

A Novel Technique to Design High Performance Radial Pumps;

An application to an engine cooling system

Prof. Dr. İ. Bedii Özdemir
ITU Fluids Group & AIY Technologies

The approach described here is concerned with designing radial turbomachines, in particular, radial pumps. The approach is also capable of designing air moving machines and compact high speed high pressure turbocharge blowers.

Turbulent flow and separation over the blades are known as the main sources of the aero-acoustic noise. Fans and pumps with improperly designed blade geometry often suffer from poor flow conditions leading to eddies that fluctuate with time and cause random dynamic forces acting on the blades. This produces broadband gust noise and, in most cases, trigger selectively organised structures over the blades causing tonal self-noise. Furthermore, the spectral characteristics of the noise may also change along the the blades.

Applications also include radial blowers of all sizes from those in electronics applications to large scale blowers used in cement factories.



It is possible to calculate lift and drag forces using mass and momentum balances on a slice of flow passage surrounding a generic airfoil. The forces are then used in an iterative procedure, in that the shape (camber, chord length and thickness) and the local angle of attack of airfoil are continuously improved from rotor base to tip in order to satisfy pressure head and flow rate for a given rpm and geometry (hub and tip diameters and height). This approach requires a look-up table for the airfoil shapes versus lift coefficient. It is important to consider the losses associated with turbulence and cross-flow effects along the blade. **Once the rotor is designed, the flow from each cascade is used to design the squirrel in a second iterative process; mass and momentum balances together with turbulent losses are invoked to calculate the polar profile of the stator. Main concern is to keep the static pressure constant so that rotor is not exposed to nonuniform pressure forces.**

The algorithm described above (also the flow chart in the next slide) is developed and programmed in a code called PRD® by Özdemir. **The output of the code are a point cloud describing surfaces of the rotor and squirrel, and an ASCII file tabulating some other critical data, as for example, the number of blades, solidity etc. The code itself defines the radial velocity profile on the pressure side of the rotor so that a blade design with diminishing radial velocities near the base and at the tip is possible. This, in turn, suppresses tip vortices developing in shear layers at both ends of the blade and eliminates the tip noise.**

The code was successfully tested in applications, such as, designing of liquid pumps and high speed turboblower applications.



