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PERFORMANCE OPTIMIZATION OF AN ORGANIC MUD AGITATOR SCREW

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Abstract. *Due to the special performances obtained by means of the optimisation method applied to the axial runners of run-of-river hydraulic turbines and of wind turbines, as well as in the case of the screws for boat propulsion, perfected by the first of the authors [1] ÷ [10], in this work one extend the application of this method at the case of an organic mud agitator screw for fermentation and biogas production. One presents the obtaining of the bio liquid circulation minimal velocity in the two possible cases [3]: extracting the fluid velocity from the peripheral force exerted by the runner, as well as from the mechanical power consumed for its driving. After the obtaining of the optimal relative peripheral angle one determines also the optimal incidence angles of the profile for other blade radii.*
This method permits in the same time to find the optimal profile, using the multitude of the profile characteristics, experimentally studied.

Keywords: Screw performances optimization, Mud agitator, Mud agitator screw, Bio fluids

1. The importance of the optimisation methods on posed problem

The problem of the bio liquid velocity minimisation, to not harm the growth biologic process of the bacteria existent in the organic mud, may be extracted from the axial F_a or peripheral F_u force, how and from the consumed mechanical power P_m at the agitator shaft and it is very important not only concerning the energy saving, but also for the environmental protection [1].

2. The primary equations, which intervene in this problem

Starting from the classical theory and practice of the airfoil placed as in figure 1, we have the following relations for the lift and drag component of resultant force:

$$F_y = C_y(i)\frac{\rho}{2}W^2 b\, l(R) \quad \text{and} \quad F_x = C_x(i)\frac{\rho}{2}W^2 b\, l(R) \qquad (1)$$

Projecting these forces, for example in the case of the blade peripheral profile, both on the axial direction and on the peripheral direction of the profile motion we can write the expressions of axial or peripheral force exerted on the rotor blades.

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$$F_a = F_y \cos\beta - F_x \sin\beta = \frac{\rho V^2 bl}{2}\left[C_y(i)\frac{\cos\beta}{\sin^2\beta} - C_x(i)\frac{1}{\sin\beta} \right], \tag{2}$$

$$F_u = F_x \cos\beta + F_y \sin\beta = \frac{\rho V^2 bl}{2}\left[C_x(i)\frac{\cos\beta}{\sin^2\beta} + C_y(i)\frac{1}{\sin\beta} \right], \tag{2'}$$

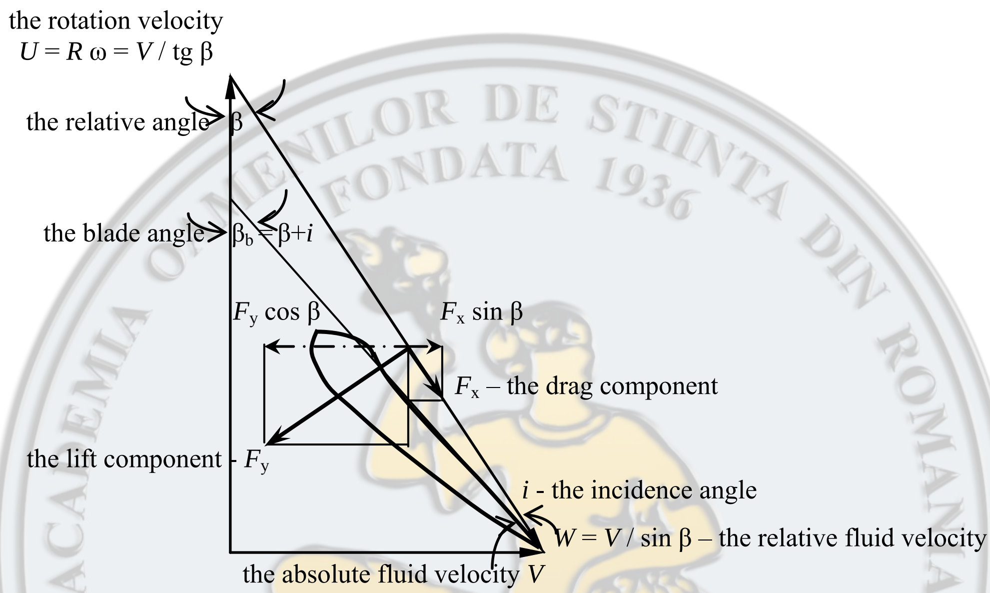

Fig. 1. Velocity triangle and the components of hydro-aero-dynamic resultant.

and also the expression of the shaft driving mechanical power

$$-P_m = U(F_y \sin\beta + F_x \cos\beta) = \frac{\rho V^3 bl}{2}\left[C_y(i)\frac{\cos\beta}{\sin^2\beta} + C_x(i)\frac{\cos^2\beta}{\sin^3\beta} \right]. \tag{3}$$

3. The obtaining of the bio fluid current minimal velocity

This optimisation method presents a special importance in the problem of optimal profiling of the axial rotor blades for an agitator, ventilator or pump.
To minimize the fluid current velocity V, we shall present three possibilities to solve this problem: using the velocity relation deduced by the axial force expression (2) or peripheral force (2'), or from that of the rotor driving power (3).

3.1. The fluid velocity minimizing using the axial force F_a relation

First, we shall consider the mathematical problem of linked minimum, corresponding to the obtaining the minimal axial fluid current velocity using the axial force expression (2), we can write the relation [3]

