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BOUNDARY PROBLEM OF SUPPORTING SURFACE IN NONSTATIONARY LIMITED--ETC(U)
FEB 77 B N BELOUSOV, V I ORISHCHENKO

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FOREIGN TECHNOLOGY DIVISION

BOUNDARY PROBLEM OF SUPPORTING
SURFACE IN NONSTATIONARY LIMITED FLOW

by

B. N. Belousov, V. I. Orishchenko

EDITED TRANSLATION

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By: B. N. Belousov, V. I. Orishchenko

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Block	Italic	Transliteration	Block	Italic	Transliteration
А а	*А а*	A, a	Р р	*Р р*	R, r
Б б	*Б б*	B, b	С с	*С с*	S, s
В в	*В в*	V, v	Т т	*Т т*	T, t
Г г	*Г г*	G, g	У у	*У у*	U, u
Д д	*Д д*	D, d	Ф ф	*Ф ф*	F, f
Е е	*Е е*	Ye, ye; E, e*	Х х	*Х х*	Kh, kh
Ж ж	*Ж ж*	Zh, zh	Ц ц	*Ц ц*	Ts, ts
З з	*З з*	Z, z	Ч ч	*Ч ч*	Ch, ch
И и	*И и*	I, i	Ш ш	*Ш ш*	Sh, sh
Й й	*Й й*	Y, y	Щ щ	*Щ щ*	Shch, shch
К к	*К к*	K, k	Ъ ъ	*Ъ ъ*	"
Л л	*Л л*	L, l	Ы ы	*Ы ы*	Y, y
М м	*М м*	M, m	Ь ь	*Ь ь*	'
Н н	*Н н*	N, n	Э э	*Э э*	E, e
О о	*О о*	O, o	Ю ю	*Ю ю*	Yu, yu
П п	*П п*	P, p	Я я	*Я я*	Ya, ya

*ye initially, after vowels, and after ъ, ь; e elsewhere. When written as ё in Russian, transliterate as yё or ё. The use of diacritical marks is preferred, but such marks may be omitted when expediency dictates.

GREEK ALPHABET

Alpha	Α	α	*α*	Nu	Ν	ν	
Beta	Β	β		Xi	Ξ	ξ	
Gamma	Γ	γ		Omicron	Ο	ο	
Delta	Δ	δ		Pi	Π	π	
Epsilon	Ε	ε	*ϵ*	Rho	Ρ	ρ	*ρ*
Zeta	Ζ	ζ		Sigma	Σ	σ	*ς*
Eta	Η	η		Tau	Τ	τ	
Theta	Θ	θ	*ϑ*	Upsilon	Τ	υ	
Iota	Ι	ι		Phi	Φ	φ	ϕ
Kappa	Κ	ϰ κ	*κ*	Chi	Χ	χ	
Lambda	Λ	λ		Psi	Ψ	ψ	
Mu	Μ	μ		Omega	Ω	ω	

RUSSIAN AND ENGLISH TRIGONOMETRIC FUNCTIONS

Russian	English
sin	sin
cos	cos
tg	tan
ctg	cot
sec	sec
cosec	csc
sh	sinh
ch	cosh
th	tanh
cth	coth
sch	sech
csch	csch
arc sin	$\sin^{-1}$
arc cos	$\cos^{-1}$
arc tg	$\tan^{-1}$
arc ctg	$\cot^{-1}$
arc sec	$\sec^{-1}$
arc cosec	$\csc^{-1}$
arc sh	$\sinh^{-1}$
arc ch	$\cosh^{-1}$
arc th	$\tanh^{-1}$
arc cth	$\coth^{-1}$
arc sch	sech^{-1}
arc csch	csch^{-1}

Russian	English
rot	curl
lg	log

GRAPHICS DISCLAIMER

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BOUNDARY PROBLEM OF SUPPORTING SURFACE IN NONSTATIONARY LIMITED FLOW

B. N. Belousov, V. I. Orishchenko
(Irkutsk)

In this article we examine a method of solving the boundary problem for a wing of arbitrary aspect ratio which makes periodic arbitrary oscillations of infinitely small amplitude in a limited fluid flow having a velocity at infinity of V_0.

