MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE

NATIONAL TECHNICAL UNIVERSITY
«KHARKIV POLYTECHNICAL INSTITUTE»

METHODOLOGICAL INSTRUCTIONS

for performing laboratory work

“Automobile engines performance characteristics”

for students of specialties
J8 Automobile transport
G11 Engineering

Kharkiv
NTU «KhPI»
2025

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CONTANT

INTRODUCTION

At present, the problems of constructing and studying mathematical models of systems for various purposes and signals of various kinds occupy one of the leading places in modern science. The penetration of mathematical methods into engineering, natural sciences and humanities follows the path of mathematical design and modelling of the corresponding objects, and the ever-increasing capabilities of computer technology ensure the great success of this scientific direction.

An important aspect of modelling is that the model must be an adequate substitute for the real situation, a real system. The model reduces the redundancy of information storage, automatically taking into account the values that correspond to the real object and characterise it, presented in the form of input and output values and state characteristics..

The MATLAB system provides an intelligent environment for organising computations for hundreds of thousands of professionals in engineering and scientific research. The MATLAB system is a leader in providing a convenient, integrated programming language for implementing a wide variety of mathematical algorithms and mathematical modelling tasks. The package also includes Simulink, a visual modelling tool that allows you to build and explore mathematical models without programming.

MATLAB programming offers the greatest flexibility, richness, and convenience for solving and exploring mathematical problems. In presenting the material, preference has been given to the simplest language constructs, by studying which you can create a wide variety of non-trivial mathematical algorithms.

Laboratory work 1

External speed characteristic of a gasoline engine.

Purpose of the work: to acquire practical skills in constructing the external speed characteristic of a spark-ignition engine based on the results of experimental data.

Task:

Based on the initial data of spark-ignition engines (options 1-5), construct graphs of the external speed characteristic:

1. Dependence of effective torque, power, specific and hourly fuel consumption on the engine shaft rotation frequency.
2. Dependence of indicator, mechanical and effective efficiency on the engine shaft rotation frequency.
3. Dependence of indicator, mechanical and effective power on the engine shaft rotation frequency.
4. Dependence of indicator, mechanical and effective pressure on the engine shaft rotation frequency.
5. Dependence of excess air coefficient, filling coefficient on the engine shaft rotation frequency.

Option 1. Passenger car with a working volume of the engine with spark ignition V_h = 1,3 *l*.

Point	n, rpm	P_w, kg	t, sec	P_{mex}, kg	ΔV_a, m^3
1	2400	8,215	109,2	2,391	2,183
2	2600	9,287	100,0	2,466	2,173
3	2800	10,358	91,7	2,541	2,162
4	3000	11,251	83,3	2,615	2,152
5	3200	12,144	75,0	2,69	2,122
6	3400	12,858	70,0	2,765	2,117
7	3600	13,573	65,0	2,839	2,122
8	3800	14,109	60,0	2,914	2,117
9	4000	14,466	55,8	2,989	2,111
10	4200	14,734	52,5	3,064	2,122
11	4400	14,787	50,0	3,138	2,132
12	4600	14,716	47,9	3,25	2,137
13	4800	14,394	46,3	3,363	2,142
14	5000	14,001	45,4	3,475	2,147
15	5200	13,608	44,2	3,587	2,152
16	5400	13,216	43,4	3,736	2,157
17	5600	12,608	42,9	3,886	2,162

18	5800	12,001	42,1	4,072	2,168
19	6000	11,358	41,7	4,259	2,173
20	6200	10,68	40,8	4,483	2,178
21	6400	9,965	40,0	4,708	2,183
22	6600	9,215	39,2	4,932	2,188
23	6800	8,429	38,3	5,156	2,193

Option 2. Passenger car with a working volume of the engine with spark ignition V_h = 1,5 *l*.

Point	n, rpm	P_w, kg	t, sec	P_{mex}, kg	ΔV_a, m^3
1	2200	9,968	100,8	2,271	2,14
2	2400	11,268	92,3	2,343	2,13
3	2600	12,568	84,6	2,414	2,12
4	2800	13,652	76,9	2,484	2,11
5	3000	14,735	69,2	2,556	2,09
6	3200	15,602	64,6	2,627	2,075
7	3400	16,469	60,0	2,697	2,08
8	3600	17,119	55,4	2,768	2,075
9	3800	17,553	51,5	2,840	2,07
10	4000	17,878	48,5	2,911	2,08
11	4200	17,943	46,2	2,981	2,09
12	4400	17,856	44,2	3,088	2,095
13	4600	17,683	42,7	3,195	2,1
14	4800	17,292	41,9	3,301	2,105
15	5000	16,976	40,8	3,408	2,11
16	5200	16,525	40,1	3,549	2,115
17	5400	16,07	39,6	3,692	2,12
18	5600	15,602	38,8	3,868	2,125
19	5800	14,952	38,5	4,046	2,13
20	6000	14,259	37,7	4,259	2,135
21	6200	13,522	36,9	4,473	2,14
22	6400	12,742	36,2	4,685	2,145
23	6600	11,918	35,4	4,898	2,15

Option 3. Passenger car with a working volume of the engine with spark ignition V_h = 1,8 *l*.