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$$\frac{V^2\rho bl}{2F_a} = \frac{1}{C_y \dfrac{\cos\beta}{\sin^2\beta} - C_x \dfrac{1}{\sin\beta}} \rightarrow v_a = \frac{V}{\sqrt{2F_a/\rho bl}} = \left(C_y \frac{\cos\beta}{\sin^2\beta} - C_x \frac{1}{\sin\beta}\right)^{-1/2}, \qquad (4)$$

from that by annulment of its partial derivation, we shall obtain the value of the relative peripheral blade setting angle β_p, we obtain by simplifying with $\sin^3\beta$

$$\frac{\partial v_a}{\partial\beta} = \frac{C_y \dfrac{2-\sin^2\beta}{\sin^3\beta} - C_x \dfrac{\cos\beta}{\sin^2\beta}}{2\left(C_y \dfrac{\cos\beta}{\sin^2\beta} - C_x \dfrac{1}{\sin\beta}\right)^{3/2}} = \frac{C_y(2-\sin^2\beta) - C_x \sin\beta\cos\beta}{2\left(C_y\cos\beta - C_x\sin\beta\right)^{3/2}} = 0, \qquad (5)$$

and now the denominator is ever differed of infinite, denoting by $x = \sin^2\beta$ and introducing the profile fineness $f = C_y / C_x$, the problem reduces to the solving of the algebraic equation of two degree

$$(f^2+1)x^2 - (4f^2+1)x + 4f^2 = 0, \qquad (6)$$

having two solutions and putting into the evidence the relative angle β as function of the fineness of the aerodynamic or hydrodynamic profiles, for the positive value under root expression, necessary to assure the non-imaginary solutions

$$x = \frac{4f^2+1 \pm \sqrt{1-8f^2}}{2f^2+2}, \quad \text{for} \quad 1-8f^2 \geq 0 \quad \rightarrow \quad f(i) = \frac{c_y}{c_x} \leq 0.3536\ldots \qquad (7)$$

which condition eliminate a lot of profiles too curved and prefers these, that have the lift force near by zero for a certain incidence angle i .

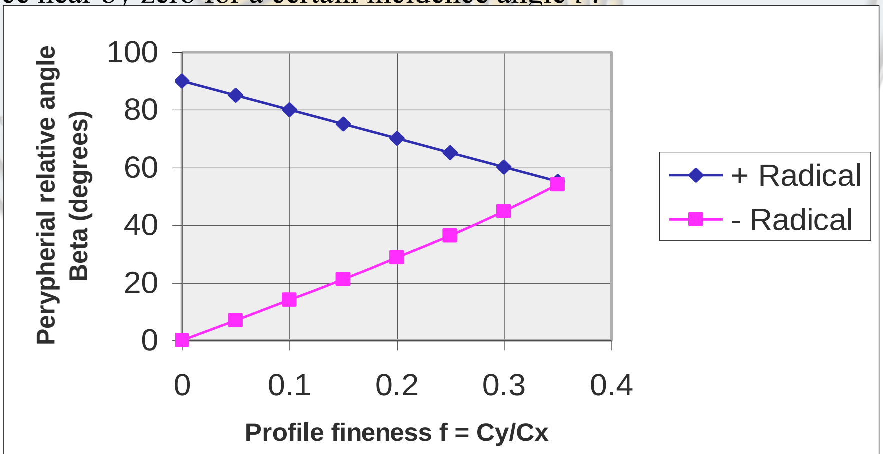

Fig.2. The peripheral relative angle β_p in function of the profile fineness f .

Because we have not find profiles which satisfy simultaneously the conditions (7) $f(i) \leq 0.3536\ldots$ and $C_y\ (i = 0) \neq 0$ in relation (4) one cannot apply this method.

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3.2. The fluid velocity minimizing using the peripheral force F_u relation

Using the (2') relation we can write

$$\frac{V^2\rho bl}{2F_u}=\frac{1}{C_x\dfrac{\cos\beta}{\sin^2\beta}+C_y\dfrac{1}{\sin\beta}}\;\rightarrow\; v_u=\frac{V}{\sqrt{2F_u/\rho bl}}=\left(C_x\frac{\cos\beta}{\sin^2\beta}+C_y\frac{1}{\sin\beta}\right)^{-1/2}, \quad (4')$$

from that by annulment of its partial derivation, we shall obtain the value of the relative peripheral setting angle β_p, we obtain by simplifying with $\sin^3\beta$

$$\frac{\partial v_u}{\partial\beta}=\frac{C_x\dfrac{2\sin\beta\cos^2\beta+\sin^3\beta}{\sin^4\beta}+C_y\dfrac{\cos\beta}{\sin^2\beta}}{2\left(C_x\dfrac{\cos\beta}{\sin^2\beta}+C_y\dfrac{1}{\sin\beta}\right)^{3/2}}=\frac{C_x(2-\sin^2\beta)+C_y\sin\beta\cos\beta}{2\left(C_x\cos\beta+C_y\sin\beta\right)^{3/2}}=0, \quad (5')$$

and now the denominator is ever differed of infinite, denoting by $x=\sin^2\beta$ and introducing the profile fineness $f=C_y/C_x$, the problem reduces to the solving of the algebraic equation of two degree

$$(f^2+1)x^2-(f^2+4)x+4=0, \quad (6')$$

having two solutions and putting into the evidence the relative peripheral angle β_p as function of the fineness of the aerodynamic or hydrodynamic profiles, for the positive value of the under radical expression, necessary to assure the non-imaginary solutions

$$x=\frac{f^2+4\pm\sqrt{f^4-8f^2}}{2\left(f^2+1\right)}, \quad \text{for} \quad f^2\geq 8 \;\rightarrow\; f(i)=\frac{c_y}{c_x}\geq\sqrt{8}=2.828, \quad (7')$$

In this case for the x (-) solution having a physical signification, the variation of the relative peripheral angle β_p (f) and the fluid velocity v_u (i) are represented in the table number 1 and figure number 3 for the plane plate, respectively in the table number 2 and figure number 4 for Gö 450 profile, in the table number 3 and figure number 5 for Gö 445 profile and in the table number 4 and figure number 6 for curved plate.

