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MODELING THE SCHEME OF MOVEMENT OF RAW COTTON AND AIRIN THE FEEDER BY THE METHOD OF FLOW THEORY

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Abstract. This article focuses on improving the feeding section of the cotton machine cleaner. In existing feeders, in a certain period of time, raw cotton is not loosened enough, which in turn leads to a decrease in the cleaning effect of the machine. In this regard, in order to eliminate this drawback, a theoretical task was set to study the reduction of cotton to a dispersed state by supplying an air flow to the feed zone and achieving a uniform cotton supply to the cleaning machine. To solve the problem, the methods of the theory of ideal fluid flows with the use of the theory of functions of a complex variable are used. The problem is solved in parametric form, while solving Zhukovsky functions and Schwarz integral formulas are also used. To determine the geometric and mechanical characteristics of the flow, the corresponding equations are obtained. The article also discusses some special cases of the problem. All possible options for solving the problem of the movement of two mixtures of raw cotton and air, as well as the necessary design parameters, have been obtained. The results obtained make it possible to determine the geometric dimensions in the design of the feeders.

Keywords. Feeder, feed rollers, flow theory methods, complex variable function theory, Zhukovsky function, Schwarz integral formula.

INTRODUCTION

In ginneries, feeders are used with a shaft and two feed rollers [1.50-51 pts]. The task of these organs is to crush cotton to a dispersed state and to transfer the cotton evenly to the working organs [1.25-27 p.]. Tests on existing feeders have shown that, as a result, the cotton is fed in lumps and not in a dispersed state. This, in turn, is the reason for the negative effect for cleaning [3.24-25 p., 4. 72-73 p., 5. 32-33 p., 6. 44-45 p.].

A number of developments, proposals and designs dedicated to the study of the reconstruction of feeders [7. 62-64 p., 8. 56-57 p., 9. 82-83 p., 10. 52-54 p., 11. 45-46 p.] were tested in production conditions, however, due to some shortcomings, they were not accepted for further operation. In the article, the authors propose to grind lumps of cotton under the feed rollers of the feeder by supplying air from the side. The processes of supplying cotton under these conditions and the laws of motion of the mixture of cotton with air have been theoretically studied.

RESEARCH METHODS

The flow theory was used to solve the problem.

STATEMENT OF PROBLEMS AND SOLUTIONS

Raw cotton, falling from top to bottom, passing between two rollers, is carried away by the air flow supplied from the nozzle of the nozzle located under the roller (Fig. 1.)

The purpose is to determine the trajectory of the cotton-air mixture flowing off the cotton from the third roller and to establish the best indicators of the calculated parameters of the problem. The coordinates of the location of all the rollers and their geometrical characteristics, radii of curvature, angle of inclination of the packing, etc. have been established. To solve the problem, the methods of the theory of flows of an ideal fluid using the theory of functions of a complex variable [1.2] are used. The problem is solved in parametric form. The problem is two-dimensional. The current is potential. The upper half-plane of the parametric variable $G_t(t = \xi + i\eta.)$ (Fig. 3.) is taken as the auxiliary domain. The conformal mapping of the domain G_t (Fig. 3) to the domain of the complex potential $G_W(W = \varphi + i\psi.)$ (Fig. 2) can be carried out by the method of Chaplygin singular points [1,2]. Then the derivative of the function $W_n(t)$ with respect to **t** has simple zeros at the point B(t=b) and poles of the first order at the points D(t=s), A(t=a) and $B_1(t = b_1)$ and building $W_n(t)$ by zeros and poles we get

$$\frac{dW_n}{dt} = N_0 * \frac{t-b}{(t-a)(t-b_1)}, \quad w_{n(t)} = \varphi_n + i\psi_n . \qquad (1.2.1).$$

