition is required. But the selection of such dimensions is a very difficult task.

It is also necessary to ensure a low level of the side lobes $q = -20dB$. This requirement will be realized by selecting a certain radius of the antenna mirror opening, which will be obtained during the calculation.

A satellite antenna is a mirror antenna for receiving (or transmitting) a signal from an artificial Earth satellite.

The most common satellite antennas are parabolic antennas (commonly referred to as satellite dishes). Satellite antennas come in different types and sizes. Most often in the world, such antennas are used to receive and transmit satellite television and radio programs, as well as to connect to the Internet.

Types of satellite dishes.

Mirrored parabolic antennas are available in prime focus and offset versions. Direct-focus antennas are also called axisymmetric. A direct-focus (axisymmetric) antenna A direct-focus (axisymmetric) antenna is an antenna with an aperture in the form of a paraboloid of rotation. The mirror of a direct-focus antenna is a paraboloid of rotation, the antenna is round, its geometric axis coincides with the electric axis. The converter is placed on the same axis, which is usually attached to the edges of the reflector with three or four racks. The diameter of the antenna determines its gain and, accordingly, the stability of satellite signal reception. Depending on the geostationary satellite used, the diameters of the receiving antennas can range from 0.55 m to 3.7 m. Typically, such antennas are used to receive signals in the C-band and Ku-band. Parabolic antennas are also used to transmit signals to satellites. Low-noise amplifiers (LNAs) with low noise levels and converters are connected to the irradiators of satellite antennas, which allows amplifying high-frequency signals directly after the irradiators and converting them into intermediate frequency signals. The intermediate frequency signals are transmitted through cables connected to converters for further amplification and detection [13].

Offset antenna.

The offset antenna is the most common in individual satellite television reception, although other principles of construction of terrestrial satellite dishes are currently used. An offset antenna is an asymmetric notch from a paraboloid of rotation with an irradiator in the focus of the paraboloid.As a rule, the notch is formed by the intersection of a paraboloid and a cylinder, the axes of which are parallel. Thus, the mirror of the offset antenna is elliptical in shape, and the direction of the electric axis of the antenna differs from the direction of the geometric axis of the mirror by a certain angle. As a rule, the electric axis is 20–30 degrees higher than the geometric axis. This eliminates shadowing of the antenna's useful area by the irradiator and its resistances, which increases its efficiency with the same mirror area as an axisymmetric antenna. In addition, the irradiator is installed below the center of gravity of the antenna, thereby increasing its stability under wind loads. The mirror of the offset antenna is mounted almost vertically. Depending on the geographical latitude, its angle of inclination varies slightly. This position eliminates the accumulation of precipitation in the antenna bowl, which greatly affects the reception quality. The antenna is not a circle, but an ellipse elongated vertically. The dimensions of an offset antenna are usually given in terms of gain in relation to a direct-focus antenna. If this size is the same horizontally, then it will be approximately 10% larger vertically [14].

Typically, offset antennas are used to receive C- and Ku-band signals (in linear and circular polarization). However, it is also possible to receive signals in the Ka-band, as well as combined signals.

Both antennas have their advantages and disadvantages. A direct-focus antenna uses the mirror area more efficiently. An offset antenna has the same effective area as a direct-focus antenna with a diameter equal to the size of the offset antenna along the minor axis. In other words, to get the effective area of an offset antenna, you need to multiply its physical area by the cosine of the angle between the electrical and geometric axes. In typical antennas, the physical area is utilized by 86–90%. On the other hand, in a direct-focus antenna, part of the surface is obscured by the converter and its mounting elements, while in an offset antenna it is not. Therefore, antennas of small diameter, up to 1.5 meters, in which the converter can cover more than 10% of the area, are usually made offset, and large antennas are more often direct-focus.

A direct-focus antenna is always raised to a certain positive angle, so it is a «bowl» in which precipitation – rain, snow, ice – can accumulate. Offset antennas in the northern latitudes are installed almost vertically, or even «look down» – so they do not have this disadvantage. On the other hand, on a direct-focus antenna, the converter will «soak» down, so you can safely use an irradiator with a leaky cover or without a cover at all, water and snow will not get inside. On an offset antenna, the converter «looks» up, so it must be sealed, otherwise water will get inside and can damage the converter electronics [15].

