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Engine Dynamics Simulation Models

A Fuel Wall Wetting Model for Real-Time Applications

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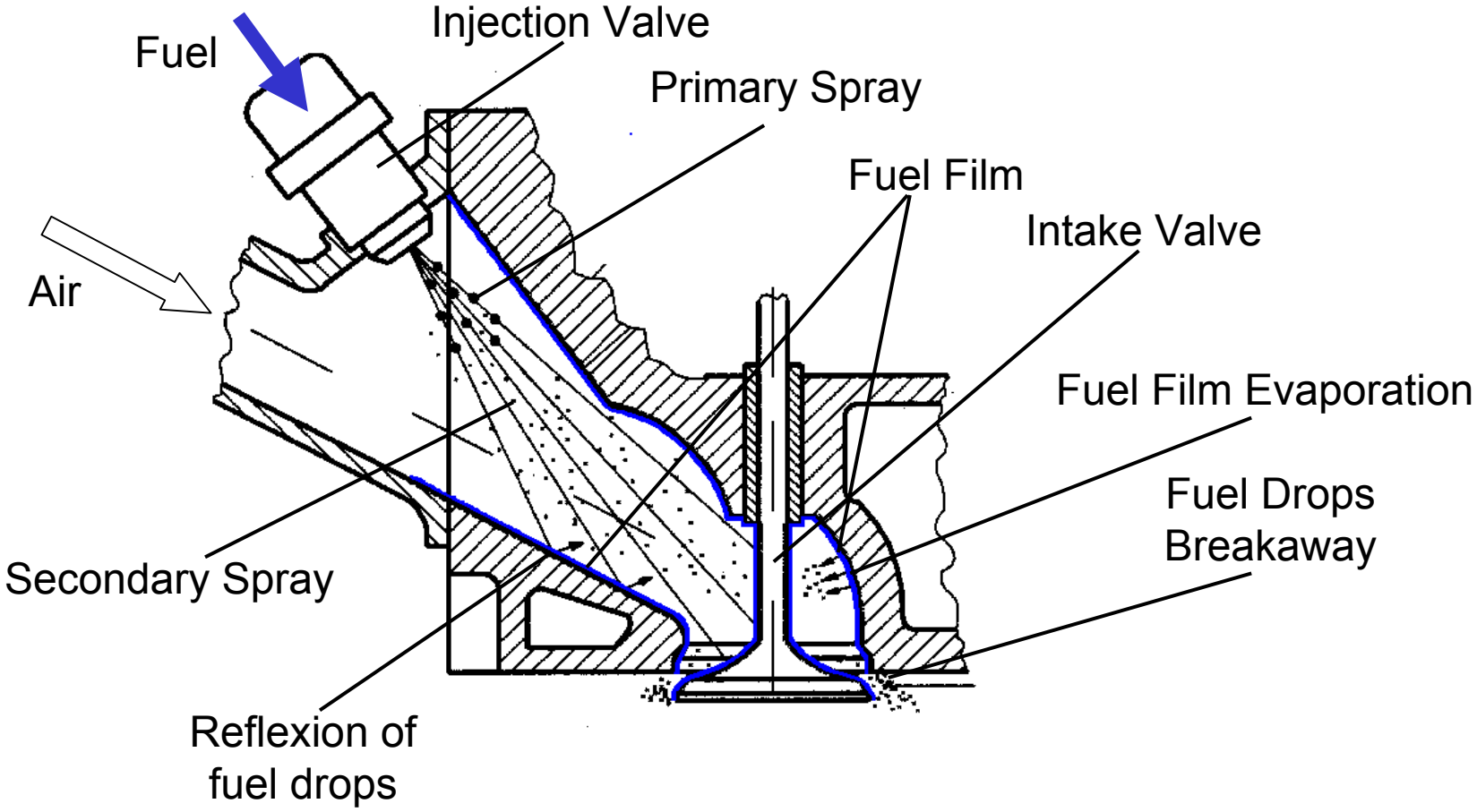
Introduction