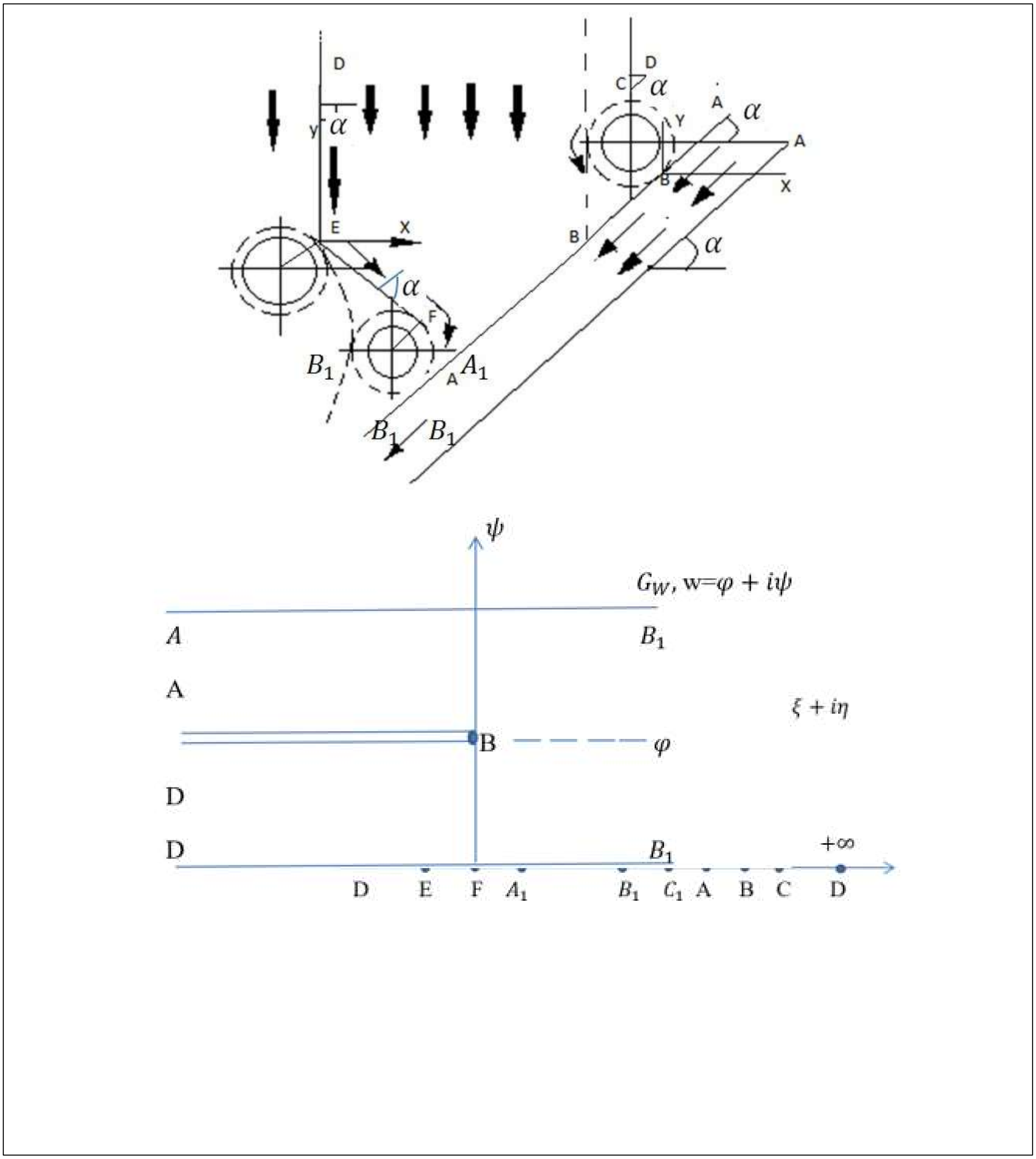
Here φ_n is the velocity potential, ψ_n is the flow function, , a, b и b_1 are mapping parameters, N_0 is calculated by the subtracted value of the function $\frac{dW_n}{dt}$ at the point t=a. $N_0 = -\frac{q_A}{\pi} * \frac{a-b_1}{a-b}$ where q_A is the air flow from the nozzle.