There is one more peculiarity of using large diameter offset antennas in the northern latitudes – they cannot always be lowered to a small enough angle of elevation. For example, if the angle of the satellite is 5 degrees, the antenna mirror must be pointed 15–25 degrees below the horizon. Offset antennas of large diameters, which are installed on a vertical stand, for example, «Supral» 1.8 m or 2.4 m, can be lowered to an angle of less than 11–12 degrees, the lower edge of the antenna rests against the stand. You can get out of the situation by turning the antenna mirror together with the irradiator mount 180 degrees, then the electrical axis will be 25–27 degrees below the geometric axis, and the antenna will need to be directed above the satellite. However, this would require serious modification of the mounting parts.

For the manufacture of satellite dishes, steel and duralumin are mainly used. Fans of satellite TV sometimes install a motorized suspension (motor), or positioner. With the help of an actuator and at the user's command (or a command from the tuner), it allows you to turn the antenna to the position of the satellite you need.

The presented research examines offset antennas with the aim of unlocking their potential and improving their application in modern radio engineering systems.

In the context of continuous technological development and the growing need for communication, offset antennas are coming to the forefront as an effective and innovative solution.

Thanks to intensive research and development, offset antennas have gained significant recognition in the world of radio engineering in recent years. Their efficiency and unique characteristics have been carefully considered and studied, which opens up wide prospects for their practical application to improve communication systems and ensure signal stability in various conditions [16].

Offset antennas, which emerged as a response to the demands of rapidly changing radio communications environments, play a key role in modern data transmission systems. They have a high level of signal directivity and provide stable communication even in difficult weather conditions and electromagnetic interference. In addition, their design reduces the impact of signal distortion, making them particularly effective in the high-frequency range. Confirmed results of experiments and practical applications show high reliability and stability of offset antennas even in critical conditions, which makes them promising for use in a variety of fields, from telecommunications and satellite communications to military equipment and scientific research.

Figure 5. Offset antenna

Offset antennas are a popular option for satellite dishes. They consist of a reflector element (usually parabolic in shape) and a support structure. However, their peculiarity lies in the fact that the antenna orientation is achieved by shifting the support structure (hence the name «offset», since the reflected subsurface of the antenna is shifted relative to the center of the parabola).

The basic principles of offset antennas are based on the focusing technique. The signal from the satellite is directed to the reflector element and then reflected towards the support structure, where the antenna concentrator (usually a lens or cone head) is placed, which collects the signal and transmits it further to the receiver or converter for processing.

Offset antennas have several advantages, such as less vulnerability to signal loss from microwave interference, better weather protection, and the ability to locate the receiver in the center of the antenna, which facilitates installation and maintenance.

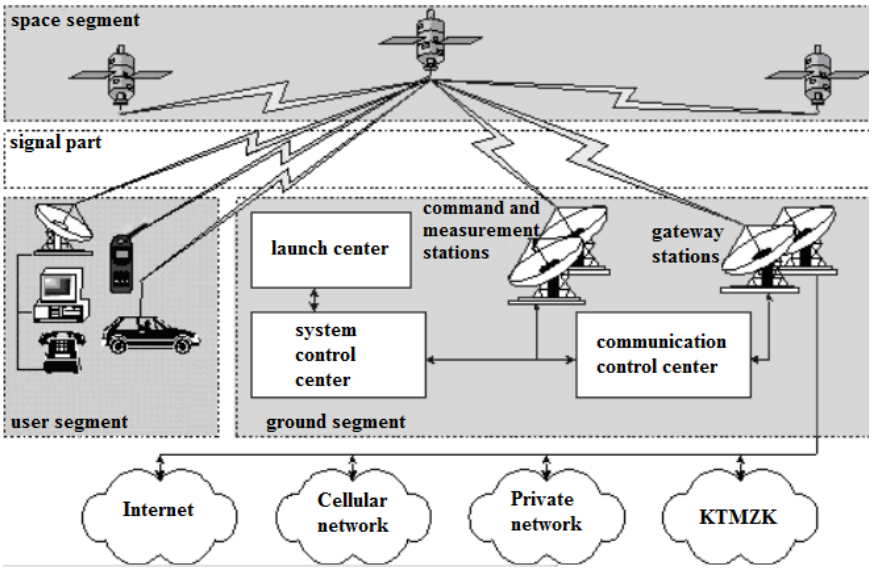


Figure 6. Principles of communication and use of antenna systems

Offset antennas are used in a variety of applications such as satellite communications, television broadcasting, mobile communications, etc. They offer better efficiency and signal quality than traditional antennas, especially in demanding communication environments.

