MODERN METHODOLOGICAL TOOLS FOR RATIONAL USE OF FUELS AND LUBRICANTS

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Abstract. The article presents a modern interpretation of Chemmotology science, its role in development of technology and society. It shows that development and promotion of alternative fuels and Chemmotology problems solving are impossible without systematic approach. In addition, having both theoretical part and practical application, Chemmotology ensures energy and environmental security of the country's economy, rational use of traditional and alternative fuels and lubricants in operation of advanced modern equipment. The article focuses on the fact that in recent years one of the most important issues has been the ecological constituent of Chemmotology, which is aimed at ultra-minimization of negative impact of fuel lubricants and technical liquids on ecosystems.

Keywords: chemmotology, fuels & lubricants, technics, quality, exploitation, system approach

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Introduction

Today the humanity has reached the level, when it possesses huge scientific and technical potential. However, they still don't manage to use this potential economically and rationally. Rational use of fuel and lubricants, energy efficiency and environmental safety are among the most important problems of our time. Their solution largely determines the sustainable development of the world economy and the preservation of human comfortable living conditions.

The article is aimed at considering purposes and goals of Chemmotology science as an effective tool for managing and rational use of fuels and lubricant in conditions of environmental awareness and minimization of negative anthropogenic impact on environment.

Processes of fuel use still face problem of highly effective fuel burning with production of maximum useful energy. Argument for this is the modern state of energy efficiency, and fuel efficiency in particular, efficiency factor of internal combustion engines (Bratkov, 1985). Fuel consumption by car engine is determined by its energy efficiency, in other words, quantity of heat produced during combustion of 1 kg of fuel. It was calculated, that today only 12% of energy produced during fuel combustion is used for car movement (Gureev et al., 1987). Today about 10 ton of fossil fuels per capita is extracted for a year. And only 1% (100 kg) is efficient (Boichenko, 2009). All the rest pollutes our atmosphere, soils and water bodies. Efficiency of fuel use can be shown as energy balance of a car (table 1).

Table 1

Energy balance of a car (Boichenko, 2009)

Energy of combusted fuel (100%)	
12%	88%
2,4% – rolling resistance 3,2% – air resistance 6,4% – inertial forces	42% – cooling system 22% – exhaust gases 13% – friction in engine 9% – friction in transmission 2% – engine accessory drive

Today efficiency factor of modern gasoline engines is about 35 – 36%, diesel engines is 42–44%, gas engines is 38–45% (table 2).

Table 2

Efficiency factor of some engines (Boichenko, 2009)

Wat heat engine	~ 2,8%
Internal combustion engine	~ 20–40%
Steam turbine	~ 35–46%
Diesel engine	~ 44%
Jet engine	~ 47%

Total efficiency factor of engine is divided into main constituents (Boichenko, 2014):

- ***fuel efficiency*** shows what quantity of fuel that was efficiently burned in engine and turned into the volume of power gas of high temperature and pressure, and what part of fuel was not burned and was emitted as unburned hydrocarbons, carbonized particles (soot, smoke, fly ash, etc). Nowadays only 75% of fuel is completely burned and transformed into heat in existing engines. Two-stroke engines provide even less amount of completely burned fuel;

- ***thermal efficiency factor*** shows what amount of heat, produced after fuel burning is transformed into useful work and what amount is uselessly wasted in environment. Let us consider that piston engine has 30% efficiency factor on average. Then 70% of produced heat is emitted uselessly into environment through cooling system together with exhaust gases;

- ***mechanical efficiency factor*** shows what quantity of mechanical work is transformed into torque force at the main axle and transmitted to the consumer and what amount is uselessly wasted for friction or used for other driving supplementary mechanisms of the engine (fig. 1).

The above arguments suggest that mankind has a significant amount of energy from the point of view of the opportunities and the necessity to improve the technical means, when the source of energy is products of oil refining.

