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ON THE LOAD OF AXIAL TURBOMACHINES BLADE

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Principala problemă în folosirea metodelor numerice, în special în hidrodinamica turbomaşinilor, constă în delimitarea suprafeţelor solide între care are loc curgerea. O determinare raţională a acestora duce la proiectarea în condiţii optime a turbomaşinilorr, reducând totodată costurile necesare modelării numerice.

În lucrarea s-au analizat influenţele circulaţiei către ieşirea palelor şi încărcările hidrodinamice pe pale în funcţie de raze.

The main problem of using numerical methods, especially in turbo machines hydrodynamics, consists in deterring the solid surfaces between the flow take places. A rational determination of these ones gives a machine designs under optimal conditions, reducing, in the same time, the costs needed for the numerical modelling.

The present paper analyses the influence of the circulation to the exit of the blades and the hydrodynamic load as function of radius on the blade shapes.

Keywords: turbomachines, hydrodynamics, optimum design

1. Introduction

Defining optimum criteria for the blade of turbo machines leads to a drastic reduction of necessary time to design and limits the calculated variants, in order to obtain higher performances for the machine.

As optimization criteria, in this paper, we will take into account an energetically one: the condition to obtain for the entire blade a hydraulic theoretical power as close as possible to the needed ones.

The optimum process to design axial turbomachines blades will be discussed from two points of view: **a.**) the influence of the circulation at the inlet (pre-rotation phenomenon [1, 2, 3]) and to the outlet (post-rotation phenomenon), and **b**.) the influence of the circulation on the entire blade on the shape of the blade itself, i.e. the influence of the load of the blade.

All the considerations will be taken under the hypothesis that the meridian speed, v_m, is an invariant as function of the radius.

The numerical modelling was made for an axial microhydroturbine, having the power P = 50 kW and head H = 5 m.

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2. The influence of the circulation at the inlet and to the outlet of the blade

From the fundamental equation, is obtained a condition witch characterised the circulation the influence of the circulation at the inlet and to the outlet of the blade (we must strongly remind that the circulation on the inlet is, in the case of the hydroturbines, influenced also by the distributor cascades):

$$r_2 \cdot v_{u2} = \frac{g \cdot H_T}{\omega} \cdot \eta_{hT} \cdot k \quad , \tag{1}$$

with

$$k = \frac{v_{u2}}{v_{u1} - v_{u2}} = \frac{v_{u2}}{\Delta v_{u\,12}} \quad . \tag{2}$$

According to the classical models of the hydroturbines, were considered three types of variation for the coefficient k along the radius, as is presented in figure 1.

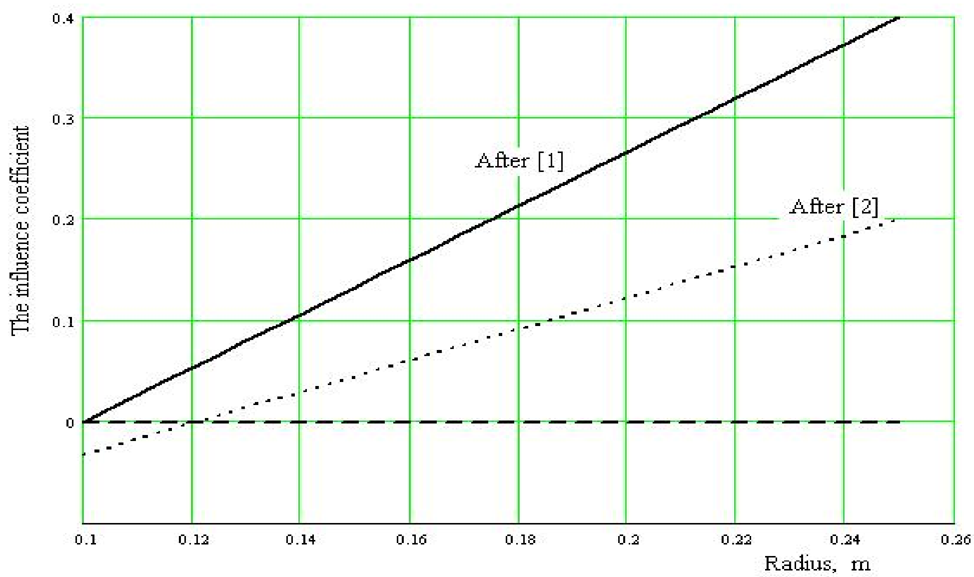

Fig. 1. The variations of the coefficient « k » with radius

In accordance to these distributions, the deflection of the flow (β_1 - β_2) along the blade is presented in figure 2.