Point	n, rpm	P_w, kg	t, sec	P_{mex}, kg	ΔV_a, m^3
1	1400	11,48	90,3	2,511	1,8
2	1600	12,978	82,8	2,589	1,9
3	1800	14,475	75,9	2,668	1,96
4	2000	15,723	69,0	2,746	2
5	2200	16,971	62,1	2,825	2,02
6	2400	17,969	57,9	2,903	2,06
7	2600	18,968	53,8	2,981	2,07
8	2800	19,716	49,7	3,060	2,075
9	3000	20,216	46,2	3,138	2,07
10	3200	20,565	43,4	3,217	2,08
11	3400	20,665	41,4	3,295	2,09
12	3600	20,565	39,7	3,413	2,095
13	3800	20,465	38,3	3,531	2,1
14	4000	20,365	37,6	3,649	2,105
15	4200	20,266	36,6	3,766	2,11
16	4400	20,116	36,2	3,923	2,115
17	4600	19,916	35,5	4,080	2,12
18	4800	19,766	34,8	4,276	2,125
19	5000	19,567	34,5	4,472	2,13
20	5200	19,317	33,8	4,707	2,135
21	5400	19,018	33,1	4,943	2,14
22	5600	18,618	32,4	5,179	2,145
23	5800	18,219	31,7	5,414	2,15
24	6000	17,82	31,0	5,649	2,155
25	6200	17,121	30,3	5,884	2,16
26	6400	16,372	29,7	6,119	2,165
27	6600	15,574	29,0	6,356	2,17

Option 4. Passenger car with a working volume of the engine with spark ignition V_h = 1,4 *l*.

Point	n, rpm	P_w, kg	t, sec	P_{mex}, kg	ΔV_a, m^3
1	1600	12,398	90	2,69	1,5
2	1800	13,127	84	2,765	1,6
3	2000	13,857	78	2,839	1,7
4	2200	14,404	72	2,914	1,75
5	2400	14,768	67	2,989	1,8
6	2600	15,024	63	3,064	1,85
7	2800	15,096	60	3,138	1,9
8	3000	15,024	57,5	3,25	1,95
9	3200	14,951	55,5	3,363	2
10	3400	14,878	54,5	3,475	2,05
11	3600	14,805	53	3,587	2,07
12	3800	14,695	52,5	3,736	2,1
13	4000	14,55	51,5	3,886	2,1
14	4200	14,44	50,5	4,072	2,105
15	4400	14,221	50	4,259	2,11
16	4600	14,003	49	4,483	2,115
17	4800	13,711	48	4,708	2,12
18	5000	13,383	47	4,932	2,125
19	5200	13,091	46	5,156	2,13
20	5400	12,763	45	5,38	2,135
21	5600	12,325	44	5,604	2,14
22	5800	11,778	43	5,828	2,145
23	6000	11,231	42	6,053	2,15

Option 5. Passenger car with a working volume of the engine with spark ignition V_h = 1,5 *l*.

Point	n, rpm	P_w, kg	t, sec	P_{mex}, kg	ΔV_a, m^3
1	1500	9,813	117,9	2,505	1,8
2	1700	11,092	108	2,583	1,9
3	1900	12,372	99	2,662	1,96
4	2100	13,439	90	2,74	2
5	2300	14,506	81	2,818	2,01
6	2500	15,359	75,6	2,896	2,05
7	2700	16,212	70,2	2,975	2,07
8	2900	16,852	64,8	3,053	2,075
9	3100	17,279	60,3	3,131	2,07
10	3300	17,577	56,7	3,21	2,08
11	3500	17,663	54	3,288	2,09
12	3700	17,577	51,75	3,405	2,095
13	3900	17,449	49,95	3,523	2,1
14	4100	17,279	49,05	3,64	2,105
15	4300	17,065	47,7	3,758	2,11
16	4500	16,724	47,25	3,914	2,115
17	4700	16,383	46,35	4,071	2,12
18	4900	15,999	45,45	4,266	2,125
19	5100	15,529	45	4,462	2,13
20	5300	15,06	44,1	4,697	2,135
21	5500	14,591	43,2	4,932	2,14
22	5700	14,122	42,3	5,167	2,145
23	5900	13,567	41,4	5,401	2,15
24	6100	12,97	40,5	5,636	2,155
25	6300	12,33	39,6	5,871	2,16
26	6500	11,647	38,7	6,106	2,165
27	6700	10,922	37,8	6,341	2,17

Calculation formulas.

1. Effective engine torque, Nm:

$$M_e = P_w \cdot g \cdot l, \quad (1.1)$$

where P_w – force on the dynamometer, kg (from the table);
g – gravity constant, 9,81 m/sec^2;
l – length of the dynamometer lever, 0,7162 m.

