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

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

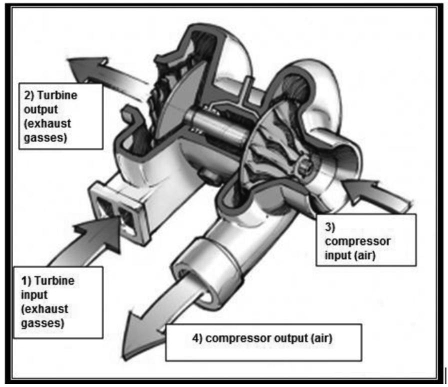
Podpořeno v rámci projektu CZ.1.07/2.2.00/15.0383
Inovace studijního oboru Dopravní a manipulační technika
s ohledem na potřeby trhu práce

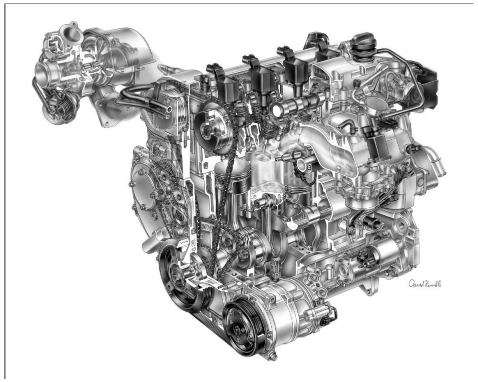
Boosting combustion engine theory

Compressors

Turbochargers

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





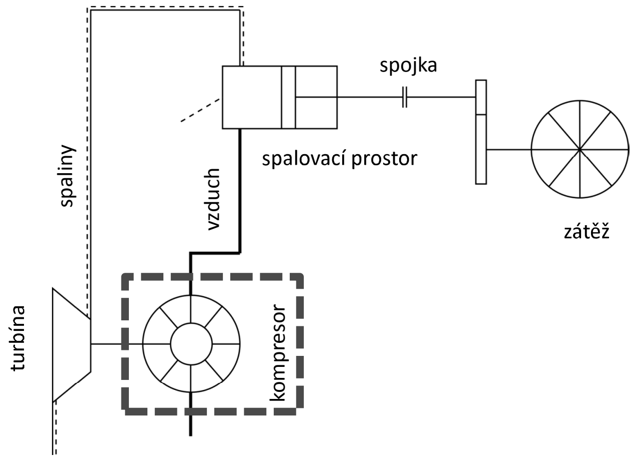
Turbocharger – principle of work [17] [18]

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).

Turbochargers



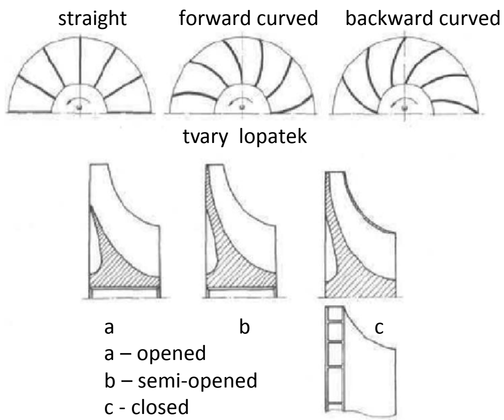
Turbocharger – schematic (without intercooler)

Centifugal compressor

- Compressor is a device which provide a compression of air and its transport to combustion chamber
- Compression in centrifugal flow compressor is achieved by centrifugal velocities
- The air in outlet from blade canal is upright to axis of rotation
- Velocity of outlet air depends by diameter of blades and rotor's RPM

Compressor types

- **Impeller and case shape**
  - Straight
  - Forward curved
  - Backward curved
  - Opened
  - Semi-opened
  - Closed



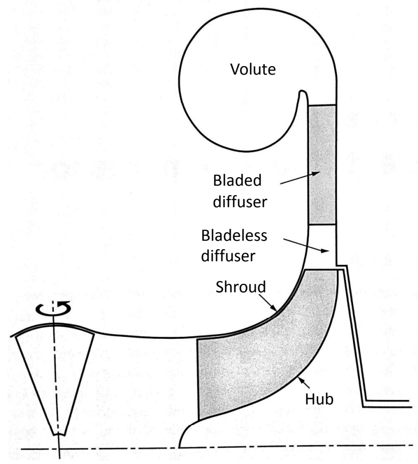
Main parts

Rotors

- Impeller
- Hub

Stator

- Diffuser
  - Bladed
  - Bladeless
- Shroud
- Manifold



Hlavní části radiálního kompresoru [7]

Oběžné kolo

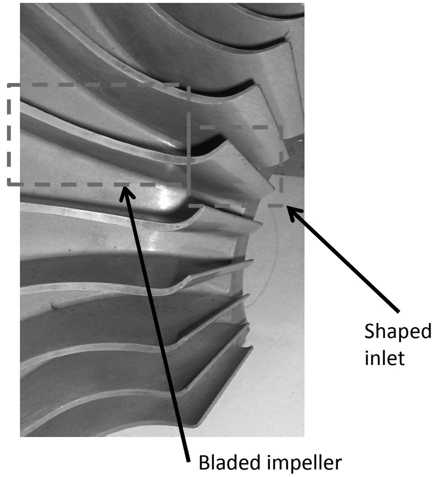
Oběžné kolo

- Provides transformation of impeller's mechanical energy to air's kinetic and pressure energy
- As a result of centrifugal forces in the compressor channel there are increasing values of absolute velocity and total pressure

