Researcher Links UK-Russia Workshop

Scientific and Technical Grounds of Future Low-Carbon Propulsion

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

CALCULATION METHOD OF CHARACTERISTICS OF GASOLINE ENGINE WITH CYLINDER SHUTDOWN

Savastenko Eduard

MOSCOW AUTOMOBILE AND ROAD CONSTRUCTION STATE TECHNICAL UNIVERSITY (MADI). RUSSIA, MOSCOW

Northumbria University NEWCASTLE

NAMI

Newcastle University

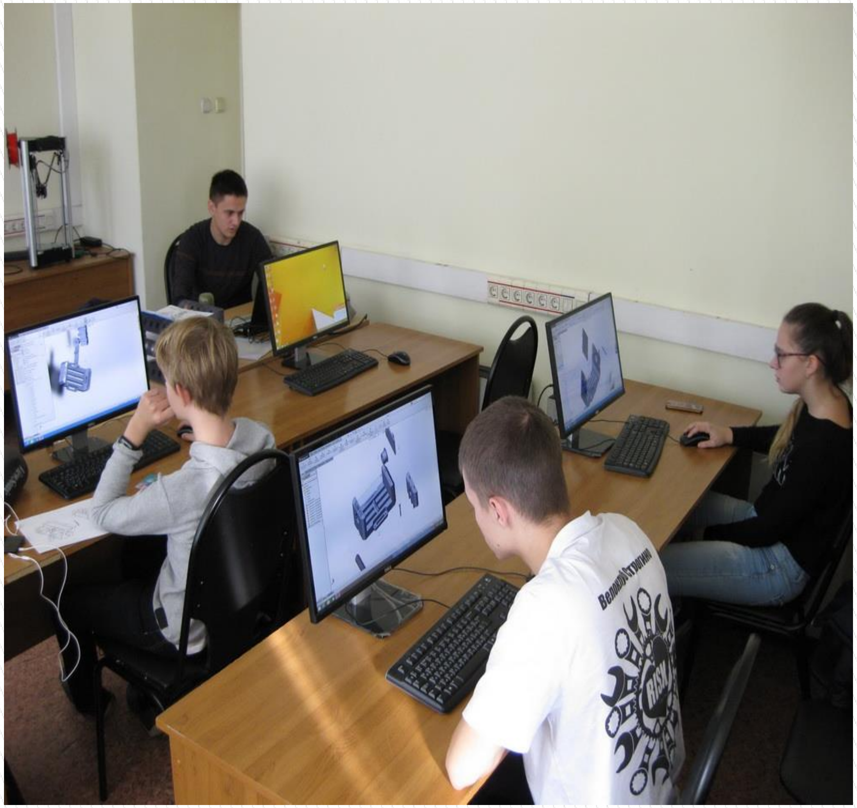
University of Sunderland

BRITISH COUNCIL

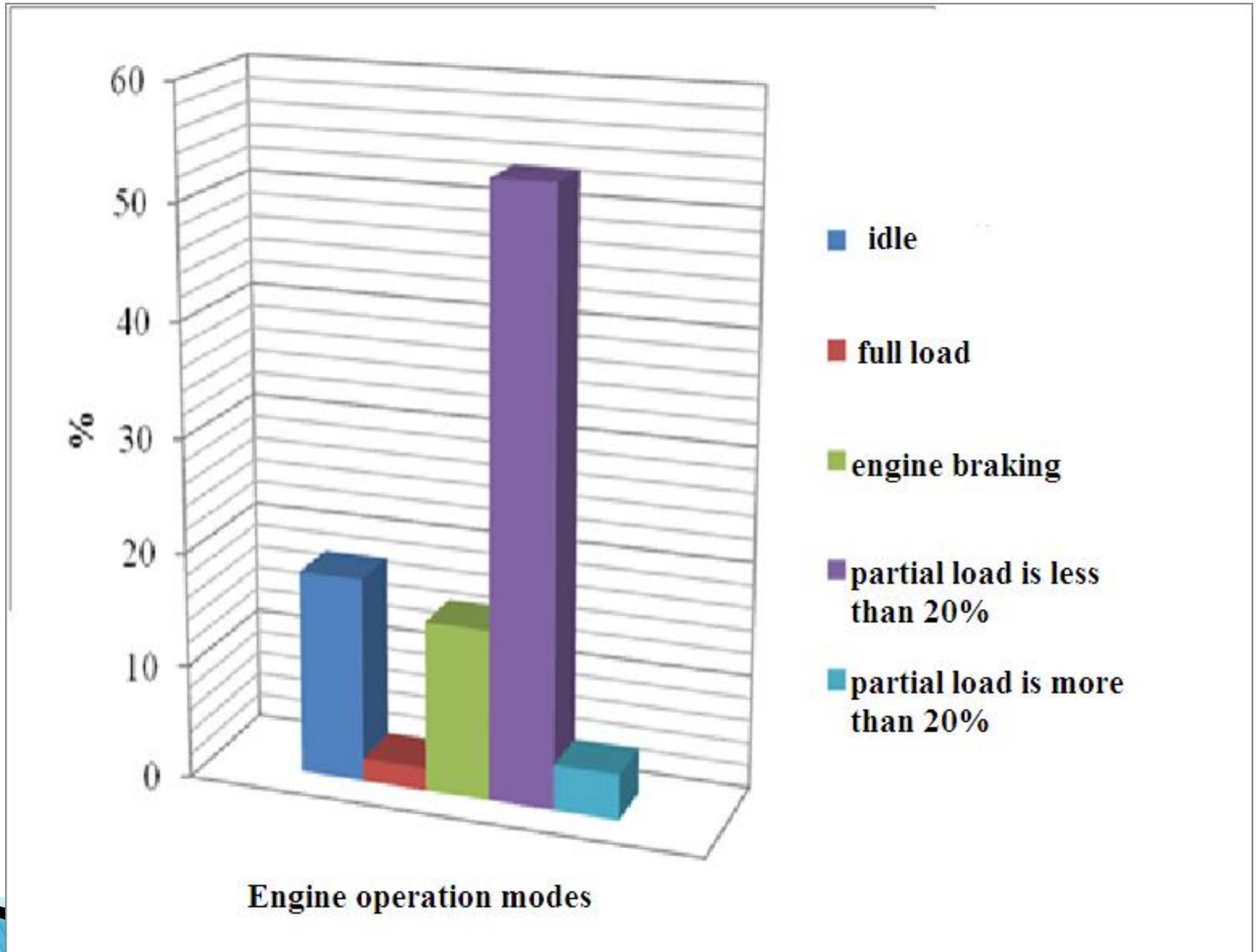
MOSCOW AUTOMOBILE AND ROAD CONSTRUCTION STATE TECHNICAL UNIVERSITY (MADI)

The main automobile university of Russia

- 10,000 students (67 countries of the world)
- 22 specialties
- Department of heat engineering and autotractor engines
- Well-known scientists: N. Briling, M. Hovah, V. Lukanin, B. Stechkin.

