# TURBOMACHINERY AERODYNAMICS

Lect 37

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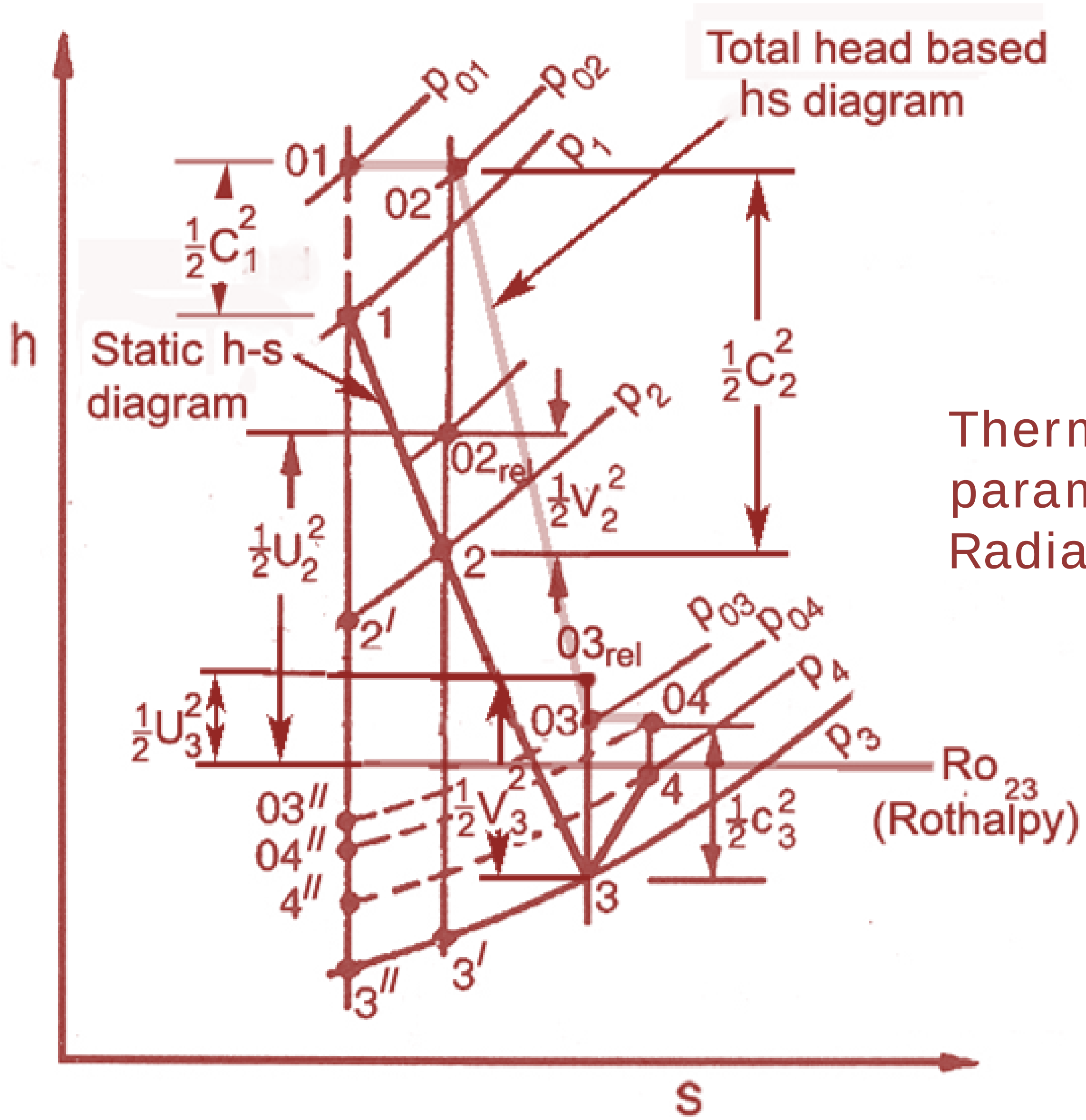
# Radial Flow Turbines

