Tractor fuel consumption, exhaust emissions and their normative assessment during field application

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Objectives and tasks of the research

The objective:

- to create a methodology for monitoring engine performance indicators and exhaust emission characteristics for a tractor working in real conditions

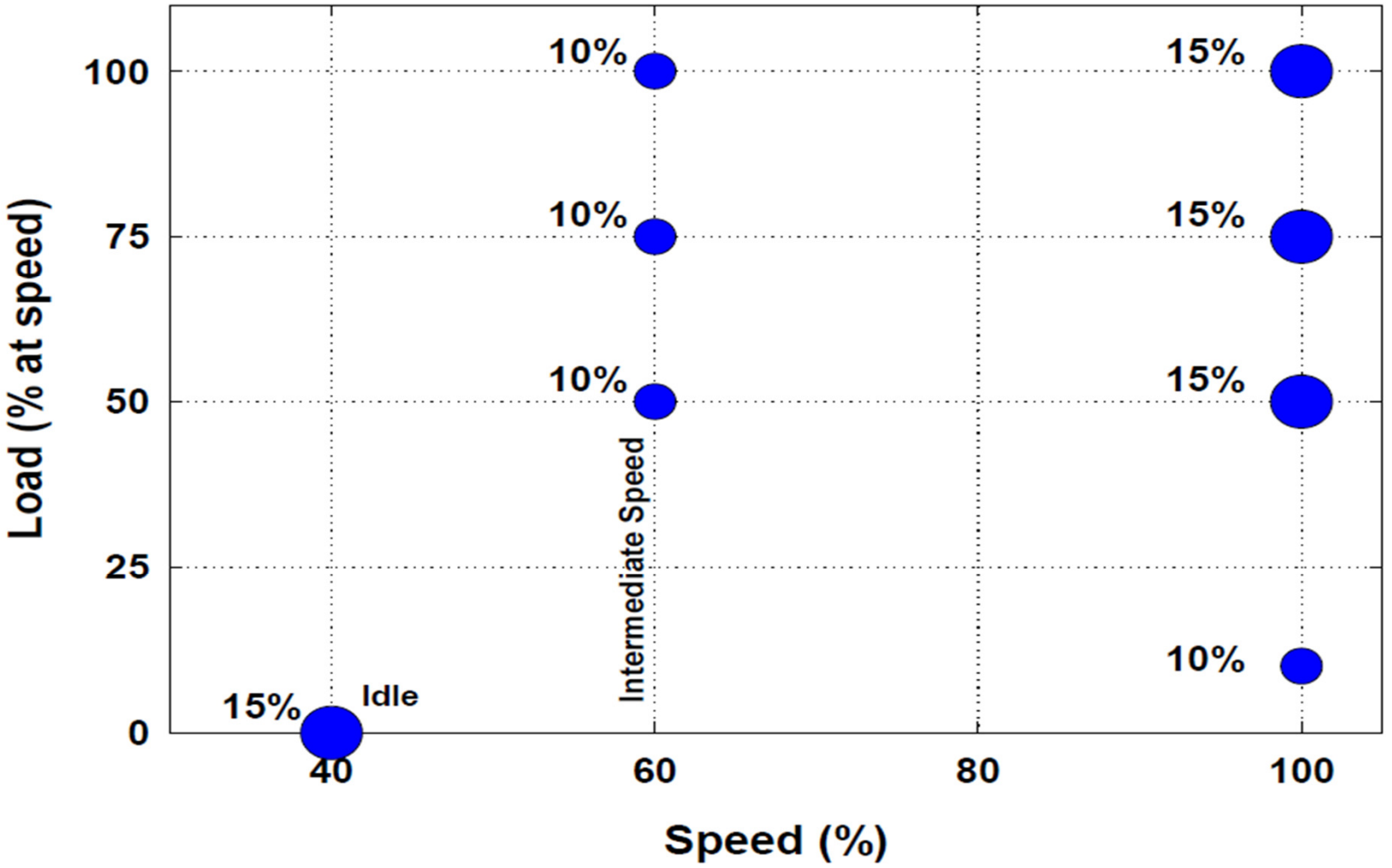
The tasks of achieving the objective:

- to investigate possibilities for monitoring engine performance indicators and emission characteristics by using information compiled in tractors' control processors;
- to analyze the level of engine performance indicators (engine load, fuel consumption, CO_2, CO and NO_x emissions) and their changes during field applications on the basis of information collected in tractor engine control processors.