Now instead of the Zhukovsky function

$$\omega_{n(t)} = r + i\theta, \quad r = \ln\frac{V_{no}}{V_n}, \theta = \theta(t),$$

we introduce a new function [3],

$\omega n(t) = \ln F(\rho_n , V_n) * e^{i\theta} = \ln F(t) + i\theta$ (1.2.2)



$$F(t)=\sqrt{\frac{\rho_1 V_{10}^2+\rho_2 V_{20}^2}{f_1\rho_1 V_1^2+f_2\rho_2 V_2^2}},$$

ρ_1 и ρ_2 are the phase densities, V_{10}, V_{20} are the velocities of the raw cotton and air, respectively, at thebeginning of the inflow, V_1, V_2 are the velocities of the mixtures, $f_1 and\ f_2$, $f_1 + f_2 = 1$are the phase concentrations,

$\theta = \theta(t)$ is the angle of the velocity vector.

Like the Zhukovsky function, function (1.2.2) will also be analytical in the flow region G_Z, Z = x + iy (Fig. 1).

Using the limiting values of the function $\omega_n(t) = r + i\theta$ (1.2.2), we obtain

$$Jm\omega_n(t) = \begin{cases} -\frac{\pi}{2} \text{ at } -\infty < t < -e \ (DE), \\ -\alpha_u\pi \text{ at } -e < t < -f \ (EF), \\ \theta_1(t) \text{ at } -f < t < -1 \ (FA_1), \\ \alpha_1\pi_1 \text{ at } 1 < t < a \ (C_1A), \\ \alpha_2\pi_1 \text{ at } a < t < b \ (AB), \\ \theta_2(t) \text{ at } b < t < c \ (BC), \\ -\frac{\pi}{2} \text{ at } c < t < \infty \ (CD), \end{cases}$$

A new function is introduced

$$\omega(t) = \frac{\omega_n(t)}{R(t)}, \quad R(t) = \sqrt{t^2-1}, \ t=\xi + i\eta \quad (1.2.3)$$

$$Jm\omega(t) = \begin{cases} \frac{-\frac{\pi}{2}}{R(t)} \text{ at } -\infty < t \le e, \\ \frac{-\alpha_4\pi}{R(t)} \text{ at } -e < t < -f, \\ \frac{\theta_1(t)}{R(t)} \text{ at } -f < t < -1, \\ 0 \text{ at } -1 < t < 1, \\ -\frac{\alpha_1\pi_1}{R(t)} \text{ at } 1 < t < a, \end{cases}$$

(1.2.4)

$\underline{\theta 2(t)}$ at $a < t < b$, at $b < t < \infty$

$R(t)$

I _ π

I

2

$R(t)$

Hence, for the distribution of the velocities of each phase, using the Schwarz integral formula, we have:

$$\omega n(t) = \frac{R(t)}{\pi} \int_{-\infty}^{\infty} \frac{Jm\omega(\xi)}{\xi - t} d\xi$$

Then, taking into account (1.2.4) in expanded form, we obtain

ω = R(t) [− 1 ∫ −e −α * dξ

n(t) 2 −∞ R(ξ)(ξ−t) 4

−f dξ

∫−e R(ξ)(ξ−t)

1 ∫1 θ1(ξ)dξ _ –

π −f R(ξ)(ξ−t)

a dξ (1.2.5)

−α ∫ +

1 1 R(ξ)(ξ−t)

b dξ

+α ∫ +

2 a Rξ(ξ−t)

+ 1 ∫c θ2(ξ)dξ _ –

π b R(ξ)(ξ−t)

$$-\frac{1}{2}\int_c^\infty \frac{d\xi}{R(\xi)(\xi-t)}\Big]$$

We calculate integrals of the form

$$\int \frac{d\xi}{R(\xi)(\xi-t)} = \int \frac{d\xi}{\sqrt{\xi^2-1}-(\xi-t)}$$

We introduce the notation:

$$\xi - t = \frac{1}{u},\ \xi = \frac{1}{u} + t,\ d\xi = -\frac{du}{u^2},\ \xi^2 - 1 = \left(\frac{1}{u} + t\right)^2 - 1 = \frac{(1 + ut)^2}{u^2} - 1 = \frac{[(1 + ut) - u] * [(1 + ut) + u]}{u^2} = \frac{[1 + (t - 1)u] * [1 + (t + 1)u]}{u^2}$$