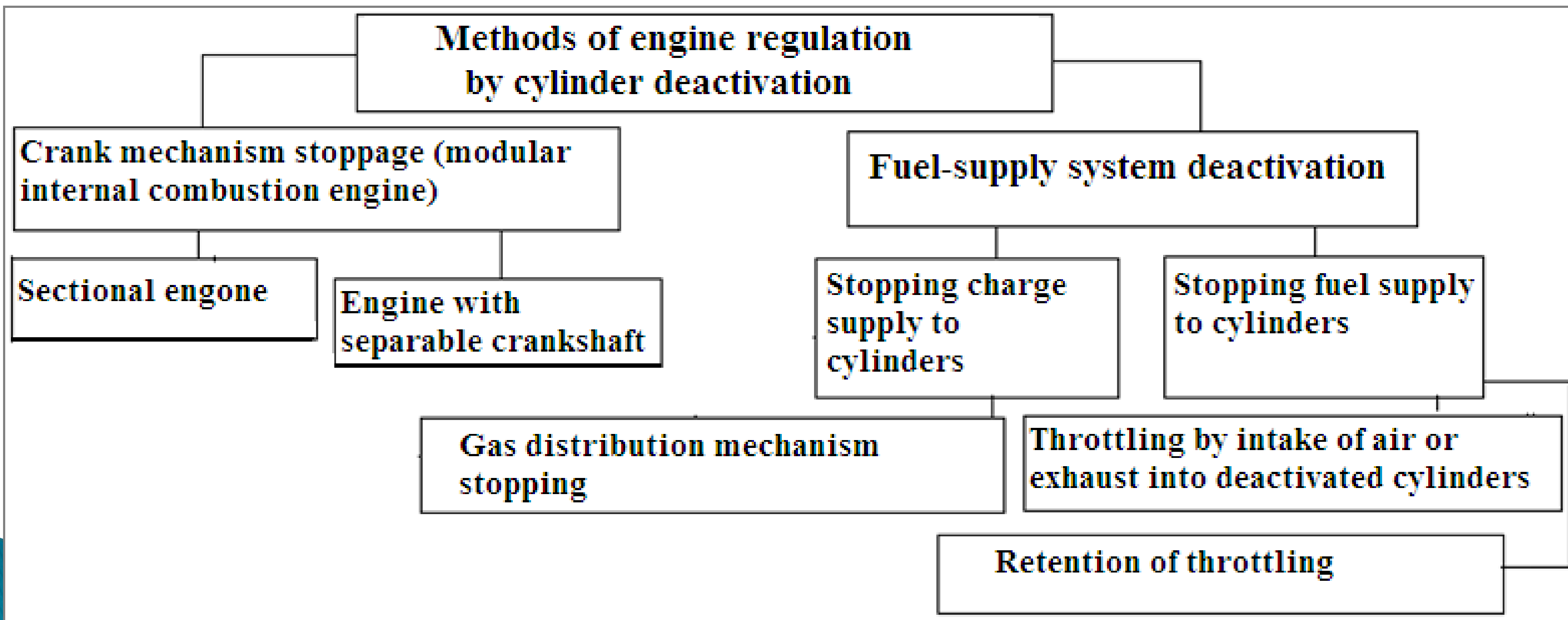


Engine work modes in urban conditions



Basic definitions

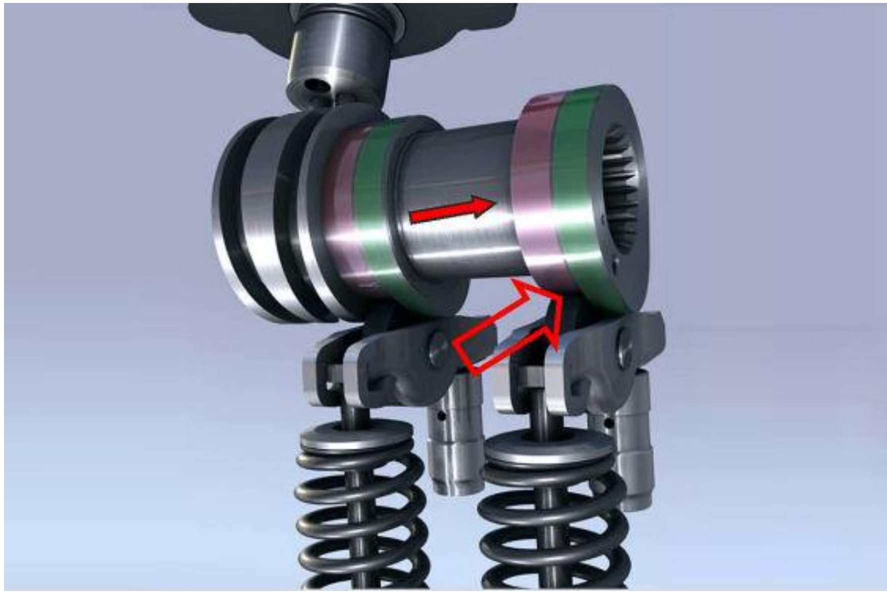
- Engine displacement volume (active swept volume) is the sum of the working volumes of its cylinders, in which the processes of mechanical energy generation take place (the active cylinders).
- Switched off cylinder is deactivated.
- *ACC – Active Cylinder Control*
- *i – complete cylinders number of full-sized engine*.
- *z* – a number of operating (active) cylinders.



Special design pusher(*MDS*)
(cars: Dodge, Jeep, Chrysler)

Multi-Displacement System

Valves control scheme of
Active Cylinder Control system (Daimler-Benz)



Active Cylinder Technology system
(concern VAG)

Influence of deactivation method on gasoline engine economy

Deactivation method	Growth in efficiency, %	%	%
	Idle	40 km/h	60 km/h
1. Cylinder deactivation by valves stoppage	42	22	16
2. Fuel supply deactivation with simultaneous inlet of air without throttling	37	14	8
3. Fuel supply deactivation with EGR	37	14	8
4. Fuel supply termination with throttling preservation	26	13	8

