


Researcher Links UK-Russia Workshop

Scientific and Technical Grounds of Future Low-Carbon Propulsion

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

The overview of biofuel using researches in NAMI

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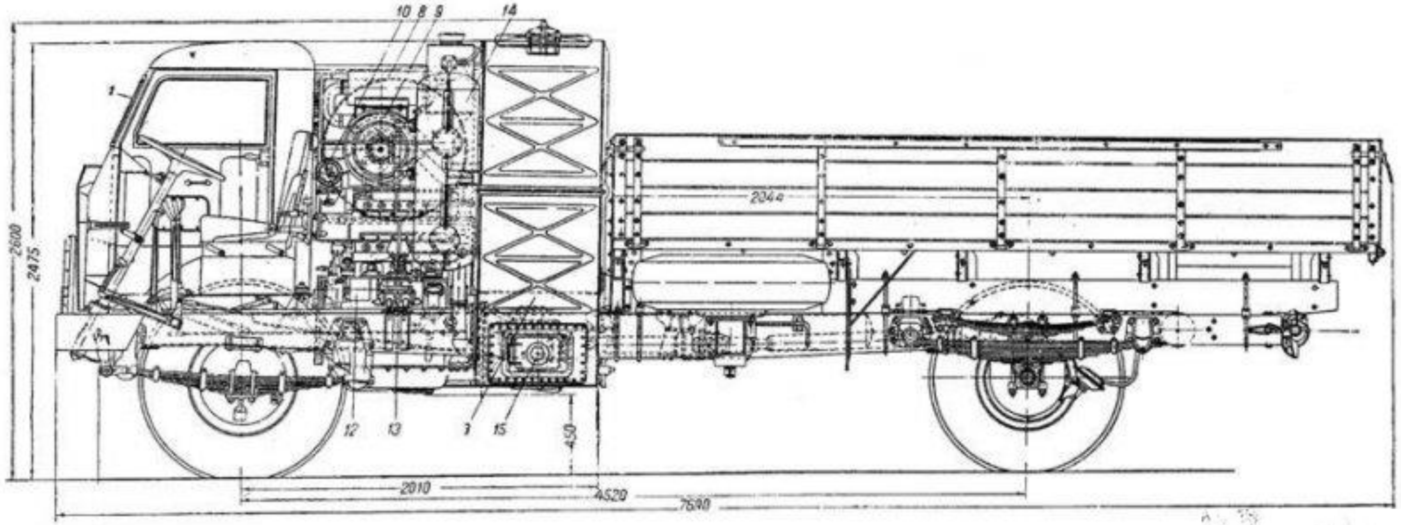
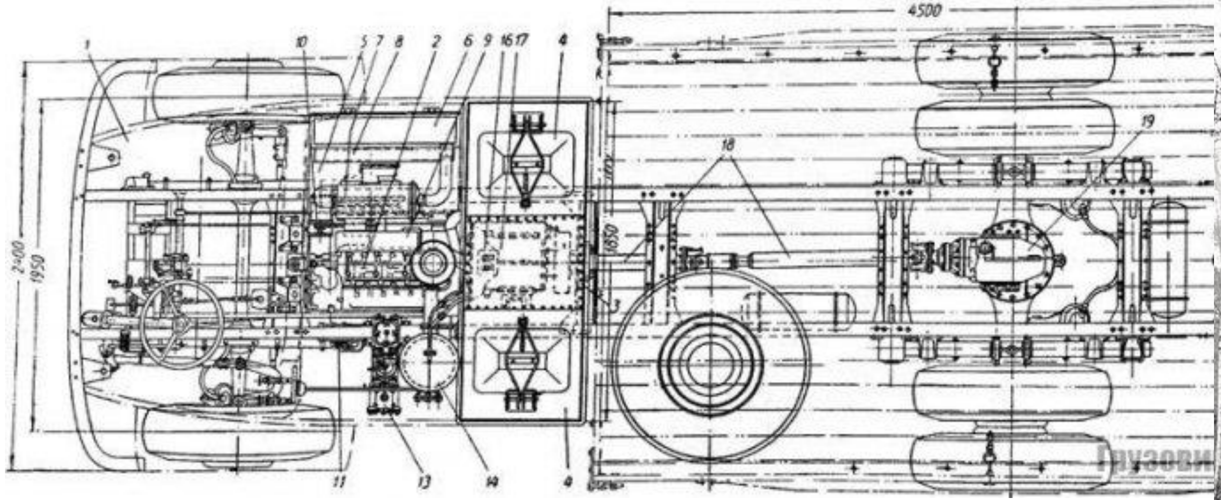
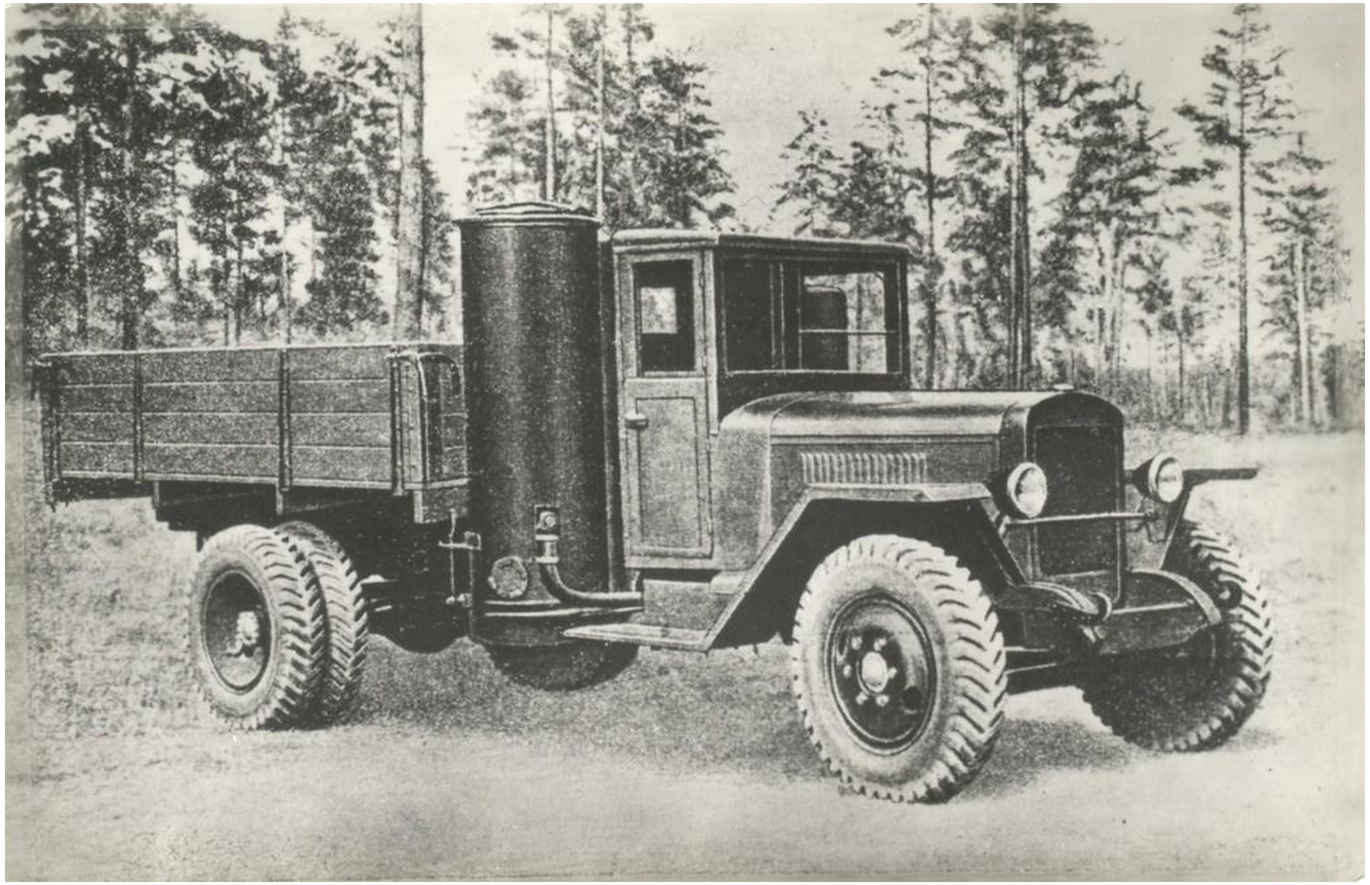
The firs soviet steam track NAMI-012 designed in 1949



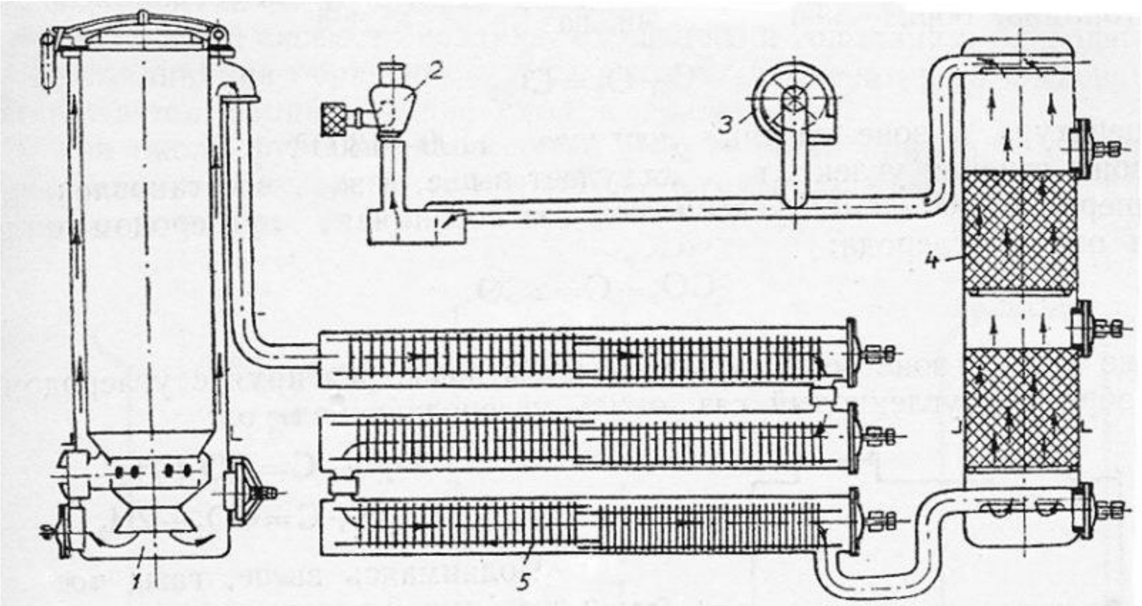
Number of cylinders – 3
Swept volume – 4.6 l
Power – 74 kW
Wood consumption 300-400 kg/ 100 km
Carrying capacity - 6 t



The track with wood gasifier ZIS-21A (series production 1946-1952)



Number of cylinders – 6
Swept volume – 5.55 l
Power – 33 kW
Maximal speed – 50 km/h
Wood consumption 110-165 kg/ 100 km
Carrying capacity - 2.5 t



Mobile plant for producing of synthetic fuels from natural and biogas

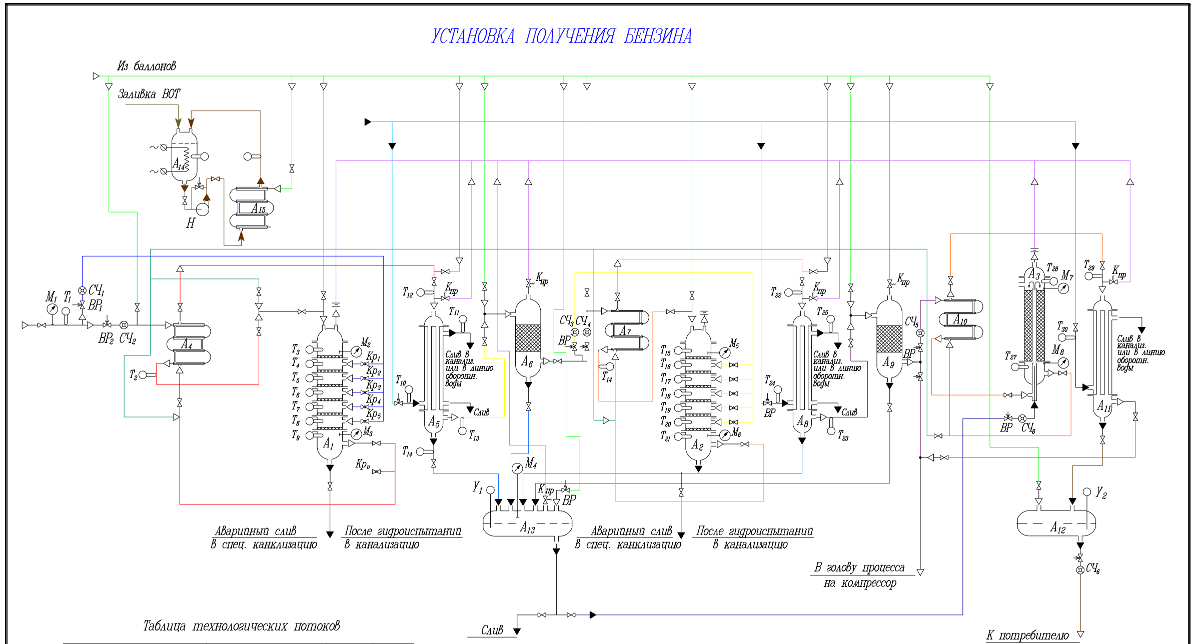


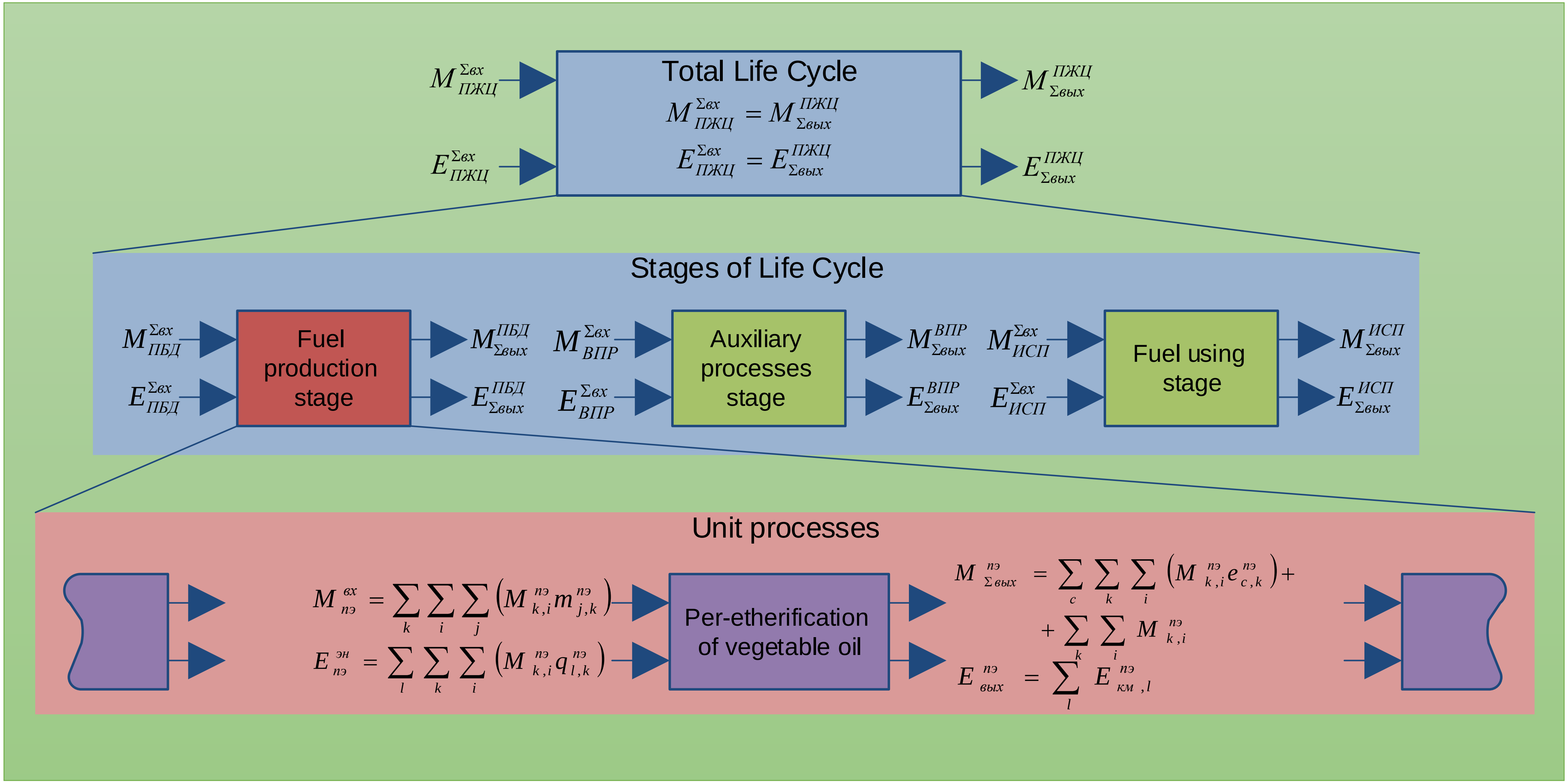
Таблица технологических потоков

Графическое обозначение	Содержание	P, МПа	t °c
2	Вода	0,6	20
3	Азот из баллонов	1,0	20
3'	Азот после подогрева	1,0	250
28	Синтез-газ холодный	6,3	20
28'	Синтез-газ после подогрева	6,3	200
29	Синтез-газ после конденсатора (поз. A_5)	6,3	45
29'	Синтез-газ после A_5, A_6 с подогревом	6,3	200
30	Синтез-газ после конденсатора (поз. A_8)	6,3	45
30'	Синтез-газ после A_8, A_9 с подогревом	6,3	200
31	Синтез-газ после конденсатора (поз. A_{11})	1,0	45
32	Метанол жидкий	6,3	45
33	Метанол жидкий	1,0	30
34	Бензин синтетический	1,0	45
35	ВОТ (высокотемпературный органический теплоноситель) жидкий	0,2	300