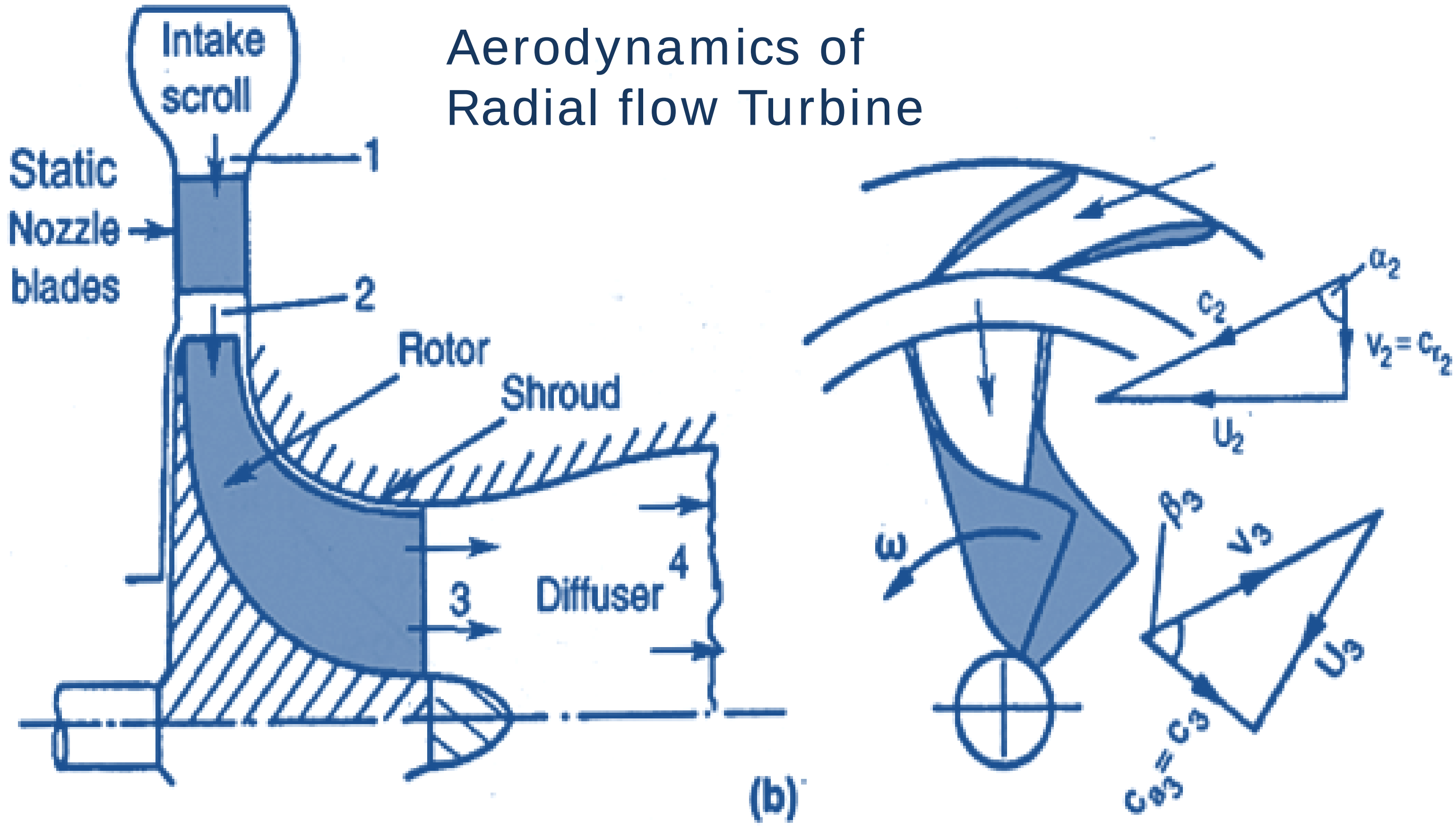
# Characteristics and Design




(a)