Advantages and disadvantages of engines with cylinder deactivation

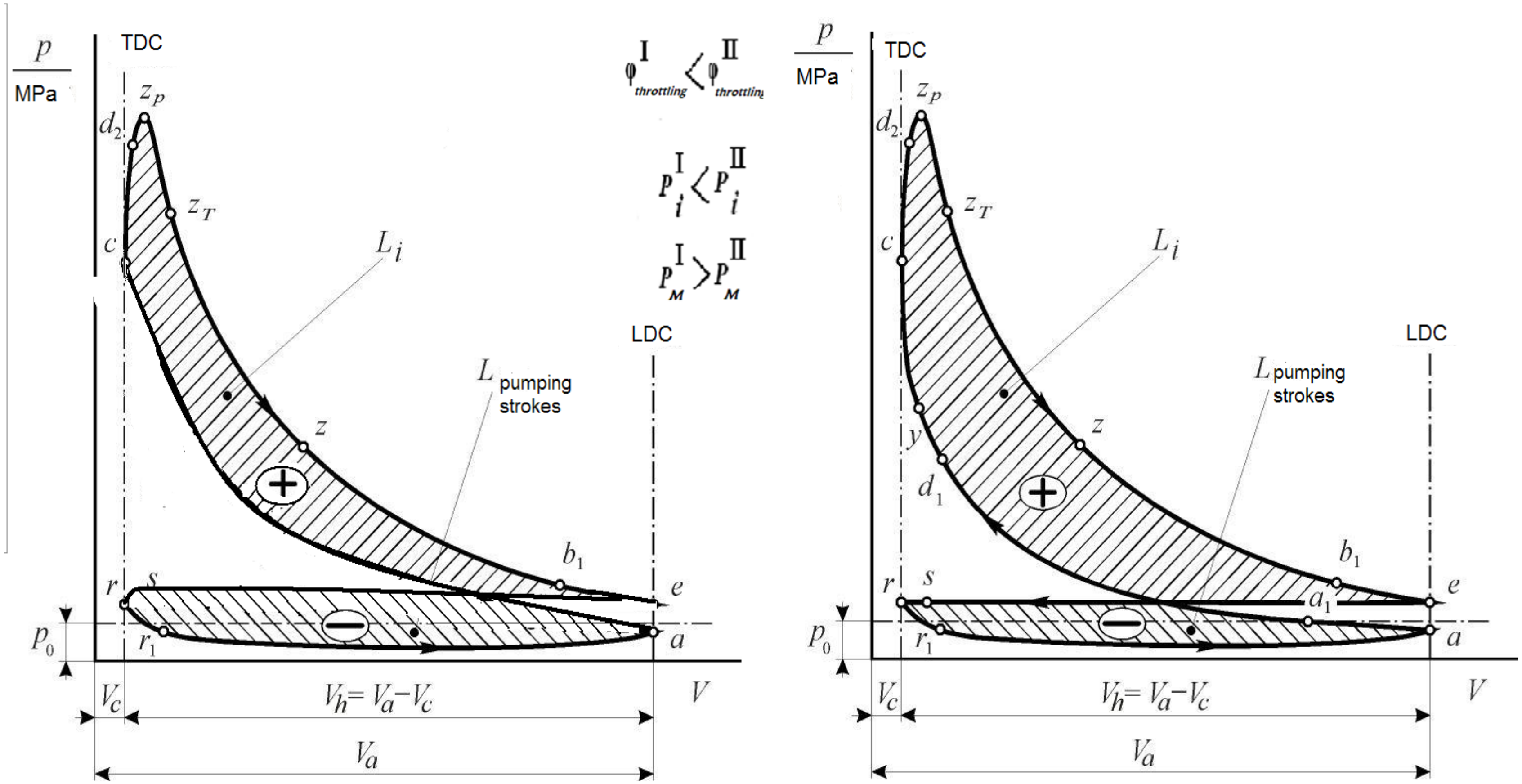
- Economy increasing
- Reduction of cylinder-piston group wear
- Reduction of resin formation and coking of rings
- Reduction of lubricant dilution
- Carbon monoxide reduction

- Pistons walls cooling
- Noisiness
- Vibrations

Advantages

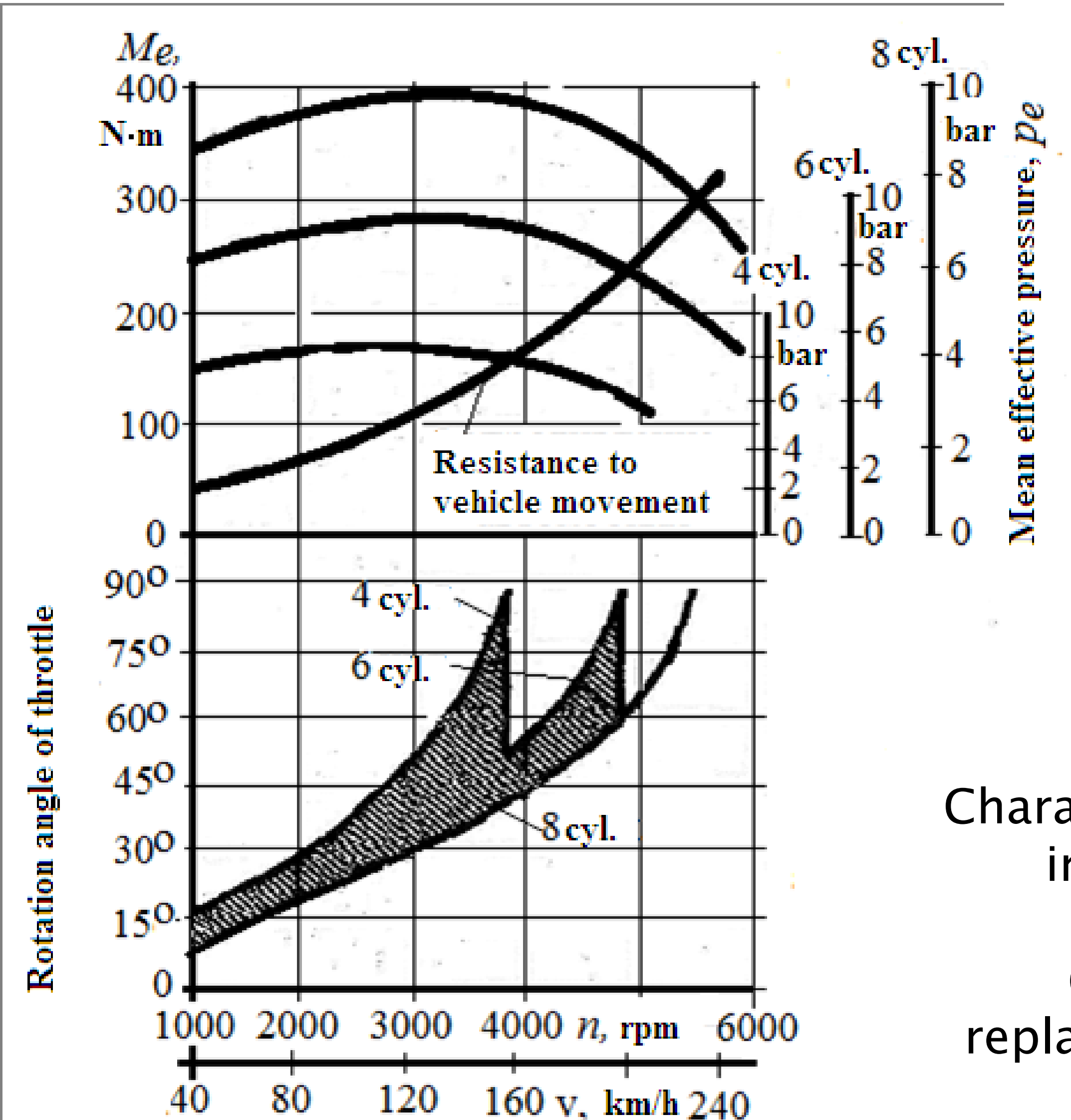
Limiting factors

Pumping movements on different loads



Lм(Pм) Pumping strokes

Adjustable parameter – specific work of engine



Lsp.$_i$ = Lfull/($i \cdot Vh$), J/dm^3

Lsp.$_z$ = Lfull/($z \cdot Vh$), J/dm^3

Lfull = 500·$pe \cdot i \cdot Vh$, J.

