



ORC Micro-power plant for combined heat and electric power generation

POWER PLANT ARRANGEMENT

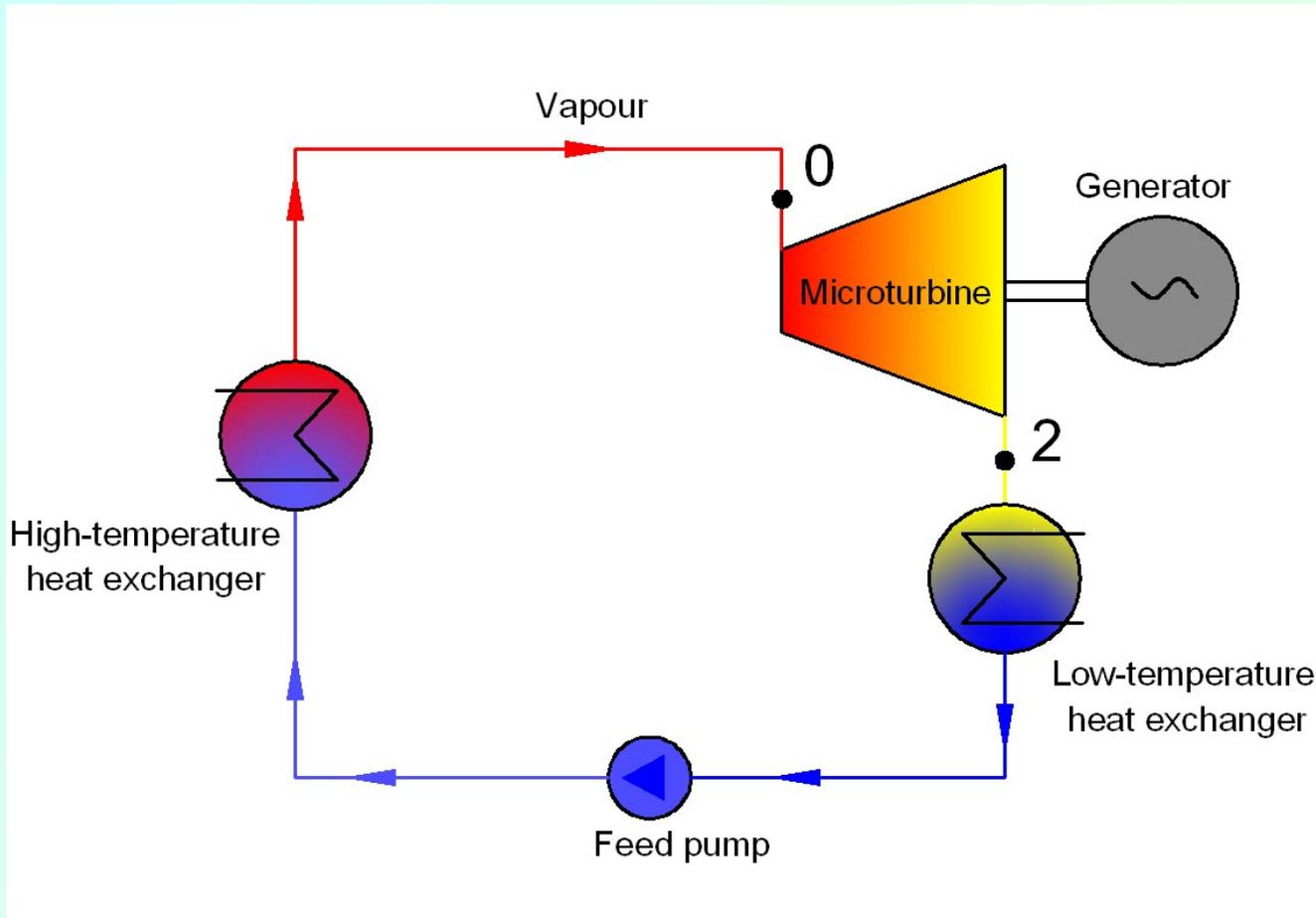
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DESIGN AND RESEARCH OF MICRO-TURBINE

Krzysztof Kosowski Marian Piwowarski Robert Stępień Wojciech Włodarski

Introduction

Introduction



HFE-7100

methoxy nano fluoro butanes
(C₅H₃F₉O) (C₅H₃F₉O)

$$P_0 = 1.2 \text{ MPa}$$

$$t_0 = 162 \text{ }^\circ\text{C}$$

$$p_2 = 119 \text{ kPa}$$

($t_s = 65 \text{ }^\circ\text{C}$)

$$m = 0.017 \text{ kg/s}$$

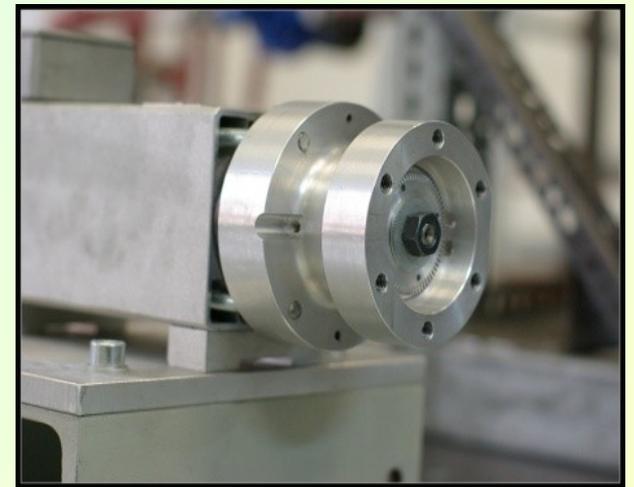
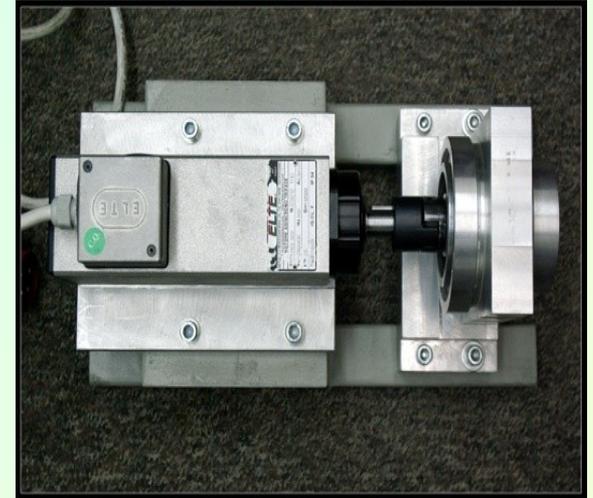
$$Q = 20 \text{ kW}$$

