



*Researcher Links UK-Russia Workshop*

## **Scientific and Technical Grounds of Future Low-Carbon Propulsion**

19th - 22nd November 2018, Northumbria University at Newcastle, UK

# The use of alternative fuels for reduction of IC engine structure-borne noise

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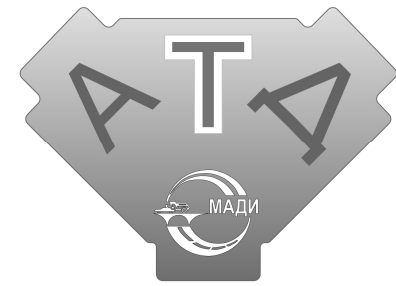
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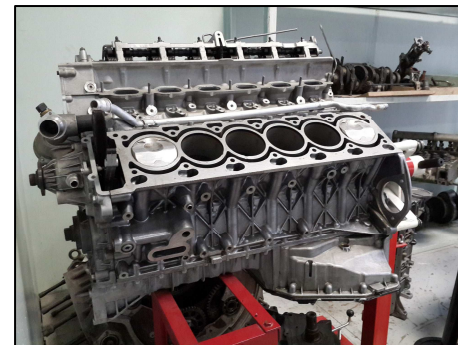
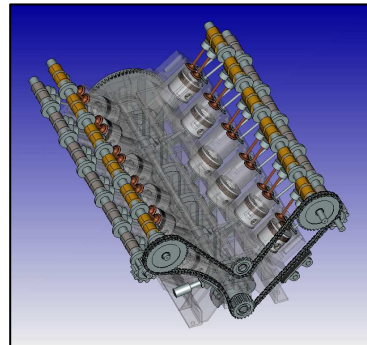
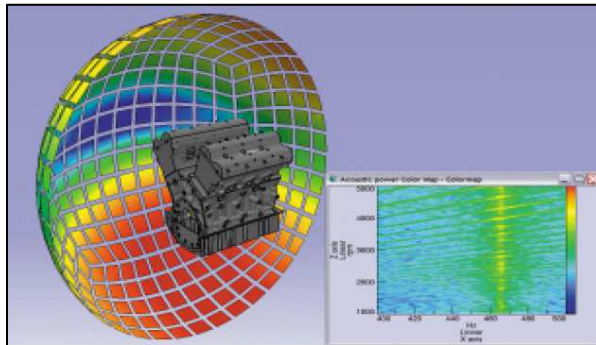
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# Department "Heat Engineering and Automotive Engines"

*Area of work*



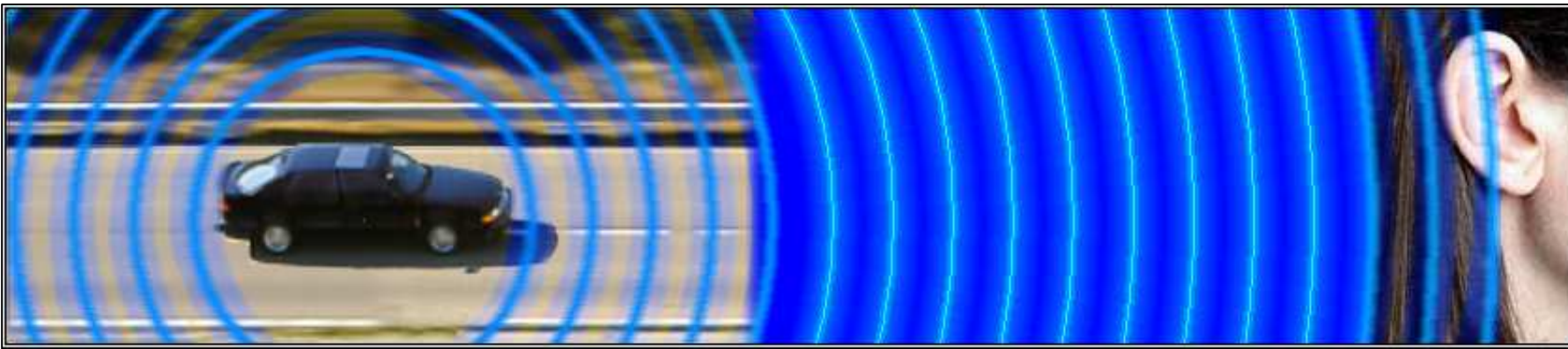
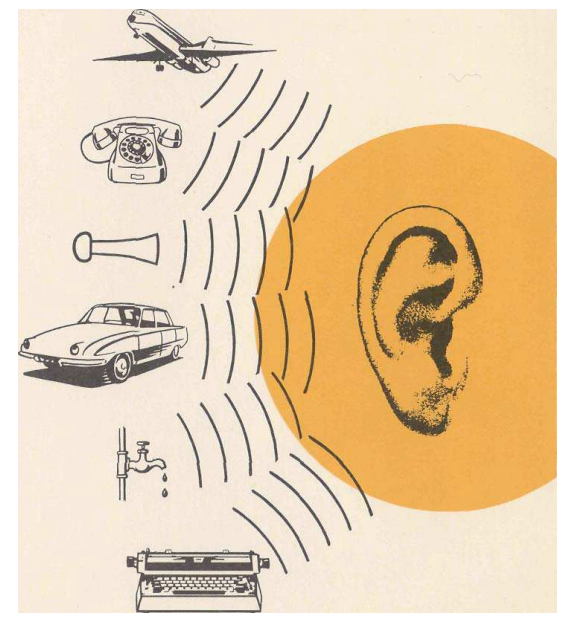
- ✓ Diesel fuel supply systems
- ✓ Alternative fuels for diesel engines
- ✓ Noise and vibration of internal combustion engine
- ✓ The development of ICE CAD
- ✓ Engine management systems
- ✓ ICE experimental researches



