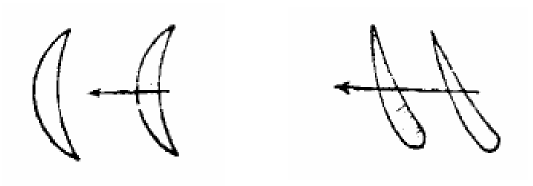
5.4. Reaction Turbine

In reaction turbine, the steam expands as it flows over the blades which, therefore act as nozzles. Each stage is consisting of fixed and moving blades. The heat drop takes place throughout in both fixed and moving blades. Unlike the impulse turbine no nozzles as such are provided in a reaction turbine. The fixed blades act both as nozzles in which the velocity of the steam is increased.

The turbine derives its name of **Reaction Turbine** because the steam expands over the moving blades also giving a reaction to the moving blades. Because the pressure drop takes place both in the fixed and moving blades, all blades are nozzle shaped. Figure (7.5) illustrates the blade arrangements for impulse and reaction turbines. The reaction turbine is so-called **impulse reaction turbine** where, the steam jet is also impulse the moving blade rather than the reaction effect into moving blades.



(a) Impulse Turbine blades

(b) Reaction Turbine blades

Figure (5.5): the blade arrangements for impulse and reaction turbines

5.1. Comparison between the Impulse and Reaction Turbines

	Impulse Turbine	**Reaction Turbine**
1	Steam completely expands in the nozzle	Steam expands partially in the nozzle and further expansion takes place in the rotor blades.
2	Turbine blades have symmetrical profile.	Turbine blades have airfoil section.
3	Steam inters the moving blade with very high velocity.	Steam velocity is not very high at the moving blades.
4	The speed of the turbine is very high.	The speed of the turbine is relatively low.
5	Need low numbers of stages.	The number of stages required is more.
6	Pressure drop in stage is high.	Pressure drop in each stage is small.

5.6. Velocity Diagram for Impulse Steam Turbine.

The steam supplied to a single wheel impulse turbine expands completely in the nozzles and leaves with a high absolute velocity (V1).

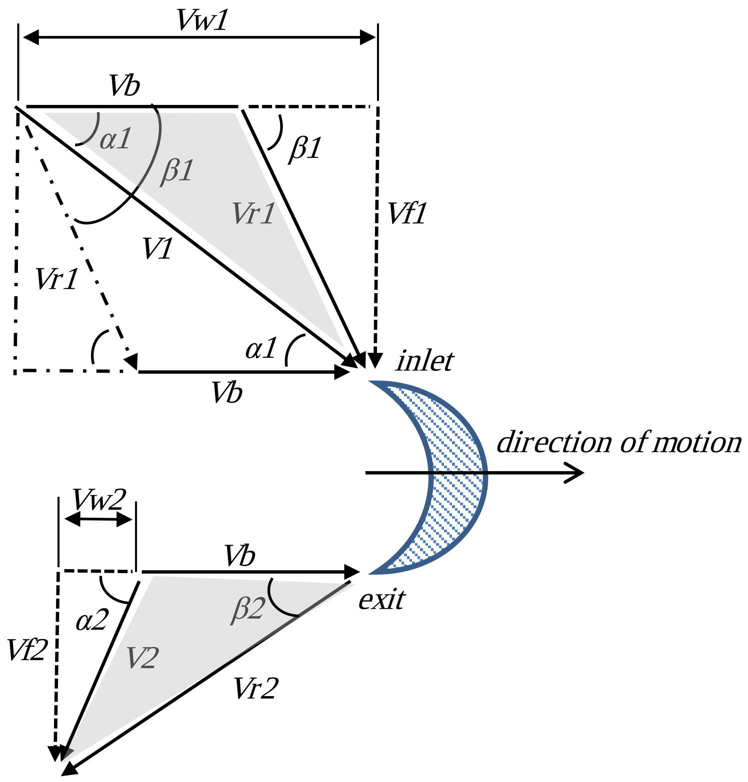


Figure (5.5): Absolute and relative velocities for simple impulse turbine blade.

α : Angle of absolute velocity measured to the direction of blade motion.

α1: Angle of absolute velocity measured to the direction of blade motion at inlet "nozzle angle"

α2: Angle of absolute velocity measured to the direction of blade motion at exit.