$$N_e = 3 \text{ kW}$$

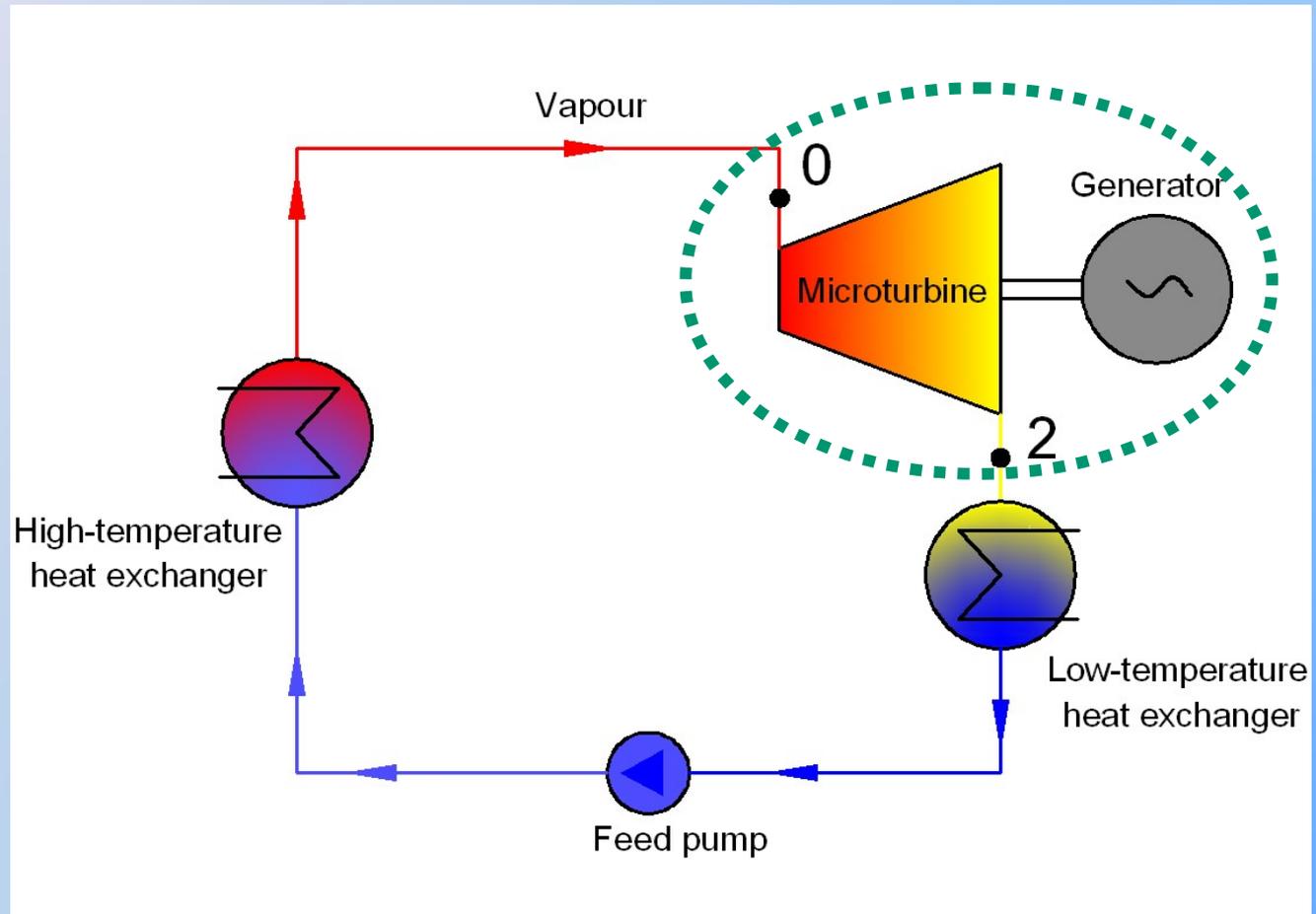
Experimental Stands



Boiler and Pumps



Micro-turbine



Design Problems

single stage turbine - design problems

single stage turbine VOLUME FLOW RATE

rotor speed: 60 000 rpm - 160 000rpm

electric generator

very short blades

very high Mach numbers $Ma > 2$

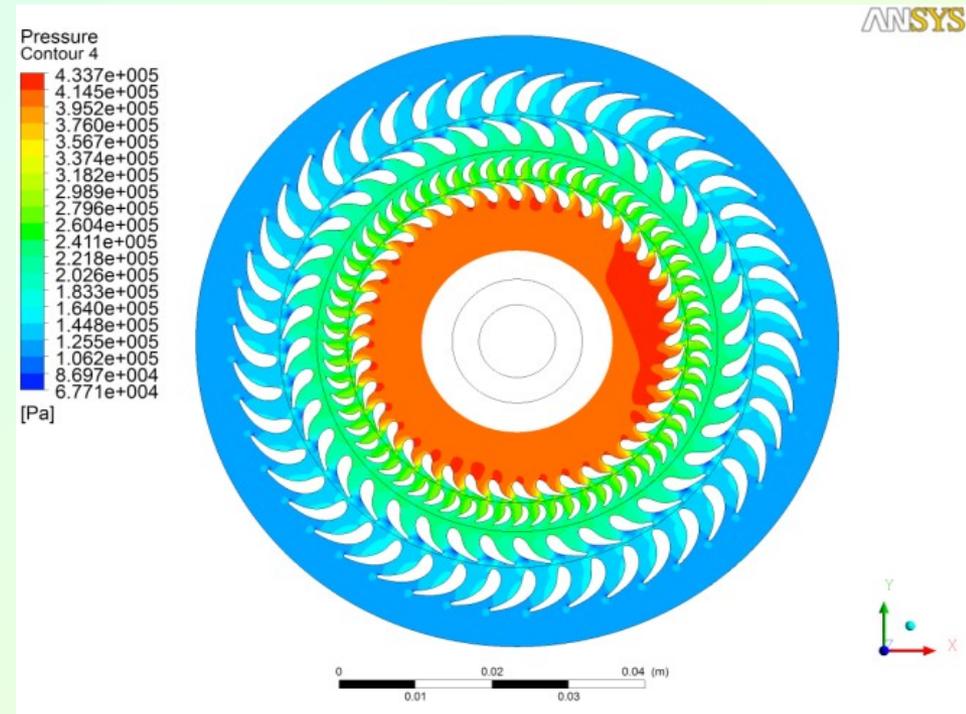
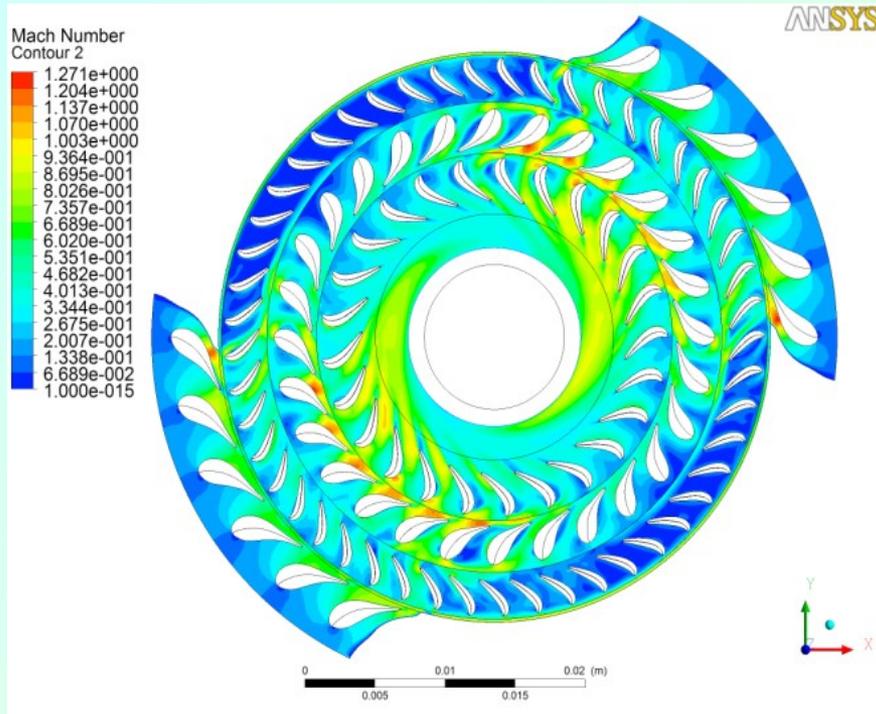
different variants

- single-stage radial and axial-flow turbines,**
- two-stage radial and axial-flow turbines,**
- four-stage radial and axial-flow turbines,**
- five-stage axial-flow turbine.**

Radial Turbine

2 centripetal stages

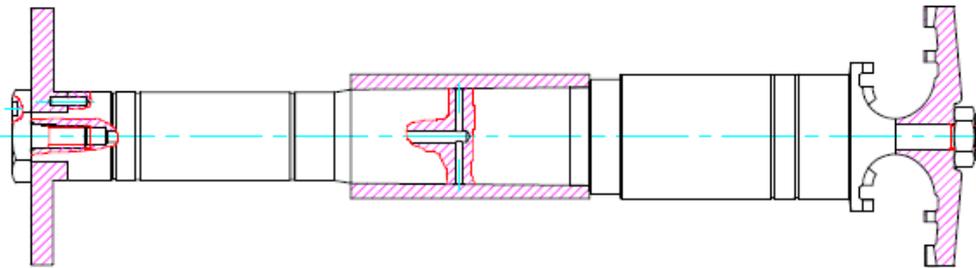
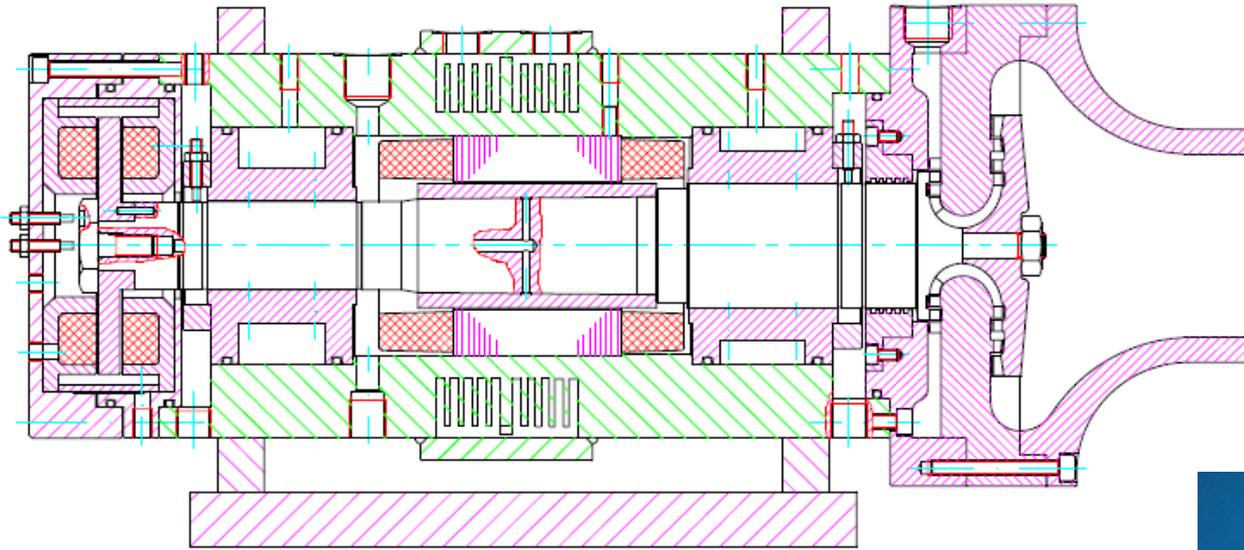
2 centrifugal stages