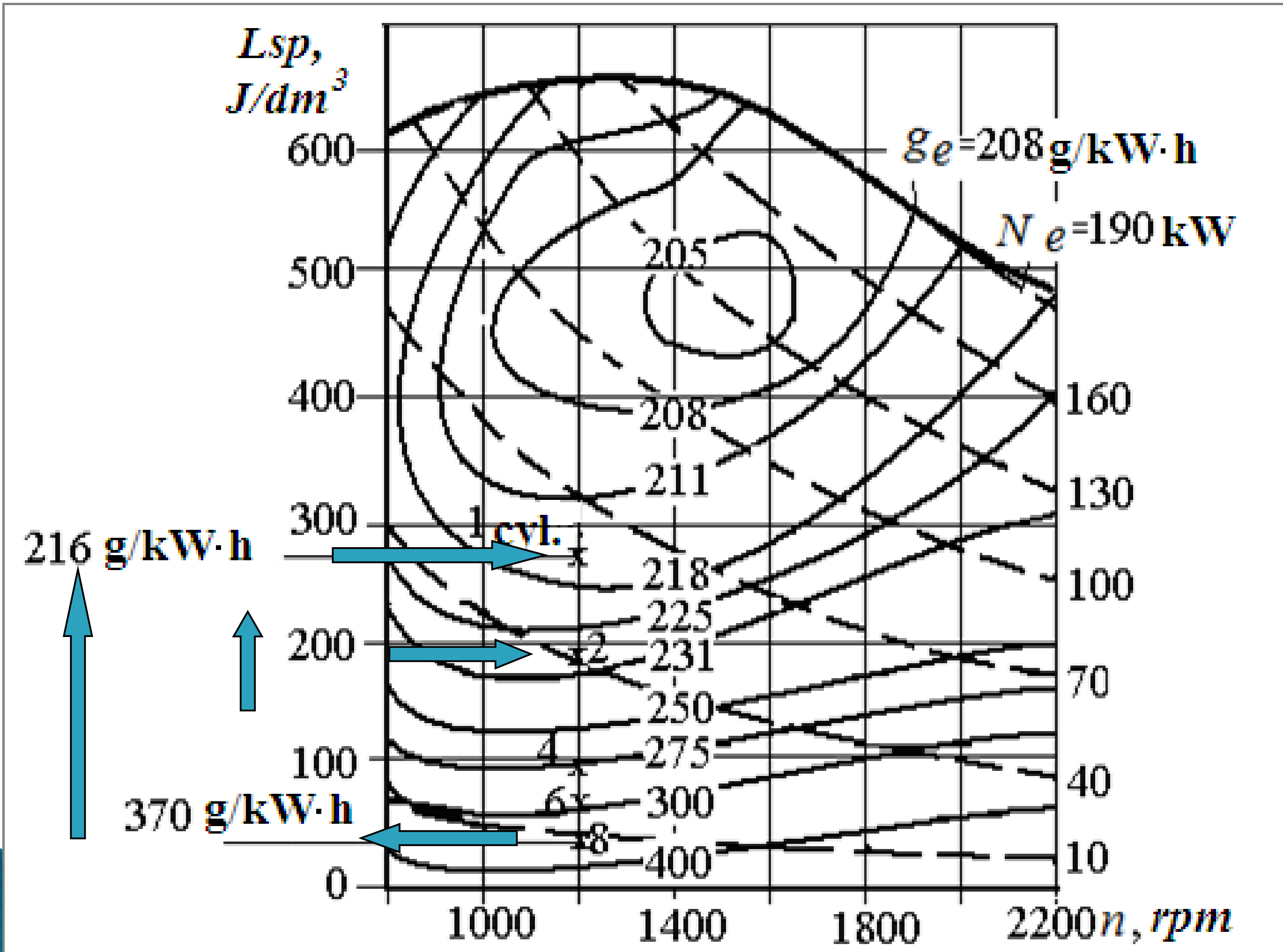
Lfull=$2 \cdot \pi \cdot Me$., J

Lsp.=$2 \cdot \pi \cdot Me/z \cdot Vh$, J/dm^3

Characteristics of *Vee*–type gasoline internal combustion engine *Daimler–Benz* ($i \cdot Vh$=5l.)
(To illustrate the need for replacement ordinates *Me* of *pe* to specific work *L*sp.).

