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# DESIGN OF THE VANE OF MICRO AXIAL TURBINE

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**Abstract**

Micro hydroelectric axial unit with capacities of 1,80 kW have been developed in this laboratory. The hydraulic perfomance and characteristic of a axial turbine are strongly affected by design configuration the blade of the runner. This work describe the development and design of runner. A number of factor were made and/or considered in the preparation of the design. The analytical studies was carried out on axial runner under conditions of two-dimensional (2D) invisid flow applied on a NACA 4406 airfoil. The possible behaviour and deviations from the theoretical results will are observed starting from experimental test on model turbine will carried out in other stage. The results are shown and can be used to the future development of there turbines.

## Design and construction of runner vane

The small hydro turbine is defined by its specific speeds which determines the type and basic shape of the runner. The specific speed is usually expressed by the equation:

$$\eta_{kW} = n.P^{+0.5}.H^{-1.25}$$

or

$$\eta_{Q} = n.Q^{+0.5}.H^{-0.75}$$

Considering the existing site on which know the hydraulic parameter: Head and Flow Rate, the turbine for low head applications is developed. The main hydraulic turbine parameter are:

| | | |
|---|---|---|
| Net Head ($H_N$) | M | 3,6500 |
| Flow Rate (Q) | $m^3/s$ | 0,0735 |

## Hydrodynamic characteristic of vanes

In order to consider a 2D treatment of the flow around the vane, it is necessary to assume that the flow proceeds through the vane along concentric cylindrical surface parallel to the axis of rotation. This assumption is a sufficient approximation of the actual conditions as long as the machine operates at or near its point of optimal efficiency. There is physical limitations of the hydraulic assumption, but if the flow conditions do not change too rapidly between the various sections, this considerations is justified.

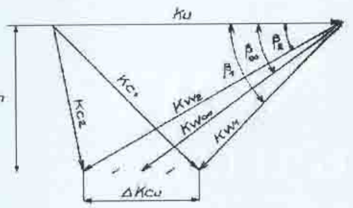
The steady ideal flow through an axial rotor of helices turbine is desired. Hence is assumed that the flow through an axial rotor occurs on coaxial cylinders. The vane elements, for each elemental channel considered, the velocity triangle on leading edge and trailing edge is defined the following manner:

$$K_{Cm} = \frac{\Delta Q}{2.\pi.r.\Delta S\varphi} x \frac{1}{\sqrt{2gH}}$$

$$K_{u} = \frac{\omega.r}{\sqrt{2gH}}$$

$$K_{Cu2} = \frac{1}{K_{u2}}\left[\frac{K_{uo}K_{Cmo}Cos\gamma_{o}}{tg\alpha_{o}} - \frac{\eta}{2}\right]$$

$$M = C_m . \varpi . \frac{C_\infty^2}{2g} . l^2 . b$$



considering the velocity triangle, the undisturbed velocity W$_8$ is given by

$$K_{W\infty} = \frac{K_{W1} + K_{W2}}{2}$$

The velocity, W$_8$ (or K$_{w8}$), to calculated hydrodynamic profile of the runner is necessary.

The shape and position of the vane are to be determined from the lift , drag, and momentum coefficient. In this aspect, the characteristic coefficient are defined by following expression:

$$X = C_x . \varpi . \frac{C_\infty^2}{2g} . l . b$$

$$Z = C_z . \varpi . \frac{C_\infty^2}{2g} . l . b$$

$$M = C_m . \varpi . \frac{C_\infty^2}{2g} . l^2 . b$$

Where C$_x$ , C$_z$ y C$_m$ are the Lift, Drag, and Moment Coefficient which are determined for a hydro vane considered and as function of the angle of attack ***i*** . The pattern of flow around the configuration is necessary, and the resultant flow pattern depends on the geometry of the profile, its orientation with respect the undisturbed free stream, and the speed at which the vane is rotate. For theoretical considerations on turbomachinery, it is desirable to have the relations between ***C$_L$*** and the form and position of the airfoil gives by an analytic expression rather that in the form of empirical curves. For this purpose, we shall introduce without derivation the theoretical equation for the lift coefficient ***C$_L$*** of a straight and infinitely thin airfoil:

$$C_L = 2.\pi.Sin(\alpha)$$

This equation was derived from 2D considerations and can be applied only to vanes on infinite aspect ratio. For this reason, it can be used for the vanes of turbomachines without correction.

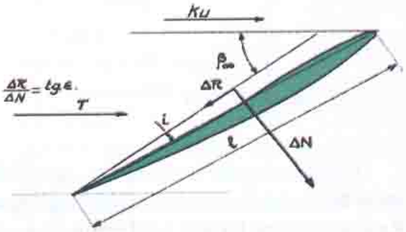
A primary design decision was to choose a free-vortex design for the intake velocity distribution. This resulted in a uniform meridian velocity distribution. Therefore, changing shroud diameter allowed the quantity of flow to increase in proportion to area, while the head remained constant. The runner is designed to have the same drop in head along all streamline from hub to shroud at the best efficiency point.

## Computations and design of the vane

Strictly speaking, all fluid motions are geometrically three-dimensional (3D) . To simplify the solution, however, it is necessary to describe flow phenomena by the smallest number of variable possible. It is conventional to resolve the resultant force on the hydrodynamic profile into a component perpendicular to the free-stream velocity direction (called the lift) and a component parallel to the free-stream velocity direction (called the Drag).

Considering the *z* elements of blade situated into the elemental channel, the normal force, ÄN, is the component acting upward, perpendicular to the direction of vane, or to the undisturbed free-stream velocity, W$_8$ ; the net normal force is given by:

$$\Delta N = C_{Z_{multi}} \varpi . \frac{W_\infty^2}{2g} . l . \Delta r$$



considering the above figure, the drag force which is the net hydrodynamic force acting in the same direction as the undisturbed free-stream velocity, W$_8$ , is obtained as:

$$\Delta R = \Delta N . \mathrm{tg}(\varepsilon)$$

## Consideration

The particular consideration respect to the coefficient which consider the local depression on the vane:

$$k = \frac{\Delta p}{W_\infty^2} \frac{2g}{\varpi}$$

this coefficient must be relatively moderate in order to prevent cavitation.

## Results

With the above computation, permit establish profile of the blade, chord line long, design angle of attack, and the wind sections. The final blade of the runner is defined considering the following step:

a) Present the profile developed in scale and with the considered angle of attack.

b) For every concentric cylindrical surface parallel to the axis considered, superpose the profile computation by coupling each with respect to the aerodynamic center.

The following pictures showing the runner.

$$K_u = \frac{\omega . r}{\sqrt{2gH}}$$