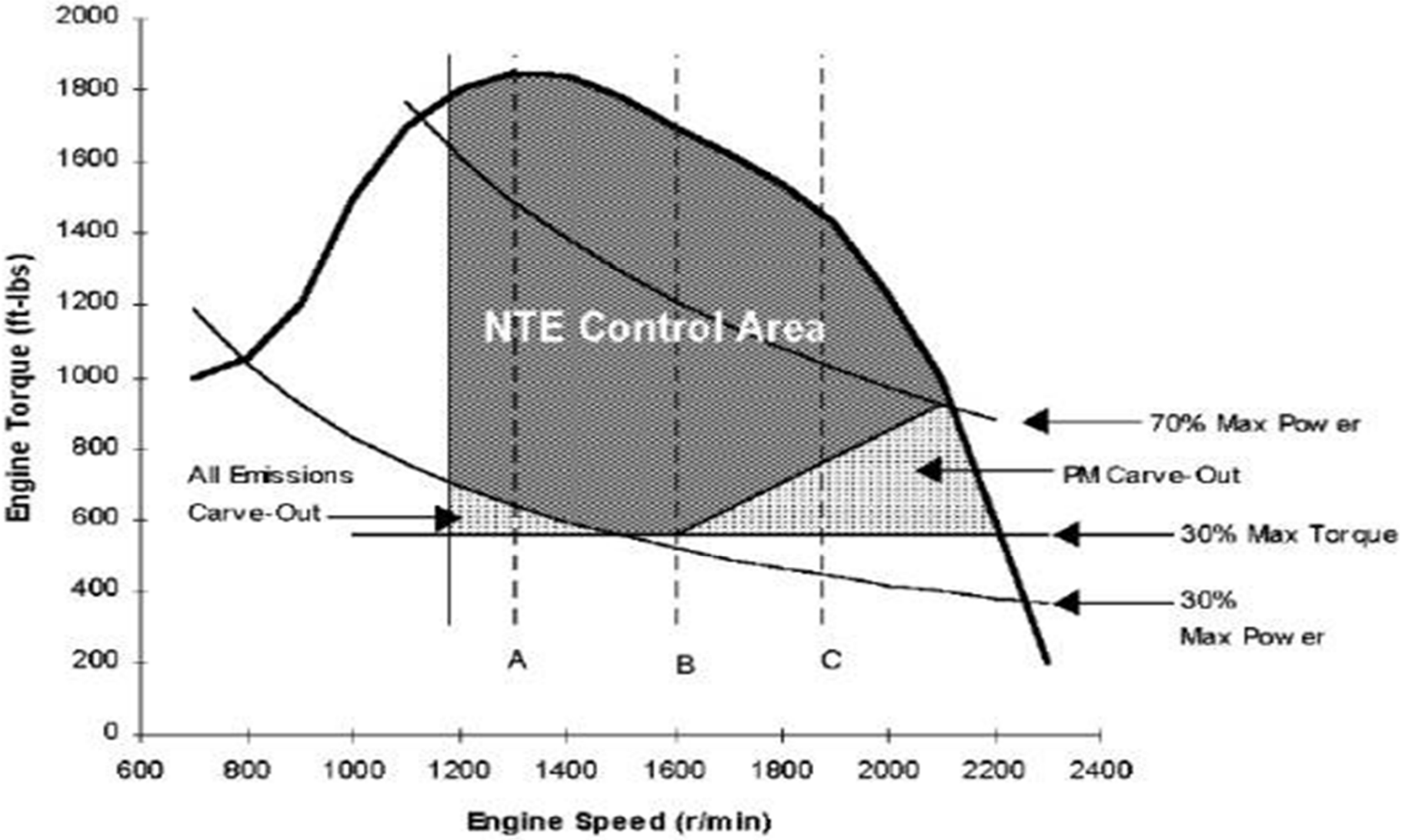
Normative assessment of engine oxide emissions

- Agricultural tractors are used all-over the year, with diverse implements to perform different field operations. The tractor engines are therefore subjected to highly variable demands in terms of speed and load.
- Current standards used to assess off-road vehicle performance regarding fuel efficiency and pollutant emissions are respectively defined by the European directive procedures and the worldwide emissions standards
- The emission standards address the emissions of NO_x, HC, PM, and CO. The ISO-8178 Type C 8-Mode Cycle is the standard test used for the emissions evaluation of off-road diesel engine powered equipment today.
- In addition to the 8-mode test of previous Tier standards, the Tier 4 standard has two added requirements, including one of the not-to-exceed (NTE) zones and the non-road transient test cycle (NRTC)
- The United States Environmental Protection Agency (US EPA) has introduced NTE emission limits and testing requirements, as an additional instrument to make sure that heavy-duty engine emissions are controlled over the full range of speed and load combinations commonly experienced in use.

Steady state Test Cycle ISO 8178 C1

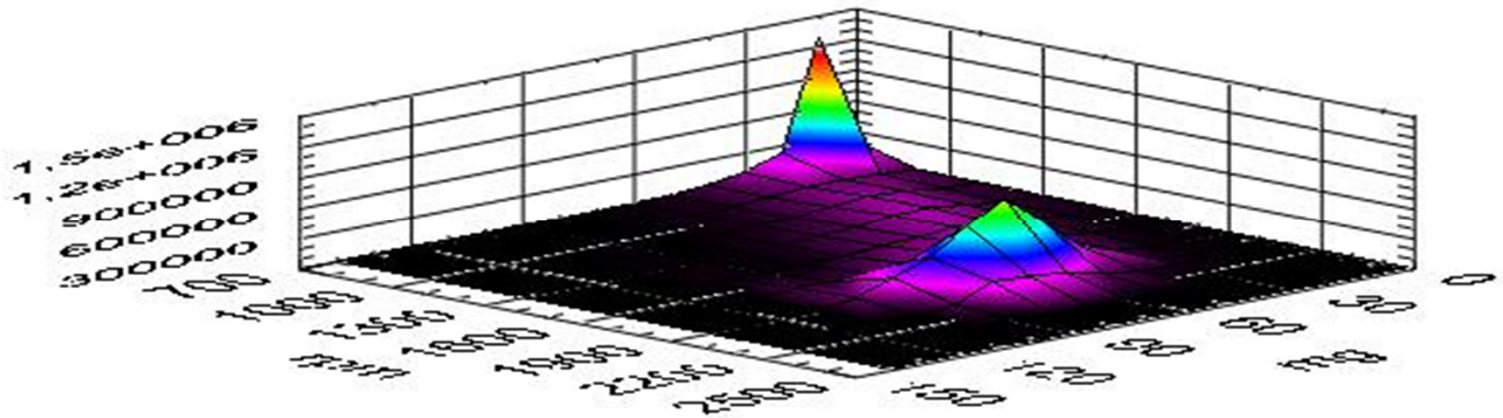


Basic NTE zone



Method and objects of the research

ECU Load Profile



load/eng sp	700-900	900-1100	1100-1300	1300-1500	1500-1700	1700-1900	1900-2100	2100-2300	2300
0-10	200391	37532	28420	23967	17076	11043	5660	1084	
10-20	1279401	63954	39427	26401	14165	6805	6420	1816	
20-30	222925	78720	82543	66773	41830	21486	12719	6482	
30-40	104672	76787	102985	109062	86360	57439	35471	16159	
40-50	50779	46435	68580	99417	103361	91082	156986	23788	
50-60	21122	22592	33519	55454	73487	107386	479232	62967	
60-70	11405	13317	20809	38576	56302	106911	758950	147877	
70-80	5254	6826	11002	19475	28127	73591	567535	181957	