- In real time simulation (e.g. HIL) of SI-engines, fuel wall wetting is often neglected
- Satisfactory for static engine operation
- Not neglectable for transient operation
- Need for a simple model
- Need for a parameterisation based on standard measurement data

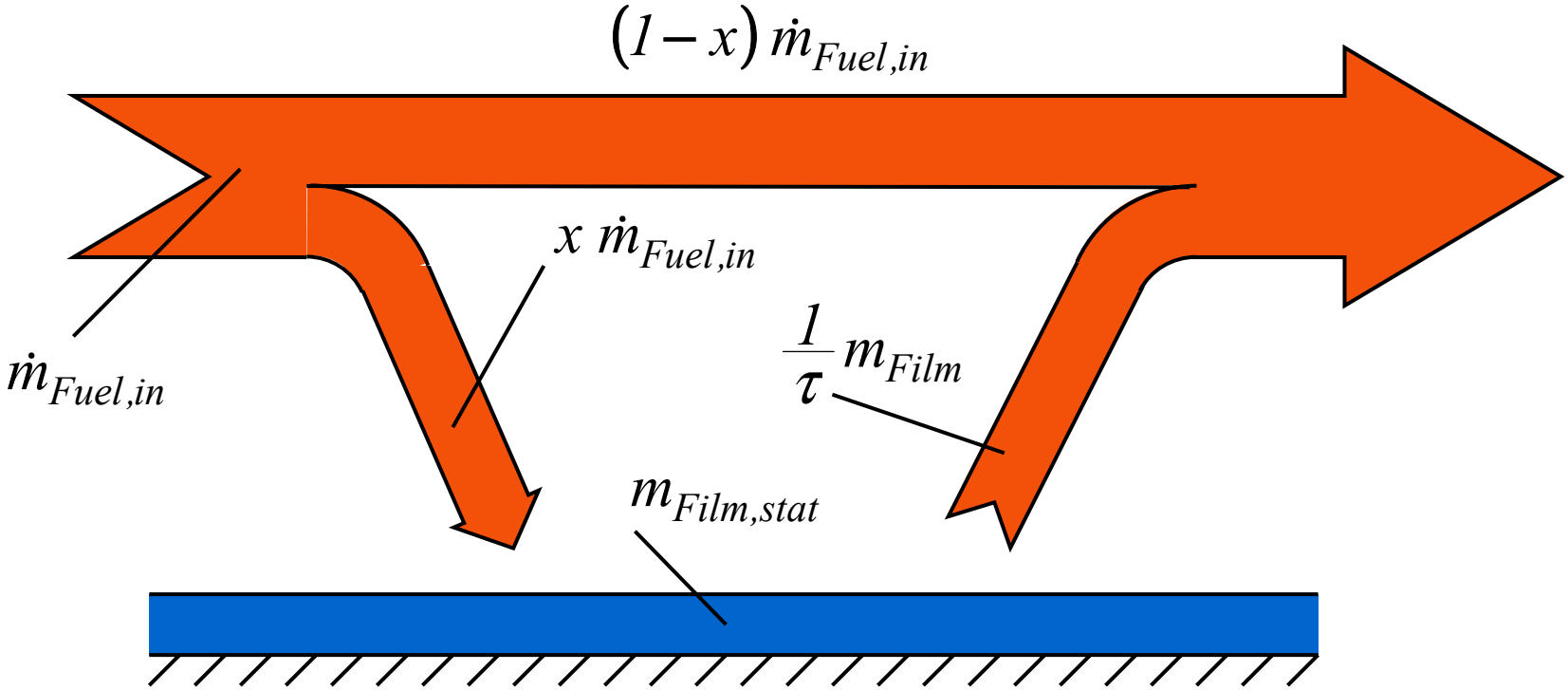
Outline

- Fuel spray transport and wall wetting effect
- Phenomenological model
- Parameterisation
- Conclusions

