The Department of Petroleum Technology and Alternative Fuels is a descendant of The Department of Petroleum Technology and Petrochemistry which was constituted in 1953. The Department was founded by Prof. Stanislav Landa, the discoverer of adamantane. Activities of the Department were focused on coal, coal tar and synthetic fuels. Since 1960, the specialization of the Department has turned to petroleum technology, in accordance with its emergence as the main raw material basis in the Czech Republic.

Biofuels become one of the important research topics of the Department in the end of the last century. In 2007, it was therefore renamed to the Department of Petroleum Technology and Alternative Fuels.

Together with Czech students, foreign students from 25 countries have also studied at the Department. These students have formed about one third of all the graduates. Some foreign students have successfully continued in graduate studies and have been awarded Ph.D. degree.

**Present research**

Present research activities of the department are focused on transport and storage of crude oil, evaluation of lubricating oils, improvement of motor fuels, development and optimization of procedures for an analysis of crude oil, crude oil fractions and products and also biofuels. Standard exhaust emissions and emissions of individual types of hydrocarbons are also measured at the combustion of liquid as well as gaseous motor fuels. Decomposition of waste plastics into fuels and petrochemicals is another research topic studied.

**Transport and storage of crude oil**

- Crude oils evaluation with respect to sludge deposition during a long-term storage, and detailed analysis of the sludge.
- The influence of crude oil composition on its low-temperature properties, possibilities of crude oil properties improvement using suitable additives.

**Research and evaluation of lubricating oils**

- New environmentally friendly lubricants and research of properties of advanced engine and gear oils.
- A monitoring of quality and lifetime of engine oils in long term operation.

**Quality improvement of motor fuels**

- Catalytic hydrotreating of middle crude oil distillates used for diesel fuel blending.
- Evaluation of motor fuels containing biocomponents (gasoline with bioethanol or biobutanol, diesel with methyl or ethyl ester of fatty acids).
Development and optimization of procedures for a detailed analysis of crude oils, crude oil fractions and products
• Detailed analyses of gasoline, middle distillates and high-boiling petroleum fractions and residues using GC, HPLC, LSC, MS and NMR.
• Evaluation of properties of alternative motor fuels, mainly bioethanol, biobutanol, fatty acid methyl esters and fractions from Fischer-Tropsch synthesis.

Analysis of organic substances in emissions from automobile internal combustion engines
• Detailed analysis of standard exhaust emissions (C₅H₅, CO, NOₓ and particulate matter) and emissions of individual types of hydrocarbons (including aromatics, polyaromatics and aldehydes) from combustion of conventional (gasoline, Diesel) and alternative (methane, LPG, bioethanol, biodiesel) fuels during driving test cycle.

Decomposition of waste plastics into fuels and petrochemicals
• Visbreaking of petroleum vacuum residue with polyethylene, polypropylene, polystyrene and other waste plastics.

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The Department of Gas, Coke and Air Protection during the fifty six years of its existence has undergone very important developments in its research scope. In the beginning, the research work was focused on high temperature carbonization of local hard coals and the soft coals gasification by the steam/oxygen mixtures in small scale plants of local reach, later in pressurized moving bed generators supplying the town gas most of the Czech Republic, further also on the de-toxication of town gas, the processing of the liquid by-products of high pressure gasification, steam reforming of natural gas, detailed analyses of fuel gases and catalytic cracking processes. The research in the Department currently consists of projects in energetics, economics and environmental fields with number of them having international character.

**Present research (Contemporary research)**

To support the possibilities of increasing the utilization on non-traditional energy sources, the research and development work at the department is currently aimed to the field of biomass and waste - especially the projects of gasification and pyrolysis pilot units with fluidized bed.

In the field of the brown coal utilization we continue in the project of decrease of the tar production during the combustion of the brown coal with atypically high tar production.