Radial Turbine

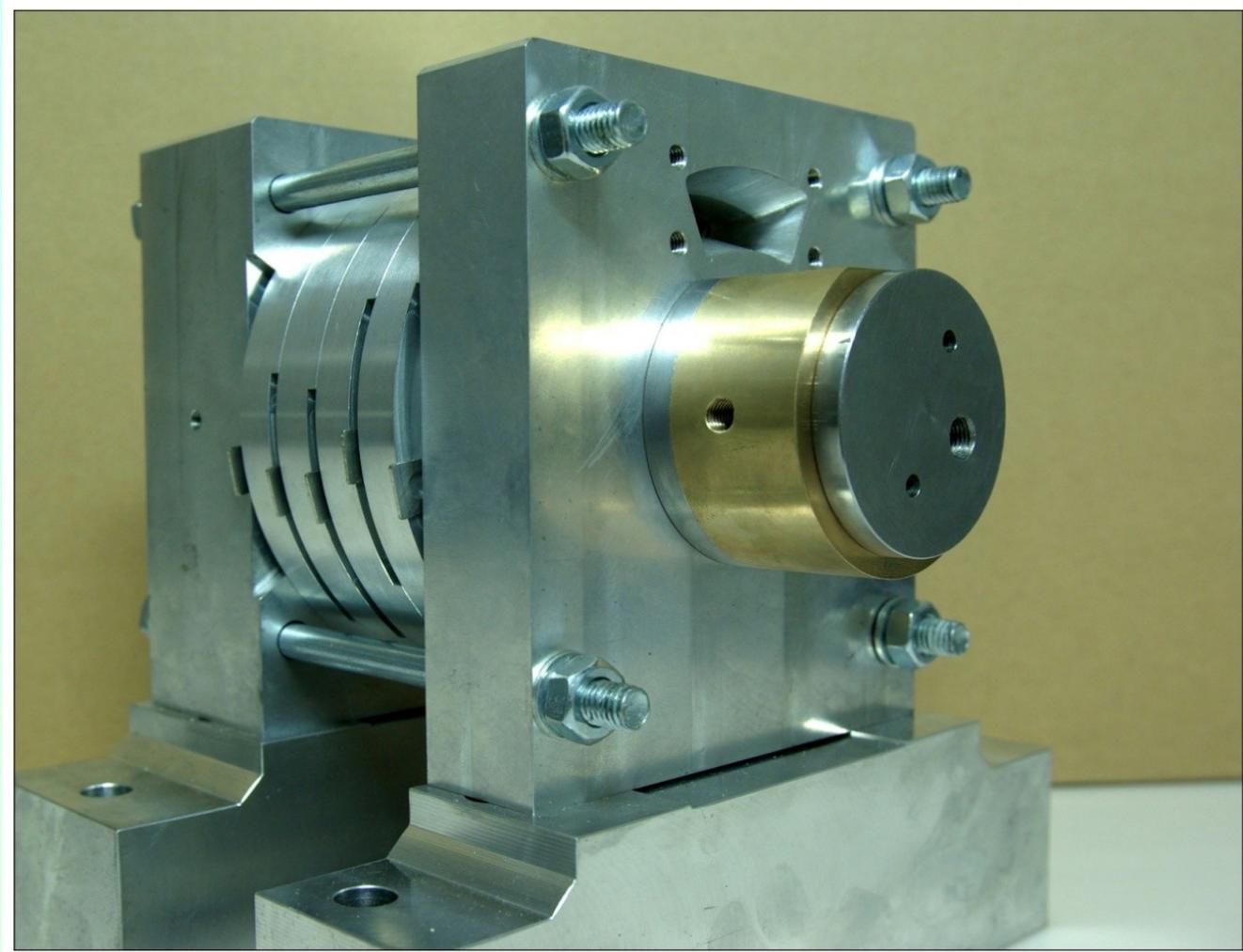
isentropic efficiency

69 %

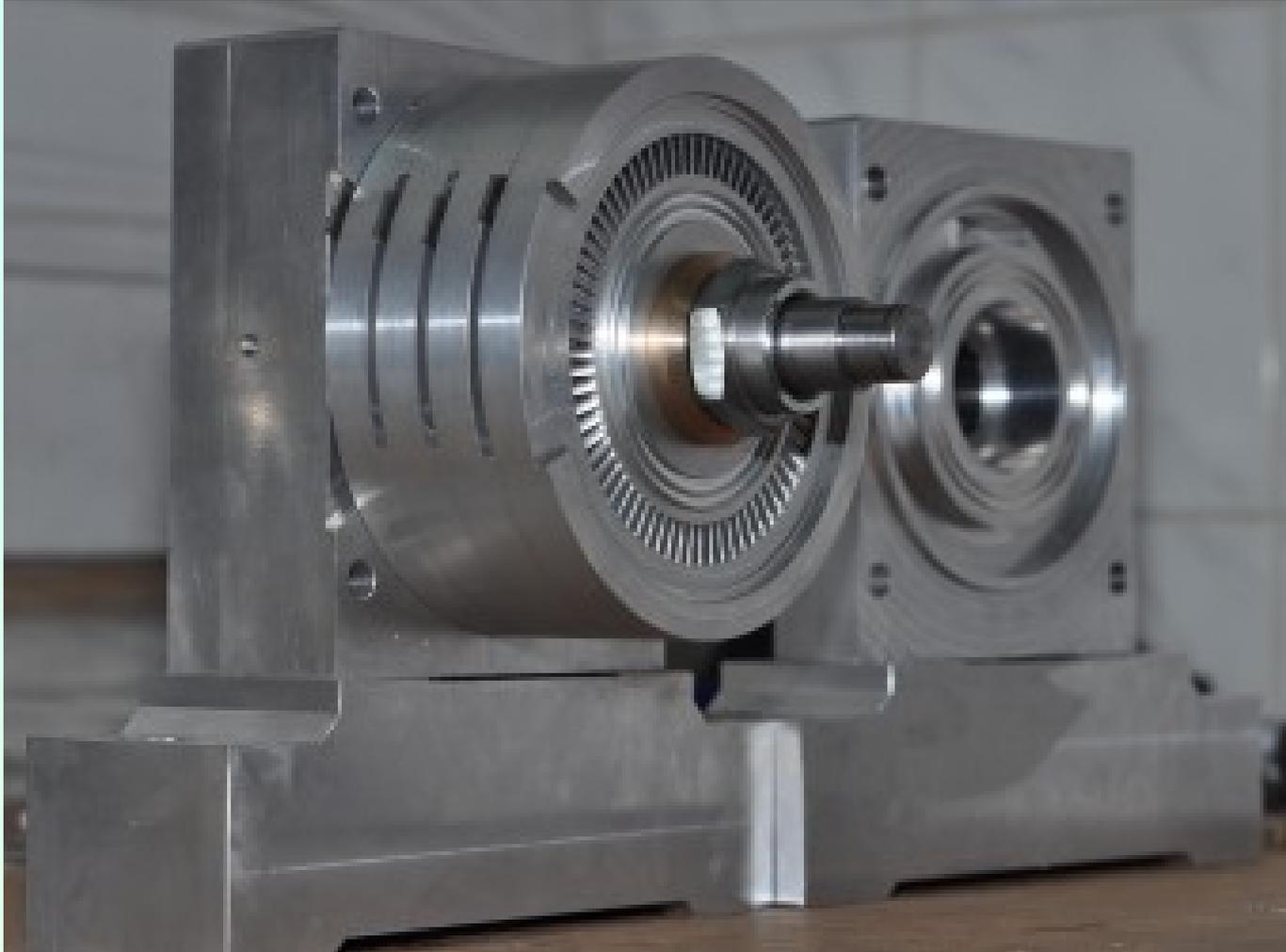


Axial Turbine

isentropic efficiency 80 %



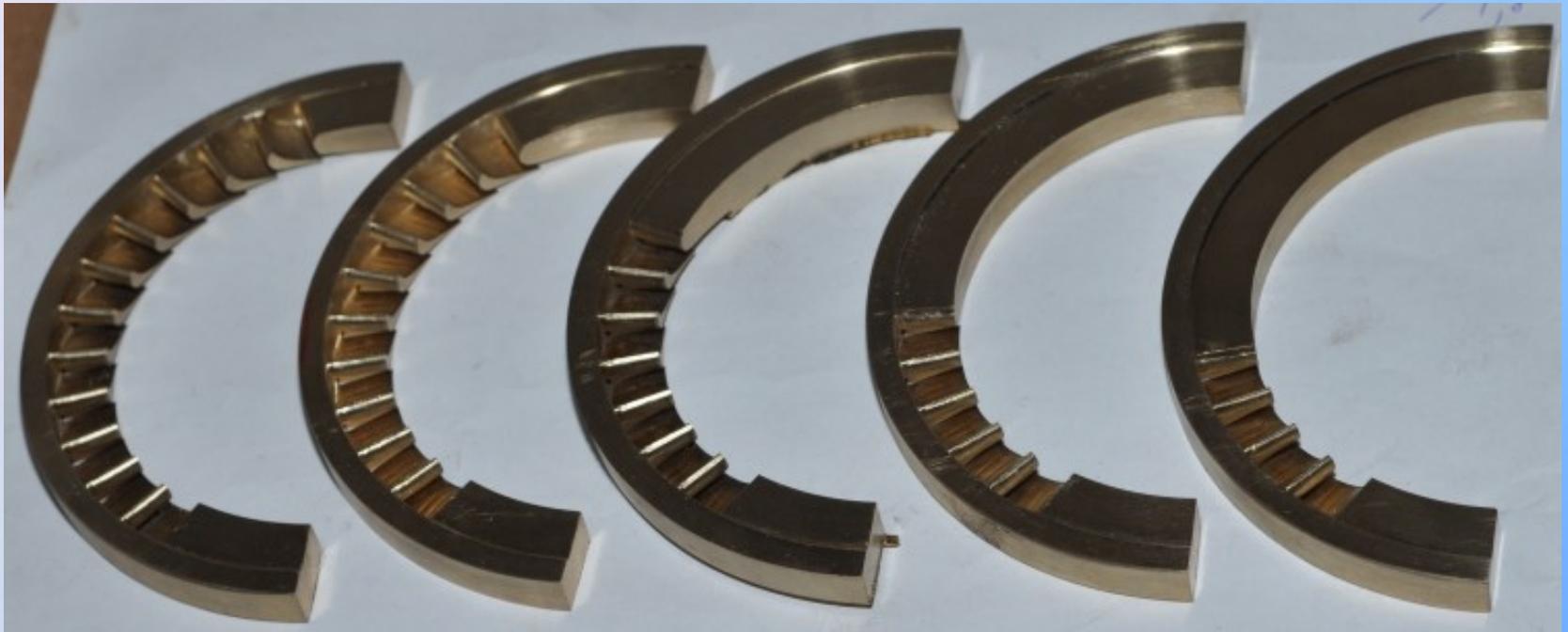
Axial Turbine



Turbine Rotor

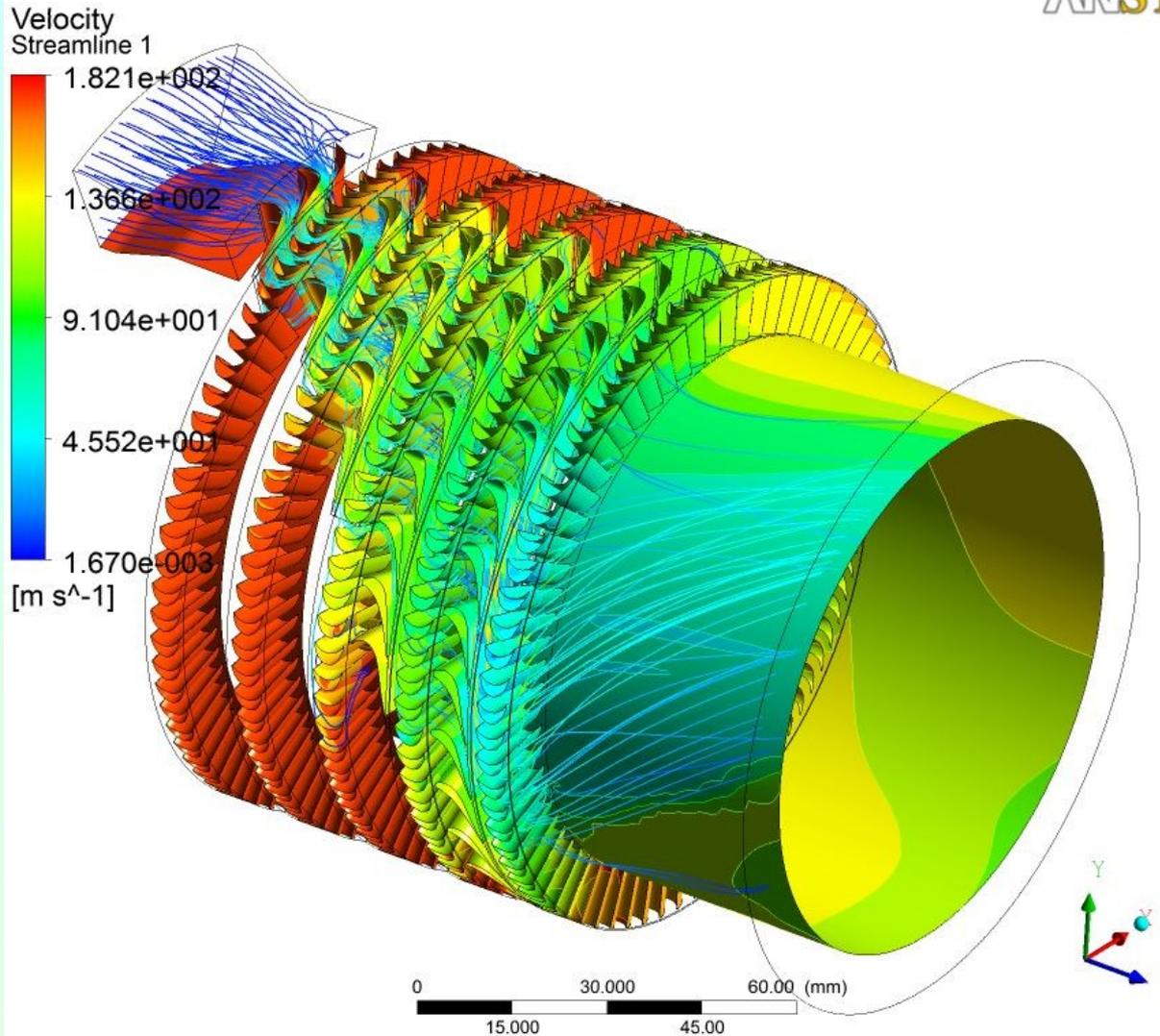


Nozzle Segments



Turbine Flow Part Velocity Streamlines

ANSYS



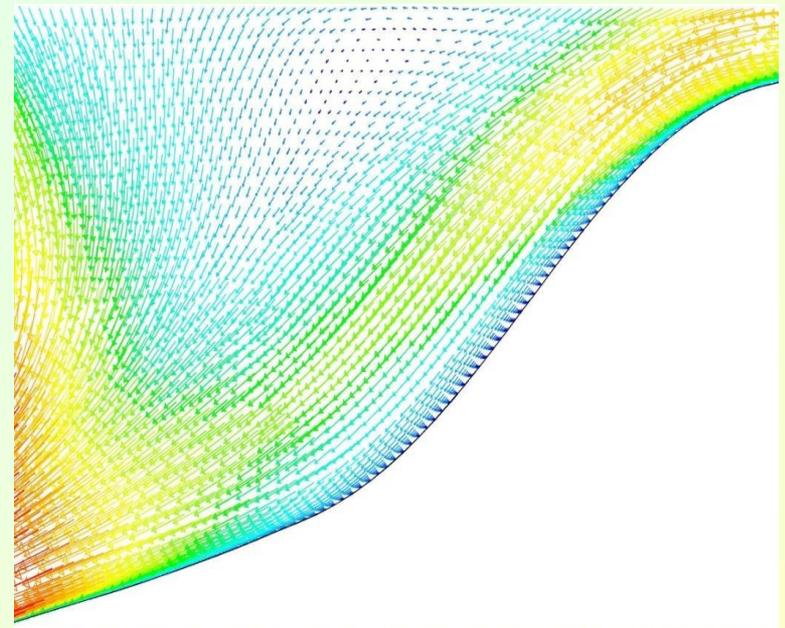