2. Effective engine power, kW:

$$N_e = \frac{M_e \cdot n}{9550}, \quad (1.2)$$

where n – engine speed, rpm (from the table);

3. Hourly fuel consumption, kg/h:

$$G_{\text{t}} = \frac{3,6 \cdot \Delta G_{\text{t}}}{t} \cdot 1000, \tag{1.3}$$

where ΔG_{t} – applied mass of fuel weight, 0.2 kg;

t – time for the engine consump the applied mass of fuel, sec (from the table);

4. Brake specific effective fuel consumption, g/(kWh):

$$g_e = \frac{G_{\text{t}}}{N_e} \cdot 1000. \tag{1.4}$$

5. Torque of mechanical losses in the engine, Nm:

$$M_{\text{mex}} = P_{\text{mex}} \cdot g \cdot l. \tag{1.5}$$

6. Mechanical loss power, kW:

$$N_{\text{mex}} = \frac{M_{\text{mex}} \cdot n}{9550}. \tag{1.6}$$

7. Indicator engine power, kW:

$$N_i = N_e + N_{\text{mex}}. \tag{1.7}$$

8. Mechanical efficiency:

$$\eta_{\text{mex}} = \frac{N_e}{N_i}. \tag{1.8}$$

9. Indicator efficiency:

$$\eta_i = \frac{3600 \cdot N_i}{H_u \cdot G_{\text{т}}}, \tag{1.9}$$

where H_u – lower calorific value of gasoline, 44000 kJ/kg;

10. Efficient efficiency:

$$\eta_e = \eta_{\text{mex}} \cdot \eta_i. \tag{1.10}$$

11. Specific indicator fuel consumption, g/(kWh):

$$g_i = \frac{G_{\text{т}}}{N_i} \cdot 1000. \tag{1.11}$$

12. Mean indicator pressure, MPa:

$$p_i = \frac{G_{\text{т}} \cdot 30 \cdot \tau}{V_h \cdot n \cdot g_i} \cdot 1000, \tag{1.12}$$

where τ – engine stroke number (τ = 4);

V_h – engine displacement according to variant.

13. Mean effective pressure, MPa:

$$p_e = \frac{G_{\text{т}} \cdot 30 \cdot \tau}{V_h \cdot n \cdot g_e} \cdot 1000, \tag{1.13}$$

14. Mechanical loss pressure, MPa:

$$p_{\text{мех}} = p_i - p_e. \tag{1.14}$$

15. Density of air entering the cylinders, kg/m^3:

$$\rho_{в} = \frac{p_0}{R_{в} \cdot T_0}, \quad (1.15)$$

where p_0 – atmospheric pressure, 10^5 Pa;

$R_{в}$ – gas constant 286 J/(kg·K);

T_0 – air temperature 293 K.

16.Hourly air flow rate, kg/h:

$$G_{в} = \frac{\rho_{в} \cdot \Delta V_{в}}{t} \cdot 3600, \quad (1.16)$$

where $\Delta V_{в}$ – air flow rate, m^3 per time t (from the table).

17.Excess air ratio:

$$\alpha = \frac{G_{в}}{l_0 \cdot G_{т}}, \quad (1.17)$$

where l_0 – the amount of air theoretically required for the complete combustion of 1 kg of fuel. For gasoline l_0=14,96 kg/kg.

18.Filling factor:

$$\eta_v = \frac{p_i}{\rho_{в}} \cdot \frac{l_0}{H_u} \cdot \frac{\alpha}{\eta_i} \cdot 1000. \quad (1.18)$$

Questions:

1. Explain each obtained graphical dependence of engine performance on engine speed based on the external speed characteristic of a gasoline engine.

2. Explain the essence of the external speed characteristic of a gasoline engine.

Laboratory work 2

External speed characteristic of a diesel engine.

Purpose of the work: to acquire practical skills in constructing the external speed characteristic of a diesel engine based on the results of experimental data.

Task:

Based on the initial data of diesel engines (options 1-5), construct graphs of the external speed characteristic:

1. Dependence of effective torque, power, specific and hourly fuel consumption on the engine shaft rotation frequency.
2. Dependence of indicator, mechanical and effective efficiency on the engine shaft rotation frequency.
3. Dependence of indicator, mechanical and effective power on the engine shaft rotation frequency.
4. Dependence of indicator, mechanical and effective pressure on the engine shaft rotation frequency.
5. Dependence of excess air coefficient, filling coefficient on the engine shaft rotation frequency.

Option 1. Engine without turbocharging V_h = 11,15 *l.*

Point	n, rpm	P_w, kg	t, sec	P_{mex}, kg	ΔV_a, m^3
1	1000	112,44	31,30	27,11	3,08
2	1050	118,22	29,54	27,21	3,09
3	1100	122,40	28,13	27,37	3,12
4	1150	125,19	26,98	27,56	3,16
5	1200	126,81	26,05	27,77	3,21
6	1250	127,44	25,30	27,97	3,27
7	1300	127,28	24,69	28,18	3,33
8	1350	126,47	24,20	28,37	3,40
9	1400	125,16	23,80	28,55	3,47
10	1450	123,47	23,49	28,72	3,54
11	1500	121,53	23,23	28,89	3,61
12	1550	119,41	23,02	29,05	3,68
13	1600	117,20	22,85	29,22	3,74
14	1650	114,95	22,70	29,39	3,80
15	1700	112,71	22,55	29,58	3,86
16	1750	110,50	22,39	29,81	3,91
17	1800	108,35	22,21	30,06	3,95
18	1850	106,22	22,00	30,37	3,98
19	1900	104,11	21,74	30,74	4,00
20	1950	101,98	21,41	31,17	4,02

21	2000	99,76	21,01	31,69	4,02
22	2050	97,38	20,54	32,30	4,01

Option 2. Engine without turbocharging V_h = 14,86 *l*.