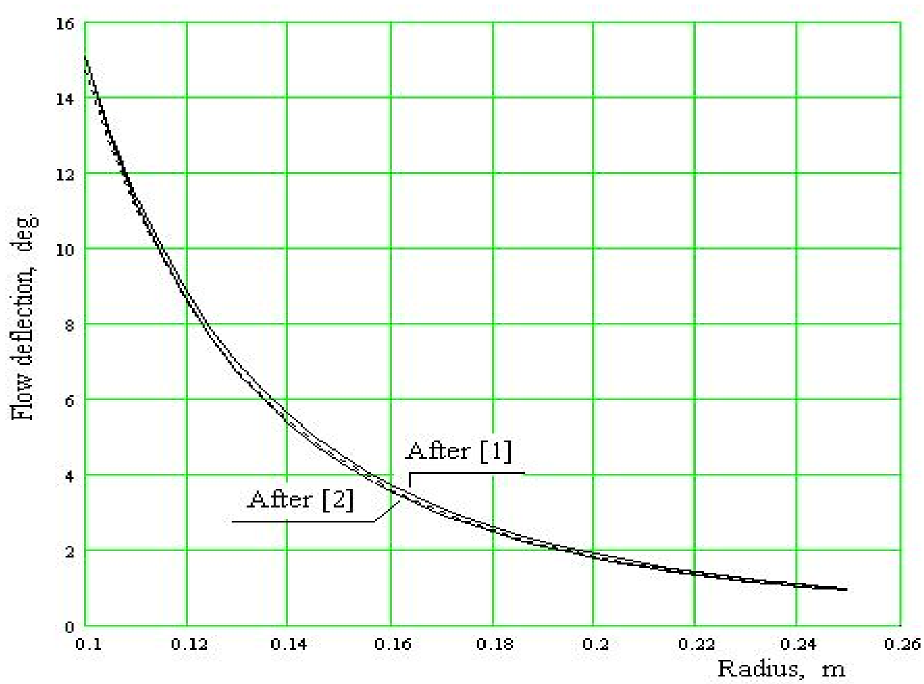

Fig. 2. The flow deflection along the blade

3. The influence of the circulation on the blade

Defining the circulation on the blade as ([1, 2, 3])

$$\Gamma_B = 2 \cdot \pi \cdot r \cdot \Delta v_u \quad , \tag{3}$$

can be observed that this value can be controlled, i.e. can be used an imposed rule for its distribution along the radius, form this resulting the shape of the blade respectively the types of profiles used in the cascade witch define the blade.

In the followings, will be considered four variation laws for the circulation (figure 3) :

- **var_1**, circulation is a constant, resulted directly from the fundamental equation,

- **var_2**, a parabolic variation, with the value at the hub equal to the value resulted from the fundamental equation,

- **var_3**, a parabolic variation having values zero at the hub and at the shroud,

- **var_4**, a parabolic variation, having the values at the hub and shroud controlled.