Given is a brief derivation of the main integro-differential equations of the problems obtained in [1] and a method for solving these equations and obtaining the numerical hydroaerodynamic characteristics of the problem is developed.

The boundary problem for the potential of accelerations θ is formulated as [2]

$$\begin{aligned}
&\Delta\theta = 0 && g\in\Omega \\
&\theta_z = F(g) && g\in S_p \\
&\theta_+ - \theta_- = 0 && g\in L \\
&\theta \to 0 && x\to\infty \\
&P(\theta) = 0 && g\in S_0.
\end{aligned}$$

Here Ω is the space occupied by the fluid; S_p - projection of supporting surface in direction of undisturbed flow; L - trailing edge of supporting surface; P - operator whose form is determined by the type of limiting surface S_0.

The solution to the problem gives integral operator $A\gamma$, assigned in space $L_1(S_p)$ with values in space $C^2(\Omega)$.

The necessary properties of operator $A\gamma$ are given in [2], and [3]. In the studied problem operator $A\gamma$ takes the form of:

$$A\gamma = \frac{1}{4\pi} \iint_{S_p} \gamma(P) \frac{\partial}{\partial\rho} \left[\frac{1}{r} + \operatorname{sign} F \frac{1}{r_1}\right] ds,$$

where

$$r = \sqrt{(x-\xi)^2 + (y-\eta)^2 + (z-\zeta)^2};$$

$$r_1 = \sqrt{(x-\xi)^2 + (y-\eta)^2 + (z+\zeta+4h)^2};$$

$$\operatorname{sign} F = \begin{cases} -1 - \text{solid screen} \\ +1 - \text{free surface of heavy fluid} \\ (F_r \to \infty). \end{cases}$$

The integral equation of the problem

$$\bar{A}_z\gamma = F(g),\ g \in S_p$$

by representing the solution in the form of 3 components

$$\gamma = \gamma_1 + \gamma_2 + \gamma_3$$

[2], [3] is reduced to the equation system:

$$N_{01}\bar{A}_z\gamma_1 = F_1 + C\ \ g \in S_p \tag{1}$$

$$N_{01}\bar{A}_z\gamma_2' = -ikF_1\ \ g \in S_p \tag{2}$$

$$N\bar{A}_z\gamma = F_1\ \ g \in S_p, \tag{3}$$

here: $N_{01} = -\int^{x} [\ ]\, d\tau;$

$\gamma_1 \in C'(S_p)$ - regular solution related to presence of break in tangential velocities during transition of surface S_p;

$\gamma_2 \in C'(S_p)$ - regular solution which describes inertial motions;

γ_3 - singular solution, determined from equation (3) transferred to space of velocity potential by operator N.

Equation (1) is not used, since it contains an indeterminant constant C for the case of a supporting surface of arbitrary aspect ratio.

Thus, the inertia component of the solution γ_2 is determined from equation (2), which in form coincides with the equations of the stationary theory, while the vortex components γ_1 and γ_3 are determined from equation (3).

The kernel equations (2) and (3)

$$K(x, \xi, y, \eta) = \frac{\sqrt{(x-\xi)^2 + \lambda^2(\eta)(y-\eta)^2}}{(x-\xi)(y-\eta)}$$

is represented by the Leydlo-Sobolev approximation for a wing of arbitrary aspect ratio in the form of two singular kernels with singularities with respect to $(x - \xi)$ and $(y - \eta)$, respectively, which from the theoretical standpoint is incorrect, although it does lead to satisfactory final results.

In this study the approximation for this kernel contains a regular term in addition to the singular components, and this makes it possible to preserve the main properties of the kernel $K(x, \xi, y, \eta)$ [1].

$$K(x, \xi, y, \eta) = \lambda(\eta)\,\mathrm{sign}(y-\eta)\left[\frac{1}{x-\xi} - \int_0^\infty e^{-2P(\lambda)k} \sin k(x-\xi)\,dk\right] + \mathrm{sign}(x-\xi)\left[\frac{1}{y-\eta} - \int_0^\infty e^{-2P\left(\frac{1}{\lambda}\right)k} \sin k(y-\eta)\,dk\right], \quad (4)$$

where

$$P(\lambda) \to 0,\ \lambda \to 0;\ P\left(\frac{1}{\lambda}\right) \to 0,\ \lambda \to \infty,$$
$$P(\lambda) \to \infty,\ \lambda \to \infty;\ P\left(\frac{1}{\lambda}\right) \to \infty,\ \lambda \to 0.$$

The kernels of equations (2) and (3), which consider the limited nature of the flow, are approximated by functions which have the form of the regular terms in the kernel approximation K(x, ξ, y, η).

