Lecture on

Kaplan Turbine

by

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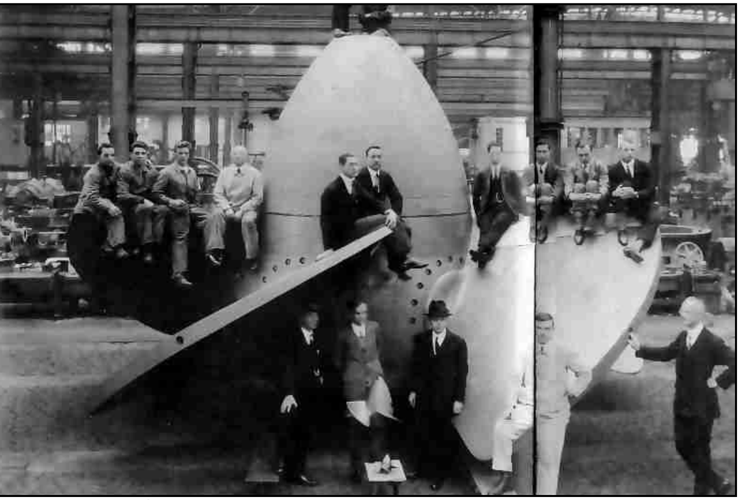
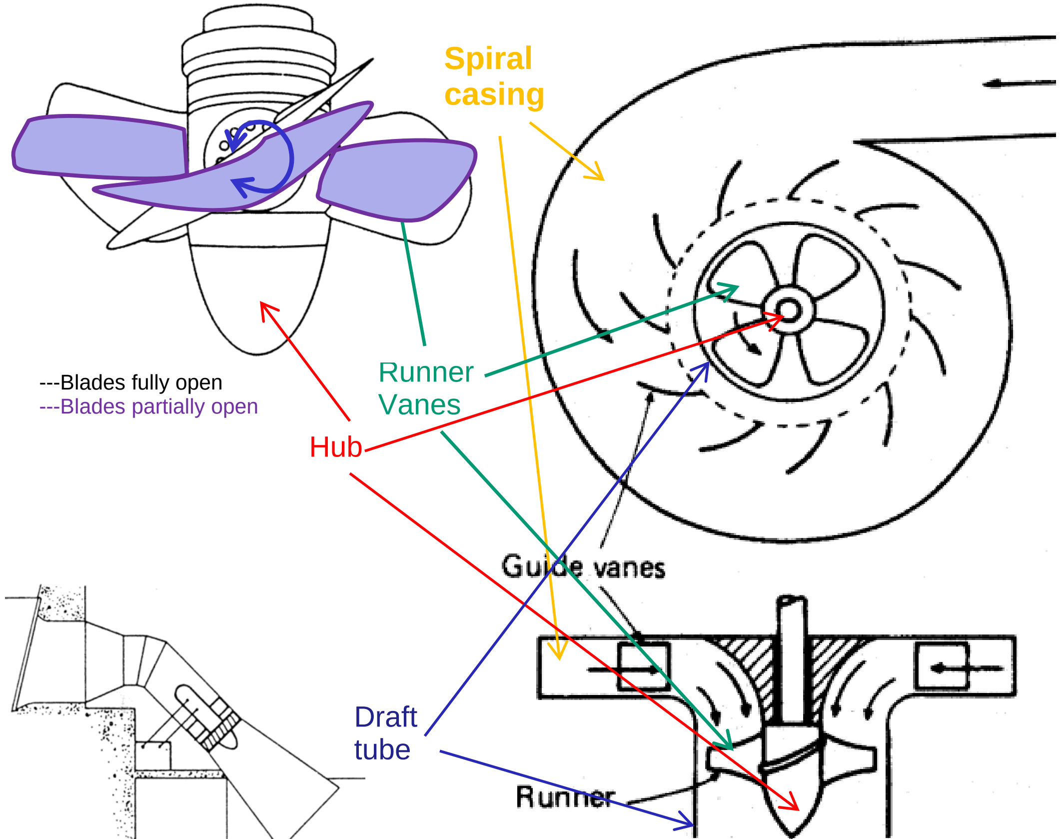
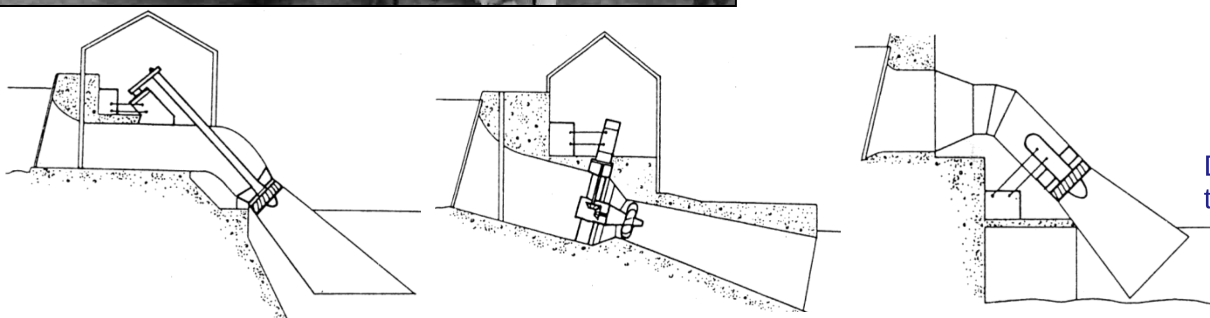
Turbine: Kaplan