In the study of the dynamic stability of an antenna mirror in the form of a spherical segment, which is bonded to a ring, the design is considered taking into account various factors and parameters. To harmonize solutions, the concept of a cylindrical shell attached to the ring as an elastic base is considered. This allows us to take into account design features such as protection from external influences.

We analyze axisymmetric and bending vibration forms and their interaction, taking into account possible motion instabilities. We use numerical analysis to assess the influence of various parameters on the dynamic stability of the structure.

Please note that the inertia of shells and aggregates is usually not taken into account, but can be an important factor for accurate analysis. In particular, it can affect the results of the study.

The conclusion is that the dynamic stability of the antenna mirror can be effectively studied and understood if various factors and design parameters are considered.

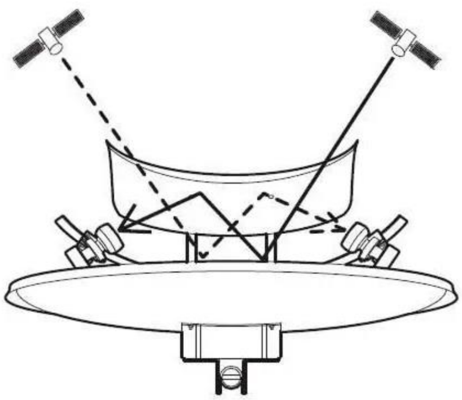


Figure 7. Toroidal satellite dual-mirror antenna

An offset antenna has several advantages over other types of antennas that can be considered in stiffness, wind loads, and radio performance. Here are some of them:

1) Stiffness. The offset antenna has a more rigid design, since the main part of the antenna (reflector) is located on the side of the emitter (feeder). This reduces deformations caused by high wind loads or mechanical stress;

2) Wind loads. An offset antenna has less wind resistance because its reflector is located behind the main structure. This reduces the effect of wind on the antenna, which can be important in regions with high wind speeds or at high altitudes.

3) Radio engineering loads. Offset antennas can have better radio engineering characteristics, such as better signal focusing and less interference between antennas. This can improve the quality of signal reception and transmission.

Despite these advantages, other factors such as cost, complexity of installation and maintenance, as well as the requirements for tuning and solving problems that may arise when using a particular type of antenna should also be considered.

In this study, we focus on the effective use of electric arc spraying technology to create a reinforced material. This method, which allows for the application of thin layers of material to a variety of surfaces, has great potential in a variety of industries, from industry to construction to telecommunications. The use of electric arc spraying opens up opportunities for improving strength, corrosion protection and other negative effects on materials subjected to high loads, including wind. In our study, we investigate the specific effect of electric arc spraying on reinforced material under wind loads and consider the possibilities of using it to create stable and reliable structures [18].

After the coating is applied to the surface, a cooling process takes place during which the material is fixed to the surface. Additional processes such as heat treatment or ultrasonic treatment are usually used to achieve maximum coating strength.

Wind loads can affect the reinforced material produced by electric arc spraying, especially in the case of structures that are used in open spaces, such as outdoors or at height. Such structures can include masts, antennas, towers, and other elements used in telecommunications systems, power transmission, or in the construction of buildings.

Wind loads can create forces that lead to deformation or failure of structures. Reinforced material applied by electric arc spraying can act as a protective layer to help reduce the impact of wind loads on the base material of the structure [19].

The complexity of manufacturing an offset antenna is determined by several factors:

1) Geometry and design. An offset antenna consists of a main parabolic part, which is usually complex in shape, and a feed horn, which directs the signal to the dielectric focus of the antenna. The manufacturing of both parts requires precision and care to ensure that the antenna functions properly.

2) Materials. Special materials with high precision and low signal loss, such as high quality metal or composite materials, are often used to make an offset antenna. Processing these materials may require specialized technology and equipment.

3) Assemble and adjust. After the individual components of the antenna are manufactured, they need to be assembled and properly tuned. This includes precise positioning of the feed horn relative to the parabolic part, as well as adjusting the antenna's directional angle.