Calculation-and-experimental method

$$\Delta g_e = [(g_{e,8} - g_{e,z})/g_{e,8}] \cdot 100\%.$$



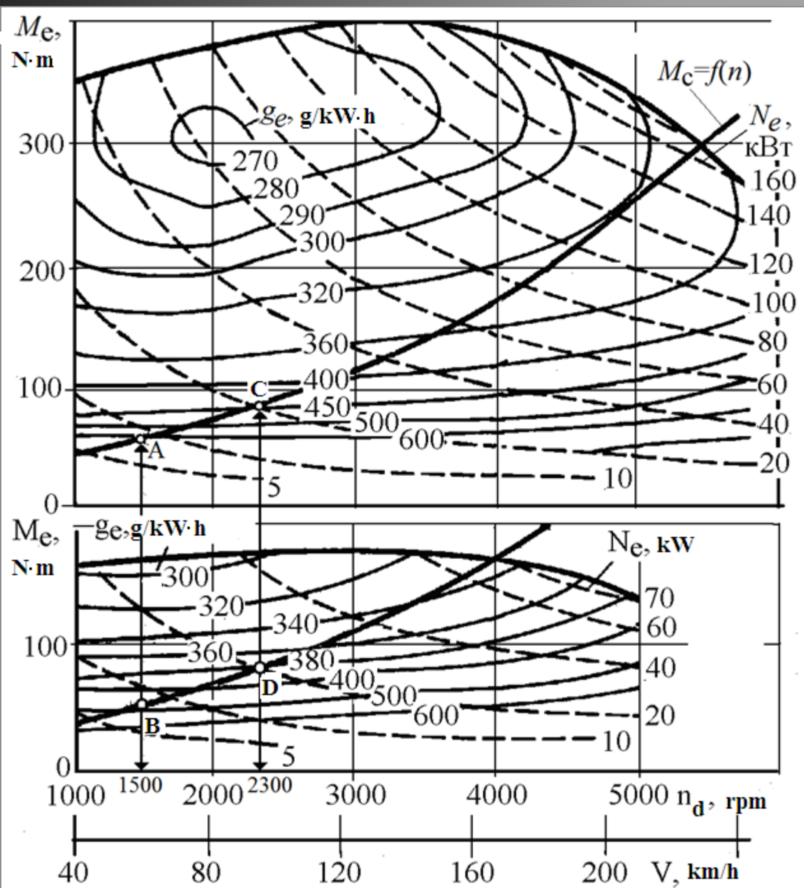
$Ne = Na/\eta_{friction}$,, kW

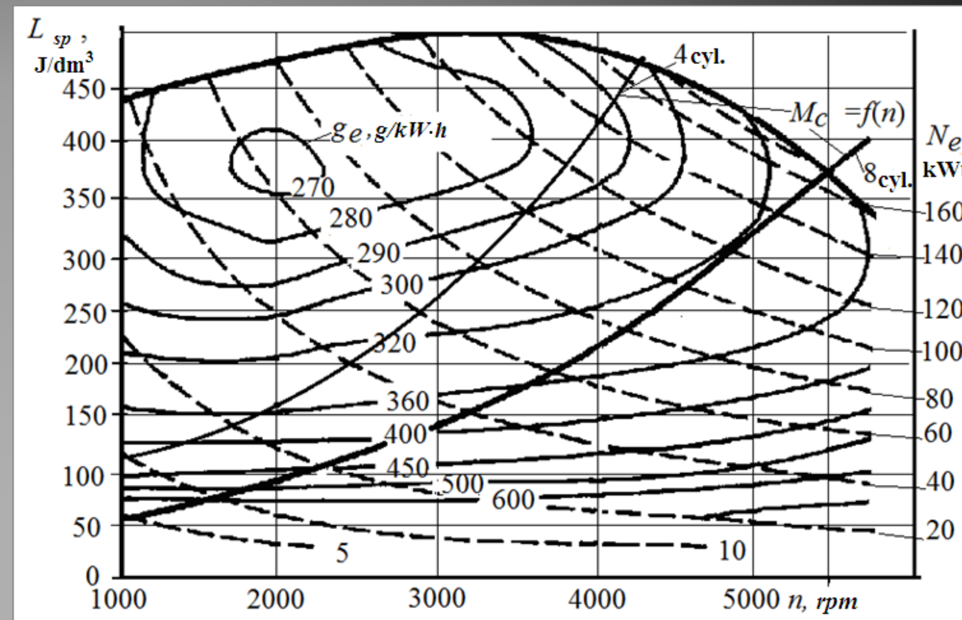
$n=(va/r_к)\cdot(30/\pi)\cdot u_{friction}$, rpm

$Q_Т= (G_Т \cdot 100)/(\rho_{comb} \cdot v'a)$, l/(100 km)

Universal characteristic of eight-cylinder engine, rebuilt into coordinates *L*sp–*n* :

Adequacy of the estimating economy method using universal characteristics





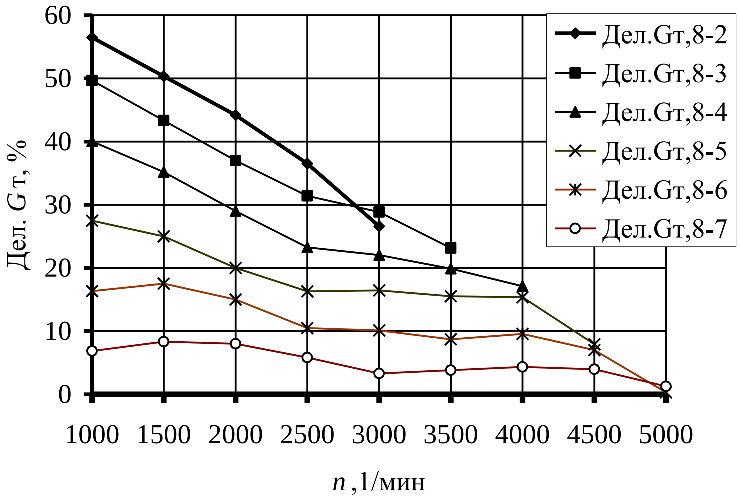
Universal characteristic of BMW engine, rebuild into coordinates *L*sp – *n*: the same load modes of the engine(*Mc* = *f* (*n*)) are rebuilt into the coordinates of the specific works performed by the full-sized(8 cyl.) engine and the engine with four active cylinders (4 cyl.).

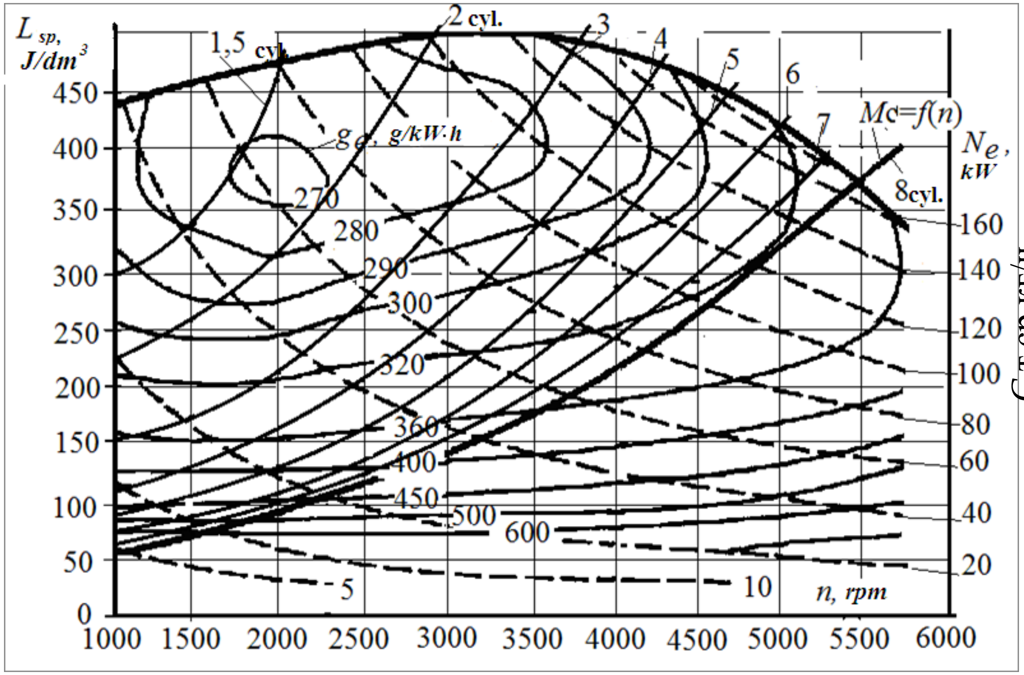
Universal characteristics of the BMW eight-cylinder engine before (above) and after turning off half of the cylinders (below) [8], obtained experimentally.