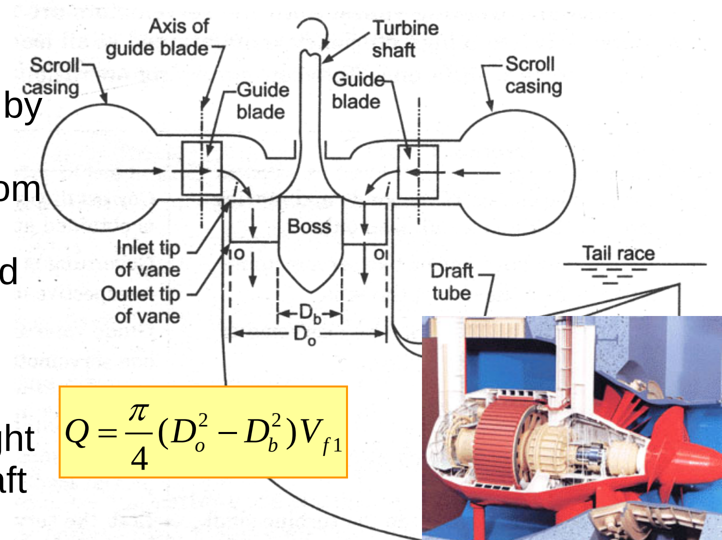






Different arrangement of axial turbine in a power plant system

(1) Suitable for low head (approx. less than 30 m), high discharge.
(2) Propeller type, water enters into the turbine laterally, gets deflected by the guide vanes and then flow through the propeller.
(3) Runner is in form of boss which is nothing but extension of the bottom end of the shaft.
(4) Capable of taking 15 to 20 % overload at all gate opening at full load and part load condition when working in constant speed and head.
(5) Blade angle may also be adjusted under all working condition.
(6) Sometimes electric generator coupled to kaplan turbine is enclosed and work inside a straight passage of a shape of bulb. This watertight bulb is submerged inside the water and bends at inlet to casing, draft tube etc. – bulb turbine.