Because the plane plate, in the case of peripheral force method, gives four or six time greater fluid velocity with respect to other profiles; and the curved plate, in the case of mechanical power method, gives two time greater fluid velocity than other profile, we shall prefer the Gö 450 and 445 profile shapes for which we shall calculate the setting profile optimum incidence angle for other radii and even the twisting of the blade profile, considering the blade relative angle for other radii

$$\beta_b(r_j)=\beta_j+i_{opt}(r_j). \quad (8)$$

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Table 1. Variation with the **plane plate** incidence angle i of the fineness f, the relative peripheral angle β_p and the fluid velocity v_u (-), which is six time greater than this of curved plane

i (degr)	C_y	C_x	$f = C_y/C_x$	x (-)	β_p (degr)	$10 \times v_u (i)$
3	0.21	0.031	7.241	0.0529	16.054	11.6202
5	0.375	0.054	7.17	0.0095	16.219	6.479
6	0.45	0.069	6.338	0.0103	18.43	6.108
9	0.63	0.122	5.164	0.0167	22.879	5.334
10	**0.68**	**0.139**	**4.8921**	**0.0238**	**24.253**	**5.089 min**
12	0.75	0.175	4.261	0.038	28.25	5.227
15	0.78	0.225	3.545	0.059	35.1565	5.996

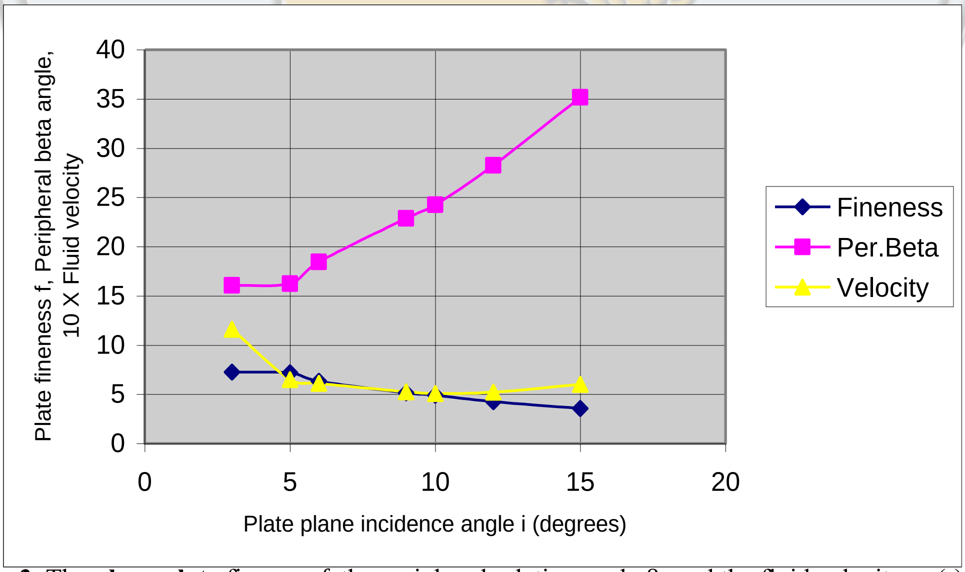

Fig.3. The **plane plate** fineness f, the peripheral relative angle β_p and the fluid velocity v_u (-) in function of the plane plate incidence angle i.

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Table 2. Variation with the **Gö 450 profile** incidence angle *i* of the fineness *f*, relative peripheral angle β_p and the fluid velocity v_u (-)

i (degr)	C_y	C_x	$f = C_y/C_x$	*x* (-)	β_p (degr)	$10 \times v_u$ (*i*)
-3	0.2	0.023	8.7	0.0529	13.31	10.35
0	0.41	0.02	20.5	0.0095	5.60	2.27
3	0.63	0.032	19.69	0.0103	5.834	1.53
6	0.85	0.055	15.455	0.0167	7.44	1.431
9	**1.05**	**0.081**	**12.963**	**0.0238**	**8.88**	**1.365 min**
12	0.75	0.112	10.268	0.038	11.24	1.546
15	0.78	0.147	8.231	0.059	14.076	1.797

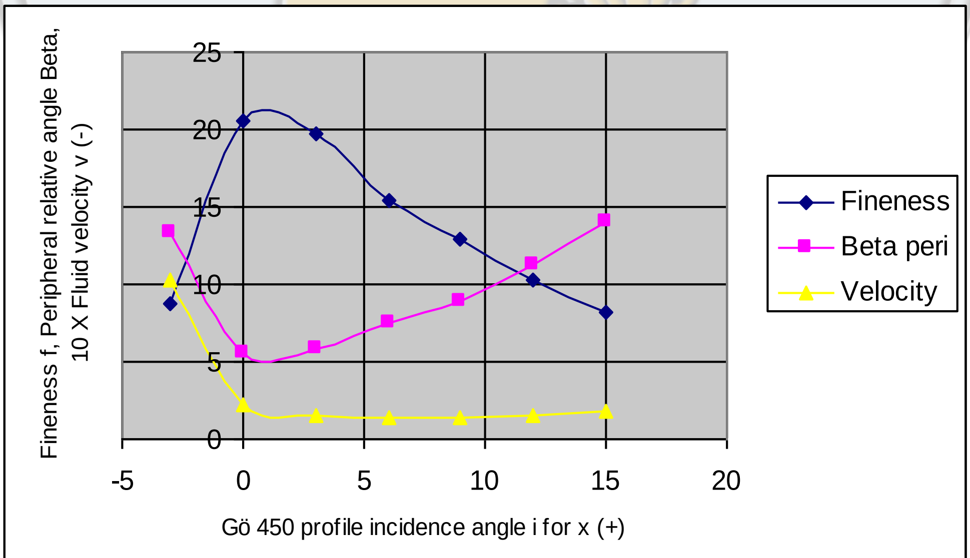

Fig. 4. Variation with the **Gö 450 profile incidence** angle of its fineness *f*, the peripheral relative angle β_p and the fluid velocity v_u (-).