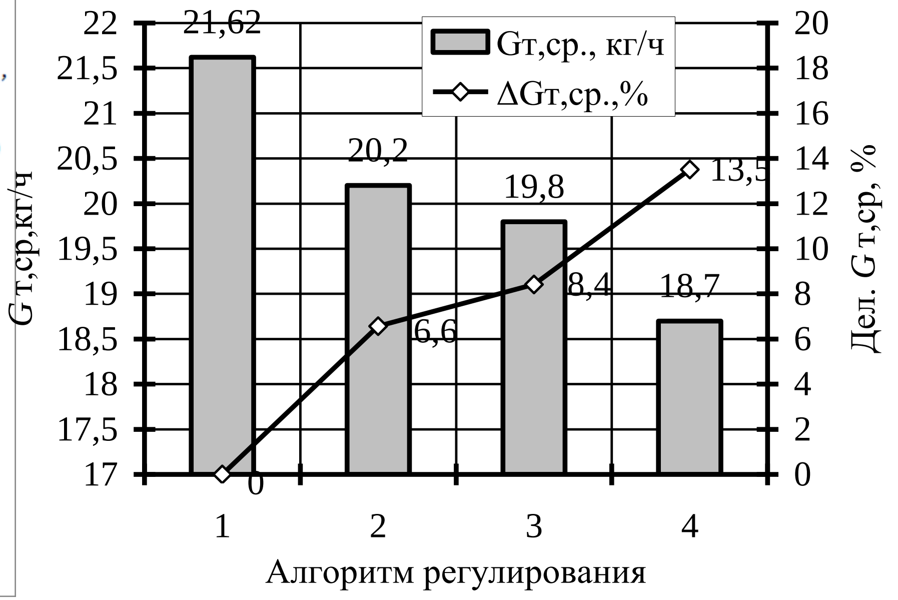
Assessment of the methodology adequacy

n, 1/min	L_{sp}, 8cyl., J/dm^3	g_e, 8cyl., g/(kW·h)	L_{sp}, 4cyl.	g_e, 4cyl.	g_e, 4cyl. Exp.	g_e, 4, Approx.	g_e, 4, Experi-mentan and approx.	**Δ. g_e, %**
1000	60	717	113	430	550	432	546	**20,9**
1500	71	600	120	389	470	388	470	**17,6**
2000	89	500	160	360	400	352	411	**14,5**
2500	113	430	205	310	370	324	369	**12,3**
3000	144	395	263	308	350	304	343	**11,6**
3500	180	367	335	294	340	291	334	**12,7**
4000	222	345	420	286	335	287	341	**15,8**

BMW engine







Dependence of the average hourly fuel consumption(*G*т,*middle*) on the BMW engine control algorithm, as well as the gains

1- full-sized engine operation, 8cyl: 2 - algorithm 2cyl.-8cyl.; 3 - algorithm 4cyl.-8cyl.; 4 - algorithm 1,5cyl.-2cyl.-3cyl.-4cyl.-5cyl.-6cyl.-8cyl.

Calculation-and-experimental method of engine toxicity indexes research

- $G_{NOx} = 0{,}001587 \cdot C_{NOx} \cdot G_{\text{ог}}$, g/h.
- $G_{CO} = 0{,}000966 \cdot C_{CO} \cdot G_{\text{ог}}$, g/h.
- $G_{CH} = 0{,}000485 \cdot C_{CH} \cdot G_{\text{ог}}$, g/h.
- $G_{NOx} = g_{NOx} \cdot Ne$, g/h.
- $G_{CO} = g_{CO} \cdot Ne$, g/h.
- $G_{CH} = g_{CH} \cdot Ne$, g/h.

$C_{NOx} = (G_{NOx} \cdot 10^{-3})/V_{\text{ог}}$, kg/m3.

$C_{CH} = (G_{CH} \cdot 10^{-3})/V_{\text{ог}}$, kg/m3.

$C_{CO} = (G_{CO} \cdot 10^{-3})/V_{\text{ог}}$, kg/m3.

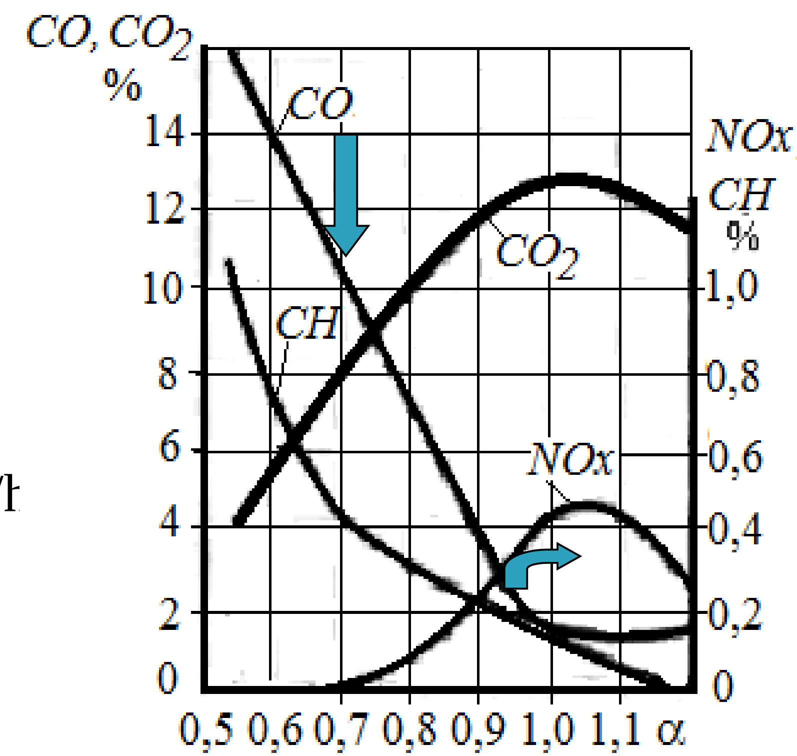
$$G_{NOx} = C_{NOx} \cdot V_{\text{exhaust}}$$

$$V_{\text{exhaust}} = G_{\text{exhaust}} / \rho_{\text{exhaust}}$$

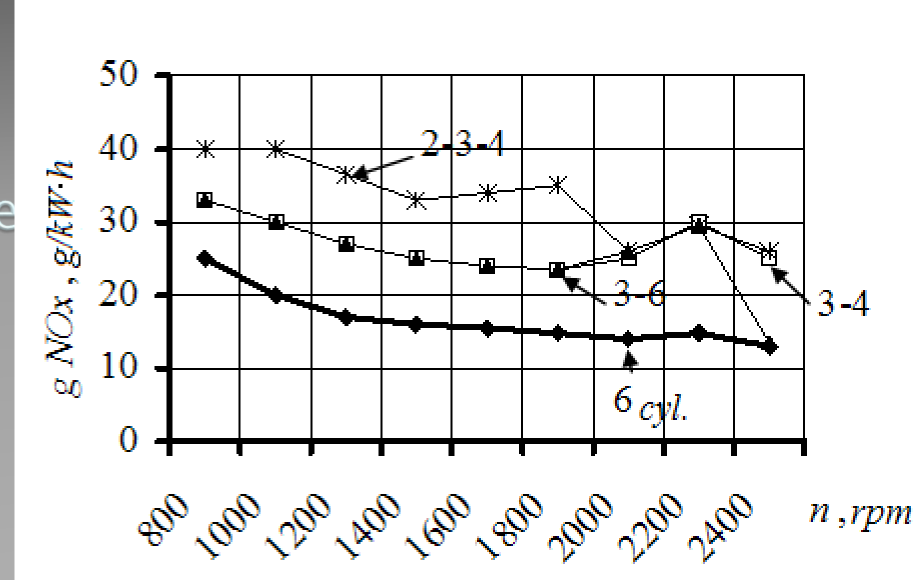
$G_{ex.} = G_{air} + G_{fuel} = z \cdot V_h \cdot \eta_v \cdot \rho_{\text{в}} \cdot n \cdot 10^{-3} \cdot 30 + G_{\text{т}}$, kg/h