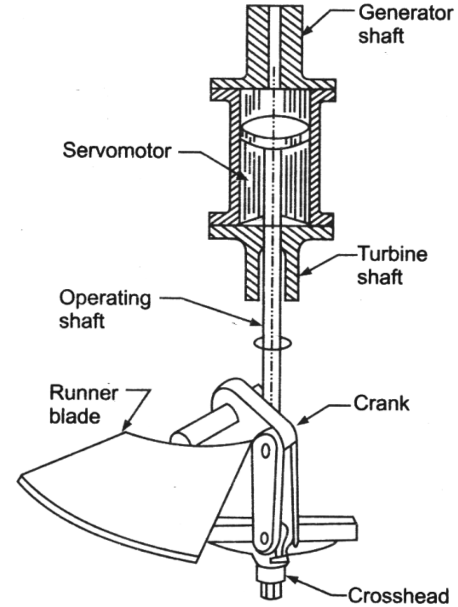


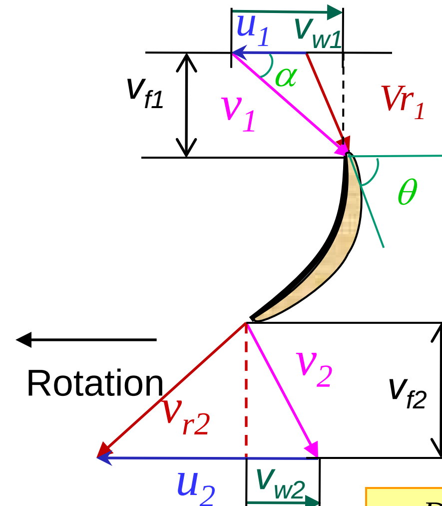
$$Q = \frac{\pi}{4}(D_o^2 - D_b^2)V_{f1}$$

Governing Mechanism: Kaplan

Francis Turbine	Kalpan Turbines
1. Correct disposition of the guide and moving vanes is obtained at full load only.	Correct disposition of the guide and moving blades is obtained at any load.
2. System may have one or two servomotors depending on the size of the unit.	Governing is always done by two servomotors irrespective of the size of the unit.
3. Guide vane regulation is done : servomotor controls only the guide vanes.	Guide vane and runner vane regulation is done; one servomotor controls the guide vanes and the second operates on the runner vanes.
4. Since only the guide vanes are controlled, high efficiency is obtained only at full load.	Due to simultaneous control of both guide and runner vanes, high efficiency is attained even at partial loads.
5. Servomotor is kept outside the turbine shaft	Both the servomotors are kept inside the hollow shaft of the turbine runner.
6. Ordinary governor is sufficient as the servomotor is of large size.	Heavy duty governor is essential due to smaller size of the servomotors.

Francis Turbine	Kalpan Turbines
1. Radially inward or mixed flow turbine.	Purely axial flow turbine.
2. Horizontal or vertical disposition of shaft.	Only vertical shaft disposition.
3. Runner vanes are not adjustable.	Runner vanes are adjustable.
4. Large number of vanes ; 16 to 24 blades.	Small number of vanes ; 3 to 8 blades.
5. Large resistance needs to be overcome owing to more vanes and greater area of contact with water.	Less resistance as there are fewer vanes and less wetted area.
6. Medium head turbine (60 m to 250 m) and works under medium flow rate.	Low head turbine (upto 30 m) and requires very large volumetric flow rates.
7. Specific speed ranges from 50-250.	Specific speed ranges from 250-850.
8. Ordinary governor is sufficient for speed controls as the servomotor is of larger size.	Heavy duty governor is essential for speed control due to smaller size of the servomotors





$$Q=\frac{\pi}{4}D_o^2(1-n^2)V_{f1}$$

$$n=\frac{D_b}{D_o}$$

$$Q=\frac{\pi}{4}D_o^2(1-n^2)k_f\sqrt{2gH}$$

Kf=0.70, n=0.35 to 0.61

Cavitation

Apply Bernoulli's equation between runner exit (2) and free surface (3)

$$\frac{p_2}{\rho g}+\frac{v_2^2}{2g}+z_2=\frac{p_3}{\rho g}+\frac{v_3^2}{2g}+z_3$$

Where $h_s=z_2-z_3$, $V_3=0$, $P_3=P_A$

$$\frac{p_2}{\rho g}+\frac{v_2^2}{2g}+h_s=\frac{p_A}{\rho g}$$

Presuming Cavitation does commence $P_2=Pv$ (vapour pressure)

$$\frac{v_2^2}{2g}=\frac{p_A}{\rho g}-\frac{p_v}{\rho g}-h_s$$

And deviding both side by working head H, and considering $P/\gamma = H$ in all terms

Total suction head = Hsu

$$\frac{v_2^2}{2gH}=\sigma=\frac{H_A-H_v-h_s}{H}$$

σ = Thoma cavitation factor, and if $\sigma<\sigma_c$, then cavitation occurs.