Fuel transport and mixture formation in the intake manifold



x -τ-model characterising the fuel film dynamics

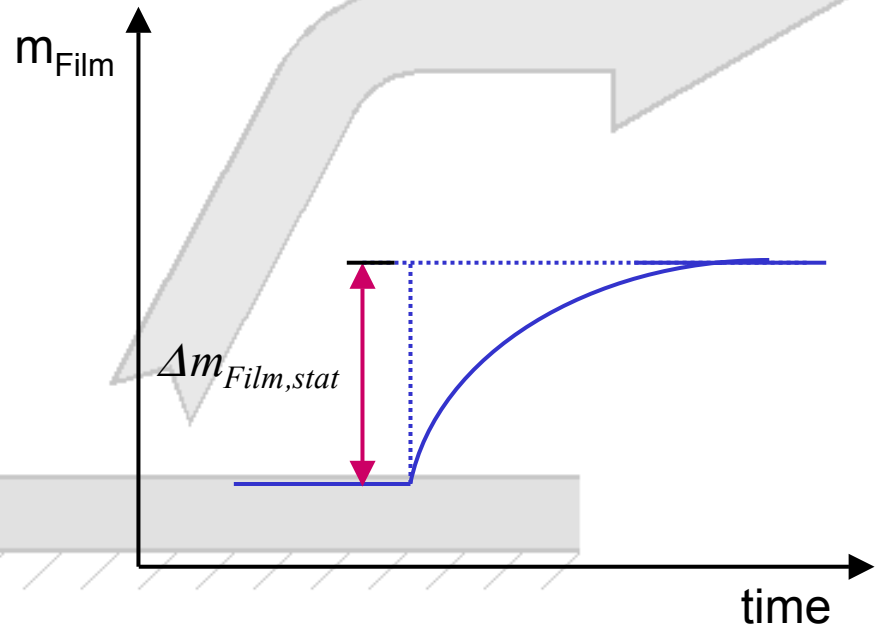


Change of the fuel film mass due to a step change in load

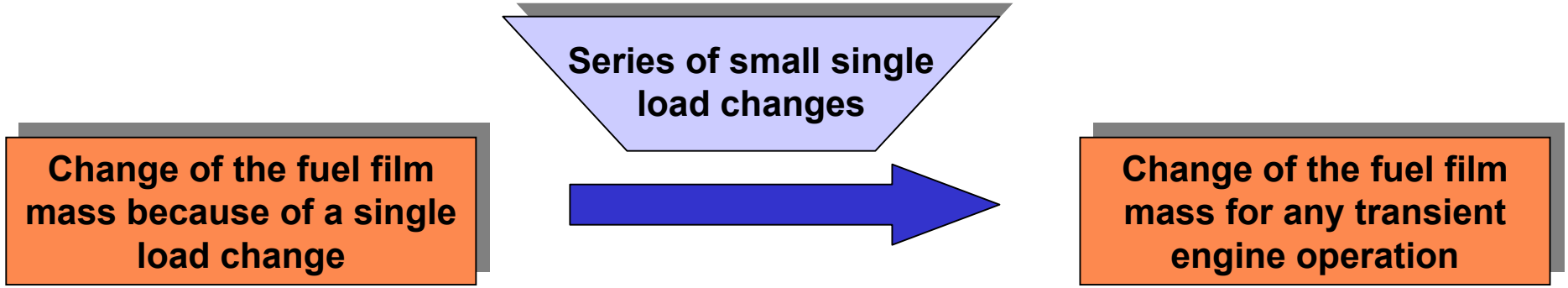
$$\frac{d\Delta m_{Film}}{dt} = x\,\Delta m_{Fuel,in}\frac{n}{2} - \frac{1}{\tau}\Delta m_{Film}$$

$$x = \frac{\Delta m_{Film,stat}}{\Delta m_{Fuel,in}\,\tau\frac{n}{2}}$$

$$\frac{d\Delta m_{Film}}{dt} = \frac{\Delta m_{Film,stat}}{\tau} - \frac{1}{\tau}\Delta m_{Film}$$



