VVT optimization with GT-POWER and Genetic Algorithms

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Overview

1. **Introduction**
2. GT-Power Model and Combustion Model
3. Model Calibration
4. GA Optimization
5. Conclusion
Introduction

Variable valve train (VVT):
• Advantages in efficiency by lower throttling losses
• Complexity raises exponentially
• Great challenge for simulation
• 3D-CFD is still time consuming
  ➔ in testing a high number of possible valve-timing combinations
• 1-D engine simulation tools best solution for these tasks

➔ How to optimize a VVT in a 1-D simulation?
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GT-Power Model
4-Cylinder SDI-Engine (2198 cm³)

External Cylinder Model used!

How does it work?
Combustion Model

External Cylinder Model/ Entrainment Model

phenomenological model is taking into account:

- residual gas fraction (laminar flame speed)
- shape of the combustion chamber (flame surface)

important for VVT simulation!
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Model Calibration

Entrainment Model

Interval of Calculations: Inlet Valve max. lift 4.5mm

…the calibartion results?
Model Calibration/ Results

Entrainment Model

- Graph showing rpm=3000 1/min imep=4bar
- Graph showing pressure vs. crank angle
- Graph showing burn rate vs. crank angle
Model Calibration/Results

Entrainment Model

- there is only one set of parameters for the combustion model for all operating points and valve timings!
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GA Optimization

Why is it useful to use genetic algorithms?

Optimizer has to deal with more than one minimum!
GA Optimization

Optimizer is coupled with the GT-Power Model for automatic optimization

Aim: Optimizing IVO, EVO, Inlet valve lift to find the global minimum of the ISFC [g/kWh]

How does the GA Optimizer work?
Crossover...
GA Optimization

Result

ISFC Distribution: 2000 rpm, 3bar imep

Best Point after 450 calculations

~42h calculation time (3GHz)
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Conclusion

VVT optimization:

- 1-D simulation in connection with an phenomenological combustion Model (Entrainment Model) is necessary to optimize VVT
- Optimization of IVC, EVO, IV lift with Genetic Algorithms to increase the Ind. Efficiency is useful because local and global minima exists
- Powerful combination of Entrainment Model and automatic optimizer based on Genetic Algorithms
- results are time consuming, but if only “good” results are necessary: these are received quickly!
   (result could be used for beginning optimization by hand then)
END
\[ \frac{dQ_b}{d\varphi} = H_u \cdot \frac{dm_v}{dt} \cdot \frac{dt}{d\varphi} \] ...burn rate

\[ \frac{dm_v}{dt} = m_E - m_v \]

\[ I_T = \frac{\sqrt{15}}{u'} \cdot \frac{v_T \cdot I}{u'} \]

\[ I = \frac{3}{\pi} \sqrt{6} \]

\[ \tau = \frac{I_T}{s_L} \]

\[ s_L = f(T_{uv}, p, x_r) \]

\[ \frac{dm_E}{dt} = \rho_{uv} \cdot A_{Fl} \cdot (u' + s_L) \]

\[ u' = \sqrt{\frac{2}{3} k} \]

Dissipationskoeffizient = 2,157
Turbulenzkoeffizient = 0,08

\[ k_{ES} = C_k \cdot \left( \frac{c_m \cdot d_{Zyl}^2}{n_{EV} \cdot d_{EV} \cdot h_{EV}} \right)^2 \]

\[ P = -\frac{2}{3} \cdot k \cdot \frac{dV_{Zyl}}{dt} \]

\[ E = \varepsilon_d \cdot \frac{k^{1.5}}{l} \]

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