FACULTY OF MECHANICAL ENGINEERING
UNIVERSITY OF WEST BOHEMIA

UNIVERSITY OF WEST BOHEMIA IN PILSEN
FACULTY OF MECHANICAL ENGINEERING
DEPARTMENT OF POWER SYSTEM ENGINEERING

Lecture on the subject
KKE/TSM - Boosting combustion engine theory

Roman Gášpár

esf evropský sociální fond v ČR | EVROPSKÁ UNIE | MINISTERSTVO ŠKOLSTVÍ, MLÁDEŽE A TĚLOVÝCHOVY | OP Vzdělávání pro konkurenceschopnost
INVESTICE DO ROZVOJE VZDĚLÁVÁNÍ

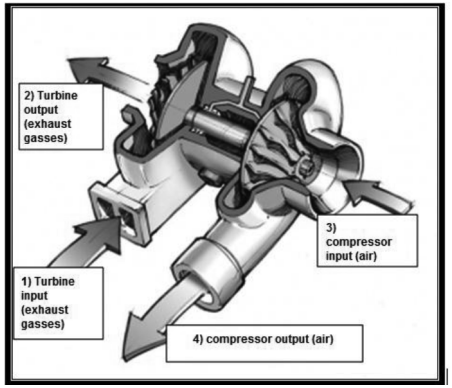
Podpořeno v rámci projektu CZ.1.07/2.2.00/15.0383
Inovace studijního oboru Dopravní a manipulační technika
s ohledem na potřeby trhu práce

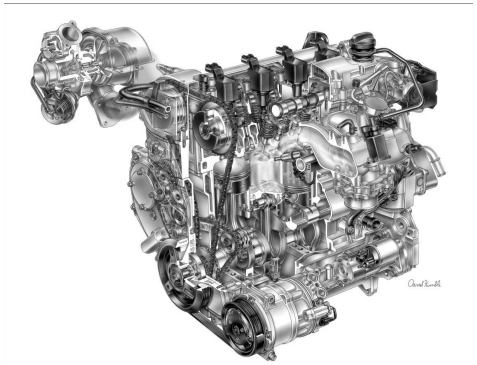
Boosting combustion engine theory

Turbines

Turbochargers

- Currently (2013) most used method of engine supercharging
  - Lower fuel consumption
  - Robust construction and higher power





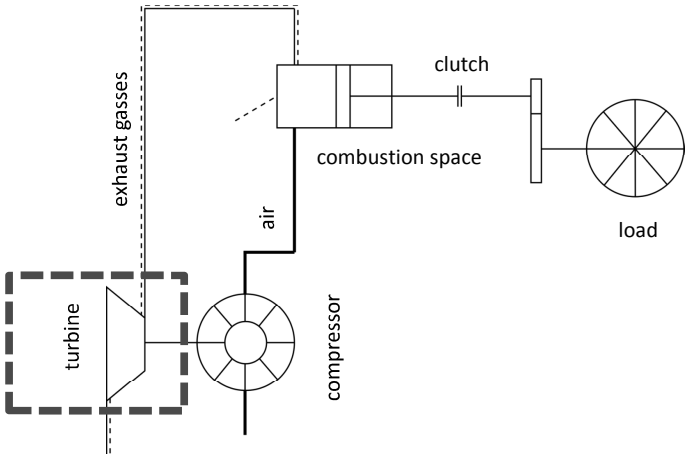
Turbocharger – principle of work [17] [18]

Turbochargers

Principle of work

- Exhaust gasses leaving combustion space and moving forward to the turbine section (1). In turbine section exhaust gasses spins turbine impeller and leaving turbine section (2) through the exhaust manifold
- Turbine section is connected with compressor section via shaft
- Turbine section spins the compressor section (compressor's impeller
- According dynamic phenomena created by compressor's impeller, the air flows into compressor (3). After that the compressor compress the air and transport it to the combustion space (4).