Point	n, rpm	P_w, kg	t, sec	P_{mex}, kg	ΔV_a, m^3
1	1000	109,83	25,75	26,97	3,10
2	1050	118,29	24,88	26,99	3,18
3	1100	125,85	24,13	27,02	3,25
4	1150	132,41	23,49	27,05	3,31
5	1200	137,92	22,93	27,10	3,37
6	1250	142,36	22,44	27,15	3,42
7	1300	145,73	21,99	27,22	3,47
8	1350	148,08	21,59	27,29	3,51
9	1400	149,46	21,22	27,38	3,55
10	1450	149,99	20,86	27,46	3,59
11	1500	149,76	20,52	27,55	3,62
12	1550	148,93	20,19	27,64	3,65
13	1600	147,62	19,85	27,73	3,67
14	1650	146,00	19,52	27,81	3,70
15	1700	144,20	19,17	27,89	3,72
16	1750	142,38	18,82	27,96	3,73
17	1800	140,64	18,46	28,04	3,74
18	1850	139,07	18,09	28,11	3,75
19	1900	137,72	17,72	28,19	3,75
20	1950	136,59	17,34	28,28	3,75
21	2000	135,60	16,96	28,39	3,74
22	2050	134,61	16,59	28,53	3,73
23	2100	133,37	16,22	28,73	3,71
24	2150	131,54	15,87	28,98	3,70
25	2200	128,65	15,54	29,32	3,69
26	2250	124,07	15,23	29,76	3,68
27	2300	117,03	14,95	30,34	3,67

Option 3. Engine without turbocharging V_h = 11,85 *l*.

Point	n, rpm	P_w, kg	t, sec	P_{mex}, kg	ΔV_a, m^3
1	1000	101,14	37,89	25,76	3,08
2	1050	106,59	35,34	25,92	3,11
3	1100	110,62	33,33	26,14	3,15
4	1150	113,40	31,74	26,38	3,20
5	1200	115,10	30,46	26,64	3,25
6	1250	115,88	29,44	26,89	3,30
7	1300	115,87	28,62	27,13	3,35
8	1350	115,22	27,96	27,37	3,41
9	1400	114,03	27,43	27,58	3,47
10	1450	112,42	27,01	27,79	3,54
11	1500	110,50	26,67	27,99	3,60
12	1550	108,35	26,40	28,18	3,67
13	1600	106,05	26,17	28,37	3,74
14	1650	103,66	25,97	28,57	3,80
15	1700	101,25	25,78	28,79	3,86
16	1750	98,86	25,57	29,03	3,91
17	1800	96,52	25,34	29,31	3,96
18	1850	94,27	25,34	29,64	3,99
19	1900	92,10	24,72	30,02	4,02
20	1950	90,03	24,30	30,48	4,03
21	2000	88,06	23,79	31,01	4,02
22	2050	86,15	23,18	31,64	4,00
23	2100	84,28	22,47	32,38	3,95
24	2150	82,41	21,66	33,23	3,87
25	2200	80,49	20,76	34,22	3,77

Option 4. Supercharged engine
(overpressure $0.7 \cdot 10^5$ Pa) V_h = 7,14 *l*.

Point	n, rpm	P_w, kg	t, sec	P_{mex}, kg	ΔV_a, m^3
1	1000	96,60	40,45	21,69	2,08
2	1050	101,46	37,55	22,05	2,11
3	1100	105,04	35,29	22,44	2,13
4	1150	107,53	33,51	22,84	2,16
5	1200	109,07	32,09	23,24	2,20
6	1250	109,80	30,96	23,63	2,23
7	1300	109,86	30,05	24,00	2,27
8	1350	109,36	29,32	24,35	2,31
9	1400	108,40	28,75	24,68	2,35
10	1450	107,10	28,28	24,98	2,39
11	1500	105,51	27,91	25,27	2,44
12	1550	103,73	27,62	25,55	2,48
13	1600	101,82	27,37	25,82	2,53
14	1650	99,81	27,15	26,10	2,57
15	1700	97,75	26,94	26,39	2,61
16	1750	95,66	26,71	26,70	2,65
17	1800	93,57	26,46	27,05	2,68
18	1850	91,47	26,16	27,44	2,70
19	1900	89,35	25,78	27,88	2,72
20	1950	87,20	25,33	28,39	2,73
21	2000	84,99	24,77	28,97	2,72

Option 5. Supercharged engine
(overpressure $0.4 \cdot 10^5$ Pa) V_h = 6.3 *l*.

Point	n, rpm	P_w, kg	t, sec	P_{mex}, kg	ΔV_a, m^3
1	1000	69,46	51,43	16,27	2,28
2	1050	74,30	47,90	16,88	2,31
3	1100	77,69	45,30	17,51	2,35
4	1150	79,88	43,33	18,13	2,40
5	1200	81,12	41,81	18,72	2,45
6	1250	81,61	40,61	19,29	2,52
7	1300	81,54	39,63	19,83	2,58
8	1350	81,06	38,80	20,33	2,65
9	1400	80,29	38,09	20,80	2,72
10	1450	79,34	37,44	21,24	2,79
11	1500	78,28	36,83	21,65	2,85
12	1550	77,14	36,25	22,05	2,90
13	1600	75,95	35,66	22,43	2,95
14	1650	74,70	35,08	22,81	3,00
15	1700	73,35	34,48	23,20	3,03
16	1750	71,82	33,88	23,60	3,06
17	1800	70,03	33,27	24,03	3,08
18	1850	67,86	32,66	24,50	3,10

Calculation formulas.

