STEAM TURBINE UPRATES, PRELIMINARY CHECKS

By Sydney Gross

Flange Steam Velocity Limits		
	Condensing	Non-Condensing
Inlet	175 ft/s	175 ft/s
Exhaust	450 ft/s	250 ft/s
Induction / Extraction	250 ft/s	

Table 1: Flange Steam Velocity Limits

Whether you're horsepower limited or you're planning to uprate that compression train as part of a de-bottlenecking project, the question has presented itself. Is the steam turbine capable of being rerated? Before you call RMS or go back to the OEM, you can do a few quick hand calculations to determine whether your turbine may be a suitable candidate for uprating.

But first, how do you uprate a turbine? Easy, you put more steam through it. Power is roughly proportional to flow. What about efficiency improvements and modern technology? Unless the turbine is operating way off design, and we'll discuss that in more detail in a later issue, or you're willing to invest in gutting the machine, chances are that efficiency improvements alone will not get you where you want to go. So, if you turbine, the casing and the rotor. If it's necessary to replace either, your decision to keep the old turbine may change.

We'll look at question 1 now and visit question 2 in the next issue.

What is a reasonable steam velocity?

The answer to that can be found in API 612 and NEMA SM23. Inlet flange velocities are limited to 175 ft/sec and exhaust flange velocities are limited to 250 ft/sec for non-condensing (back pressure) turbines or 450 ft/sec for condensing turbines. Extraction/induction flanges are also limited to 250 ft/sec. There are several reasons for limiting the steam velocity. Some of them are excessive noise, pressure drop, pressure shock, turbulence, and erosion.

We're interested in an average velocity for this consideration. In order to calculate the average steam velocities at the flanges you need to know the flange sizes, steam mass flow rate, the states of the steam at inlet and exhaust and the Prandtl-Meyer Supersonic Expansion Function.

You don't need the last one. I just wanted to see if you were still with me.

The equation for the average velocity is,

$v = m \div (\rho * A)$

where

m = mass flaw rate a steam in lbm/sec

p = steam density in lbm/ft3

A = flange crass sectional area in in2

The mass flow rate, m, should be obtainable from the performance data sheet in the original instruction book for the equipment. Or, it should be measured by an orifice flow meter upstream of the turbine. Remember that the power is approximately proportional to the flow so the new flow can be approximated by multiplying the current flow by a ratio of the new desired power to the power at the current flow.

The steam density. ρ, is obtained from the steam tables for the conditions at inlet and exhaust . The inlet is easy since the inlet pressure and temperature are always available. The exhaust may be a challenge especially for a condensing turbine because you need steam quality. Chances are. you'll have to make an assumption about the machine's efficiency, apply it to the isentropic enthalpy drop from inlet to exhaust pressure then go back to the steam tables and get the density from the exhaust pressure and assumed exhaust enthalpy. If you don't follow that, just give me a call and we'll figure it out together.

The flange area, A, is simply equal to $\pi * (d^2 \div 4)$ for a round flange with an ID of d or L * W for a rectangular flange.

Plug in the numbers and check it against the criteria above. Now. I'm not going to sit here and tell you that if the inlet velocity is 176 ft/sec you can't rerate your turbine. Velocities exceeding the criteria may be acceptable in cases. It takes a little judgment if your turbine is marginal. Things to consider are how far beyond the criteria the velocity is and how long the turbine will run there .

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