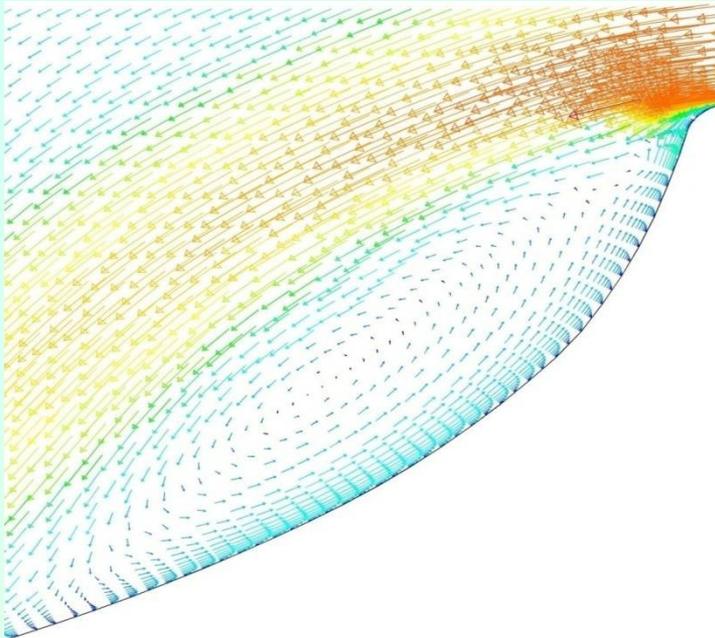
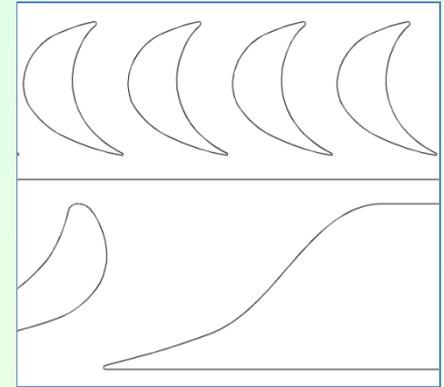
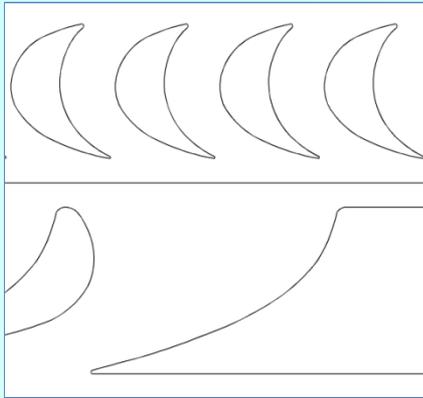
Axial Turbine

stage diameter	$D = 100\text{mm}$
blade height	$h = 10\text{mm}$
aspect ratio	$D/h = 10, \quad h/c = 1.3-1.5$
velocity ratio	0.5
Mach number	$Ma < 0.9$
rotor speed	8000rpm
turbine power	3kW

Blade Shields

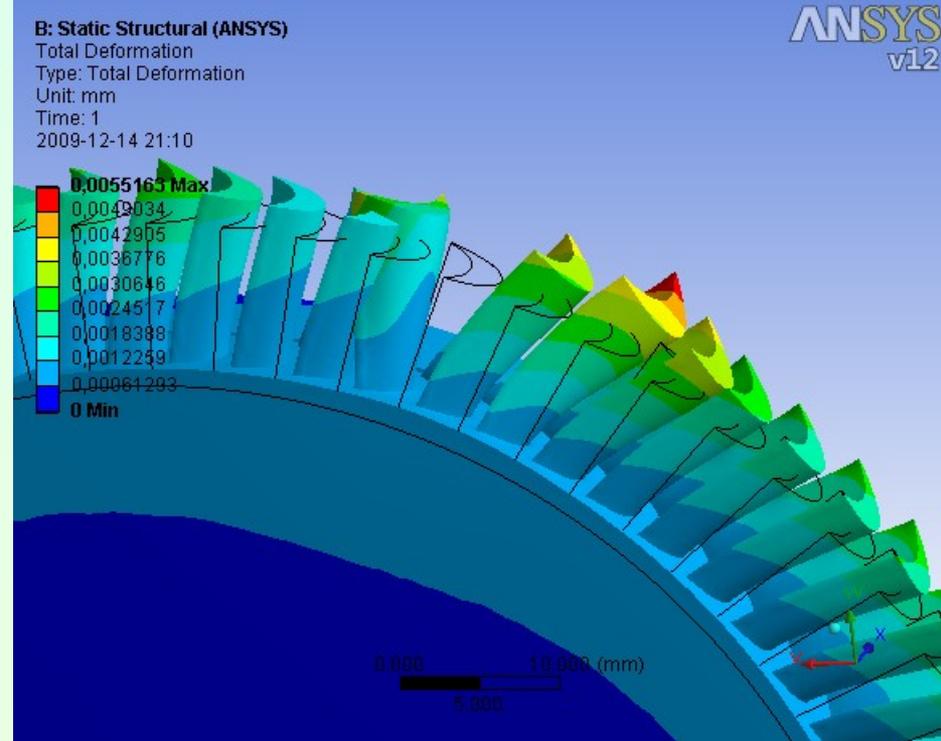
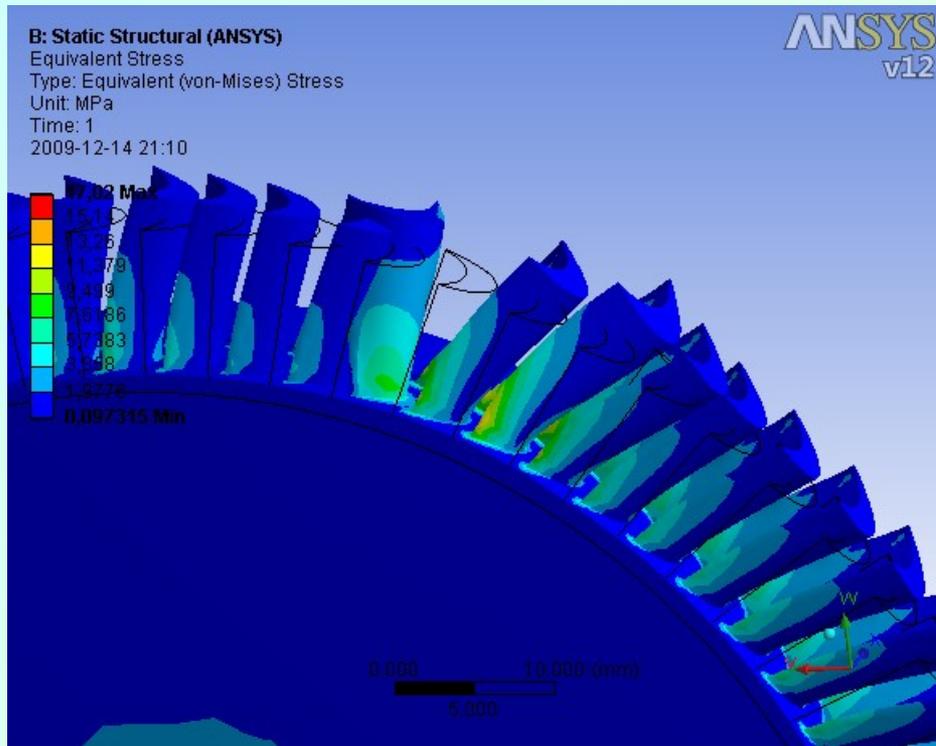