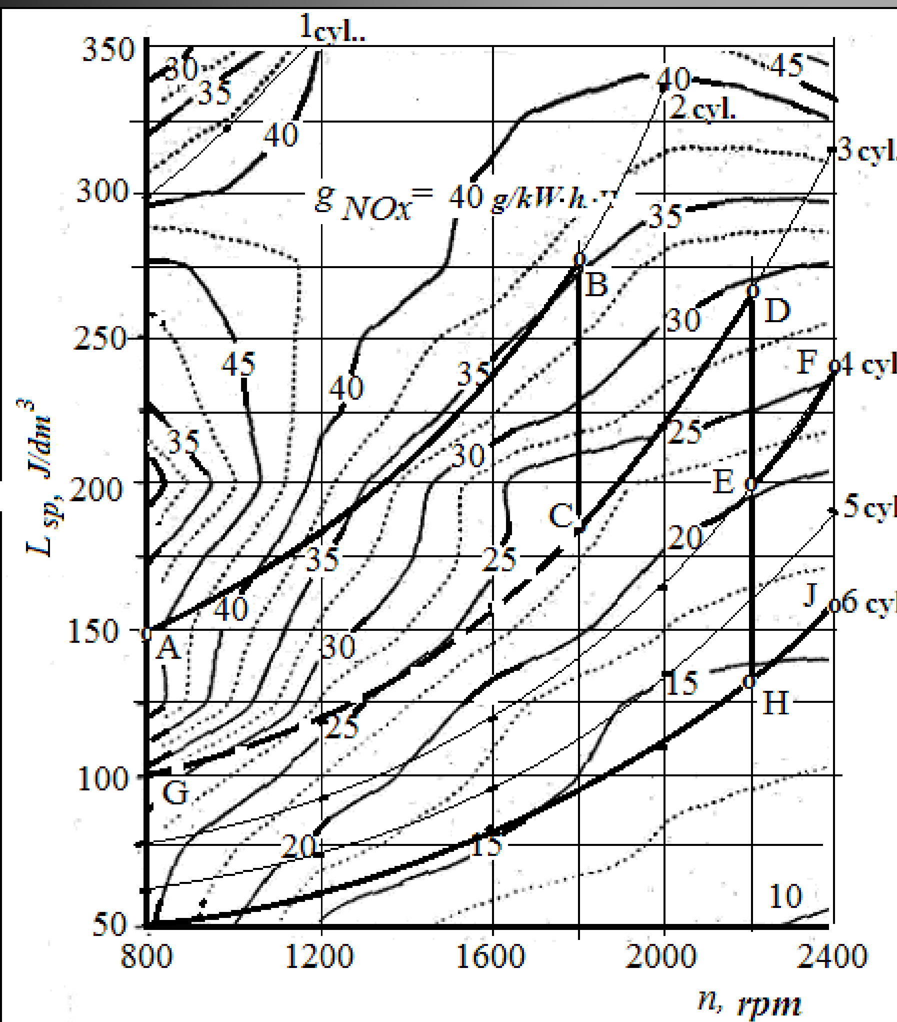
$G_{ex.} = G_{air} + G_{fuel} = i \cdot V_h \cdot \eta_v \cdot \rho_{\text{в}} \cdot n \cdot 10^{-3} \cdot 30 + G_{\text{т}}$, kg/h

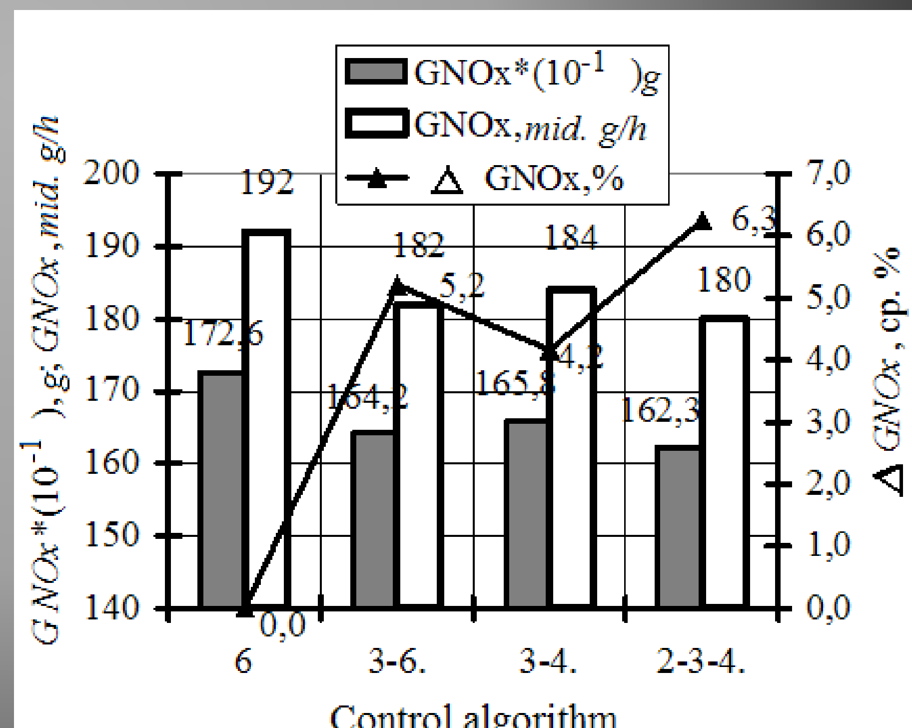
1 *ppm* = 10^{-4} %, i.e. $500 \cdot 10^{-4}$ % = 500 *ppm*