Francis Turbine:

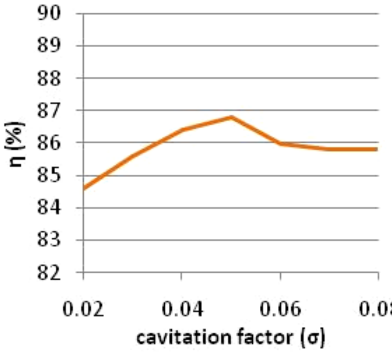
$$\sigma_c=0.044(N_s/100)^2$$

Propeller Turbine:

$$\sigma_c=0.3+0.0032(N_s/100)^{2.73}$$

Kaplan Turbine:

$$\sigma_c=1.1\sigma_c\big|_{propeller}$$



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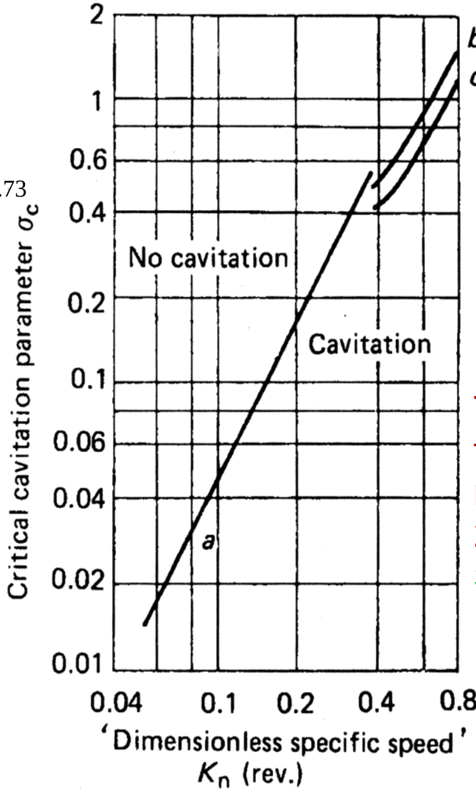

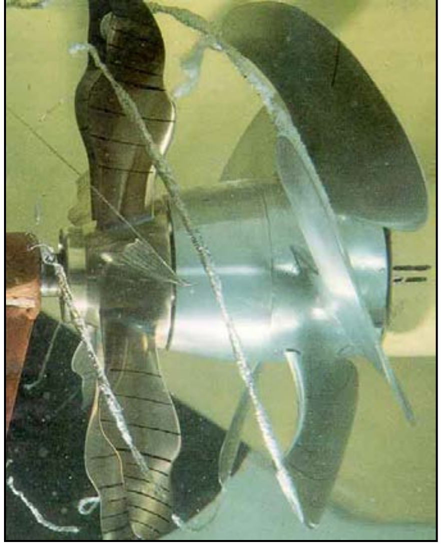

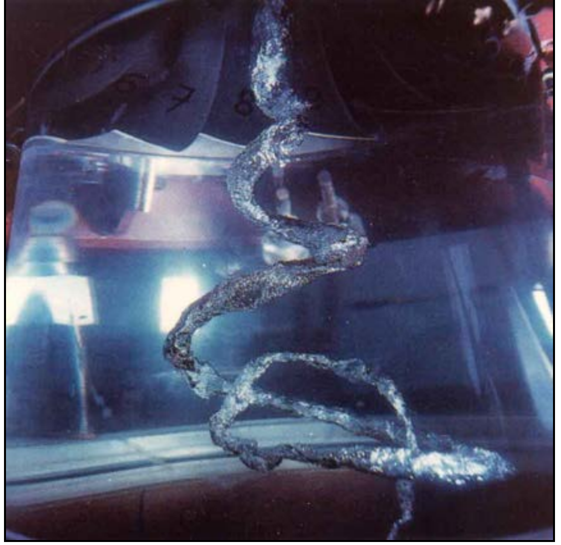

Turbines: L-1 propeller turbine designed for minimal cavitation after 25,000 hours