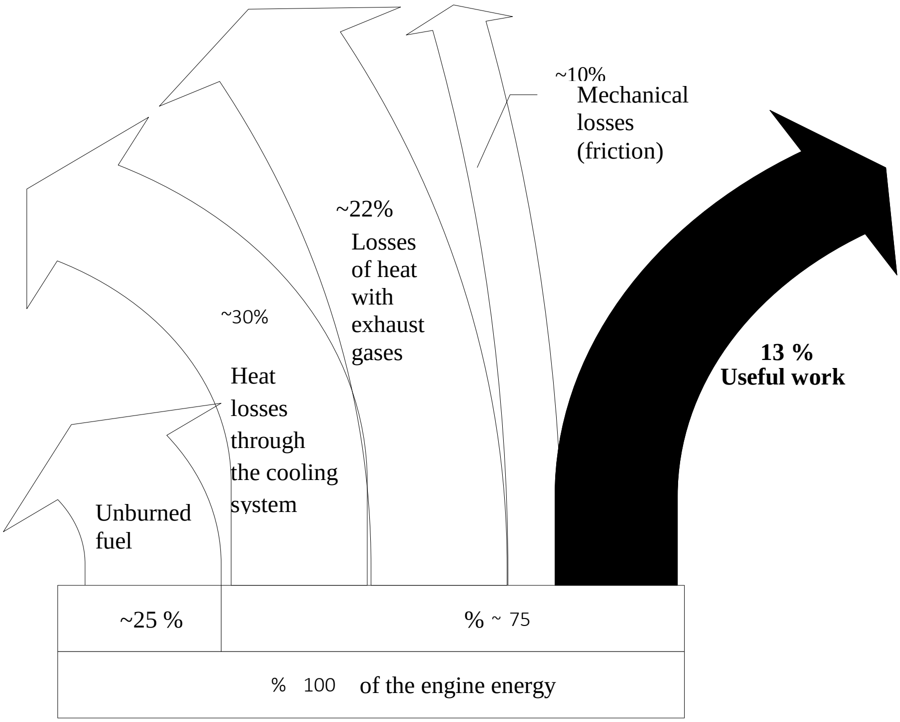

Fig. 1. Energy balance of internal combustion engine (Evdokimov et al., 2005)

The current state of natural resources and the environment causes change of future prospects of economic development and technological progress and evaluates them, considering environmental priorities, environmental risks and state of environmental safety. Rapid industrialization and urbanization together with quick development of transport infrastructure and strengthening of other impacts on environment have disturbed the life cycle of substances, natural metabolic energy processes and regeneration mechanisms in the biosphere *(Bolshakov, 1987)*. As a result progressive destruction has begun. Air, water and soil are polluted, landscape and biological diversity are depleted; these facts cause negative effect on living organisms and humans.

In order to eliminate this danger, existing environmental management practices should be revised, Production, economic activities and environmental systems should be radically restructured, taking into account social and economic needs of society and the biosphere opportunities *(Yanovskyi et al., 2005).*

According to the forecasts of the World Energy Council, energy consumption will raise by 55% by 2020. According to the data of Organization of the Petroleum Exporting Countries, oil takes more than one third in world balance (table 3).

Despite the fact that in future share of crude oil in total primary energy consumption will be reduced in absolute terms, oil consumption (as well as other energy sources) will only increase. Being an exhaustible and non-renewable natural resource, crude oil requires its rational use. Even Mendeleev paid attention to the rational use of raw materials: "Oil is not a fuel, you can heat by assignats."

