An Analysis of the Temperature Pulsations of Exhaust Gas before the THREE-WAY CATALYST

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Brno, 15. 11. 2020

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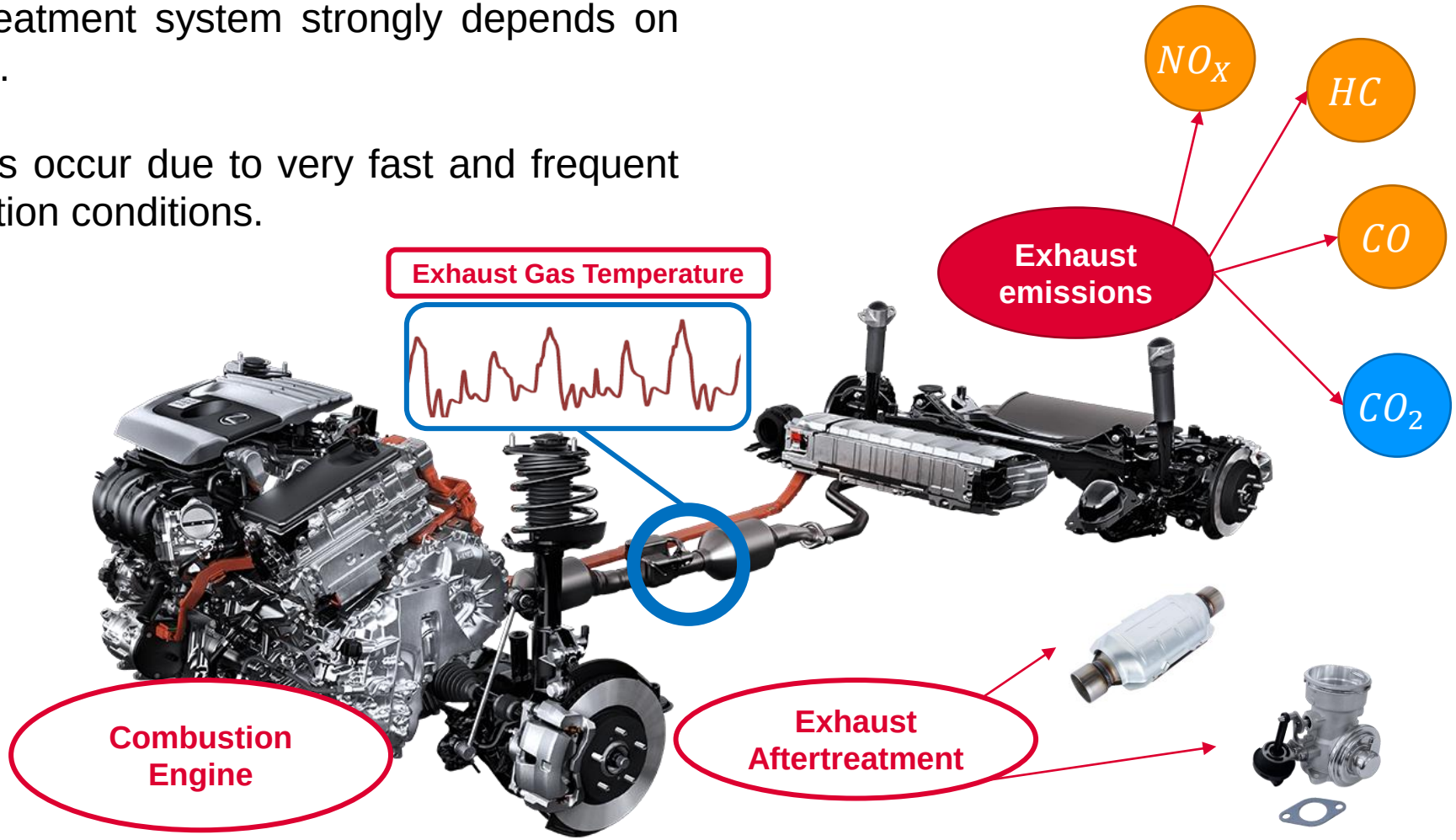
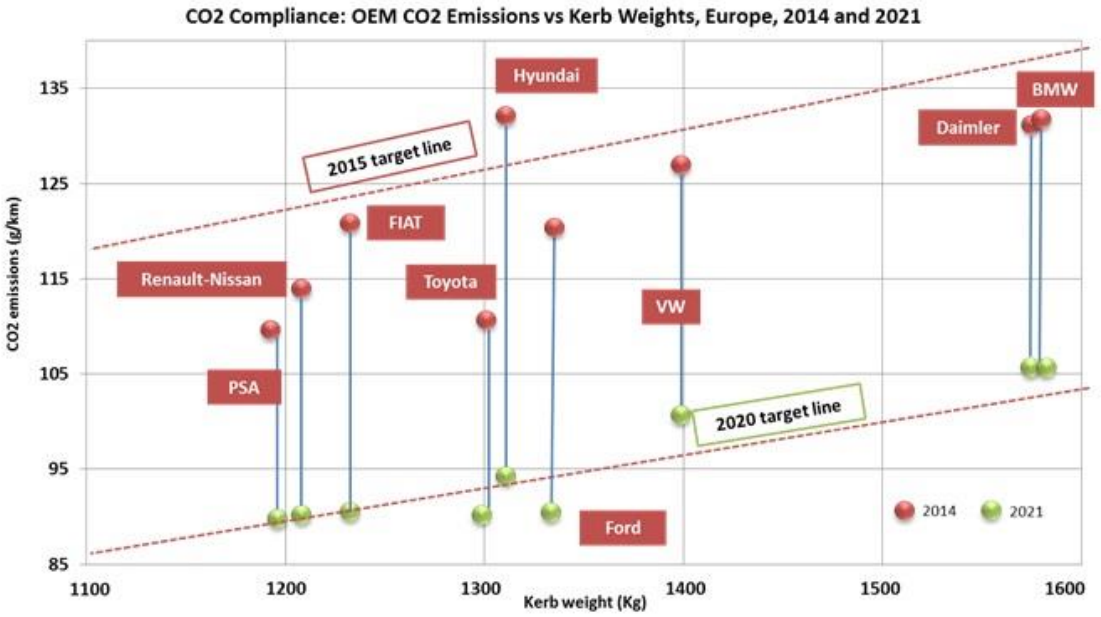
Problem description