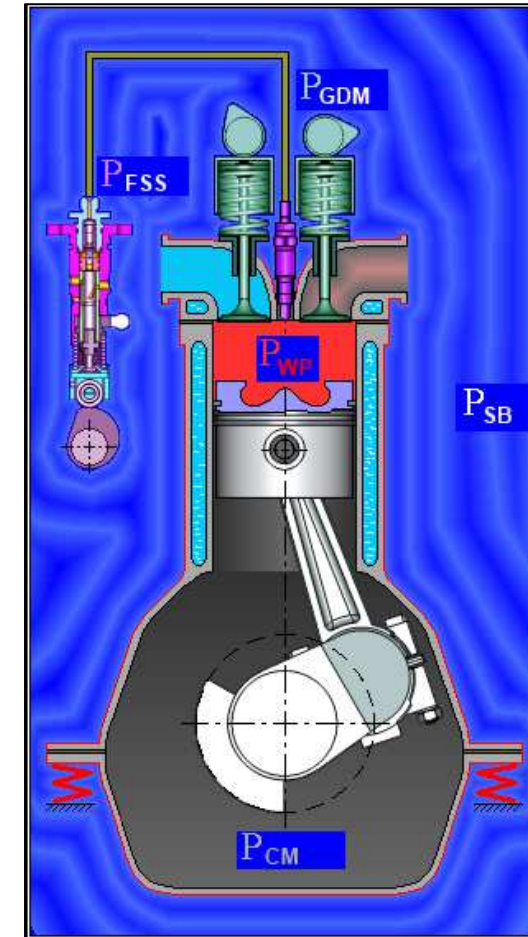
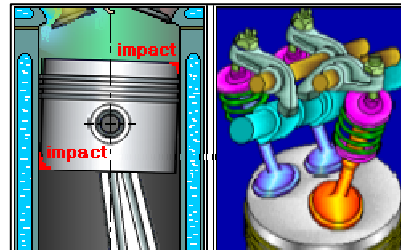
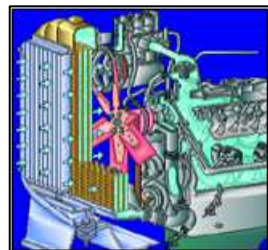
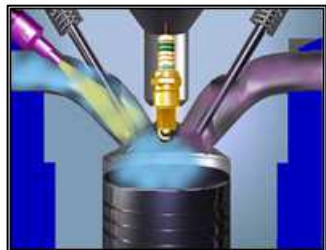
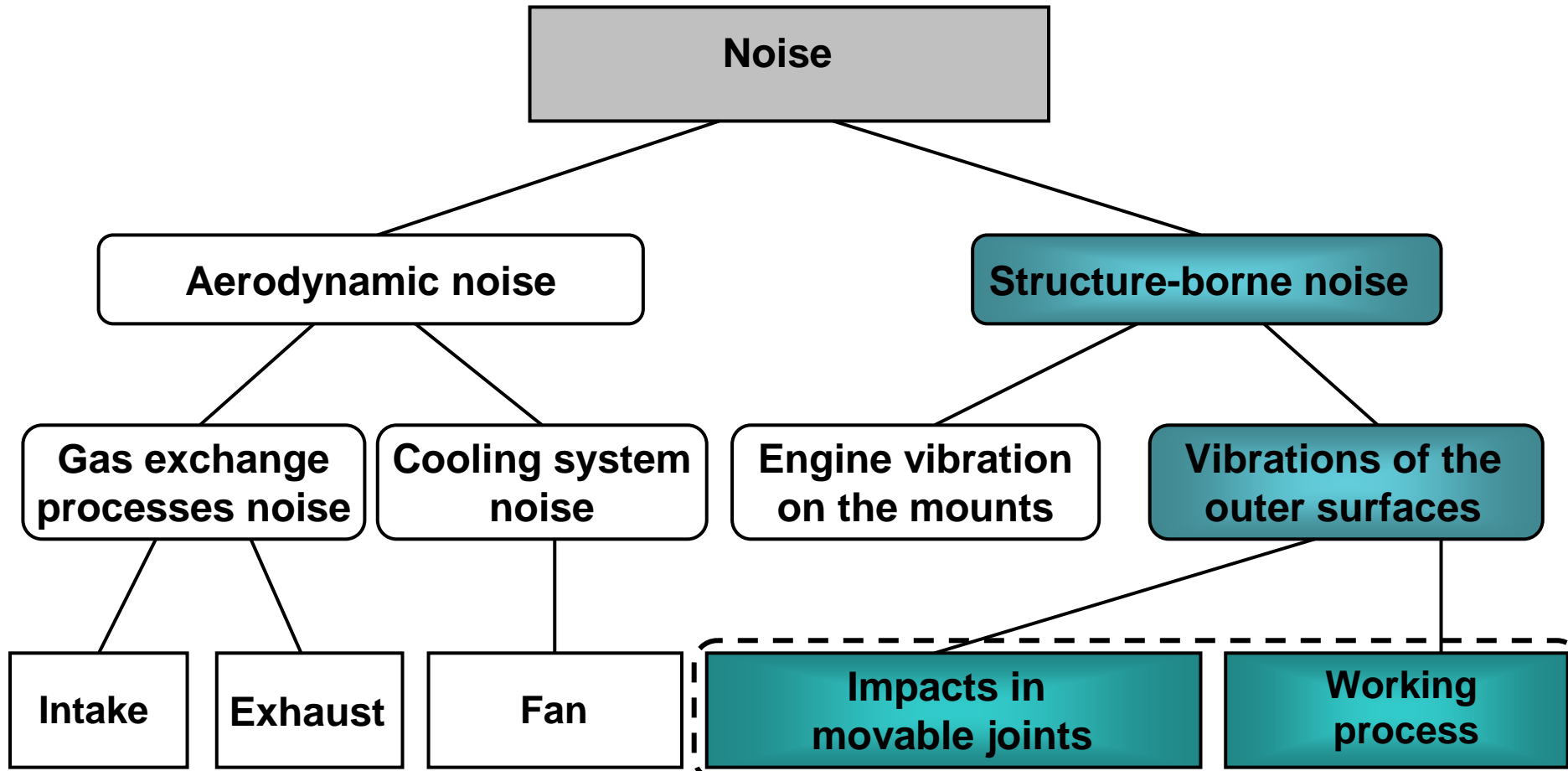
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# Harmful effects of noise and vibration on humans

- The decrease in labor productivity
- Diseases of the nervous and cardiovascular system
- Difficulties of perception of useful information
- Reduced sensitivity of the ear until the complete loss of hearing

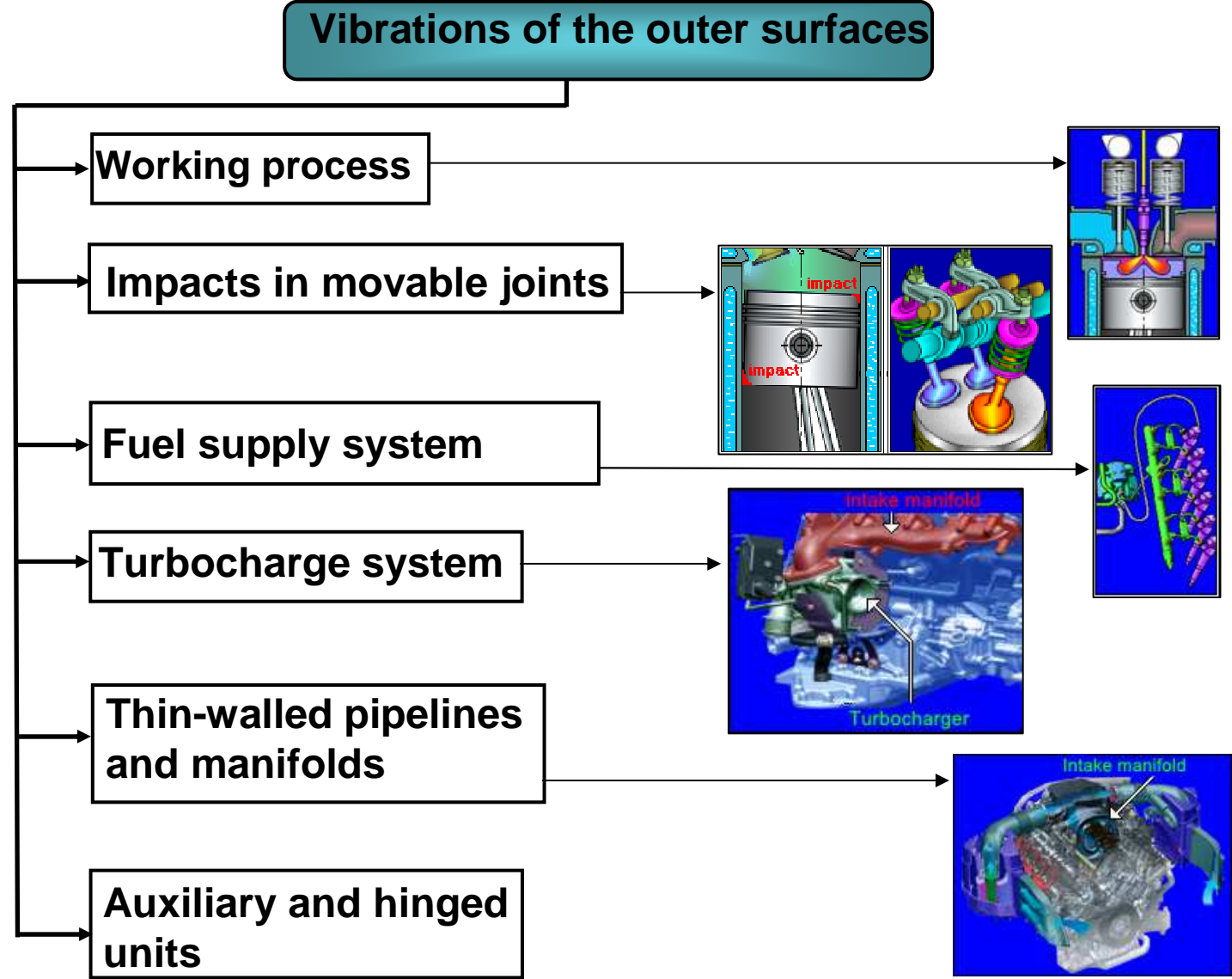
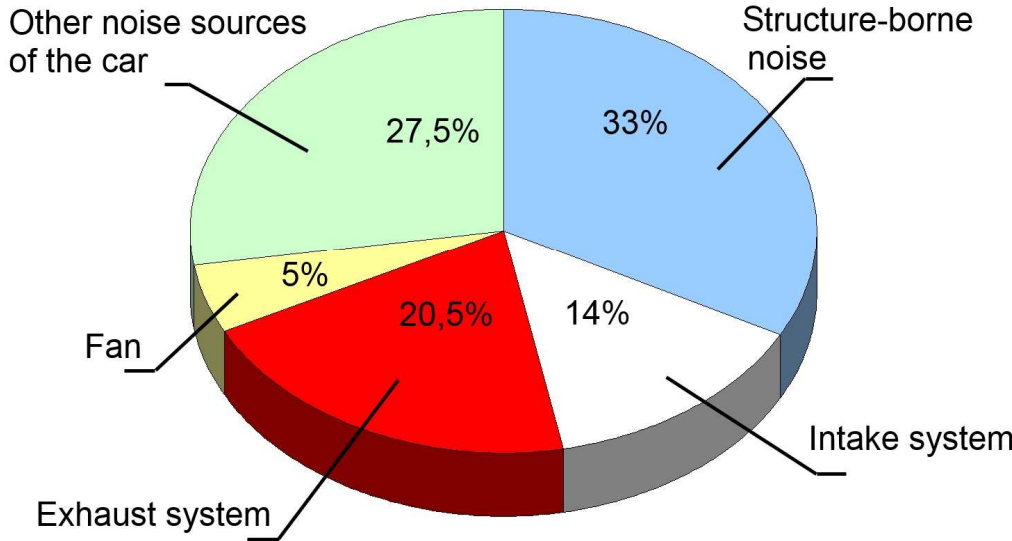