Table 3

World energy balance (OPEC forecast, data of World Oil Outlook, 2010)

Name of energy source	Volume, mln m BOE per day			Part, %		
	2010	2020	2030	2010	2020	2030
Oil	80,4	89,9	97,6	35,0	32,7	30,2
Coal	66,2	80,1	92,1	28,8	29,2	28,5
Gas	52,1	64,5	79,1	22,7	23,5	24,5
Nuclear energy	14,7	16,9	20,7	6,4	6,2	6,4
Hydroenergy	5,8	7,3	9,0	2,5	2,7	2,8
Biofuel	9,2	12,9	17,5	4,0	4,7	5,4
Other renewable energy sources	1,5	3,2	6,8	0,7	1,2	2,1
Total:	229,9	274,8	322,9	100,0	100,0	100,0

* Per unit of fuel (coal equivalent) accepted the calorific value of 1 kg of coal = 29.3 MJ or 7000 kcal. The International Energy Agency (IEA) has adopted a unit of oil equivalent, usually abbreviated as TOE (born ton of oil equivalent). One ton of oil equivalent is equal to 41.868 GJ or 11.63MW•h It is also used barrel of oil equivalent (BOE). Ratio: 1 toe = 7,11, 7,33 or 7,4 boe

Growth in use of natural resources, their depletion and degradation necessitated development and implementation of strategies and tactics for sustainable environmental management and continuous monitoring of changes in natural and anthropogenic processes for the integrated management of natural resources and environment (Evdokimov, 2011).

There is no alternative to environmental management, which is based on considering laws of nature and forming of safe conditions of human life and living organisms. Therefore, humanity has already generated and implemented strategy and tactics of natural resources use, ensuring systematic (integrated) management of natural resources and their rational use, protection from pollution and depletion. Besides, constant monitoring of natural and anthropogenic processes changes in environmental systems is applied.

Science that became responsible for ensuring integrity in dealing with a variety of tasks connected to these problems, is Chemmotology (Aksenov, 2008). Encyclopedic concept of science defines it as a sphere of human activity, the function of which is the development and theoretical systematization of objective knowledge of reality (Piskunov, 1983). The direct goals of the science are description, explanation and prediction of the processes and phenomena of reality, which are the subject of its study on the basis of public law, i.e. the theoretical reflection of reality. Chemmotology possesses all these features (Danilov, 2003).

Chemmotology, being an independent science today, can systematically solve complex environmental and energy problems, for example, in the transport sector. Currently there is a new stage in the development of this science and its role in the overall system of knowledge.

Chemmotology gave comprehensive solutions of such important practical tasks as design and production of machinery, equipment maintenance, development and use of fuels, oils, lubricants and fluids. Chemmotology unites and embodies the efforts of developers and manufacturers of machinery, oil products, oil refineries and operators of technique.

The origin of Chemmotology dates back to 1964. The separation of Chemmotology into the independent applied science united scientists and practitioners of engineering, oil and chemical industries along with the companies which operate the technologies for Chemmotological problems solving.

For the modern science it is the transition from subjective to problematic orientation that becomes more typical. The new areas of knowledge arise because of advancement of some major theoretical and practical problems. This is the reason for the edge sciences to appear and Chemmotology, in particular, being a problem science, is at the edge of Chemistry, Physics, Engineering, Economics and others. It is even possible to use such word combination as “technical Philosophy,” since it describes the essence of this science.

The modern definition of Chemmotology is interpreted as following: It is the science about the technological processes, properties, quality and methodology for the rational use of fuels, oils, lubricants and technical liquids in the operation of machinery (Bratkov, 1985). It is necessary to consider both conventional and alternative fuels and lubricants.

Knowledge of technology not involves only knowledge of design, kinematic, dynamic, temperature characteristics; physical and chemical properties of construction materials are also necessary for the analysis and prediction of physico-chemical processes during the application of specific fuels and lubricants (Boichenko, 2009; Gureev et al.,1987).

For example, the aircraft is a huge amount of metallic and composite parts, which are flying at a speed of 900 km/h (0.85 from the speed of sound, it is a typical speed of the Boeing 787 Dreamliner) at an altitude of 10 km. A couple of million parts are manufactured and assembled into one product and aircraft flies, providing comfort for passengers and profit for owners (Fig. 2).

