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The Effect of Supersonic Flows on Different Profiles of Aircraft Wings

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THEEFFECTOFSUPERSONICFLOWSONDIFFERENTPROFILESOFAIRCRAFTWINGS

Strictly as per the compliance and regulations of:

The Effect of Supersonic Flows on Different Profiles of Aircraft Wings

Ahmed Soliman M. Sherif

Abstract- When a supersonic stream flows around a thin profile, the pressure acting on the surface element does not depend on the shape of the rest of the profile, but depends only on the slope of the element itself, that is, on the local angle of attack. The local angle of attack is the angle between the surface element and the velocity vector of the undisturbed flow Coefficient of pressure. $C_p = -\frac{2\cdot\Theta}{\sqrt{M_\infty^2-1}}$,

$\boldsymbol{\Theta}$– Angle of rotation (local angle of attack).

Keywords: supersonic stream flows, angle of attack, angle of rotation, pressure of surface profiles, coefficient of pressure.

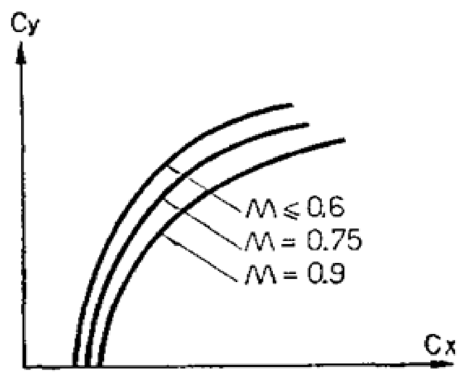

Fig.1

It can be seen from the graph **1**. that the most advantageous angle of attack of an airplane is greater than the most advantageous angle of attack of the wing by $(2^\circ \div 3^\circ)$.

I. Introduction

The aim of my research is Determining the coefficient of profile-wave resistance for the four profiles which shown with relative thickness $\bar{c}=5\%$, With the number $M_\infty=2.5$. Construct the pressure distribution diagram for each profile at angles of attack $\alpha = 0,-5^\circ,+5^\circ$.

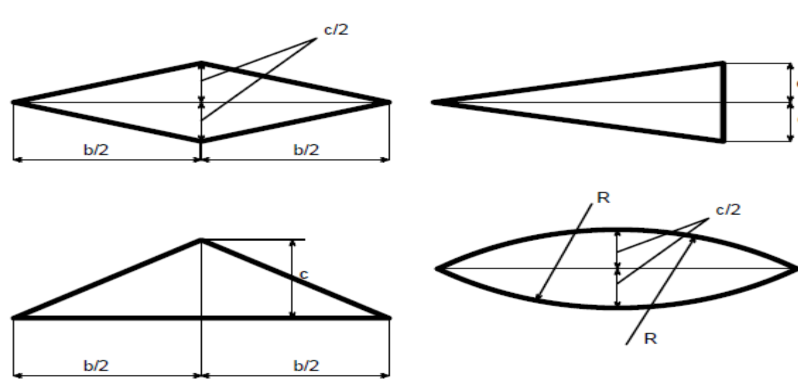

Fig. 2: four profiles shown with relative thickness

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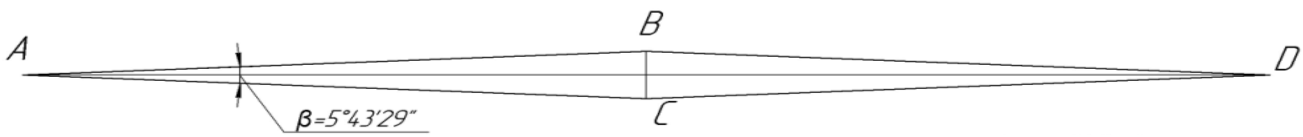
II. Working Process of the Research

Profile 1.

$$tg\left(\frac{\beta}{2}\right) = \frac{5}{100} = 0.05$$

$$\frac{\beta}{2} = 0.049958 \text{ rad} = 2.862405° = 2°51'45''$$

$$\beta = 0.099917 \text{ rad} = 5.724811° = 5°43'29''$$



Angle of Attack Profile : $\boldsymbol{\alpha = -5° = -0.08727}$ rad

Area AB

$$\Theta_{AB} = \alpha - \frac{\beta}{2} = -0.08726646 - 0.0499584 =$$

$$= -0.13722 \text{ rad} = -7.86241° = -7°51'45''$$

$$C_p = -\frac{2 \cdot \Theta_{AB}}{\sqrt{M_\infty^2 - 1}} = -\frac{2 \cdot (-0.13722486)}{\sqrt{2.5^2 - 1}} = 0.1198$$

Area BD

$$\Theta_{BD} = \alpha + \frac{\beta}{2} = -0.08726646 + 0.0499584 = -0.03731 \text{ rad} = -2.13759° = -2°8'15''$$

$$C_p = -\frac{2 \cdot \Theta_{BD}}{\sqrt{M_\infty^2 - 1}} = -\frac{2 \cdot (-0.03730806)}{\sqrt{2.5^2 - 1}} = 0.0326$$

Area AC

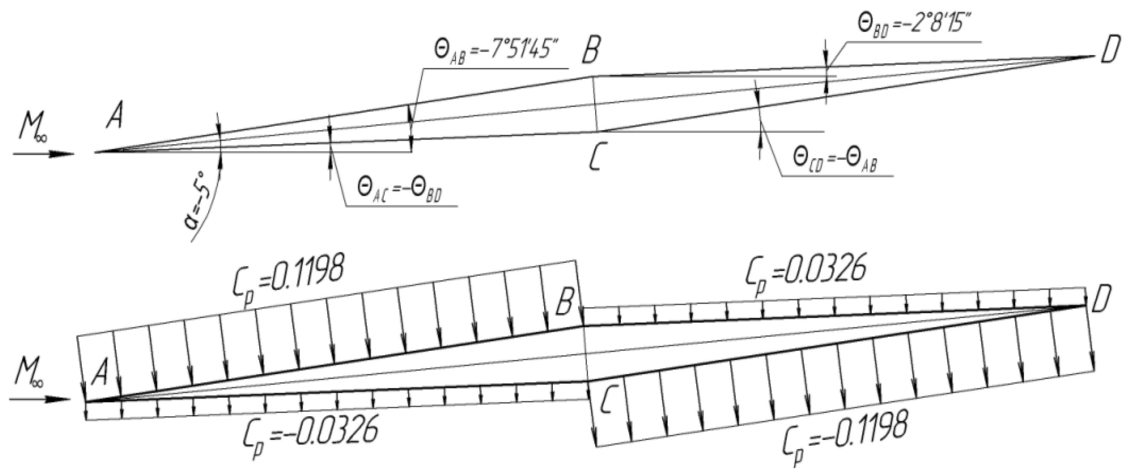
$$\Theta_{AC} = -\Theta_{BD} = 0.037308 \text{ rad} = 2.137594° = 2°8'15''$$

$$C_p = -\frac{2 \cdot \Theta_{AC}}{\sqrt{M_\infty^2 - 1}} = -\frac{2 \cdot (0.03730806)}{\sqrt{2.5^2 - 1}} = -0.0326$$

Area CD

$$\Theta_{CD} = -\Theta_{AB} = 0.137225 \text{ rad} = 7.862405° = 7°51'45''$$

$$C_p = -\frac{2 \cdot \Theta_{CD}}{\sqrt{M_\infty^2 - 1}} = -\frac{2 \cdot (0.13722486)}{\sqrt{2.5^2 - 1}} = -0.1198$$