Thermodynamic parameters of Radial Flow Turbine

# Aerodynamics of Radial flow Turbine





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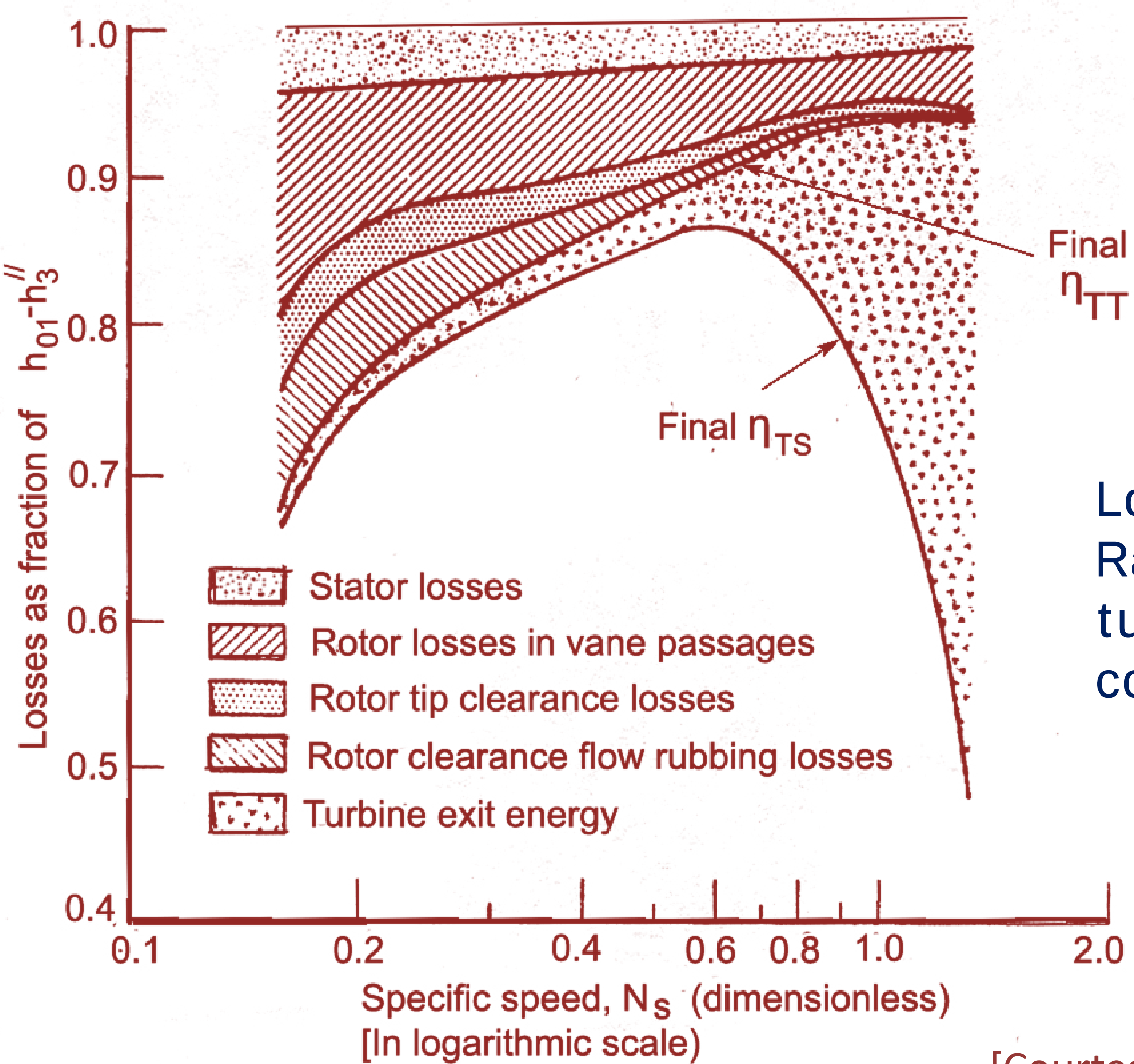
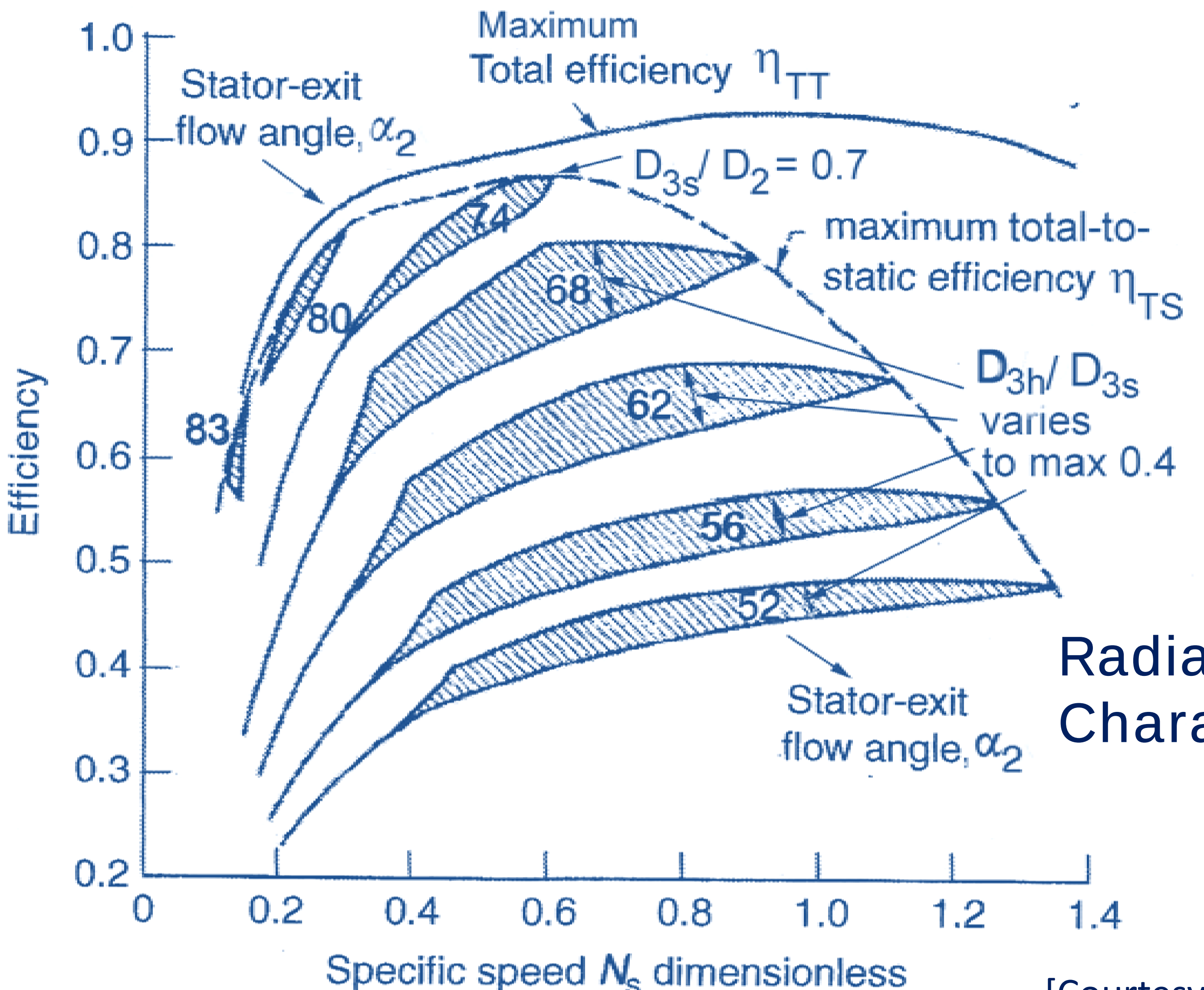



Losses in Radial turbine components

[Courtesy : NASA, USA]




## Radial Turbine Characteristics

[Courtesy : NASA, USA]