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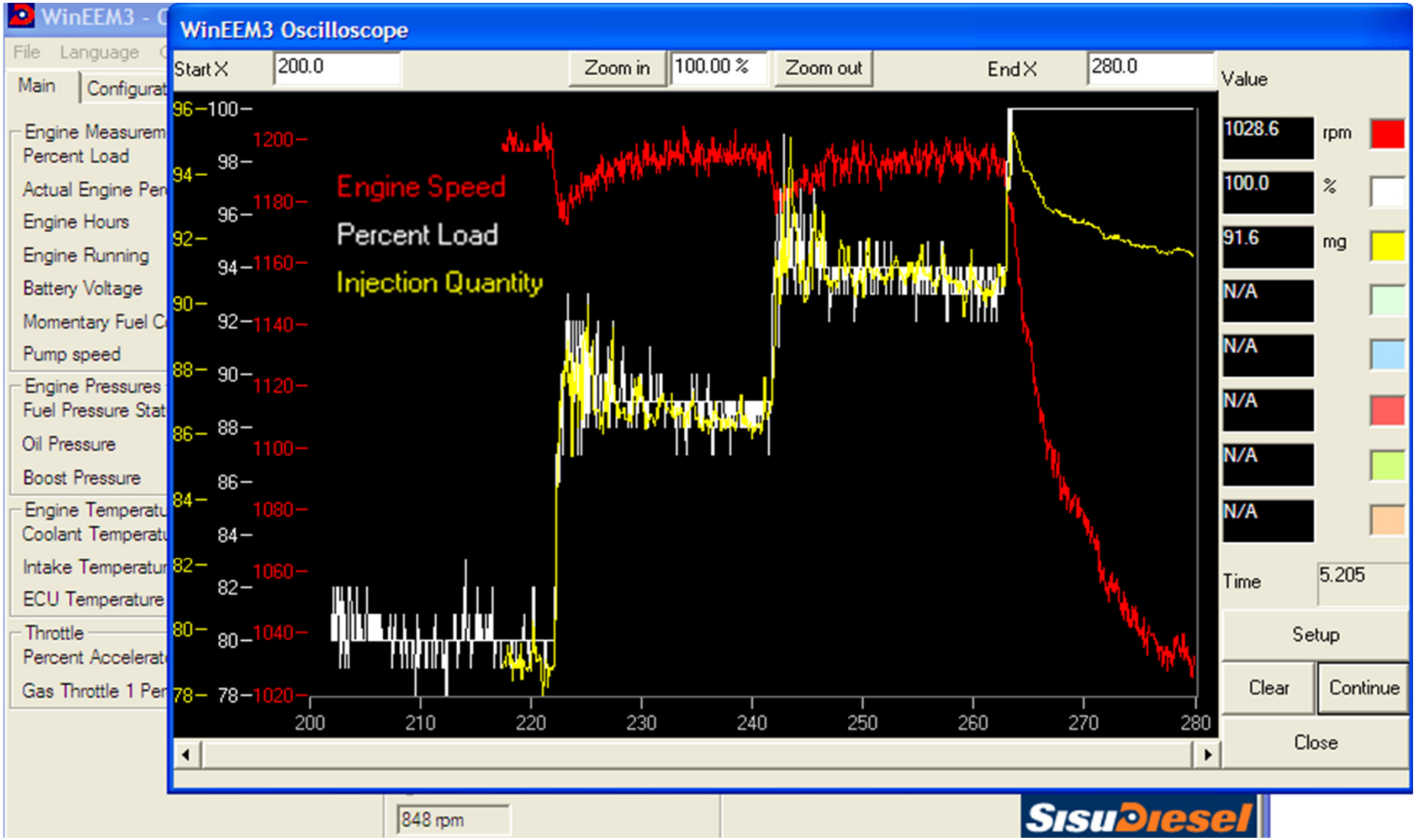