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Table 3. Variation with the **Gö 445 profile** incidence angle i of the fineness f, relative peripheral angle β_p and the fluid velocity v_u (-)

i (degr)	C_y	C_x	$f = C_y/C_x$	x (-)	β_p (degr)	v_u (i)
0	0.08	0.008	10	0.0400	11.54	0.367
3	0.25	0.013	19.231	0.0108	5.973	0.201
6	0.45	0.03	15	0.0178	7.666	0.152
9	0.63	0.088	7.159	0.0782	16.244	0.134
12	**0.715**	**0.159**	**4.497**	**0.2003**	**26.600**	**0.133**
14	0.685	0.20	3.309	0.3877	38.520	0.150

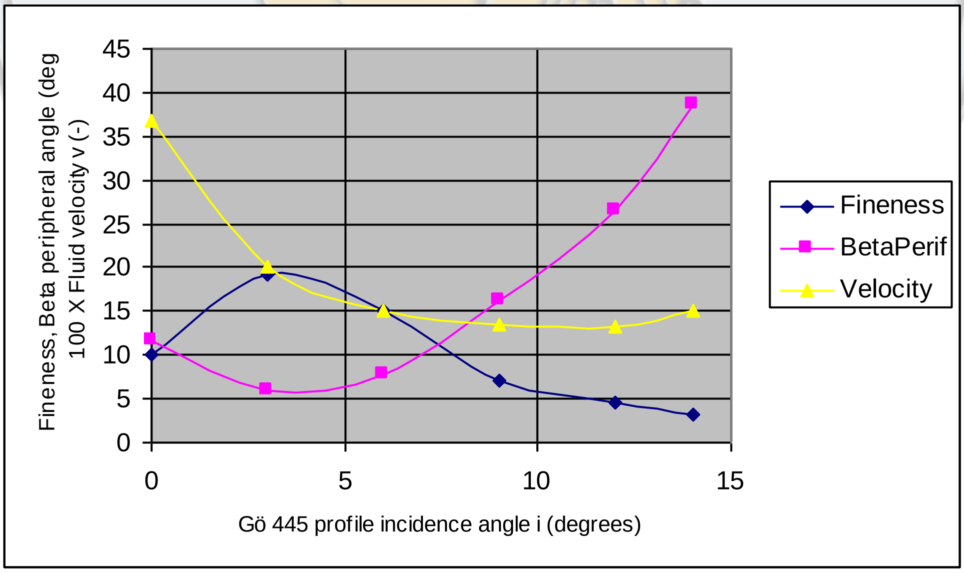

Fig. 5. Variation with the **Gö 445 profile** incidence angle of its fineness f, the peripheral relative angle β_p and the fluid velocity v_u (-).

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Table 4. Variation with the **curved plate** incidence angle *i* of the fineness *f*, relative peripheral angle β_p and the fluid velocity v_u (-)

i (degr)	C_y	C_x	$f = C_y/C_x$	*x* (-)	β_p (degr)	v_u (*i*)
-3	0.32	0.068	4.706	0.1825	25.300	0.1968
0	0.58	0.068	8.53	0.0550	13.574	0.1377
3	0.88	0.086	10.233	0.0382	11.279	0.1107
6	1.14	0.11	10.364	0.0373	11.135	0.0972
9	1.32	0.148	8.919	0.0503	12.969	0.0910
12	**1.47**	**0.194**	**7.577**	**0.0698**	**15.322**	**0.0872min**
15	1.52	0.35	4.343	0.2152	27.654	0.0917

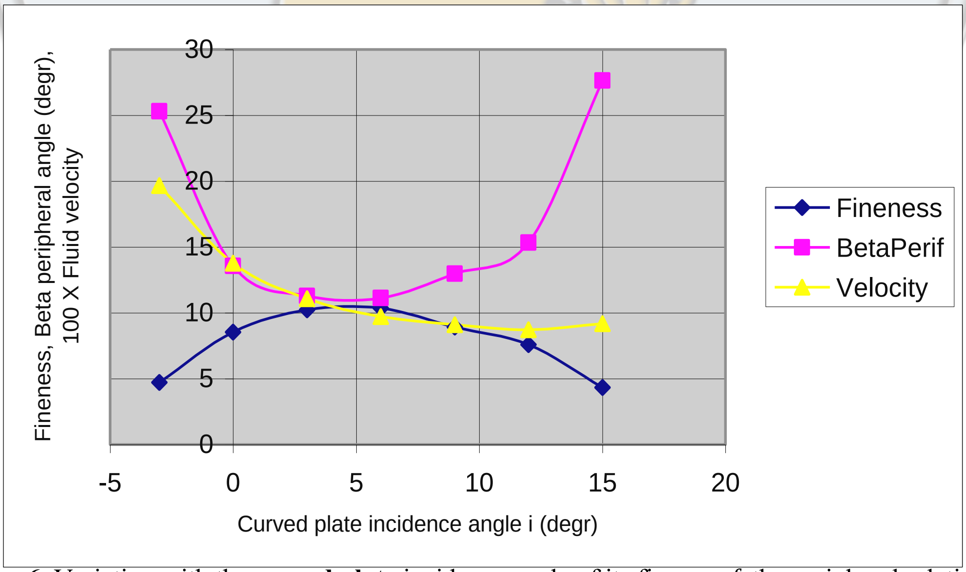

Fig. 6. Variation with the **curved plate** incidence angle of its fineness *f*, the peripheral relative angle β_p and the fluid velocity $100 \times v_u$ (-).

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For other radii, because the peripheral relative angle is already determined by the relation $V = R_j\, \omega\, \mathrm{tg}\, \beta_j = R_p\, \omega\, \mathrm{tg}\, \beta_p$, at which we have the considered profile

$$\mathrm{tg}\, \beta_j\left(r_j\right) = \frac{R_{per}}{R_j}\, \mathrm{tg}\, \beta_{per} = \frac{1}{r_j}\, \mathrm{tg}\, \beta_{per} \ , \qquad (9)$$

we shall determine the blade profile incidence angle i canceling the expression of the relative velocity (4') writen as

$$v_u = \frac{V}{\sqrt{2F_u / \rho b l}} = \left[\left(C_{x0} + i\,C_{x1} + i^2 C_{x2}\right)\frac{\cos\beta_j}{\sin^2\beta_j} + \left(C_{y0} + i\,C_{y1} - i^2 C_{y2}\right)\frac{1}{\sin\beta_j}\right]^{-1/2}, \qquad (4')$$

with respect to the incidence angle i of the profile [3], obtaining the relation

$$\frac{\partial v_u}{\partial i} = \frac{\left(C_{y1} - 2i\,C_{y2}\right)\cos\beta_j - \left(C_{x1} + 2i\,C_{x2}\right)\sin\beta_j}{2\left[\left(C_{y0} + i\,C_{y1} - i^2 C_{y2}\right)\cos\beta_j - \left(C_{x0} + i\,C_{x1} + i^2 C_{x2}\right)\sin\beta_j\right]} = 0\,, \qquad (10)$$

the denominator being different of infinite we shall obtain the optimal incidence i_{opt} for each relative radius r_j from the relation

$$i_{opt} = \frac{C_{y1} r_j - C_{x1}\mathrm{tg}\beta_p}{2\left(C_{x2}\mathrm{tg}\beta_p + C_{y2} r_j\right)} \qquad (11)$$

the values being presented in the table 5 and in the figure 7.