Angle of Attack Profile : $\boldsymbol{\alpha} = \mathbf{0°{=}0}$ rad

Area AB

$$\Theta_{AB} = \alpha - \frac{\beta}{2} = 0 - 0.0499584 = -0.04996\ \text{rad} = -2.86241° = -2°51'45''$$

$$C_p = -\frac{2\cdot\Theta_{AB}}{\sqrt{M_\infty^2-1}} = -\frac{2\cdot(-0.0499584)}{\sqrt{2.5^2-1}} = 0.0436$$

Area BD

$$\Theta_{BD} = \alpha + \frac{\beta}{2} = 0 + \Theta_{CD} = -\Theta_{AB} = 0.049958\ \text{rad}=2.862405°=2°51'45''$$

$$C_p = -\frac{2\cdot\Theta_{BD}}{\sqrt{M_\infty^2-1}} = -\frac{2\cdot 0.0499584}{\sqrt{2.5^2-1}} = -0.0436$$

Area AC

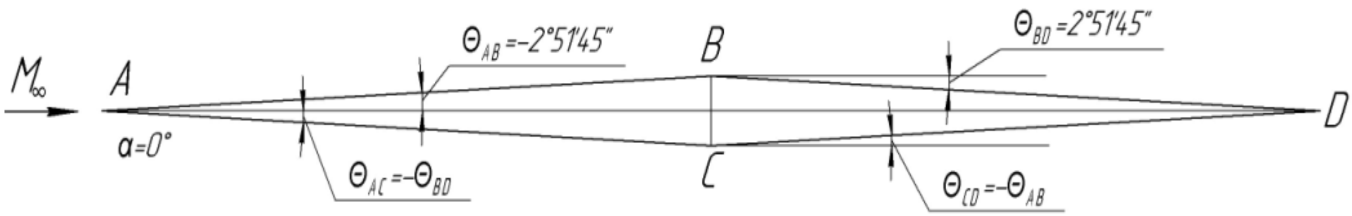
$$\Theta_{AC} = -\Theta_{BD} = -0.04996\ \text{rad} = -2.86241° = -2°51'45''$$

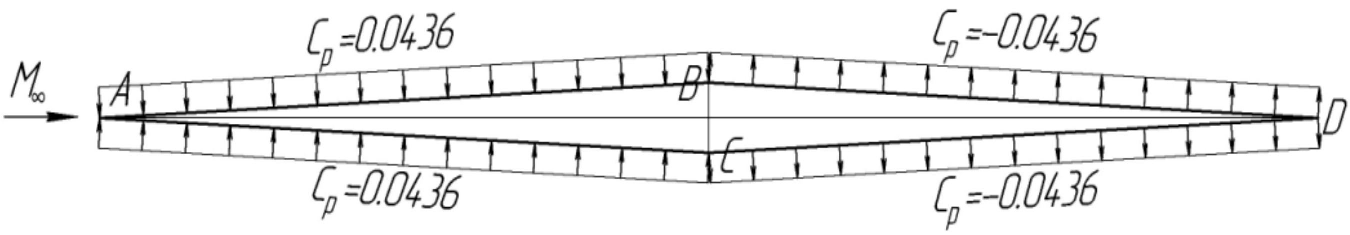
$$C_p = -\frac{2\cdot\Theta_{AC}}{\sqrt{M_\infty^2-1}} = -\frac{2\cdot(-0.0499584)}{\sqrt{2.5^2-1}} = 0.0436$$

Area CD

$$\Theta_{CD} = -\Theta_{AB} = 0.049958\ \text{rad}=2.862405°=2°51'45''$$

$$C_p = -\frac{2\cdot\Theta_{CD}}{\sqrt{M_\infty^2-1}} = -\frac{2\cdot(0.0499584)}{\sqrt{2.5^2-1}} = -0.0436$$





Angle of Attack Profile : $\boldsymbol{\alpha} = \mathbf{5°=0.087266}$ rad

Area AB

$$\Theta_{AB} = \alpha - \frac{\beta}{2} = 0.08726646 - 0.0499584 = 0.037308 \text{ rad}=2.137594°=2°8'15''$$

$$C_p = -\frac{2 \cdot \Theta_{AB}}{\sqrt{M_\infty^2 - 1}} = -\frac{2 \cdot 0.03730806}{\sqrt{2.5^2 - 1}} = -0.0326$$

Area BD

$$\Theta_{BD} = \alpha + \frac{\beta}{2} = 0.08726646 + \Theta_{CD} = -\Theta_{AB} = 0.137225 \text{ rad}=7.862405°=7°51'45''$$

$$C_p = -\frac{2 \cdot \Theta_{BD}}{\sqrt{M_\infty^2 - 1}} = -\frac{2 \cdot 0.13722486}{\sqrt{2.5^2 - 1}} = -0.1198$$

Area AC

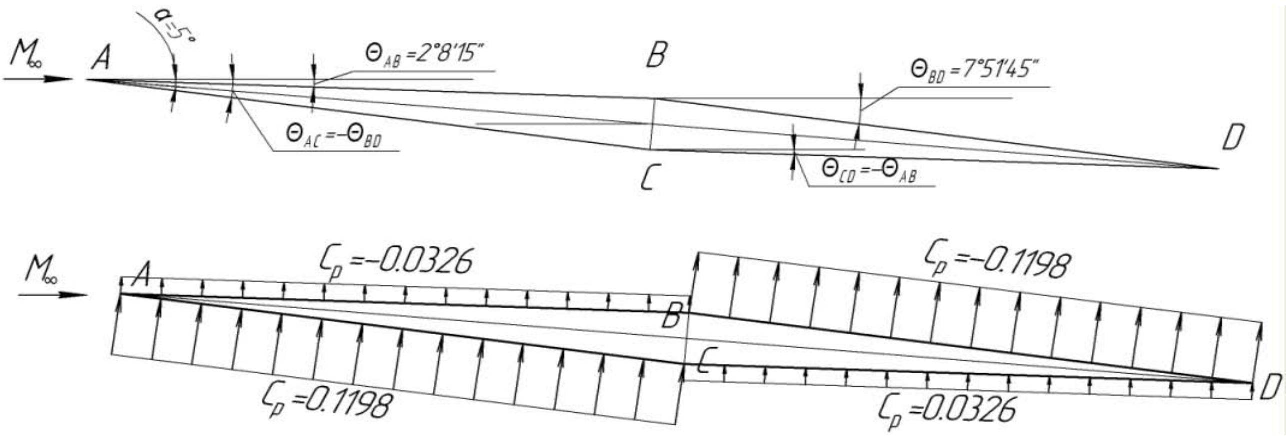
$$\Theta_{AC} = -\Theta_{BD} = -0.13722 \text{ rad}= -7.86241°= -7°51'45''$$

$$C_p = -\frac{2 \cdot \Theta_{AC}}{\sqrt{M_\infty^2 - 1}} = -\frac{2 \cdot (-0.13722486)}{\sqrt{2.5^2 - 1}} = 0.1198$$