Hence,

$$\int \frac{d\xi}{\sqrt{\xi^2 - 1}(\xi - t)} = -\int \frac{\frac{du}{u^2}}{\frac{\sqrt{1 + (t - 1)u}}{u} * \frac{\sqrt{1 + (t + 1)u}}{u} * \frac{1}{u}} = \int \frac{du}{\sqrt{1 + (t - 1)u} * \sqrt{1 + (t + 1)u}} =$$

$$= -\frac{2}{R(t)} \ln\left(\sqrt{(t - 1) * [1 + (t + 1)u]} + \sqrt{(t + 1) * [1 + (t - 1)u]}\right)$$

$$= -\frac{2}{R(t)} \ln\left(\sqrt{(t - 1)} * \left(1 + \frac{t + 1}{\xi - t}\right) + \sqrt{(t + 1)}\left(1 + \frac{t - 1}{\xi - t}\right)\right) =$$

$$= -\frac{2}{R(t)} \ln \frac{\sqrt{(t - 1)(\xi + 1)} + \sqrt{(t + 1)(\xi - 1)}}{\sqrt{(\xi - t)}}$$

Then using (1.2.5), we have:

$$1).\ -\frac{R(t)}{2} \int_{-\infty}^{-e} \frac{d\xi}{\sqrt{\xi^2 - 1} * (\xi - t)} = \ln \frac{\sqrt{(t-1)(\xi+1)} + \sqrt{(t+1)(\xi-1)}}{\sqrt{\xi - t}} \Bigg|_{-\infty}^{-e} = \ln \frac{\sqrt{(t - 1)(1 - e)} + \sqrt{(t + 1)(-e - 1)}}{\sqrt{-e - t}}$$

$- \ln$

$\sqrt{(t-1)} + \sqrt{(t+1)}$

$=$

1

on DE.

$= \ln \sqrt{(e-1)(t-1)}+\sqrt{(e+1)(t+1)}$

$\sqrt{(e+t)}(\sqrt{t-1}+\sqrt{(t+1)})$

2). $\frac{-\alpha 4 R(t)}{} * \int^{f} \frac{d\xi}{} - 2\alpha$

$\ln \sqrt{(t-1)(\xi+1)}+\sqrt{(t+1)(\xi-1)} |^{-f} =$

1 $-e$ $\sqrt{\xi-t}$ $-e$

$\sqrt{\xi^2-1}(\xi-t)$ 4

[$\sqrt{(t-1)(-e+1)}+\sqrt{(t+1)(-e-1)}$ $\sqrt{(f-1)(t-1)}+\sqrt{(f+1)(t+1)}$

$\sqrt{(t-1)(-f+1)}+\sqrt{(t+1)(-f-1)}$

$= 2\alpha 4 \ln$ $- \ln$ $\sqrt{-e-t}$ $] =$ $= 2\alpha 4 \ln$

$\sqrt{-f-t}$

$\sqrt{(e-1)(t-1)}+\sqrt{(e+1)(t+1)}$ *

$e+t$ on EF.

$\sqrt{}$

3). $-\alpha R(t) \int^{a}$

$d\xi$ $f+t$

$\ln \sqrt{(t-1)(\xi+1)}+\sqrt{(t+1)(\xi-1)} |^{a} =$

$- 2\alpha$

1 1 $\sqrt{\xi^2-1}(\xi-t)$ 1 $\sqrt{\xi-t}$ 1

[$\sqrt{(t-1)(a+1)}+\sqrt{(t+1)(a-1)}$ $\sqrt{2(t-1)}$ $\sqrt{(a+1)(t-1)}+\sqrt{(a-1)(t+1)}$ $\sqrt{2}$

$=2\alpha 1 \ln$ $- \ln$ $] = 2\alpha_1 [\ln$ $- \ln$ $] =$

$\sqrt{a-t}$ $\sqrt{1-t}$ $\sqrt{a-t}$ i

$i(\sqrt{(a+1)(t-1)}+\sqrt{(a-1)(t+1)})$

$2\alpha 1 \ln \frac{}{\sqrt{2(a-t)}}$ on $C_1 A$

4). $$-\frac{\alpha}{2} R(t)\int_a^b \frac{d\xi}{\sqrt{\xi^2-1}\,(\xi-t)} = \frac{2\alpha}{2}\ln\frac{\sqrt{(t-1)(\xi+1)}+\sqrt{(t+1)(\xi-1)}}{\sqrt{\xi-t}}\Big|_a^b = 2\alpha\left[\ln\frac{\sqrt{(t-1)(b+1)}+\sqrt{(t+1)(b-1)}}{2\sqrt{b-t}} - \ln\frac{\sqrt{(t-1)(a+1)}+\sqrt{(t+1)(a-1)}}{\sqrt{a-t}\,2}\right] = 2\alpha\ln\frac{\sqrt{(t-1)(b+1)}+\sqrt{(t+1)(b-1)}}{\sqrt{(t-1)(a+1)}+\sqrt{(t+1)(a-1)}} * \sqrt{\frac{a-t}{b-t}}$$ on AB