# Design of Radial Inflow Turbines

- Design of a radial turbine is often an exercise in selecting a size and a shape that maximizes the performance and minimize the losses
- Selection of flow parameters e.g. flow angles $\alpha_2$ and $\beta_3$ are made on the basis of earlier design data bank or correlations.
- Selection of rotor tip to rotor eye tip diameter ratio, $D_2/D_{3s}$ , and rotor exit hub to tip diameter ratio ,$D_{3h}/D_{3s}$, need to be done judiciously
- Flow coefficient, $C_{a3}/U_2$ also needs a selection
- All the above flow and geometric parameters are selected by the designer.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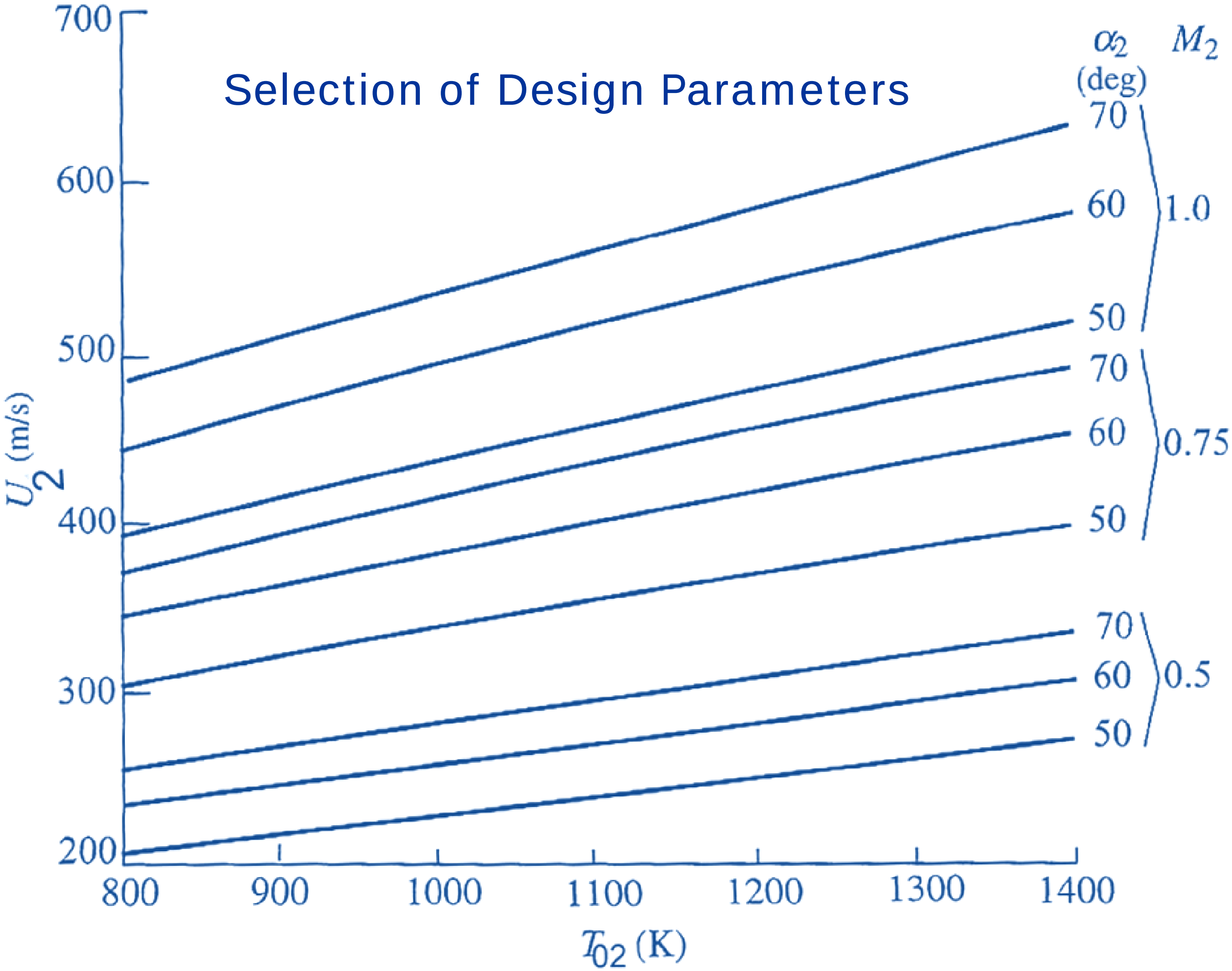


Selection of Radial turbine design operating parameters

# Design of Radial Inflow Turbines

1) It is assumed, to begin with, that the exit flow at rotor exit is axial.
2) From the earlier characteristics plots one can start with a $D_{3h}/ D_{3s} \geq 0.4$ and $D_{3s}/ D_2 \leq 0.7$. Such selections provide maximum efficiency of about 87%. [refer slide 6]
3) Blade tip speed to spouting velocity ratio $U_2/C_o$ and the flow coefficient at the rotor exit $C_{a3}/U_2$ is selected from available characteristics plots as given in slide 10.