- The efficiency of the aftertreatment system strongly depends on the exhaust gas temperature.
- Large temperature pulsations occur due to very fast and frequent changes in the engine operation conditions.



Motivation

- Internal combustion engines are currently the most common type of engine in cars and trucks.
- Car manufacturers are preparing for the arrival of almost emission-free transport, due to emission limits.



Economy

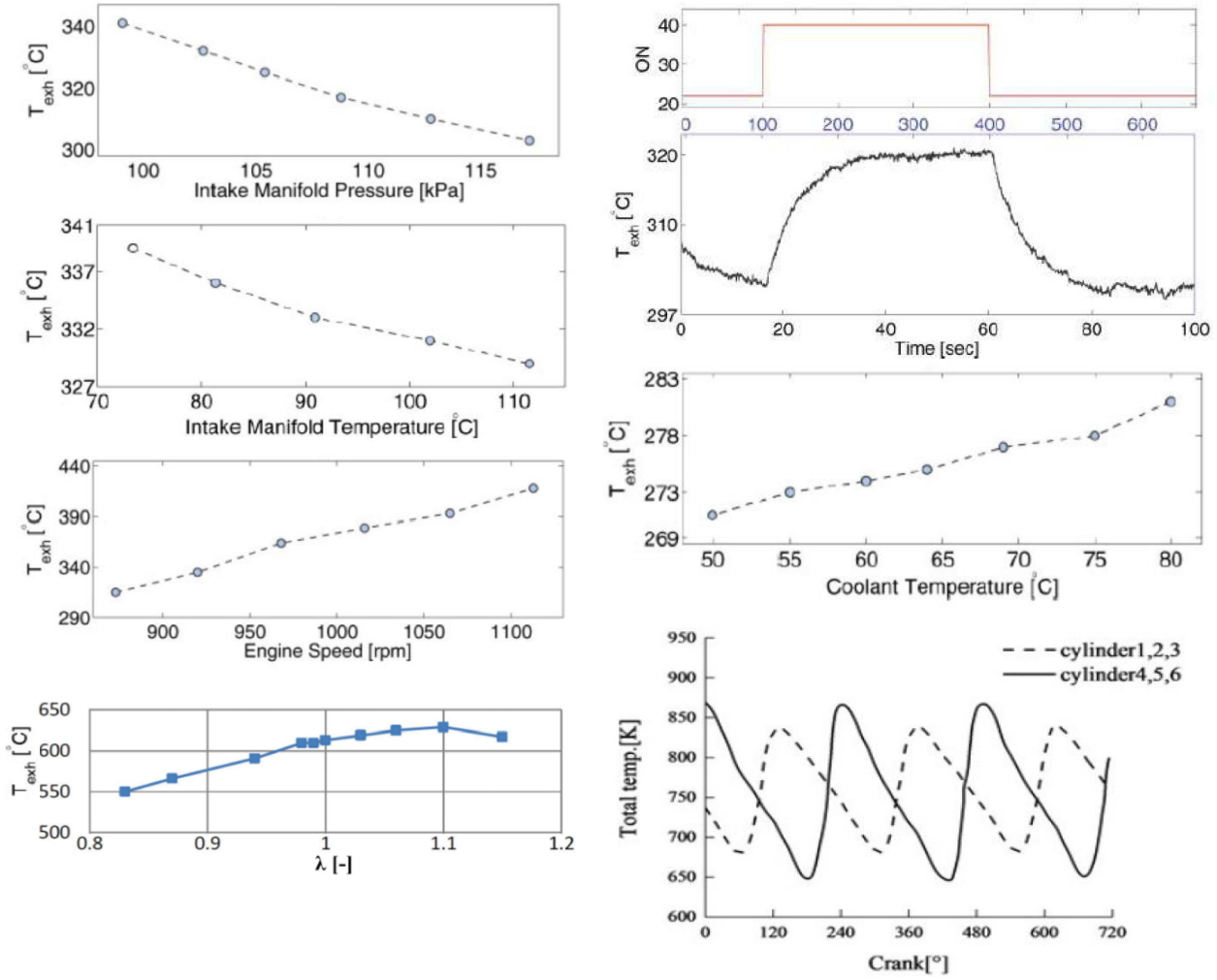
Ecology

State of art

Exhaust Gas Temperature

- The exhaust gas temperature never reaches steady state, even at the steady state of the engine.
- Dependency parameters:

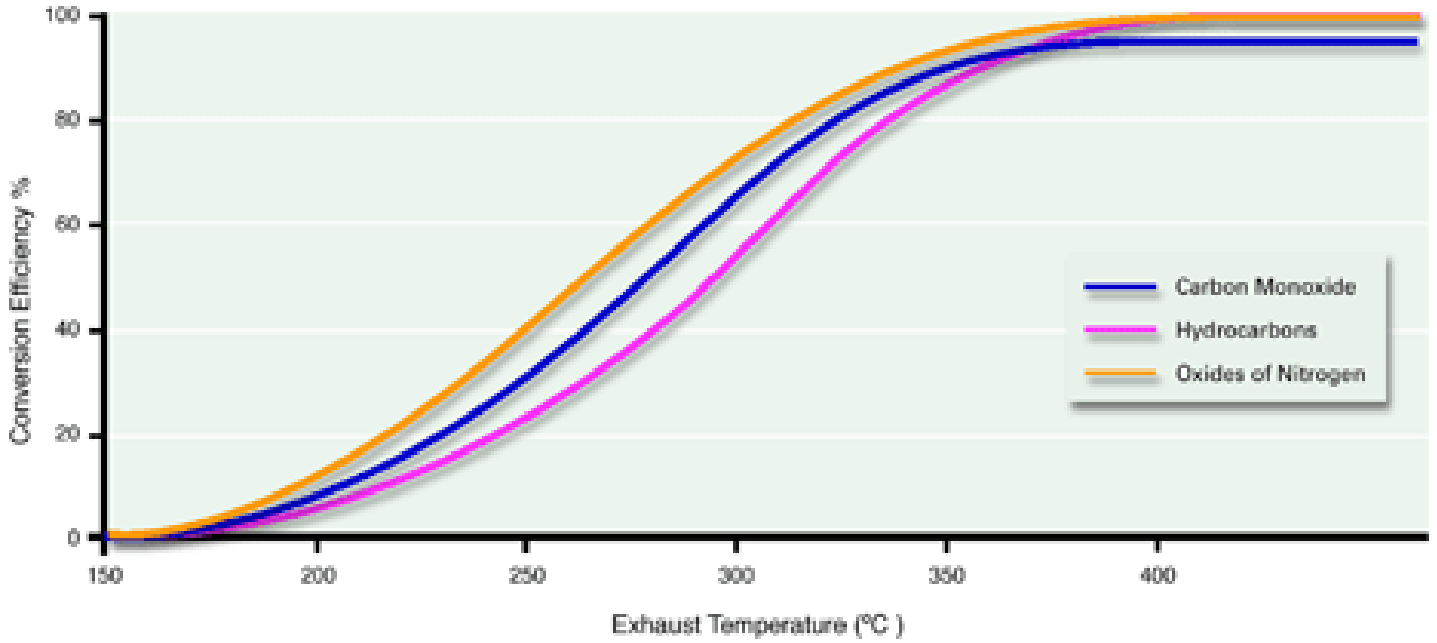
1. **intake pressure,**
2. **octane number of the fuel,**
3. **temperature of the cooling fluid,**
4. **intake temperature,**
5. **air-fuel ratio,**
6. **engine load and speed.**