It is possible catalytic conversion of gas to

- synthetic gas (H_2+CO+…)
- methanol
- dimethyl ether
- synthetic gasoline

Total life cycle assessment of different fuels



Total life cycle assessment of a vehicle working on different fuels (flow diagrams)

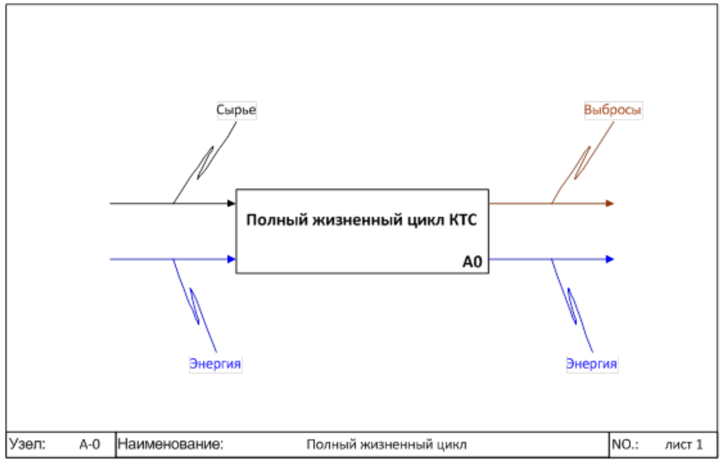


Diagram of Total Life Cycle (TLC)

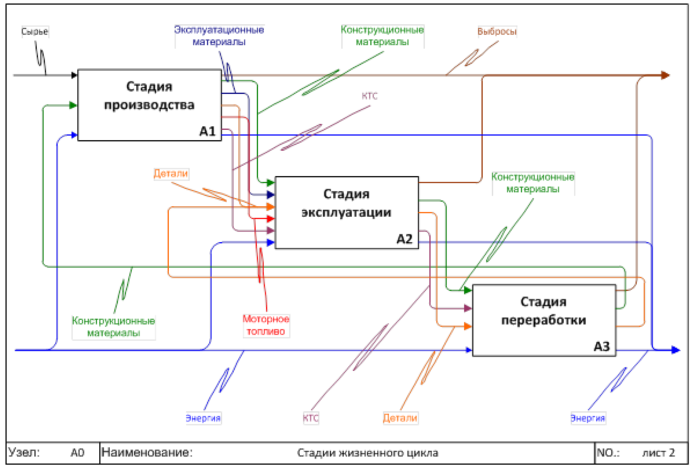


Diagram of TLC stages

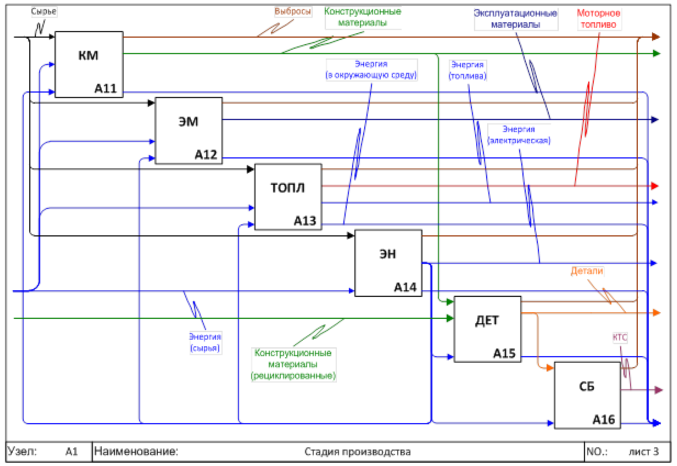


Diagram of production stage

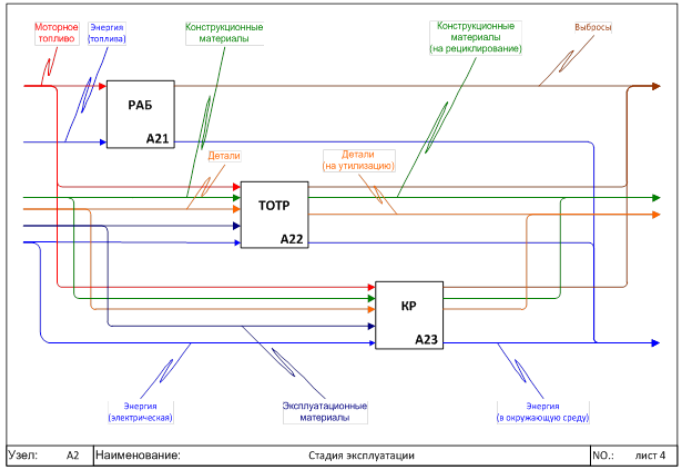


Diagram of operation stage

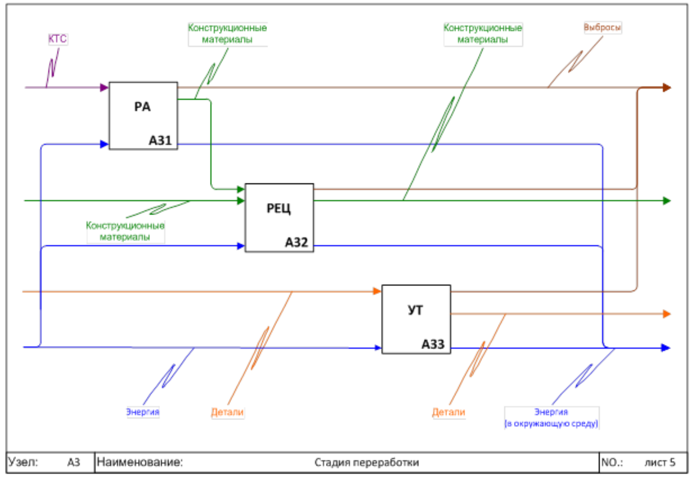


Diagram of recycling stage

A mathematical model of TLC of the power unit working on CNG in total

Input flows

Raw material resources, kg:

(32) $M^{in}_{TLC} = M^{in}_{FPS,NG} + M^{in}_{APS,raw}$.

Energy, MJ:

(33) $E^{in}_{TLC} = E^{in}_{FPS,NG} + E^{in}_{APS,raw}$.

Output flows

Harmful substances, kg:

(34) $M^{TLC}_{out} = M^{FPS}_{out,HE} + M^{APS}_{out,HE} + M^{FUS}_{out,HE}$.ЩЩ

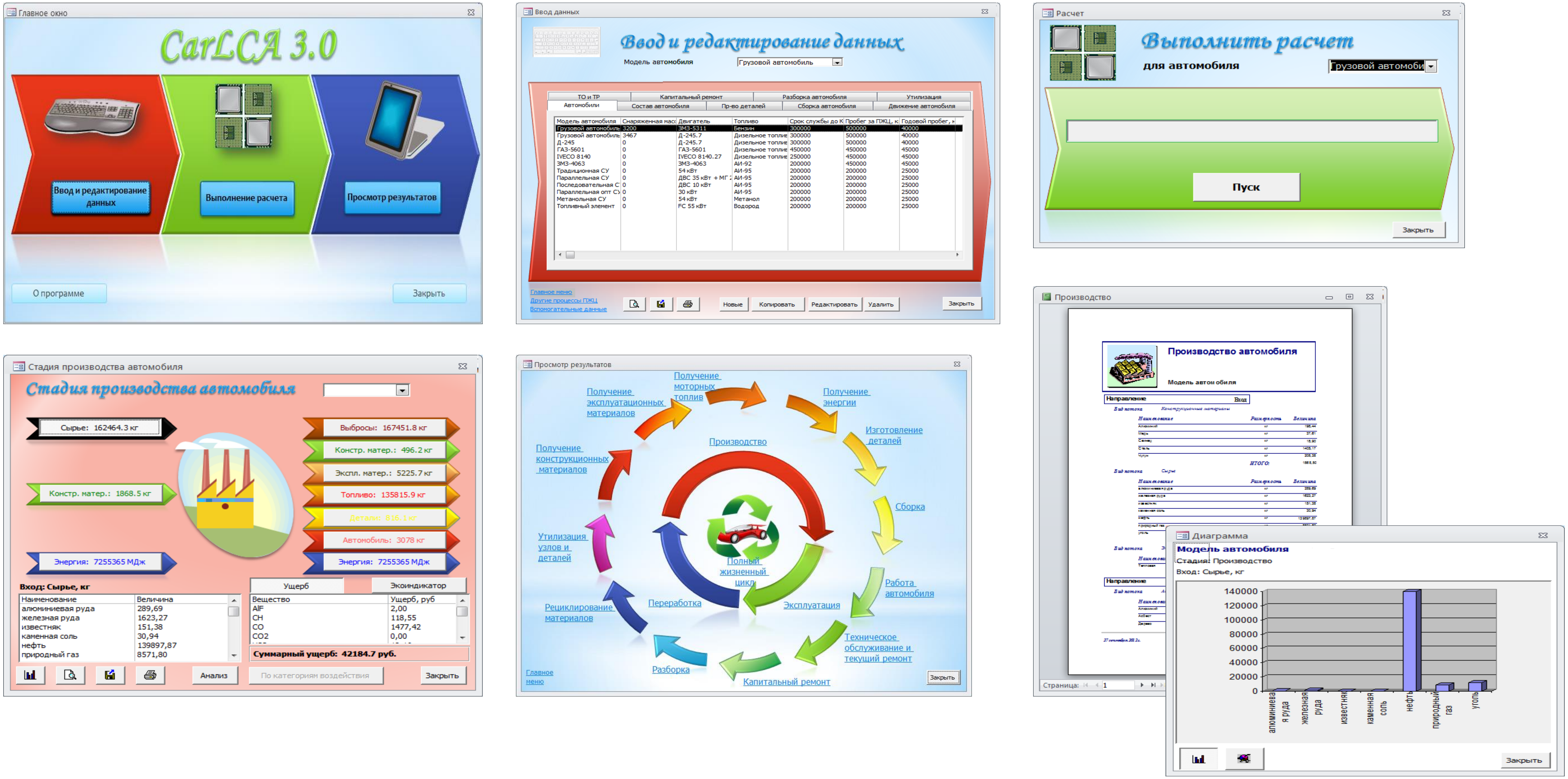
Energy to the environment, MJ:

(35) $E^{TLC}_{out,en.to\,env.} = E^{FPS}_{out,en.to\,env.} + E^{APS}_{out,en.to\,env.} + E^{FUS}_{out,en.to\,env.}$.

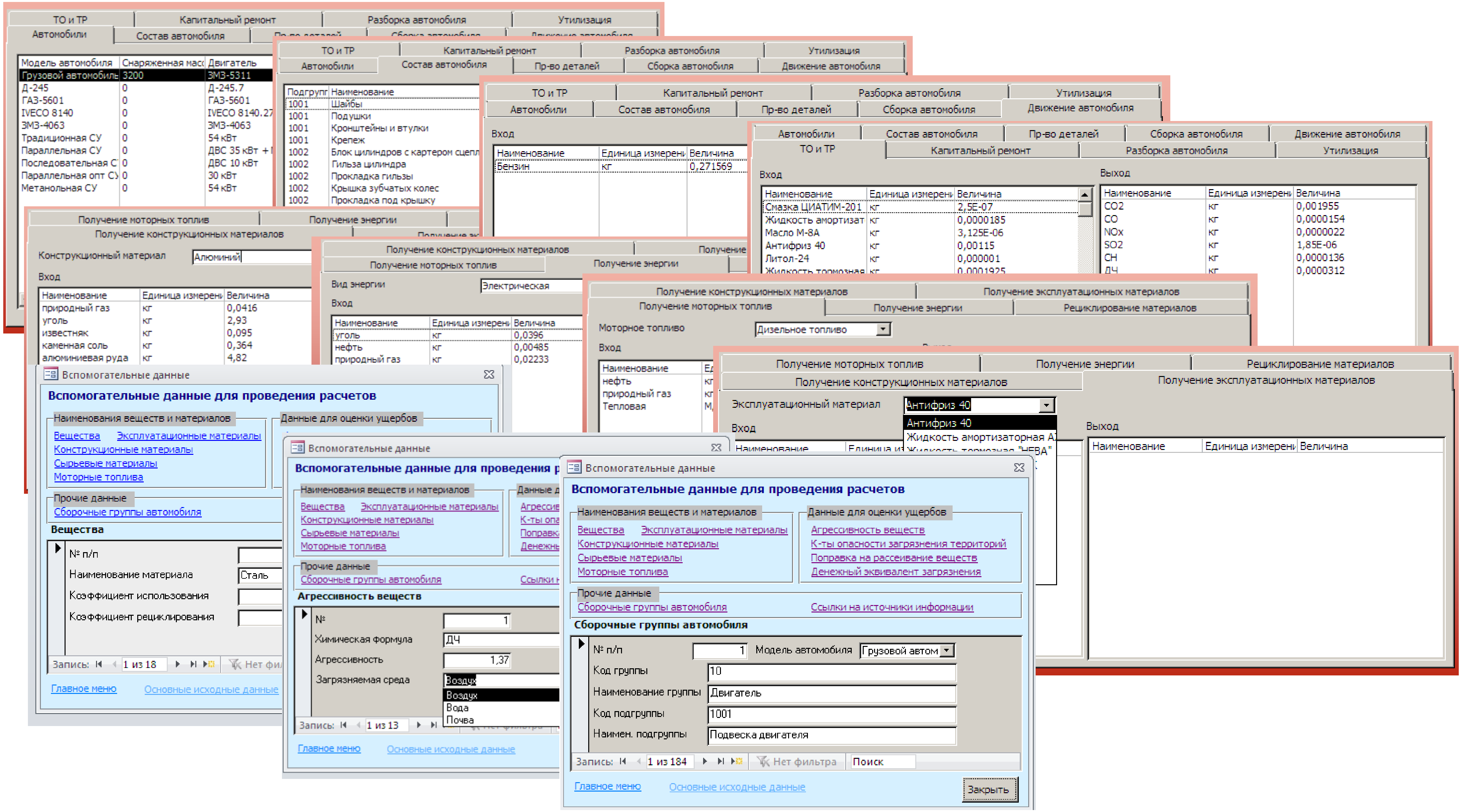
Energy (useful work), MJ:

(36) $E^{TLC}_{out,work} = E^{FUS}_{out,work}$.

