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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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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

Supercharging methods

Impulse charging

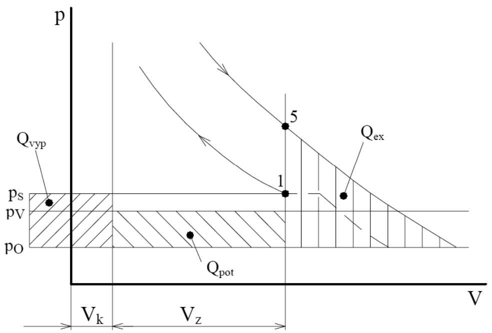
- The aim is conservation of pressure and heat pulses, which are created during exhaust process from cylinder and they transport to the turbine of the turbocharger
  - For goof efficiency of impulse turbocharging is necessary:
    - Small volume of the exhaust manifold (small diameter and short distance from turbine)
    - Separate manifold from each cylinder

Impulse charging

- ***Energy of the impulse charging Q_{imp}***

$$Q_{imp} = Q_{ex} + Q_{pot} + Q_{vyp}$$

- Q_{ex} – energy losses during expansion
- Q_{pot} – piston potential energy during exhaust stroke
- Q_{vyp} – energy of the flushing air



Total energy given to turbine during impulse charging [2]

Impulse charging

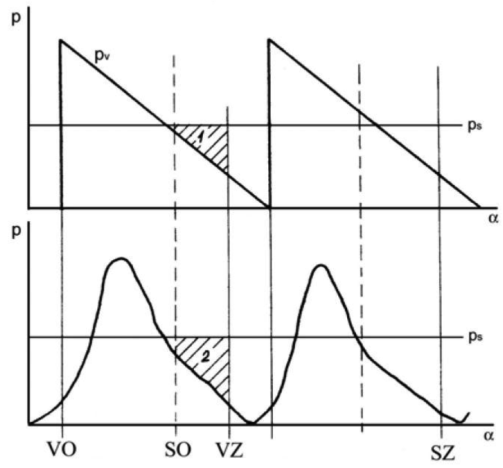
Losses

- Flow through valves (suction and exhaust)
- Nonstationary phenomena between engine and turbine
- Heat fluxes between engine and surroundings
- Mixing of fresh (flushing) air and exhaust gasses

Impulse charging

Pressure waves creation

- Ideal case
  - Exhaust valve opens at very short time (step pressure increase)
  - Step filling of exhaust manifold and drain
  - Without losses
- Real case
  - Gradual pressure increase
  - Gradual manifold filling
  - Losses

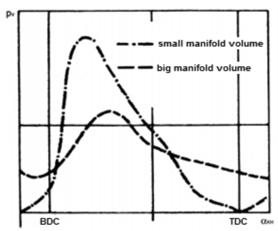


Graph of pressure waves evolution [2]

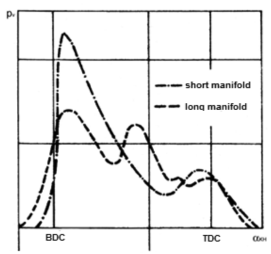
Impulse charging

Real evolution of pressure waves is given by:

- Construction parameters of the manifold between the engine and the turbine
  - Manifold volume
  - Length of the manifold



Effect of manifold volume to the pressure waves [2]

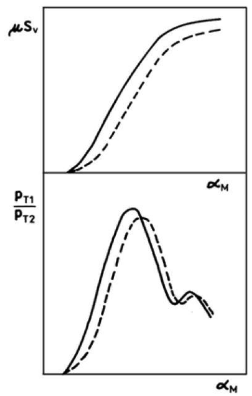


Effect of manifold length to the pressure waves*[2]*

Impulse charging

Real evolution of pressure waves is given by:

- Data from exhaust valves
  - Sped od opening
  - Amount of overlap
  - Moment of opening
  - Flow area of the inlet/outlet valve



Dependence between the valve cross-flow and pressure ratio[2]