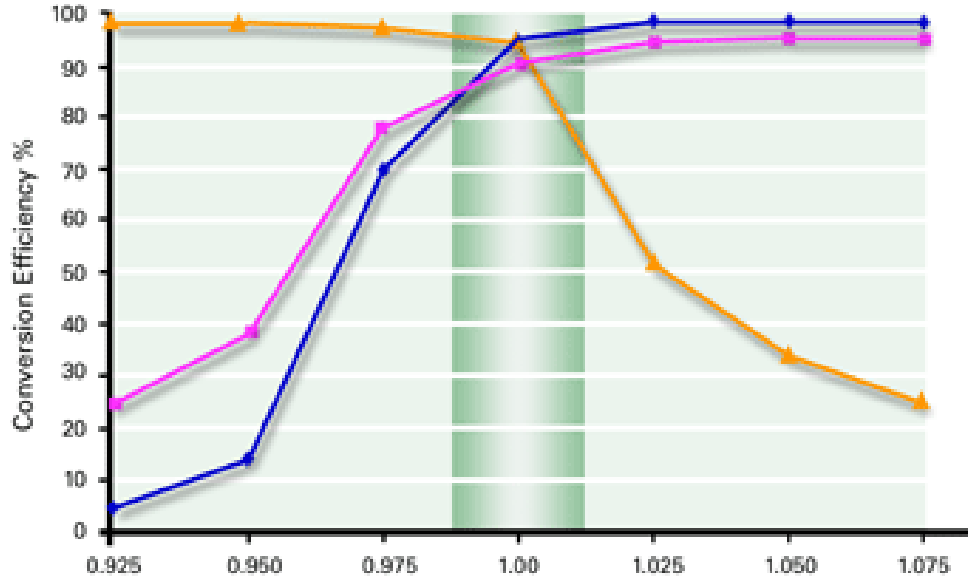


State of art

Three-Way Catalyst

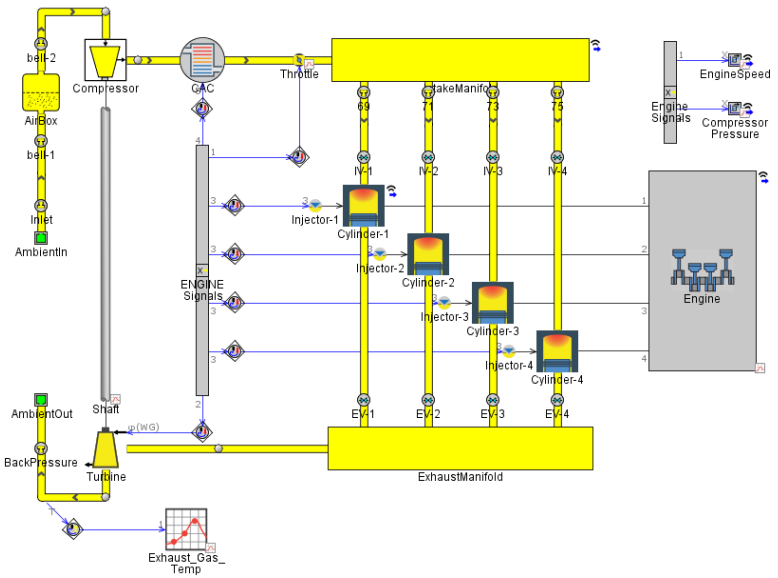
- Three-Way Catalyst works with high efficiency only under the optimal conditions (temperature, air-fuel ratio).



