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RADIOABSORBING MATERIAL OPTIMAL USING IN THE REDUCTION OF AIRCRAFT RADAR CROSS-SECTION

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ABSTRACT

It's well known, local scattering parts on a smooth convex object elements make the most important contribution to reflected signal energy. So these surface parts of complex shape objects are coated by radioabsorbing materials (RM) in camouflage purpose. As a rule, the radioabsorbing coating (RC) has the sizeable weight and the cost. In this case the problem of optimal using of RM on the object surface has been occurred. The optimal coating method for the reduction of radar cross-section (RCS) has been obtained for a certain illumination and reception directions in limitation conditions for a quantity of the RC using. Optimal coating has been realized due to decision of some integer linear programming problem. Using this method we have had RCS numerical results for reductive aircraft model partly coated by RM.

BASE CALCULATION RELATIONS

The object construction and coating technology determine the surface fragmentation on some parts. These ones may be have RC or may be perfectly conducting. In this case object RCS is approximately represented as sum of RCS of these parts

$$\sigma(\theta) = \sum_{i=1}^{N} \sigma_i(\theta), \tag{1}$$

where N is the number of object surface parts, θ is an illumination or reception angle and RCS is a function of this angle. Finally, the values of object RCS averaged in some range of illumination or reception angles will be interested by us and RCS representation by (1) is reasonably for calculation. The method offered in [1] may be used for calculation of RCS separate object parts. Let a mean RCS for whole object and a mean RCS for i-th surface part for angle range $\theta_1 \le \theta \le \theta_2$:

$$\overline{\sigma} = \frac{1}{|\theta_2 - \theta_1|} \int_{\theta_1}^{\theta_2} \sigma(\theta) d\theta, \quad \overline{\sigma}_i = \frac{1}{|\theta_2 - \theta_1|} \int_{\theta_1}^{\theta_2} \sigma_i(\theta) d\theta. \tag{2}$$

Calculating the range averaging for (1), we obtain

$$\overline{\sigma} = \sum_{i=1}^{N} \overline{\sigma}_i . \tag{3}$$

We'll minimize the sum (3) of separate part RCS averaged in a finite range of illumination or reception angles. Let $\overline{\sigma}_{i1}$ is a mean RCS of i-th part with perfectly conducting surface, $\overline{\sigma}_{i2}$ is a mean RCS of the same part in case of using RC on a surface of this part. The RCS of completely coated object is

$$\overline{\sigma}_2 = \sum_{i=1}^{N} \overline{\sigma}_{i2} . \tag{4}$$

If subtract (4) from (3), we'll obtain

$$\overline{\sigma}-\overline{\sigma}_2=\sum_{i=1}^{N}\left(\overline{\sigma}_i-\overline{\sigma}_{i2}\right)=\sum_{i=1}^{N}\kappa_i\left(\overline{\sigma}_{i1}-\overline{\sigma}_{i2}\right)=\sum_{i=1}^{N}\kappa_i\Delta\sigma_i\,. \quad (5)$$

Here κ_i is binary factor, which equals zero if i-th part uses RC and equal one if this surface part is perfectly conducting. Let S_0 is as much as a possible square of RM on an object surface, S is the total square of an object surface and

$$S=\sum_{i=1}^{N}S_i\,. \quad (6)$$

The RC square limitation using $\kappa_i(i=1,...,N)$ can be written as

$$\sum_{i=1}^{N}\kappa_i S_i \geq S-S_0\,. \quad (7)$$

The problem of RM optimal distribution on an object surface comes to problem of integer linear programming – determination of binary factors κ_i series, that minimize representation (5) and satisfy the limitation condition (7). The solution of this problem may be obtain by any standard method, for example, additive method or method of branches and boundaries [2].

NUMERICAL RESULTS

The reductive aircraft model (Fig.1) has been used for numerical calculation. The model includes the surfaces of 4 ellipsoids. The model length is 18m, width is 22m, height is 4.25m. The model RCS has been calculated for sounding frequency 10GGz. The RC parameters are: thickness 1.3mm, permitivity $\varepsilon_1'=20+i0.1$, permeability $\mu_1'=1.35+i0.8$. This material reduces plate RCS by 15dB for a normal incidence of sounding signal with given frequency. The object surface has been broken into 140 parts $N=140$. The dependence of aircraft averaged RCS on optimal used RM square has been represented on Fig.2 for azimuth range –10°...+10° relatively aircraft axis and elevation angle (range 0°...-8°) relatively wing plane (monostatic case and illumination from a lower

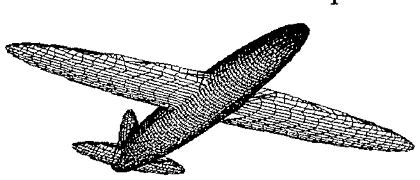

Fig. 1.