4) Calibration. After assembling the antenna, it is important to calibrate it to ensure that the antenna is working properly and has the desired radiation pattern and gain characteristics.

5) Precision and quality control. The production of offset antennas requires high precision and quality control at every stage of production to avoid defects and ensure proper operation of the antenna.

The complexity of calculating an offset antenna lies in taking into account additional parameters that traditional parabolic antennas do not have.

An offset antenna has a more complex geometry because the focus of the parabola is offset from the center of the antenna. This creates a deviation in the beam direction that needs to be taken into account in the calculations to properly direct the signal.

An offset antenna has additional components, such as a feed horn, that affect the antenna characteristics, such as the radiation pattern and gain. Calculations must take into account the interaction between these components.

When calculating, you need to take into account possible manufacturing and installation errors, such as incorrect positioning of the antenna components or mismatch of material parameters.

An offset antenna may have deviations from an ideal antenna due to the focusing of the signal on the outgoing element. This may require complex calculations and modeling to determine the exact characteristics of the antenna.

Consideration of electromagnetic properties: Offset antenna calculations include consideration of the electromagnetic properties of the materials and antenna shape, such as signal loss, radiation pattern, and directional characteristics.

These aspects are taken into account in the calculation of offset antennas nsure their proper operation and optimal performance. Such calculations may require the use of specialized software and tools for modeling and analyzing electromagnetic systems [20].

3. ANALYSIS OF ANTENNA ACCURACY, STIFFNESS, AND STABILITY USING SIMULATION MODELING

In this study, we focus on the effective use of electric arc spraying technology to create a reinforced material. This method, which allows for the application of thin layers of material to a variety of surfaces, has great potential in a variety of industries, from industry to construction to telecommunications.

The main stages of electric arc spraying are surface preparation, material preparation, electric arc, spraying, cooling, and fixing. The surface to be coated must be thoroughly prepared: cleaned of dirt, oil, rust and other contaminants, and may require grinding or other operations to improve the adhesion of the coating to the surface. The material to be applied is usually supplied in the form of wire or powder. It is melted in an electric arc to a very high temperature.

The arc generates a very high temperature that melts the material and turns it into a liquid chip. The molten material is sprayed onto the prepared surface using a gas jet (usually argon or air). Upon contact with the surface, it quickly solidifies and forms a thin coating. After the coating is applied, the surface undergoes a cooling process, during which the material is fixed to the surface. Additional processes such as heat treatment or ultrasonic treatment are usually used to achieve maximum coating strength.

Wind loads can affect the reinforced material produced by electric arc spraying, especially in the case of structures that are used in open spaces, such as outdoors or at height. Such structures can include masts, antennas, towers, and other elements used in telecommunications systems, power transmission, or in the construction of buildings.

Wind loads can create forces that lead to deformation or failure of structures. Reinforced material applied by electric arc spraying can act as a protective layer to help reduce the impact of wind loads on the base material of the structure.

When calculating, it is necessary to take into account possible manufacturing and installation errors, such as incorrect positioning of the antenna components or mismatch of material parameters. The offset antenna is shown in Figure 8.

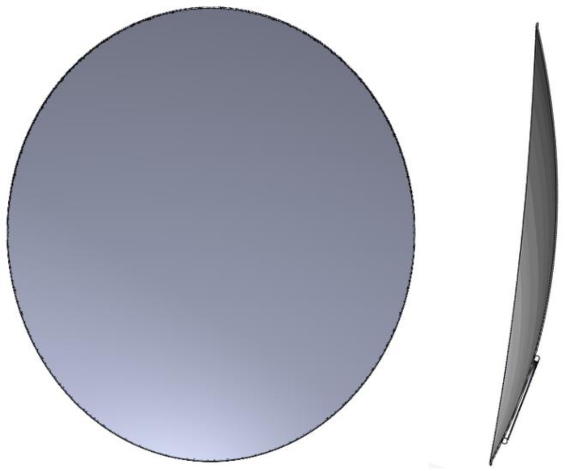


Figure 8. Offset aluminum antenna with a thickness of 2 mm (front view and side view in section)

Figure 9. Offset composite antenna with a thickness of 2 mm (general view of the antenna structure

An offset antenna may have deviations from an ideal antenna due to the focusing of the signal on the feed element. This may require complex calculations and modeling to determine the exact characteristics of the antenna.