Suction Specific Speed

$$S_{su}=\frac{N\sqrt{P}}{H_{su}^{\;5/4}}\qquad N_s=\frac{N\sqrt{P}}{H^{\;5/4}}$$

$$\sigma=\left(\frac{N_s}{S_{su}}\right)^{4/5}$$

Cavitations in Kaplan Turbines

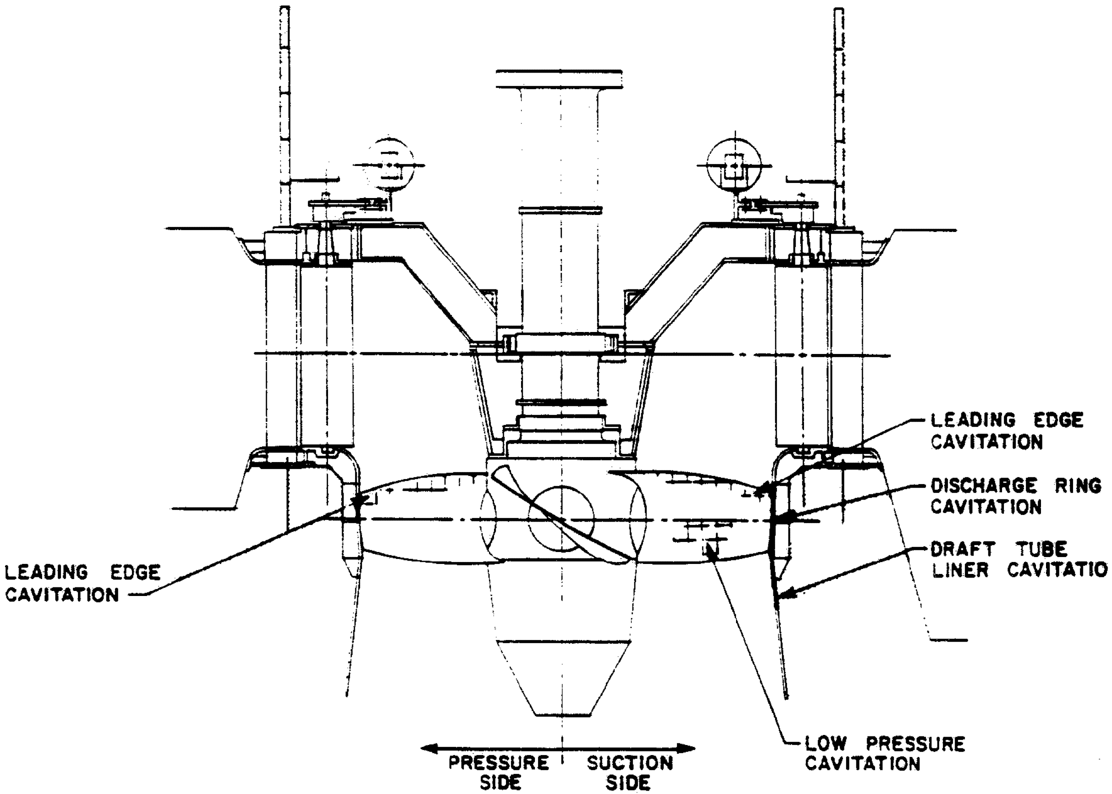