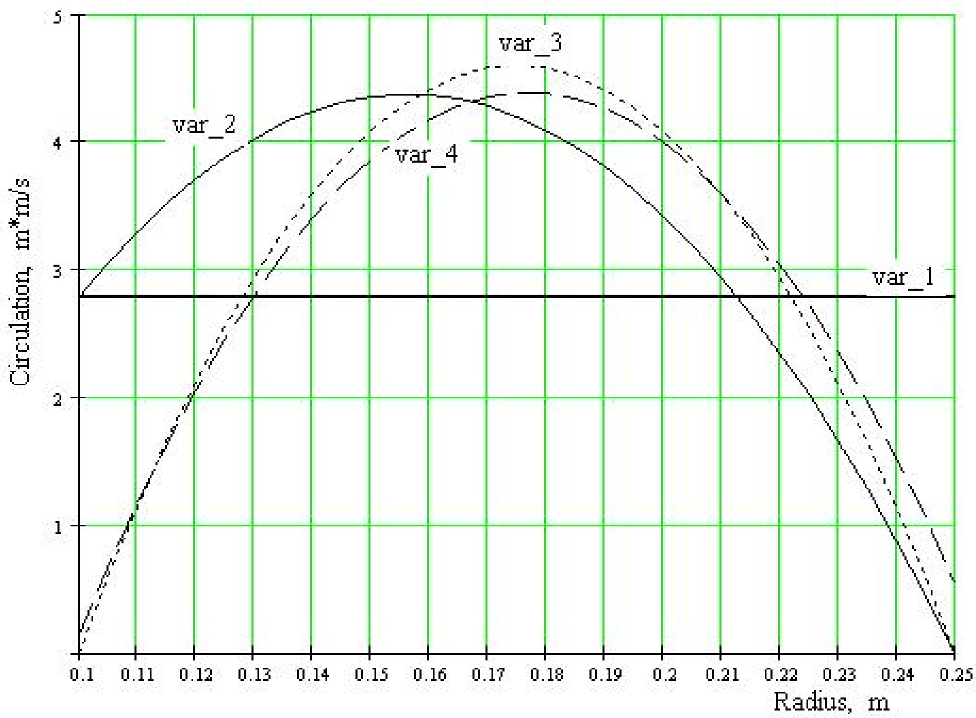

Fig. 3. The considered circulation variations

In the calculus, there were considered the classical ([1, 2]) hypothesis of the normal outlet of the flow from the blade.

In figure 4 there are presented the variations of the asymptotic angle, β_∞ , as function of radius. In figure 5 there are presented the variations of the needed lift coefficient : $(c_a \cdot l/t)_{needed}$.

The blade was supposed formed from NACA four digits type profiles. The needed geometrical characteristics of these profiles are presented in figures 6 and 7.

In figure 8 is presented the skeleton of the blade, based on the var_4 variant.