Proudové přeplňování dmychadlem (Turbodmychadlo/Turbokompresory)

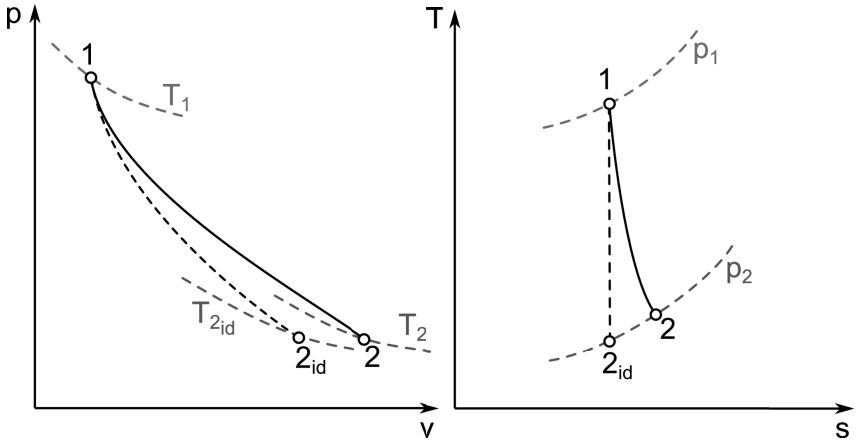


Turbocharger – schematic (without intercooler)

Turbine

- In turbines is transforming heat and pressure energy to kinetic energy and mechanical work with very high efficiency
- The transformation is provided in stator and rotor channels
- In stator vanes is transformed heat and pressure energy to kinetic energy
- In rotor blades is transformed heat and pressure energy to kinetic energy and mechanical work

Thermodynamics



Evolution of expansion in p-v and T-s diagram

Stage reaction

- **Stage reaction is a ratio of adiabatic static work of the rotor and the elementary stage's adiabatic static work**

$$\rho = \frac{\Delta h_r}{\Delta h_{st}}$$

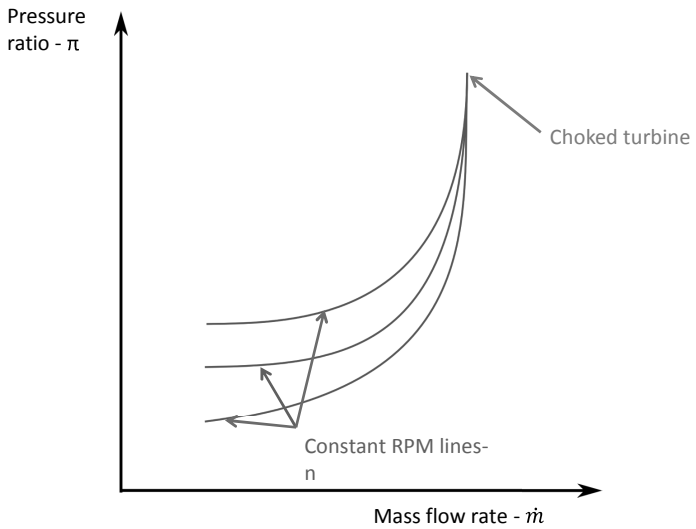
$$0 \leq \rho \leq 1$$

ρ=1 transformation of the energy is provided just in the rotor (radial turbines without regulation)

ρ=0 transformation of the energy is provided just in the stator part

ρ=0,5 half of the energy is transformed at stator and half in the rotor part (aircraft engines, generators)

Turbine map



Turbine map

Turbine construction

Types

- **According of the flow direction**
  - Radial
    - Centripetal
    - Centrifugal
  - Axial
- **According to flow output**
  - Non-homogeneous flow field
  - Homogeneous flow field
- **According to stage reaction**
  - Impulse stage
  - Reaction stage

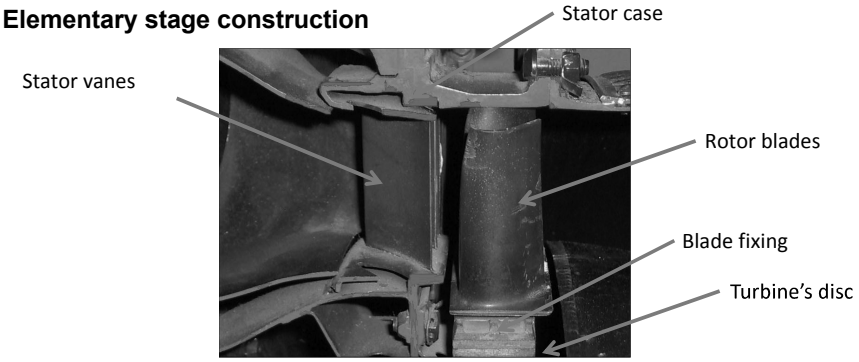
Axial turbines

- **Rotor part**
  - Rotor blades
  - Rotor's disc
  - Rotor's hub
  - Fixing of rotor blades
- **Stator blades**
  - Stator cases
  - Stator blades
  - Seal of rotor blades