β : Angle of relative velocity measured to the direction of blade motion.

β1: Angle of relative velocity measured to the direction of blade motion at the entrance of moving blade "blade inlet angle".

β2: Angle of relative velocity measured to the direction of blade motion at the outlet of moving blade "blade outlet angle".

In the impulse turbine, the symmetrical offer a constant cross-section area between two consecutive blades from inlet to exit and so no expansion occurs in the moving blade. The steam expansion only occurs in the nozzle. Also, in the absence of expansion across moving blade the pressure of steam remains constant from inlet to exit under ideal conditions. For symmetrical blades the inlet and exit angles of blade are same i.e. β1 = β2.

Vb: linear velocity of the blade "mean blade speed " $V_b = \frac{\pi DN}{60}$,

D: mean diameter of wheel in (m)

N: Speed in (rpm)

V1: Absolute velocity of steam at inlet to moving blade or velocity of steam leaving nozzle

V2: Absolute velocity of steam at exit of moving blade.

Vr1: Relative velocity of steam at inlet of moving blade.

Vr2: Relative velocity of steam at exit of moving blade.

Vf1: velocity of flow at inlet to moving blade or axial component of absolute velocity at inlet to moving blade. $[V_{f1} = V_1 \times \sin\alpha 1]$or $V_{f1} = V_{r1} \times \sin\beta 1$, see Figure (5.5).

Vf2: velocity of flow at exit of moving blade or axial component of absolute velocity at exit of moving blade $[V_{f2} = V_2 \times \sin\alpha 2]$,see Figure (5.5).

Vw1: Whirl velocity at inlet to moving blade or tangential component of absolute velocity at inlet to moving blade $[V_{w1} = V_1 \times \cos\alpha 1]$,see Figure (5.5).

Vw2: Whirl velocity at exit of moving blade or tangential component of absolute velocity at exit of moving blade.$[V_{w2} = V_2 \times \cos\alpha 2]$,see Figure (5.5).

m^o :Mass of steam flowing over blade (*kg/s*).

Actually, there always exist some friction over the blade so the relative velocity at outlet will be smaller than the relative velocity at inlet, i.e. Vr2<Vr1. This reduction in relative velocity is quantified by parameter called Blade velocity coefficient (*K*) is defined:

K = Blade velocity coefficient (Ratio of relative velocity at exit and inlet).

$K = \frac{Vr_2}{V_{r1}}$ also, for multi-stage turbine $K = \frac{V_3}{V_2}$ where V3 Absolute velocity of steam at inlet to the second moving blade.

Figure (5.6) illustrates the combination of velocity triangles for inlet and outlet for moving blade of impulse turbine.

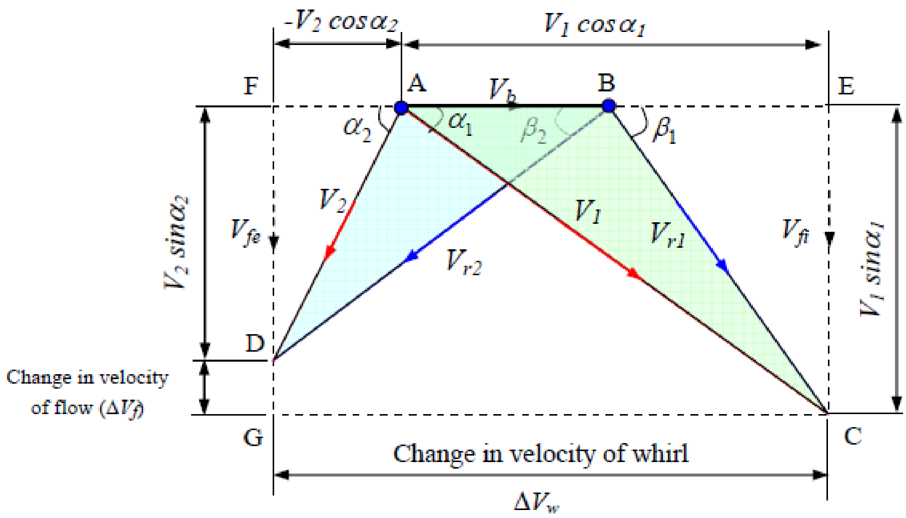


Figure (5.6): Combined Inlet and Outlet Velocity Diagram for Impulse Turbine