5). $$-\frac{R(t)}{2}\int_c^\infty \frac{d\xi}{\sqrt{\xi^2-1}\,(\xi-t)} = \ln\frac{\sqrt{(t-1)(\xi+1)}+\sqrt{(t+1)(\xi-1)}}{\sqrt{\xi-t}}\Big|_c^\infty = \ln\frac{\sqrt{t-1}+\sqrt{t+1}}{1} - \ln\frac{\sqrt{(c+1)(t-1)}+\sqrt{(c-1)(t+1)}}{\sqrt{c-t}} = \ln\frac{\sqrt{c-t}\,(\sqrt{t-1}+\sqrt{t+1})}{\sqrt{(c+1)(t-1)}+\sqrt{(c-1)(t+1)}}$$ on CD.

The angle of the velocity vector $\theta(\xi)$ along FA_1 for $-f < \xi, < -1$ is determined by the finite-dimensionalapproximation method [1].

Therefore, using Figs. 1 and 2 and the formula for the angle of the velocity vector along the contour FA_1 $\theta(t) = At + B$ we have

$$\begin{cases} -\alpha_4\pi = -Af + B & \text{F in } t = -f \\ -\alpha_2\pi = -A + B & A_1 \text{ in } t = -1 \end{cases}$$

Hence

,

$$A = \frac{(\alpha 4 - \alpha 2)\pi}{f-1}, \mathrm{B} = \frac{\alpha 4\pi - \alpha 2\pi f}{f-1}$$

Then

$\theta\ (t) = \frac{(\alpha 4 - \alpha 2)\pi t + \alpha 4\pi - \alpha 2\pi f}{f-1} = \{ \alpha_4\pi$ at $t = -f$; $\alpha_1\pi$ at $t = -1 \}$ (1.2.6)

6) Hence, taking into account (1.2.6), we obtain:

$$\frac{R(t)}{\pi}\int_{-f}^{-1} \frac{\theta 1(\xi)d\xi}{\sqrt{(\xi^2-1)}(\xi - t)} = \frac{R(t)}{\pi}\int_{-f}^{-1} \frac{(\alpha 4 - \alpha 2)\pi\xi + \alpha 4\pi - \alpha 2\pi f}{(f-1) * \sqrt{\xi^2 - 1} * (\xi - t)} d\xi =$$

$R(t)$ $\pi(f-1)$ $[(\alpha_4 \pi - \alpha_2 \pi) \int_{-f}^{-1} \frac{d\xi}{\sqrt{\xi^2-1}} + [(\alpha_4 - \alpha_2)\pi]t + (\alpha_4 - \alpha_2 f)\pi * \int_{-f}^{-1} \frac{d\xi}{\sqrt{\xi^2-1}(\xi-t)}] = \frac{R(t)}{(f-1)\pi}\{(\alpha_4 - \alpha_2)\pi * \ln(\xi + \sqrt{\xi^2 - 1}) + [(\alpha_4 - \alpha_2)t + (\alpha_4 - \alpha_2 f)]\pi * (\frac{2}{\sqrt{\xi - t}}) * \ln \frac{}{\sqrt{(t-1)(\xi+1)}+\sqrt{(t+1)(\xi-1)}}\}\Big|_{-f}^{-1} = \frac{R(t)}{(f-1)\pi}$ $(\alpha_4 -$

$\alpha_4\ \alpha_2)\pi\ \ln \frac{1}{}$ $\frac{2}{}[\ln \frac{}{\sqrt{(t-1)(t+1)}+\sqrt{(-1+1)(-1-1)}} - \ln \frac{}{\sqrt{(t-1)(-f+1)}+\sqrt{(t+1)(-f-1)}}] \frac{R(t)}{} * (\alpha_4 - \alpha_2)\pi *$