Axial turbine

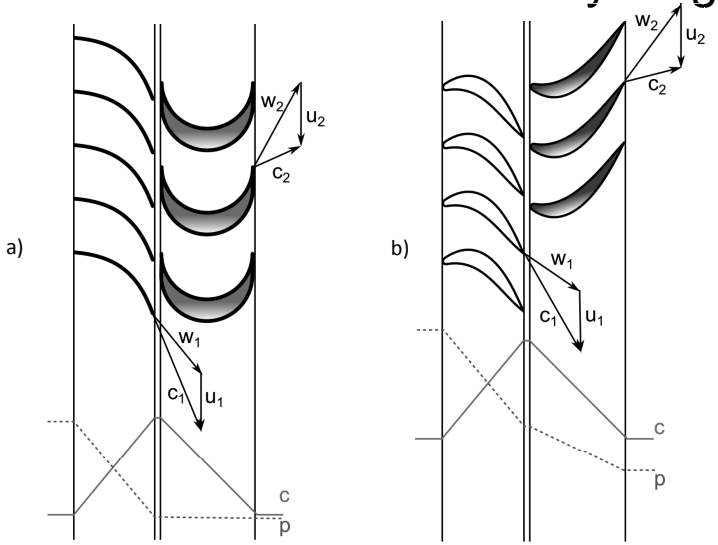
- Widely used at high power engines
- Elementary stage includes a row of stator vanes and a row of rotor wanes
- Allows easy multistage construction

Elementary stage construction



Elementary axial turbine stage - construction

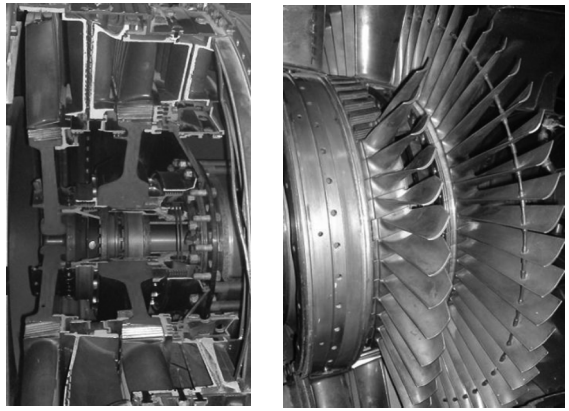
Axial turbine – elementary stage



Flow parameters through the elementary stage
a) Impulse stage
b) Reaction stage

Axial turbine – multi-stage

- Higher efficiency
- Lower speed through the stage
- Less losses
- Better cooperation with compressor (avoiding surge line)
- Higher dimensions



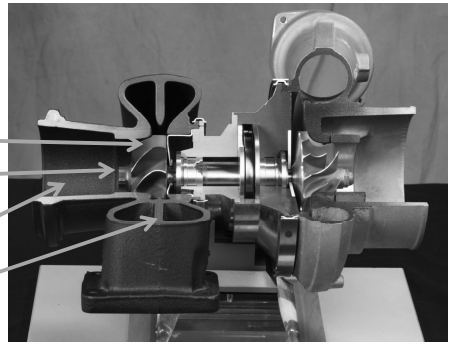
Multistage turbines

Turbines – radial turbines

- Widely used at car's turbocharges
- Very good expansion pressure gradient, small dimensions, high RPM, good control