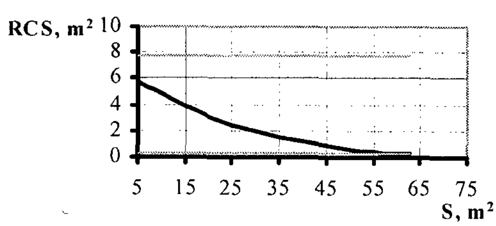

Fig.2.

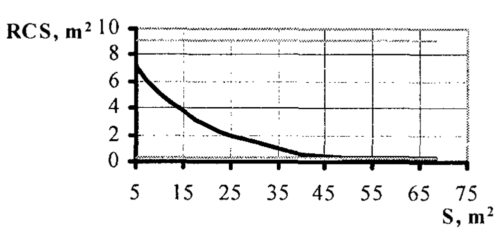

Fig.3.

half-space). The similar dependence for bistatic case for front sounding and bistatic angle by azimuth -10°...+10° and by elevation 0°...-8° has been represented on Fig.3. In bistatic case the averaged RCS decreases quicker than in monostatic case. This is determined by lesser displacements of local scattering centers on object surface in bistatic case and, therefore, by different optimal distribution of RM. The acceptable

RCS values have been obtained by RM optimal using on 20-25% of object surface. The similar results have been represented on Fig.4 (monostatic case) and Fig.5 (bistatic case) for bigger average angle range (azimuth –20°...+20°, elevation angle 0°...–20°).

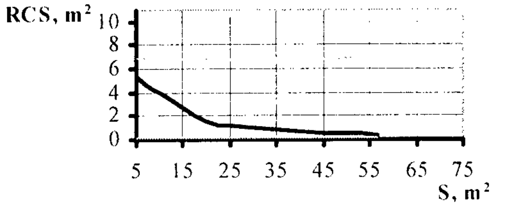

Fig.4.

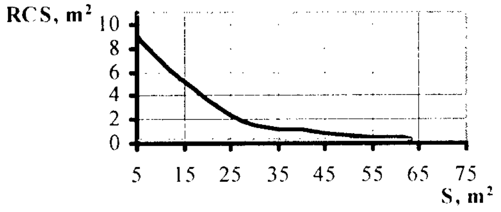

Fig.5.

The RC optimal distribution for averaged RCS in azimuth range –5°...+5° and elevation range –3°...+ 3° has been represented on Fig.6 (Fig.6a is the model view from upper half-space and Fig.6b – the same model from lower one. RC places pointed by gray color and frames. RC square is 40m^2. Averaged RCS for this model is 0.68m^2. RCS for perfectly coated model is 0.26m^2 and for completely conducting one is 8.11m^2.

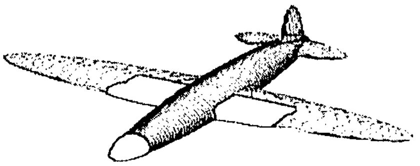

Fig.6a

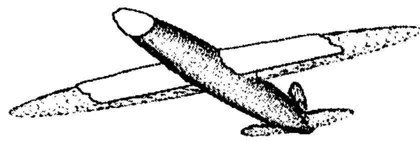

Fig.6b

The RC optimal distribution for averaged RCS in azimuth range –20°...+20° and elevation range 0°...+ 20° has been represented on Fig.7. RC square is 40m^2. RCS for this case is 0.74m^2. RCS for completely coated model is 0.23m^2 and perfectly conducting one is 6.81m^2. The picture analysis shows the visible difference between optimal distributions of RM limited quantity for two mentioned ranges of illumination and reception angles.

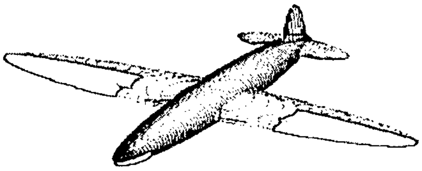

Fig.7a

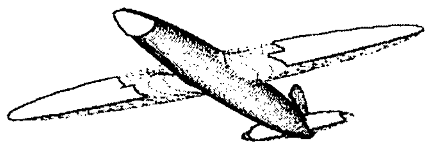

Fig.7b

The RCS reduction estimation in finite range of illumination and reception angles has been proposed in RM optimal using on the part of object surface. It can conclude that the essential and actually complete reduction of RCS has been obtained for wide range of fighting angles at using RM only 20-25% of an aircraft model surface.

REFERENCES

[1] O.Sukharevsky, V.Vasilets, S.Gorelyshev, A.Sazonov. Electromagnetic Scattering By Complex Shape Objects Partly Coated With Absorbing Materials. //MMET-2000 Proceedings, Kharkov, Ukraine, 2000, v.1, pp. 94-101

[2] Romanovskiy V.O. Solution algorithms for extremum problem. – Moscow.: Nauka, 1977, 352p. (in Russian)