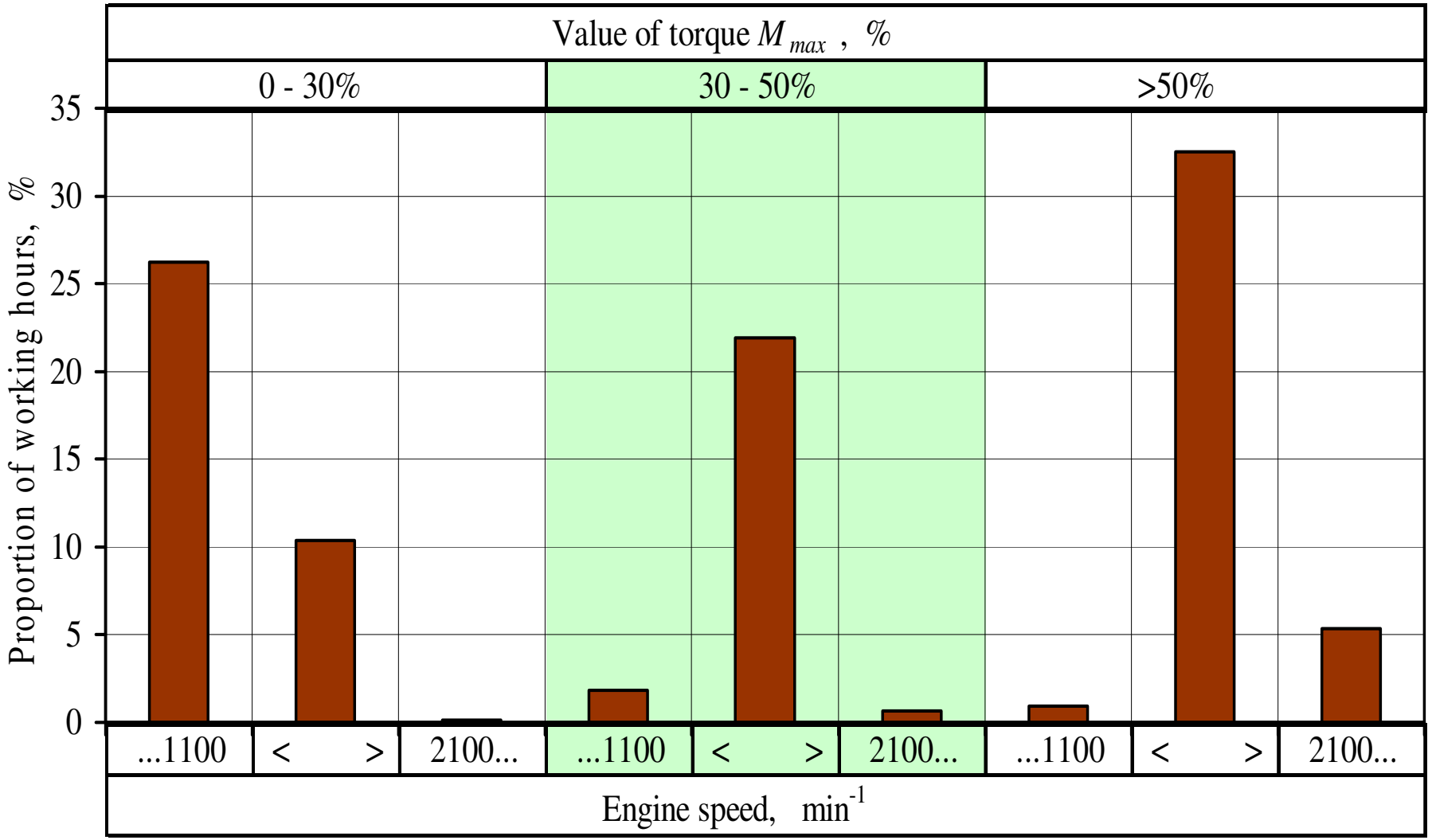
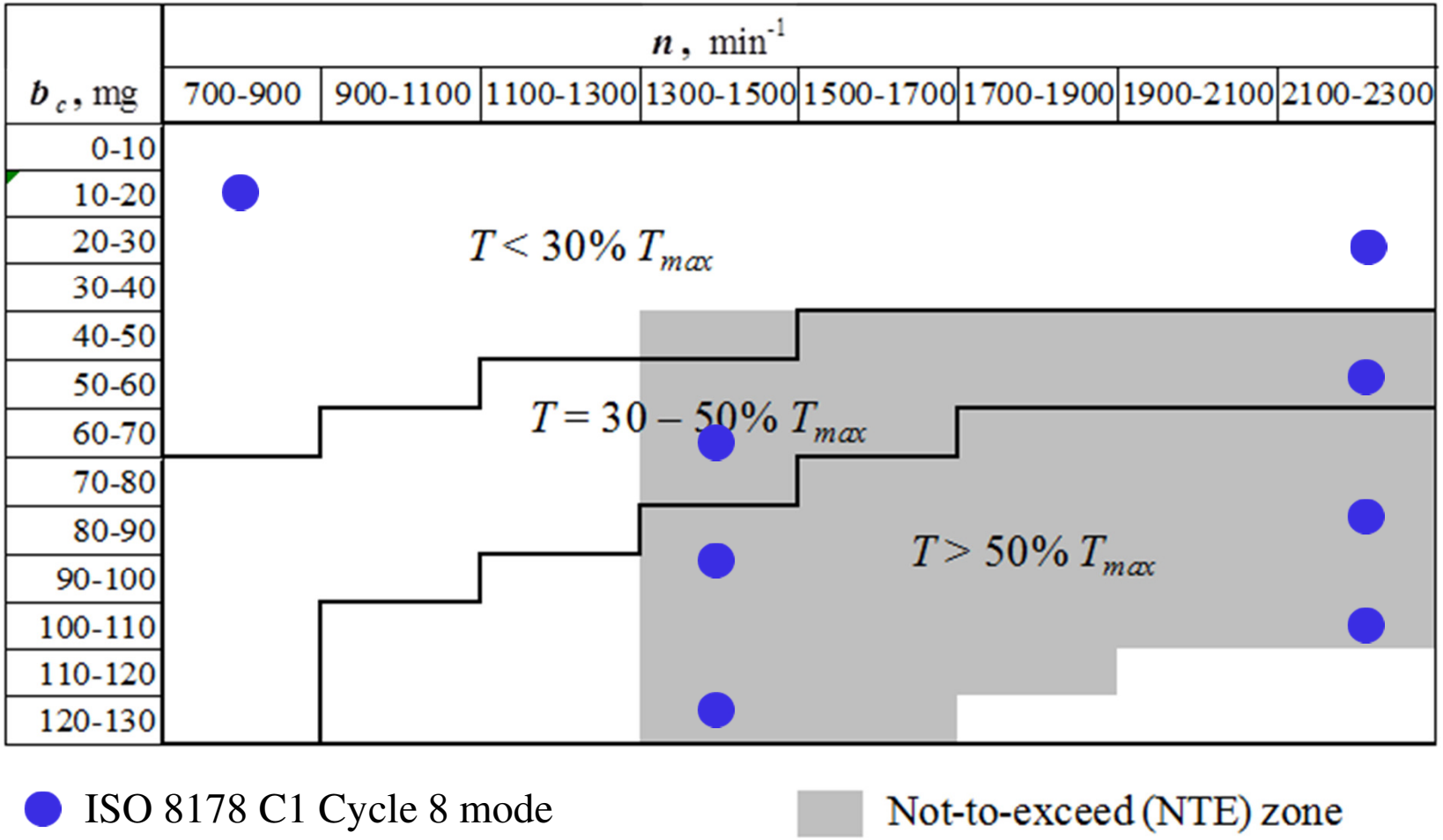
Method and objects of the research