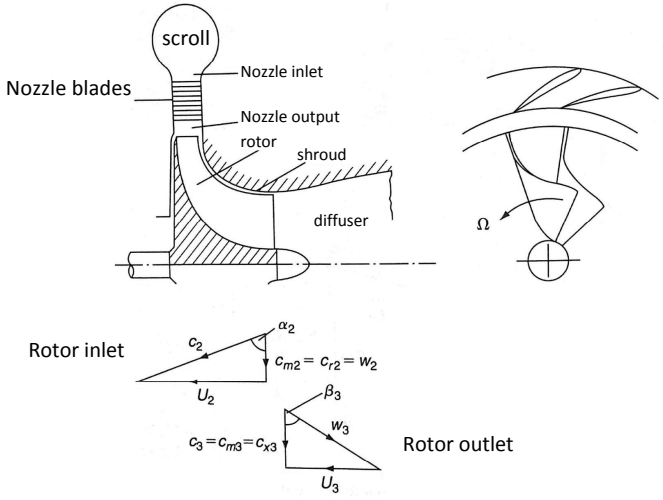
Konstrukce:

- **Rotorová part**
  - Impeller with blades
  - Hub
- **Stator part**
  - Diffuser part
  - Scroll
  - Variable geometry stator vanes



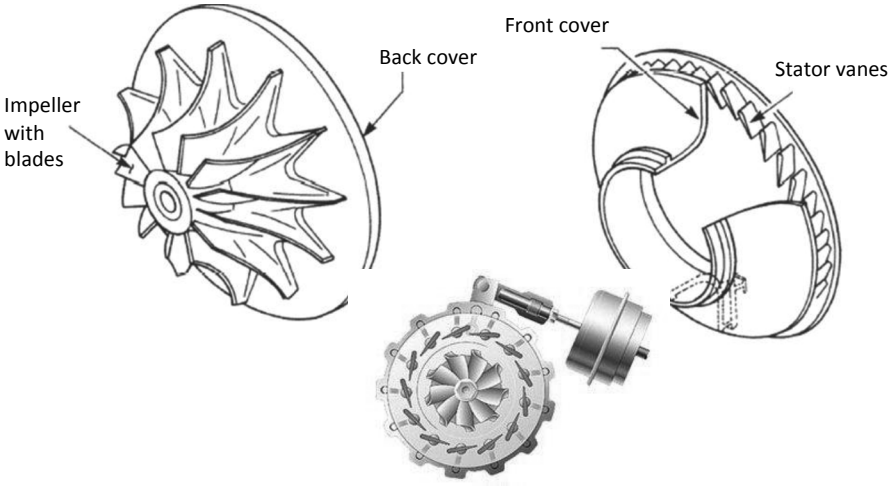
Radial turbine with radial compressor

Radial turbine – construction



Radial turbine construction and speed triangles [7]

Radial turbine – construction



Variable geometry stator vanes construction of the radial turbine [10][8]

References

[8]http://www.dsautosolutions.ie/npics/infos/turbocharger_diagramjpg_1.jpg

[9]http://media.gm.com/content/Pages/news/us/en/2010/Nov/1109_gm_buick/_jcr_content/rightpar/sectioncontainer/par/download/file.res/2011-Powertrain-4-Cylinder-Ecotec-2.0L-I4-VVT-DI-Turbo-LHU-012.jpg

[10] Ott, A.: Základy teórie a konstrukce LLM I,II,III, VAAZ, Brno, 1977

[11]http://www.autozine.org/technical_school/engine/tech_engine_3.htm#VTG

References

[1] J. Macek; B. Suk : Spalovací motory I. - Praha 1996

[2] L. Bartoníček: Přeplňování pístových spalovacích motorů – Liberec 2004

[3] K. Hoffman: Regulované přeplňování vozidlových motorů. Brno, 2000.

[4] J. Macek; V. Kliment: Spalovací turbyny, turbodmychadla a ventilátory (Přeplňování spalovacích motorů) – Praha 2003

[5] Hiereth H., Prenninger P.: Charging the Internal Combustion Engine, Springer, Wien 2007

[6] Bell C : Maximum Boost, Bentley Publishers, Cambridge – 1997

[7] Baines C.N.: Fundamentals of Turbocharging, NREC, Vermont 2005

DISCUSSION...

...QUESTIONS

Poděkování

Tento projekt je spolufinancován
Evropským sociálním fondem a státním rozpočtem České republiky

Projekt CZ.1.07/2.2.00/15.0383
Inovace studijního oboru Dopravní a manipulační technika
s ohledem na potřeby trhu práce