MARINE STEAM TURBINES

(*FORMING THE SUPPLEMENTARY VOLUME TO "MARINE ENGINES AND BOILERS"*)

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§ 36. **Ideal Impulse Turbine.**—As stated in § 32 the fundamental type of an impulse turbine consists of rotating blades on which impinges the steam issuing from a nozzle. The whole of the energy contained in the steam on leaving the nozzle is converted into velocity, this velocity being transformed into mechanical work in the wheel. Fig. 11 represents a nozzle and one blade of such a turbine.

We will first of all assume the simplest case, that is, angles of $\alpha_1 = 0$ and $\alpha_2 = 180°$.

The energy imparted to the wheel by the steam jet per second is:

$$W = \frac{Q}{g} \, . \, u \, . \, (v_1 - v_2).$$

In this case the velocity v_1 is equal to the absolute velocity of the steam jet which we denote with c_o and the absolute final velocity v_2 with c_2.

A simple reflection will show that this final velocity c_2 is equal to the absolute inlet velocity c_o less twice the blade velocity.

Or, $$c_2 = c_o - 2u.$$

The relative velocity of the steam in the blade is:

$$w_1 = c_o - u.$$

The absolute outlet velocity must be less than the relative velocity in the blades by the amount u as the blade is moving through space with this velocity in an opposite direction. The total change in velocity of the steam jet in a tangential direction is:

$$v_1 - v_2 = c_o + (c_o - 2u) = 2(c_o - u).$$

The absolute outlet velocity $c_o - 2u$ is positive, as this velocity has an opposite direction to c_o.

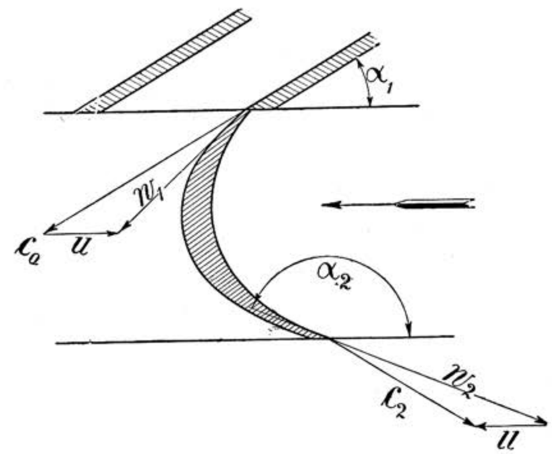

Fig. 11.

The work done by the steam is:—

$$W = \frac{Q}{g} \cdot 2 \cdot (c_o - u)u,$$

and becomes a maximum when $u = \frac{c_o}{2}$, so that:

$$W_{max} = \frac{Q}{g} \cdot \frac{c_o^2}{2},$$

from which the efficiency will be:

$$\eta = \frac{W}{W_{max}} = \frac{2(c_o - u)u}{\frac{c_o^2}{2}} = 4\left[\frac{u}{c_o} - \left(\frac{u}{c_o}\right)^2\right].$$

Fig. 12 shows how the efficiency varies. The values of $\frac{u}{c_o}$ are entered as abscissæ, and the efficiencies as ordinates. At the value of $\frac{u}{c_o} = 0$ and $\frac{u}{c_o} = 1$, the efficiency becomes zero, and is a maximum at $\frac{u}{c_o} = \cdot 5$. In accordance with the character of the formula for $\frac{W}{W_{max}}$, the efficiency curve is a parabola. This investigation shows that:

"*The theoretical maximum efficiency of impulse blading is obtained when the blade velocity is one-half the velocity at which the steam leaves the nozzle.*"

We can make the same deductions for more complicated blade shapes where the direction of the inlet and outlet velocities form acute angles with the direction of the blade velocity. In doing so it must not be overlooked that only the tangential components of the inlet and outlet velocities of the steam are entered into the formula for the work done by the steam.