Results and discussions

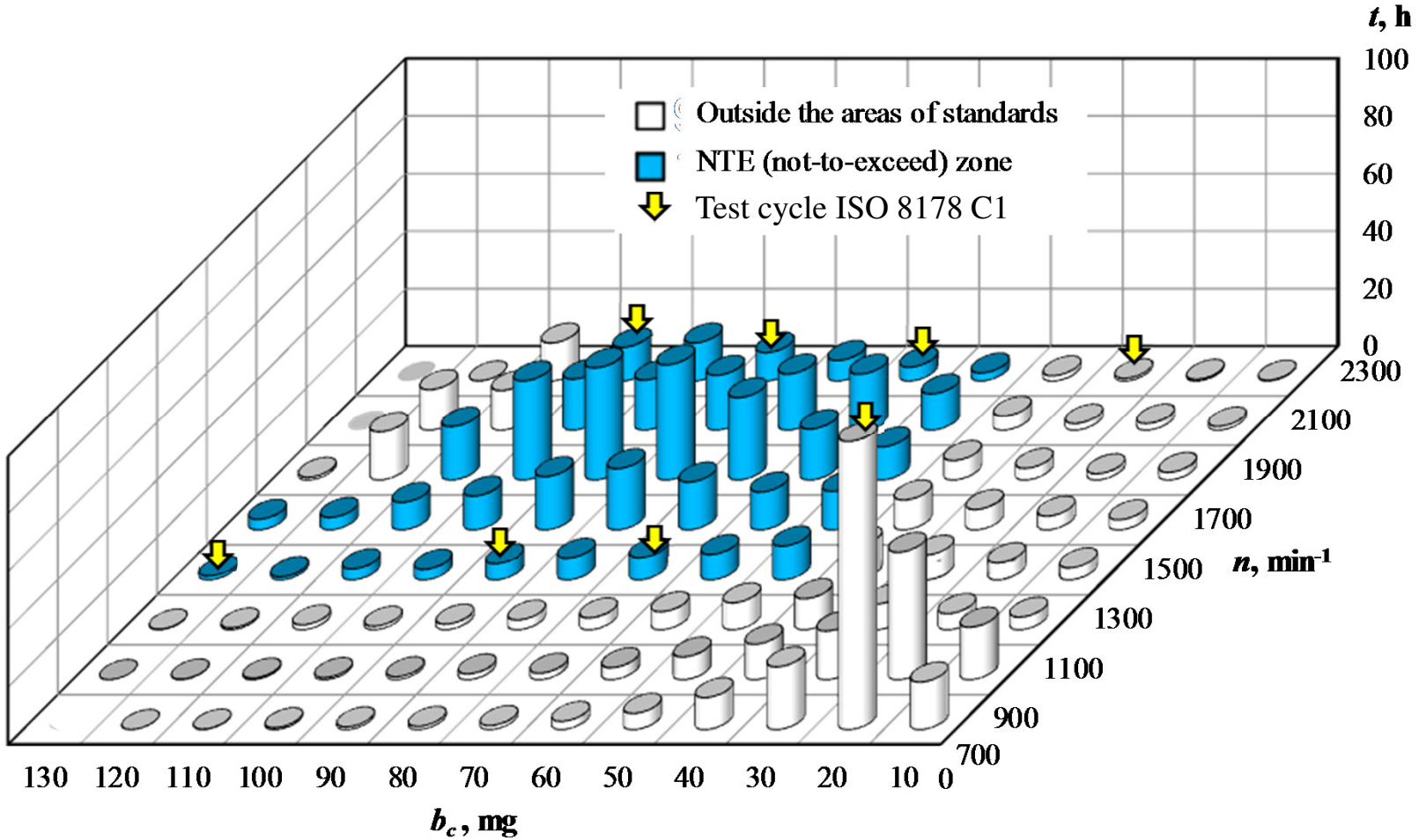


Results and discussions



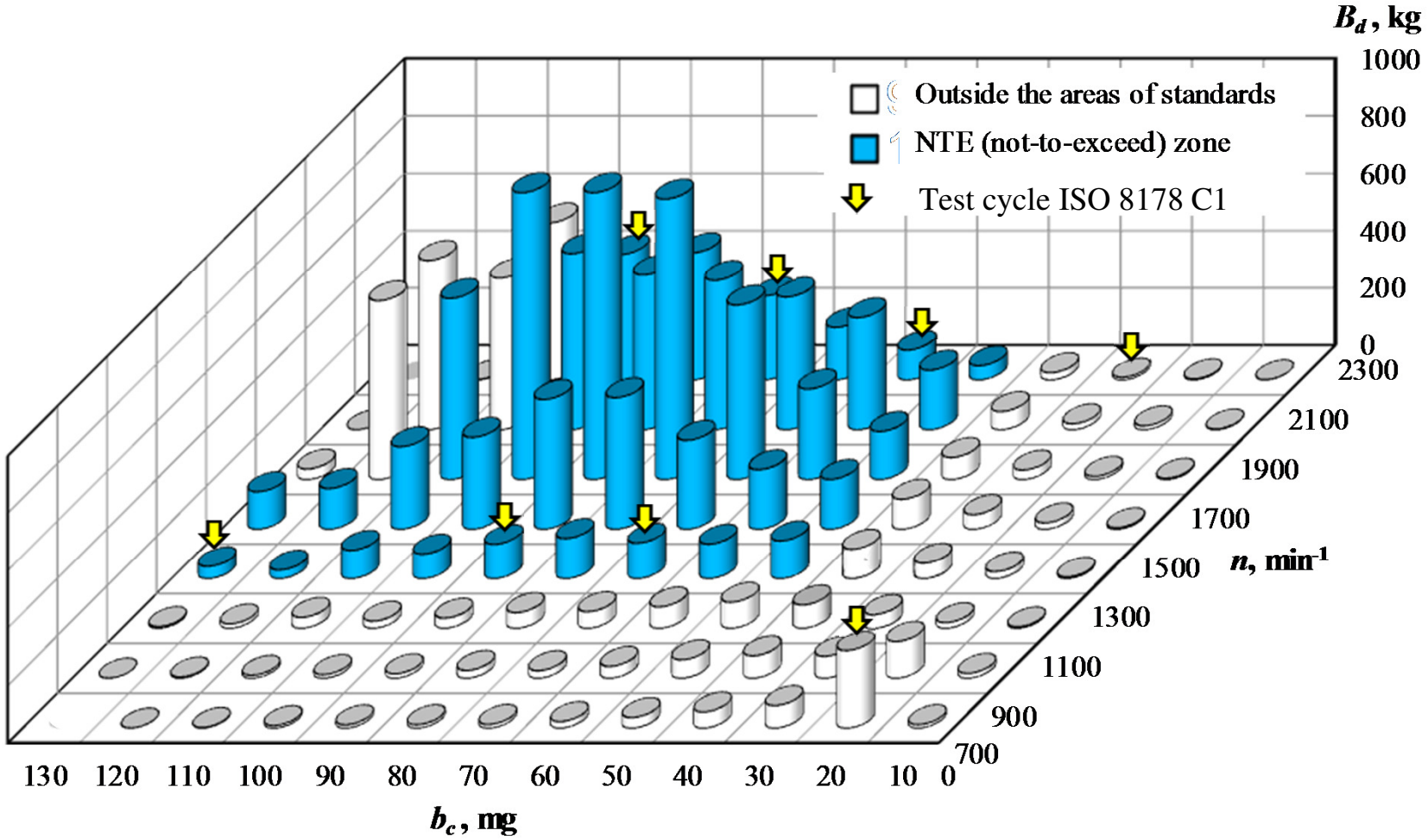
Layout of the values of engine torque, NTE zone and ISO 8178 Cycle in the plan of modes of engine speed (n) and cyclic fuel injection quantity (b_c)