Area CD

$$\Theta_{CD} = -\Theta_{AB} = -0.03731 \text{ rad}= -2.13759°= -2°8'15''$$

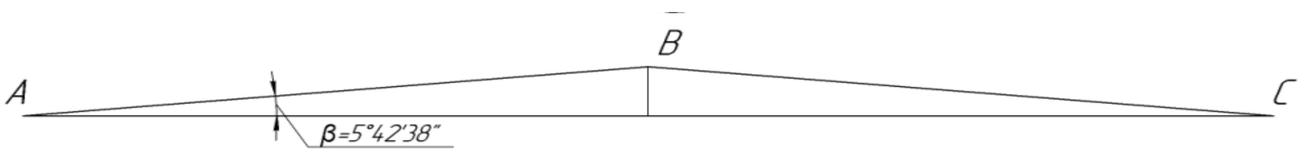
$$C_p = -\frac{2 \cdot \Theta_{CD}}{\sqrt{M_\infty^2 - 1}} = -\frac{2 \cdot (-0.03730806)}{\sqrt{2.5^2 - 1}} = 0.0326$$



Profile 2.

$$tg(\beta)=\frac{2\cdot 5}{100}=0.1$$

$$\beta = 0.099669 \text{ rad}=5.710593°=5°42'38''$$



Angle of Attack Profile : $\boldsymbol{\alpha = -5° = -0.08727}$ rad

Area AB

$$\Theta_{AB} = \alpha-\beta = -0.08726646-0.09966865 =$$

$$= -0.18694 \text{ rad}= -10.7106°= -10°42'38''$$

$$C_p = -\frac{2\cdot\Theta_{AB}}{\sqrt{M_\infty^2-1}} = -\frac{2\cdot(-0.18693511)}{\sqrt{2.5^2-1}} = 0.1632$$

Area AC

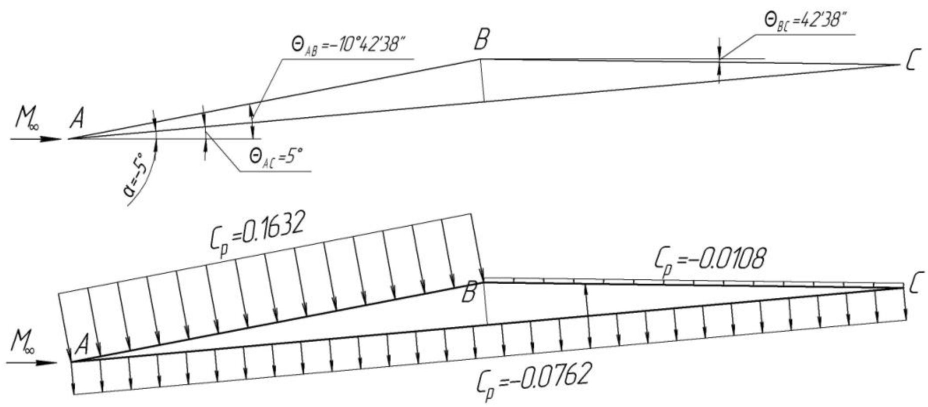
$$\Theta_{AC} = -\alpha = 0.087266 \text{ rad}=5°$$

$$C_p = -\frac{2\cdot\Theta_{AC}}{\sqrt{M_\infty^2-1}} = -\frac{2\cdot(0.08726646)}{\sqrt{2.5^2-1}} = -0.0762$$

Area BC

$$\Theta_{BC} = \alpha+\beta = -0.08726646+0.09966865 = 0.012402 \text{ rad}=0.710593°=0°42'38''$$

$$C_p = -\frac{2\cdot\Theta_{BC}}{\sqrt{M_\infty^2-1}} = -\frac{2\cdot(0.01240219)}{\sqrt{2.5^2-1}} = -0.0108$$



Angle of Attack Profile : $\boldsymbol{\alpha} = \mathbf{0°=0}$ rad

Area AB

$$\Theta_{AB} = \alpha - \beta = 0 - 0.09966865 = -0.\ 09967 \text{ rad} = -\ 5.71059° = -\ 5°42'38''$$

$$C_p = -\frac{2 \cdot \Theta_{AB}}{\sqrt{M_\infty^2 - 1}} = -\frac{2 \cdot (-0.09966865)}{\sqrt{2.5^2 - 1}} = 0.087$$

Area AC

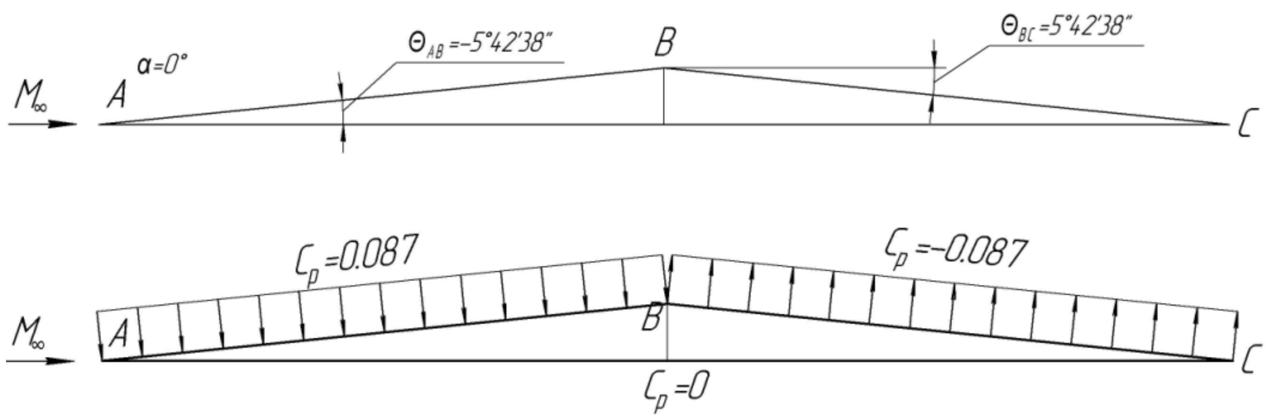
$$\Theta_{AC} = -\alpha = 0 \text{ rad} = 0°$$

$$C_p = -\frac{2 \cdot \Theta_{AC}}{\sqrt{M_\infty^2 - 1}} = -\frac{2 \cdot (0)}{\sqrt{2.5^2 - 1}} = 0$$

Area BC

$$\Theta_{BC} = \alpha + \beta = 0 + 0.09966865 = 0.099669 \text{ rad} = 5.710593° = 5°42'38''$$

$$C_p = -\frac{2 \cdot \Theta_{BC}}{\sqrt{M_\infty^2 - 1}} = -\frac{2 \cdot (0.09966865)}{\sqrt{2.5^2 - 1}} = -0.087$$



Angle of Attack Profile : $\boldsymbol{\alpha} = \mathbf{5°=0.087266}$ rad

Area AB

$\Theta_{AB} = \alpha - \beta = 0.08726646 - 0.09966865 = -0.0124$ rad$= -0.71059° = -0°42'38''$

$$C_p = -\frac{2 \cdot \Theta_{AB}}{\sqrt{M_\infty^2 - 1}} = -\frac{2 \cdot (-0.01240219)}{\sqrt{2.5^2 - 1}} = 0.0108$$

