WHY WORRY ABOUT DOWNSTREAM

By Christopher Sykora

If you have been reading a structural analysis report that covered vibrations of multistage compressors or turbines lately, you might have noticed something referred to as "downstream excitations" on the Campbell or Interference diagram. A common question is "What are downstream excitations and why should we care about them if they are downstream"? First, recall that an excitation is a source of forced vibration (typically rotor imbalance and/or flow disturbances) that could potentially excite damaging resonant vibrations in the rotor. These excitation frequencies will cause resonance if they match the natural frequencies of any components of the rotor. Figure 1 shows an example of upstream & downstream stator vanes.

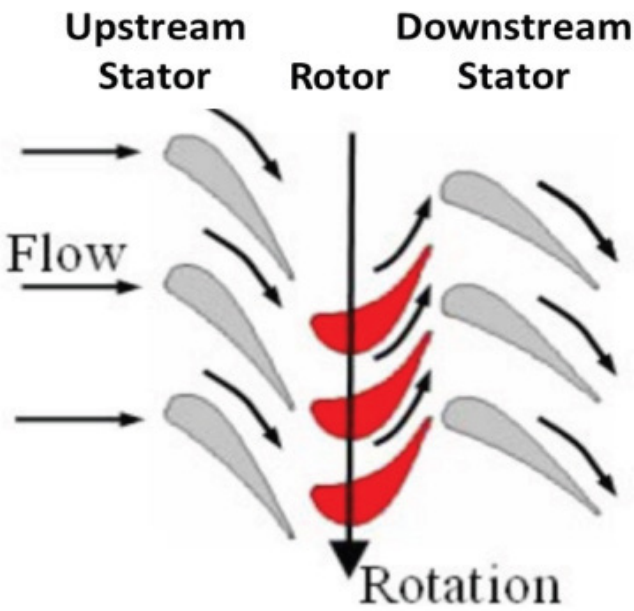

Figure 1

It is usually pretty easy to imagine how the flow disturbances from upstream stator vane wakes could have an influence on the rotor blades that are just downstream. Just picture the wakes behind a boat that are bumping into a swimmer being towed behind the boat. These wakes can be strong and would be noticed by even a swimmer that was fairly far behind the boat. The same is true for aerodynamic wakes coming from the trailing edge of airfoils in a compressor (see Figure 2). This trailing wake is relatively strong and travels far downstream due to the separated, turbulent flow behind the airfoil (although the aerodynamic designer attempts to minimize this turbulence for best efficiency).

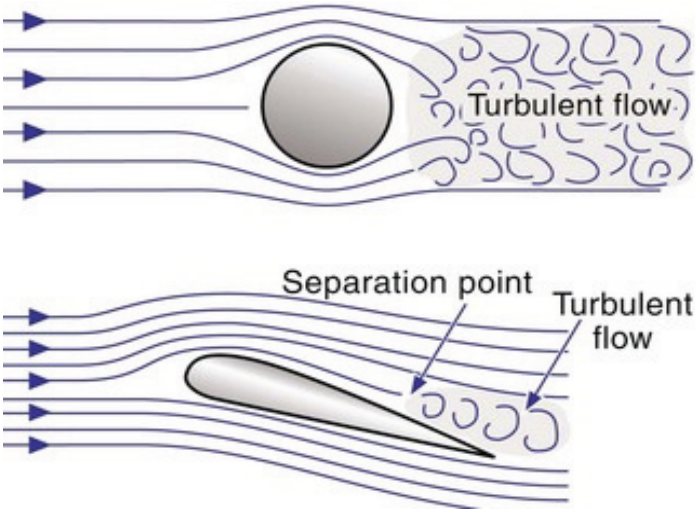

Figure 2

However, it can be harder to envision how stator vanes that are downstream of the rotor blade rows could have an impact on the blades ahead of them. It isn't as obvious why this is considered on the Campbell diagrams. Is this just being extra conservative? The answer depends on how closely the stator vanes follow the preceding rotor blade row. If you look carefully again at the streamlines surrounding the airfoil shown in Figure 2, you will notice that they tend to bend around the leading edge of the airfoil. This effect occurs upstream, before the streamlines even reach the front of the airfoil. This effect isn't as strong as the turbulent flow coming off the back of the airfoil, but if the rotor blades are close enough to the leading edge of the stator vanes, then they will certainly experience this "extra" flow disturbance. Thus it is required that this also be considered in the vibration evaluations. Axial compressors and steam turbines generally have stator vanes close enough that downstream is always included. For centrifugal compressors, the distance downstream can be larger, so this is weighed when deciding whether or not the downstream excitations should be included.

For more information:
Email: RMS@rotatingmachinery.com
Tel: 484-821-0702

Headquarters
2760 Baglyos Cir.
Bethlehem, PA 18020

Houston Office
16676 Northchase Dr., Ste 400
Houston, TX 77060

rotatingmachinery.com
Tel: 484-821-0702
Parts: rms@rotatingmachinery.com