Table 5. Variation with the radius of the relative β_j , the **Gö 450** profile incidence angle i and the blade twisting.

r_j	β_j (degr)	i_{opt} (degr)	$\beta_b = \beta_j + i_{opt}$	delta β_b
1	8.88	7,091E-05	8.885	0
0,8	11.056	4,561E-05	11.056	2.172
0,6	14.603	2,587E-05	14.603	5.719
0,4	21.346	1,169E-05	21.346	12.462
0,2	38.016	3,057E-06	38.016	29.132

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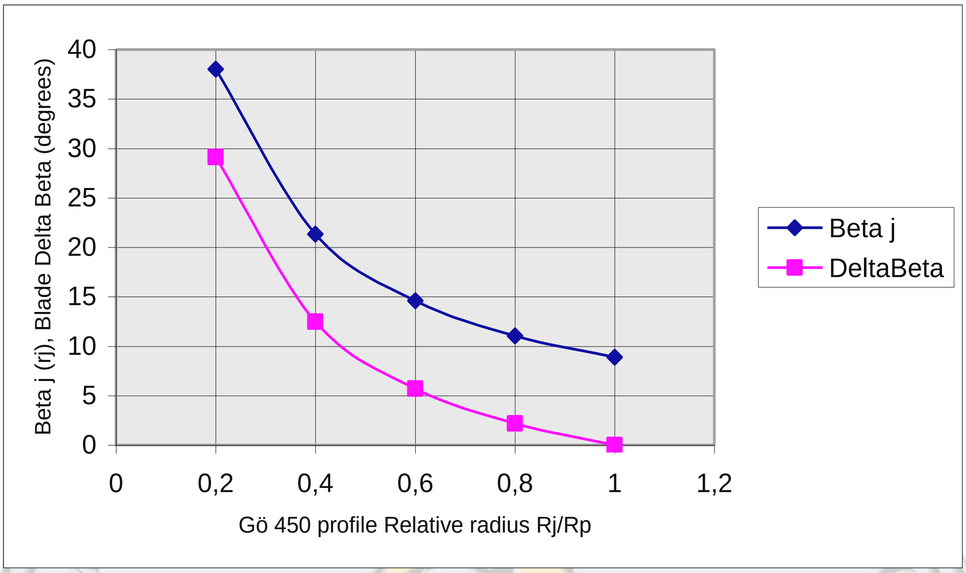

Figure 7. Variation with the radius of the relative angle β_j and the blade twisting in the case of Gö 450 profile shape.

and for the other profile Gö 445 we have the data in the table number 6, represented in the figure number 8.

Table 6. Variation with the radius of the of the relative β_j , **Gö 445** profile incidence angle *i* and the blade twisting

r_j	β_j (degr)	i_{opt} (degr)	$\beta_b = \beta_j + i_{opt}$	delta β_b
1	26.6134	0.000154	26.6134	0
0,8	32.0608	0.000105	32.0608	5.447
0,6	39.8686	6.500E-05	39.8686	13.255
0,4	51.4087	3.437E-05	51.4087	24.795
0,2	68.2632	1.303E-05	68.2632	41.650

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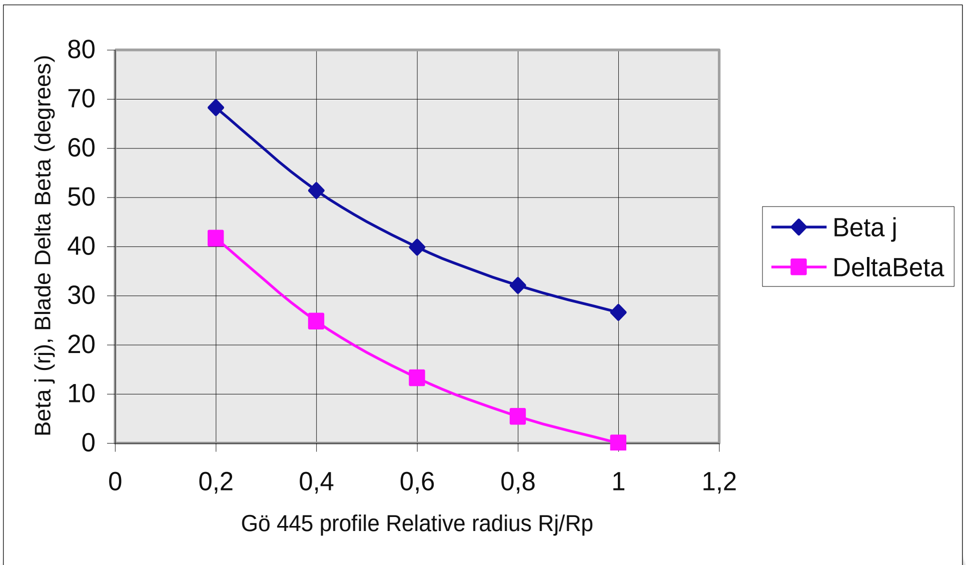

Fig. 8. Variation with the radius of the relative angle β_j and the blade twisting in the case of Gö 445 profile shape.