Figure 4-1. Kaplan Turbine
Typical Areas of Cavitation Pitting

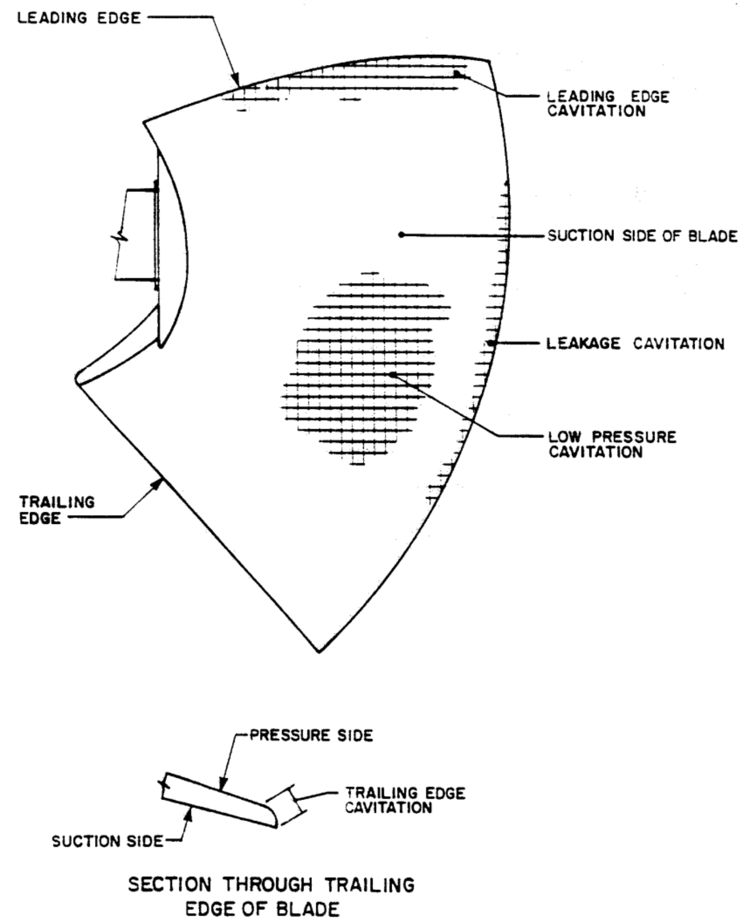

Figure 4-2. Areas of Runner Cavitation Pitting
Propeller and Kaplan Turbines

Cavitations in Francis Turbines

