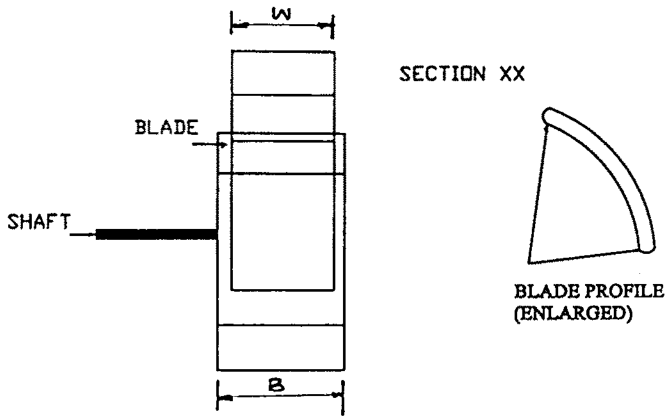
CHAPTER 1
INTRODUCTION

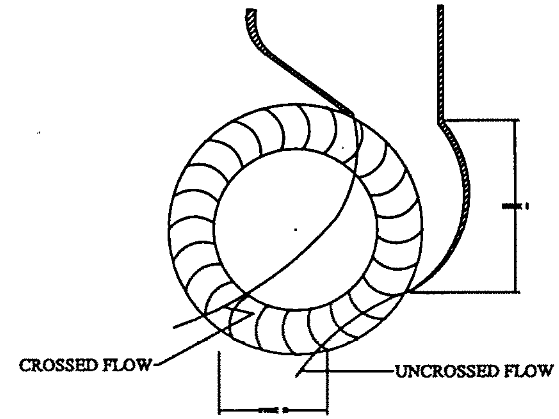
Cross-flow turbine though developed in the earlier part of 20th century, did not gain momentum in the later part of the century probably because it is a very low head and a very low discharge turbine. In order to tap hydropower in terms of many megawatts from high heads, high discharge and their combinations efficiently, other type of turbines viz., Kaplan, Francis and Pelton turbines are used. The maximum power produced from cross-flow turbine extends only upto a few hundred kilowatts. Hence not much concentration was focused on it. But today's requirements are different and necessitate seeking ways and means to utilize resources in Eco-friendly manner, as the big turbines require a huge reservoir, which affects the ecosystem. Hence, the present pursuit is in the direction of using even tiny resources, which are in the form of low head and low discharge using the Cross Flow Turbines.

1.1 THEORY OF CROSS FLOW TURBINE:

The general layout of a cross-flow turbine is shown in Fig.1.1, which composed of two major components, the runner and the nozzle. The nozzle converts the available potential head into kinetic energy. It is of rectangular cross section with curved back walls. The flow directed by the nozzle impinges on the runner at a certain angle of attack (α), also referred as inlet flow angle. A portion of water jet directed by the nozzle passes through the runner blade passage twice, first from outside to inside (first stage), and second from inside to outside (second stage), hence, called as *Cross Flow*. The energy from water is transferred to the turbine at two instants because of the crossed flow and hence the turbine is also popularly termed as *'two stage turbine'*. A minor portion of jet does not cross the turbine interior. Hence for this portion of jet, the energy transfer takes place in single stage and it is called as *uncrossed flow*. The cross flow turbine is normally classified as impulse or free jet turbine, however, some investigations treat CFT attached with draft tube as semi impulse turbine.



(a) 'CFT' WITH ESSENTIAL COMPONENTS



(b) TYPICAL FLOW PATTERN IN 'CFT'

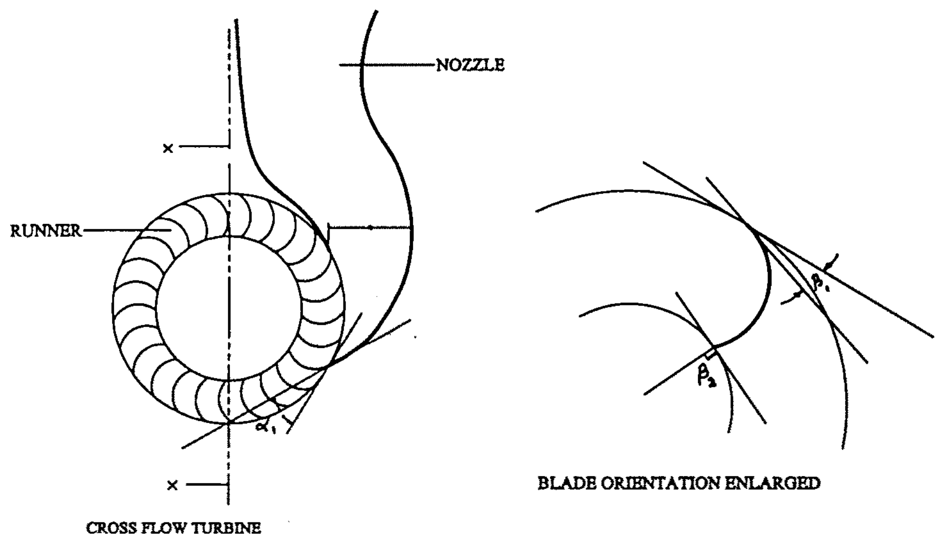


Fig.3.1 GEOMETRY OF CFT NOZZLE

The flow through the runner is divided in to SIX regions (A-F) as illustrated in Fig.1.2.

REGION A:

This is the region where a part of the blade passage is filled with water after it starts to receive the free jet issued from the nozzle.