# Classification of noise sources of the internal combustion engine

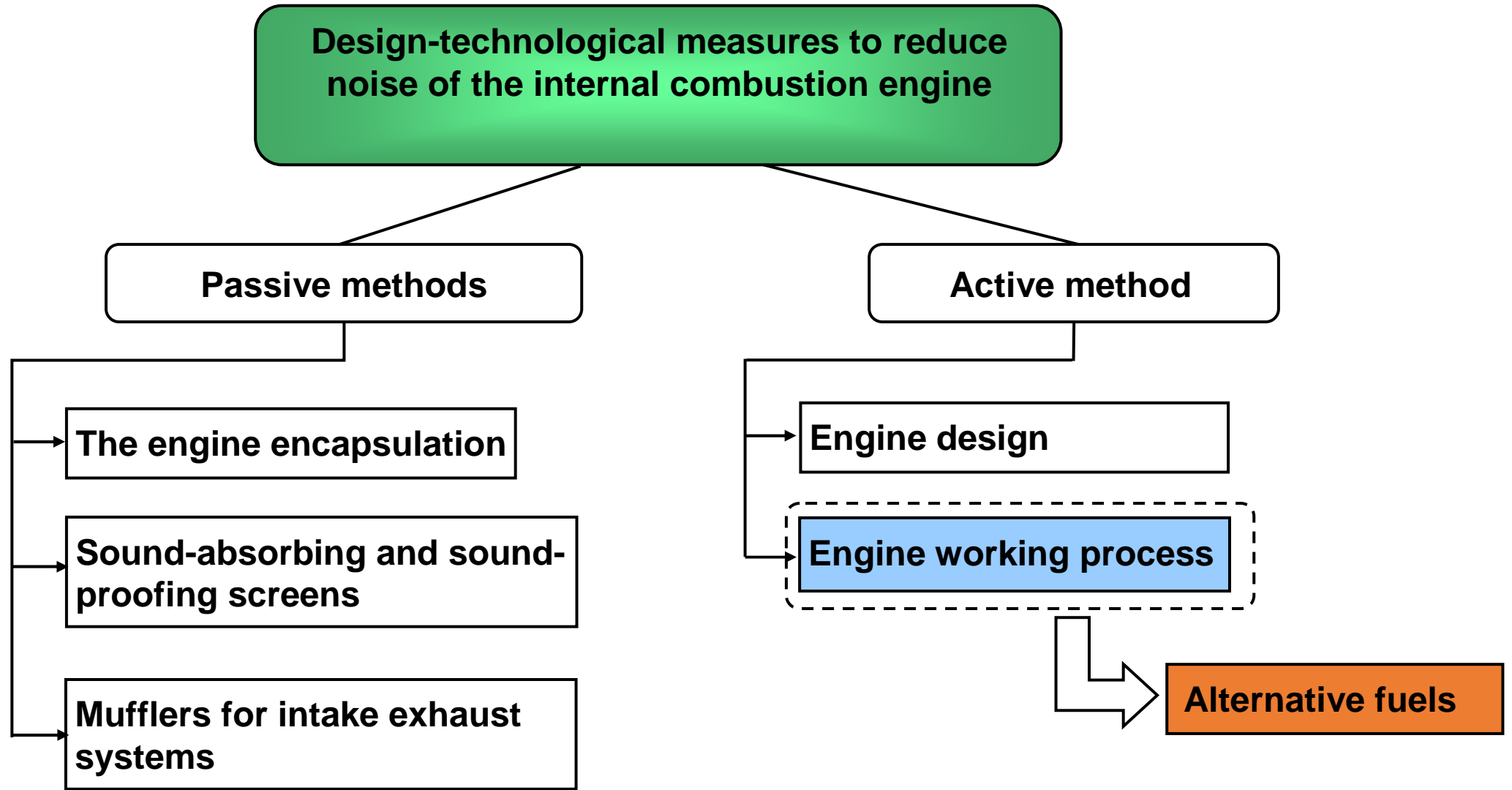


# Classification of structure-borne noise sources of the internal combustion engine

## Acoustic balance of the car



# Methods for reducing of the internal combustion engine structure-borne noise

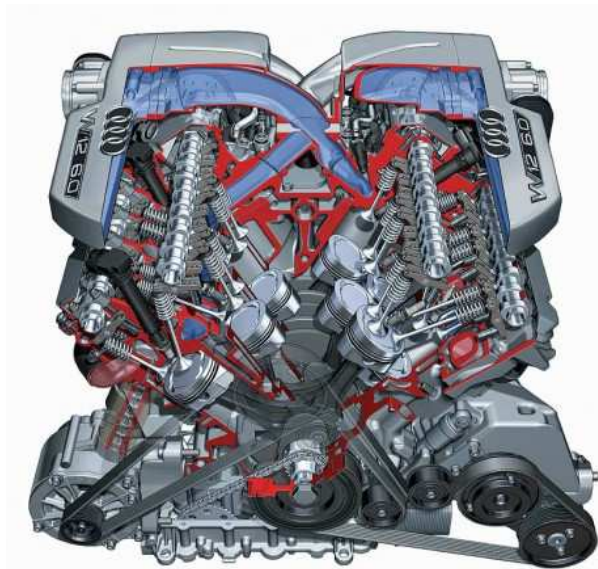
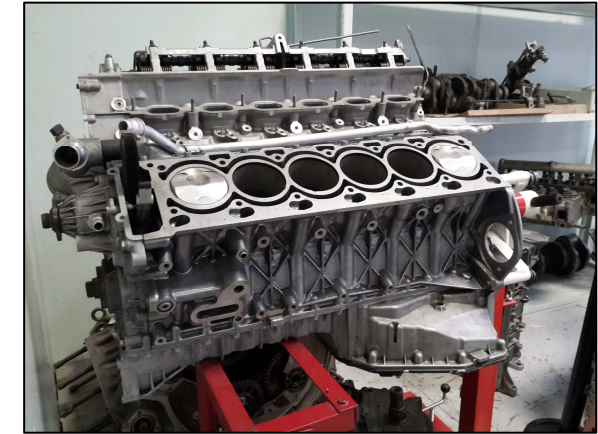
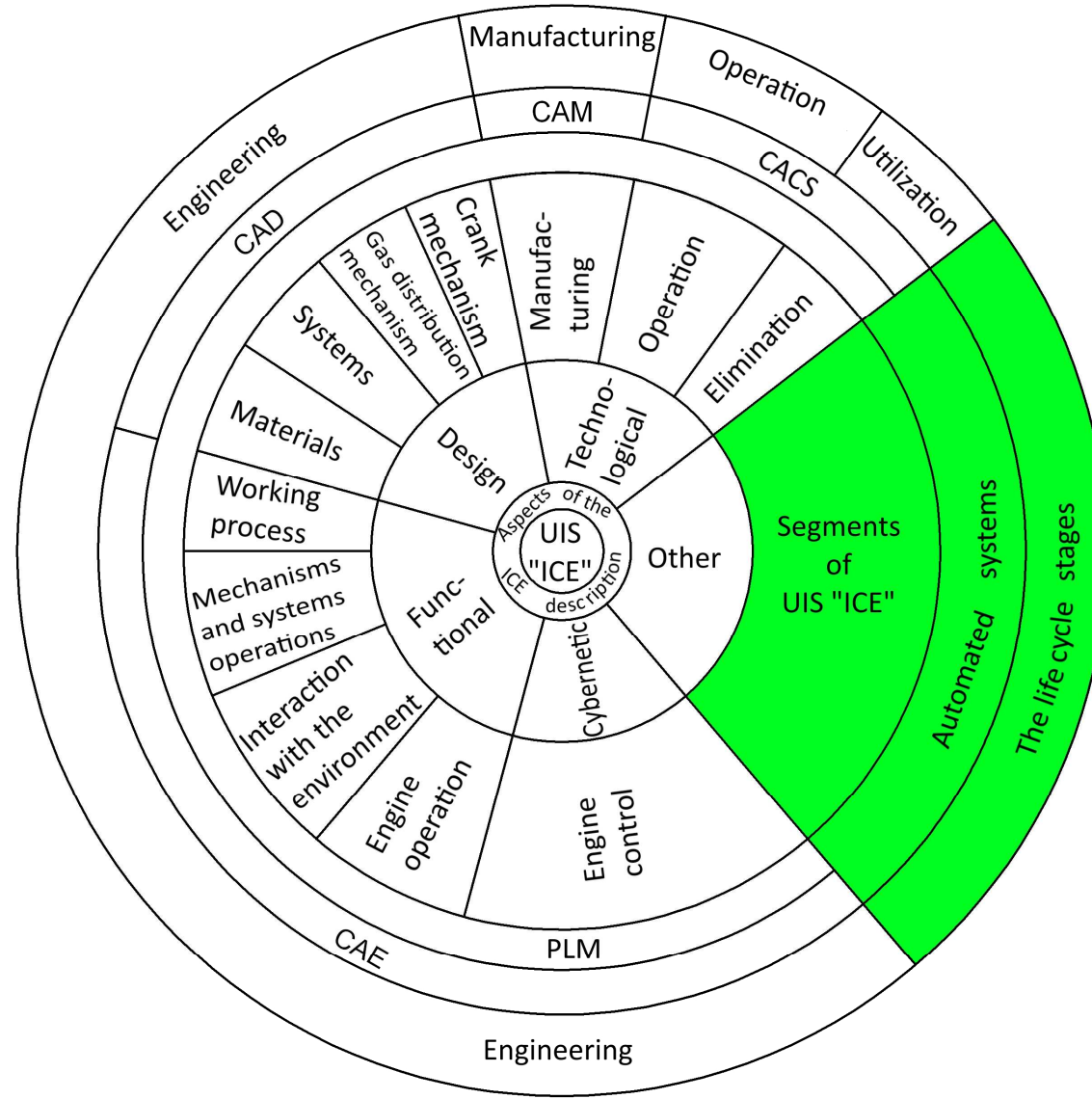
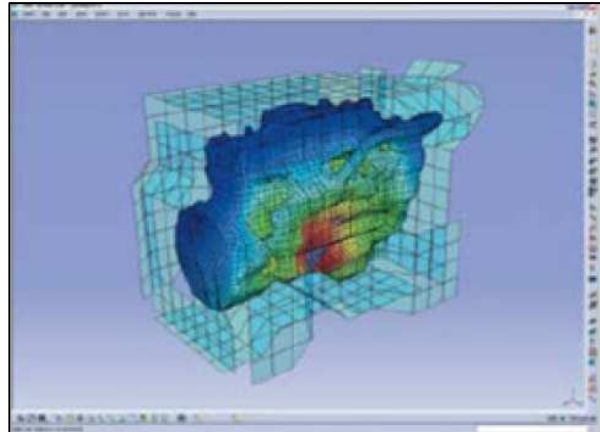
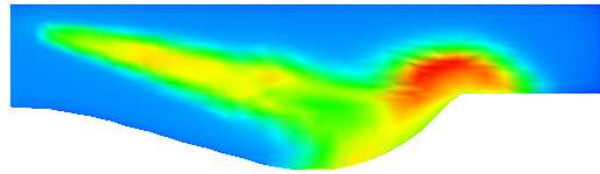
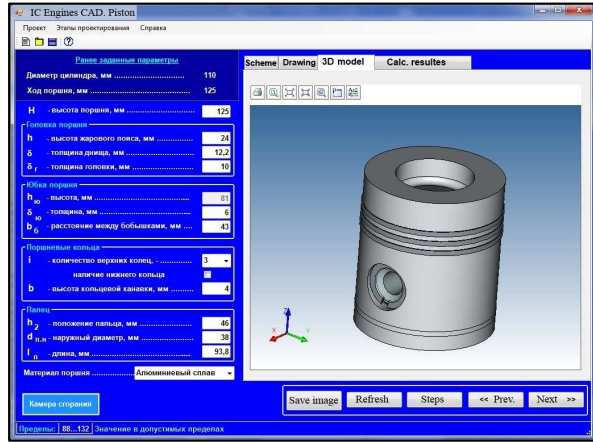


# The benefits of using alternative fuels in internal combustion engines

- *renewability;*
- *reduction of emissions of exhaust gases toxic components;*
- *reduction of engine noise;*
- *improvement of the engine efficiency;*
- *reduction of contamination on engine parts, increase of engine reliability;*
- *improved engine startup characteristics.*

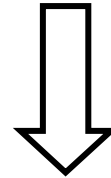


# Unified information space "Internal combustion engine"



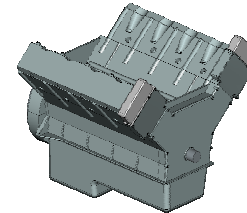
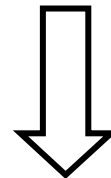
# The method of calculating the structure-borne noise of the internal combustion engine at steady mode

1. Setting the conceptual parameters of the engine

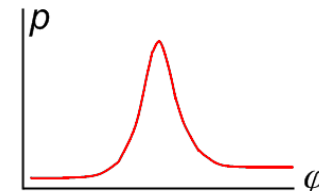
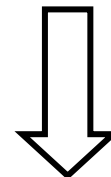


	Значение
$D$	110 мм
$S$	125 мм
...	...