Area AC

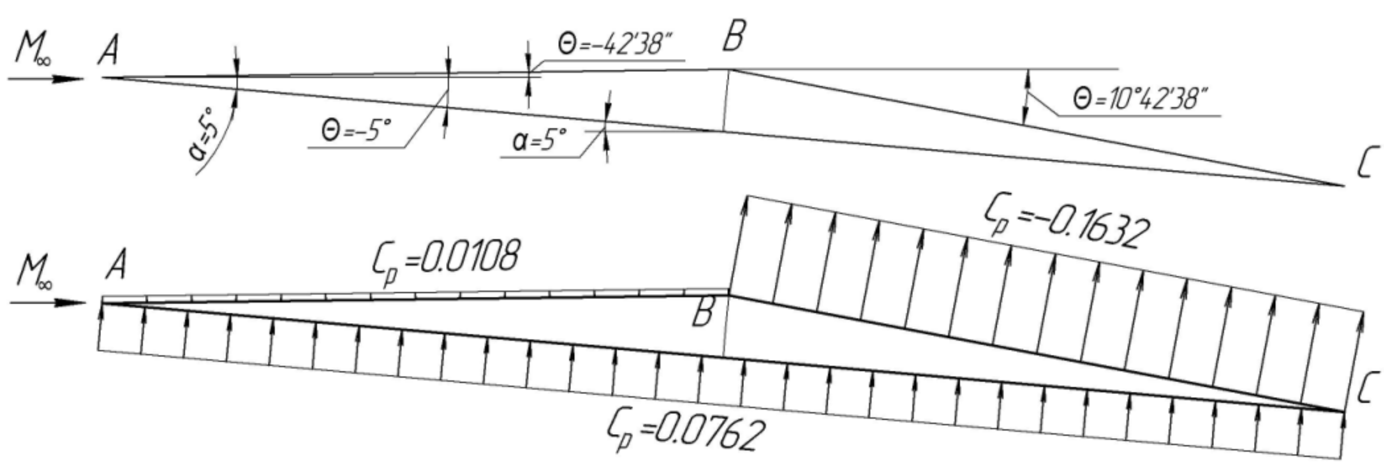
$$\Theta_{AC} = -\alpha = -0.08727 \text{ рад} = -5°$$

$$C_p = -\frac{2 \cdot \Theta_{AC}}{\sqrt{M_\infty^2 - 1}} = -\frac{2 \cdot (-0.08726646)}{\sqrt{2.5^2 - 1}} = 0.0762$$

Area BC

$\Theta_{BC} = \alpha + \beta = 0.08726646 + 0.09966865 = 0.186935$ rad$=10.71059°=10°42'38''$

$$C_p = -\frac{2 \cdot \Theta_{BC}}{\sqrt{M_\infty^2 - 1}} = -\frac{2 \cdot (0.18693511)}{\sqrt{2.5^2 - 1}} = -0.1632$$

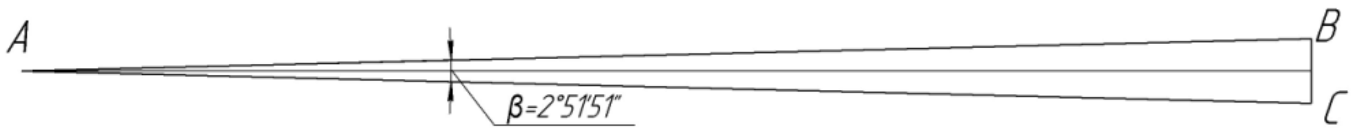


Profile 3.

$$tg\left(\frac{\beta}{2}\right) = \frac{5}{2 \cdot 100} = 0.025$$

$$\frac{\beta}{2} = 0.024995 \text{ rad} = 1.432096° = 1°25'56''$$

$$\beta = 0.04999 \text{ rad} = 2.864192° = 2°51'51''$$



Angle of Attack Profile : $\boldsymbol{\alpha} = \mathbf{-5°= - 0.08727}$ rad

<u>Area AB</u>

$$\Theta_{AB} = \alpha - \frac{\beta}{2} = -0.08726646 - 0.02499479 =$$

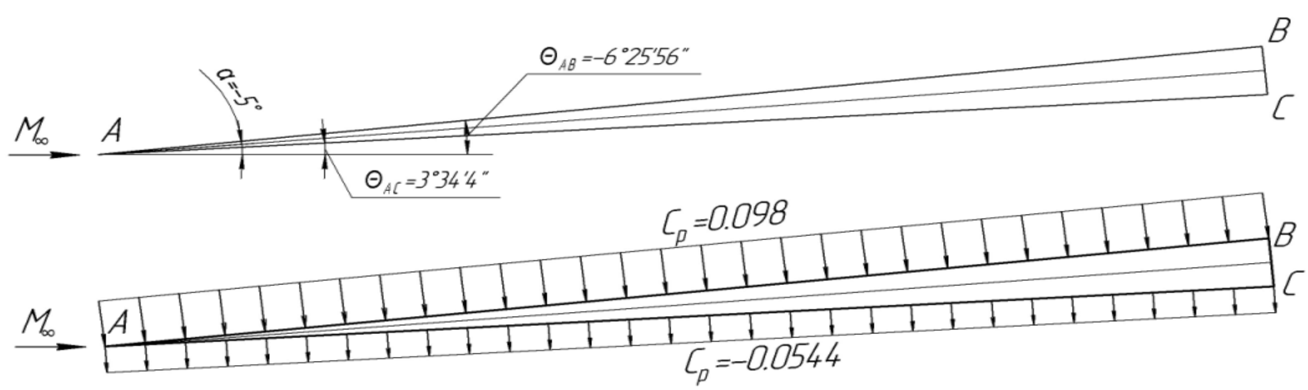
$$= -0.11226 \text{ rad} = -6.4321° = -6°25'56''$$

$$C_p = -\frac{2 \cdot \Theta_{AB}}{\sqrt{M_\infty^2 - 1}} = -\frac{2 \cdot (-0.11226125)}{\sqrt{2.5^2 - 1}} = 0.098$$

<u>Area AC</u>

$$\Theta_{AC} = -\alpha - \frac{\beta}{2} = - - 0.08726646 - 0.02499479 = 0.062272 \text{ rad} = 3.567904° = 3°34'4''$$

$$C_p = -\frac{2 \cdot \Theta_{AC}}{\sqrt{M_\infty^2 - 1}} = -\frac{2 \cdot (0.06227167)}{\sqrt{2.5^2 - 1}} = -0.0544$$



Angle of Attack Profile : $\boldsymbol{\alpha} = \mathbf{0°=0}$ rad

<u>Area AB</u>

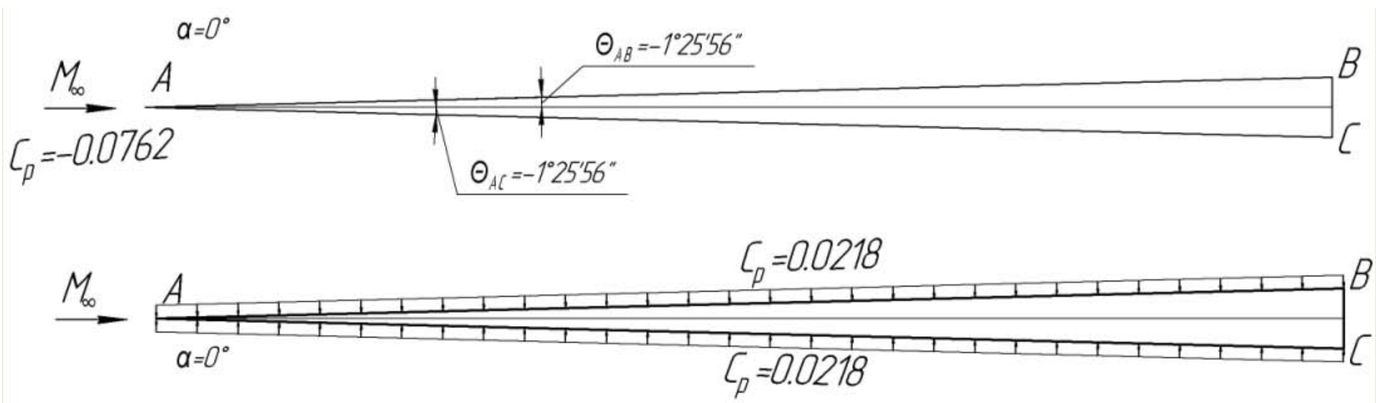
$$\Theta_{AB} = \alpha - \frac{\beta}{2} = 0 - 0.02499479 = -0.02499 \text{ rad} = -1.4321° = -1°25'56''$$

$$C_p = -\frac{2 \cdot \Theta_{AB}}{\sqrt{M_\infty^2 - 1}} = -\frac{2 \cdot (-0.02499479)}{\sqrt{2.5^2 - 1}} = 0.0218$$