Providing reliable and economical joint flight of these details, linking the most different requirements (load capacity, fuel consumption, flight range, noise during takeoff and landing, the requirements for the length of the takeoff and landing, the need for easy maintenance on the ground, the lack of icing, the safety of people on board and so on) is possible only with the help of system engineering approach, taking into account the requirements of a variety of specialists, representing a variety of professional and community groups (Bratkov, 2004).

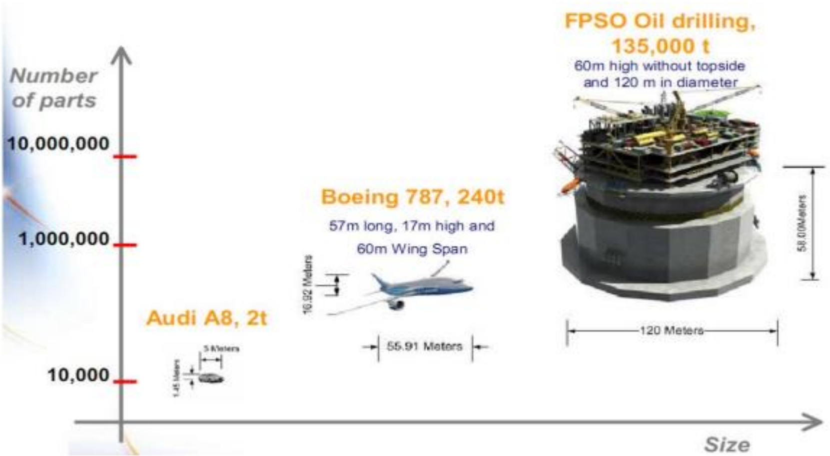

Fig. 2. Number of details and weight of some engineering constructions

Generalized utility function of fuels and lubricants as socially useful products (as opposed to a generalized function of vehicles) cannot be described by appropriate design of documentation and drawings (Sereda, 2004; Lahshi, 2004). This fundamental difference between the fuels and lubricants, on the one side, and mechanical engineering products, on the other side, objectively led to the emergence of Chemmotology (Boichenko, 2009; Fuks et al. 2004; Volgin et al., 2009).

The analysis of publications for the recent years gives a possibility to distinguish three main directions of development of theoretical fundamentals of Chemmotology:

– study of local mechanisms performance of components and various functionality additives in fuels and lubricants;

– search for more general patterns in Chemmotology based on the use of fundamental laws of Physics, Chemistry and other sciences;

– study of Chemmotological processes for prognostication of fuels and lubricants performance in technological equipment at various conditions.

The main goals of Chemmotology are the following ones:

– optimization of requirements for quality and composition of fuels, lubricants and technical fluids, their service performance taking into account the primary energy sources reserves, achievements of scientific and technological advance in the development of technology, peculiarities of technological equipment and the conditions of its performance, ecological and economic requirements;

– development of recommendations as for unification, interchangeability and determination of conditions of rational and economic use of fuels, lubricants and special fluids;

– improving of oil product supply systems and quality management during production, storage, transportation and application of fuels, lubricants and special fluids;

– modernization of compliance assessment system (certification, testing, permission to production and application), modernization of methods of qualifying tests for fuels, lubricants and special fluids;

– unification of local standards for testing methods of fuels, lubricants and special fluids with international ones;

– development of new highly efficient kinds of fuels, lubricants and special fluids that ensure the improvement in technical and ecological performance of technological equipment;

– disposal and recycling of the off-grade and worked-off fuels, lubricants and special fluids;

– building grounds for conducting logistic measures for preserving the quality and decreasing the losses of fuels, lubricants and special fluids during their storage, pumping and transportation;

– developing methods for service performance and quality control assessment of fuels and lubricants, along with disposal of worked-off, unmarketable and off-grade fuels and lubricating materials;

– improvement of the existing and development of the new technologies for fuels, lubricants and special fluids production.