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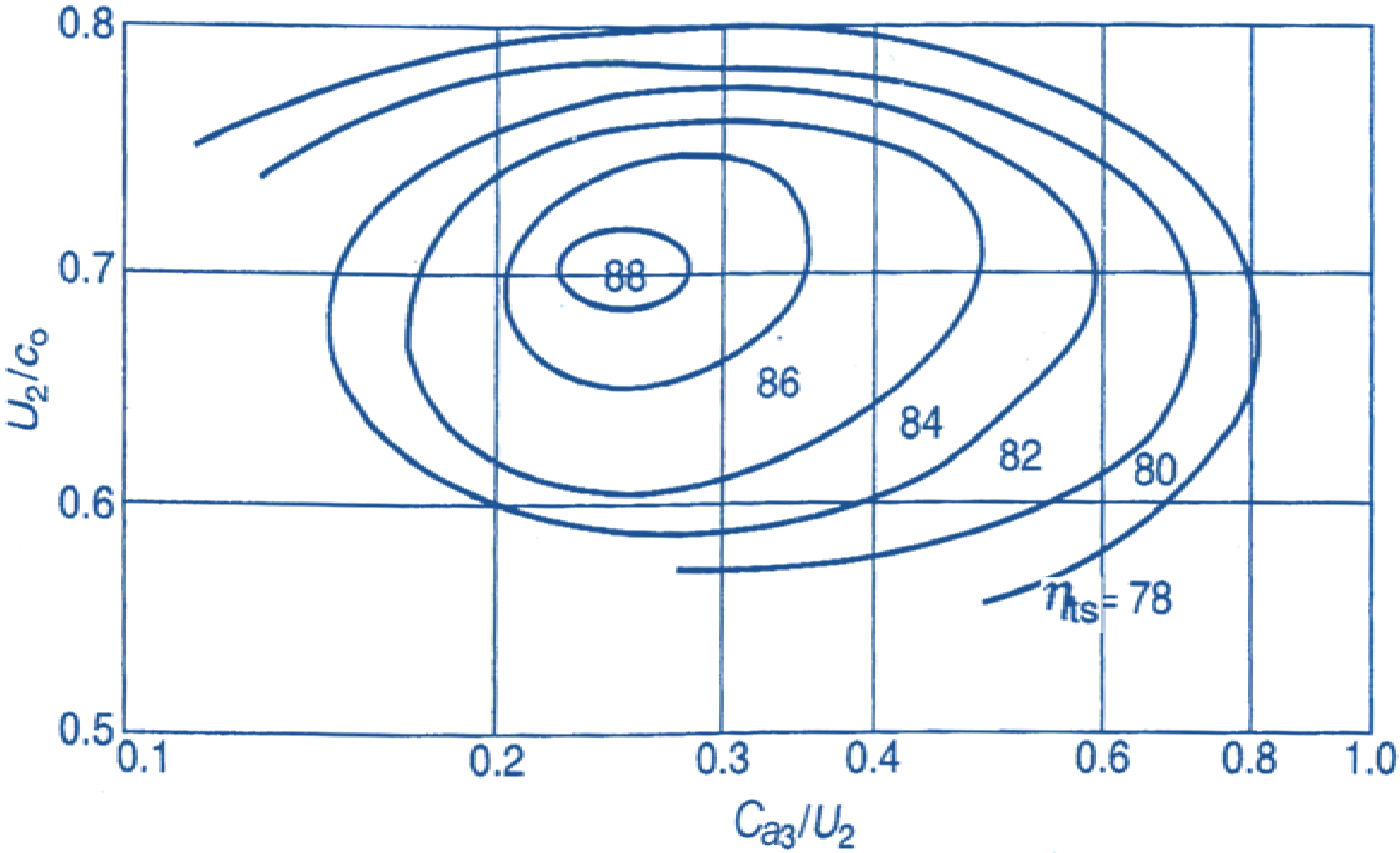


Correlation of attainable efficiency levels vs velocity ratios


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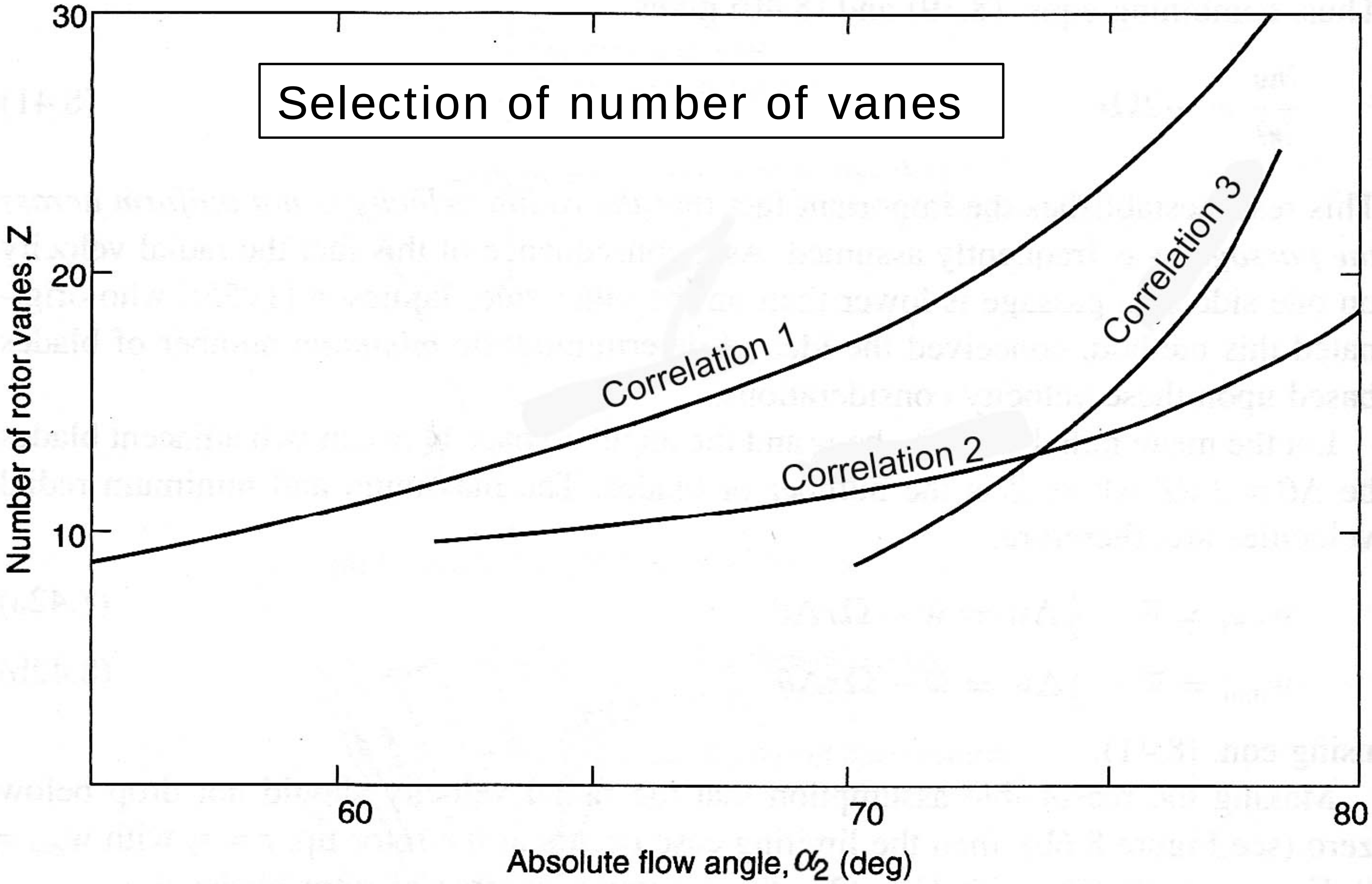
## Selection of number of vanes




Flow angle at rotor inlet as a function of the number of rotor vanes.