Total life cycle assessment software CarLCA 3.0 developed in NAMI



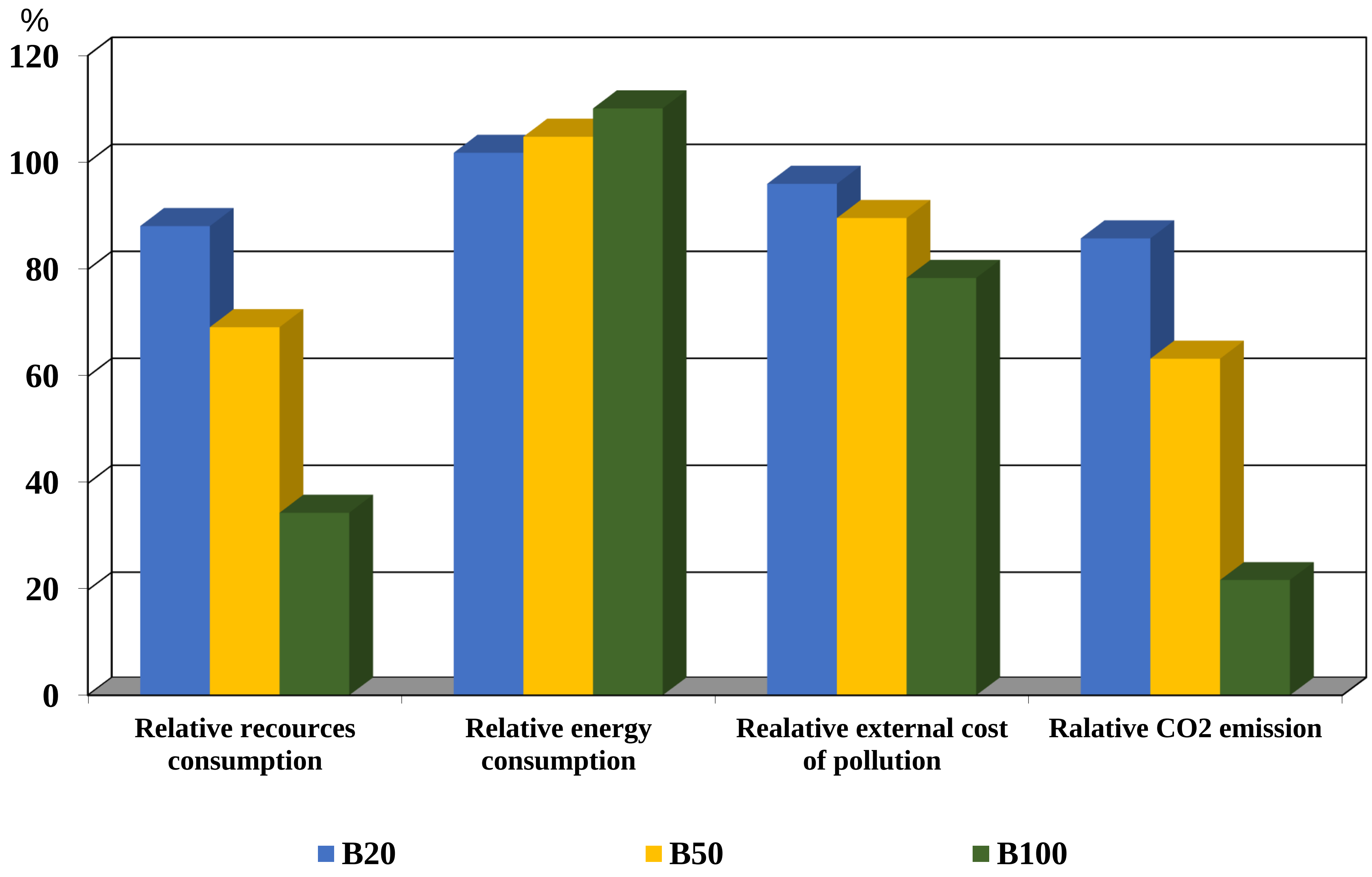
Total life cycle assessment software CarLCA 3.0 – database and input data windows



An example of total life cycle assessment of biofuels (input data)

Flow		Diesel	Biodiesel		
			B20	B50	B100
Input					
Diesel fuel consumption, g		240	196,4	127,1	0,0
Biodiesel consumption, g		0	49,1	127,1	270,3
Output					
Brake work of an engine, kWh		1,0	1,0	1,0	1,0
Waste heat, MJ		6,4	6,4	6,4	6,4
Emissions	CO, g	2,1	1,911	1,638	1,155
	CH, g	0,66	0,5742	0,44	0,24
	NOx, g	5	5,075	5,15	5,30
	PM, g	0,1	0,088	0,08	0,06
	SO_2, g	0,036	0,0288	0,02	0,002
	CO_2, g	773,3	774,7	776,8	780,8

An example of total life cycle assessment of biofuels (results)

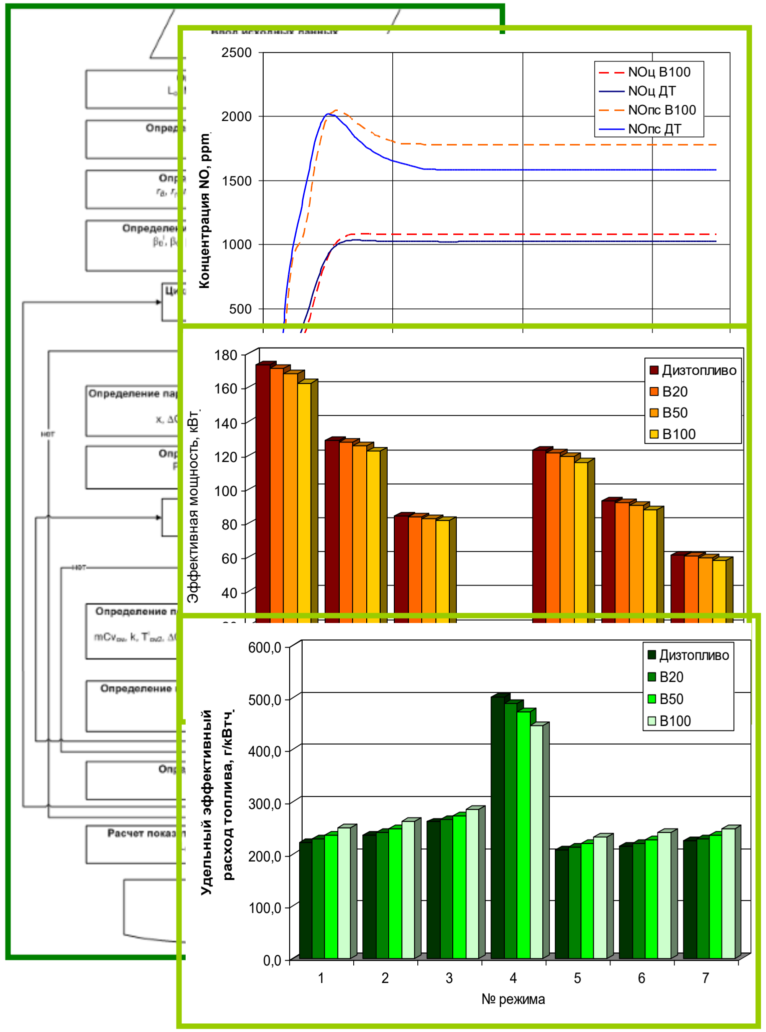


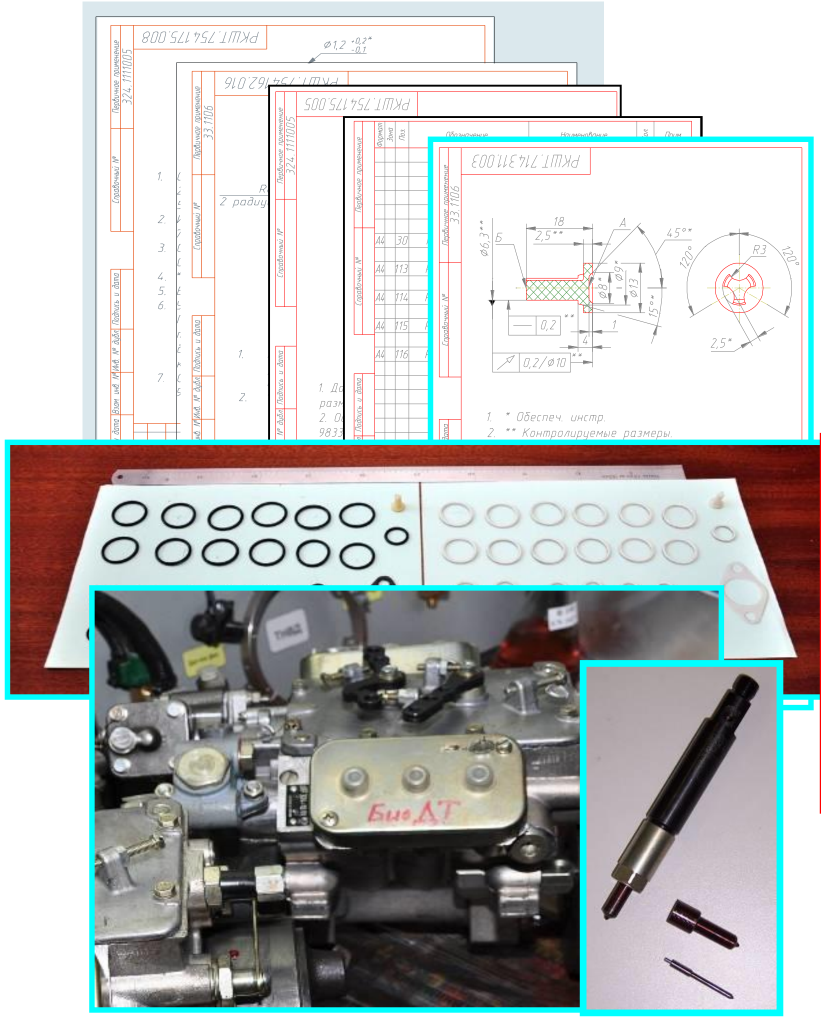
Project: Research of the environmental, energy and economic efficiency of the use of biodiesel in diesel engines for the conditions of the Russian Federation (2007-2009)

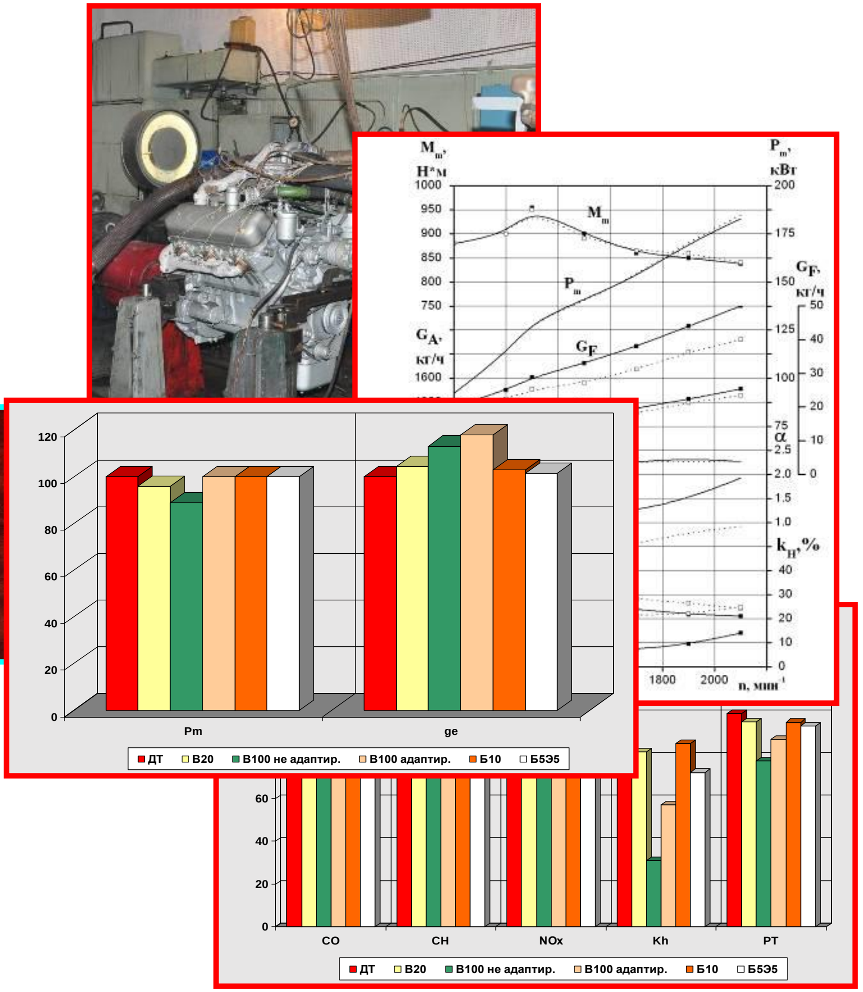
Simulation of working process on biodiesel fuel

Development of components of a fuel system

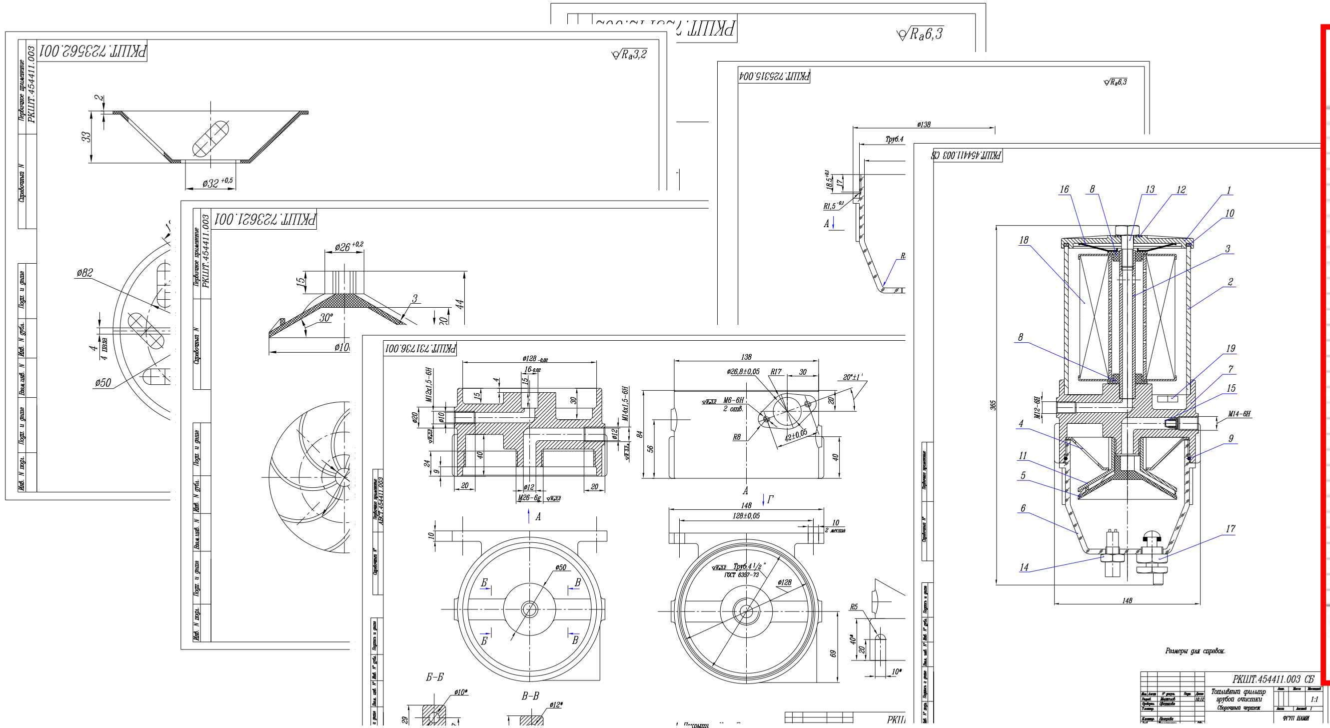
Experimental research of an engine

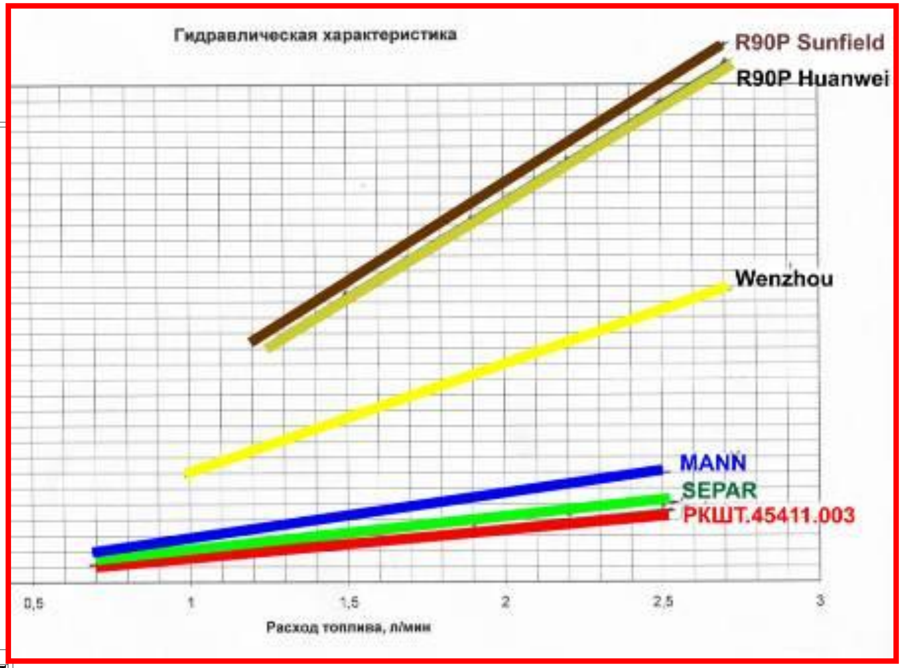


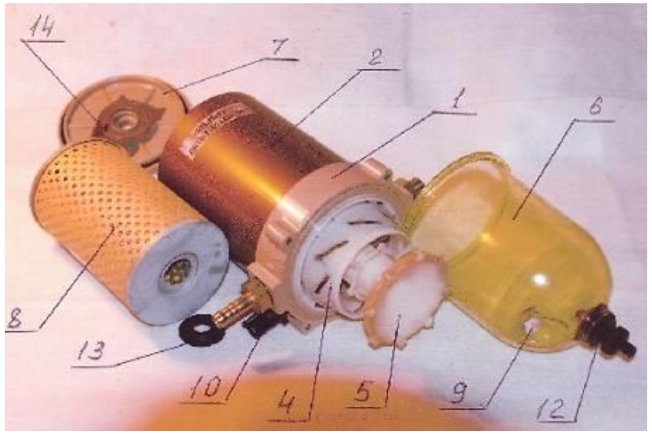




Project: Research of the environmental, energy and economic efficiency of the use of biodiesel in diesel engines for the conditions of the Russian Federation (2007-2009) – biodiesel filter research and development