$2\ \frac{}{(f-1)}\ \frac{}{\pi}\ \sqrt{-1-t}\ \sqrt{-f-t}\ (f-1)\pi\ 4\ 2$

$f-\sqrt{f^2-1}$

$\ln(f - \sqrt{f^2} - 1) - \frac{}{}\ 2$

$* [\ln \sqrt{-2(t+1)} * \sqrt{-(f+t)}] = (R(t) * \sqrt{(\alpha 4-\alpha 2)\pi}$

$\ln(f - \sqrt{f^2 - 1}) +$

$(f-1)\pi \quad \sqrt{-(t+1)} \quad \sqrt{-(t-1)(f-1)}+\sqrt{(t+1)(f+1)} \quad \sqrt{2(f+t)} \quad (f-1)\pi \quad \frac{1}{2}$

2

$(f-1)\pi$

$\sqrt{2(f+t)}$

$* \ln \frac{}{(f-1)\pi} \frac{}{\sqrt{(f-1)(t-1)}+\sqrt{(f+1)(t+1)}}) = - \ln [(f - \sqrt{f^2 - 1}) * (\frac{}{\sqrt{(f-1)(t+1)}+\sqrt{(f+1)(t+1)}})]$

Similarly along the CB contour:

$$\theta(t) = \frac{(1-\alpha 2)t+(\alpha 2c-b)}{2} * \pi = \{ \begin{matrix} \pi \text{ at } t = c \\ \alpha_2\pi \text{ at } t = b \end{matrix} \qquad (1.2.7)$$

7) Then

$$\frac{R(t)}{\pi} \int_b^c \frac{(1 - \alpha 2)t + (\alpha 2c - b)}{c - b} * \pi * \frac{d\xi}{\sqrt{(\xi^2 - 1)}(\xi - t)}$$

$$= \frac{R(t)}{(c - b)\pi} [(1 - \alpha 2)\pi \int_b^c \frac{d\xi}{\xi^2 - 1} + ((1 - \alpha 2)\pi t + (\alpha 2c - b)\pi) \int_b^c \frac{d\xi}{\sqrt{\xi^2 - 1}(\xi - t)}]$$

$$= \frac{R(t)}{(c - b)\pi} \{(1 - \alpha 2)\pi$$

$* \ln (\xi - \sqrt{\xi^2 - 1}) |_b^c + (- \frac{2}{})$

$) ((1 - \alpha)\pi t + (\alpha\ c - b)\pi) * \ln \frac{\sqrt{(t - 1)(\xi + 1)} + \sqrt{(t + 1)(\xi - 1)}}{\sqrt{\xi - t}} |_b^c$

$R(t)$ 2 2 b 2

$$= \frac{R(t)}{(c - b)\pi} (1 - \alpha 2)\pi \ln \frac{c - \sqrt{c^2 - 1}}{b - \sqrt{b^2 - 1}} - \frac{2}{(c - b)\pi}$$

$* \ [(1-\alpha 2)\pi t + (\alpha 2 c - b)\pi]$ $\underline{(1-\alpha 2) * R(t)}$

$\sqrt{(c+1)(t-1)} + \sqrt{(c-1)(t+1)}$ $b-t$ $c-\sqrt{c^2-1}$ $c-b$

$* \ \ln \frac{}{} * \sqrt{} = \ln(\ )$

$\sqrt{(b+1)(t-1)} + \sqrt{(b-1)(t+1)}$ $c-t$ $b-\sqrt{b^2-1}$

$\underline{2[(1-\alpha 2)t+(\alpha 2 c - b)]}$

$c-b$

$\sqrt{(b+1)(t-1)} + \sqrt{(c-1)(t+1)}$ $c-t$

$* \left(\frac{}{\sqrt{}} * \right)$

$\sqrt{(c+1)(t-1)} + \sqrt{(c-1)(t+1)}$ $b-t$

Thus, for the function$\omega_n(t)$ by formula (1.2.2), taking into account n1-7, we have the following expression: ω n(t) =