Channel modifications

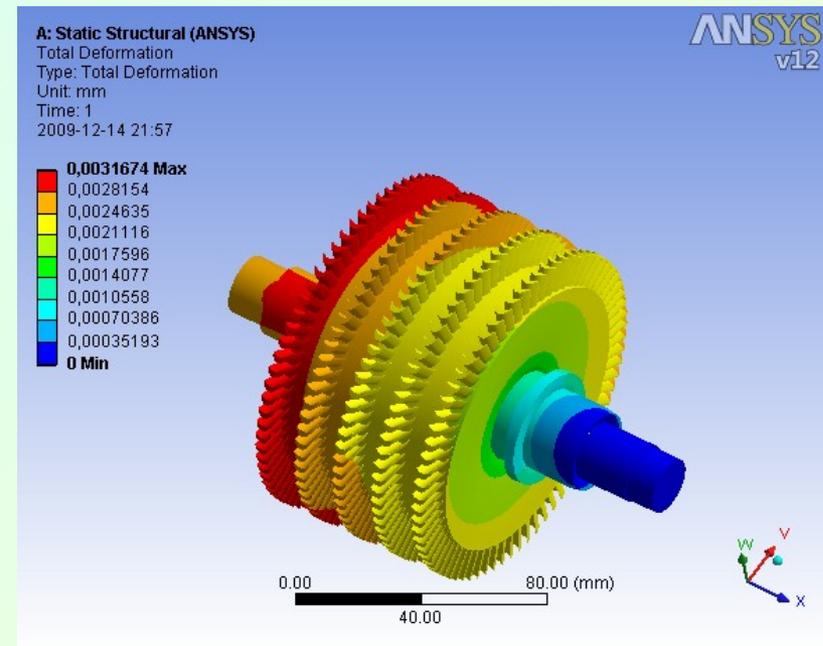
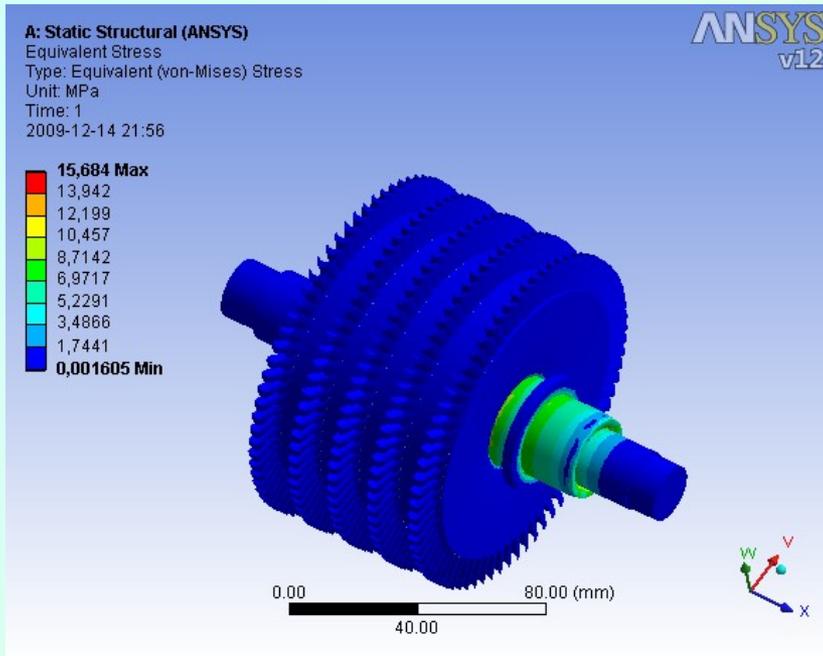


Structural Calculations

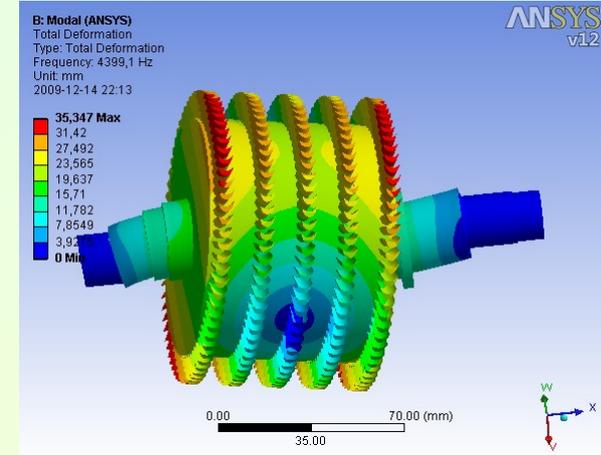
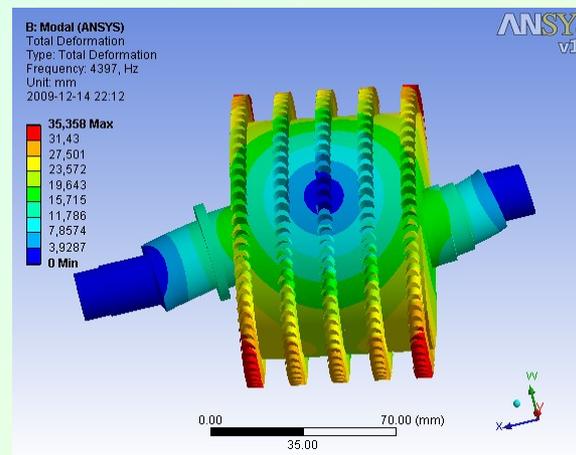
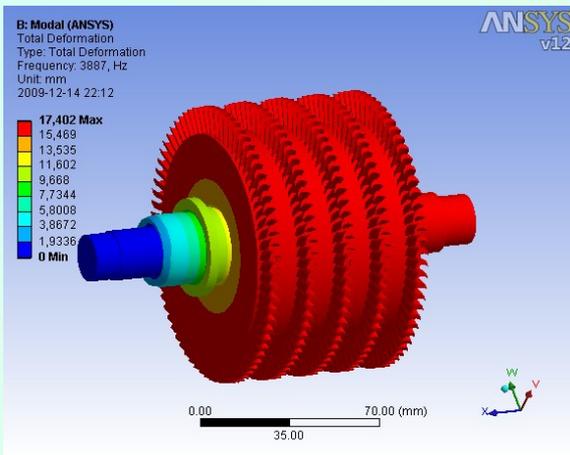
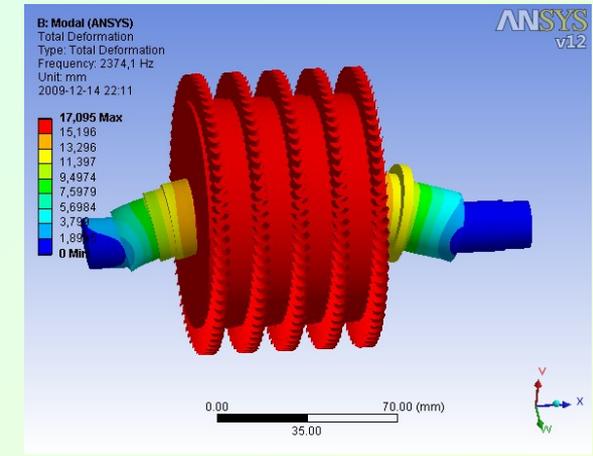
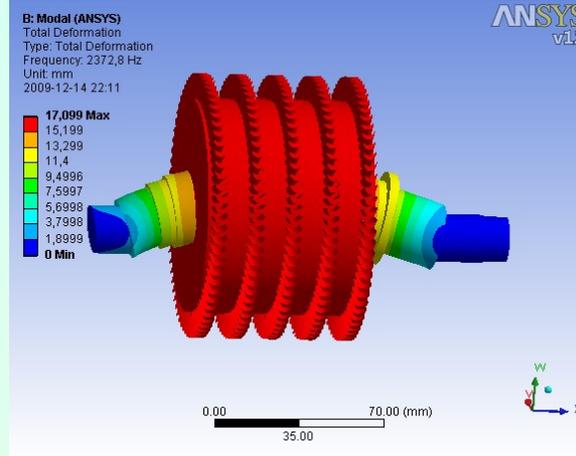
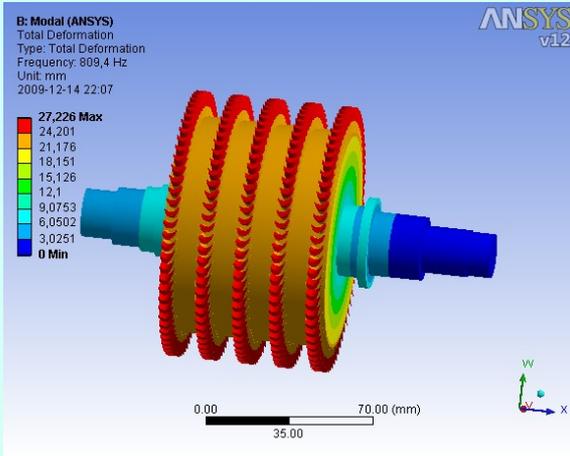
Stress and Deformation