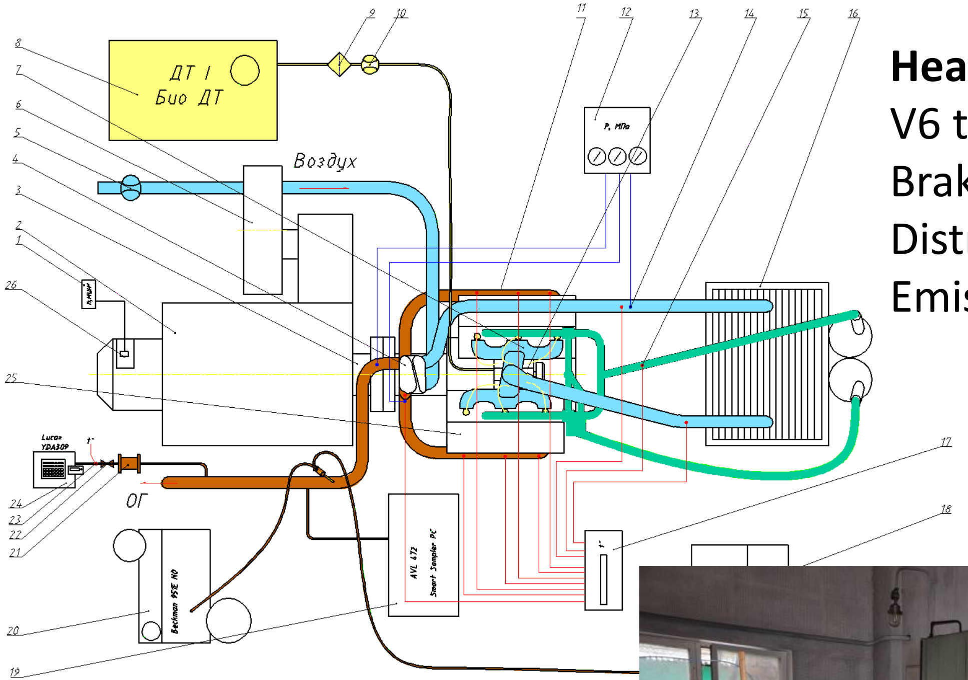




Параметры	Значения параметров					
	РКШТ 454411. 003	Wenzhou Yongyu Filter	HUANWEI ANMA R 90P	SUN FIELD ST-CX 785 R90P	MANN Filter PreLine PL270	Separ
1.Гидравлическое сопротивление фильтров кгс/см2	0,015	0,084	0,148	0,152	0,027	0,018
2. Полнота отделения воды, %	94	88,3	82,7	83,3	94	93
3. Номинальная тонкость отсева (95%), мкм	25	8,0	19,4	17,4	27	24

Project: Research of the environmental, energy and economic efficiency of the use of biodiesel in diesel engines for the conditions of the Russian Federation (2007-2009) – results of an engine tests on a motor bench

Motor Bench



Heavy Duty Engine:

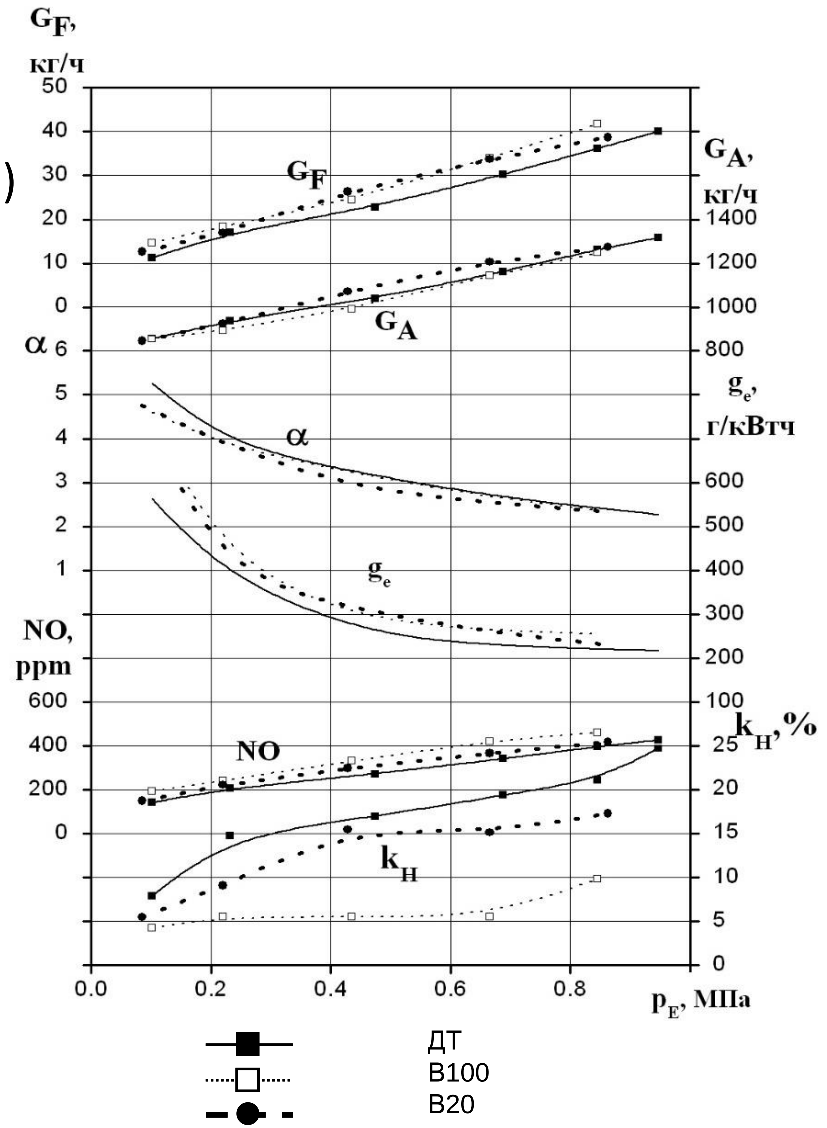
V6 turbocharged

Brake power 174 kW (2100 RPM)

Distributed Fuel system

Emission level Euro-III

Engine Test Results



Project: Theoretical and experimental research of the physical, chemical and chemotological properties of biodiesel fuel in order to improve climatic behaviors and fuel stability (2010-2011)

Tested fuels:

1. Diesel (GOST R 52368-2005)
2. Biodiesel B5M (with additives)
3. Biodiesel B20M (with additives)
4. Biodiesel B100M (with additives)

Developed a package of additives for biofuels:
Washing: dosage - 0,025% vol.
Depressor-dispersant: dosage - 0.05% vol.

Test bench NAMI-2DK

Determination of the stability of biodiesel fuels in storage and transportation

Determination of the stability of biodiesel fuels when working on the engine - the tendency of fuels to coking of injector nozzles

Determination of cold filtering limit temperature

Determination of the stability of biodiesel fuels from stratification at low temperatures

Achievements:

Lower working temperature:
B5M: -30^{0}C
B20M: -27^{0}C
B100M: -20^{0}C

Tendency to coking:
B5 B5M
B20 > B20M > Diesel
B100 B100M

Stability at negative temperatures:
Stratification of fuels during storage is not observed.

Filterability limit temperature:
B100: -12^{0}C
B100M: -22^{0}C

Project: Research and development of fuel supply and control systems for the modernization of conventional medium and high-speed diesel engines for using of different alternative fuels (2013-2015)

Experimental diesel YAMZ-6566

Cylinders number	6
Swept volume	11,15 L
Compression ratio	17,5
Bore/Stroke	130/140 mm
Engine weight	1450 kg
Brake power at 1900 RPM (on diesel fuel)	197 kW
Maximal torque at 1100…1500 RPM	882 Nm

Biodiesel fuel system

Targets:

- decreasing of smoke – 15-20%,
- decreasing of NOx emission - 5-10%,
- increasing of efficiency – 2-3%.

Dual-fuel natural gas and diesel fuel system

Targets:

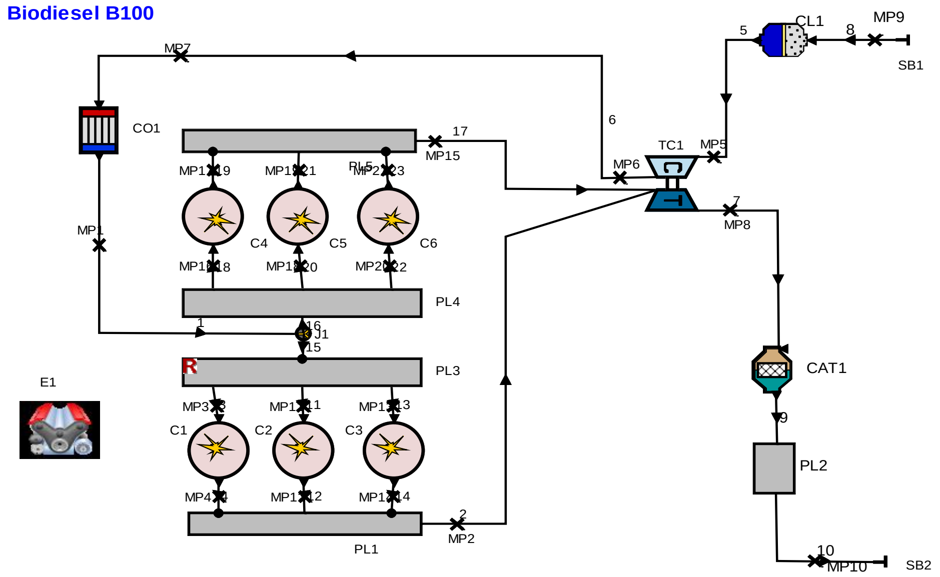
- decreasing of smoke – 30-40%,
- decreasing of NOx emission - 5-10%,
- increasing of efficiency – 2-3%.

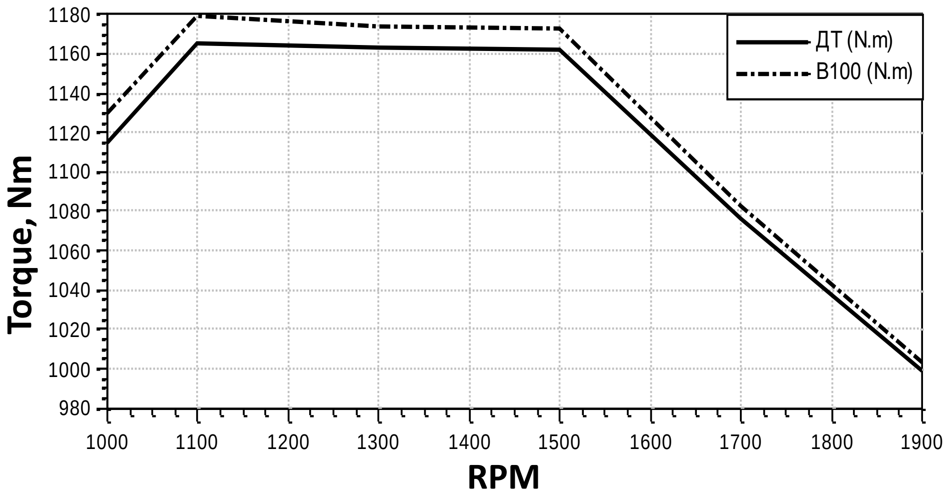
Dual-fuel natural gas and DME system

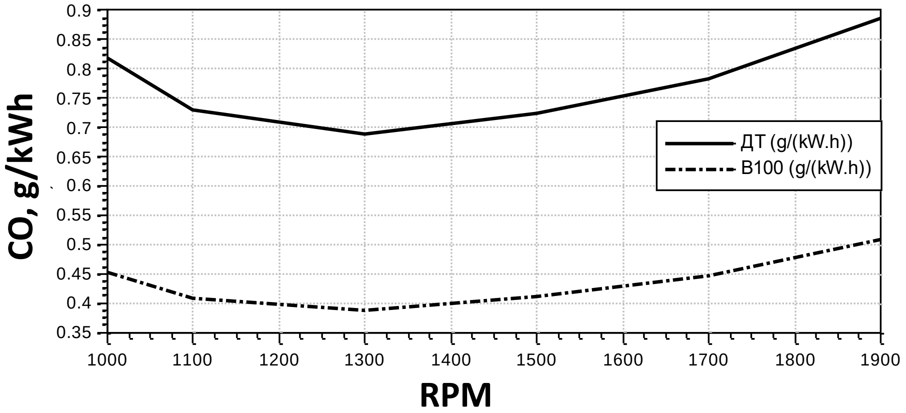
Targets:

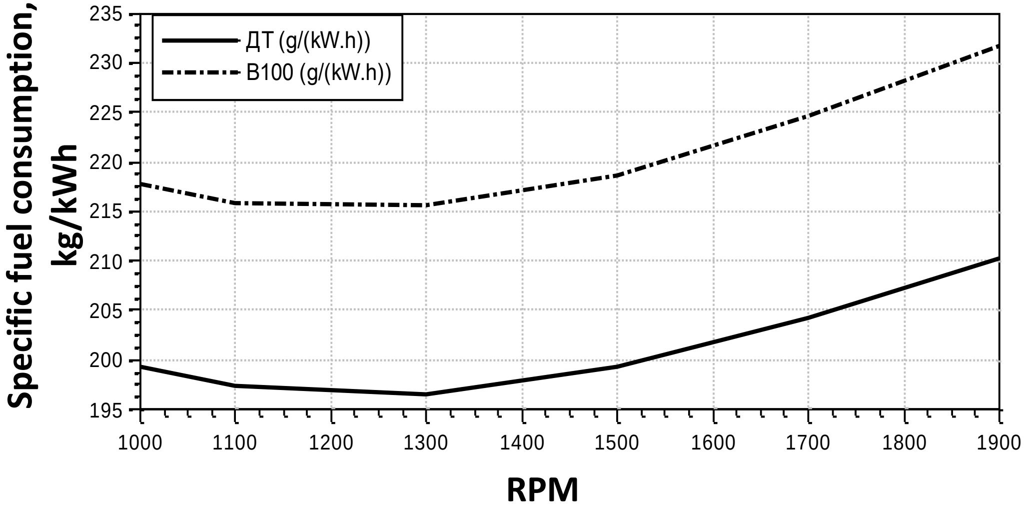
- decreasing of smoke – 50-60%,
- decreasing of NOx emission - 15-20%,
- increasing of efficiency – 1-2%.