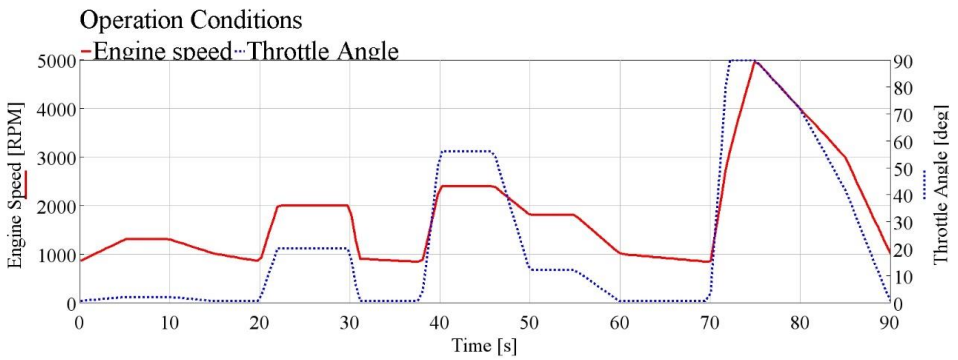


Temperature pulsation analysis

- Engine simulation model was created in GT-Suite based on a **1,5 TSI EVO EA211** engine manufactured by VW.
- The internal conditions of the combustion in the engine were selected for the highest thermal efficiency and stoichiometric mixture.
- The variable parameters of the simulation were the engine speed and load.

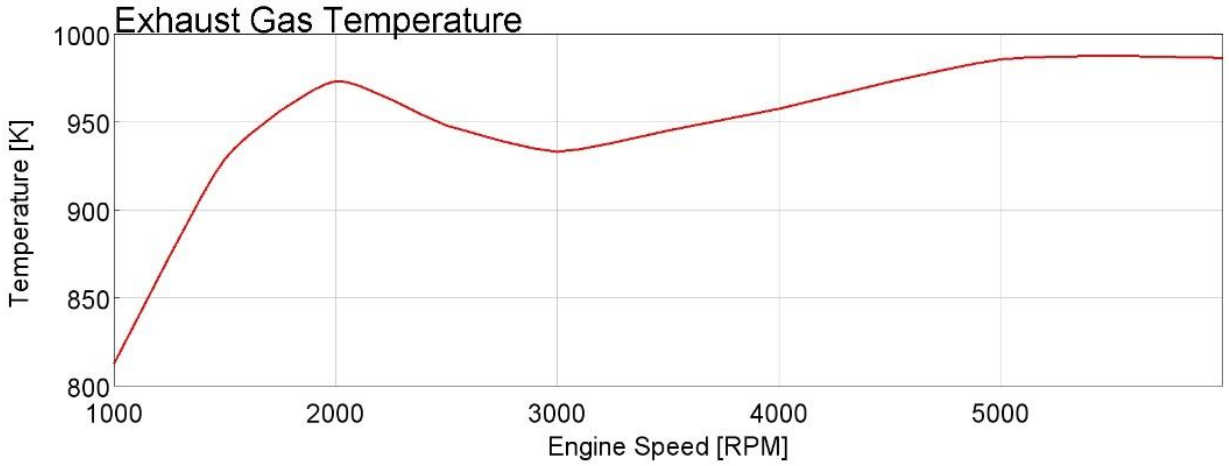


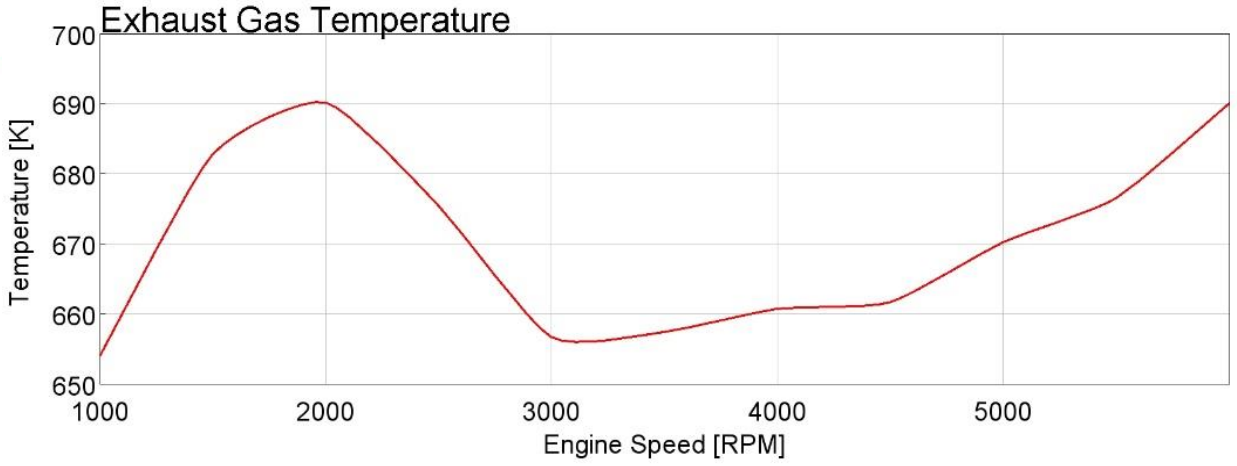
	Case 1	Case 2	Case 3
Simulation type	Steady state	Steady state	transient
Engine speed [min^{-1}]	1000-6000	1000-6000	Fig. 2
Engine load [%]	100	0	Fig. 2