From single load change to a model for any transient engine operation



$$\frac{dm_{Film}}{dt} = \frac{m_{Film,stat}}{\tau} - \frac{1}{\tau} m_{Film}$$

$$m_{Film,stat} = F_{T,p}\, p_m + F_{T,\lambda} (\lambda_{theo} - 1)$$

Analysis of a single load step

- The change of the fuel film mass is calculated from a balance of mass

$$\Delta m_{Film} = \sum_{i=1}^{n} \left(m_{Fuel,in_i} - m_{Fuel,ex_i} \right)$$

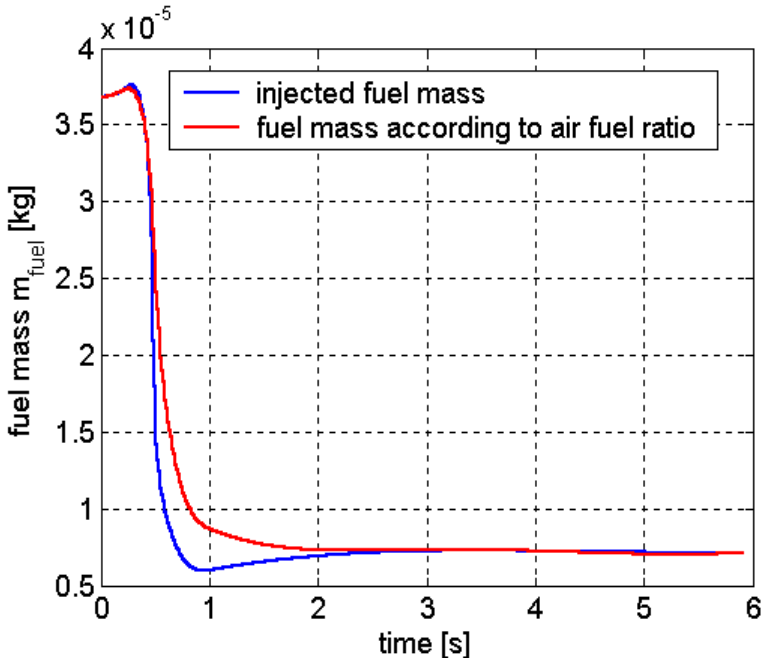
n = number of engine cycles during the analysed load change

$m_{Fuel,in}$ = injected fuel mass per engine cycle

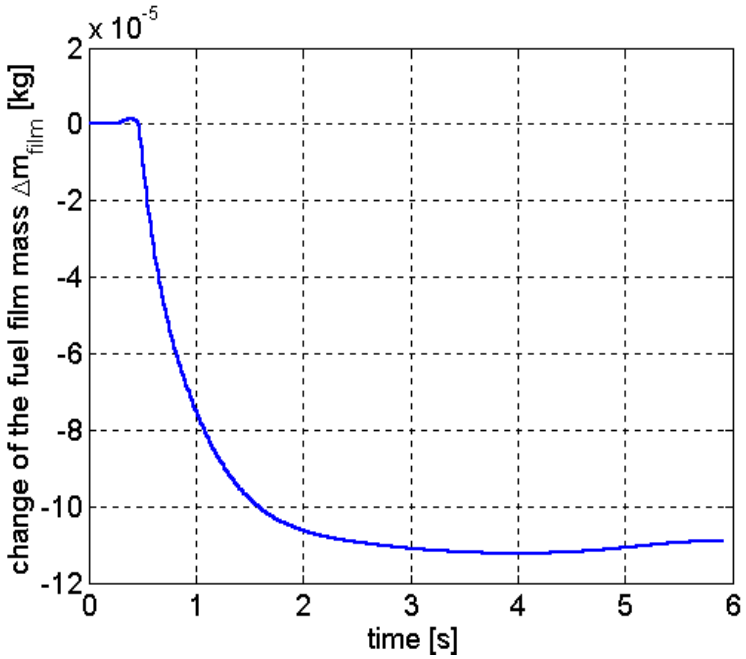
$m_{Fuel,ex}$ = fuel mass according to the air fuel ration of the exhaust gas