As we know from the classical scientific works on Chemmotology (Piskunov, 1983; Aksenov et al., 2009), there is a universal four-tier Chemmotology system in any kind of machinery and equipment, which uses fuel, lubricants and technical liquids (Fig. 3). This system takes into account the relationship between the quality of the fuels and lubricants, the reliability of equipment and the conditions of its operation (Grishin et al., 2004; Aksenov et al., 2013). It can also be seen in Fig. 4 that shows an improved Chemmotology system.

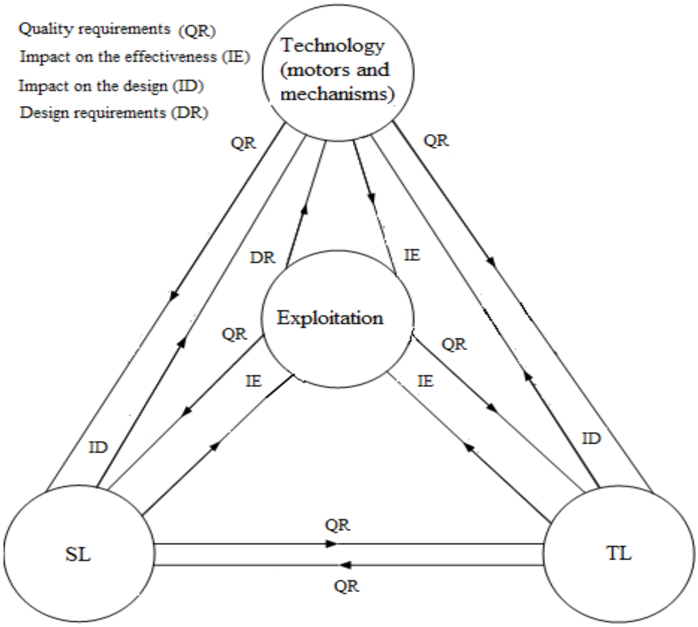

Fig. 3. Improved four-tier Chemmotology system (Aksenov et al., 2013).

Initially Chemmotology science is characterized by systematicity. Chemmotology, as well as system technology and system engineering, has such methodological tools in science and technology, which cover design, development, testing and operation of complex systems. To a certain extent, it is an applied embodiment of system theory in which the term "system" is used in a special way, referring to the way of thinking to explain coherent links between elements of the system, synergy and emergence.

Here, the "system" not only means the essence, but is also related to the nature of the object, emphasizing the class properties, which distinguish it from diversity of definitions and a huge number of possible ways of the system decomposition and release of subsystems (Boichenko, 2009; Shkolnikov, 2007).

These ideas can be illustrated by Fig.3. It shows the integrated interdisciplinarity of Chemmotology, science system itself, it hierarchy, Chemmotology coherent connections, structure, nature, synergy and emergence Boichenko, 2009; Aksenov et al., 2013). It is clearly shown how the interaction of elements and coherent processes on the example of an aircraft engine results in synergistic and emergent effects: ecological compatibility, efficiency, reliability and durability of the equipment.

Economical meaning of Chemmotology is achievement of maximal economy of raw materials, fuels, lubricants and special fluids through optimization of balance and quality of products, their rational and efficient usage.