This study proved that the production of offset antennas by electric arc spraying and plastic deposition using a two-layer method is not inferior in terms of rigidity and stability compared to other production methods Fig. 9. Electric arc spraying allows for a high quality coating that meets the requirements for efficient operation of antennas in various operating conditions [21].

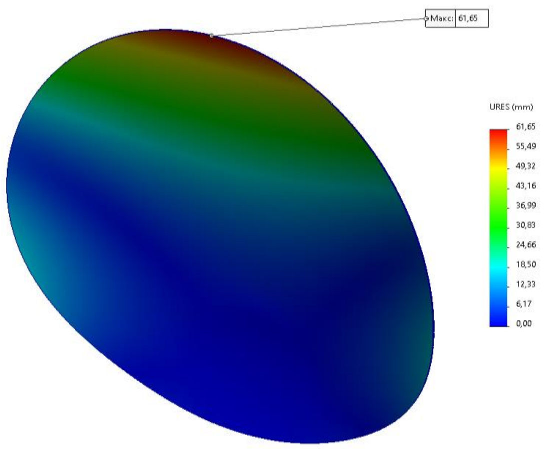


Figure 10. Displacement diagram

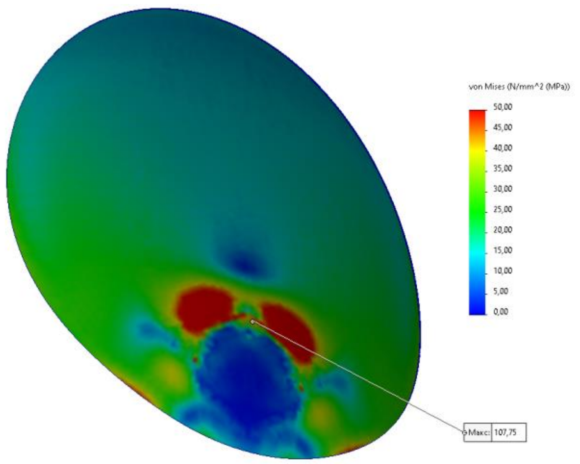


Figure 11. Stress diagram

According to the results of the analysis of the stress-strain state of the two variants of the offset antenna design, it was found that the safety factor for the offset antenna of the proposed design is 5.7 times less than that of the antenna of the basic design, but greater than the minimum allowable safety factor of 1.5 for such designs; the normal stresses for the offset antenna of the proposed design are 4.5 times greater than those of the antenna of the basic design and amount to ≈ 108 MPa; the maximum displacements of the upper edge of the offset antenna of the proposed design are 20 times larger than those of the antenna of the basic design and amount to ≈ 62 mm, which completely prevents the normal operation of the antenna under the considered conditions (wind speed of 20 m/s) [22]. The results can be seen in Figures 10–12.

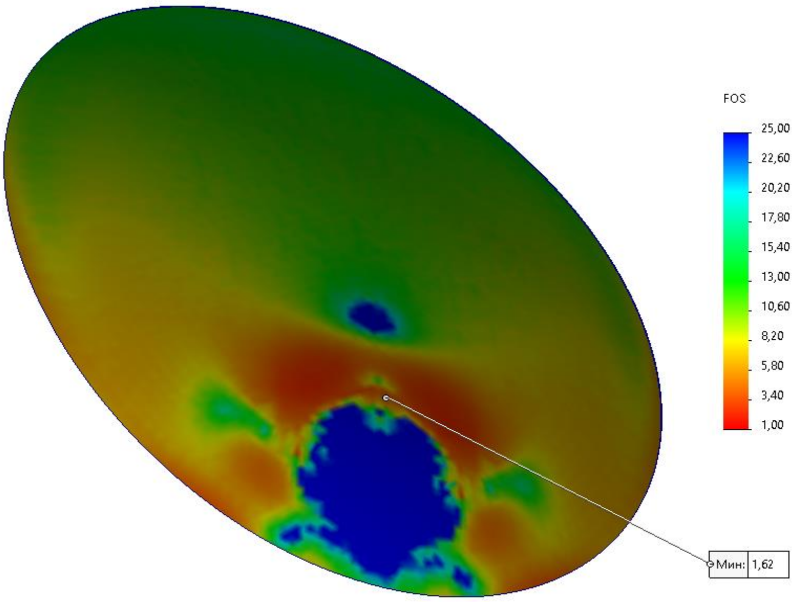


Figure 12. Safety factor diagram

Thus, these results indicate the prospects of using electric arc spraying and two-layer plastic deposition in the production of offset antennas and confirm it as an efficient and competitive process.