- The balance of mass is calculated based on standardised measurements for calibration of the ECUs

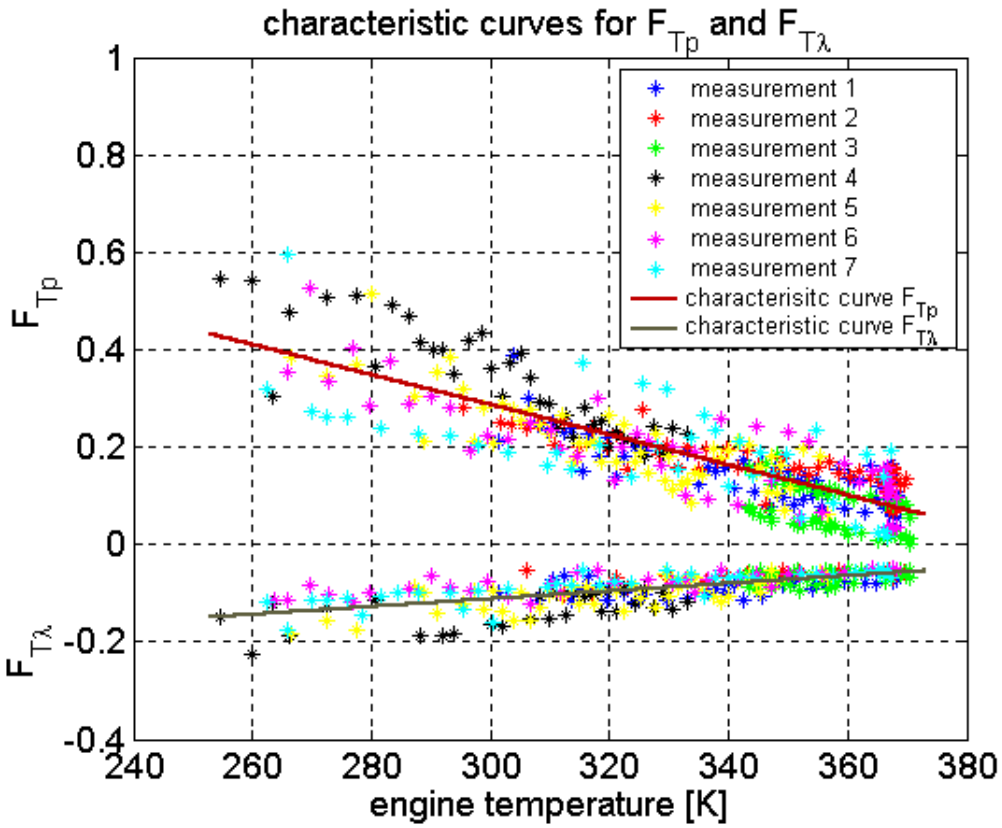
Fuel film behaviour when closing the throttle