Impeller

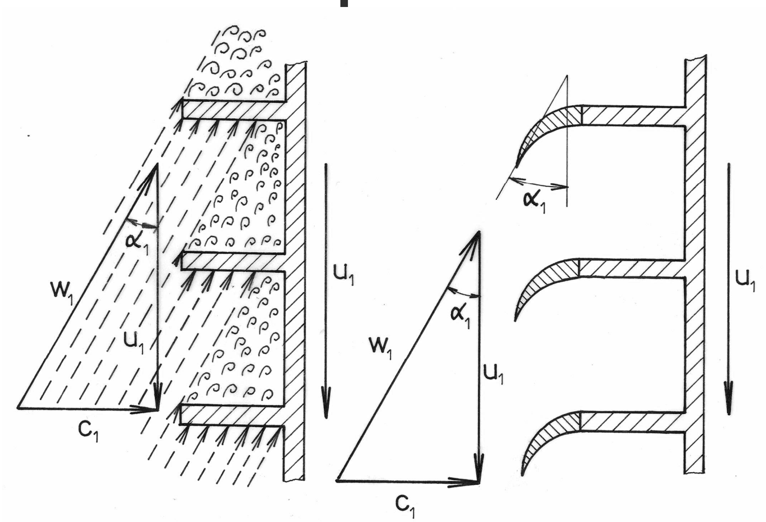
Impeller – Main parts

- Shaped inlet
- Bladed impeller
- Shaped inlet
  - Curved inlet part of the blades, which provides fluent flow of the air in the compressor inlet.



Detail of the centrifugal compressor impeller

Impeller



Impact of the shaped inlet to the flow parameters in compressor [7]

Diffuser

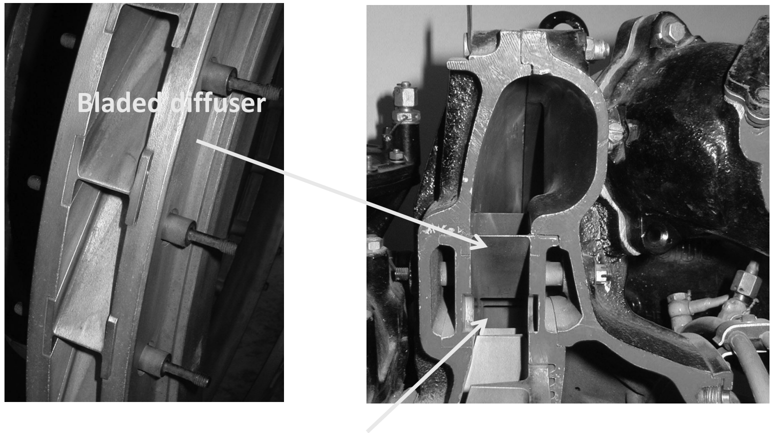
Diffuser

- Provides transformation of air's kinetic energy to the heat and pressure energy with special shape of the channel

Types

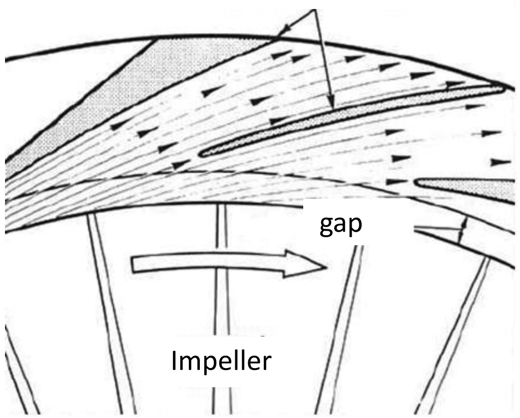
- Bladed
- Semi-bladed

Diffuser



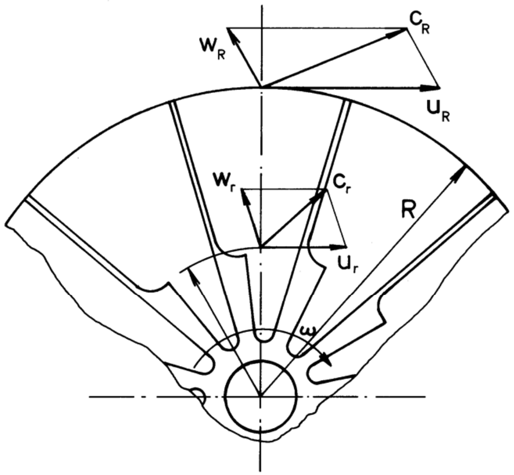
Detail of bladed and bladeless diffuser

Diffuser



Flow through the bladed diffuser [10]