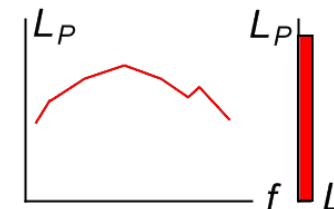
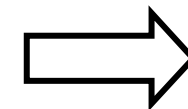
2. Development of 3D model of engine using ICE CAD



3. Calculation of working cycle and obtaining indicator diagrams of internal combustion engine

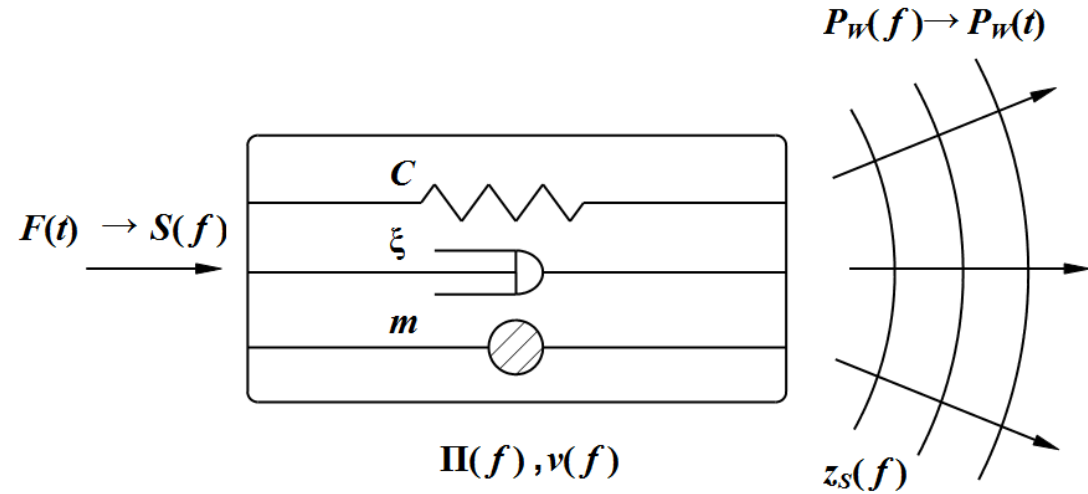


4. The calculation of the noise from the work process and the pistons tilting



# Modeling of structure-borne noise of the internal combustion engine

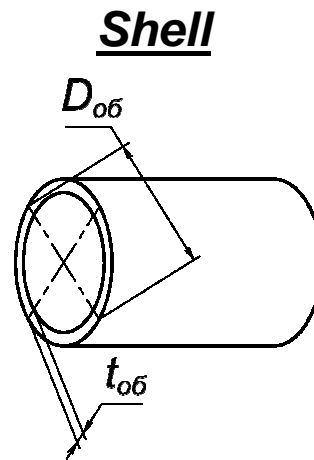
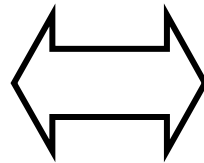
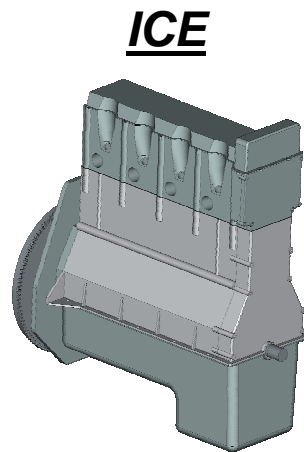
## 1. The sound power of the structure-borne noise source of the ICE



$$P_W(kf_0) = z_S(kf_0) \cdot \rho c \cdot S_{ICE} \bar{v}_{e(S)}^2(kf_0)$$

$$\bar{v}_{e(S)}^2(kf_0) = \frac{1}{2\pi \cdot M_{ICE} \cdot T^2} \sum_{k=A}^N G^2(kf_0) \frac{1}{z_V(kf_0) \cdot \eta(kf_0) \cdot (kf_0)}$$

## 2. Engine design model



**Equivalence conditions:**

$$L_{shell} = L_{ICE}$$

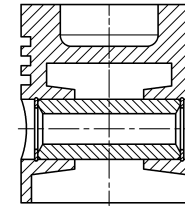
$$M_{shell} = M_{ICE}$$

$$S_{shell} = S_{ICE}$$

# Features of structure-borne noise modeling at different stages of engine design

## *External design*

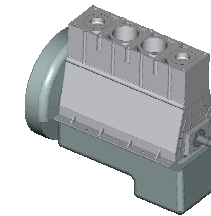
1. Determination of mass-geometric parameters of the internal combustion engine by analytical dependences and 2D-models.
2. The calculation of structure-borne noise by the analytical and empirical dependences.



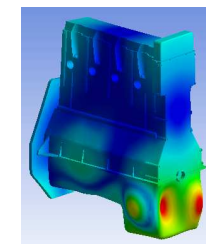
$$P_W = f(D, n, N_e)$$

## *Interior design*

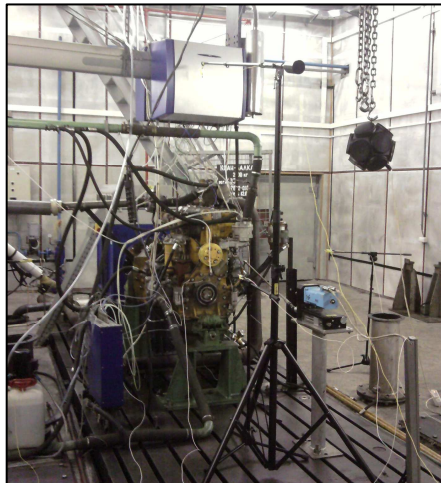
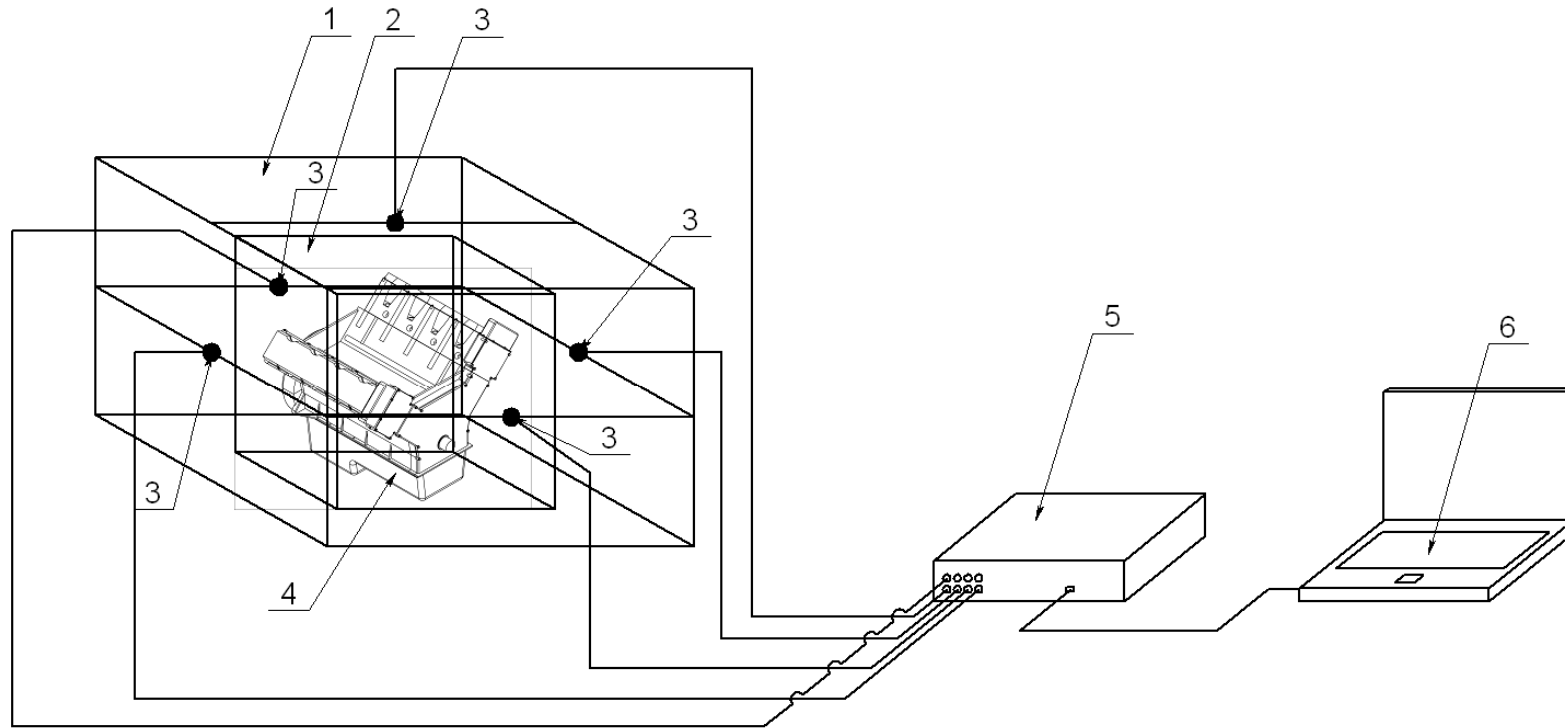
1. Three-dimensional modeling of engine structure.
2. Modeling individual sources of structure-borne noise of the engine.
3. Use of finite element and boundary element modeling for structure-borne noise calculation.