REGION B:

This is the region where the jet issued from the nozzle flows in to the blade passage and flows out in to the open inner space of the runner. The major portion of energy is transferred in this region. The flow in this region is steady and the width of this region is proportional to the nozzle entry arc

REGION C:

This is the region where water is not supplied from the nozzle but the water in the blade passage flows out in to the open inner space of the runner by the inertia force.

REGION D:

This is the region where water flow reverses in the blade passage, but does not flow out of the blade passage.

REGION E:

This is the region where water flows in to the blade passage from the inner periphery of the runner and the same time flows out of the outer periphery of the runner. This is the region of work done in second stage.

REGION F:

This is the region where the water in the blade passage flows out of the outer periphery of the runner and the blade passage becomes empty.

The part of the runner blades where water flows from the outer periphery to the inner periphery is called the *FIRST STAGE* and the part where it flows from the inside to outside is called the *SECOND STAGE.*

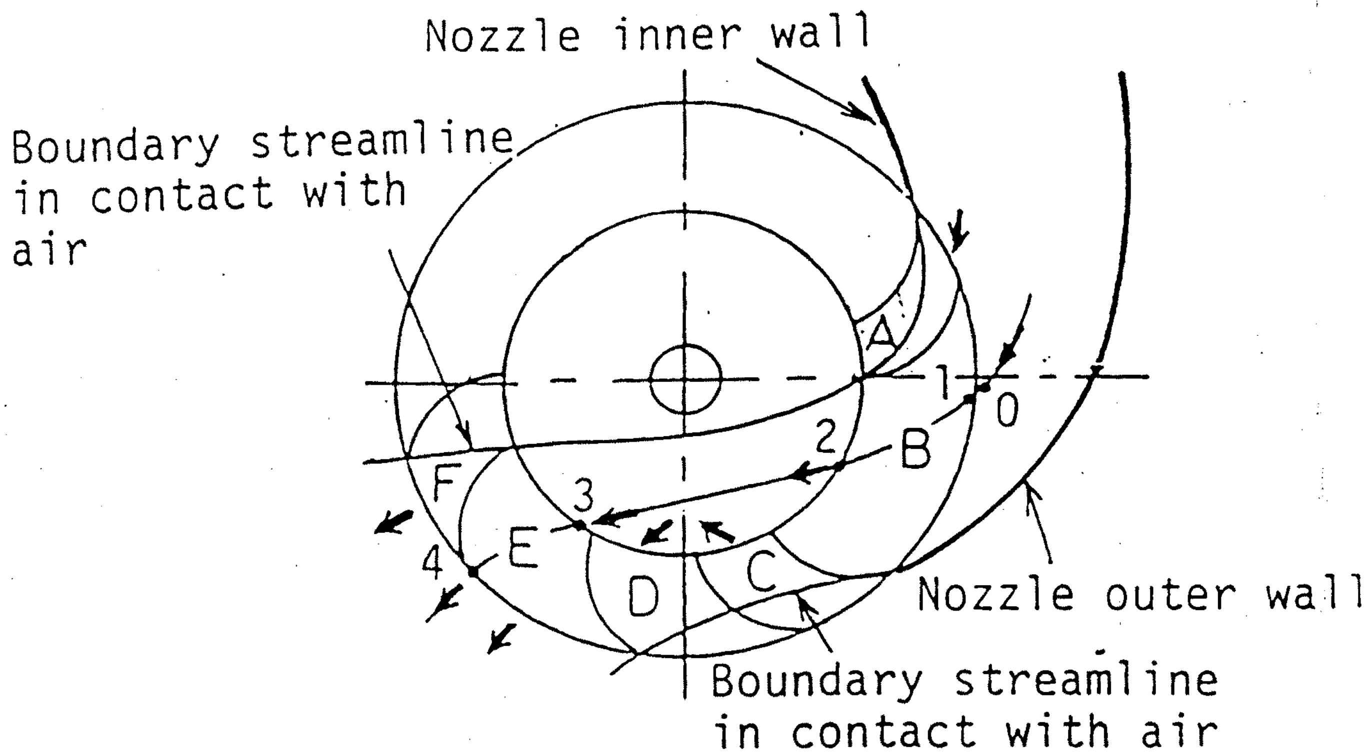


Fig.2 Division of flow field

1.2 FLOW THROUGH RUNNER INETRIOR:

The water from the first stage exit expands freely in the interior space. Since the runner interior is an open free space, the issuing streams from the first stage exit initially converges immediately after exit (similar to the Vena-contracta in flow through orifices) and then expands. The boundary streamlines in contact with air (shown in Fig.1.2) are found to move up when the runner speed is decreased.

1.3 CLOSING REMARKS:

The investigations carried out so far in the area of CFT have been thoroughly reviewed in the **Chapter 2.** The review indicated that a proper theory for Design of CFT nozzle is not been reported. It has been fulfilled using Ideal Fluid Theory and the various parameters of nozzles have been analysed using Finite Element Method and verified through experiments, which forms the contents of the **Chapter 3.**

The flow the runner passages for various heads, angles of attack, nozzle entry arcs, number of blades etc., that affect the CFT performance are investigated thoroughly. The details.are presented in **Chapter 4.**

Chapter 5 deals with the experiments carried-out with various nozzles and runner combinations. It also includes a new idea - CFT with two nozzles, which has been conceived of to enhance the performance of CFT further, for a given set of input conditions. This has been experimentally investigated.

The major conclusions arrived at along with the scope for further work is narrated in **Chapter** 6. Appendices covering certain specific areas needed for the main content are supplemented along with.