

HELICOPTER SCREW ROTATION INFLUENCE ON FORM DIRECTIONAL DIAGRAM ONBOARD ANTENNA

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Abstract—Based on the mathematical modeling systems such "standard antenna–helicopter fuselage" effects pulsation its directional diagram. Indicated causes pulsation and their features. Indicated effects, which may be result of pulsation directional diagram.

Index Terms—Helicopter; helicopter screw; screw blades; directional diagram; mathematical modeling diagram; diagram pulsation.

I. INTRODUCTION

The body helicopter on which the standard antenna and which contains metallic construction elements, it becomes an integral part of a complex antenna system. Main rotor helicopter is part of this system. Length of the main rotor blades is commensurate to overall dimensions helicopter. Therefore, periodic spatial change the provisions of the blades during rotation the main rotor is accompanied by pulsations directional diagram (DD) total antenna system. Antenna system at the same time gets parametric properties. Its general parameter that becomes dependent on time t , is effective height $h_e(t)$ [1]. A DD pulsation is a consequence of this circumstance – DD becomes a function of time. The frequency F_N and period T_N of pulsation DD in any spatial direction are related by ratio, Hz

$$F_N = \frac{1}{T_N} = \frac{n N}{60}, \quad (1)$$

where: n – the number of revolutions of the rotor main screw helicopter for one minute (several hundred), $N \geq 2$ – the number blades of the screw. In the ratio (1) $n/60$ is the frequency rotation main screw of the rotor, Hz.

Form space DD character and extent of its irregularity amplitude pulsation in different directions depending from the design features system "standard antenna – helicopter fuselage."

For a quantitative evaluation individual characteristics of the normalized DD recommended full-scale tests using reduced models of aircraft [2]. An effective alternative to these recommendations may be research DD antenna systems such as "standard antenna – helicopter fuselage" on their grid models or on models based on use finite element in software environment, for example, FEKO.

$$\bar{E}(t) = \frac{60 \pi I_A(t)}{r \lambda} \bar{l}(t). \quad (2)$$

A variety of types of helicopters, main screw constructions, types of antennas and their locations on the fuselage indicated individual features of DD. Therefore, to research the general features of DD use conditional construction helicopter, mesh model which you can build in a software environment FEKO (Fig. 1). Standard antenna – the vertical pin placed in anterior lower part fuselage. Spatial angles DD in azimuth φ and meridian θ planes are reckoned from the corresponding positive direction of the coordinate axis.

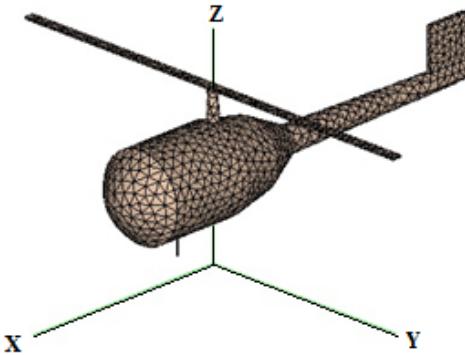


Fig. 1. Mesh model of the system "quarter wave pin antenna - fuselage helicopter"

Parameters F_N and T_N determine periodicity recovery geometric form system "standard antenna – body helicopter" relative to any spatial direction in boundaries angle between the main screw blades. The angular position $\Delta(t)$ of individual blades of the screw in the plane of rotation relative to, for example, the longitudinal axis of helicopter, at any point of time $t \leq \frac{T_n}{N} = \frac{60}{n}$ is determined considering (1):

$$\Delta(t) = 2\pi F_N t = 2\pi \frac{t}{T_N} \leq \frac{2\pi}{N}. \quad (2)$$

Ratio (2) indicates that the normalized DD for the chosen direction $[\theta, \varphi]$ becomes continuous periodic function of the angular position of the blade screw $\Delta(t)$, that is depends on the relative time $\frac{t}{T_n}$.

II. FORMULATION OF THE PROBLEM

Using the possibilities of mathematical modeling to detect the characteristics of DD pulsation antenna systems such as "quarter pin antenna – helicopter fuselage" with the type of uniaxial main screw.