Impulse charging

Using pulsed operation

- Lower charging pressures
- At engines which high charging pressures during partially load when is necessary a very fast turbine reaction
- At two stroke engines, where is the exhaust gas pressure lover than in 4 stroke engines

Equipressure charging

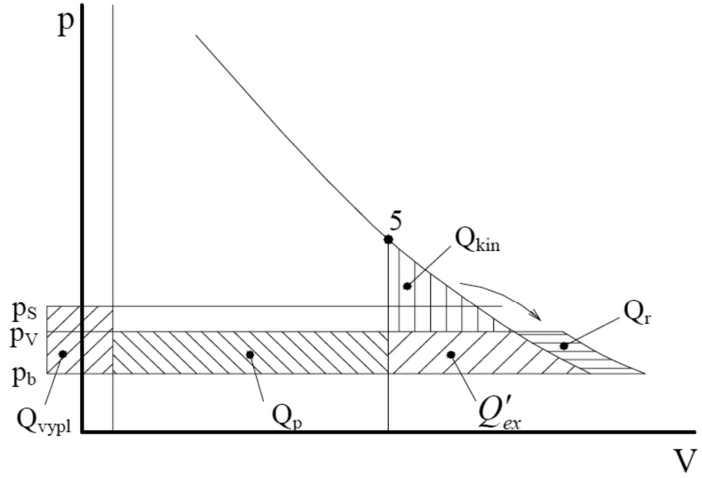
- Using potential and heat energy of exhaust gasses
- Typical is big volume of exhaust manifold with joint output of all cylinders (prevent oscillations at manifold)
- Most of lost energy during expansion is transformed to kinetic energy and this kinetic energy is transformed during turbulence phenomenon to heat energy → energy recuperation.

Equipressure charging

$$Q_{rov} = Q_{vypl} + Q_p + Q'_{ex} + Q_r = Q_{imp} - Q_z$$

- Q_{rov} – available turbine energy during equipressure charging
- Q_{vypl} – energy of the flushing air
- Q_p – piston potential energy during exhaust stroke
- Q'_{ex} – Energy of the incomplete expansion
- Q_r – recuperated energy (increase temperature before turbine)
- Q_{imp} – available turbine energy during impulse charging
- Q_z – recuperation losses

Equipressure charging



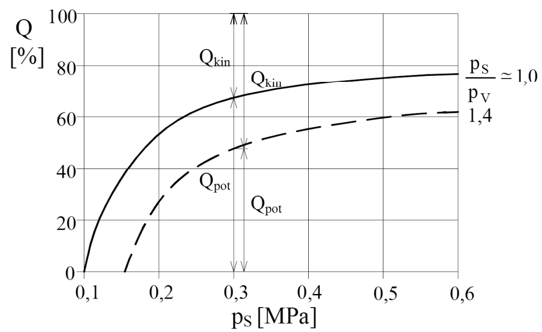
Total energy given to turbine during equipressure charging[2]

Rovnotlaké přeplňování

Summary

- Useful for stationary engines (constant load)
- Easy connection of the engine and the turbine (bigger diameter → less flow losses)

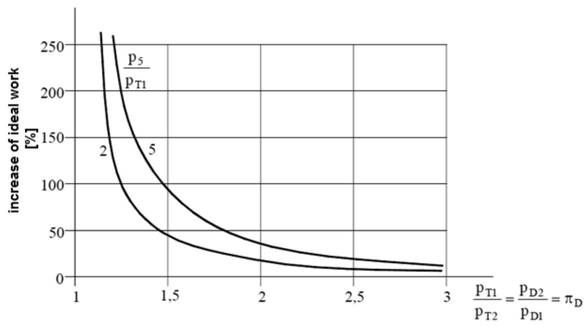
Comparison



Comparison of impulse and equipressure charging[2]

- If flushing ration increase p_s/p_v , then Q_{kin} increase as well but Q_{pot} decrease (importance of impulse charge increasing)
- During decrease of engine load (decrease p_s) , Q_{kin} is increasing na at the expense of Q_{pot}

Comparison



Comparison of equipressure and impulse charging[2]

- Small benefits of impulse charging at high values of expansion pressure

References

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

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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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