The system of equations (2) and (3) based on approximation (4) is reduced to the system of one-dimensional integro-differential equations of the Prandtl type

$$\Gamma_n(y) = \frac{\Psi_n(\lambda)\pi}{2\lambda(y)}\left[\alpha_n(y) - \frac{1}{2\pi}\int_{-1}^{+1}\frac{\partial\Gamma_n(\eta)}{\partial\eta}G(y-\eta)\,d\eta\right]; \tag{5}$$

$$\Gamma_B(y) = \frac{C(k)\Psi_c(\lambda)\pi}{\lambda(y)}\left[\alpha_B(y) - \frac{P_1(k)}{\pi}\int_{-1}^{+1}\frac{\partial\Gamma_B(\eta)}{\partial\eta}G(y-\eta)\,d\eta - \right. \tag{6}$$

$$\left. - \frac{ikP_2(k)}{\pi}\int_{-1}^{+1}\frac{\partial\Gamma_n(\eta)}{\partial\eta}G(y-\eta)\,d\eta - \frac{P_3(k)}{2\pi}\int_{-1}^{+1}\frac{\partial\Gamma_B(\eta)}{\partial\eta}G_1(y-\eta)\,d\eta\right].$$

Here

$$G(y-\eta) = \frac{1}{y-\eta} - \int_0^\infty \{e^{-2P\left(\frac{1}{\lambda}\right)k} + e^{-4Hk} -$$

$$- e^{-2\left[P\left(\frac{1}{\lambda}\right)+2H\right]k}\}\sin k(y-\eta)\,dk,$$

$$G_1(y-\eta) = \int_0^\infty \{e^{-2P\left(\frac{1}{\lambda}\right)k} + e^{-4Hk} - e^{-2\left[P\left(\frac{1}{\lambda}\right)+2H\right]k}\}\sin k(y-\eta)\,dk.$$

From equation (6) when k → 0 we get the stationary theory equation.

The equation for the inertial component of the solution is represented in the form of

$$\frac{\lambda(y)}{\pi}\int_{-1}^{+1}\frac{\partial}{\partial\xi}\gamma(\xi, y)\,G(x-\xi)\,d\xi + \frac{1}{\pi}\int_{-1}^{+1}\frac{\partial}{\partial\eta}\gamma(x,\eta)\,G(y-\eta)\,d\eta = -ikF_1;$$

$$G(x-\xi) = \frac{1}{x-\xi} - \int_0^\infty \{e^{-4hk} + e^{-2P(\lambda)k} -$$

$$- e^{-2[P(\lambda)+2h]k}\}\sin k(x-\xi)\,dk. \tag{7}$$

As an example of solving equations of this type let us analyze the method of solving the equation of the stationary theory

$$\frac{\lambda(y)}{\pi}\int_{-1}^{+1}\gamma(\xi, y)\,G(x-\xi)\,d\xi-\frac{1}{\pi}\int_{-1}^{+1}\frac{\partial\Phi(x,\eta)}{\partial\eta}\,G(y-\eta)\,d\eta-$$

$$-\frac{1}{2\pi}\int_{-1}^{+1}\frac{\partial\Gamma(\eta)}{\partial\eta}\,G_1(y-\eta)\,d\eta=F(x, y). \qquad (8)$$

Here:

$$\Phi(x, \eta)=\int_{x}^{1}\gamma(\xi, \eta)\,d\xi; \quad \Gamma(\eta)=\int_{-1}^{+1}\gamma(\xi, \eta)\,d\xi.$$