Results and discussions



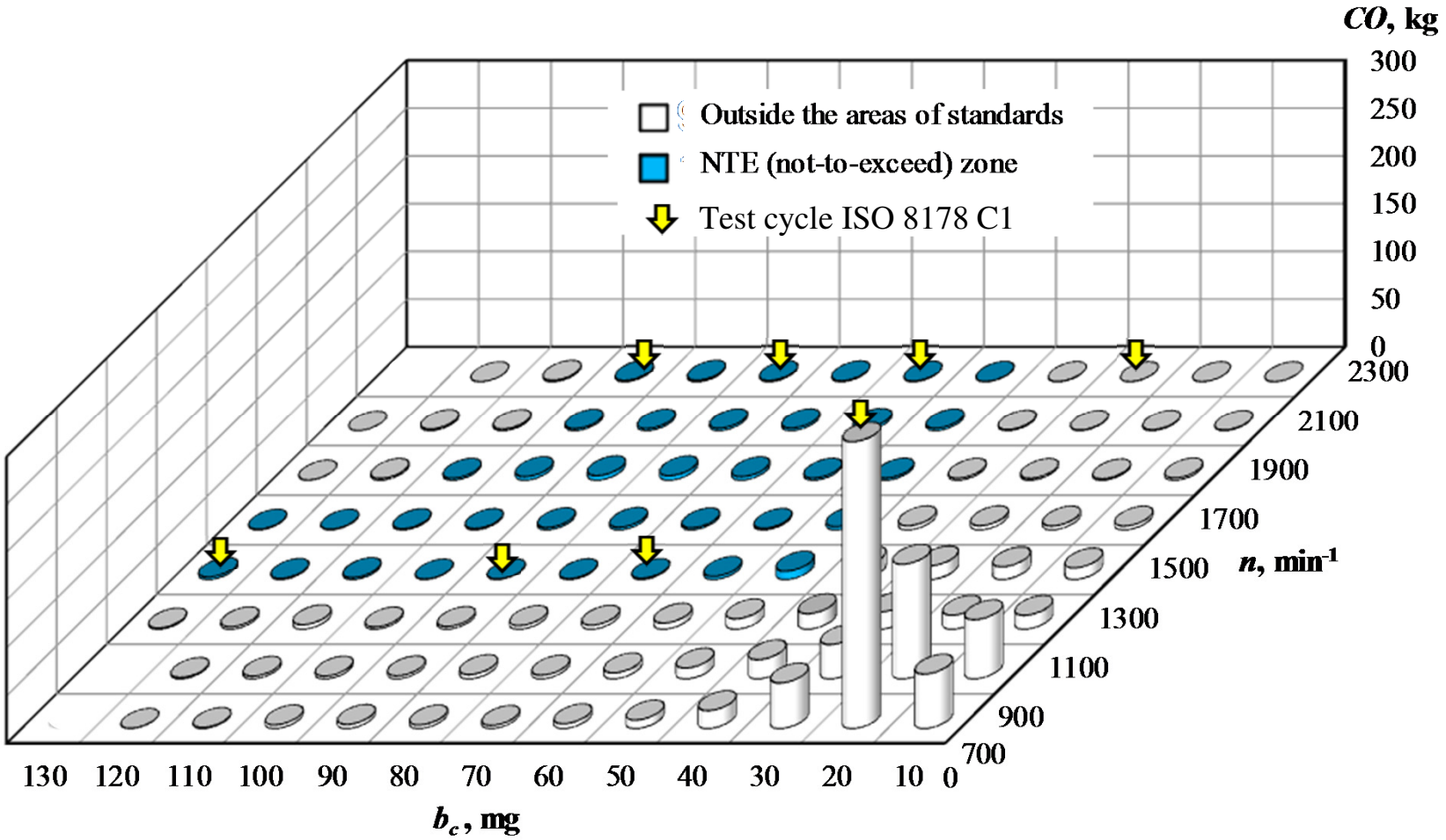
The average distribution of 1000 h tractor operational time in modes of engine speed (n) and cyclic fuel injection quantity (b_c)