The optimization of utilization of our natural gas pipeline system is in the work of department represented by research of physical and transport properties of model mixtures of gaseous fuels under high pressures which is necessary for application of the modern methods for the measurement of the consumption and flow of gases. Research is aimed also at data collection of programmes for simulation of gas transmission and distribution and at modelling of pipeline and gas storage accidents.

In co-operation with the Department of Power Engineering there is taking place the unique research of the pipe corrosion under stress. Firm foundations were also laid for the research of natural gas drying by glycols under elevated pressure, de-sulfurization of natural gas by solid sorbents and natural gas odorization by sulfur free compounds.

The study of the removal of volatile organic compounds from the emission aerosols is aimed at processes of catalytic combustion, bio-filtration and at adsorption based on active carbon and zeolitic materials. On laboratory as well as industrial scale, various applications of adsorbents for hydrogen sulfide, ammonia, formaldehyde and volatile organic compounds removal are observed together with the possibilities of increase of adsorption capacity of these sorbents.

In the departmental laboratories there are further improved the measurement instruments enabling the observation of emissions from various sources in very great detail. There is also pursued the possibility of rational decreasing of SO2 emissions by wet as well as dry methods and the same for further pollutants during different stages of various industrial processes.

In the field of the emissions study the attention is focused on the mechanisms of ozone formation and on observation of concentrations of selected group of analytes in the discrete samples of air at the high elevation locations placed on the selected TV transmitters in Czech Republic with the aim of the determination of direction of movement of inorganic as well as organic air contaminants over the territory of Czech Republic.
Supposed future research activities at the department:

- Chemical and technological aspects of natural gas utilization.
- Biomass processing (gasification, pyrolysis, biomass using for the heat and electricity production).
- Intensification of wet limestone process for flue gas desulfurization.
- Emissions produced by the combustion of solid fuels in small hearths.
- System of characterization of the influence of mining, cleaning and energetics processing of brown coal on the air quality on regional scale.
- Adsorption gas cleaning.
- Development and verification of new procedures for the emissions and immissions measurement.
- Development of new types of nano-catalysts for the gas cleaning.

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The Department of Water Technology was established in 1953. In 1973 the teaching and research program extended and the name was changed to Department of Water Technology and Environmental Engineering. Pedagogic and research activities of the Departments are complex comprehensive of all aspects of water and wastewater treatment.

Contemporary research

Water Treatment

- Removal of iron and manganese from ground and mine water.
- Water clarification by means of activated suspensions and polyelectrolytes.
- Removal of heavy metals from water by adsorption and precipitation.
- Removal of beryllium from drinking water.
- Removal of radon from drinking water.
- Removal of priority pollutants from drinking water, disinfection by-products.
- Determination of BDOC parameter in drinking water.
- Evaluation of drinking water aggressive quality.
- Destruction of organic compounds in water using electrical discharge.

Wastewater Treatment

- Population dynamics of activated sludge.
- Separation problems of activated sludge.
- Mathematical models - simulation of activated sludge process.
- Biological nutrient removal, kinetic and metabolic studies of main physiological groups of microorganisms.
- Bioaugmentation of activated sludge microorganisms.
- On-line control of nitrification and denitrification processes.
- Limits of wastewater treatment processes, wastewater reclamation and reuse.
- Membrane biological reactor technology.
- Advanced oxidation processes.
- Heavy metals removal from wastewaters.
- Removal of sulphate from industrial wastewater.
- Combination of anaerobic and aerobic processes at wastewater treatment.

Sludge Management

• Improvement and stimulation of sludge digestion, mechanical and thermal sludge disintegration.
• Thermophilic anaerobic digestion of sludge.
• Methods of sludge hygienization.
• Separate sludge liquor (reject water) treatment.
• Organic substrate production from sludge for biological nutrient removal.

**Anaerobic Digestion**

• Anaerobic wastewater treatment and design of anaerobic reactors.
• Anaerobic fermentation of biowastes.
• Testing of activity of anaerobic microorganisms and anaerobic biodegradability of organic compounds.
• Use of microaerobic condition at anaerobic digestion (hydrogen sulphide removal, improvement of specific compounds biodegradability).