# Design of Radial Inflow Turbines

4. Number of vanes are selected with the help of some connected parameters e.g. nozzle exit flow angle [slide 11]. The correlation 2 gives a more realistic selection choice. Higher number of vanes would result in large surface friction losses, and lower efficiency. High nozzle exit flow angle requires large flow turning and guidance and hence asks for higher number of vanes

5. A size parameter, solidity, $Z.L/D_2$ has been used to create the design selection plot in slide 13. (L is the curvilinear length of the rotor vane)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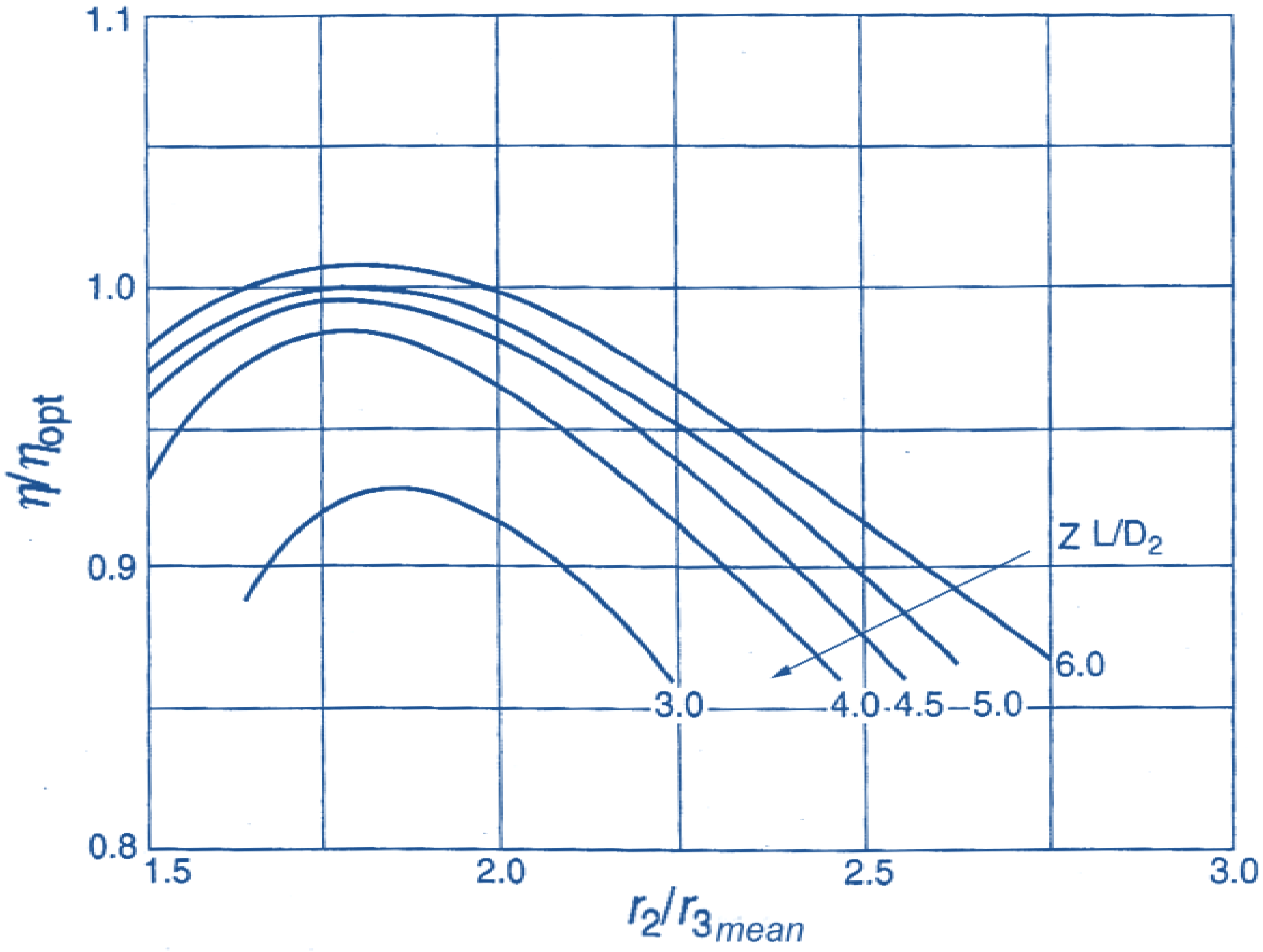


Effects of vane solidity and rotor radius ratio on the efficiency ratio


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## Design of Radial Inflow Turbines

6. Thus the design of the rotor or impeller of a conventional radial turbine can be proceeded with the help of a number of graphs and plots that the first cut design.