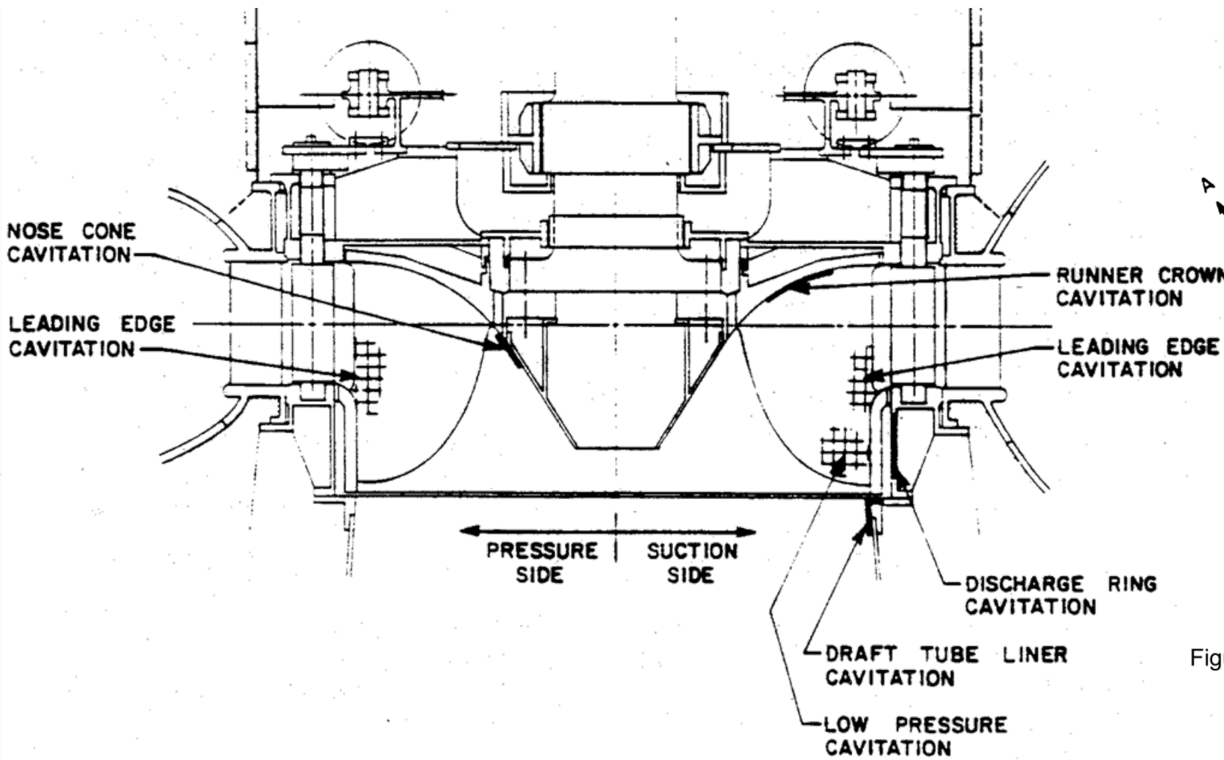

Figure 4-3. Francis Turbine - Typical Areas of Cavitation Pitting

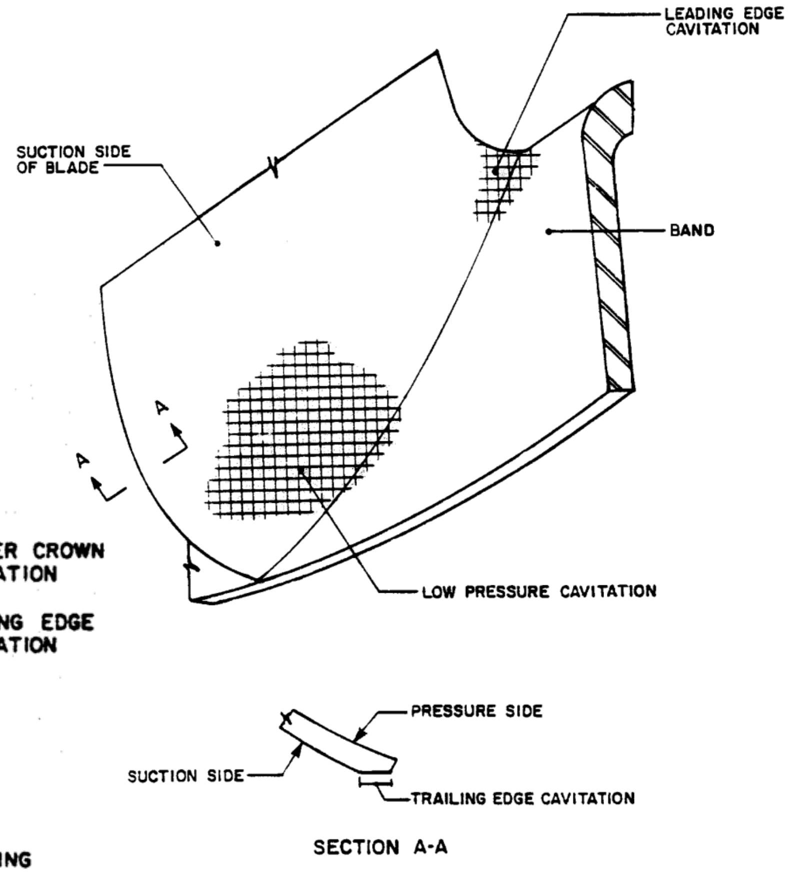

Figure 4-4. Areas of Runner Cavitation Pitting - Francis Turbine