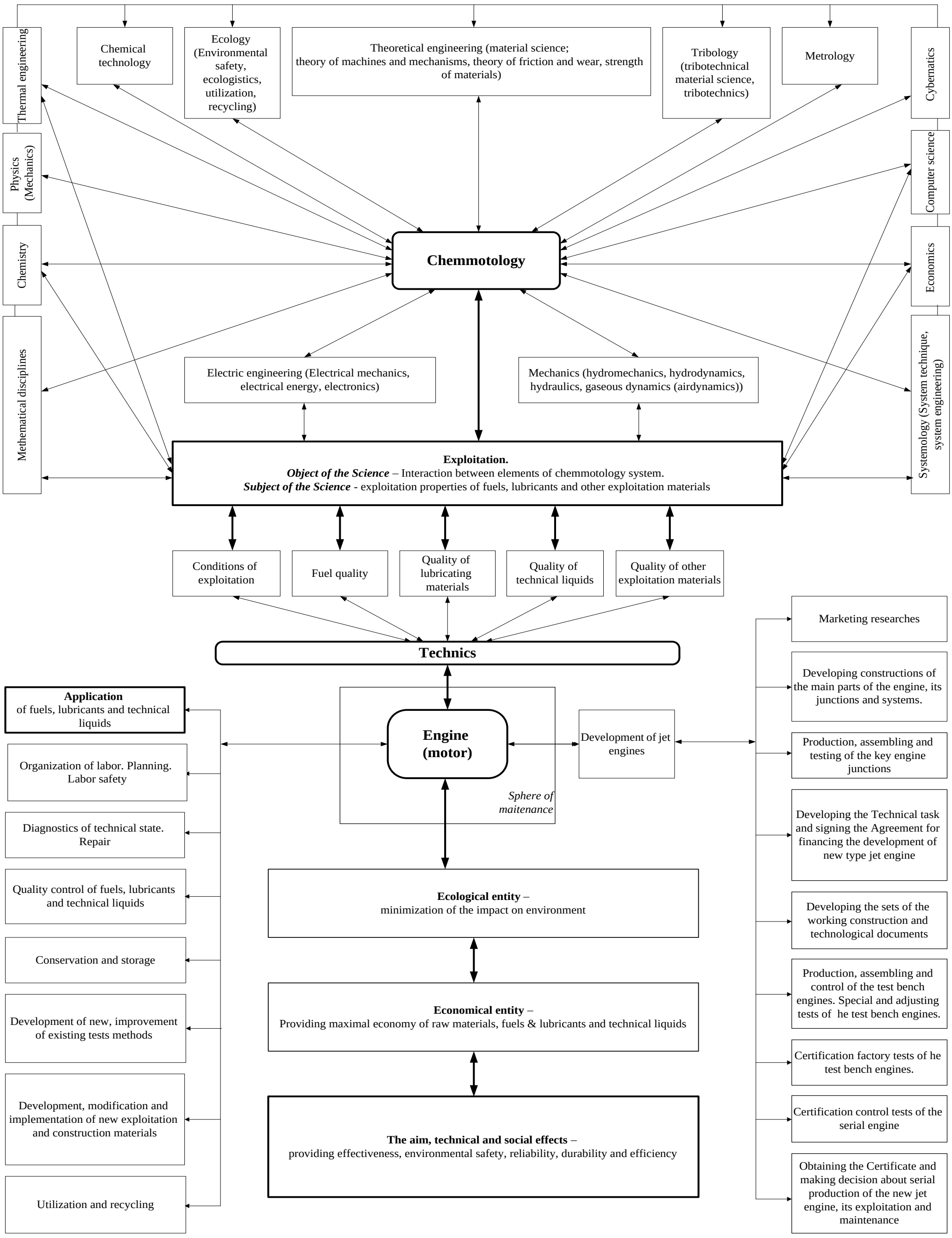

Fig. 4. The phenomenological scheme (model) of Chemmotology (Boichenko, 2003)

Theoretical fundamentals of Chemmotology consist of development of general theory and establishing laws that connect the quality of fuels, lubricants and special fluids together with reliability, durability, ecological compatibility, economy and efficiency of technical equipment; substantiation of optimal requirements for the quality; selection (development) of the new grades; unification of types and grades; ensuring the quality preservation; study of physical, chemical, and ecological properties during the storage, transportation and distribution; decreasing specific consumption and normed losses; decreasing the overall volume of quality control; development of quality regeneration methods; solving the problems of interchangeability of fuels, lubricants and special fluid grades produced in different countries; developing methods, equipment and service performance testing systems and quality parameters tests; protection of the environment from the influence of Chemmotological system.

Chemmotology creates the necessary “basement” for ensuring optimal conditions of oil products rational use and modern requirements to their quality.

Social and economical impact of Chemmotology comes in the shaping of highly-educated specialist which, first of all, could meet modern level of highly-technological production and service. The role of this kind of specialists is constantly increasing in many countries since deep knowledge and superior technologies are becoming new strategic resources nowadays.