Results and discussions



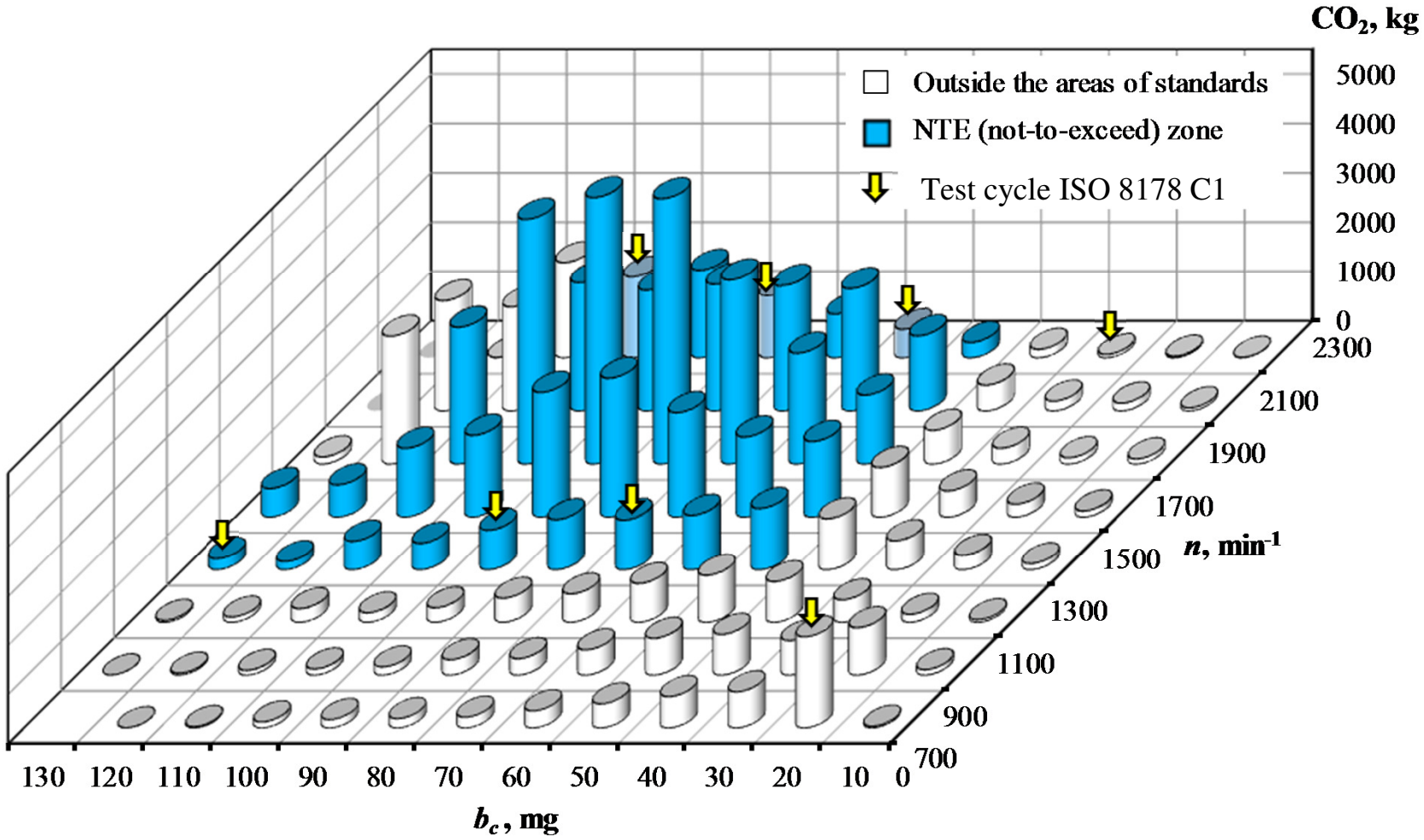
The average distribution of fuel used by tractor within 1000 h operational work in modes of engine speed (n) and cyclic fuel injection quantity (b_c)

Results and discussions



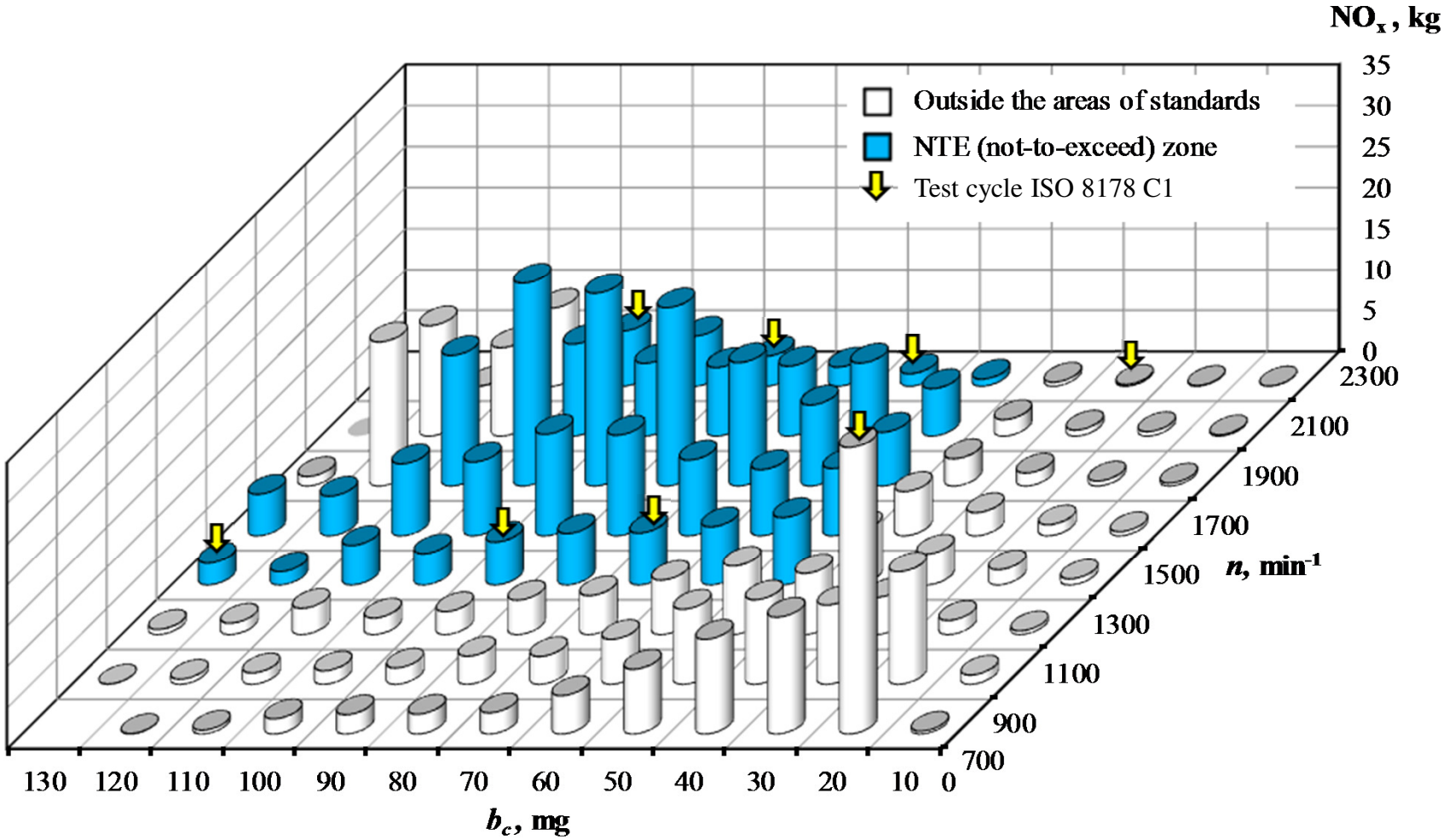
The average distribution of CO emission within 1000 h tractor operational work in modes of engine speed (n) and cyclic fuel injection quantity (b_c)