The solution $\gamma(\xi, \eta)$ is sought in the form of a series

$$\gamma(\xi, \eta)=\sqrt{\frac{1+\xi}{1-\xi}}\sqrt{1-\eta^2}\cdot\sum_{n=0}^{k}\sum_{p=0}^{k}A_{np}\xi^n\eta^p.$$

Using the method of moments with weight factor $\sqrt{1-y^2}\sqrt{1-x^2}$, equation (8) is reduced to a system of algebraic equations

$$\frac{1}{\pi}\sum_{n=0}^{k}\sum_{n=0}^{k}A_{np}\cdot B_{npqs}=G_{qs}, \qquad (9)$$

where coefficients B_{npqs} are represented in the form of series in powers of functional parameters

$$\tau_h=\sqrt{4h^2+1}-2h,$$

$$\tau_{P(\lambda)}=\sqrt{P^2(\lambda)+1}-P(\lambda),$$

$$\tau_{h, P(\lambda)}=\sqrt{4\left[h+\frac{P(\lambda)}{2}\right]^2+1}-2\left[h+\frac{P(\lambda)}{2}\right].$$

In order to solve equation system (9) a program was compiled on the BESM-4 computer. Calculation results in the form of the distribution of circulation Γ over the wing span are shown in Fig. 1.

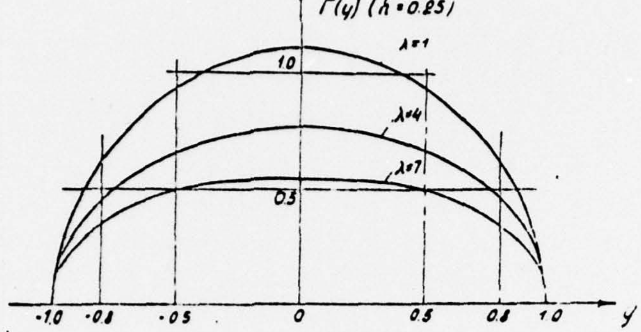

Fig. 1.

The solution to an analogous equation by the Multopp method, which did not consider the distribution of circulation over the chord, was given in the work by I. P. Tkachenko [4]. The results of the calculations agree.

Equation (7) for inertia component γ_2 is solved by the method used to solve equation (8). The solution of $\gamma(\xi, \eta)$ is sought in the form of

$$\gamma(\xi, \eta) = \sqrt{1-\xi^2}\sqrt{1-\eta^2} \sum_{n=0}^{k} \sum_{n=0}^{k} A_{np} \xi^n \eta^p.$$

The weight factors are used in the same form. Calculation results are shown in Fig. 2.

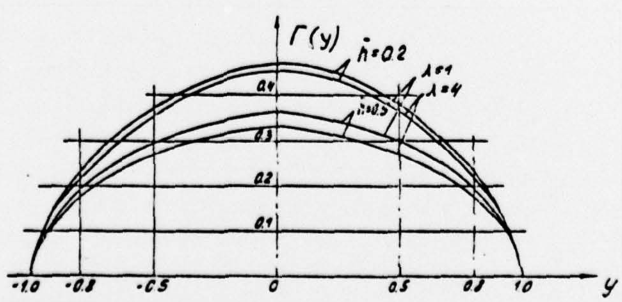

Fig. 2.

BIBLIOGRAPHY

1. Белоусов Б. Н., Панченков А. Н. Теория несущей поверхности в нестационарном потоке, основанная на одномерных интегро-дифференциальных уравнениях, сборник „Асимптотические методы в теории нестационарных процессов", Изд-во „Наука", 1970 (в печати).

2. Панченков А. Н. Несущая поверхность в нестационарном потоке ограниченной жидкости (статья I), сборник „Гидродинамика больших скоростей", вып. 4, Изд-во „Наукова думка", К. 1968.

3. Панченков А. Н. Несущая поверхность в нестационарном потоке ограниченной жидкости (статья II), сборник „Гидродинамика больших скоростей", вып. 5, Изд-во „Наукова думка", К. 1968.

4. Ткаченко И. П. Влияние формы в плане на характеристики крыла вблизи экрана, доклады к XVIII Всесоюзной научно-технической конференции по теории корабля (Крыловские чтения), Ленинград, 1968.

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