1. Effective engine torque, Nm:

$$M_e = P_w \cdot g \cdot l, \tag{2.1}$$

where P_w – force on the dynamometer, kg (from the table);
g – gravity constant, 9,81 m/sec^2;
l – length of the dynamometer lever, 0,7162 m.

2. Effective engine power, kW:

$$N_e = \frac{M_e \cdot n}{9550}, \tag{2.2}$$

where *n* – engine speed, rpm (from the table);

3. Hourly fuel consumption, kg/h:

$$G_t = \frac{3,6 \cdot \Delta G_t}{t} \cdot 1000, \tag{2.3}$$

where ΔG_t – applied mass of fuel weight, 0.2 kg;
t – time for the engine consump the applied mass of fuel, sec (from the table);

4. Brake specific effective fuel consumption, g/(kWh):

$$g_e = \frac{G_t}{N_e} \cdot 1000. \tag{2.4}$$

5. Torque of mechanical losses in the engine, Nm:

$$M_{\text{mex}} = P_{\text{mex}} \cdot g \cdot l. \quad (2.5)$$

6. Mechanical loss power, kW:

$$N_{\text{mex}} = \frac{M_{\text{mex}} \cdot n}{9550}. \quad (2.6)$$

7. Indicator engine power, kW:

$$N_i = N_e + N_{\text{mex}}. \quad (2.7)$$

8. Mechanical efficiency:

$$\eta_{\text{mex}} = \frac{N_e}{N_i}. \quad (2.8)$$

9. Indicator efficiency:

$$\eta_i = \frac{3600 \cdot N_i}{H_u \cdot G_{\text{т}}}, \quad (2.9)$$

where H_u – lower calorific value of diesel fuel, 42500 kJ/kg;

10. Efficient efficiency:

$$\eta_e = \eta_{\text{mex}} \cdot \eta_i. \quad (2.10)$$

11. Specific indicator fuel consumption, g/(kWh):

$$g_i = \frac{G_{\text{т}}}{N_i} \cdot 1000. \quad (2.11)$$

12. Mean indicator pressure, MPa:

$$p_i = \frac{G_{\text{т}} \cdot 30 \cdot \tau}{V_h \cdot n \cdot g_i} \cdot 1000, \quad (2.12)$$

where τ – engine stroke number (τ = 4);

V_h – engine displacement according to variant.

13. Mean effective pressure, MPa:

$$p_e = \frac{G_{\text{т}} \cdot 30 \cdot \tau}{V_h \cdot n \cdot g_e} \cdot 1000, \quad (2.13)$$

14. Mechanical loss pressure, MPa:

$$p_{\text{мех}} = p_i - p_e. \quad (2.14)$$

15. Density of air entering the cylinders, kg/m^3:

$$\rho_{\text{в}} = \frac{p_0 + p_{\text{ep}}}{R_{\text{в}} \cdot T_0} \quad (2.15)$$

where p_0 – atmospheric pressure, 10^5 Pa;

p_{ep} – excess pressure according to the option, Pa;

$R_{\text{в}}$ – gas constant 286 J/(kg·K);

T_0 – air temperature 293 K.

16. Hourly air flow rate, kg/h:

$$G_{\text{в}} = \frac{\rho_{\text{в}} \cdot \Delta V_{\text{в}}}{t} \cdot 3600, \quad (2.16)$$

where $\Delta V_{в}$ – air flow rate, m^3 per time t (from the table).

17. Excess air ratio:

$$\alpha = \frac{G_{в}}{l_0 \cdot G_{т}}, \tag{2.17}$$

where l_0 – the amount of air theoretically required for the complete combustion of 1 kg of fuel. For diesel fuel l_0=14,45 kg/kg.

18. Filling factor:

$$\eta_v = \frac{p_i}{\rho_{в}} \cdot \frac{l_0}{H_u} \cdot \frac{\alpha}{\eta_i} \cdot 1000. \tag{2.18}$$

Questions:

1. Explain each obtained graphical dependence of engine performance on the speed of rotation according to the external speed characteristic of a diesel engine.

2. Explain the essence of the external speed characteristic of a diesel engine.

Laboratory work 3

Gasoline engine load characteristic.

Objective: to acquire practical skills in constructing the load characteristic of a spark-ignition engine based on experimental data.

Task:

Based on the initial data of spark-ignition engines (options 1-5), construct load characteristic graphs:

1. Dependence of hourly fuel consumption on engine power.
2. Dependence of indicative and effective specific fuel consumption on engine power.
3. Dependence of indicative, mechanical and effective efficiency on engine power.
4. Dependence of indicative and effective pressure on engine power.
5. Dependence of excess air coefficient, filling coefficient on engine power.

Option 1. A passenger car with spark ignition with an engine displacement of V_h = 1,3 *l* at 5400 rpm.