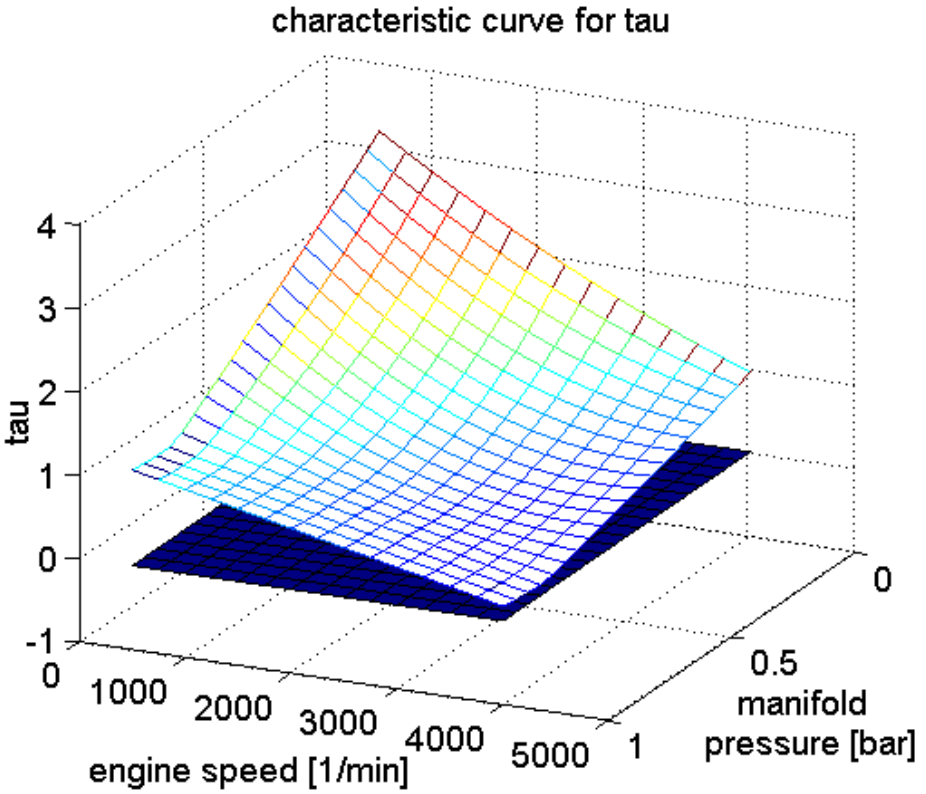


Calculated change of the fuel film mass

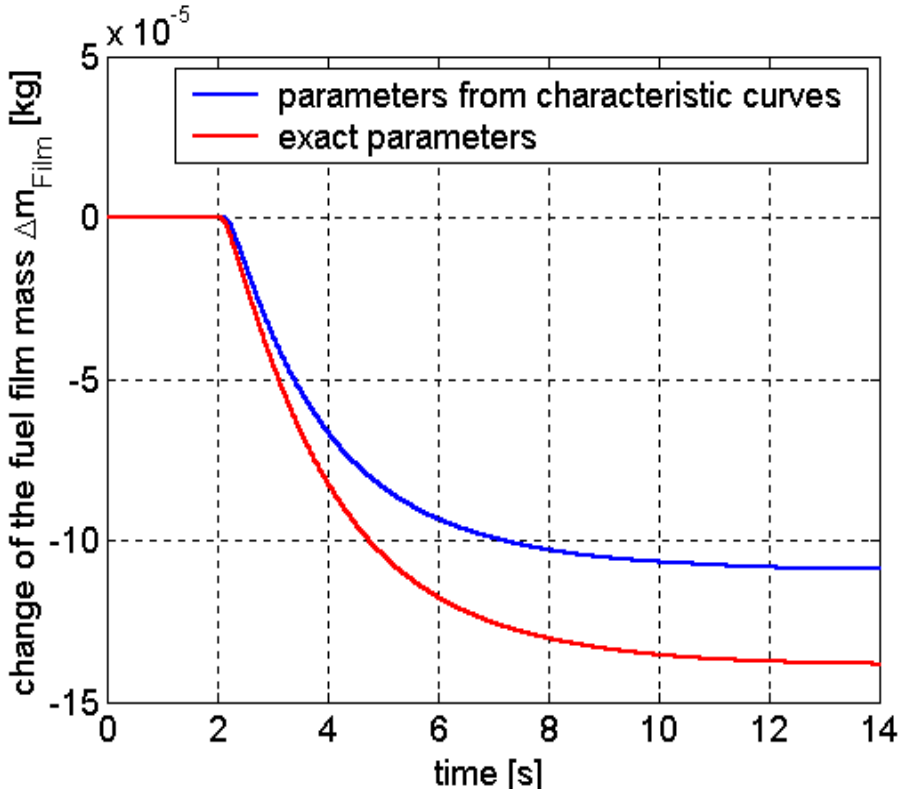


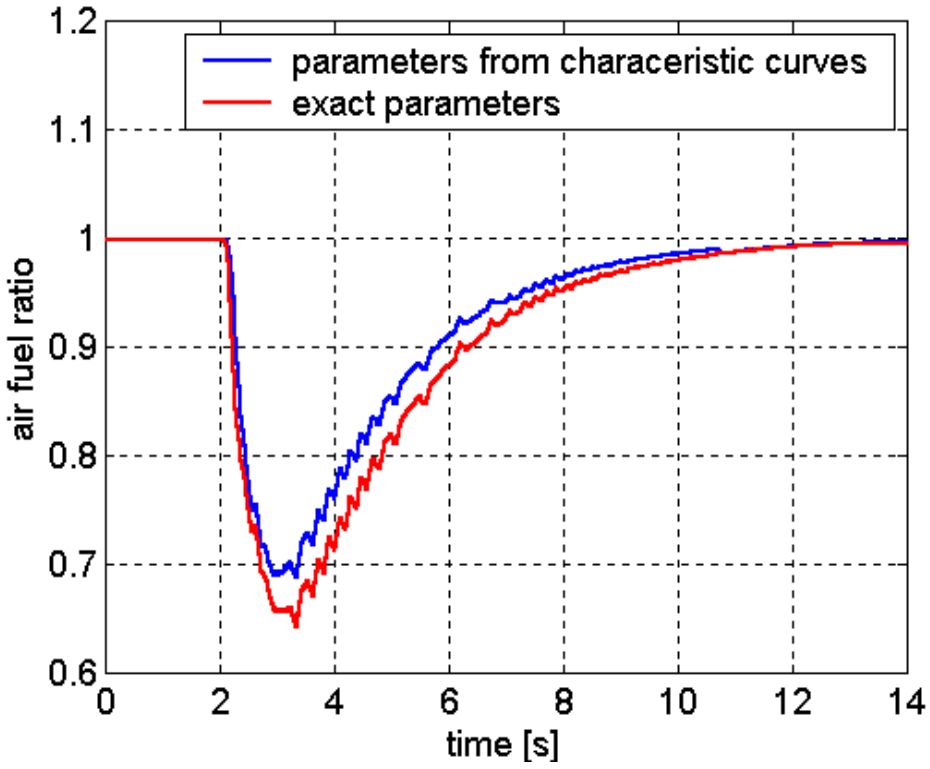
Results


characteristic curves for F_{Tp} and $F_{T\lambda}$
measurement 1
measurement 2
measurement 3
measurement 4
measurement 5
measurement 6
measurement 7
characterisitc curve F_{Tp}
characteristic curve $F_{T\lambda}$
F_{Tp}
$F_{T\lambda}$
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
240
260
280
300
320
340
360
380
engine temperature [K]