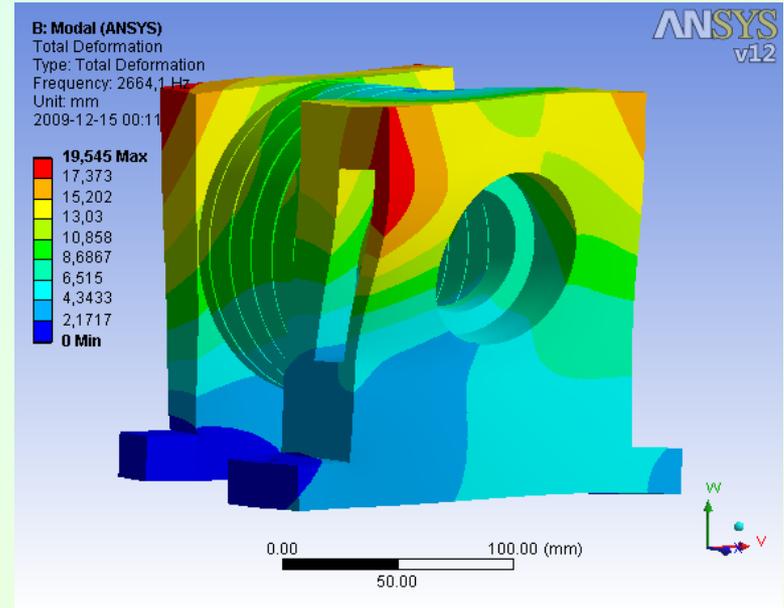
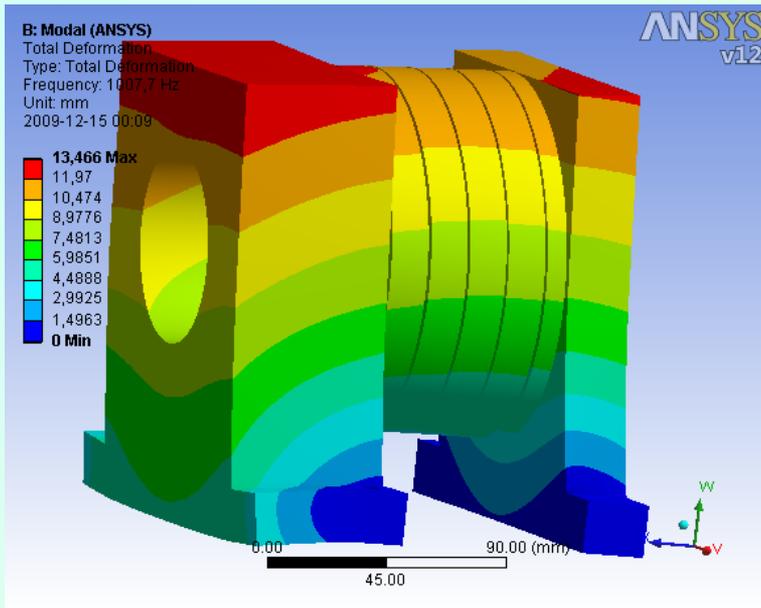
Stress and Deformation