Point	P_w, kg	t, sec	ΔV_a, m^3
1	0,1	82,3	1,89
2	0,503	80,6	1,977
3	1,007	79,1	2,062
4	1,51	77,6	2,144
5	2,014	76,2	2,223
6	2,517	74,8	2,301
7	3,021	73,6	2,375
8	3,524	72,3	2,447
9	4,027	71,2	2,515
10	4,531	70,0	2,578
11	5,034	68,9	2,636
12	5,538	67,8	2,687
13	6,041	66,6	2,731
14	6,545	65,5	2,767
15	7,048	64,3	2,793
16	7,551	63,0	2,807
17	8,055	61,7	2,809
18	8,558	60,3	2,797
19	9,062	58,8	2,771
20	9,565	57,2	2,729
21	10,069	55,6	2,671
22	10,572	53,8	2,597

23	11,075	51,9	2,507
24	11,579	50,0	2,401
25	12,082	48,0	2,281
26	12,586	45,9	2,147

Option 2. A passenger car with spark ignition with an engine displacement of V_h = 1,5 *l* at 4200 rpm.

Point	P_w, kg	t, sec	ΔV_a, m^3
1	0,1	92,0	1,552
2	0,647	90,0	1,656
3	1,295	88,1	1,756
4	1,942	86,2	1,853
5	2,589	84,4	1,946
6	3,236	82,7	2,036
7	3,884	81,1	2,124
8	4,531	79,6	2,208
9	5,178	78,2	2,289
10	5,825	76,8	2,367
11	6,473	75,4	2,44
12	7,12	74,2	2,509
13	7,767	72,9	2,572
14	8,414	71,7	2,629
15	9,062	70,4	2,679
16	9,709	69,2	2,72
17	10,356	67,9	2,752
18	11,003	66,5	2,773
19	11,651	65,1	2,782
20	12,298	63,6	2,779
21	12,945	62,0	2,761
22	13,593	60,4	2,729
23	14,24	58,6	2,681
24	14,887	56,7	2,618
25	15,534	54,8	2,539
26	16,182	52,7	2,446
27	16,829	50,6	2,338
28	17,476	48,4	2,217
29	18,123	46,1	2,085

Option 3. A passenger car with spark ignition with an engine displacement of V_h = 1,8 *l* at 6000 rpm.

Point	P_w, kg	t, sec	ΔV_a, m^3
1	0,1	51,8	0,773
2	0,68	51,4	0,912
3	1,359	50,7	1,048
4	2,039	49,9	1,181
5	2,719	49,0	1,311
6	3,398	48,0	1,437
7	4,078	47,0	1,559
8	4,757	46,0	1,677
9	5,437	45,1	1,791
10	6,117	44,3	1,902
11	6,796	43,5	2,009
12	7,476	42,7	2,112
13	8,156	42,1	2,21
14	8,835	41,5	2,303
15	9,515	40,9	2,389
16	10,194	40,3	2,467
17	10,874	39,8	2,535
18	11,554	39,2	2,59
19	12,233	38,7	2,631
20	12,913	38,0	2,654
21	13,593	37,3	2,657
22	14,272	36,5	2,637
23	14,952	35,6	2,593
24	15,631	34,6	2,521
25	16,311	33,4	2,423
26	16,991	32,1	2,298
27	17,67	30,7	2,147

Option 4. A passenger car with spark ignition with an engine displacement of V_h = 1,4 *l* at 4600 rpm.

Point	P_w, kg	t, sec	ΔV_a, m^3
1	0,1	93,2	1,505
2	0,591	91,0	1,668
3	1,182	89,0	1,819
4	1,773	87,2	1,96
5	2,364	85,4	2,09
6	2,955	83,8	2,209
7	3,546	82,3	2,318
8	4,137	80,8	2,415
9	4,728	79,4	2,5
10	5,319	78,0	2,573
11	5,91	76,5	2,634
12	6,501	75,1	2,681
13	7,092	73,6	2,714
14	7,683	72,0	2,732
15	8,274	70,3	2,736
16	8,865	68,5	2,725
17	9,456	66,6	2,699
18	10,047	64,6	2,658
19	10,638	62,4	2,603
20	11,229	60,2	2,536
21	11,82	57,8	2,456
22	12,411	55,4	2,366
23	13,002	52,8	2,267
24	13,593	50,2	2,161

Option 5. A passenger car with spark ignition with an engine displacement of V_h = 1,5 *l* at 6500 rpm.

Point	P_w, kg	t, sec	ΔV_a, m^3
1	0,1	68,9	1,36
2	0,418	67,6	1,488
3	0,836	66,4	1,611
4	1,255	65,2	1,729
5	1,673	64,1	1,842
6	2,091	63,1	1,95
7	2,509	62,1	2,051
8	2,928	61,2	2,147
9	3,346	60,4	2,236
10	3,764	59,6	2,319
11	4,182	58,8	2,395
12	4,601	58,0	2,463
13	5,019	57,3	2,524
14	5,437	56,5	2,576
15	5,855	55,8	2,62
16	6,273	55,0	2,655
17	6,692	54,2	2,68
18	7,11	53,3	2,694
19	7,528	52,4	2,698
20	7,946	51,4	2,69
21	8,365	50,3	2,671
22	8,783	49,2	2,641
23	9,201	47,9	2,6
24	9,619	46,6	2,548
25	10,038	45,1	2,485
26	10,456	43,6	2,413
27	10,874	42,0	2,332
28	11,292	40,4	2,244
29	11,71	38,7	2,151

Calculation formulas.