1. Metal Screw, N = 2.

In Fig. 2 shows cross sections normalized DD in

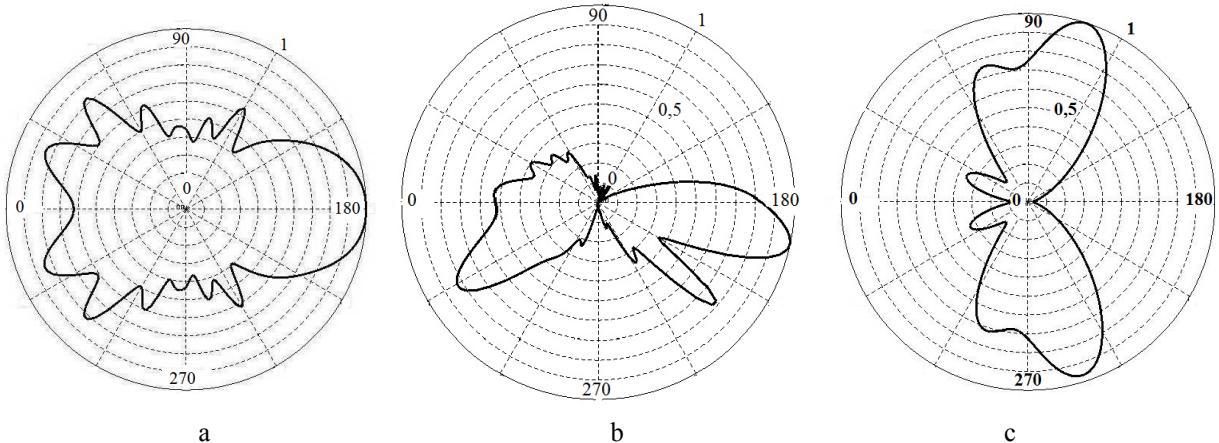


Fig. 2. Drawings DD sections: a in the plane $X0Y$; b in the plane $X0Z$; c in the plane $Y0Z$

Differences presented DD from the respective diagrams for separate vertical dipole (excitation frequency – 150 MHz) are obvious.

In Fig. 3 shows the DD pulsation in the plane $X0Y$ as dependencies $U\left(\frac{t}{T_n}\right)$ in directions several spatial

angles. Based on the expression (2) determine the range of relative time supervision periodic pulsations

$$0 \leq \frac{t}{T_n} \leq 0.5 .$$

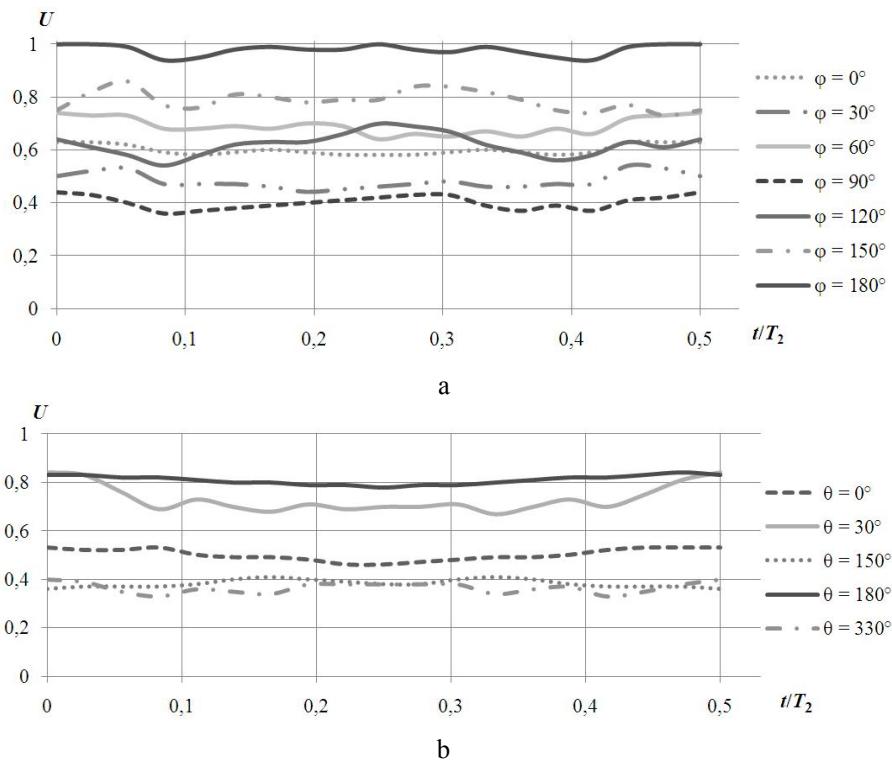


Fig. 3. Pulsations DD: a in the plane $X0Y$; b in the plane $X0Z$; c in the plane $Y0Z$