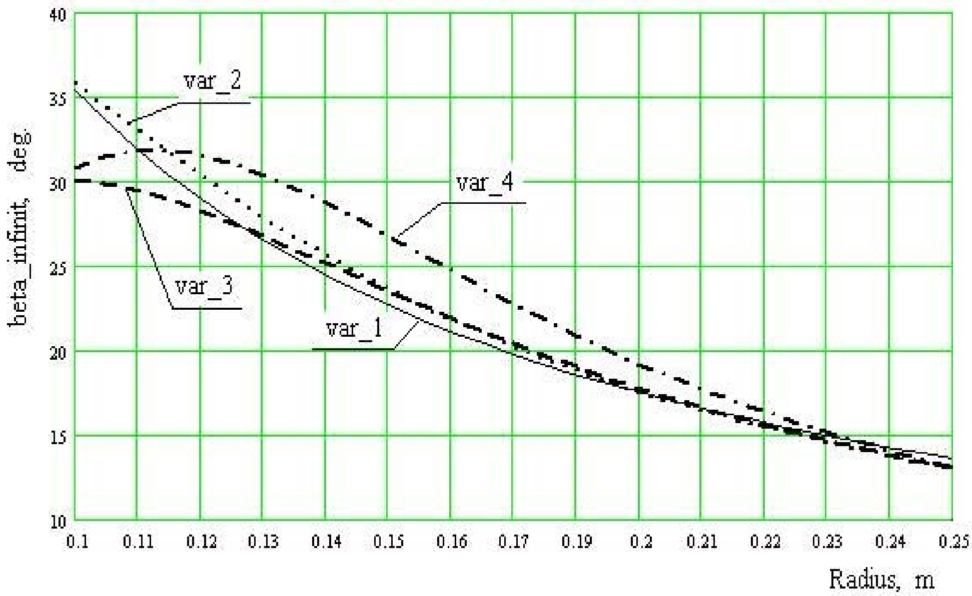

Fig. 4. The variation of the asymptotic angle

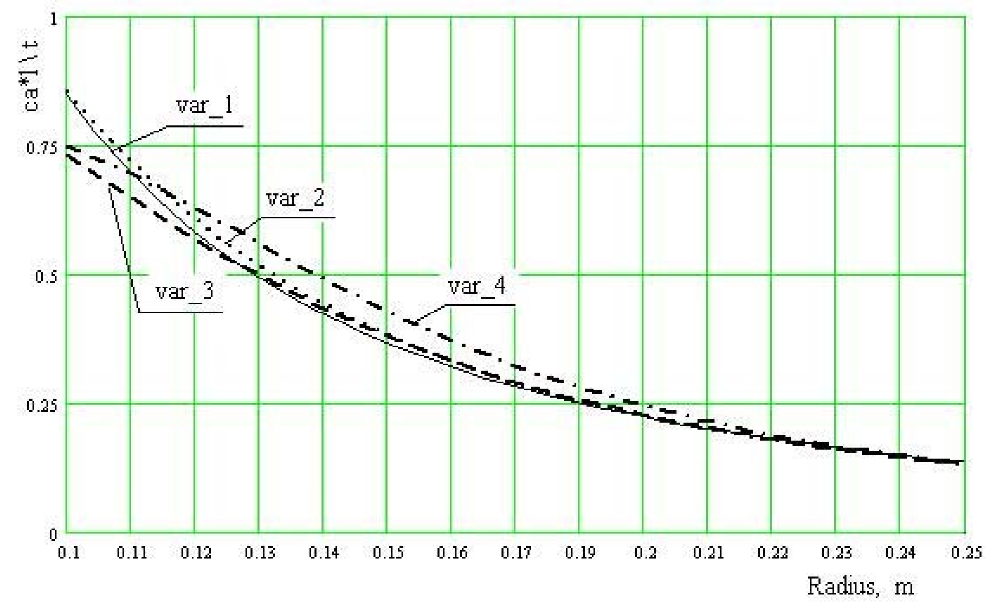

Fig. 5. The variation of the needed lift coefficient

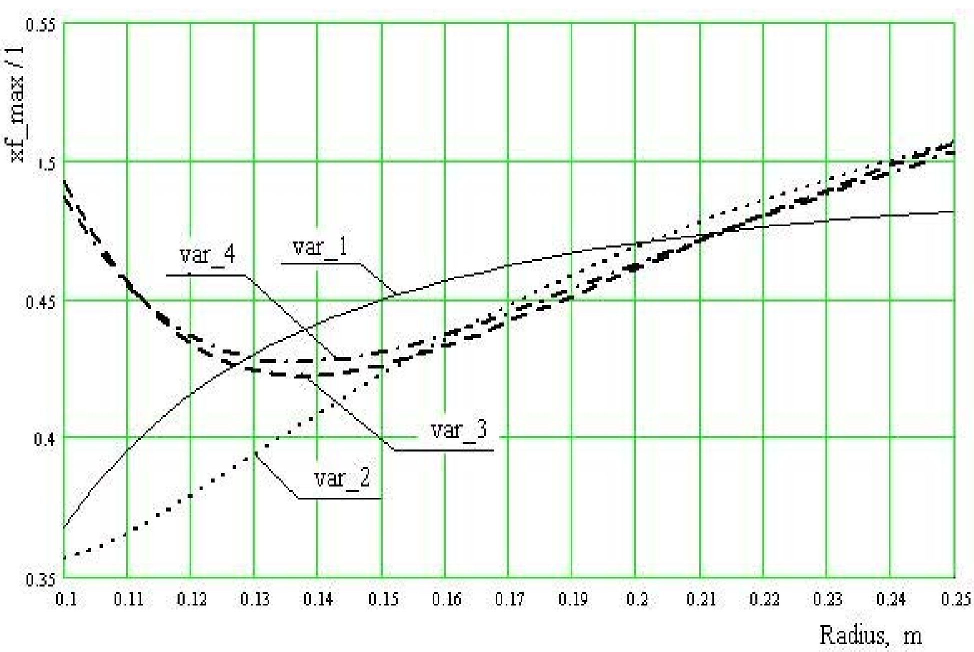

Fig. 6. The variation of the maximum adimensional position of the maximum curvature