1. Effective engine torque, Nm:

$$M_e = P_w \cdot g \cdot l, \quad (3.1)$$

where P_w – force on the dynamometer, kg (from the table);
g – gravity constant, 9,81 m/sec^2;
l – length of the dynamometer lever, 0,7162 m.

2. Effective engine power, kW:

$$N_e = \frac{M_e \cdot n}{9550}, \quad (3.2)$$

where n – engine speed, rpm (from the table);

3. Hourly fuel consumption, kg/h:

$$G_t = \frac{3,6 \cdot \Delta G_t}{t} \cdot 1000, \quad (3.3)$$

where ΔG_t – applied mass of fuel weight, 0.2 kg;

t – time for the engine consump the applied mass of fuel, sec (from the table);

4. Brake specific effective fuel consumption, g/(kWh):

$$g_e = \frac{G_t}{N_e} \cdot 1000. \quad (3.4)$$

5. Torque of mechanical losses in the engine, Nm:

Not needed. (3.5)

6. The power of mechanical losses is taken from laboratory work on the external speed characteristic of the same variant number at the crankshaft rotation frequency according to the task, kW:

$$N_{mex} = f(n). \quad (3.6)$$

7. Indicator engine power, kW:

$$N_i = N_e + N_{mex}. \quad (3.7)$$

8. Mechanical efficiency:

$$\eta_{mex} = \frac{N_e}{N_i}. \quad (3.8)$$

9. Indicator efficiency:

$$\eta_i = \frac{3600 \cdot N_i}{H_u \cdot G_т}, \quad (3.9)$$

where H_u – lower calorific value of gasoline, 44000 kJ/kg;

10. Efficient efficiency:

$$\eta_e = \eta_{mex} \cdot \eta_i. \quad (3.10)$$

11. Specific indicator fuel consumption, g/(kWh):

$$g_i = \frac{G_т}{N_i} \cdot 1000. \quad (3.11)$$

12. Mean indicator pressure, MPa:

$$p_i = \frac{G_т \cdot 30 \cdot \tau}{V_h \cdot n \cdot g_i} \cdot 1000, \quad (3.12)$$

where τ – engine stroke number (τ = 4);

V_h – engine displacement according to variant.

13. Mean effective pressure, MPa:

$$p_e = \frac{G_т \cdot 30 \cdot \tau}{V_h \cdot n \cdot g_e} \cdot 1000, \quad (3.13)$$

14. Mechanical loss pressure, MPa:

$$p_{\text{мех}} = p_i - p_e . \quad (3.14)$$

15.Density of air entering the cylinders, kg/m^3:

$$\rho_{\text{в}} = \frac{p_0}{R_{\text{в}} \cdot T_0}, \quad (3.15)$$

where p_0 – atmospheric pressure, 10^5 Pa;

$R_{\text{в}}$ – gas constant 286 J/(kg·K);

T_0 – air temperature 293 K.

16.Hourly air flow rate, kg/h:

$$G_{\text{в}} = \frac{\rho_{\text{в}} \cdot \Delta V_{\text{в}}}{t} \cdot 3600, \quad (3.16)$$

where $\Delta V_{\text{в}}$ – air flow rate, m^3 per time t (from the table).

17.Excess air ratio:

$$\alpha = \frac{G_{\text{в}}}{l_0 \cdot G_{\text{т}}}, \quad (3.17)$$

where l_0 – the amount of air theoretically required for the complete combustion of 1 kg of fuel. For gasoline l_0=14,96 kg/kg.

18.Filling factor:

$$\eta_v = \frac{p_i}{\rho_{\text{в}}} \cdot \frac{l_0}{H_u} \cdot \frac{\alpha}{\eta_i} \cdot 1000 . \quad (3.18)$$

Questions:

1. Explain each obtained graphical dependence of engine performance on power according to the load characteristic of a gasoline engine.

2. Explain the essence of the load characteristic of a gasoline engine.

Laboratory work 4

Diesel engine load characteristic.

Objective: to acquire practical skills in constructing the load characteristic of a diesel engine based on experimental data.

Task:

Based on the initial data of spark-ignition engines (options 1-5), construct load characteristic graphs:

1. Dependence of hourly fuel consumption on engine power.
2. Dependence of indicative and effective specific fuel consumption on engine power.
3. Dependence of indicative, mechanical and effective efficiency on engine power.
4. Dependence of indicative and effective pressure on engine power.
5. Dependence of excess air coefficient, filling coefficient on engine power.

Option 1. Naturally aspirated engine V_h = 11,15 *l* at 1800 rpm.

Point	P_w, kg	t, sec	ΔV_a, m^3
1	0,01	125,22	17,78
2	3,78	109,08	15,49
3	7,55	96,64	13,72
4	11,33	86,75	12,32
5	15,10	78,69	11,17
6	18,88	71,98	10,22
7	22,65	66,30	9,41
8	26,43	61,44	8,72
9	30,21	57,21	8,12
10	33,98	53,50	7,59
11	37,76	50,22	7,12
12	41,53	47,30	6,71
13	45,31	44,67	6,33
14	49,08	42,30	6,00
15	52,86	40,14	5,69
16	56,64	38,17	5,41
17	60,41	36,37	5,15
18	64,19	34,71	4,92
19	67,96	33,18	4,70
20	71,74	31,76	4,49
21	75,51	30,44	4,30
22	79,29	29,22	4,13

23	83,07	28,07	3,96
24	86,84	27,00	3,81
25	90,62	25,99	3,66
26	94,39	25,05	3,52
27	98,17	24,16	3,39
28	101,94	23,33	3,27
29	105,72	22,54	3,15

Option 1. Naturally aspirated engine V_h = 14,86 *l* at 2200 rpm.