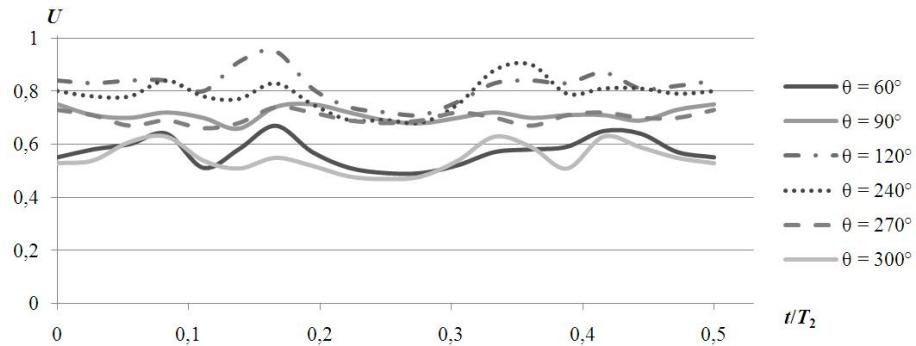


Fig. 3. Ending. (See also p. 20)

In periodicity interval T_2 for any spatial direction pulsation are continuous functions with the same initial and final values that fluctuate slowly over time. Pulsation is less pronounced in the plane $X0Z$, and more pronounced – in the plane $Y0Z$. Comparing DD, shown in Figs 2 and 3 for the same values spatial angles, find practical independence of the geometric form DD of the provisions main screw blades.

Note that the geometric form DD (Fig. 2) and by its uneven angular coordinates (Fig. 3) essentially depend from point installing standard antenna on the fuselage helicopter.

2. Screw from carbon, N = 2.

In a virtual helicopter, shown in Fig. 1, Two-bladed screw made from carbon (carbon fiber). Modeling DD indicates that its geometric forms in

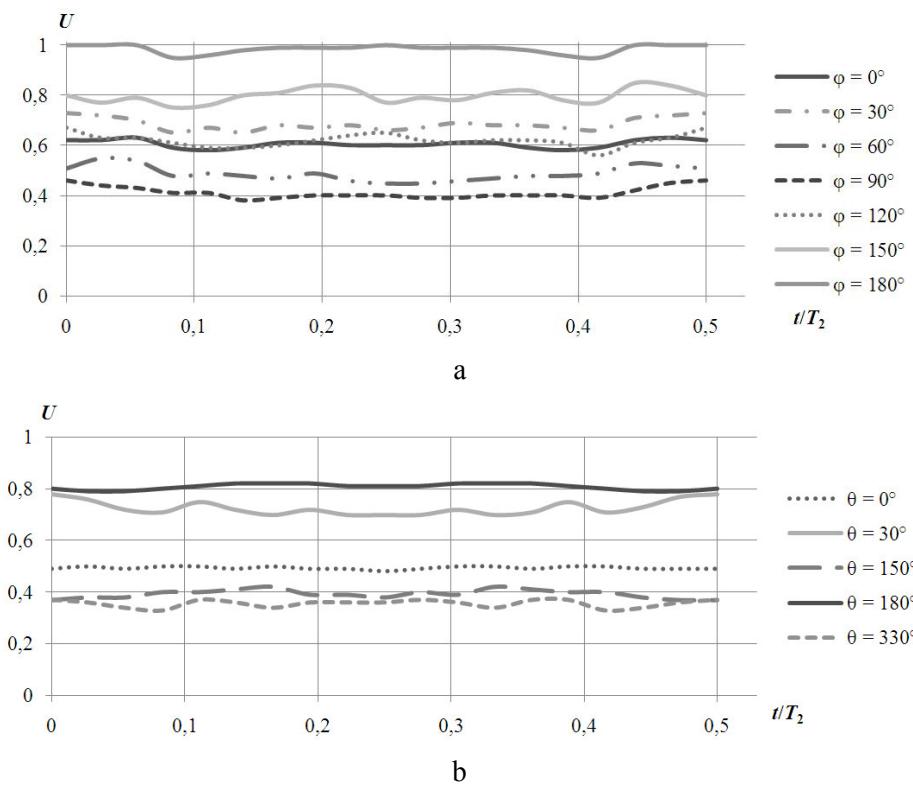
the corresponding coordinate planes practically coincide with the images in Fig. 1. Figure 4 shows the graphs DD pulsation in these planes.