7. This design would then be subject to CFD analysis to finalize and fine tune the design for best efficiency

8. Radial turbines are normally not cooled. However, new cooling technologies may emerge in future.


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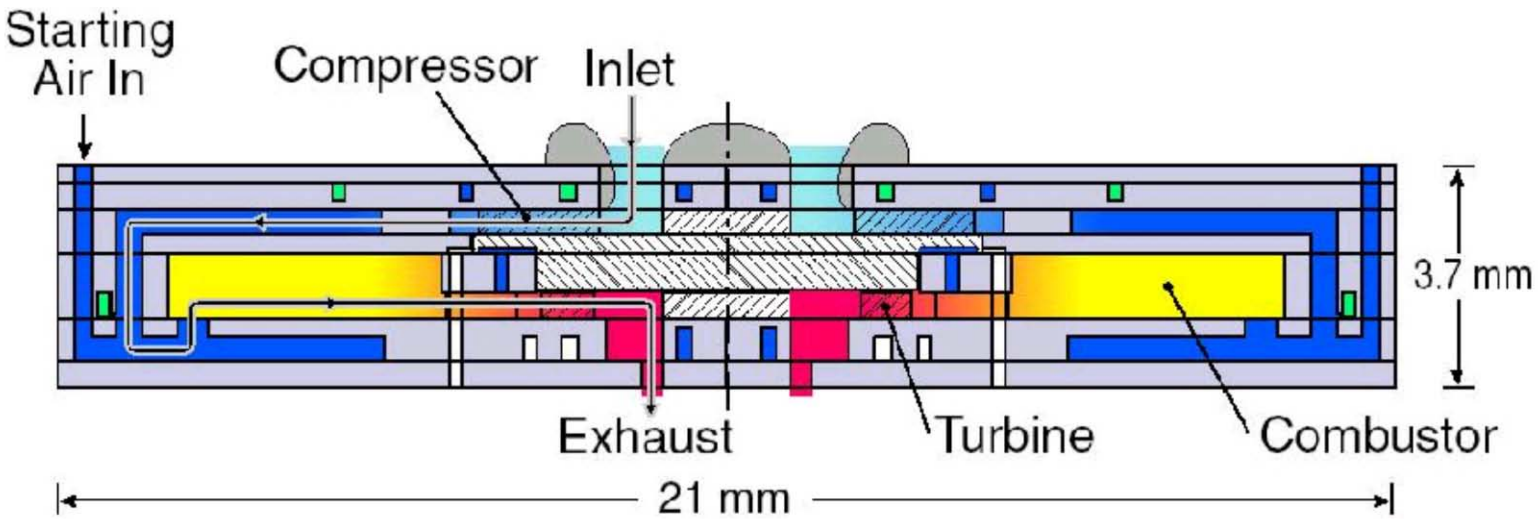
# Micro Gas Turbines