Modal Analysis

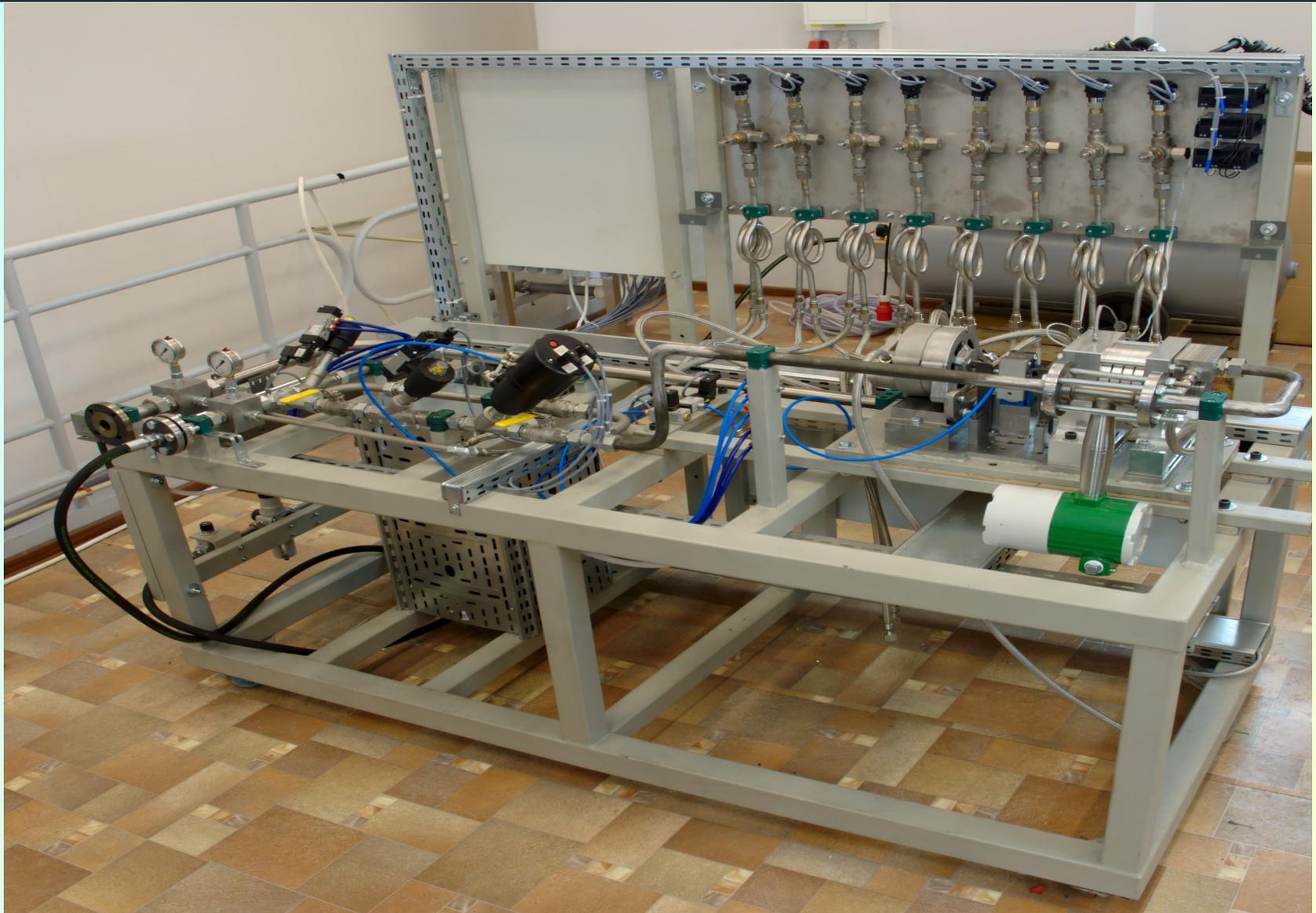


Cylinder Deformation

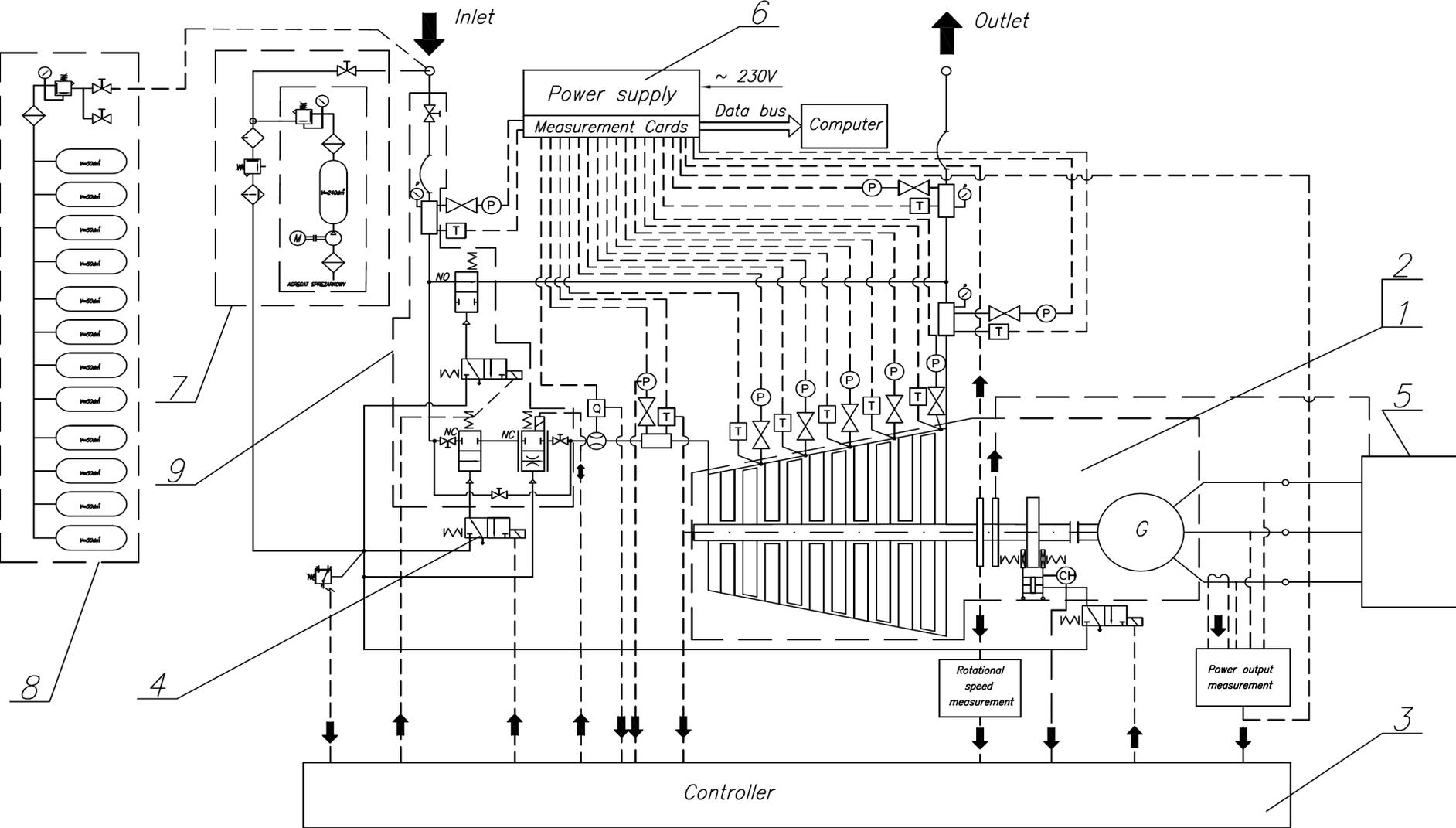


Experimental Research

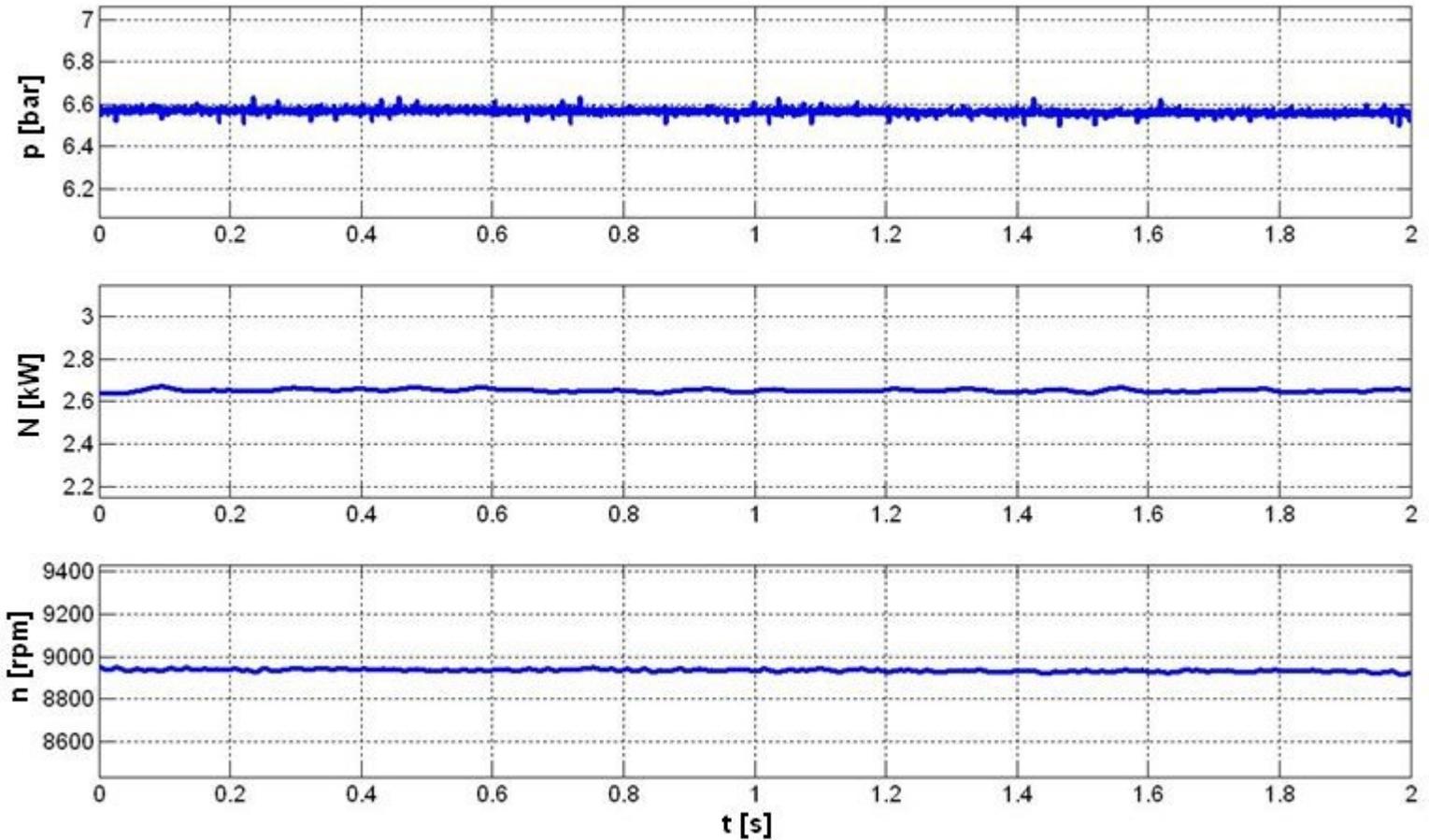
EXPERIMENTAL RIG



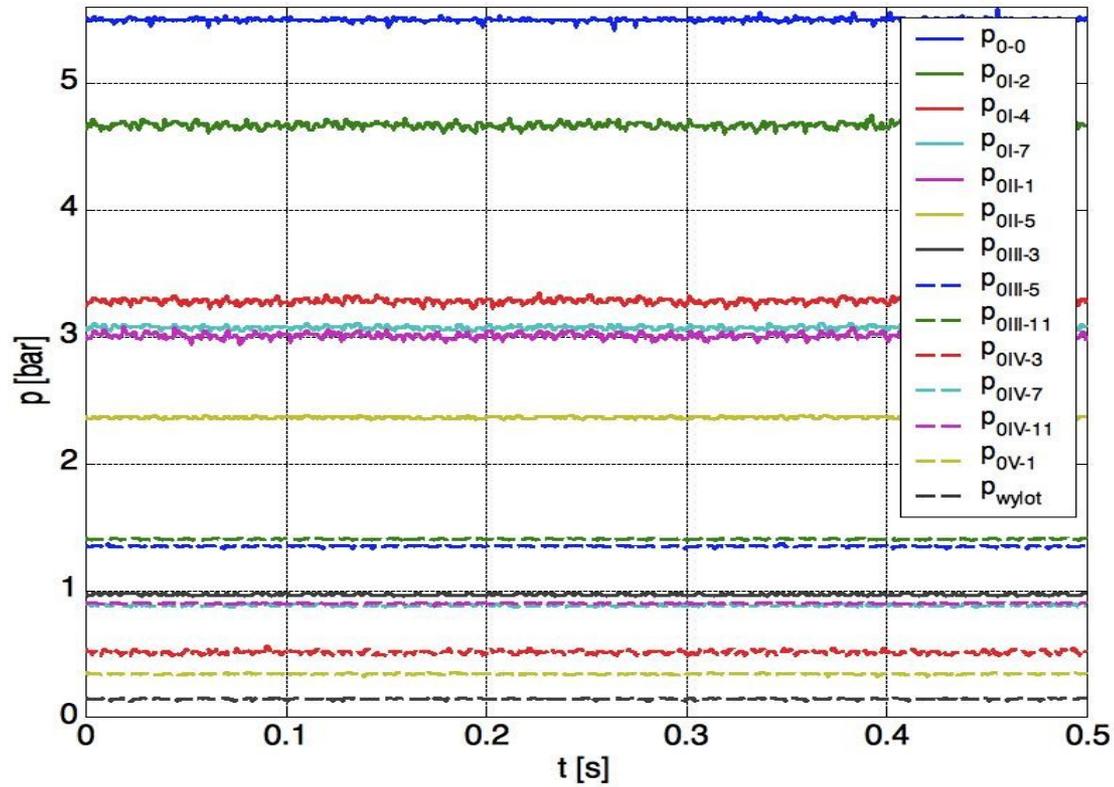
Measuring System



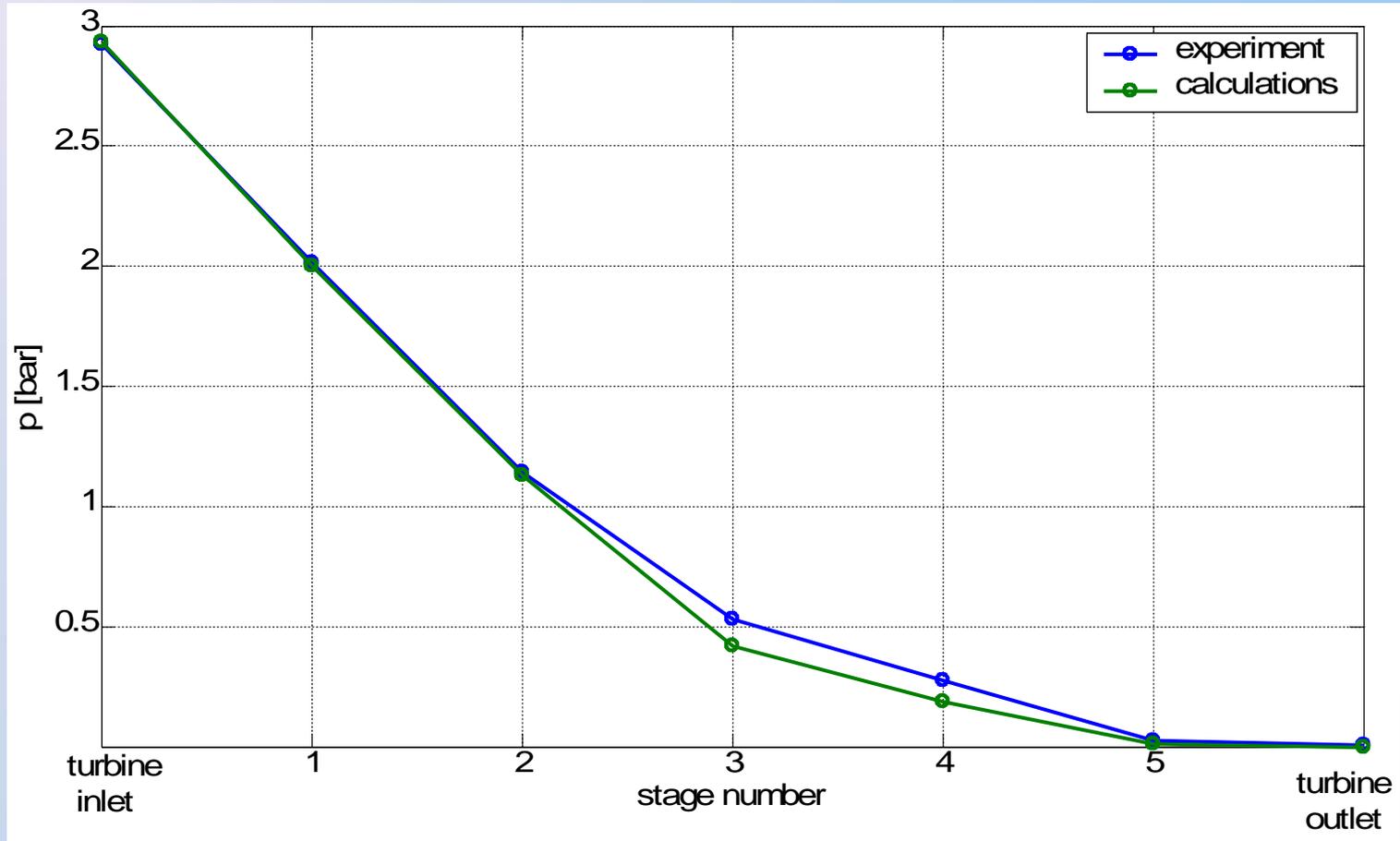
Examples of Results



Examples of Results

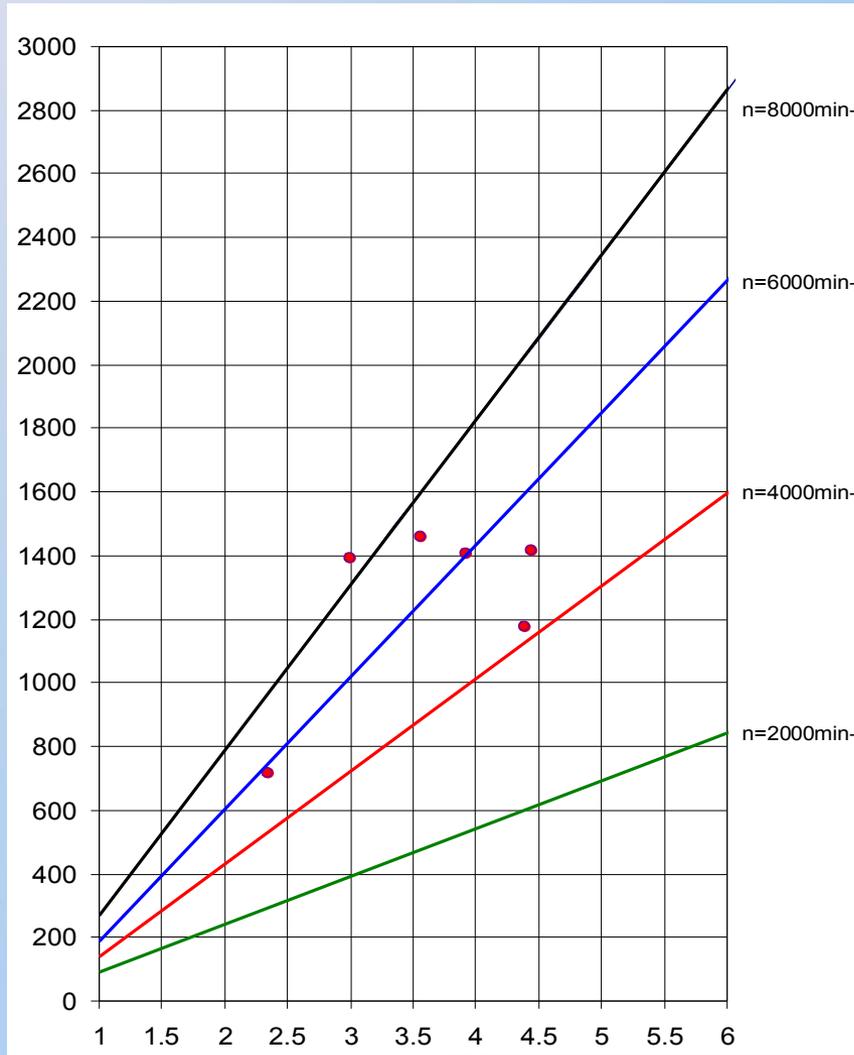


Examples of Results