Area AC

$$\Theta_{AC} = -\alpha - \frac{\beta}{2} = -0 - 0.02499479 = -0.02499 \text{ rad} = -1.4321° = -1°25'56''$$

$$C_p = -\frac{2 \cdot \Theta_{AC}}{\sqrt{M_\infty^2 - 1}} = -\frac{2 \cdot (-0.02499479)}{\sqrt{2.5^2 - 1}} = 0.0218$$



Angle of Attack Profile : $\boldsymbol{\alpha} = \mathbf{5°=0.087266}$ rad

Area AB

$$\Theta_{AB} = \alpha - \frac{\beta}{2} = 0.08726646 - 0.02499479 = 0.062272 \text{ rad} = 3.567904° = 3°34'4''$$

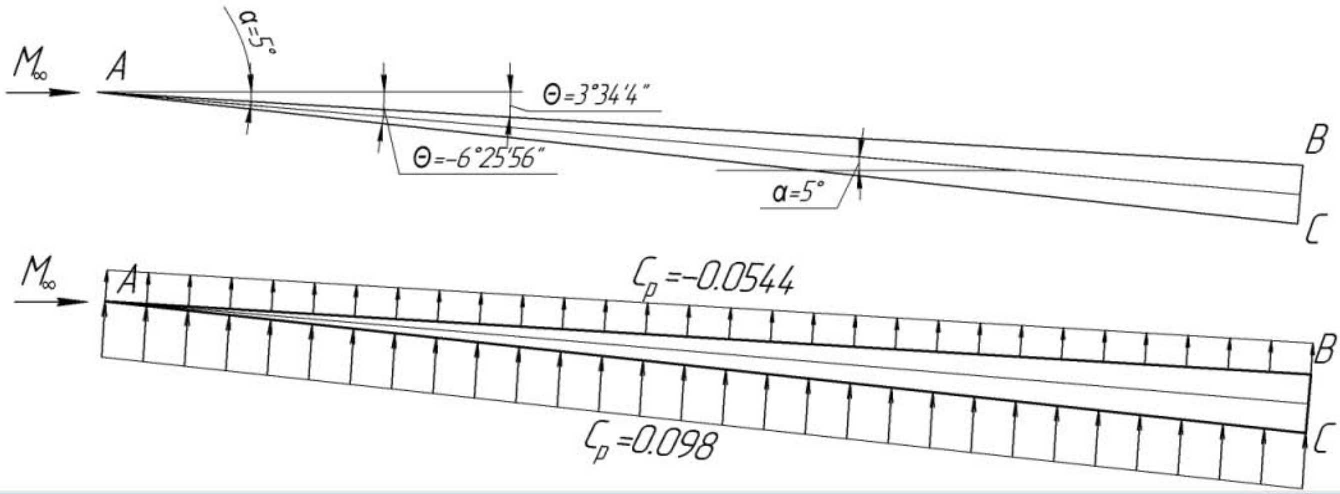
$$C_p = -\frac{2 \cdot \Theta_{AB}}{\sqrt{M_\infty^2 - 1}} = -\frac{2 \cdot 0.06227167}{\sqrt{2.5^2 - 1}} = -0.0544$$

Area AC

$$\Theta_{AC} = -\alpha - \frac{\beta}{2} = -0.08726646 - 0.02499479 =$$

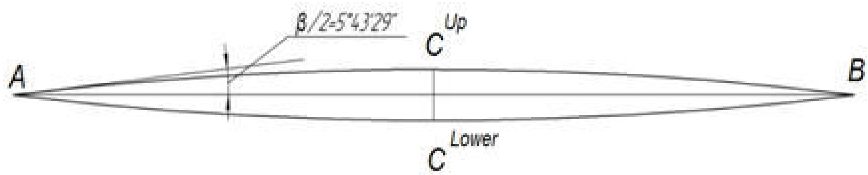
$$= -0.11226 \text{ rad} = -6.4321° = -6°25'56''$$

$$C_p = -\frac{2 \cdot \Theta_{AC}}{\sqrt{M_\infty^2 - 1}} = -\frac{2 \cdot (-0.11226125)}{\sqrt{2.5^2 - 1}} = 0.098$$



Profile 4.

$$\frac{\beta}{2} = 0.099917 \text{ rad}=5.724822°= 5°43'29''$$



Angle of Attack Profile : $\boldsymbol{\alpha} = \mathbf{5°{=}0.087266}$ rad

$$\Theta_A^{up} = \alpha - \frac{\beta}{2} = (0.08726646) - 0.099917 = -0.01265 \text{ rad}= -0.72482°= -0°43'29''$$

$$C_p = -\frac{2 \cdot \Theta_A^{up}}{\sqrt{M_\infty^2 - 1}} = -\frac{2 \cdot (-0.01265054)}{\sqrt{2.5^2 - 1}} = 0.011$$

$$\Theta_C^{up} = \alpha = 0.087266 \text{ rad}=5$$

$$C_p = -\frac{2 \cdot \Theta_C^{up}}{\sqrt{M_\infty^2 - 1}} = -\frac{2 \cdot (0.08726646)}{\sqrt{2.5^2 - 1}} = -0.0762$$

$$\Theta_B^{up} = \alpha + \frac{\beta}{2} = (0.08726646) + 0.099917 = 0.187183 \text{ rad}=10.72482°=10°43'29''$$

$$C_p = -\frac{2 \cdot \Theta_B^{up}}{\sqrt{M_\infty^2 - 1}} = -\frac{2 \cdot (0.18718346)}{\sqrt{2.5^2 - 1}} = -0.1634$$

$$\Theta_A^{Lower} = -\alpha - \frac{\beta}{2} = (-0.08726646) - 0.099917 =$$

$$= -0.18718 \text{ rad} = -10.7248° = -10°43'29''$$

$$C_p = -\frac{2 \cdot \Theta_A^{Lower}}{\sqrt{M_\infty^2 - 1}} = -\frac{2 \cdot (-0.18718346)}{\sqrt{2.5^2 - 1}} = 0.1634$$

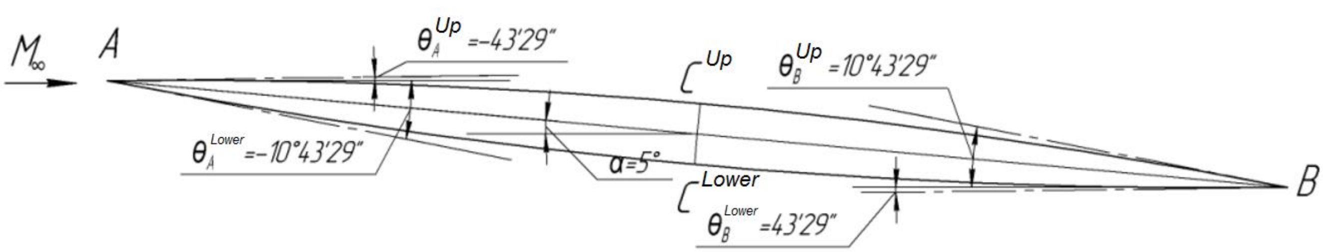
$$\Theta_C^{Lower} = -\alpha = -0.08727 \text{ rad} = -5$$