Currently, considering problems of Chemmotology to be beyond a systematic approach to knowledge is not possible. It is higher qualitatively than just a substantive way of knowing. (Synergies is summarizing effect of the interaction of two or more factors, characterized by the fact that their effect is much greater than the effect of each individual component in the form of a simple sum). In its turn, emergence is a quality, property of the system, which is not inherent in its elements separately, but instead rises by combining these elements into a single, integral system.

From a philosophical point of view, we can easily state that Chemmotology science makes the consolidating function of integration of communication scholars and practitioners of engineering, chemical, oil-refining and petrochemical sectors of the economy, together with technique operators to solve evolution problems of scientific and technological progress. For example, refiners produce gasoline, diesel and other fuels for further use in engines (Boichenko, 2003). Knowing fuels, lubricants and technical liquids means to have a clear understanding of the relationship of indicators characterizing quality of a physico-chemical and energy processes that occur during their use in specific conditions, and the relationship with their chemical and group composition.

The lack of such an analysis and forecasts makes it impossible to achieve the objective technical and social effects. There is another clear evidence of synergy effects in the operation of Chemmotology system (Seregin, 2009). Quality control of fuels, lubricants and technical liquids plays a special role in Chimmotology on the way from their producer to consumer (Sereda, 2008). As we can see from Fig. 3 quality of materials exploitation is included into the parameter of the system itself. Practice has proved that the use of fuels, lubricants and technical liquids with the overestimated indicators of quality (quality level) leads to excess of costs in their production and cost escalation in mechanical engineering and operation of equipment.

Considering any scientific problem is known to be impossible without a coherent ideological system. Worldview, which selects a particular civilization, defines the whole character of the activities of society and its impact on the environment. On this basis, the environmental essence of Chemmotology lies in ultra- minimizing the negative impact of fuels, lubricants and technical liquids on ecosystems (Boichenko et al., 2013; Seregin, 2009).

The importance of tasks solved by the Chemmotology is shown by its role as an applied science, namely, ensuring energy and environmental safety of the country's economy, rational use of traditional and alternative fuels, lubricants and technical liquids in the operation of advanced modern equipment.

Deterioration of fuels, lubricants and technical liquids quality is also typical for operation of technique as result of evaporation, oxidation products accumulation, precipitation and leaching of some additives, mixing fuels, lubricants and technical liquids of different brands, to name just a few. (Fig. 4). The processes of regeneration, restoring quality, utilization and recycling are of utmost importance.

Classic of systematic approach indicates that the solution of any problem is characterized by the following elements:

1) someone (or some group) should be put into the front of the problem, i.e. requires the existence of decision-makers;

2) the purpose, desire of decision-maker is aimed at solving a problem situation that is its purpose and the basis for formulation of the problem and achieving goal;

3) decision-makers should have a choice among alternative actions that lead to achieving goal.

These arguments allow us to assert that Chemmotology system "engine-fuel-lubricants-technical liquid" is a management task, in which prescriptive and descriptive methods are applied. Here we can trace Chemmotology coherence with cybernetics (which depicts connections in the upper part of Fig 4). At each stage of engine creation (the right side of Fig. 4), operation and application of SCL also demonstrates the need for decision-making (the left side of Fig.), which is eventually embodied in the synergetic result: to ensure efficient, ecological, reliable and economical operation of equipment.

Conclusions and suggestions

Consequently, the fundamentality of Chemmotology science is the manifestation of the system of methodological characteristics for solving modern engineering problems, improving technology and development of energy sources for motor vehicles simultaneously. Applying Chemmotology it is possible to achieve significant results of scientific and technical progress in technique. The concept of Chemmotology is the systematic integration of engineering knowledge into chemical, oil-refining and petrochemical spheres of scientific and practical activities to achieve synergistic results in ensuring reliability, safety, durability and efficiency of equipment.

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