$$P_{W\Sigma} = P_{Ww.p} + P_{Wtil} + \dots$$

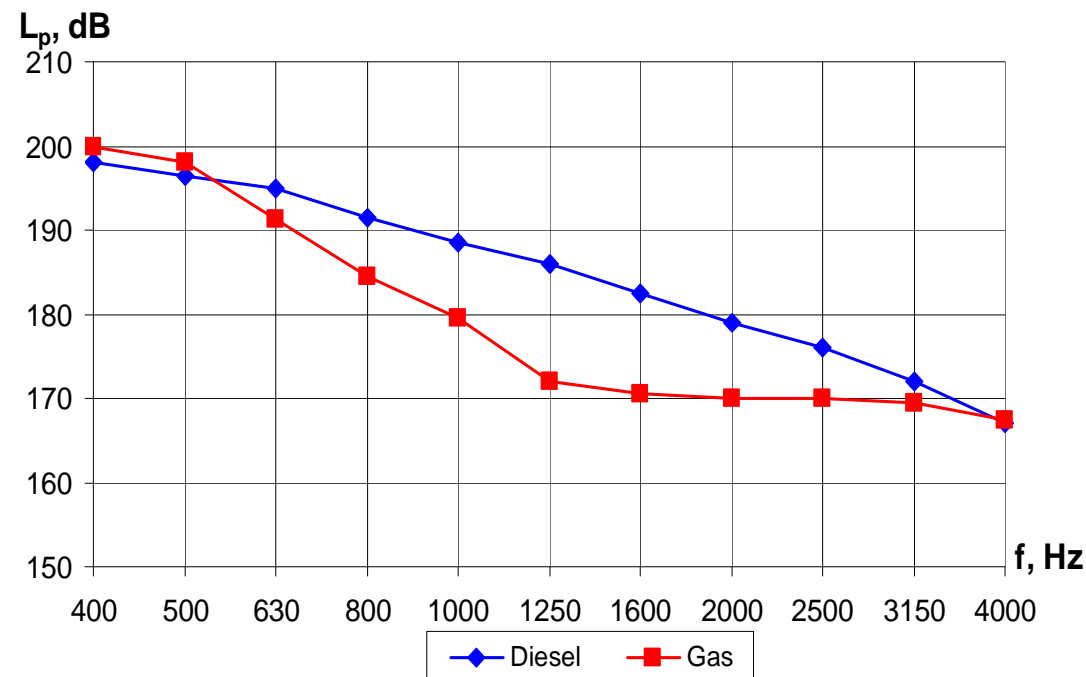
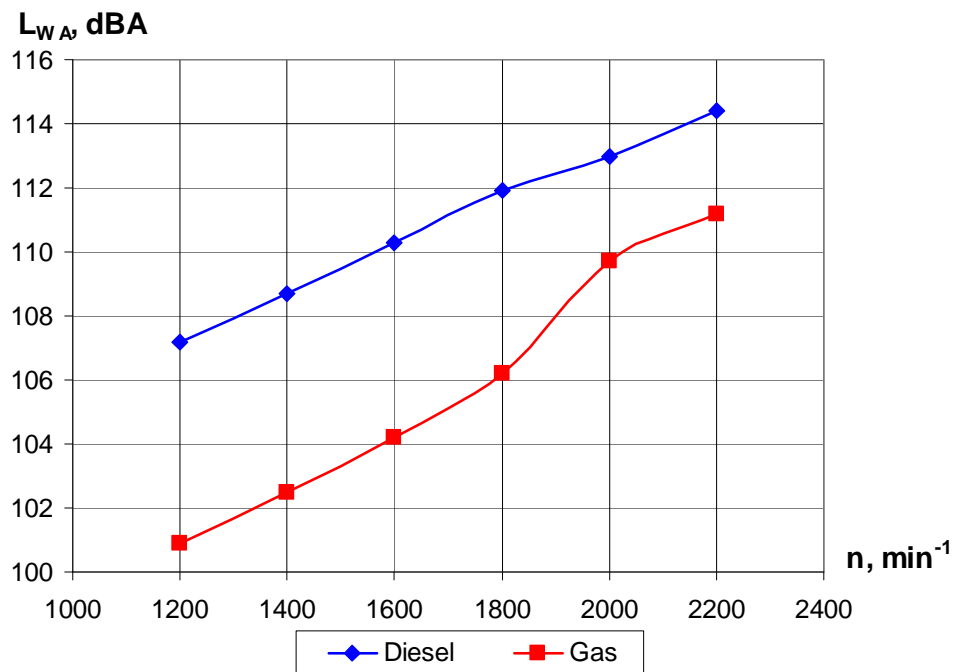
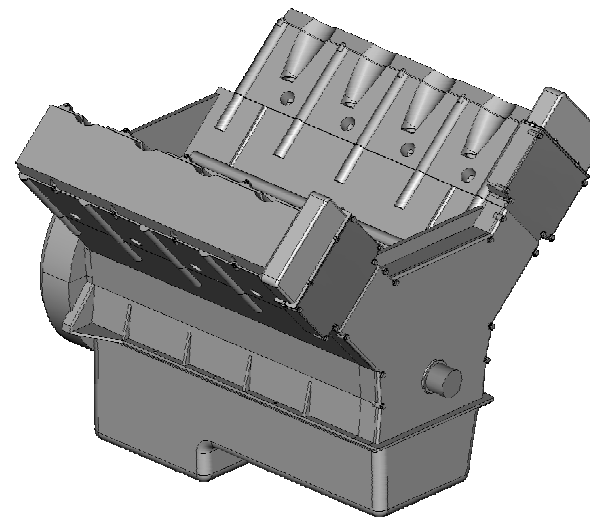