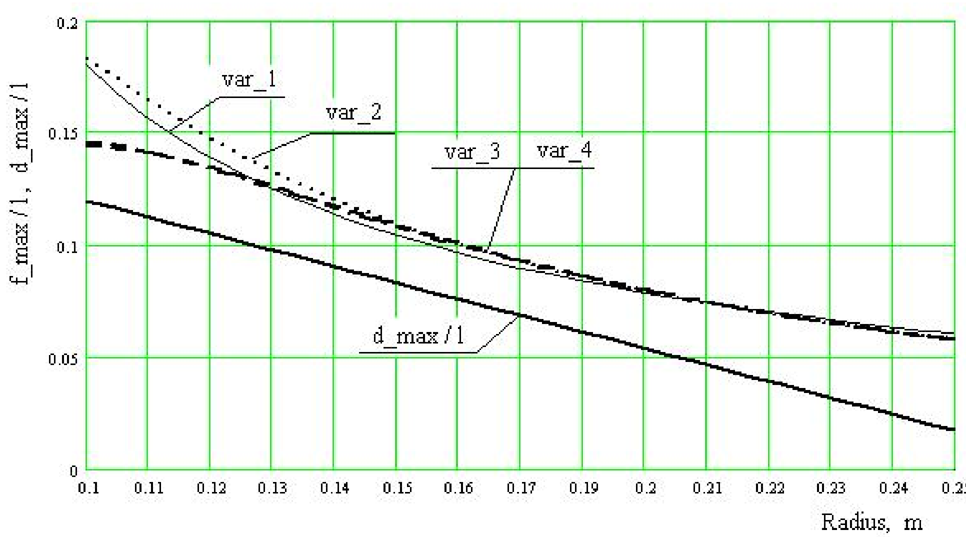

Fig. 7. The variation of the maximum adimensional curvature and the maximum adimensional thickness

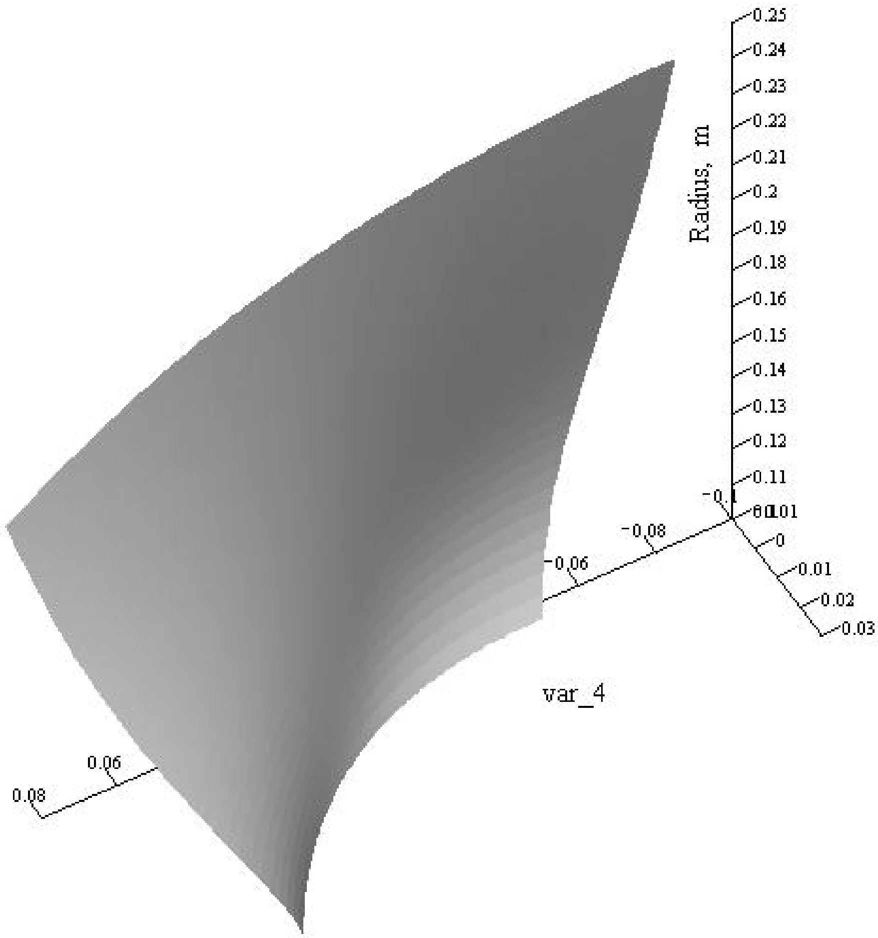

Fig. 8. The shape of the skeleton of the blade – var_4

4. Conclusions

The paper presents same criteria to optimise the shape of the blade of an axial turbomachine, with application for a micro hydroturbine. The calculus reveals that there is possible to consider the observations made before.

Also, the results presented in the paper can be a leading point in using, further, computer codes and specialised soft to analyze the flow in such a turbomachines.

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