From the graphs follows that in planes $X0Y$ and $X0Z$ level pulsation DD decreased, and in the frontal plane $Y0Z$ was left unchanged.

3. Metal Screw, N = 4.

In the virtual construction helicopter four-blade metal screw installed. Calculations DD indicate that in this case its shape virtually identical to shown in Fig. 2.

In the case which is regarded, the period pulsation decreased twofold: $0 \leq \frac{t}{T_4} \leq 0.25$. In Fig. 5 shows the pulsation DD for two periods of supervision (which is not significant).

Fig. 4. Pulsations DD: a in the plane $X0Y$; b in the plane $X0Z$; c in the plane $Y0Z$

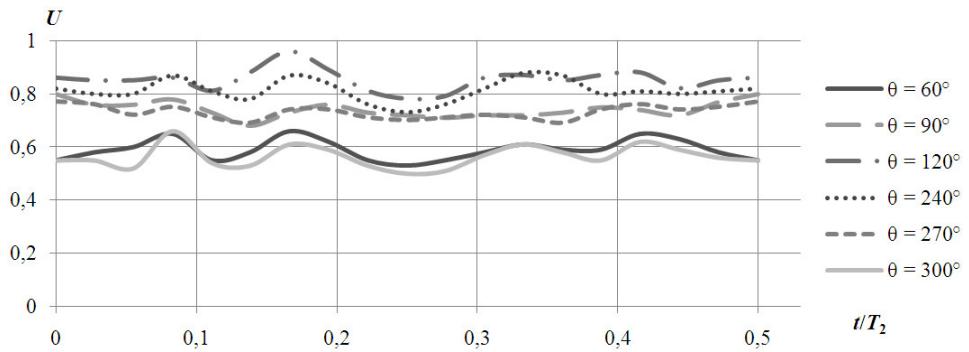
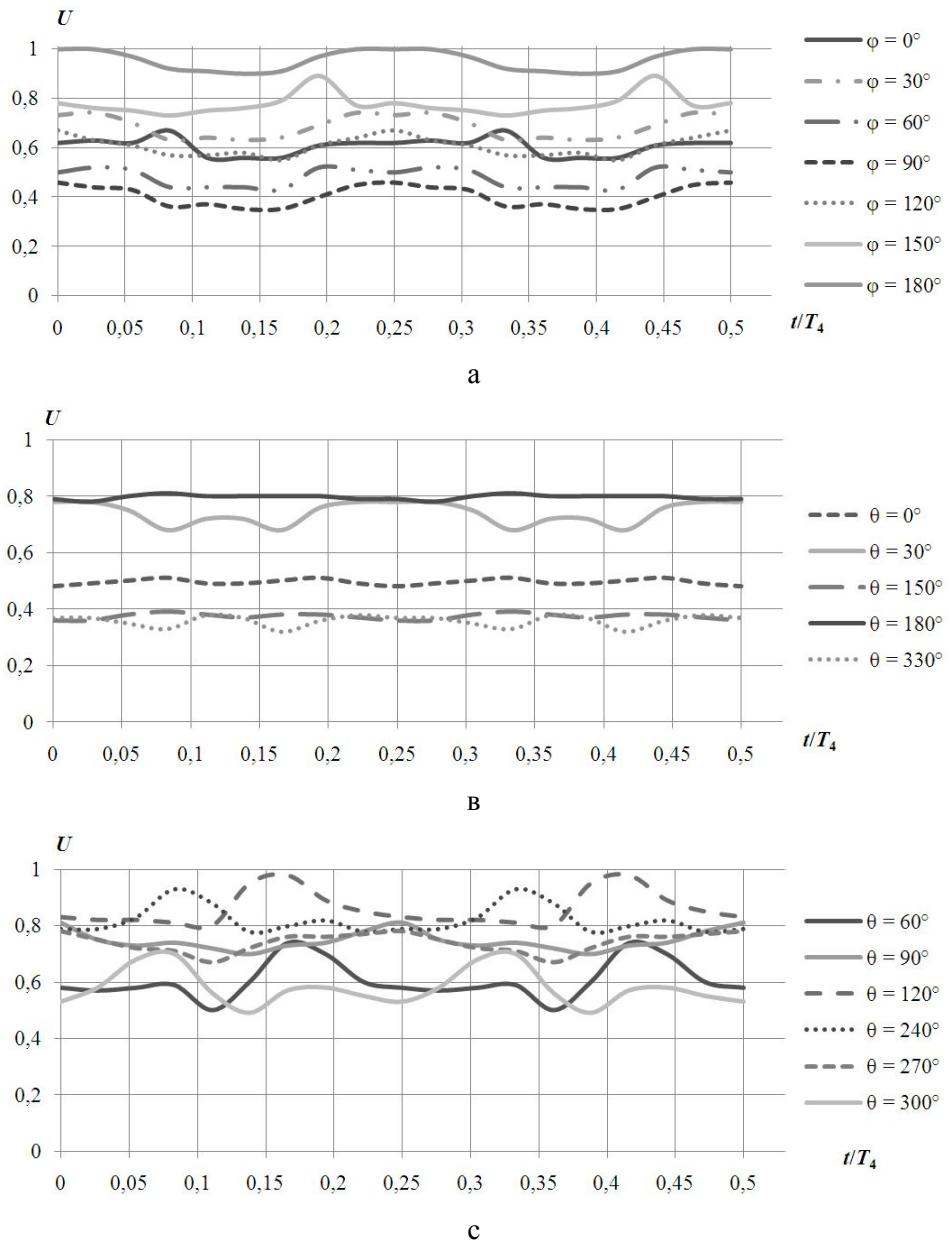