Simulation of the performances and emissions of a diesel engine using conventional and biodiesel fuels



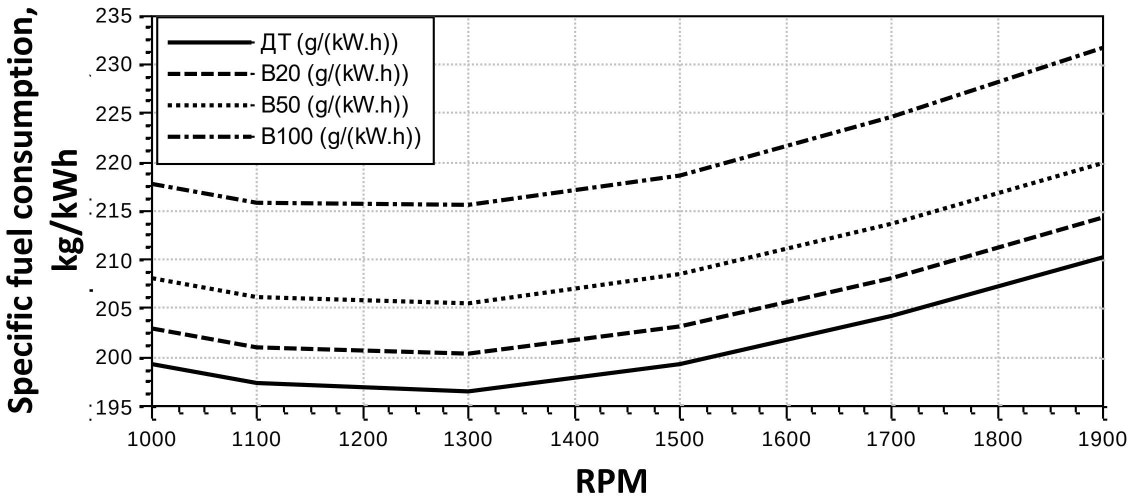


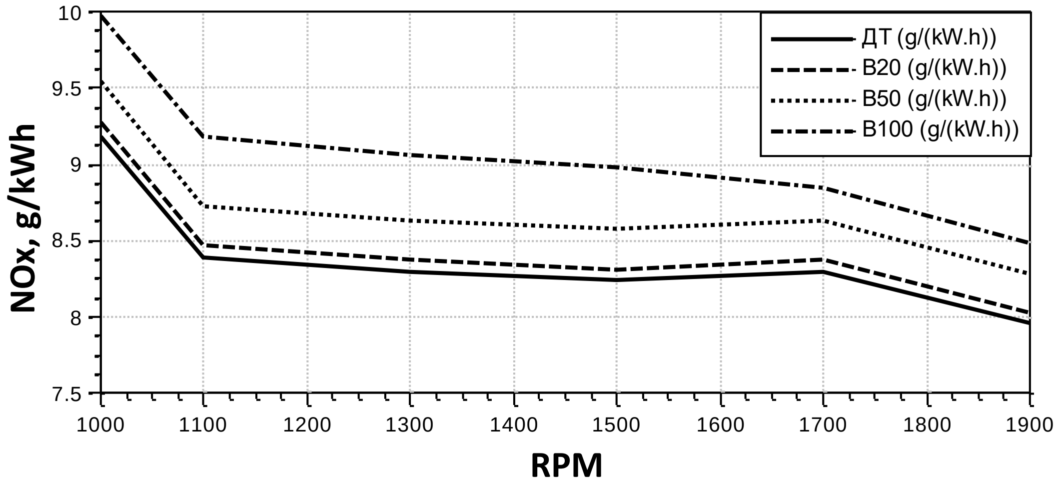


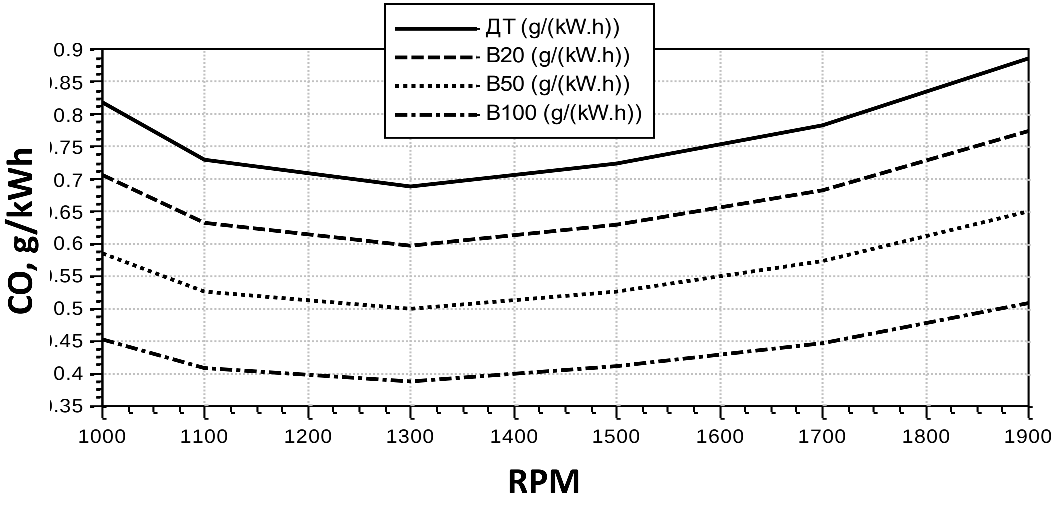


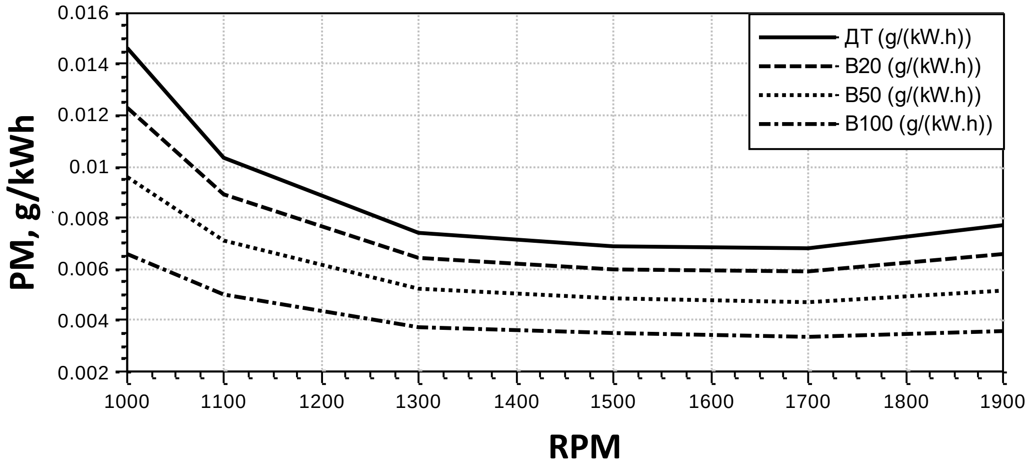
The use of biodiesel fuel makes it possible to reduce emissions of carbon monoxide by 1.8 times and particles 2.2...2.3 times with the same brake power, while increasing emissions of nitrogen oxides by 6...10%

Simulation of the performances and emissions of a diesel engine using conventional diesel, biodiesel fuels and their blends B20 and B50



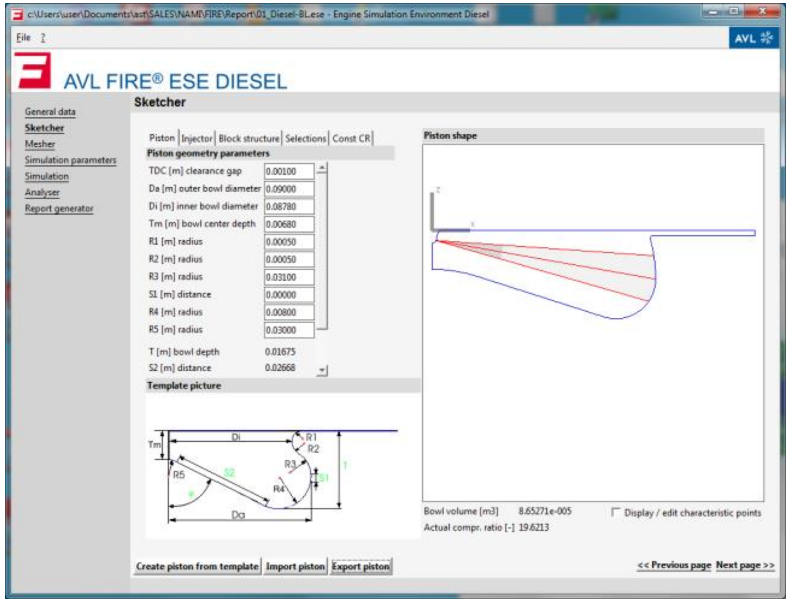


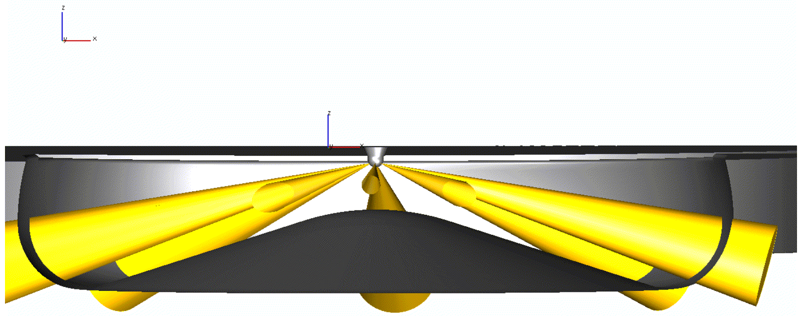




The mass fraction of biodiesel fuel in a blend with diesel was varied from 20 to 100%. Then more biodiesel we use than more NOx emission and less power and particle emission we observed in simulation results.

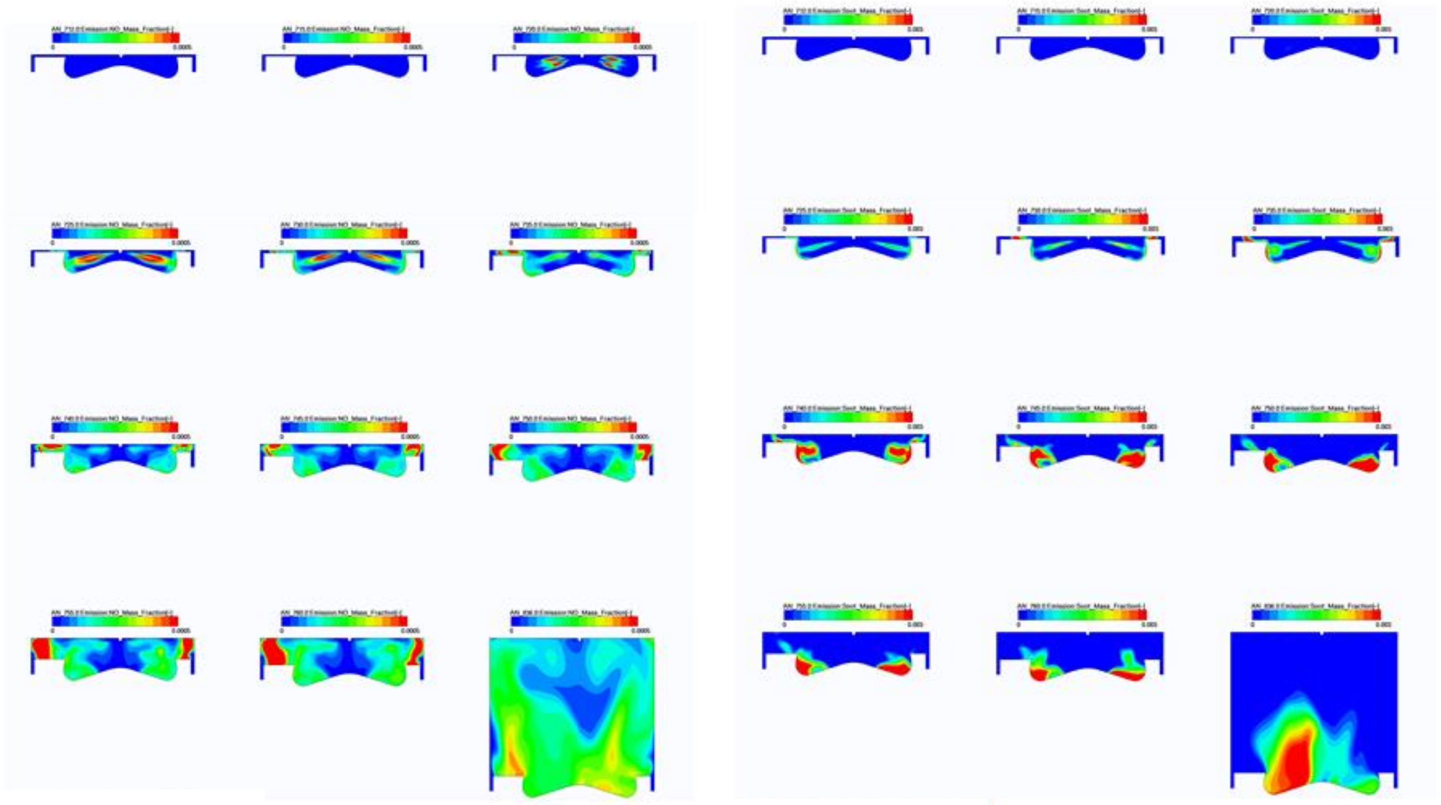
3D Simulation of in-cylinder processes of a diesel engine using biodiesel fuel



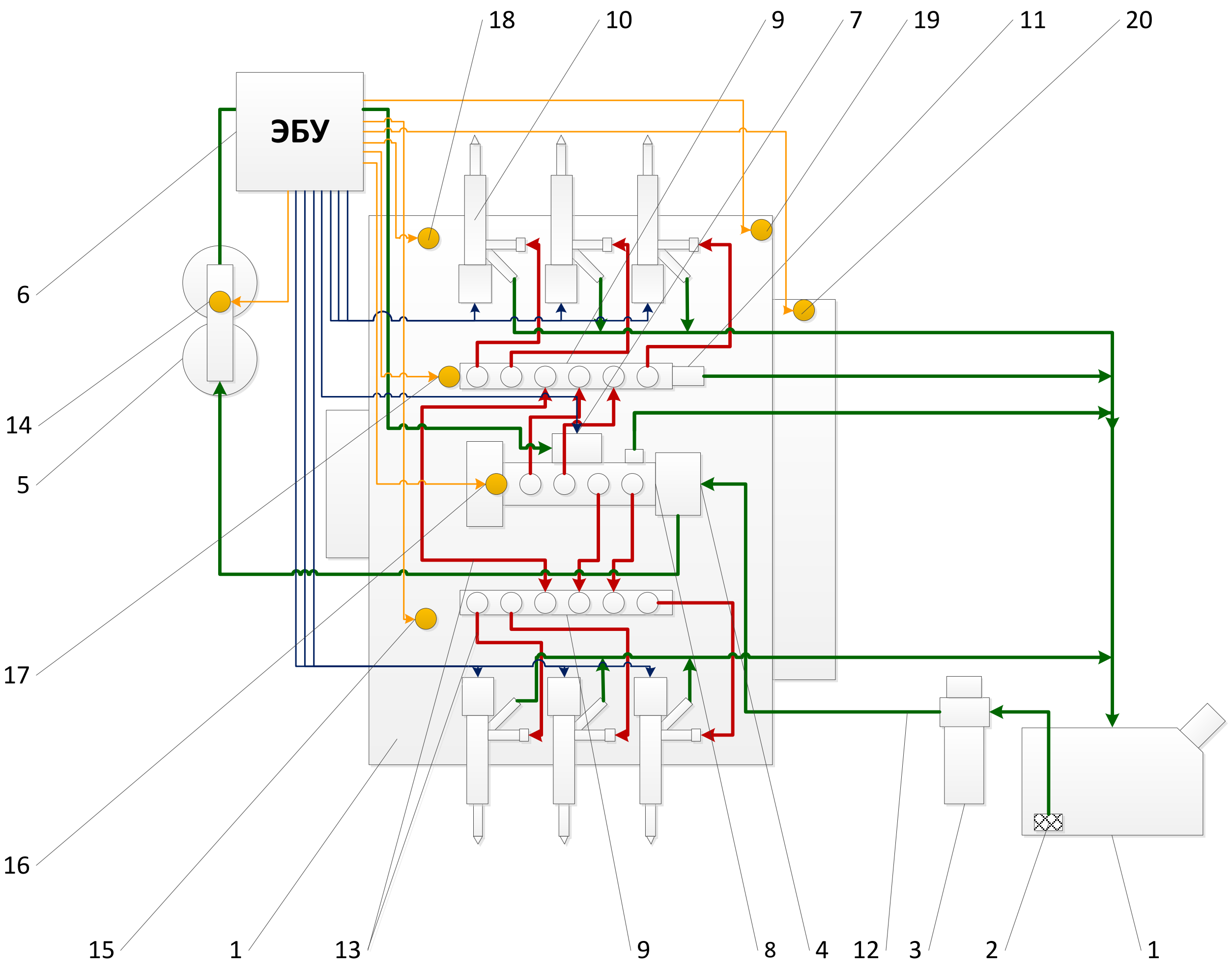


Mass fraction:

