Extension Of *TurbAero* To Wind Turbines And Wave Turbines

In 2008, a consulting company (a licensed user of *CompAero* and *TurbAero*) contacted me for some software support in the application of the software to wind turbine designs. At that time, this was a very modest effort seeking only to accomplish an aerodynamic performance analysis using program *AxTurb*. That user was applying the *CompAero* program *BLADE* to use its axial-flow compressor blade profiles to define the wind turbine rotor blades. I do not know exactly how that was done, but it clearly can supply the data needed by *AxTurb* if the flow direction is reversed (since compressor cascades have the throat at the inlet rather than at the discharge). But they apparently found it to be useful for this purpose. At that point, this was a minor support activity in getting the blade geometry properly configured for a turbine rotor to enter it into *AxTurb*. The only significant software extension at that time was to add program *BLADE* to the *TurbAero* system in case other users might find it useful.

A few months later, another consulting company (a licensed *TurbAero* user) developed a similar interest with respect to wave turbines. That user requested an upgrade to the preliminary design program *AFTSIZE*, so that its many productivity features would be available for this type of turbine design. Basically this required a program extension to allow designing a turbine stage consisting of a rotor only (no nozzle). After a brief investigation, it was found practical to accomplish that by simply assigning the stage reaction to a value that produces an absolute swirl velocity component of zero at the rotor inlet and exit. That is a reasonable model for a wind turbine or wave turbine rotor preliminary design. It also allows direct export to *AxTurb* for a performance analysis and to *AIRFOIL* for detailed blade design.

Subsequently clients of the two consulting companies, who manufacture these two turbine types became interested and licensed *TurbAero*. A couple other licensed users are currently using *TurbAero* for similar low-pressure air turbine applications. With the increased usage, a few recent minor upgrades were found necessary for error-free operation and interaction of the above three programs on actual designs. These typically involved ignoring some features and limit checks related to nozzle design that were troublesome in these cases and also irrelevant for these “rotor-only” designs.

Note that the available design charts normally used by *AFTSIZE* to estimate stage efficiency, the number of blades and to guide the selection of the design flow and work coefficients are of questionable validity for this class of turbine. But that is not a critical limitation, since *AxTurb* can easily be used to supply most of that information and guidance by iterative running of the two programs.

AFTSIZE also employs some simple estimates of several blade and seal parameters to be used in the preliminary design process. Refinement of these parameters is left to the detailed design phase in *AIRFOIL*. Default values supplied within the *AFTSIZE* have been adequate for conventional turbines. But they were found to be less adequate for these “rotor-only” designs. The most recent version of *AFTSIZE* includes revised default values of these estimates that are more general. Blades for this class of turbines tend to have thinner leading edges and smaller “wedge” angles than conventional industrial turbine blades. Usually the detailed blade geometry specifications are not required until the detailed airfoil design phase anyway. But the new estimates supply an initial input file for *AIRFOIL* that is less confusing and more reliable for a wider class of turbines. These *AFTSIZE* default values can be edited by the user based on normal practice or preference within the organization or particular applications of primary interest. The edited values will be saved to be used on future preliminary designs. The program will also let you recover the original default initial guesses later if appropriate,

Current users interested in this class of turbine are advised to upgrade to the latest version. The nominal cost of an upgrade will be recovered in short order with the improved productivity it offers.

Ron Aungier
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