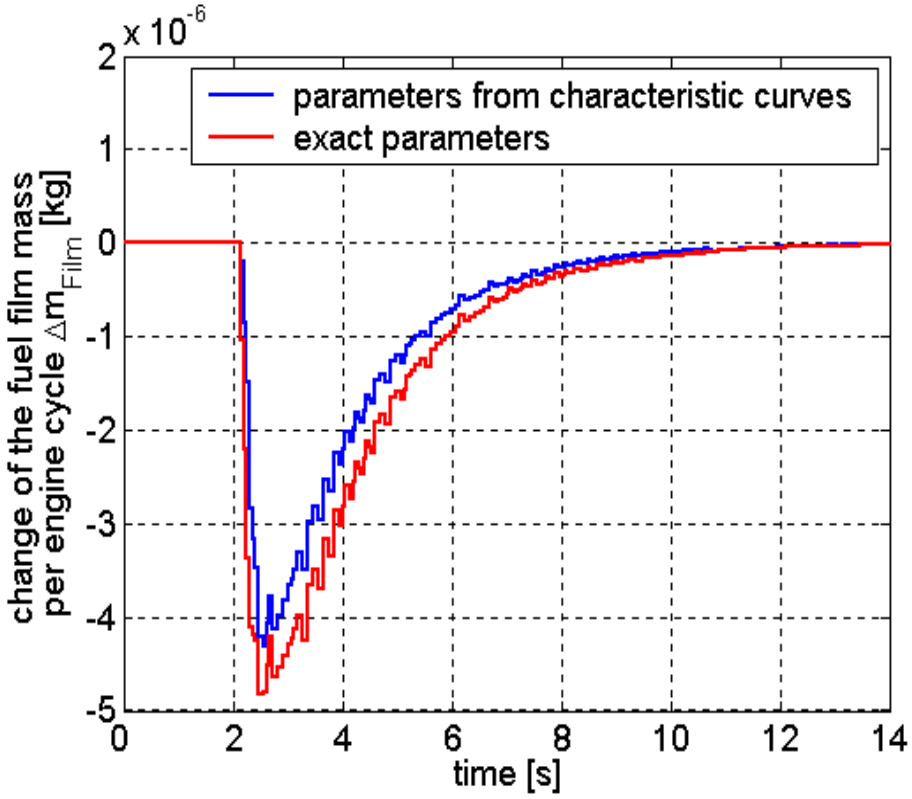

characteristic curve for tau
tau
4
3
2
1
0
-1
0
1000
2000
3000
4000
5000
engine speed [1/min]
1
0.5
0
manifold
pressure [bar]

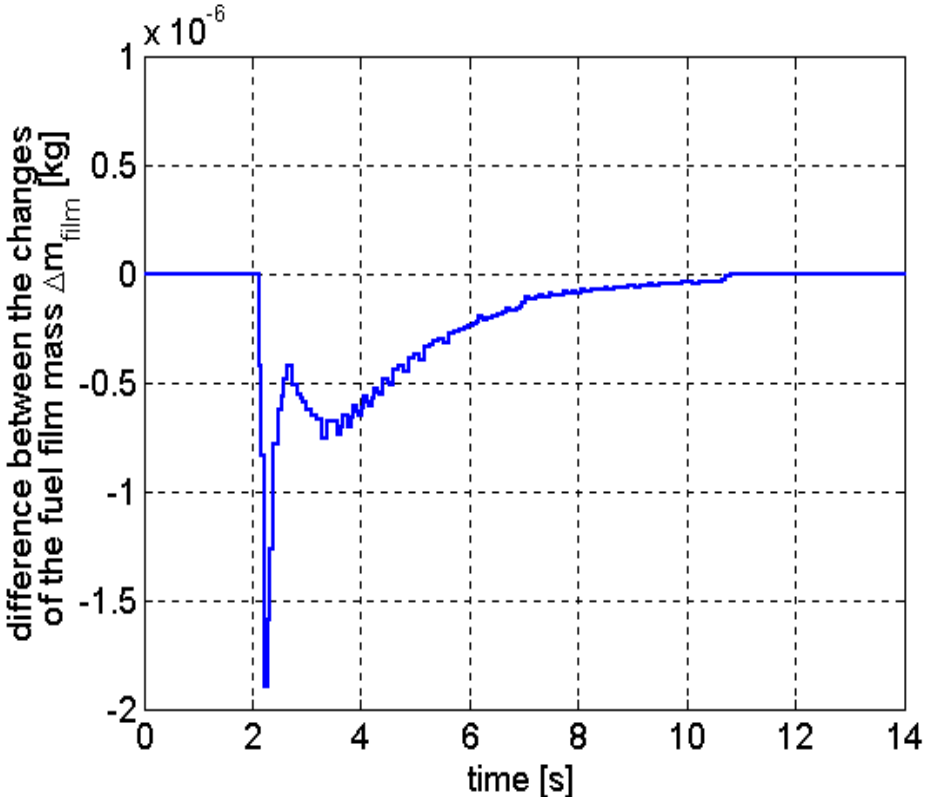
Comparison between exact parameters and those from the characteristic curves





Parameterisation





Conclusion

- Simple real time capable model for characterising the fuel film dynamics
- Influence of engine temperature is considered by two temperature dependent factors
- Dynamic behaviour is characterised by the x-τ-model:

$$\tau = f(p_m, n)$$

Parameterisation of the model is possible with the result of standardised measurements

Thank you for your attention

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