Fig. 4. Ending. (See also p. 21)

Fig. 5. Pulsations DD: a in the plane $X0Y$; b in the plane $X0Z$; c in the plane $Y0Z$

From the above graphs follows that pulsation DD in the planes $X0Y$ and $Y0Z$ become more significant, and in the lateral plane $X0Z$ have not changed.

Using graphs, we can determine the coefficients irregularity DD as the ratio maximum value U to their minimum values in the direction of flight dB.

For radio communication equipment and Collision Avoidance System permissible value coefficients irregularity DD in azimuth plane XOY is 3 dB, for glidepath radio receiver the sector $\pm \phi = 45^\circ$ – equal to 6 dB [2]. In other coordinate surfaces normative values for the coefficients are not specified. For equipment installed on board helicopter, it is expedient consider these standards averaged.

Directional diagram pulsation coefficient for any spatial angle can be defined on the basis of graphs, such as illustrated in Figs 3, 4 and 5. Quantitatively its can be defined as the ratio maximum to minimum value pulsation corresponding spatial angle dB.

III. CONCLUSIONS

1. Outline cross section DD antenna in any coordinate plane is weakly dependent from the design of main screw and the type of material from which made his blade, but much depends from the installation location antennas on the fuselage helicopter.

2. Pulsations DD antennas are consequences depending the values its effective height from angular position main screw blades in the azimuth plane.

3. In the frontal plane $Y0Z$ DD pulsation with similar circumstances is most intense.

4. Having pulsation DD antennas complicates ensuring permissible coefficient irregularity and can stimulate the emergence additional bit errors during emission or reception service information if it provided in digital form.

5. Mathematical modeling systems type “standard antenna-helicopter fuselage” simplifies the procedure for finding the optimal placement of points actual number of antennas on a real helicopter with the aim of weakening their interaction.

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В. О. Іванов, О. С. Задорожний. Вплив обертань гвинта гелікоптера на форму діаграми спрямованості бортової антени

На основі математичного моделювання системи типу «штатна антена–фюзеляж гелікоптера» досліджено ефект пульсацій її діаграми спрямованості. Вказано причини виникнення пульсацій та їх особливості. Відмічено наслідки, до яких може привести наявність пульсацій діаграми спрямованості.

Ключові слова: гелікоптер; гвинт гелікоптера; гвинтові лопаті; діаграма спрямованості; математичне моделювання; схема пульсації.

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В. А. Иванов, А. С. Задорожный. Влияние вращений винта вертолёта на форму диаграммы направленности бортовой антенны

На основе математического моделирования системы типа «штатная антенна–фюзеляж вертолёта» исследован эффект пульсаций её диаграммы направленности. Показаны причины возникновения пульсаций и их особенности. Отмечены последствия, к которым могут привести пульсации диаграммы направленности.

Ключевые слова: вертолет; винт вертолета; винтовые лопасти; диаграмма направленности; математическое моделирование; схема пульсации.

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