NOx **PM**

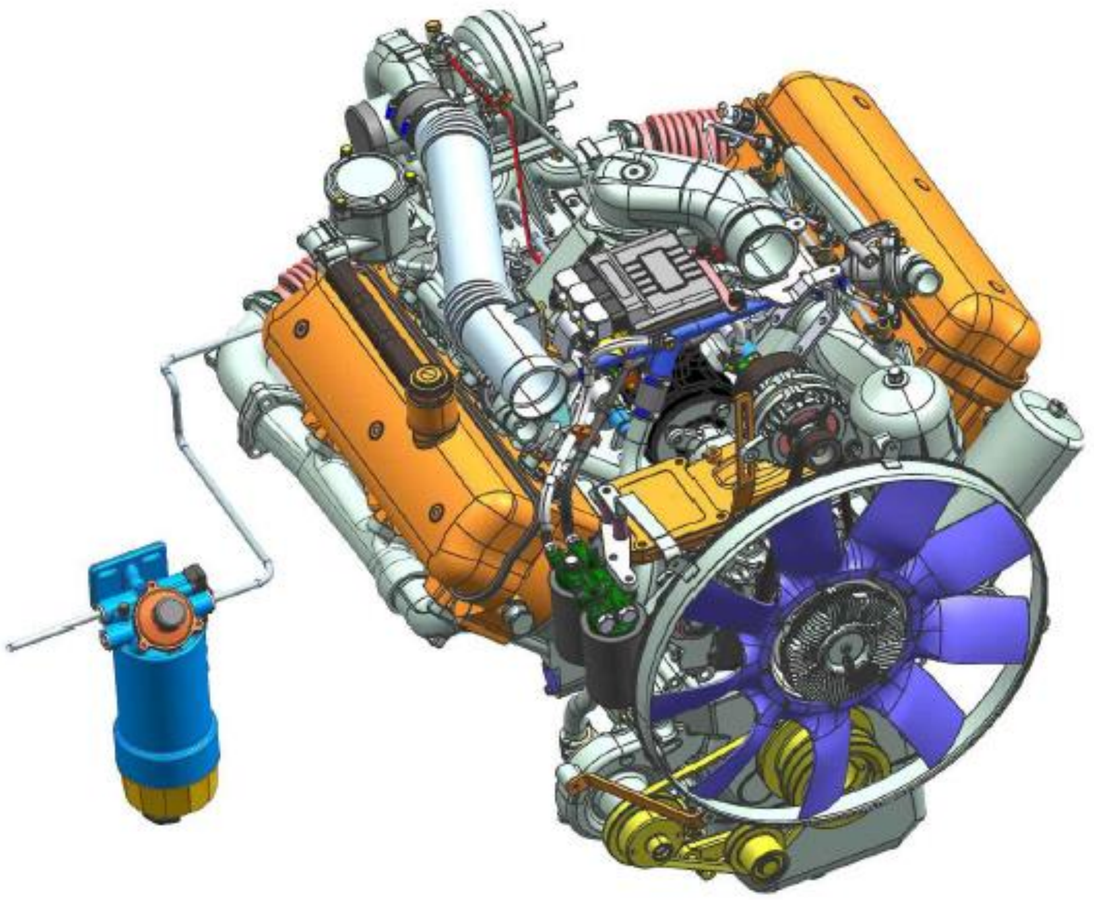


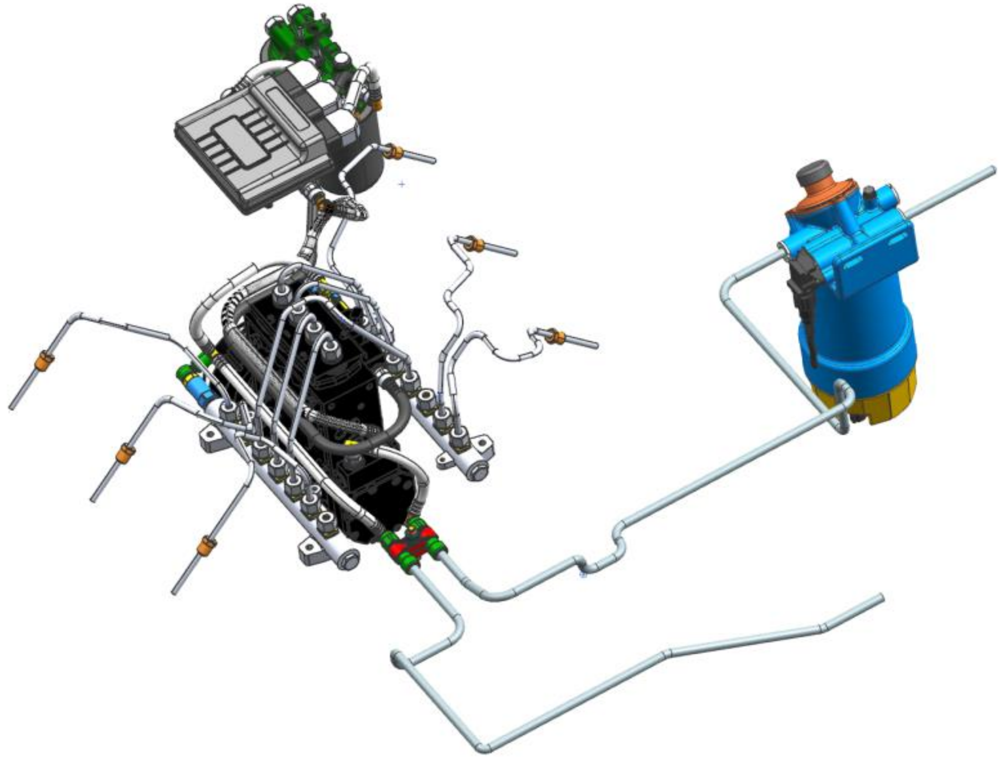
The scheme of the common rail fuel system for the operation on biodiesel fuel



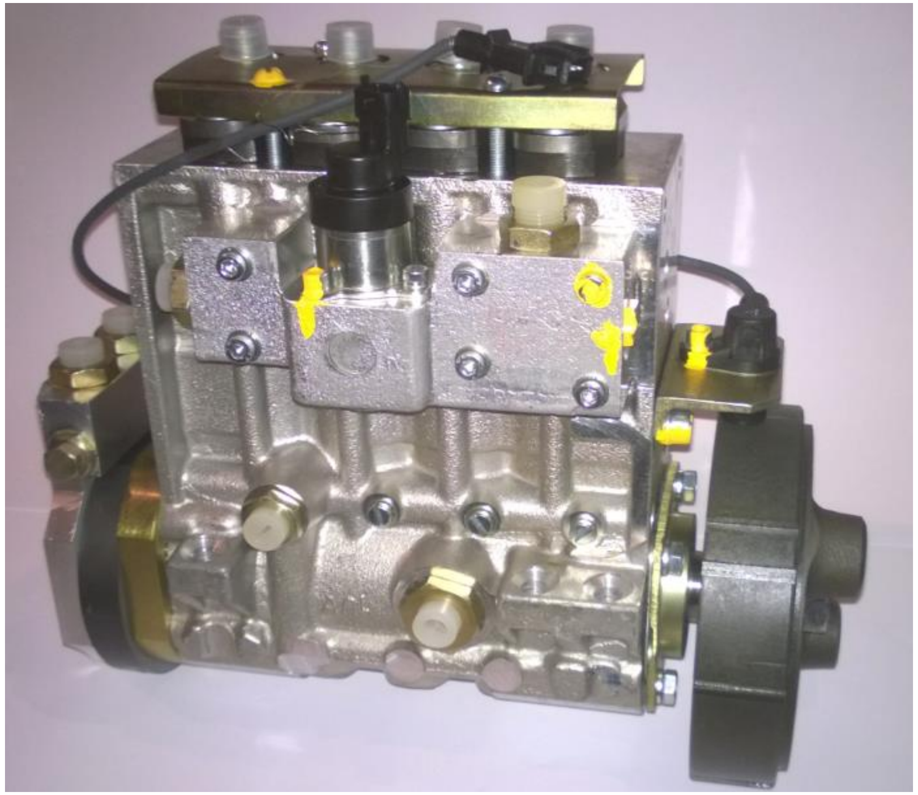
1 - fuel tank; 2 - fuel intake device; 3 - fuel prefilter; 4 - fuel pump; 5- fine fuel filter; 6 - electronic control unit; 7 – fuel pressure regulator; 8 - high pressure fuel pump; 9 - fuel rail; 10 - injectors; 11 - emergency valve; 12 - low-pressure fuel line; 13 - high-pressure fuel; 14 - pressure and fuel temperature sensor in the fine filter; 15 - pressure and temperature of intake air sensor; 16 - camshaft position sensor; 17 - pressure sensor in the rail; 18 - coolant temperature sensor; 19 - oil temperature sensor; 20 - crankshaft position sensor

Design of the common rail fuel system for the operation on biodiesel fuel





High-pressure fuel pump for biodiesel fuel



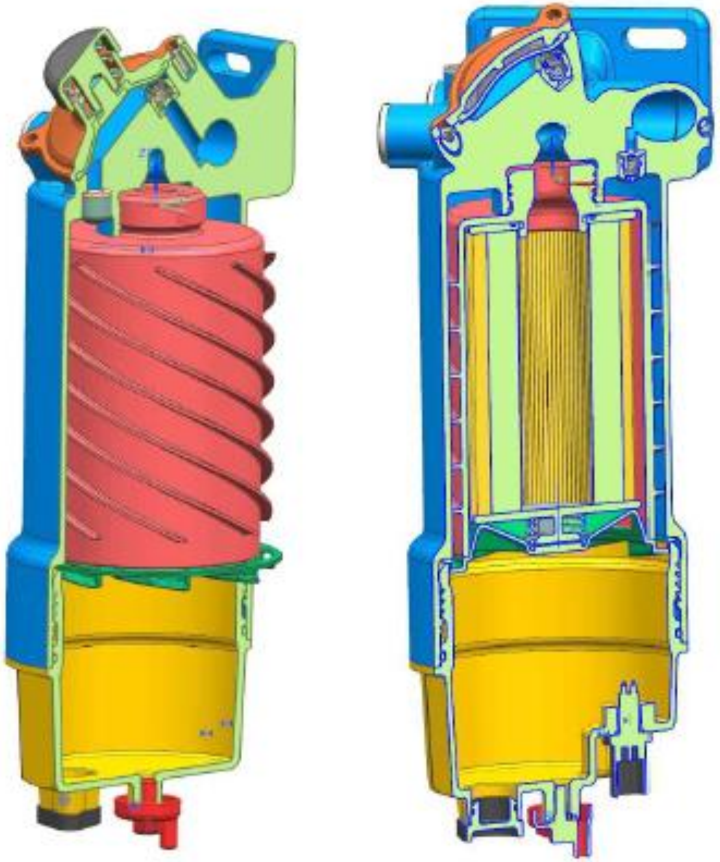
High-pressure fuel pump test results

Test mode	Camshaft RPM	Pressure regulator current, A	Rail pressure, bar	Fuel supply, l/h	Outflow, l/h
Maximal fuel supply	950	0,4	500±20	244,6	241,2
Maximal torque $M_{крмах}$	600	0,4	1600±20	140,0	153,6
Fuel supply is OFF	950	1,72	0	0	—
Engine start	80	0,4	200±10	21,6	—

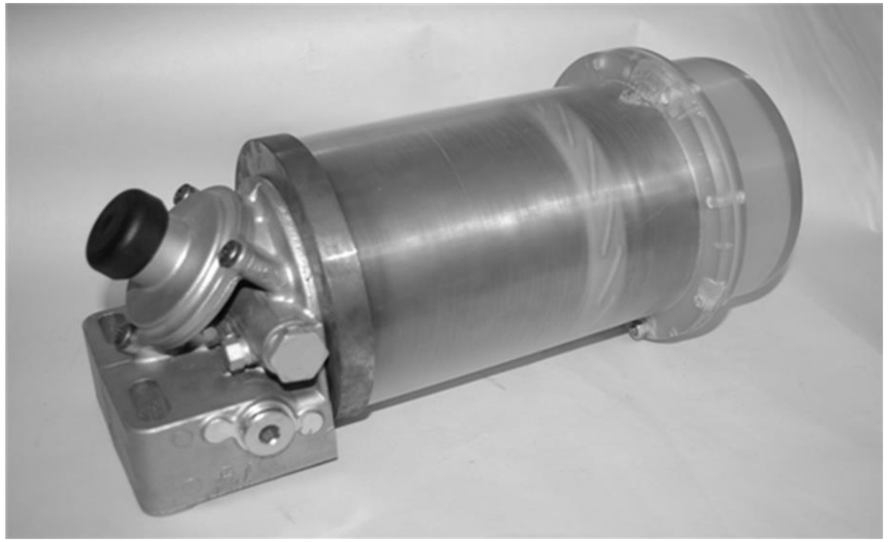
Pre-Filter dehumidifier for biodiesel fuel