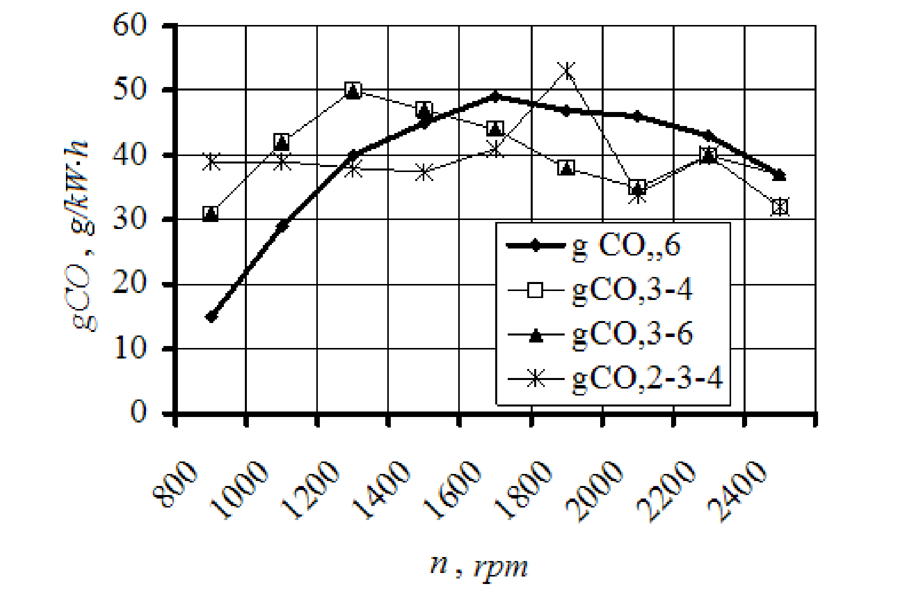
Environmental effect assessment from using the engine regulation control method (UPS 292 SC engine by changing its working volume

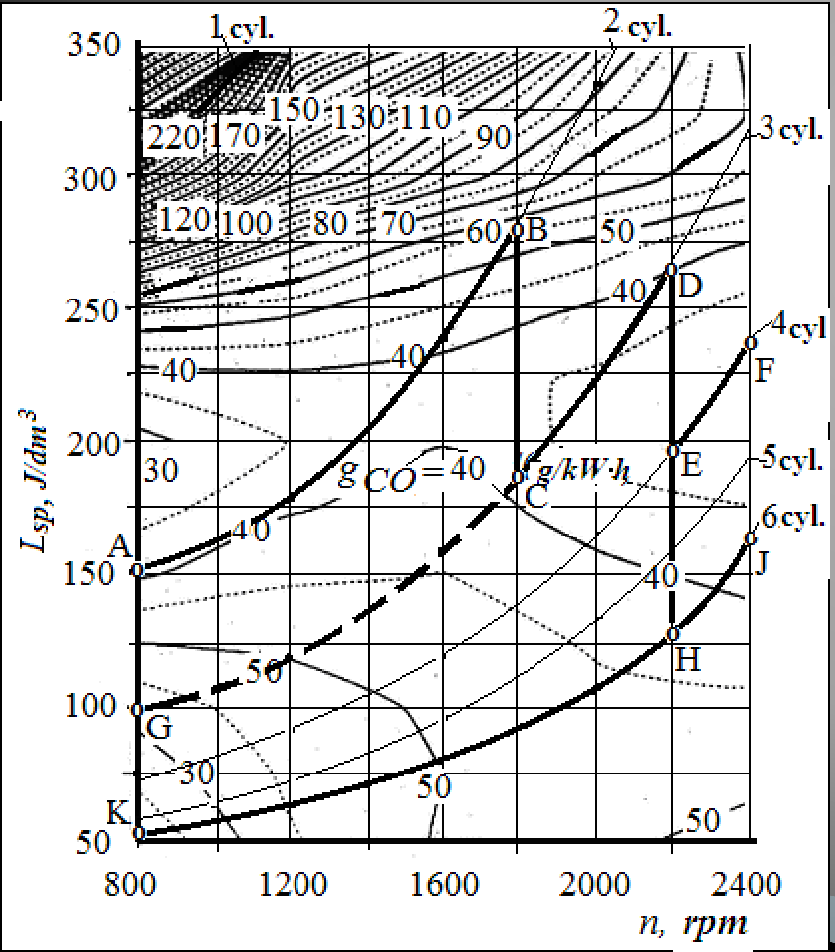


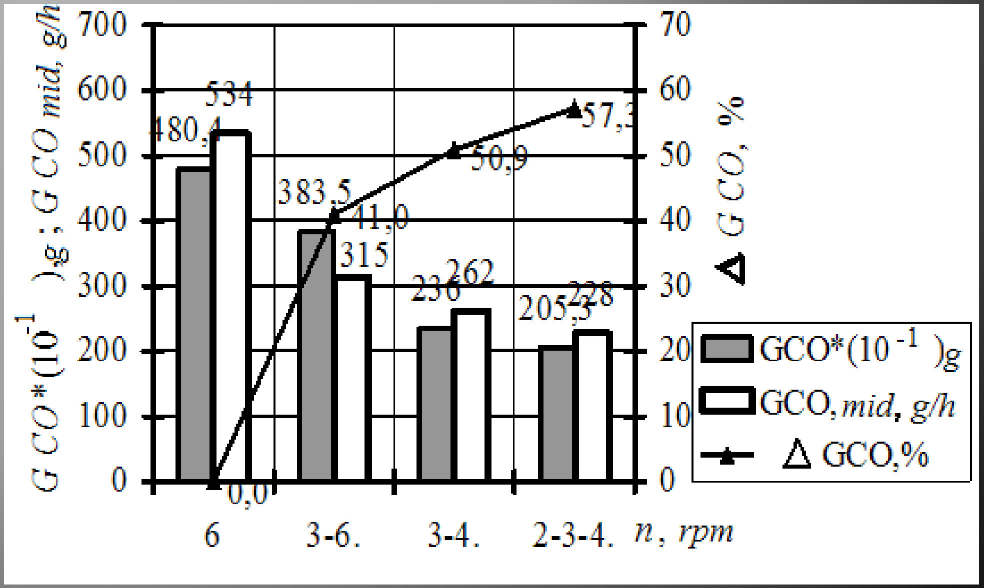




Universal characteristic of the UPS 292 PS engine in terms of specific emissions of carbon oxides(gCO),







Conclusions

1. The effectiveness of the cylinder (cycles) deactivation method is proved
2. The calculation-and-experimental method allows to calculate the gain in ecology and economy indexes cheap and quickly in engines with cylinder deactivation system.
3. Most effective engine regulation method is carried out by changing the number of deactivating cylinders or cycles depending on the value of the current engine load (7-18% more than deactivation half of the cylinders)
4. Decrease in average hourly fuel consumption by 11-14%.
5. NO_x↓ - 6,3 % (half of the cylinders 5,2 %);

   CO ↓- 57 % (half of the cylinders 41 %)

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

Eduard Savastenko
MOSCOW AUTOMOBILE AND ROAD CONSTRUCTION STATE TECHNICAL UNIVERSITY (MADI)
e.d.u.a.r.d@inbox.ru
Mobile: +7 963 766 60 51
64, Leningradsky prospect, Moscow, Russia, 125319
http://www.madi.ru

Northumbria University NEWCASTLE
НАМИ
Newcastle University
University of Sunderland
BRITISH COUNCIL