Parameters through the compressor



Speed triangles on inlet and outlet of the compressor

Parameters through the compressor

- **Velocities**

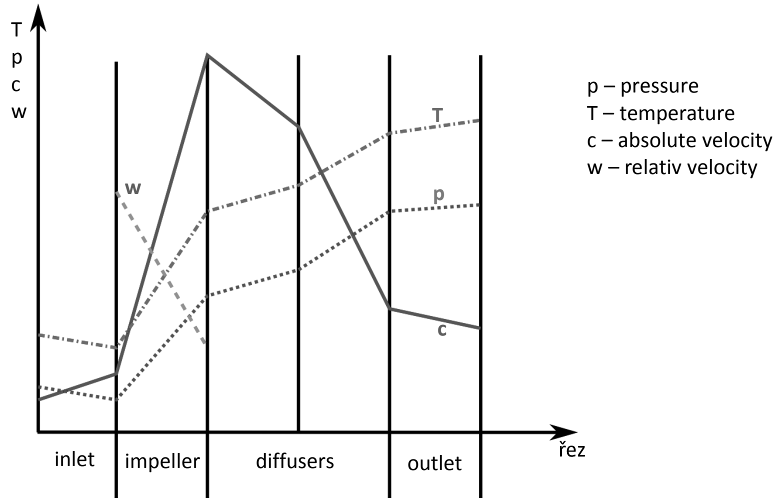
  Rotating impeller have circumferential speed *u*, absolute velocity *c* and relative velocity *w*. Diffuser shape of the channel causes that relative velocity *w* is decreasing. Circumferential speed *u* is increasing along impeller radius toward to impeller output. By vector sum of velocities alongside the impeller radius it is obvious that the absolute velocity *c* have to increase toward to impeller output, where obtain it's maximum. Behind impeller there is just absolute velocity *c* component of velocity, because there is no rotating component. In diffuser channel absolute velocity *c* decreasing according to diffusivity of the channel. Further velocity decrease is caused by friction.

Parameters through the compressor

- **Pressure and temperature**

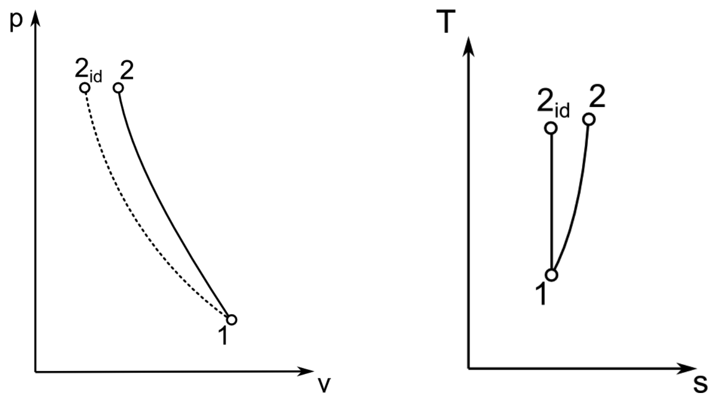
  Pressure *p* and temperature *T* have similar evolution. Temperature and pressure are increasing at impeller (energy transformation). At diffuser channel is transformed kinetic energy to the heat and pressure energy so the temperature and pressure are increasing as well. This trend is continuing at outlet manifold but with smaller gradient.

Parameters through the compressor



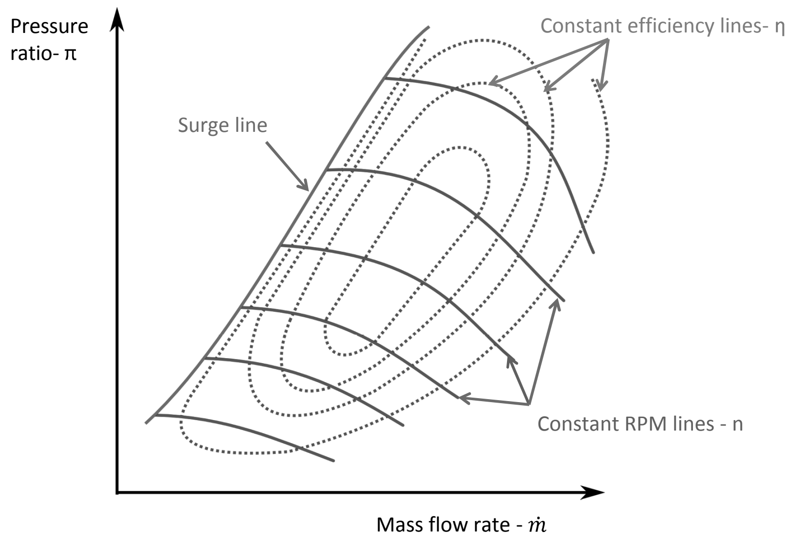
Parameters evolution through the centrifugal compressor

Thermodynamics



p-v and T-s diagrams of the compression

Compressor map



Compressor map

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[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

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DISCUSSION...

...QUESTIONS

INVESTICE DO ROZVOJE VZDĚLÁVÁNÍ

Poděkování

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

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