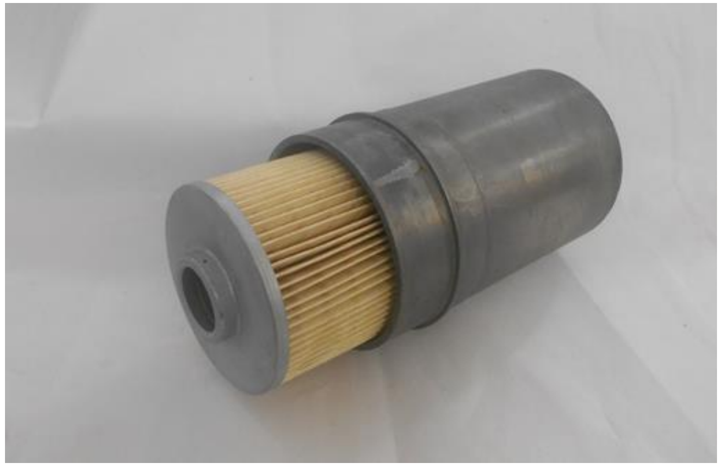
Variant 1

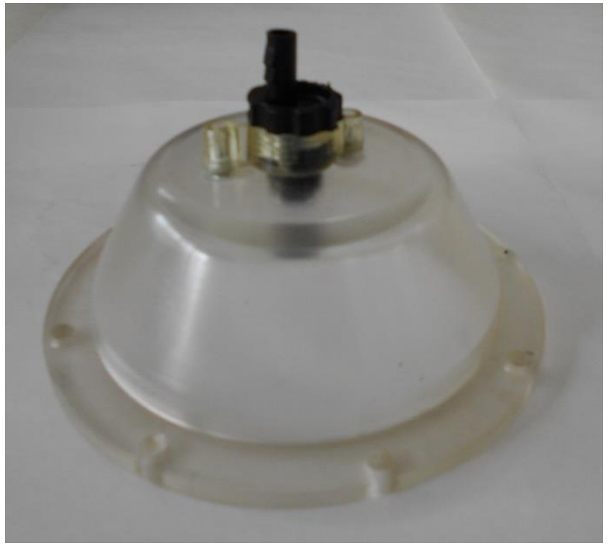
Variant 2



Pre-Filter dehumidifier for biodiesel fuel

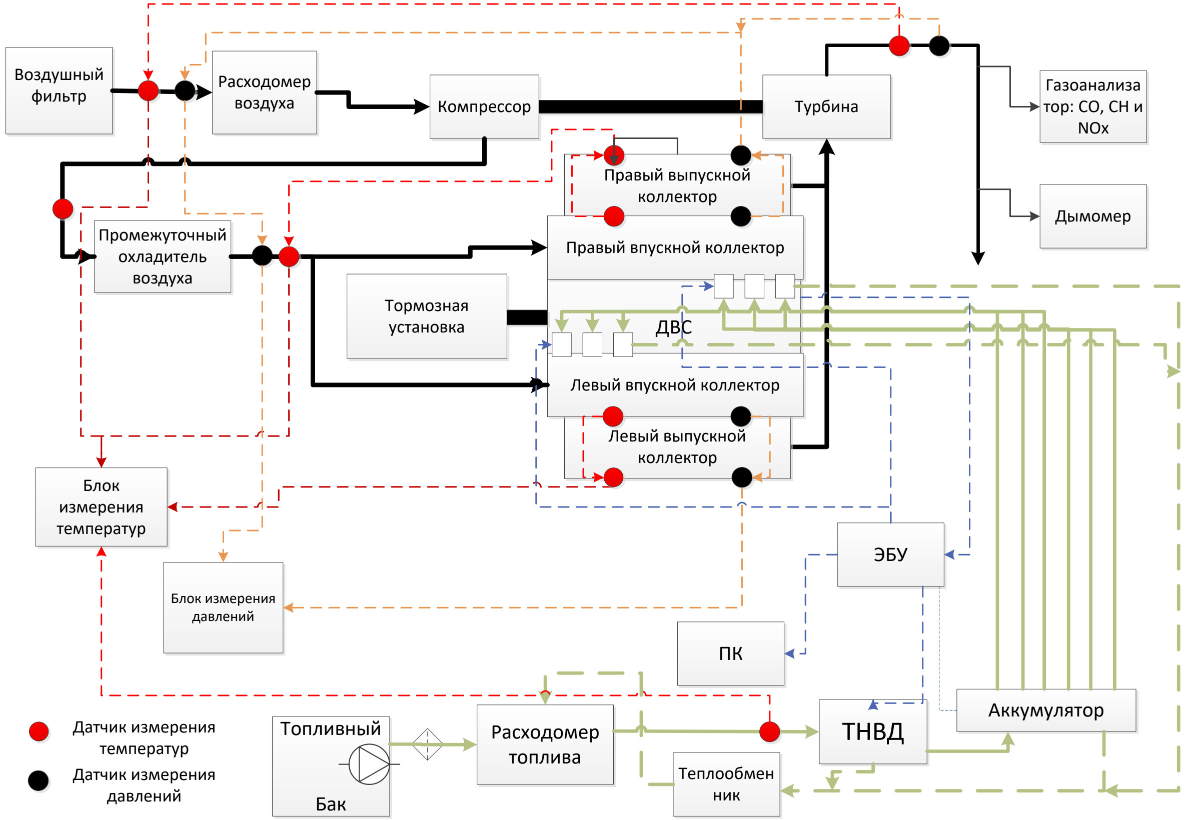






Experimental research an engine and components of fuel system for biodiesel fuel

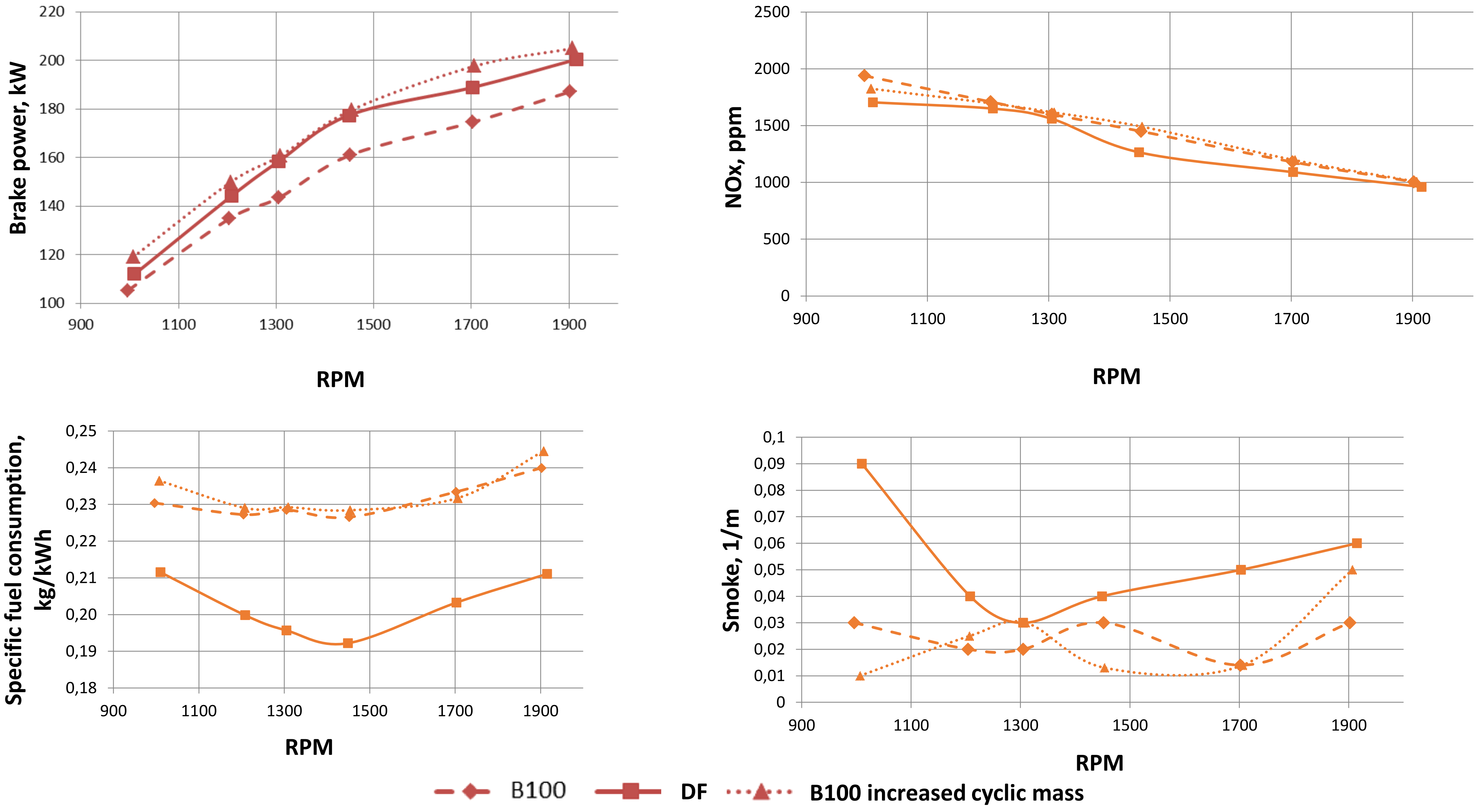
Motor bench scheme



Motor bench

Fuel filter test bench

Test results of the engine working on diesel and biodiesel fuels



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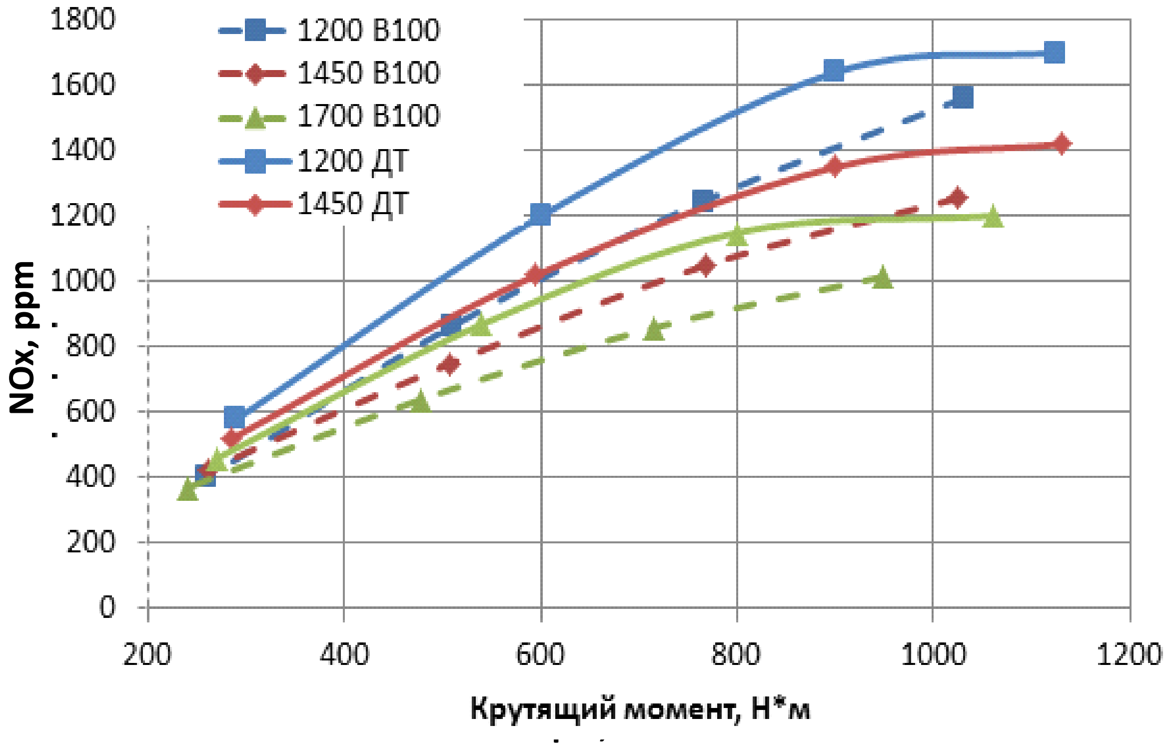
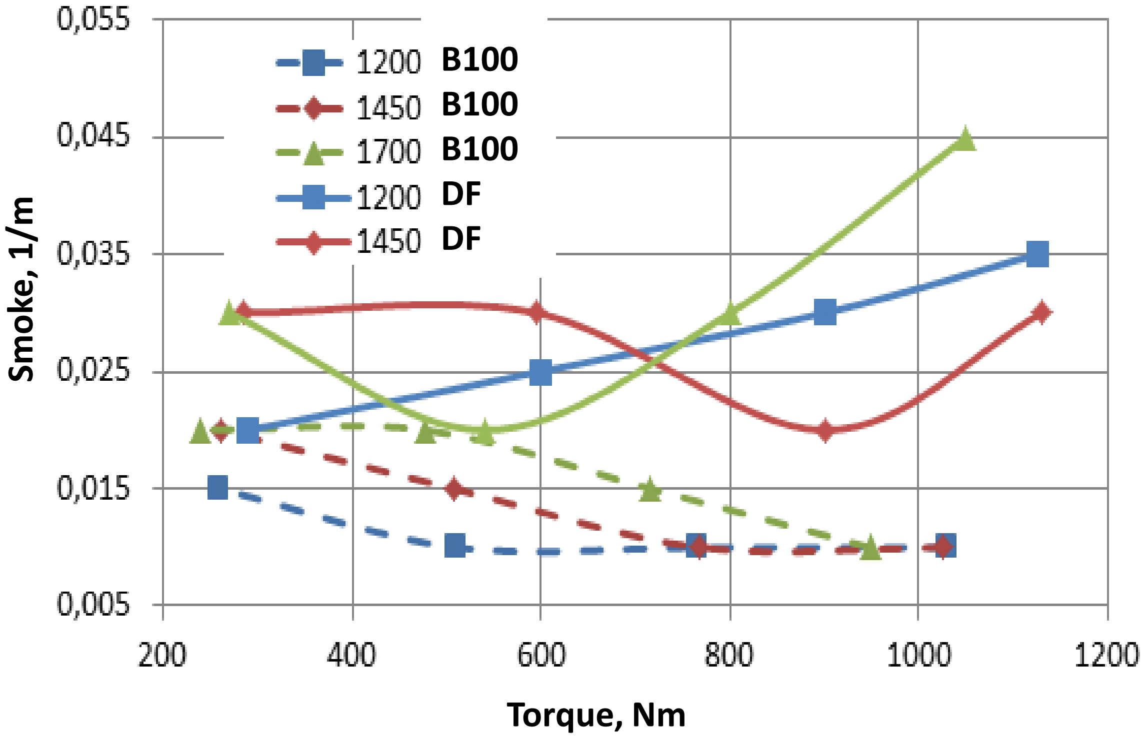


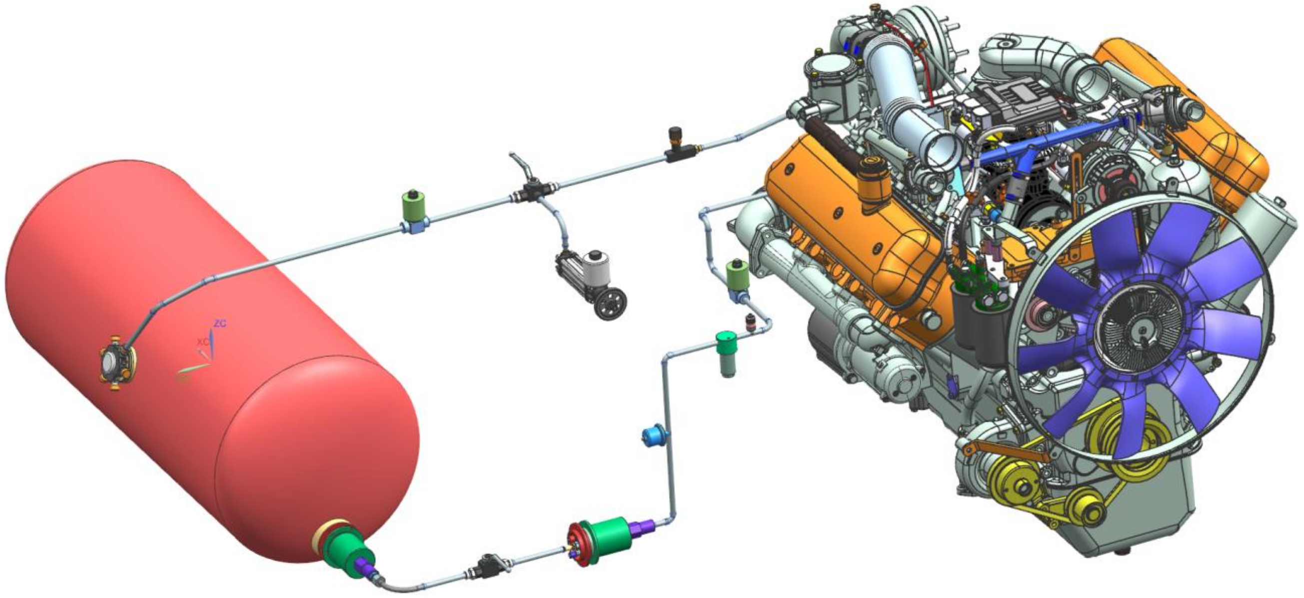


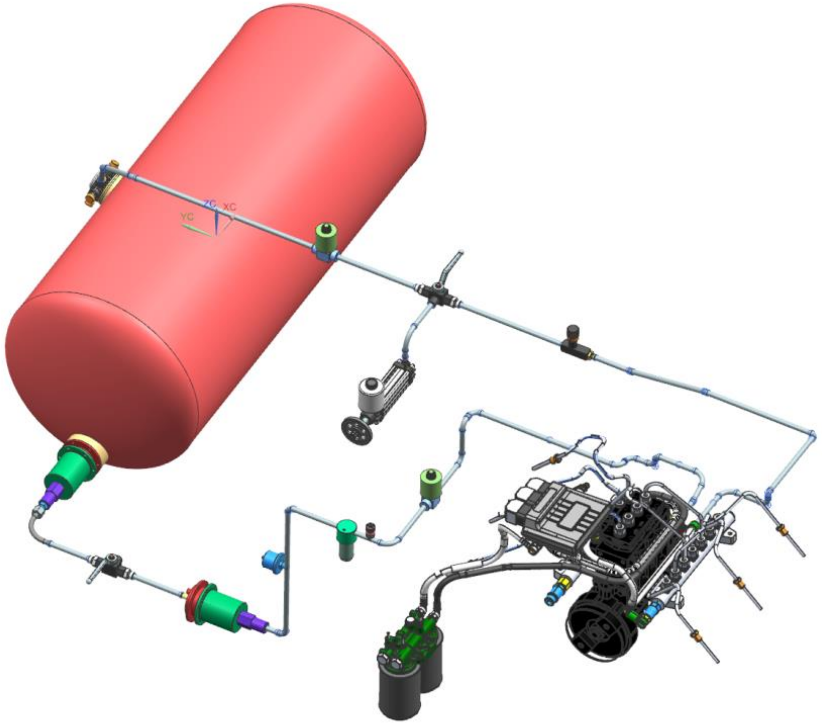
Injection advance for pilot and main portions was decreased on 3 deg.CA, pilot portion 5 mg