$7\ln\prod_{i=1} I_i(t)$ i = (1 , .. 7)

where

$$I_1(t) = \frac{\sqrt{(e-1)(t-1)} + \sqrt{(e+1)(t+1)}}{\sqrt{e+t}(\sqrt{t-1}+\sqrt{t+1})};$$

$2\alpha 4$

$\sqrt{(f-1)(t-1)}+\sqrt{(f+1)(t+1)}$ $e+t$

$I_2(t)=(\quad * \sqrt{\quad})$;

$\sqrt{(e-1)(t-1)}+\sqrt{(e+f)(t+1)}$ $f+t$

$\underline{(\alpha 4-\alpha 2)t+(\alpha 4-\alpha 2)f}$

2 $(f-1)\pi$

$\underline{R(t)(\alpha 2-\alpha 4)}$

$\sqrt{2(f+t)}$

$I_3(t)=[(f-\sqrt{f^2-1})$ f^{-1} $**(\quad)]$;

$\sqrt{(f-1)(t+1)}+\sqrt{(f+1)(t-1)}$

$2\alpha 2$

$\sqrt{(b+1)(t-1)}+\sqrt{(b-1)(t+1)}$ $a-t$

$I_4(t)=(\quad * \sqrt{\quad})$;

$\sqrt{(a+1)(t-1)}+\sqrt{(a-1)(t+1)}$ $b-t$

$\sqrt{c-t}\,(\sqrt{(t-1)}+\sqrt{(t+1)})$

$I_5(t)=$;

$\sqrt{(c+1)(t-1)}+\sqrt{(c-1)(t+1)}$

$2\alpha 1$

$\sqrt{(a+1)(t-1)}+\sqrt{(a-1)(t+1)}$

$I_6(t)=(\quad)$;

$\sqrt{2(t-a)}$

$(1-\alpha\ )R(t)$ $\underline{2[(1-\alpha 2)t+(\alpha 2c-b)]}$

2 $c-b$

$c-\sqrt{c^2-1}$ $c-$ $\sqrt{(b+1)(t-1)}+\sqrt{(b-1)(t+1)}$ $b-t$

$I_7(t)=(\quad)$ b $**(\quad * \sqrt{\quad})$;

$b-\sqrt{b^2-1}$ $\sqrt{(b+1)(t-1)}\sqrt{(b-1)(t+1)}$ $c-t$

From here we obtain an expression for the conjugate complex velocity for two media, (mixtures):

$V_n=V_{n0}[f(t)]^{-1}$ (1.2.8)

Here $f(t)=\prod_{i=1}^{7} I_i(t)$ for the geometry problem using (1.2.1) and (1.2.8) we obtain

1. $dz=\frac{dz}{dW_n}*dW_n=F*H\frac{t-b}{f(t)}*$

(1.2.9)

dt dW_n π $(t-a)(t-b_1)$

where dt

$\overline{1+g^2}$ V_{10}

$\hat{\rho}_2$

$F = F(\rho_n, V_n) = \sqrt{}$ по

V_1

$\hat{\rho} = \frac{\rho_2}{\rho}$, and ρ - density of each medium. *

f_1+f_2

$g^2\hat{\rho}_2$

2 ρ_1 1 2

$g^2_{по} = \left(\frac{V_{20}}{V_{10}}\right)^2$, $g^2_n = \left(\frac{V_2}{V_1}\right)^2$

$f_1 + f_2 = 1$- phase concentration, V_{10} and V_{20} - phase velocity. (mixture) before their movement, V_1 and $V_2$are thespeeds of the phases at the end of the removal.

Thus, to solve the problem, all the necessary characteristic functions are obtained by formulas (1.2.1), (1.2.8) and(1.2.9) in the form of analytic functions that satisfy all the boundary conditions of the problem.

CONCLUSIONS

To solve the problems posed, the methods of the theory of flows of an ideal fluid with the use of the theory of functions of a complex variable are used. The problem is solved in a parametric form, the solution also uses the Zhukovsky function and the Schwarz integral formula. To determine the geometric and mechanical characteristics of the flow, the corresponding equations are obtained. Also, some special cases of the problem are considered. All possible options for solving the problem of the movement of two mixtures of raw cotton and air, as well as the necessary design parameters, have been obtained.

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