4. CONCLUSIONS

This study proved that the production of offset antennas by electric arc spraying and two-layer plastic application is not inferior in terms of rigidity and durability compared to other production methods. Electric arc spraying allows to provide a high quality coating that meets the requirements for efficient operation of antennas in various operating conditions. Thus, these results indicate the prospects of using electric arc spraying and two-layer plastic deposition in the production of offset antennas and confirm it as an effective and competitive process.

Offset antennas are a type of parabolic antenna where the feed (or feed horn) is located offset from the center of the parabola. This creates several advantages and disadvantages compared to traditional parabolic antennas. The advantages of offset antennas include: lower distortion. The offset design reduces signal blockage that can occur from the antenna itself.

Reduced signal loss: The majority of the parabola remains free of blockage, which reduces signal loss. Compact design: The offset antenna can be more compact because it does not require a large free space under the parabola to install the feeder.

However, there are also disadvantages: complexity of manufacturing and calculations. Offset antennas can be more difficult to manufacture and calculate due to their more complex geometry and additional components.

Need for precise installation: Due to the offset design, the antenna needs precise installation and calibration to ensure proper operation.

Consequently, offset antennas can be attractive in applications where compactness is important, and where large parabolic antennas may have signal distortion issues. However, their complexity in manufacturing and installation may be a factor to consider when choosing an antenna system.

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АНАЛІЗ ТОЧНОСТІ, ЖОРСТКОСТІ ТА СТІЙКОСТІ АНТЕН З ДОПОМОГОЮ ІМІТАЦІЙНОГО МОДЕЛЮВАННЯ

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Резюме. *Досліджено процес утворення відбиваючих оболонок, знаходження положення елементів сітки після деформування. Фіксація вузлів сітки методом електродугового напилення. Після цього відбувається нанесення композиційного матеріалу типу полістирол для утворення відбиваючих оболонок. Результатом роботи є утворення оболонки антенної решітки методом електродугового напилення та нанесення композиційного матеріалу. Схема конструкції дзеркала: сферична та циліндрична оболонки, стиковані з кільцем. Оболонка для кільця є деякою пружною основою, що перешкоджає його руху. Вплив оболонки при розгляді руху кільця під дією імпульсного тиску враховується запровадженням контактних зусиль взаємодії, що визначаються під час вирішення відповідних контактних завдань сполучення. Графічно представлено оцінювання жорсткістно – міцнісних характеристик антен суцільної та армованої конструкції, проведено розрахунок їх напружено-деформованого стану при дії вітрового навантаження та сили земного тяжіння. Розглянуто офсетні антени з метою розкриття їх потенціалу та вдосконалення їхнього застосування в сучасних радіотехнічних системах. В умовах постійного технологічного розвитку та зростаючої потреби у зв'язку, офсетні антени виходять на передній план як ефективне та інноваційне рішення. Розглянуто завдання локальної стійкості при навантаженні. Значним є вивчення відповідних завдань при впливі крайового динамічного навантаження, яке виникає при вібраціях дзеркала антени і передається від основи. Досліджено динамічну стійкість дзеркала як сферичного сегмента, скріпленого з кільцем. З метою узгодження рішення вважаємо, що до цього кільця приєднано циліндричну оболонку кінцевої довжини (випадок, коли дзеркало антени виконано у вигляді лише однієї сферичної оболонки. Наявність циліндричної оболонки пов'язана з конструктивним рішенням щодо захисту антени від зовнішнього впливу, наприклад потоку, що набігає. Рух, що виникає після застосування імпульсу, складається з осесиметричних коливань і згинальних коливань, пов'язаних з неминучими відхиленнями імпульсу від рівномірного.*

Ключові слова: *електродугове напилення, сітка, армований композиційний матеріал, пуансон, дзеркало, антена.*

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