Test results of Pre-Filter dehumidifier for biodiesel fuel

Parameters	Parameters values		
	Technical requirements	Test results	
		Variant 1	Variant 2
1.Hydraulic filter resistance (with separator) at a fuel consumption of 5.0 l/min and a swirler with a blade angle of 10 degrees, MPa	less than 0,030	0,0136	0,0137
2. Filtering efficiency, %	more than 30,0	43	42
3. Nominal (95%) dropout rate, µm, not more	30,0	23	25
4. Completeness of water separation by the filter (with separator, without filter element) at a fuel consumption of 5.0 l/min and a swirler with a blade angle of 10 degrees,%	-	85	84
5. Completeness of filter water separation (with separator and filter element) at a fuel consumption of 5.0 l / min and a swirler with a blade angle of 10 degrees,%	more than 95	98,5	98,5
6. Filter tightness with air pressure 6.0 bar	hermetical	>6,5	>6,5

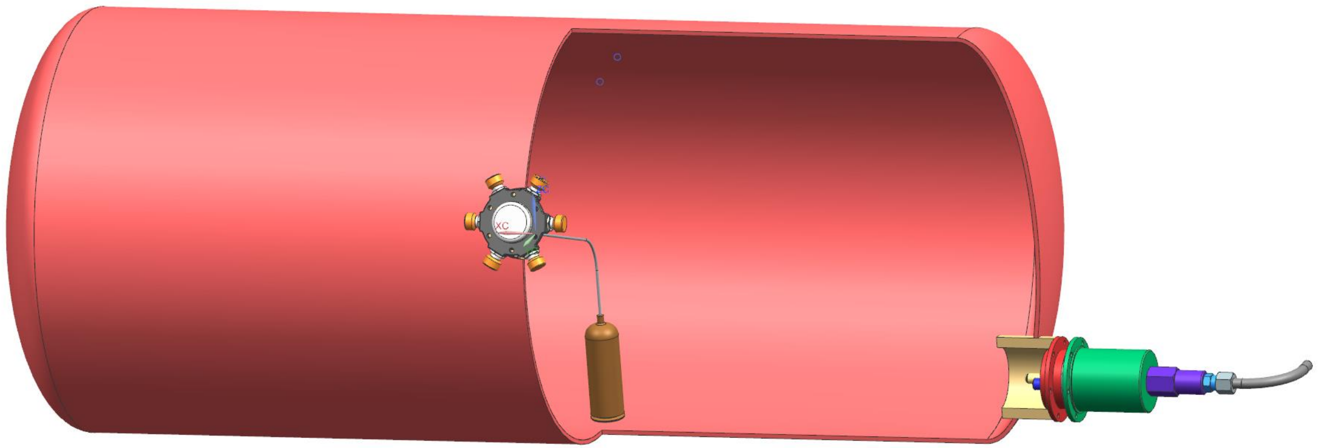
Design of the DME common rail fuel system for dual-fuel engine



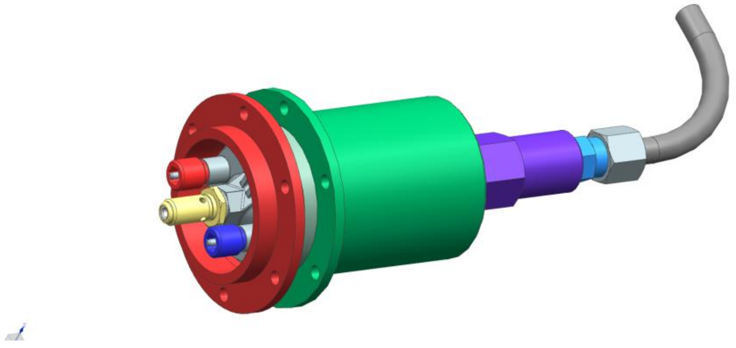


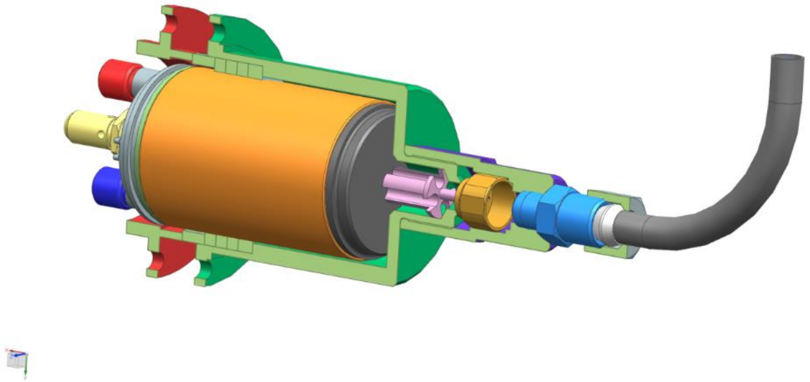
Components of the DME common rail fuel system for dual-fuel engine

Dimethyl ether balloon



Low-pressure pump for dimethyl ether





Components of the DME common rail fuel system for dual-fuel engine

Low-pressure pump for dimethyl ether

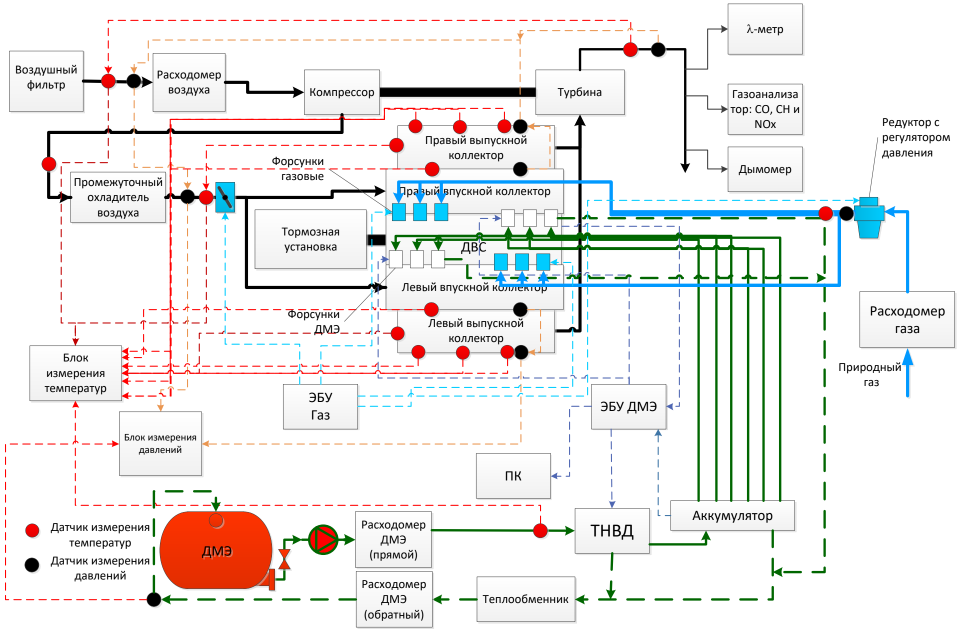
Pre-filter for dimethyl ether

Main solenoid valve

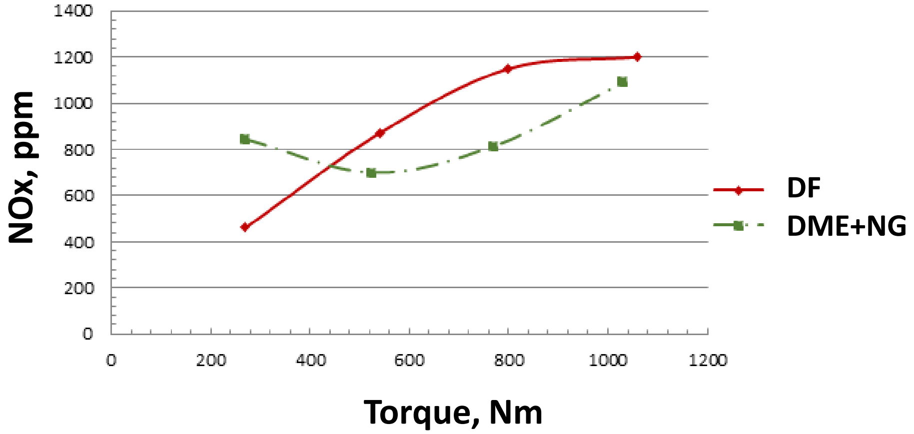
Lubricator

Experimental research of dual-fuel engine

Motor bench scheme



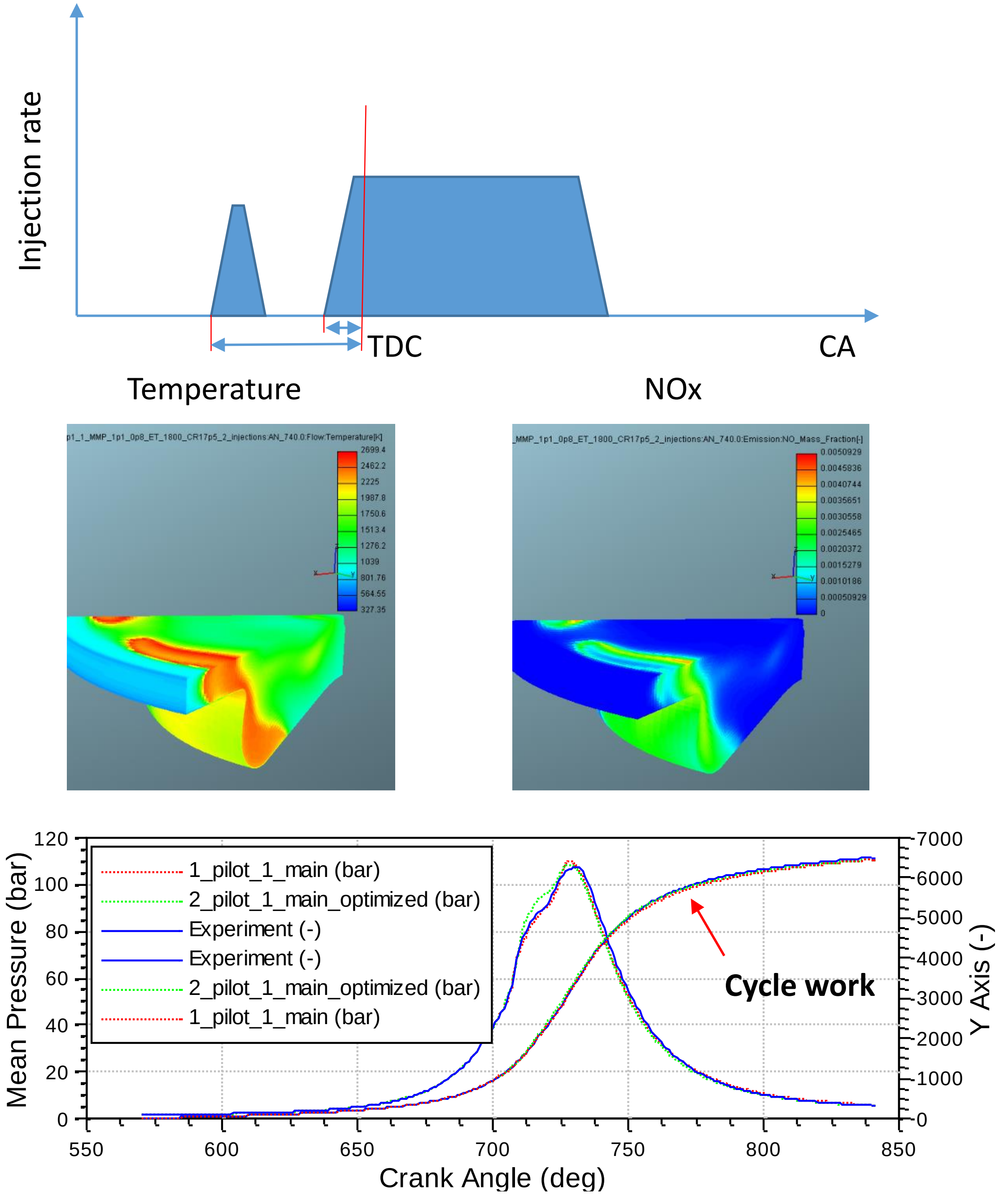
1700 RPM

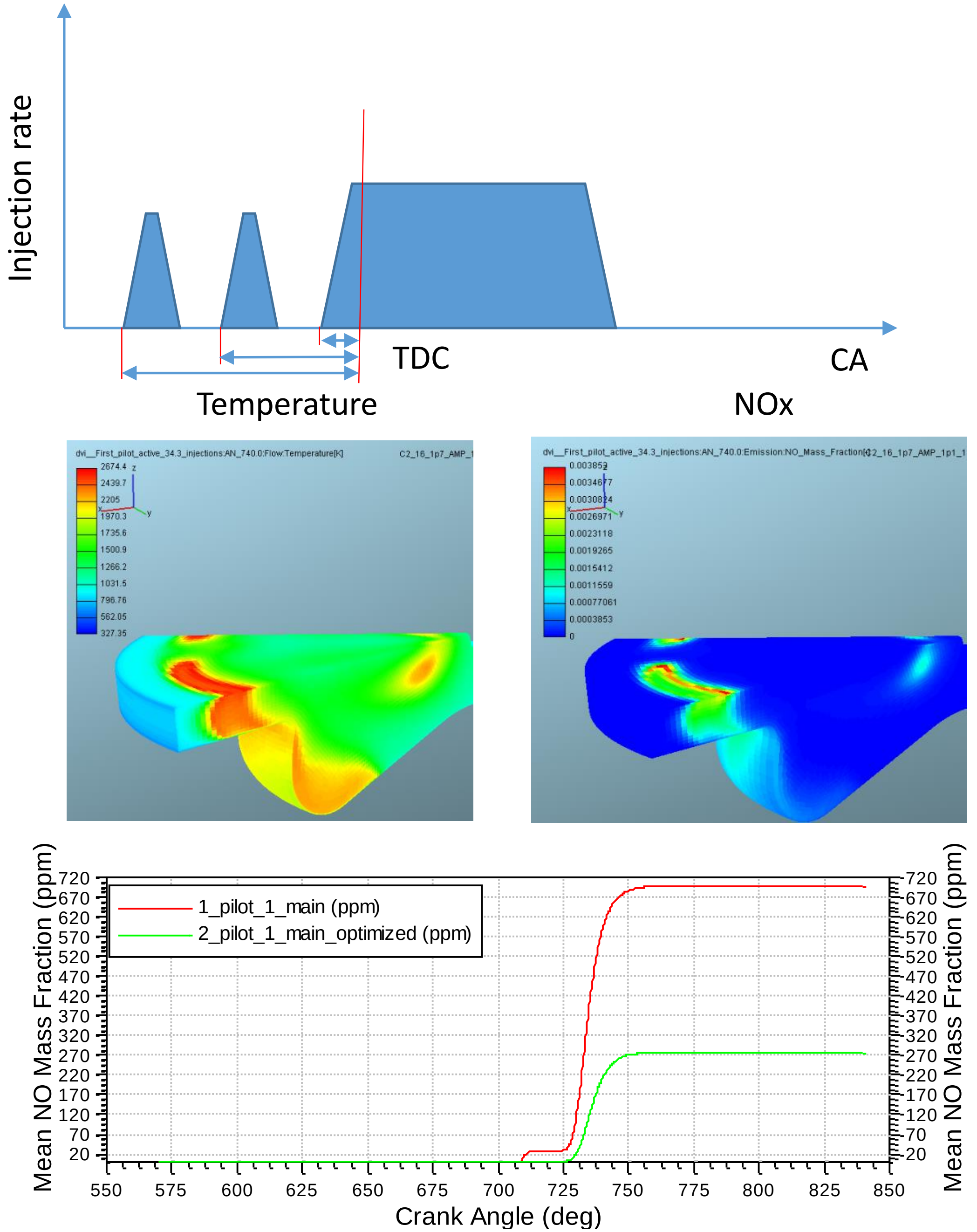


Motor bench control desk with DME and NG flow meters

DME balloons

On-going researches on simulation and optimization of biodiesel engine





Researcher Links UK-Russia Workshop

Scientific and Technical Grounds of Future Low-Carbon Propulsion

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

Thank you for your attention
Ready to answer your questions

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