# Measurements of engine noise



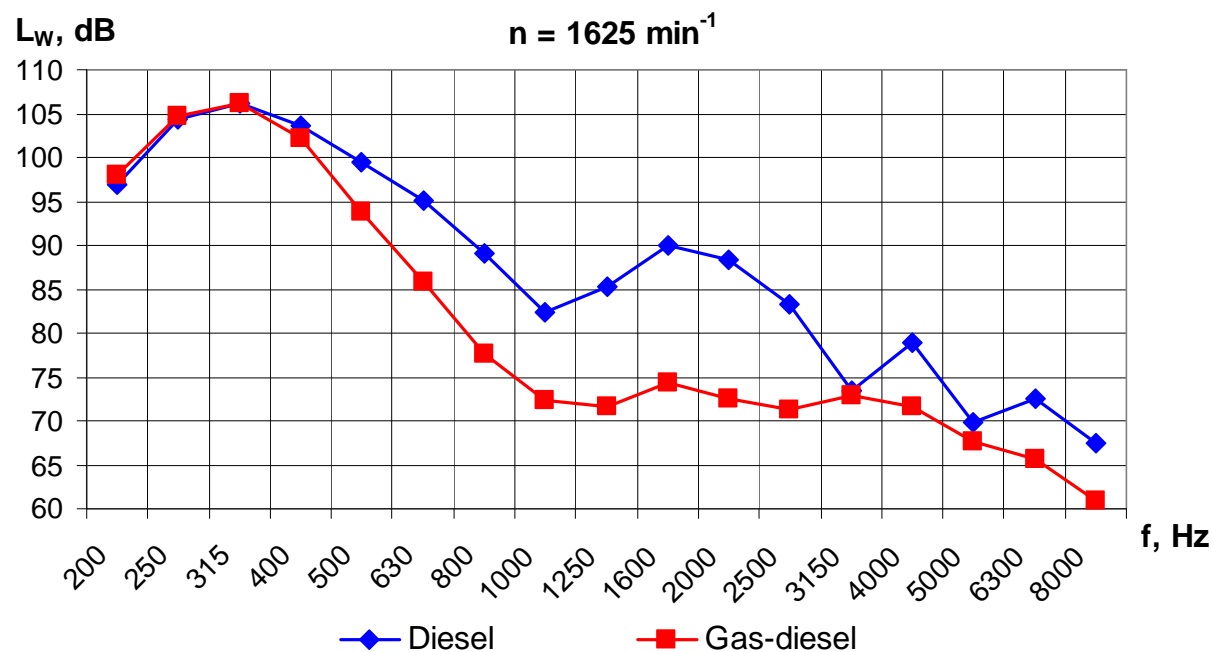
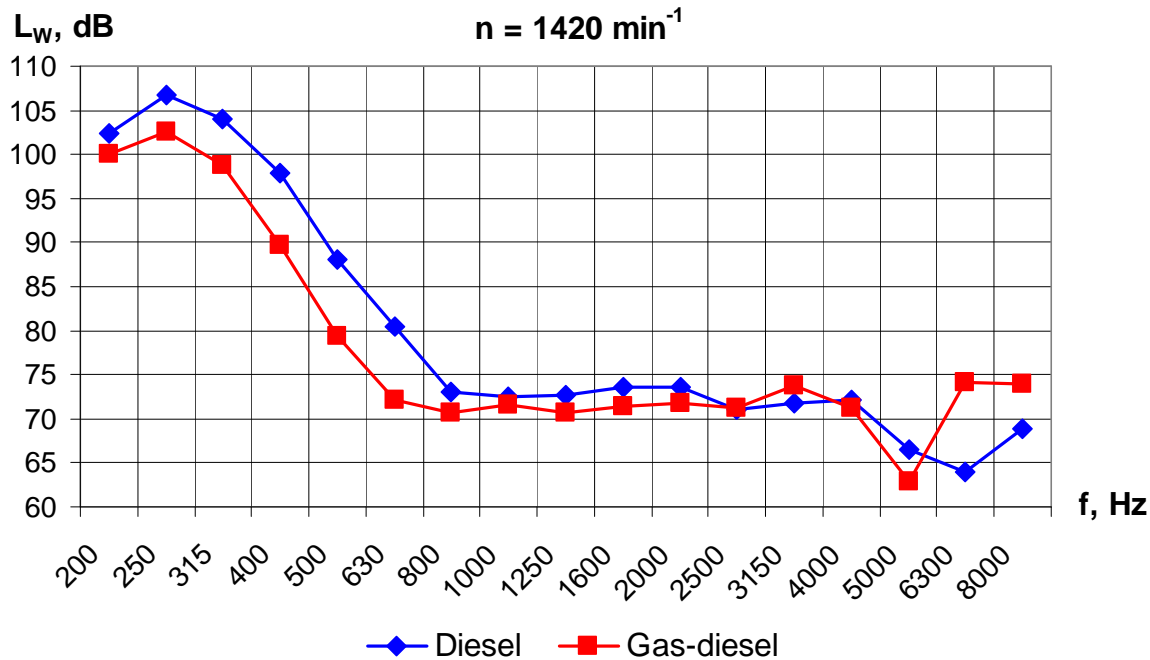
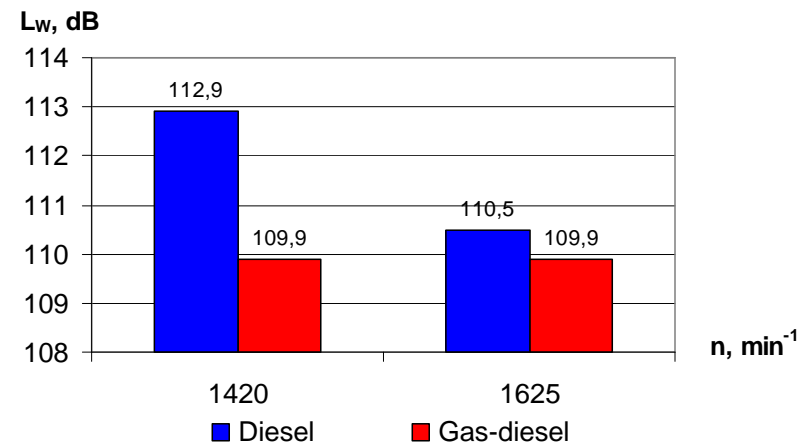
# The results of the research of V8 120mm/120mm diesel noise after adaptation to natural gas supply and spark ignition

No	Parameter name	Value
1	Engine type	diesel
2	Configuration	V8
3	Bore $D$ , mm	120
4	Stroke $S$ , mm	120
5	Compression ratio $\varepsilon$	16
6	Nominal speed $n_{nom}$ , $\text{min}^{-1}$	2200
7	Nominal power $Ne_{nom}$ , kW	160