3.3. The fluid velocity minimizing using the mechanical power P_m relation

From the relation (3) we can write

$$v_m = \frac{V}{\sqrt[3]{2P_m/\rho b l}} = \frac{1}{\left[C_y(i)\dfrac{\cos\beta}{\sin^2\beta} + C_x(i)\dfrac{\cos^2\beta}{\sin^3\beta}\right]^{1/3}}. \quad (12)$$

and cancelling its partial differential with respect to relative peripheral angle β

$$\frac{\partial v_m}{\partial\beta} = \frac{C_y\left(\sin^5\beta + 2\sin^3\beta\cos^2\beta\right) + C_x\left(2\sin^4\beta\cos\beta + 3\sin^2\beta\cos^2\beta\right)}{3\left(C_y\sin\beta\cos\beta + C_x\cos^2\beta\right)^2} = 0, \quad (13)$$

because the denominator is always different of infinite, we shall have

$$\sin^2\beta\left[C_y\left(\sin^3\beta + 2\sin\beta\cos^2\beta\right) + C_x\left(2\sin^2\beta\cos\beta + 3\cos^2\beta\right)\right] = 0 \quad (14)$$

and except the particular solution $x = \sin^2\beta = 0$ or $\beta = \mathcal{M}\pi$, dividing with C_x we reduce the problem to solve the polynomial algebraic relation

$$P(x) = \left(f^2+1\right)x^3 - \left(4f^2+7\right)x^2 + \left(4f^2+15\right)x - 9 = 0, \quad (15)$$

having the values of the real solution given in the table 7 for the best Gö 450 profile and being represented also in the figure 9.

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Table 7. Variation with Gö 450 incidence angle *i* of fineness *f*, relative peripheral angle β_{per} and the fluid velocity v_m (-)

i (degr)	C_y	C_x	$f=C_y/C_x$	*x* (-)	β_p (degr)	v_m (*i*)
-3	0.2	0.023	8.7	0.0292	9.84	0.0954
0	0.41	0.02	20.5	0.00533	4.191	0.0191
3	0.63	0.032	19.7	0.00578	4.363	0.0176min
6	0.85	0.055	15.45	0.009361	5.555	0.0236
9	1.05	0.081	12.96	0.01327	6.618	0.0292
12	1.15	0.112	10.27	0.02104	8.345	0.0410
15	1.21	0.147	8.23	0.03248	10.388	0.0571

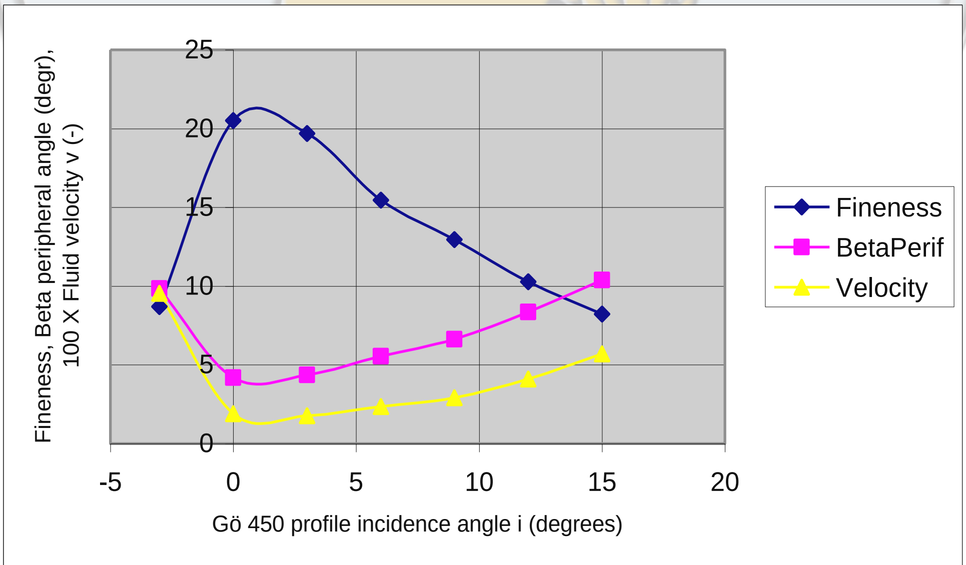

Fig. 9. Variation with incidence angle *i* of the Gö 450 profile fineness *f*, relative peripheral angle β_p and fluid velocity $100 \times v_m$.

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Table 8. Variation with Gö 445 incidence angle *i* of the fineness *f*, the relative peripheral angle β_{per} and the fluid velocity v_m (-)

i (degr)	C_y	C_x	$f = C_y/C_x$	*x* (-)	β_p (degr)	v_m (*i*)
0	0.08	0.008	10	0.0222	8.566	0.5525
3	0.25	0.013	19.23	0.0061	4.466	0.2447
6	**0.45**	**0.030**	**15**	**0.00993**	**5.723**	**0.2374min**
9	0.63	0.088	7.159	0.0426	11.923	0.3469
12	0.715	0.159	4.497	0.1034	18.768	0.4503

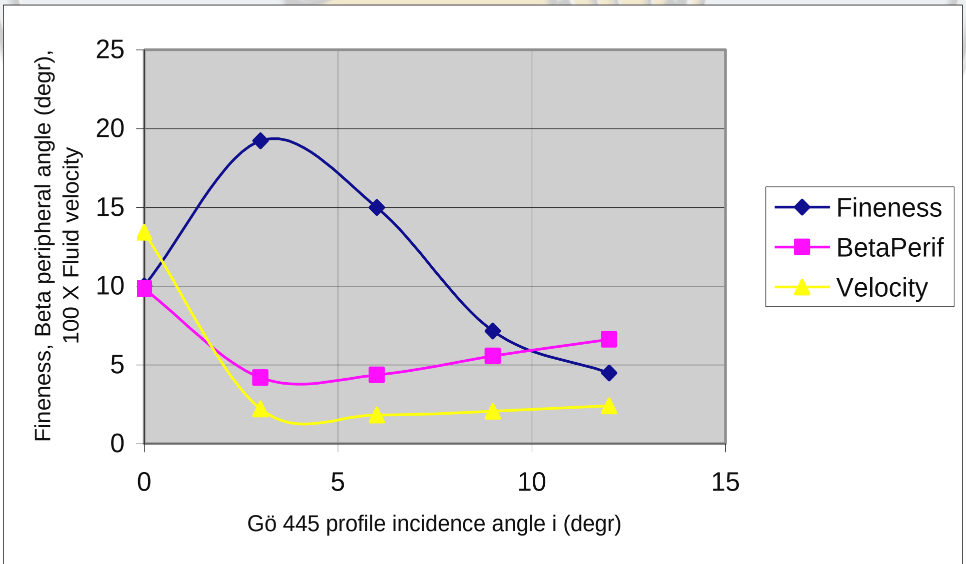

Fig. 10. Variation with incidence angle *i* of the Gö 445 profile the fineness *f*, relative peripheral angle β_p and fluid velocity $100 \times v_m$.