Point	P_w, kg	t, sec	ΔV_a, m^3
1	0,01	85,71	16,66
2	4,94	73,43	14,27
3	9,89	64,13	12,46
4	14,83	56,87	11,05
5	19,77	51,06	9,92
6	24,71	46,32	8,99
7	29,66	42,39	8,23
8	34,60	39,08	7,59
9	39,54	36,27	7,04
10	44,49	33,84	6,56
11	49,43	31,73	6,15
12	54,37	29,87	5,79
13	59,31	28,23	5,47
14	64,26	26,76	5,19
15	69,20	25,45	4,93
16	74,14	24,25	4,70
17	79,08	23,16	4,49
18	84,03	22,16	4,29
19	88,97	21,24	4,11
20	93,91	20,38	3,94
21	98,86	19,57	3,79
22	103,80	18,81	3,64
23	108,74	18,08	3,50
24	113,68	17,39	3,36
25	118,63	16,73	3,23
26	123,57	16,09	3,11
27	128,51	15,48	2,99

Calculation formulas.

1. Effective engine torque, Nm:

$$M_e = P_w \cdot g \cdot l, \quad (4.1)$$

where P_w – force on the dynamometer, kg (from the table);
g – gravity constant, 9,81 m/sec^2;
l – length of the dynamometer lever, 0,7162 m.

2. Effective engine power, kW:

$$N_e = \frac{M_e \cdot n}{9550}, \quad (4.2)$$

where n – engine speed, rpm (from the table);

3. Hourly fuel consumption, kg/h:

$$G_t = \frac{3,6 \cdot \Delta G_t}{t} \cdot 1000, \quad (4.3)$$

where ΔG_t – applied mass of fuel weight, 0.2 kg;
t – time for the engine consuming the applied mass of fuel, sec (from the table);

4. Brake specific effective fuel consumption, g/(kWh):

$$g_e = \frac{G_t}{N_e} \cdot 1000. \quad (4.4)$$

5. Torque of mechanical losses in the engine, Nm:

Not needed. (4.5)

6. The power of mechanical losses is taken from laboratory work on the external speed characteristic of the same variant number at the crankshaft rotation frequency according to the task, kW:

$$N_{mex} = f(n). \quad (4.6)$$

7. Indicator engine power, kW:

$$N_i = N_e + N_{mex}. \quad (4.7)$$

8. Mechanical efficiency:

$$\eta_{mex} = \frac{N_e}{N_i}. \quad (4.8)$$

9. Indicator efficiency:

$$\eta_i = \frac{3600 \cdot N_i}{H_u \cdot G_т}, \quad (4.9)$$

where H_u – lower calorific value of diesel fuel, 42500 kJ/kg;

10. Efficient efficiency:

$$\eta_e = \eta_{mex} \cdot \eta_i. \quad (4.10)$$

11. Specific indicator fuel consumption, g/(kWh):

$$g_i = \frac{G_т}{N_i} \cdot 1000. \quad (4.11)$$

12. Mean indicator pressure, MPa:

$$p_i = \frac{G_т \cdot 30 \cdot \tau}{V_h \cdot n \cdot g_i} \cdot 1000, \quad (4.12)$$

where τ – engine stroke number (τ = 4);

V_h – engine displacement according to variant.

13.Mean effective pressure, MPa:

$$p_e = \frac{G_т \cdot 30 \cdot \tau}{V_h \cdot n \cdot g_e} \cdot 1000, \quad (4.13)$$

14.Mechanical loss pressure, MPa:

$$p_{мех} = p_i - p_e. \quad (4.14)$$

15.Density of air entering the cylinders, kg/m^3:

$$\rho_в = \frac{p_0}{R_в \cdot T_0}, \quad (4.15)$$

where p_0 – atmospheric pressure, 10^5 Pa;

$R_в$ – gas constant 286 J/(kg·K);

T_0 – air temperature 293 K.

16.Hourly air flow rate, kg/h:

$$G_в = \frac{\rho_в \cdot \Delta V_в}{t} \cdot 3600, \quad (4.16)$$

where $\Delta V_в$ – air flow rate, m^3 per time t (from the table).

17.Excess air ratio:

$$\alpha = \frac{G_в}{l_0 \cdot G_т}, \quad (4.17)$$

where l_0 – the amount of air theoretically required for the complete combustion of 1 kg of fuel. For diesel fuel l_0=14,45 kg/kg.

18.Filling factor:

$$\eta_v = \frac{p_i}{\rho_в} \cdot \frac{l_0}{H_u} \cdot \frac{\alpha}{\eta_i} \cdot 1000. \quad (4.18)$$

Questions:

1. Explain each obtained graphical dependence of engine performance on power according to the load characteristic of a diesel engine.

2. Explain the essence of the load characteristic of a diesel engine.

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до виконання лабораторних робіт
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