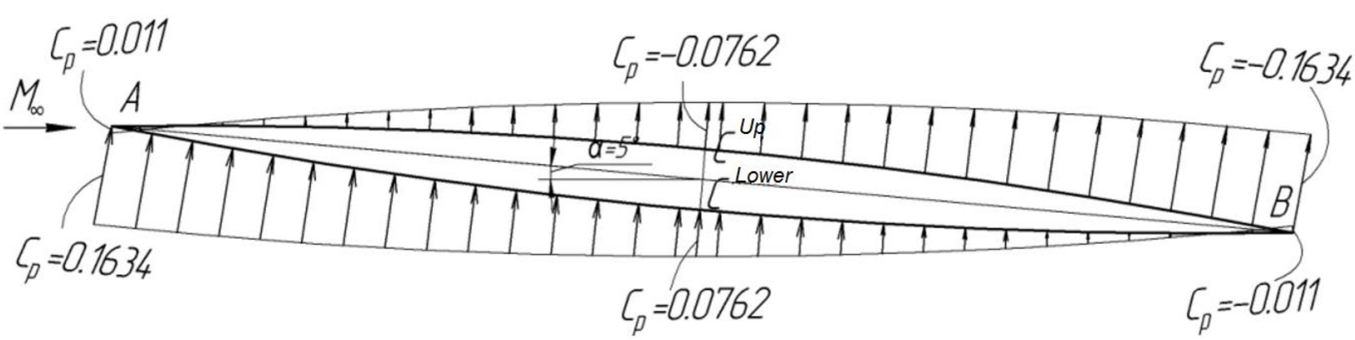
$$C_p = -\frac{2 \cdot \Theta_C^{Lower}}{\sqrt{M_\infty^2 - 1}} = -\frac{2 \cdot (-0.08726646)}{\sqrt{2.5^2 - 1}} = 0.0762$$

$$\Theta_B^{Lower} = -\alpha + \frac{\beta}{2} = (-0.08726646) + 0.099917 =$$

$$= 0.012651 \text{ rad} = 0.724823° = 0°43'29''$$

$$C_p = -\frac{2 \cdot \Theta_B^{Lower}}{\sqrt{M_\infty^2 - 1}} = -\frac{2 \cdot (0.01265054)}{\sqrt{2.5^2 - 1}} = -0.011$$





Angle of Attack Profile : $\boldsymbol{\alpha = 0° = 0}$ **rad**

$$\Theta_A^{up} = \alpha - \frac{\beta}{2} = (0) - 0.099917 = -0.09992 \text{ rad} = -5.72482° = -5°43'29''$$

$$C_p = -\frac{2 \cdot \Theta_A^{up}}{\sqrt{M_\infty^2 - 1}} = -\frac{2 \cdot (-0.099917)}{\sqrt{2.5^2 - 1}} = 0.0872$$

$$\Theta_C^{up} = \alpha = 0 \text{ rad=0}$$

$$C_p = -\frac{2 \cdot \Theta_C^{up}}{\sqrt{M_\infty^2 - 1}} = -\frac{2 \cdot (0)}{\sqrt{2.5^2 - 1}} = 0$$

$$\Theta_B^{up} = \alpha + \frac{\beta}{2} = (0) + 0.099917 = 0.099917 \text{ rad=}5.724822° = 5°43'29''$$

$$C_p = -\frac{2 \cdot \Theta_B^{up}}{\sqrt{M_\infty^2 - 1}} = -\frac{2 \cdot (0.099917)}{\sqrt{2.5^2 - 1}} = -0.0872$$

$$\Theta_A^{Lower} = -\alpha - \frac{\beta}{2} = (-0) - 0.099917 = -0.09992 \text{ rad=} -5.72482° = -5°43'29''$$

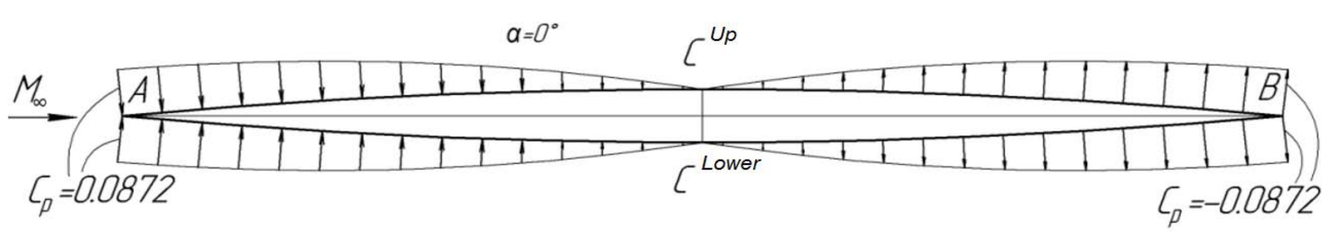
$$C_p = -\frac{2 \cdot \Theta_A^{Lower}}{\sqrt{M_\infty^2 - 1}} = -\frac{2 \cdot (-0.099917)}{\sqrt{2.5^2 - 1}} = 0.0872$$

$$\Theta_C^{Lower} = -\alpha = 0 \text{ rad=0}$$

$$C_p = -\frac{2 \cdot \Theta_C^{Lower}}{\sqrt{M_\infty^2 - 1}} = -\frac{2 \cdot (0)}{\sqrt{2.5^2 - 1}} = 0$$

$$\Theta_B^{Lower} = -\alpha + \frac{\beta}{2} = (-0) + 0.099917 = 0.099917 \text{ rad=}5.724822° = 5°43'29''$$

$$C_p = -\frac{2 \cdot \Theta_B^{Lower}}{\sqrt{M_\infty^2 - 1}} = -\frac{2 \cdot (0.099917)}{\sqrt{2.5^2 - 1}} = -0.0872$$



Angle of Attack Profile : $\boldsymbol{\alpha = -5° = -0.08727}$ rad

$$\Theta_A^{up} = \alpha - \frac{\beta}{2} = (-0.08726646) - 0.099917 =$$

$$= -0.18718 \text{ rad} = -10.7248° = -10°43'29''$$

$$C_p = -\frac{2 \cdot \Theta_A^{up}}{\sqrt{M_\infty^2 - 1}} = -\frac{2 \cdot (-0.18718346)}{\sqrt{2.5^2 - 1}} = 0.1634$$

$$\Theta_C^{up} = \alpha = -0.08727 \text{ rad} = -5$$

$$C_p = -\frac{2 \cdot \Theta_C^{up}}{\sqrt{M_\infty^2 - 1}} = -\frac{2 \cdot (-0.08726646)}{\sqrt{2.5^2 - 1}} = 0.0762$$

$$\Theta_B^{up} = \alpha + \frac{\beta}{2} = (-0.08726646) + 0.099917 = 0.012651 \text{ rad} = 0.724823° = 0°43'29''$$

$$C_p = -\frac{2 \cdot \Theta_B^{up}}{\sqrt{M_\infty^2 - 1}} = -\frac{2 \cdot (0.01265054)}{\sqrt{2.5^2 - 1}} = -0.011$$

$$\Theta_A^{Lower} = -\alpha - \frac{\beta}{2} = (- -0.08726646) - 0.099917 =$$

$$= -0.01265 \text{ rad} = -0.72482° = -0°43'29''$$

$$C_p = -\frac{2 \cdot \Theta_A^{Lower}}{\sqrt{M_\infty^2 - 1}} = -\frac{2 \cdot (-0.01265054)}{\sqrt{2.5^2 - 1}} = 0.011$$