Results and discussions



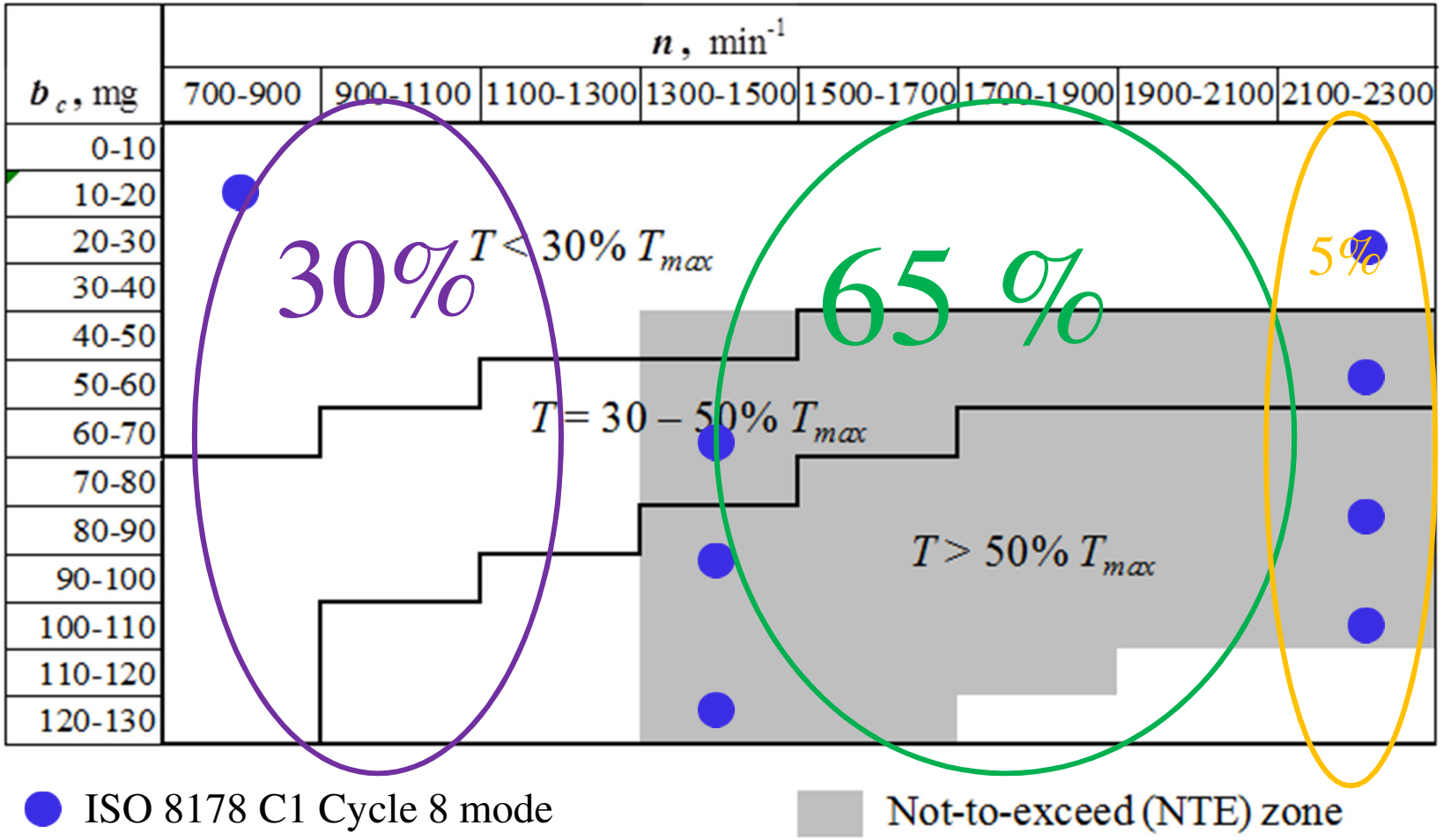
The average distribution of CO_2 emission within 1000 h tractor operational work in modes of engine speed (n) and cyclic fuel injection quantity (b_c)

Results and discussions



The average distribution of NO_x emission within 1000 h tractor operational work in modes of engine speed (n) and cyclic fuel injection quantity (b_c)

Results and discussions



Layout of the values of engine torque, NTE zone and ISO 8178 Cycle in the plan of modes of engine speed (n) and cyclic fuel injection quantity (b_c)

Conclusions

- Conducted studies have shown that a working time, fuel consumption, CO_2 ,CO and NO_x emissions in engine working modes of the “Massey Ferguson MF 6499”, during operational periods, could be identified from a database stored in engine control processors.
- Distribution of fuel consumption of three tractors in engine working modes during exploitational periods were as follows: About 11% of fuel was used in <30% T_{max} engine load modes, about 16% of fuel was used in the 30–50% T_{max} load mode and about 73% of fuel was used in the >50% T_{max} load mode. Meanwhile, in the mode of 1500–1900 min^{-1} economic engine speed and a >50% T_{max} load, tractors used on average about 40% of fuel during their operational time.
- The greatest quantities of CO_2 emissions (over 60% of the whole CO_2 emission) emerged in the >50% T_{max} modes of engine load, in which tractors used most fuel (over 73%) and operated approximately 43.5% of the whole operational period.
- About 87% of CO emission were composed in the < 30% T_{max} modes of engine load, in which the tractor’s work lasted about 41.5% of the whole operational period. The major part of this CO was emitted when engines worked in a mode of idle run (10–20 mg cyclic fuel injection quantity and 700–1100 min^{-1} speed).
- The investigations ascertained that tractors worked, on average, 51% of the operational period in engine working modes, controlled by the NTE zone. By working in these modes, tractors consumed about 73.4% of fuel used for the whole the operational period, emitted into the environment about 76% of CO_2 and 9.7% of CO compared to emissions of the whole operational period.
- From fuel economy and environmental points of view, it is important that tractor engines would get proper operation, including improved starting conditions, shortening time of idling, at a too high and too low load, and at a high speed ensured regular thermal conditions. Conducted research shows that there are possibilities to reduce fuel consumption, and CO_2 and CO emissions during tractor operational periods by improving tractor exploitation, which includes more rational selection of engine working modes, shortening times of engine idle run and at high revs. Resolution of this issue could thus, be induced by monitoring tractor work quality (fuel consumption and harmfull effects to the environment) during operational period.