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Table 9. Variation with the plane Plate incidence angle i of the fineness f, the relative peripheral angle β_{per} and the fluid velocity v_m (-)

i (degr)	C_y	C_x	$f = C_y/C_x$	x (-)	β_p (degr)	v_m (i)
0	0	0.02	0	0.9998	89.15	46.557
3	0.21	0.029	7.241	0.0417	11.79	0.1246
6	**0.45**	**0.071**	**6.338**	**0.0540**	**13.44**	**0.1185**
9	0.63	0.125	5.04	0.0836	16.81	0.1492
12	0.75	0.176	4.261	0.1143	19.76	0.1796
15	0.78	0.22	3.545	0.1593	23.53	0.2292

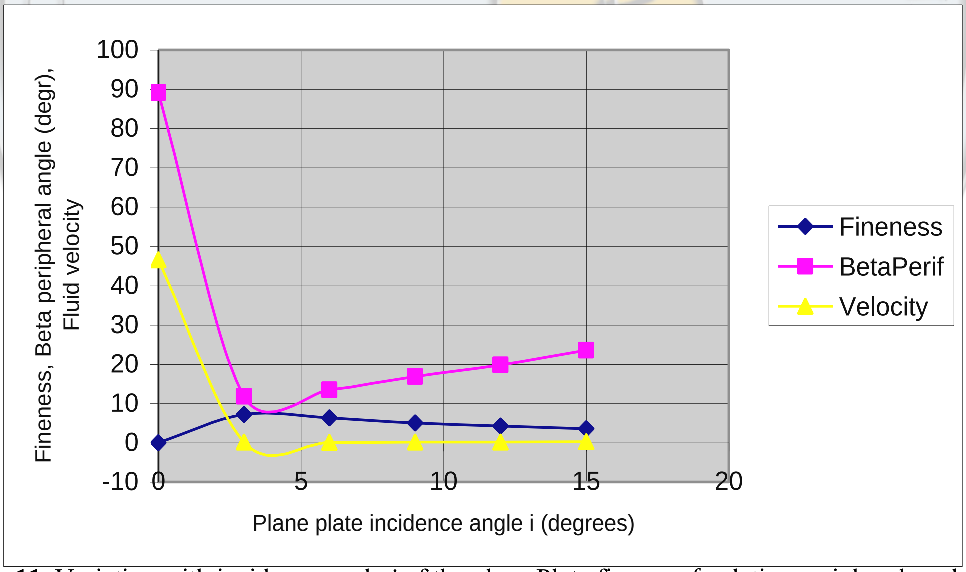

Fig. 11. Variation with incidence angle i of the plane Plate fineness f, relative peripheral angle β_p and fluid velocity $100 \times v_m$.

For other radii, because the peripheral relative angle is already determined by the relation $V = U$ tg β_j, by tg $\beta_j = R_{per}$ tg β_{per} / R_j the velocity minimization following to be obtained only by the election of the optimum incidence angle in case of the considered profile, as we shall see below only for any profiles.

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Table 10. Variation with the curved Plate incidence angle *i* of the fineness *f*, the relative peripheral angle β_{per} and the fluid velocity v_m (-)

i (degr)	C_y	C_x	$f = C_y/C_x$	*x* (-)	β_p (degr)	v_m (*i*)
-3	0.32	0.068	4.706	0.095	17.96	0.20667
0	0.58	0.068	8.523	0.0303	10.03	0.6896
3	0.88	0.086	10.233	0.0212	8.373	0.0451
6	**1.14**	**0.11**	**10.364**	**0.0207**	**8.268**	**0.0406min**
9	1.32	0.148	8.919	0.0278	9.595	0.0489
12	1.47	0.194	7.577	0.0382	11.274	0.0608
15	1.52	0.35	4.343	0.1103	19.407	0.1381

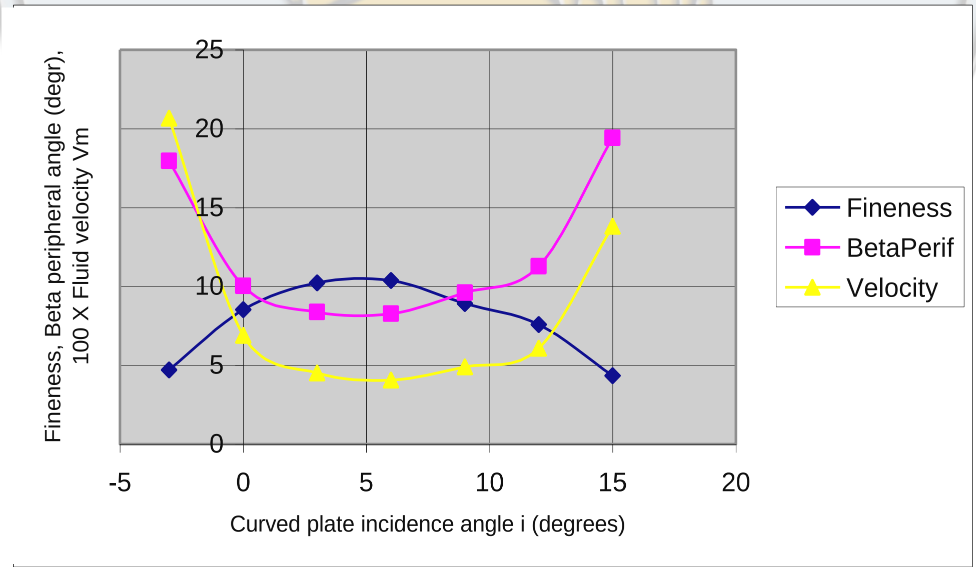

Fig. 12. Variation with the curved Plate incidence angle *i* of the fineness *f*, the relative peripheral angle β_p and the fluid velocity $100 \times v_m$.