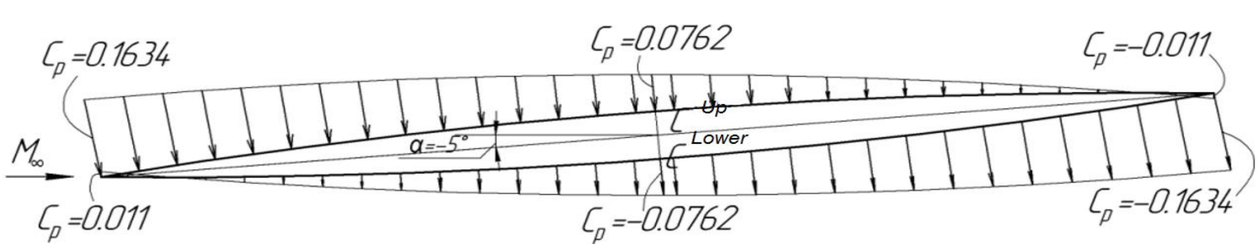
$$\Theta_C^{Lower} = -\alpha = 0.087266 \text{ rad} = 5$$

$$C_p = -\frac{2 \cdot \Theta_C^{Lower}}{\sqrt{M_\infty^2 - 1}} = -\frac{2 \cdot (0.08726646)}{\sqrt{2.5^2 - 1}} = -0.0762$$

$$\Theta_B^{Lower} = -\alpha + \frac{\beta}{2} = (- -0.08726646) + 0.099917 =$$

$$= 0.187183 \text{ rad} = 10.72482° = 10°43'29''$$

$$C_p = -\frac{2 \cdot \Theta_B^{Lower}}{\sqrt{M_\infty^2 - 1}} = -\frac{2 \cdot (0.18718346)}{\sqrt{2.5^2 - 1}} = -0.1634$$



Determination of the coefficient of profile-wave resistance for given angles of attack

The coefficient of profile-wave resistance:

$$C_x = \frac{4 \cdot \alpha^2}{\sqrt{M_\infty^2 - 1}} + \frac{K_1 \cdot \bar{c}^2}{\sqrt{M_\infty^2 - 1}}$$

Parameter K1 depends on the shape of the profile:

$$K_1 = 2\int_0^1 \left[\left(\frac{d\bar{y}_{\mathrm{U}}}{d\bar{x}}\right)^2 + \left(\frac{d\bar{y}_{\mathrm{L}}}{d\bar{x}}\right)^2\right] d\bar{x}$$

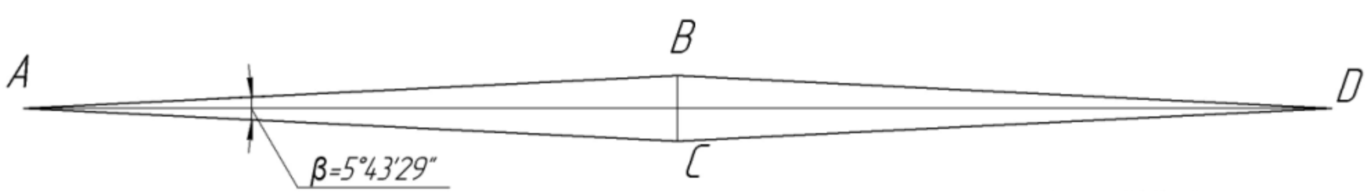
$$\frac{d\bar{y}_{\mathrm{U}}}{d\bar{x}} = \frac{1}{\bar{c}} \cdot \frac{dy_{\mathrm{U}}}{dx}$$

$\frac{dy_{\mathrm{U}}}{dx}$ $-$ *Angle of inclination of the upper profile area to the profile chord*

$$\frac{d\bar{y}_{\mathrm{L}}}{d\bar{x}} = \frac{1}{\bar{c}} \cdot \frac{dy_{\mathrm{L}}}{dx}$$

$\frac{dy_{\mathrm{L}}}{dx}$ $-$ *Angle of inclination of the lower profile area to the profile chord*

Defining the value of the parameter K1 for profile 1:



$$\bar{c} = \frac{\beta}{2}$$

$$\frac{dy_{\mathrm{U}}}{dx} = \frac{\beta}{2}, \quad \frac{d\bar{y}_{\mathrm{U}}}{d\bar{x}} = 1 \quad - \textit{for the platform } AB$$

$$\frac{dy_{\mathrm{U}}}{dx} = -\frac{\beta}{2}, \quad \frac{d\bar{y}_{\mathrm{U}}}{d\bar{x}} = -1 \quad - \textit{for the platform } BD$$

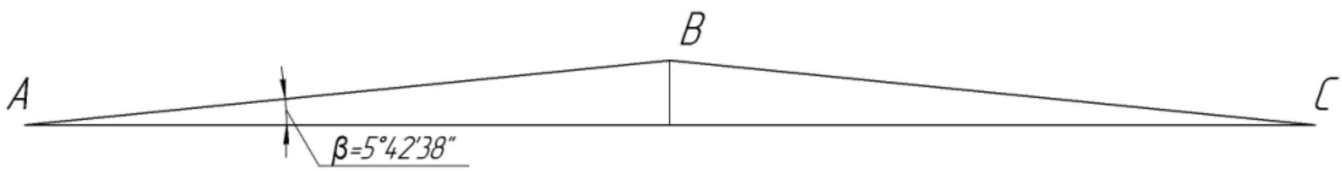
$$\frac{dy_{\mathrm{L}}}{dx} = -\frac{\beta}{2}, \quad \frac{d\bar{y}_{\mathrm{L}}}{d\bar{x}} = -1 \quad - \textit{for the platform } AC$$

$$\frac{dy_{\mathrm{L}}}{dx} = \frac{\beta}{2}, \quad \frac{dy_{\mathrm{L}}}{d\bar{x}} = 1 - \textit{for the platform } CD$$

Then the parameter K1 for profile 1 will be equal to

$$K_1 = 2 \cdot (1^2 \cdot 0.5 + (-1)^2 \cdot 0.5 + (-1)^2 \cdot 0.5 + 1^2 \cdot 0.5) = 2 \cdot 2 = 4$$

Defining the value of the parameter K1 for profile 2:



$$\bar{c} = \frac{\beta}{2}$$

$$\frac{dy_U}{dx} = \beta, \quad \frac{d\overline{y_U}}{d\bar{x}} = 2 \quad - for\ the\ platform\ AB$$

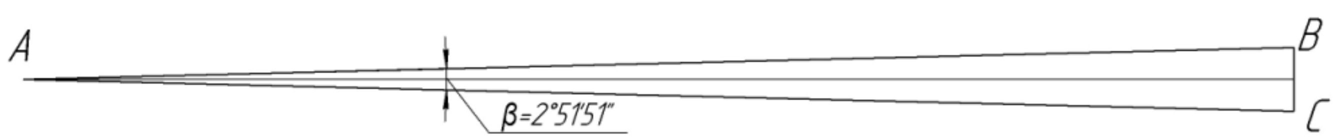
$$\frac{dy_U}{dx} = -\beta, \quad \frac{d\overline{y_U}}{d\bar{x}} = -2 \ - for\ the\ platform\ BC$$

$$\frac{dy_L}{dx} = 0 \ - for\ the\ platform\ AC$$

Then the parameter K1 for profile 2 will be equal to

$$K_1 = 2 \cdot ((2)^2 \cdot 0.5 + (-2)^2 \cdot 0.5 + (0)^2 \cdot 1) = 2 \cdot 4 = 8$$