Examples of Results

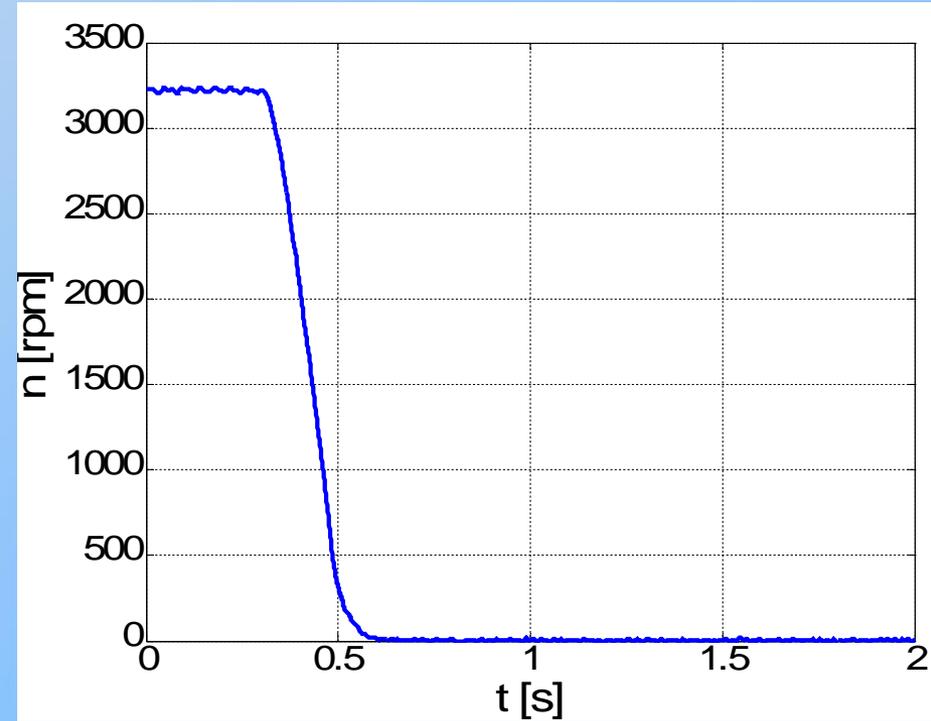
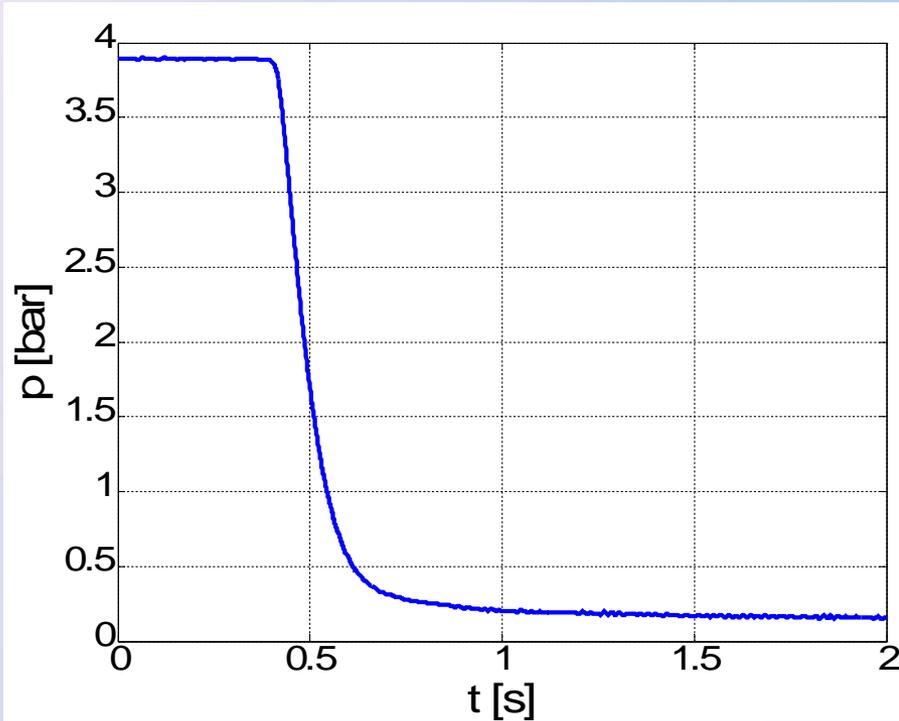
Power [W]



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Examples of Results



Conclusions

Question:

is it possible to build a microturbine of high efficiency?

Conclusions

Answer:

YES!

Efficiency $>$ 80%

Slide last but one

Thank You for Your Attention



THE END

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