**Hydrochemistry and Water Analysis**

• Solution of chemical equilibria in natural and wastewaters.
• Determination of non-ionic and cationic surfactants in waters.
• Determination of heavy metals in waters and sludge.
• Determination of POC (purgeable, volatile OC).
• Determination of TOC and DOC in waters and sludge.
• Supercritical fluid extraction of organic contaminants from environmental samples.
• Solid phase micro extraction.
• Analysis of toxicologically relevant pollutants in water and environmental solids.
• Determination of AOX in water and sludge.
• Study of chloridioxide system.
• Spectrometric determination of fluoride in water.
• Spectrometric determination of CODMn.
• Determination of humic substances from water.
• Analyses of residual compounds in activated sludge treatment plants effluents e.g. Separation of non-steroidal antirheumatic from water.

**Microbiology**

• Filamentous microorganisms identification and suppression.
• Microbiological analysis of activated sludge and biological foams.
• Identification methods of molecular biology (gene probes).
• Biological degradability of substances containing quartenary nitrogen.
• Determination of relation between chemical structure of substances containing quartenary nitrogen (with aliphatic or aromatic parts) and biodegradability.
• Microbiological analysis of drinking water.
• Analysis of main physiological groups of microorganisms (C, N, S cycle) in surface, underground and waste water and sludge.
• Ecological testing - effect of the contamination of soils on the composition and activity of microflora.
• Toxicity of wastewater, chemicals and new products and their effect on surface water and biological treatment.
• Molecular biology methods.

**Hydrobiology**

• Regional studies of the saprobic and trophic relations of rivers, brooks and storage reservoirs.
• Bioassays of acute, subchronic and chronic toxicity on biological material.
• Biological conditions (microscopic studies) in different model treatment units.
• Biological analyses and evaluation of raw surface and underground water sources, drinking water treatment plants and biological regrowth in distribution systems.
• Biological (hydro- and microbiological) audits.
• Biological evaluation of wastewater treatment plant effluents.
• Biological evaluation of cooling waters.

**Expected future orientation**

• New trends in drinking water treatment and distribution.
• Upgrade and innovation of wastewater treatment processes.
• Alternative methods of wastewater treatment.
• Biological degradability of environmentally hazardous substances.
• Utilization of wastewaters, organic wastes and sludges as a source of energy and raw materials.

**Contacts**

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In past the research activities of the Department of Power Engineering were focused on segments of production of water serving as a medium for power generation (especially using ion exchangers) and corrosion phenomena in power engineering. Nowadays, the traditional research interests were shifted more towards environmental matters: usage of ion exchangers and other sorbents for specific removal of heavy metals and other contaminants from water, water treatment using membrane processes, material science including corrosion phenomena, alternative source of energy and heat. The research projects of the Department are closely connected with practice and are solved in collaboration with research institutions in Czech Republic and abroad.

**Present research**

In the field of water treatment the Department is involved in the following areas: selective removal and recovery of metal cations and oxoanions from contaminated water, utilization of biosorbents and composite sorbents in water treatment, recovery of metal values from waste waters via combination of electrochemical and ion exchange methods. Desalination of water using membranes and ion exchangers is also investigated. Attention is also paid to degradation of ion exchangers (total and breakthrough capacities, grain size analysis, pressure drop across the column) during their life-cycle. For the analysis of heavy metals the Department possesses excellent tools: ion coupled plasma and for the analysis of anions ionic chromatography instruments, respectively.

Research in biomass and waste fuel field is focused on efficient chemical energy release, its recovery and GHG’s emission reduction. Physical and chemical properties of fytomass residues other than wood are evaluated as an alternative fuel option with the potential to replace petroleum and natural gas fuels for domestic heating. Due to its potential in replacing landfilling option the properties of waste fuels are studied with the aim to understand the behavior of fuel and ash under wide range of conditions. Collaboration on the evaluation of the behaviors of the biomass/waste components in inert and oxidative atmosphere particularly for nonconventional fuels, processing byproducts and various wastes is offered including expertise use of analytical methods XRF, DSC-TGA and bomb combustion calorimetry in fuel R&D.