Defining the value of the parameter K1 for profile 3:



$$\bar{c} = \beta$$

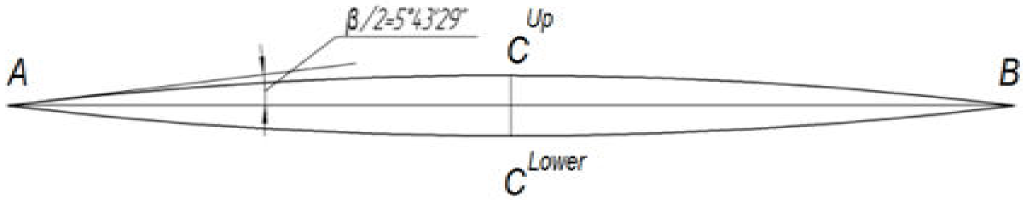
$$\frac{dy_U}{dx} = \frac{\beta}{2}, \quad \frac{d\overline{y_U}}{d\bar{x}} = 0.5 \quad - for\ the\ platform\ AB$$

$$\frac{dy_L}{dx} = -\frac{\beta}{2}, \quad \frac{d\overline{y_L}}{d\bar{x}} = -0.5 \ - for\ the\ platform\ AC$$

Then the parameter K1 for profile 3 will be equal to

$$K_1 = 2 \cdot ((0.5)^2 \cdot 1 + (-0.5)^2 \cdot 1) = 2 \cdot 0.5 = 1$$

Defining the value of the parameter K1 for profile 4:



III. Results

By determining the parameter K1 for each profile, we can calculate the coefficients of the profile-wave resistance for given angles of attack:

$$K_1 = \frac{16}{3}$$

Profile 1.

$$K_1 = 4$$

$$\alpha = 0° = 0 \text{ rad}$$

$$C_x = \frac{4 \cdot \alpha^2}{\sqrt{M_\infty^2 - 1}} + \frac{K_1 \cdot c^2}{\sqrt{M_\infty^2 - 1}} = \frac{4 \cdot 0^2}{\sqrt{2.5^2 - 1}} + \frac{4 \cdot 0.05^2}{\sqrt{2.5^2 - 1}} = 0.0044$$

$$\alpha = \pm 5° = \pm 0.087266 \text{ rad}$$

$$C_x = \frac{4 \cdot \alpha^2}{\sqrt{M_\infty^2 - 1}} + \frac{K_1 \cdot c^2}{\sqrt{M_\infty^2 - 1}} = \frac{4 \cdot 0.08726646^2}{\sqrt{2.5^2 - 1}} + \frac{4 \cdot 0.05^2}{\sqrt{2.5^2 - 1}} = 0.0177$$

Profile 2.

$$K_1 = 8$$

$$\alpha = 0° = 0 \text{ rad}$$

$$C_x = \frac{4 \cdot \alpha^2}{\sqrt{M_\infty^2 - 1}} + \frac{K_1 \cdot c^2}{\sqrt{M_\infty^2 - 1}} = \frac{4 \cdot 0^2}{\sqrt{2.5^2 - 1}} + \frac{8 \cdot 0.05^2}{\sqrt{2.5^2 - 1}} = 0.0087$$

$$\alpha = \pm 5° = \pm 0.087266 \text{ rad}$$

$$C_x = \frac{4 \cdot \alpha^2}{\sqrt{M_\infty^2 - 1}} + \frac{K_1 \cdot c^2}{\sqrt{M_\infty^2 - 1}} = \frac{4 \cdot 0.08726646^2}{\sqrt{2.5^2 - 1}} + \frac{8 \cdot 0.05^2}{\sqrt{2.5^2 - 1}} = 0.022$$

Profile 3.

$$K_1 = 1$$

$$\alpha = 0° = 0 \text{ rad}$$

$$C_x = \frac{4 \cdot \alpha^2}{\sqrt{M_\infty^2 - 1}} + \frac{K_1 \cdot c^2}{\sqrt{M_\infty^2 - 1}} = \frac{4 \cdot 0^2}{\sqrt{2.5^2 - 1}} + \frac{1 \cdot 0.05^2}{\sqrt{2.5^2 - 1}} = 0.0011$$

$$\alpha = \pm 5° = \pm 0.087266 \text{ rad}$$

$$C_x = \frac{4 \cdot \alpha^2}{\sqrt{M_\infty^2 - 1}} + \frac{K_1 \cdot c^2}{\sqrt{M_\infty^2 - 1}} = \frac{4 \cdot 0.08726646^2}{\sqrt{2.5^2 - 1}} + \frac{1 \cdot 0.05^2}{\sqrt{2.5^2 - 1}} = 0.0144$$

Profile 4.

$$K_1 = \frac{16}{3} = 5.333$$

$$\alpha = 0° = 0 \text{ rad}$$

$$C_x = \frac{4 \cdot \alpha^2}{\sqrt{M_\infty^2 - 1}} + \frac{K_1 \cdot c^2}{\sqrt{M_\infty^2 - 1}} = \frac{4 \cdot 0^2}{\sqrt{2.5^2 - 1}} + \frac{5.333 \cdot 0.05^2}{\sqrt{2.5^2 - 1}} = 0.0058$$

$$\alpha = \pm 5° = \pm 0.087266 \text{ rad}$$

$$C_x = \frac{4 \cdot \alpha^2}{\sqrt{M_\infty^2 - 1}} + \frac{K_1 \cdot c^2}{\sqrt{M_\infty^2 - 1}} = \frac{4 \cdot 0.08726646^2}{\sqrt{2.5^2 - 1}} + \frac{5.333 \cdot 0.05^2}{\sqrt{2.5^2 - 1}} = 0.0191$$

IV. Conclusions

1. As the angle of attack increases to a certain value, the aerodynamic quality increases. At a certain angle of attack, the quality reaches a maximum value of K_{max}. This angle is called the most advantageous angle of attack, $\alpha_{The\ most\ advantageous}$.
2. On the angle of attack of the zero lifting force, where C_Y=0, the aerodynamic quality will be zero.
3. The effect on the aerodynamic quality of the profile shape is related to the relative thickness and curvature of the profile. The shape of the profile contours, the shape of the sock and the position of the maximum profile thickness along the chord
4. To obtain large values of K_{max}, the optimum thickness and curvature of the profile, the shape of the contours and the extension of the wing are selected.
5. To obtain the highest quality values, the best shape of the wing is elliptical with a rounded leading edge.
6. The zero lifting force angle α_0 is at the intersection of the polar with the axis C_x. At this angle of attack, the coefficient of lift is zero (C_Y=0). For the wings of modern aircraft, usually (α_0=2°÷0°). For modern wings, $\alpha_{The\ most\ advantageous}$ lies within (α_0=4°÷6°).

7. The angle of attack of the zero lifting force (α) of the aircraft is practically no different from the angle of attack of the zero lift of the wing. Since the lifting force is zero on the angle, at this angle of attack only the vertical movement of the aircraft downward, called a vertical dive, or a vertical hill at an angle of 90 ° is possible.
8. Angles of attack with the same aerodynamic quality are carried out from the origin of the coordinates of the secant to the field. At the points of intersection, we find the angles of attack (α_1 & α_2) When flying, where the aerodynamic quality will be the same and necessarily smaller

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