Results and discussion

- **Steady state cases:**
  - It is almost impossible for the engine to reach these values of the temperature.
  - These values only represent possible maximum values for chosen parameters.

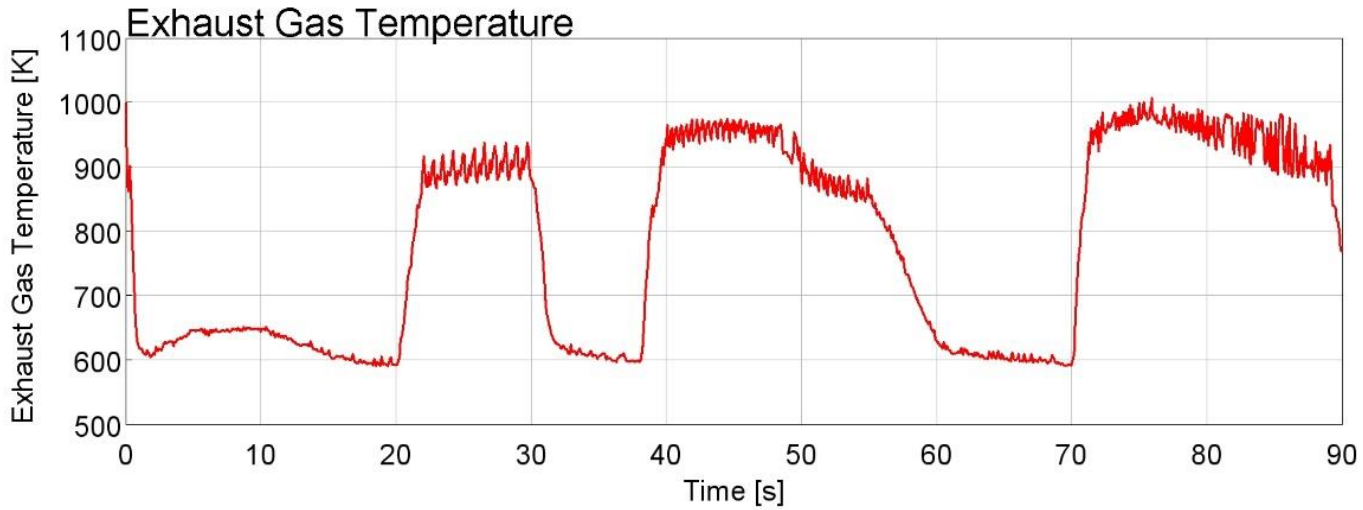




Results and discussion

- **Transient case:**
  - The temperature dynamically changes; its value corresponds to the changes in the load and the speed of the engine.
  - During the partial load (and full load) the temperature is high enough for efficient work of the catalyst.
  - During the low speed and load conditions, the values of the temperature do not meet the basic condition of the effective work of the three-way catalyst:

$$T_{EXHAUST} \geq T_{CAT\_LOW} \quad \text{✖} \quad T_{CAT\_LOW} = 630\ K$$



Conclusions

- The condition of the combustion has an effect on the exhaust temperature, but it is better to choose these variables for the highest possible thermal efficiency rather than for the optimal exhaust gas temperature
- Exhaust gas temperature has under the steady state conditions almost constant value and the trend of the temperature corresponds to the engine load and speed.
- During the transient conditions, which are more accurate for the real drive, the exhaust gas temperature pulsates. These pulsations reach in their minimum values temperatures that are lower than the light-off temperature of the catalyst. This causes a rapid reduction in the efficiency of the catalyst and increases the emissions.
- **Future research: Stabilization of the exhaust gas pulsations using thermal energy of the exhaust gas.**

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Thank you for your attention

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