**Cross-section of the demonstration micro gas turbine**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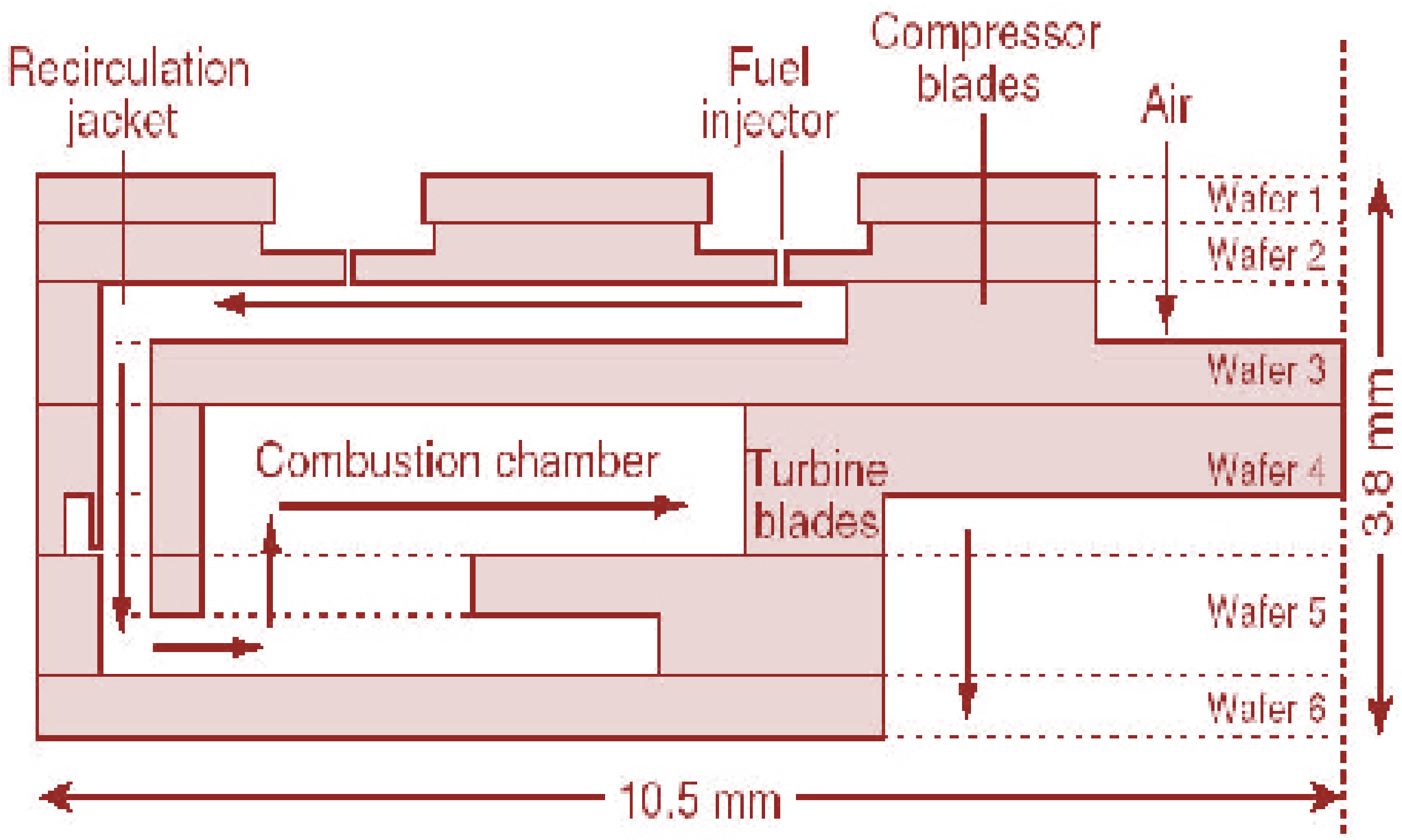
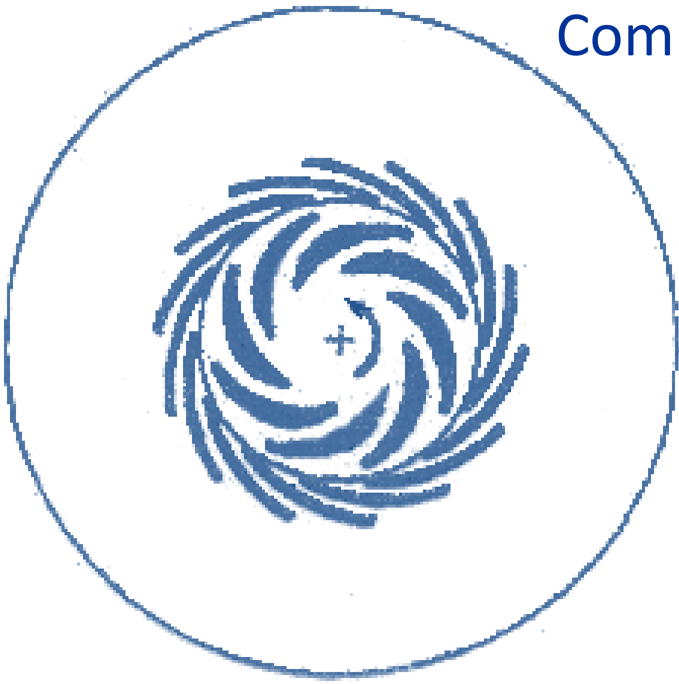
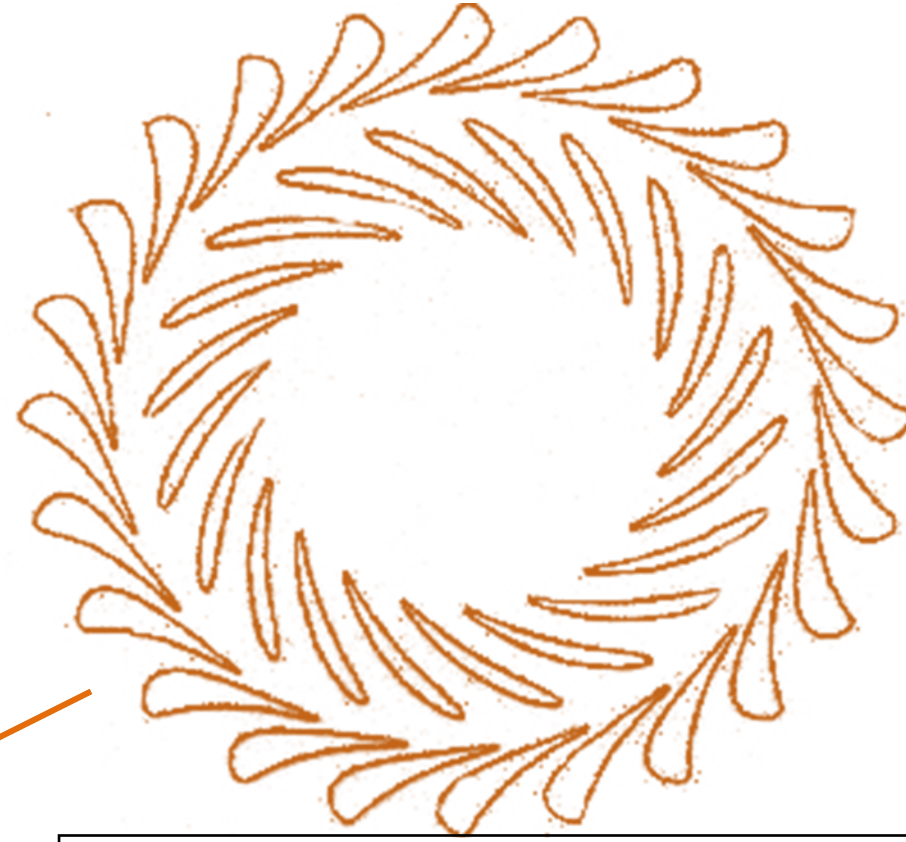
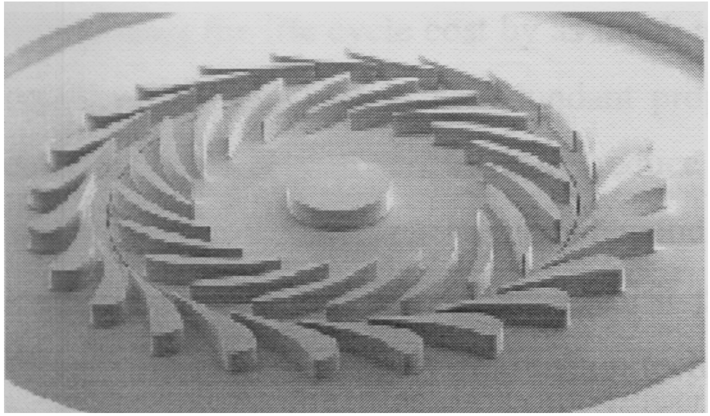

Recirculation jacket
Fuel injector
Compressor blades
Air
Wafer 1
Wafer 2
Wafer 3
Wafer 4
Wafer 5
Wafer 6
Combustion chamber
Turbine blades
3.8 mm
10.5 mm

Compressor



Turbine





**Turbine blade design. The rotor spins anti clockwise.**

Next class

Use of CFD in Turbomachines