In the field of corrosion research, the activities of Department are currently focused on study of formation and properties of corrosion layers formed on nuclear fuel cladding under conditions of primary circuit of pressurized water reactor (PWR), corrosion protective properties of physical vapour deposition (PVD) coatings, environment-friendly corrosion inhibitors development, corrosivity and corrosion protection in air-conditioning systems, corrosivity and electric properties characterization of liquid alcohol-based biofuels. As an important research tool, electrochemical techniques and surface analysis techniques are applied. New methodological approach is developed including such techniques like Micro Electrochemical Impedance Spectroscopy (MEIS), Acoustic Emission (AE), Electron Spectroscopy for Chemical Analysis (ESCA) and Thin-Layer Electrochemical Impedance Spectroscopy (TLEIS). The Department is equipped with electrochemical measuring systems, autoclaves, experimental loops and loading machines and has possibility to use surface analysis techniques of Central Laboratories of Institute of Chemical Technology, Prague (XPS, SEM etc).
Expected future orientation

- Preparation of highly selective polymeric and composite sorbents.
- Design and application of low-waste ion exchange and hybrid technologies for metal recovery from waste waters.
- Study and modelling of degradation of ion exchangers and polymeric sorbents.
- Biomass and waste fuel pretreatment paths and methods for modification of waste biomass fuels before combustion.
- Mitigation of superheater corrosion in a high pressure boiler during combustion of fuels other than currently used woody biomass.
- Better control of alkalis, chlorine and sulfur compounds being present in the flue gas in order to increase the boiler integrity and its lifetime.
- Exploration of inorganic mineral matter content on devolutilization process, the catalytic effect of mineral matter on thermal degradation and methods to increase ash sintering temperatures.
- Development of methodology of Electrochemical Impedance Spectroscopy in special applications (high temperature systems, high resistivity systems).
- Study of corrosion under specific conditions like super critical water systems, material degradation with focus on special alloys for power producing industry.
- International cooperation in the framework of research of IV. generation of nuclear reactors. This cooperation will be focused on localized types of corrosion like pitting stress corrosion cracking and corrosion fatigue, oxide layer characterization.
- Study of oxide layers will be oriented on structure, chemical analyses, morphology and influence on heat exchange phenomenon, protective properties of oxide layers created under supercritical water conditions and under conditions of intensive heat exchange.

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Department of Environmental Chemistry

Department aims to prepare experts on environmental protection for the industry, state administration, and business, with a particular emphasis to waste management and treatment. Graduates are specialized in the field of waste management and treatment, environmental toxicology, environmental risks and monitoring, and legislation. Department employs 4 professor, 8 assistant professors, and 25 Ph.D. students. Major courses provided by the department include Waste Management and Treatment, Ecology, Ecotoxicology, Environmental Toxicology, Contaminated Soil Treatment, Environmental Sampling and Analysis, Environmental Legislation and Economics. Department further provides short termed educational courses for professionals as well as the two years study program within „The University Of The Third Age“.

Present research

The main research activities of the department include:

• Development of new soil remediation techniques and increasing efficiency of the techniques, which are currently in use. The research effort is mainly directed to soil flushing, soil vapour extraction, phytoremediation, membrane separation, in-situ chemical oxidation, thermal desorption and reactive barriers.

• Development of special instrumental techniques for soil analysis, such as for example analysis of volatile contaminants and analysis of polychlorinated bifenylys.

• Developments of terrestrial ecotoxicological tests (the tests, which can be performed directly on the soil samples).

The above specified research is mainly based on financial support from the national sources, such as for example Grant Agency of the Czech Republic, the department effort is also directed to the European scientific foundations.

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