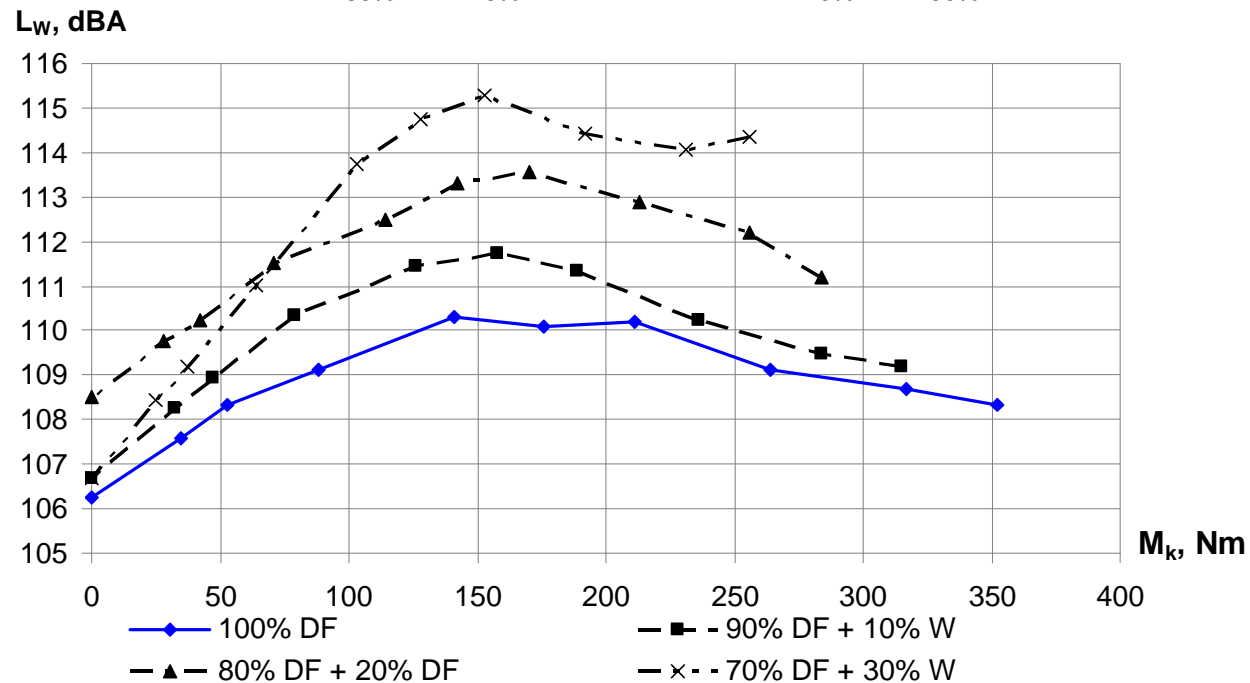
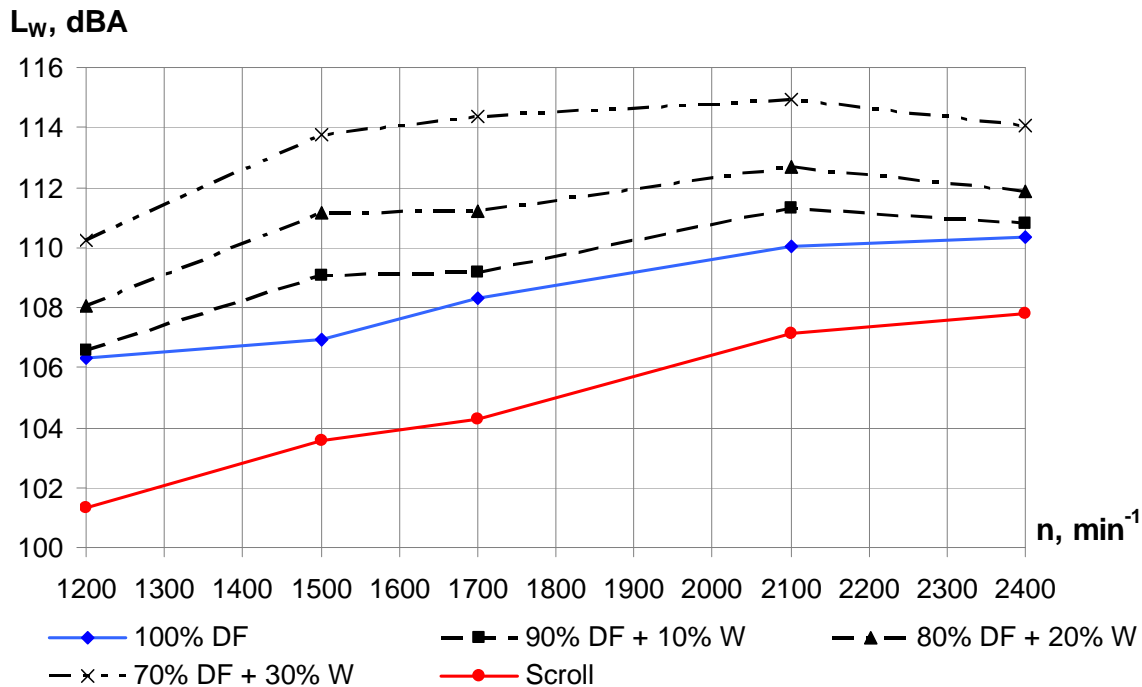
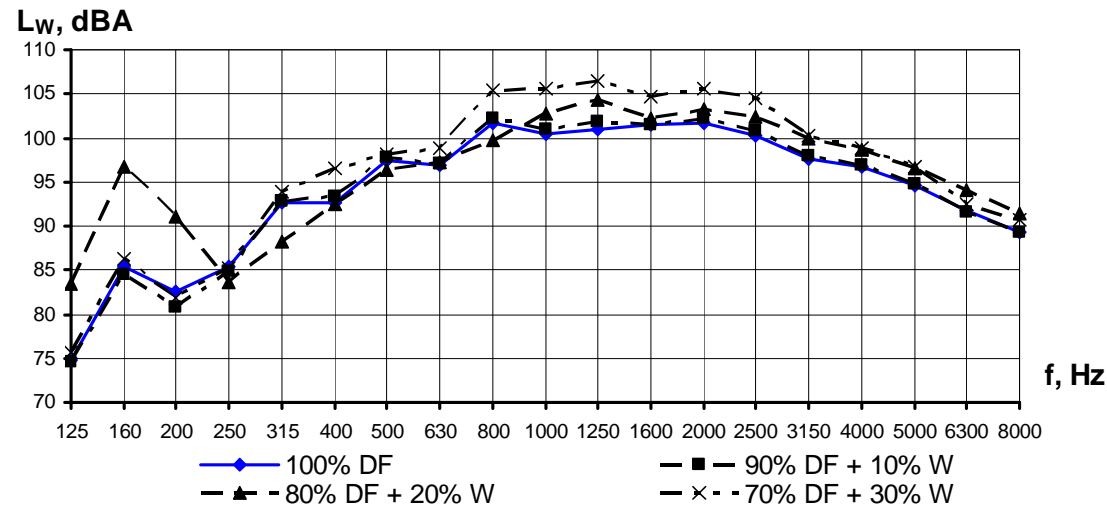
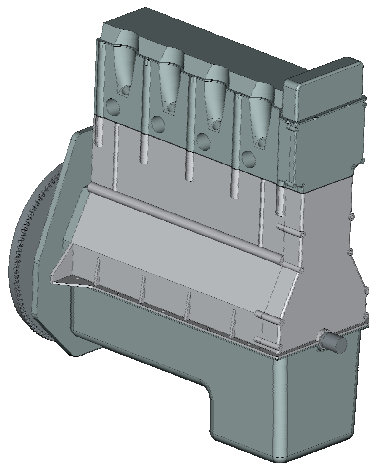
# The results of the research of L6 107mm/124mm diesel noise after adaptation to natural gas supply and gas-diesel working process

№	Parameter name	Value
1	Engine type	diesel
2	Configuration	L6
3	Bore $D$ , mm	107
4	Stroke $S$ , mm	124
5	Compression ratio $\varepsilon$	17,3
6	Nominal speed $n_{nom}$ , $\text{min}^{-1}$	2260
7	Nominal power $Ne_{nom}$ , kW	100



# The results of the research of L4 110mm/125mm diesel noise after adaptation to mixed fuel supply

№	Parameter name	Value
1	Engine type	diesel
2	Configuration	L4
3	Bore $D$ , mm	110
4	Stroke $S$ , mm	125
5	Compression ratio $\varepsilon$	17
6	Nominal speed $n_{nom}$ , $\text{min}^{-1}$	2400
7	Nominal power $Ne_{nom}$ , kW	102





## Conclusion

1. The use of gas fuel reduces the structure-borne noise level of the engine
2. The noise level of V8 120mm/120mm diesel decreased by 3 ... 6 dBA after adaptation to natural gas supply and spark ignition. It is a result of the of pressure grow-up rate reducing
3. The noise level of L6 107mm/124mm diesel decreased by 0,6 ... 3 dB after adaptation to natural gas supply and gas-diesel working process. It is a result of the of pressure grow-up rate reducing as for V8 diesel
4. When using a mixed fuel (water-fuel emulsion), there was an increase of the L4 110mm/125mm diesel noise level due to an increase in the ignition delay period at a constant injection advance angle



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# Thank you for your attention Ready to answer your questions

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