PERFORMANCE EFFECTS OF INCIDENCE

By Scott MacFarlane

Steam turbines are designed to perform at specified steam pressures, temperatures, flows and rotor speeds throughout their lifecycle. However, in real life applications they are more frequently than not operating at off-design conditions. A primary example of this is the reapplication of surplus turbines. The same holds true for the individual stages of blades within the steam turbine. Most blades are designed to perform at an optimum level, which occurs when the inlet flow angle is close to the blade's inlet angle. When these angles are off, the resulting flow entering the stage of blades is considered off incidence. Incidence is defined as the difference between the inlet blade angle and the inlet flow angle. These angles are measured with respect to the tangential plane at the leading edge shown as 0° in Figure 1.

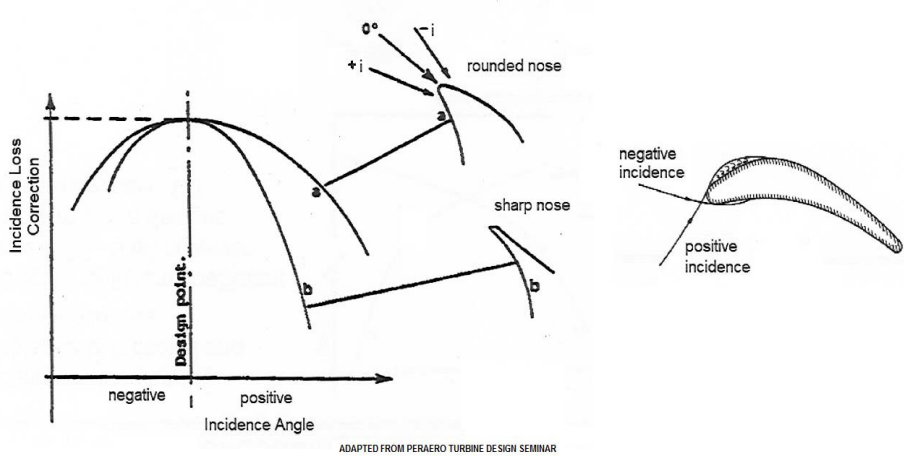

Figure 1

Off-incidence can occur when the turbine is required to operate at common off design conditions such as idling, variable speed and varying loading. The effects of off-incidence on the total loss vary with different blade profiles and geometry. Off-incidence losses are highly affected by the leading edge geometry. The nose shape will determine the extent of flow separation with respect to the incident angle, which can also be seen in Figure 1. A negative incidence angle is more desirable due to the minimized amount of flow separation from the blade. A positive incidence angle causes increased blade loading which results in a thicker boundary layer on the suction side and greater separation.

Reaction style blade profiles are designed with the ability to withstand a wider range of incidence without negatively effecting losses. This is due to the flow acceleration through the stages. The variation of profile losses against the angle of incidence range for impulse and reaction turbine blades can be seen in Figure 2.

When deciding to operate an existing or reapplied turbine at off design conditions, consideration should be given to the possible performance penalty of off-incidence from a mismatched flow path.

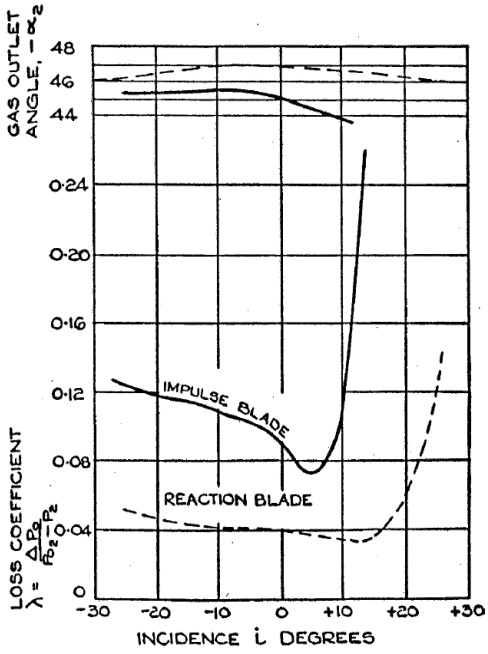

Figure 2

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