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We shall determine the blade profile incidence angle i canceling the partial differential expression of the relative velocity (12)

$$v_{\mathrm{m}}=\frac{V}{\sqrt[3]{2P_{\mathrm{m}}/\rho bl}}=\left[\left(C_{\mathrm{y0}}+iC_{\mathrm{y1}}-i^{2}C_{\mathrm{y2}}\right)\frac{\cos\beta_{\mathrm{j}}}{\sin^{2}\beta_{\mathrm{j}}}+\left(C_{\mathrm{x0}}+iC_{\mathrm{x1}}+i^{2}C_{\mathrm{x2}}\right)\frac{\cos^{2}\beta_{\mathrm{j}}}{\sin^{3}\beta_{\mathrm{j}}}\right]^{-1/3}, \quad (12)$$

with respect to the incidence angle i of the profile, obtaining the relation

$$\frac{\partial v_{\mathrm{m}}}{\partial i}=\frac{-\left\lfloor\sin^{2}\beta_{\mathrm{j}}\cos\beta_{\mathrm{j}}\left(C_{\mathrm{y1}}-2iC_{\mathrm{y2}}\right)+\sin\beta_{\mathrm{j}}\cos^{2}\beta_{\mathrm{j}}\left(C_{\mathrm{x1}}+2iC_{\mathrm{x2}}\right)\right\rfloor}{3\left[\sin\beta_{\mathrm{j}}\cos\beta_{\mathrm{j}}\left(C_{\mathrm{y0}}+iC_{\mathrm{y1}}-i^{2}C_{\mathrm{y2}}\right)+\cos^{2}\beta_{\mathrm{j}}\left(C_{\mathrm{x0}}+iC_{\mathrm{x1}}+i^{2}C_{\mathrm{x2}}\right)\right]^{4/3}}=0 \quad (16)$$

and because the denominator is always different of infinite, we obtain the optimal incidence for each relative radius $r_{\mathrm{j}}=R_{\mathrm{j}}/R_{\mathrm{p}}$

$$i_{\mathrm{opt}}=\frac{C_{\mathrm{y1}}\sin\beta_{\mathrm{j}}+C_{\mathrm{x1}}\cos\beta_{\mathrm{j}}}{2\left(C_{\mathrm{y2}}\sin\beta_{\mathrm{j}}-C_{\mathrm{x2}}\cos\beta_{\mathrm{j}}\right)}=\frac{C_{\mathrm{y1}}\mathrm{tg}\beta_{\mathrm{p}}+C_{\mathrm{x1}}r_{\mathrm{j}}}{2\left(C_{\mathrm{y2}}\mathrm{tg}\beta_{\mathrm{p}}-C_{\mathrm{x2}}r_{\mathrm{j}}\right)}, \quad (17)$$

the twisted blade angle being represented in the table 10 and also in the figure 13.

Table 10. Variation with the relative radius of the blade setting angle β_{j} and its twisting for the Gö 450 profile

r_{j}	β_{j} (degr)	i_{optim}	β_{blade}	x (-)	Delta β_{p} (degrees)	v_{m} (i)
1	0.2	0.023	8.7	0.0529	13.31	1.035
0,8	0.41	0.02	20.5	0.0095	5.60	0.227
0,6	0.63	0.032	19.7	0.0103	5.83	0.153
0,4	0.85	0.055	15.46	0.0167	7.44	0.143
0,2	1.05	0.081	12.96	0.0238	8.88	0.137 min

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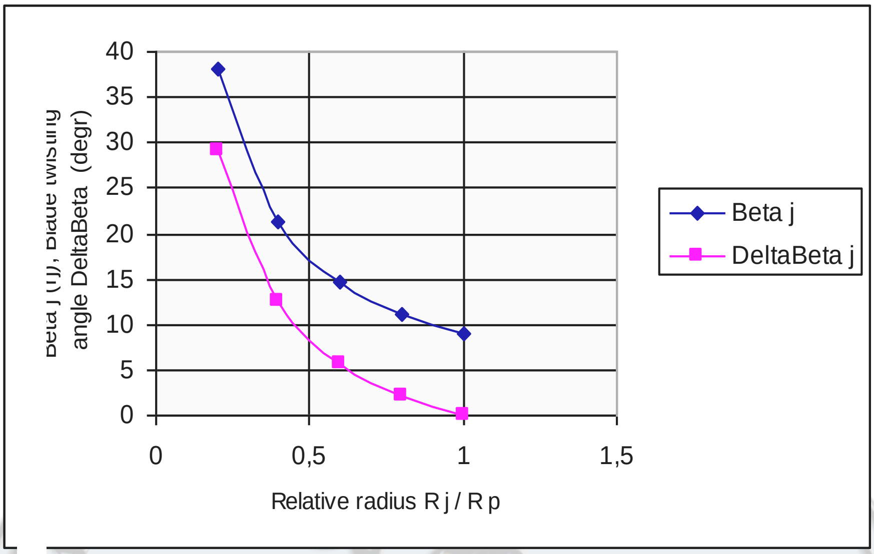

Fig. 13. The blade twisting angle for different radii of the Gö 450 profile.

Conclusions

(1) These researches attest the performance optimization methods to be the very important proceedings to establish the best profile of the rotor blades and its twisting shape on the radii length.

(2) If the first method is not proper to minimizing the fluid velocity, the other two methods are very important for the modern design of organic mud agitator screws in comparison with the older empirical methods.

(3) Because the plane plate, in the case of peripheral force method, gives four or six time greater fluid velocity with respect to other profiles and the curved plate, in the case of mechanical power method, gives two time greater fluid velocity than other profile, we shall prefer the Gö 450 and 445 profiles.

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