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EDITOR'S PAGE

OIL SHALE RELATED FUNDAMENTAL RESEARCH AND INDUSTRY DEVELOPMENT

The unbelievable has happened. The brent crude oil price has dropped to around 50 $/bbl. It is quite a different situation compared with that just seven years ago when the oil price was about 120 $/bbl. The present situation makes it economically unfeasible and unpractical to produce shale oil from oil shale. Without power generation the oil shale industry in Estonia would collapse, since for production of only oil the mining costs at present prices would be unreasonable. The current state is a real challenge to oil shale industries and related research. There is a vast amount of research to do to find proper solutions and technologies for shale oil and oil shale power co-production to make this industry more efficient and environmentally friendlier to survive.

World energy supply clearly represents the biggest challenge in the 21st century. One of the key issues is to have a flexible and knowledge based energy sector that supports energy security.

The Department of Thermal Engineering in Tallinn University of Technology has been one of the leading investigative bodies in oil shale power production and shale oil research in Estonia. The conditions for excellent research were significantly improved two years ago when the Department was moved from the old building in Kopli city district of Tallinn to the University's main campus in Mustamäe city district, where the labs have been specially designed for our needs. This gave an opportunity to design and build a new circulating fluidized bed (CFB) test facility with a thermal capacity of 60 kW coupled with a Fourier transform infrared spectrometric (FTIR) analyzer in the new building. A thermal gravimetric analyzer/differential scanning calorimeter (TGA/DSC) coupled with a quadrupole mass spectrometer (QMS) was also procured. Last year funding for purchasing a laser ablation inductively coupled plasma mass spectrometer (LA-ICP-MS), an X-ray fluorescence spectrometer (WDXRF), an elemental analyzer and an automated gas sorption analyzer (for determination of surface area and pore size) was received to support research.

Below I would like to give a short overview of the research work done so far by the Department of Thermal Engineering, as well as of its future perspectives. Recently we have been dealing with studies of oil shale oxyfuel firing in TGA, a batch reactor and the CFB test facility. Oxyfuel favors oil shale and the results are promising for a successful utilization of oil shale oxyfuel in utility boilers. More work is needed for oil shale and fuel mixes co-combustion studies within oxyfuel research. Another topic to be dealt with in parallel is fast pyrolysis of oil shale where semicoke could be used as a source of solid heat carrier in order to increase the overall process efficiency.

This is quite a new level in oil shale related research where the new infrastructure will help achieve goals set in the respective field and in pioneering the oil shale technologies to be used in the industries.

The new infrastructure is there to support the research of young scientists, PhD students. They are working on topics such as the compositional and kinetic analysis of oil shale pyrolysis, experimental analysis of combustion characteristics of Estonian oil shale in regular and oxyfuel atmosphere, algorithmic solutions for heat transfer calculations in fluidized bed processes (thermal processing, direct combustion, heat exchange), and integrated greenhouse gas emissions analysis at processes of energy production from Estonian oil shale.

After two decades we have a reason to celebrate. Two young scientists, Alar Konist and Kristjan Plamus, have defended their PhD thesis in the field of oil shale power production.

In 2012, Kristjan Plamus defended a thesis "The Impact of Oil Shale Calorific Value on CFB Boiler Thermal Efficiency and Environment". The aim of the paper was to investigate the quality of Estonian oil shale in terms of relevant technical and environmental indicators of a CFB boiler. The investigation was based on full-scale firing tests where oil shales with lower heating values (LHV) of 8.2–11.5 MJ/kg were fired. The firing tests demonstrated that oil shale quality significantly influenced the CFB boiler technical and environmental indicators. When firing upgraded oil shale with an LHV of 10.5 MJ/kg instead of conventional fuel with an LHV of 8.4 MJ/kg, the specific CO_2 emission per MWh_e was reduced by 7% and the ash mass flow rate was reduced by 25%. Oil shale quality had a weak influence on the boiler thermal efficiency, which increased by 1% due to the reduction of ash and flue gas enthalpies.

In the year 2013, Alar Konist defended a thesis "Environmental Aspects of Oil Shale Power Production". The goal of his dissertation was to analyze the current situation at Estonian oil shale fired power plants by determining the boiler efficiencies, ash flows, chemical ash composition, specific emissions, fine particulates, trace metals and ash behavior in ash fields by different combustion technologies. The thesis presents a detailed review of the data obtained in the course of in-situ tests and compares it with earlier results. A comparison of the chemical compositions of the ash formed by different combustion technologies is made. The analysis and estimation of changes in the emission of all primary polluting components generated in CFB firing compared to PF are presented. This analysis includes the mass balance of trace metals in the initial fuel and the formed ash, the emissions of dioxins/furans (PCDD/F), polychlorinated biphenyls (PCB), polyaromatic hydrocarbons (PAH) and particulate matter (PM 2.5–10), and conventional air emissions, such as NO_x, SO_2, CO_2, CO, HCl, and total suspended particles (TSP). With the introduction of CFB firing at Estonian oil shale power plants, the environmental impact of oil shale power production has decreased significantly, not only in terms of conventional air pollutants but also trace metals, PAH, dioxins/furans and ash as a CO_2 absorber. The co-combustion of oil shale with biomass in a CFB boiler decreases the environmental footprint of oil shale power generation even more.

Estonia has invested into a new 300 MWel power production unit that utilizes oil shale. This is a mono CFB unit with the capability to co-combust semicoke gas and up to 50% of biofuels by thermal fuel input. Even though sceptics have claimed this decision to be unfeasible, the present situation has proved the opposite. Oil shale power is competitive on Nord Pool Spot's energy market. Even old oil shale pulverized combustion units that are in the power production fleet have been renewed to meet the stricter environmental legislation criteria.

New shale oil production units called Petroter and Enefit-280 are employed in private and state companies. This has led to domestic competition for raw oil shale and related technology development which should need more analyses and attention by renewed politics.

To support oil shale related research in Tallinn University of Technology, the Department of Thermal Engineering has been granted by the Estonian Government a new professorship in oil shale technologies.

One of the topics to be dealt with by the new professorship will be the fundamental investigation of combustion characteristics of oil shale and its mixture with other fuels (biomass) in a fixed bed, which plays a key role to understand the combustion parameters such as ignition and burning rates in combustion performance. The pyrolysis and combustion behavior of biomass, an indigenous oil shale and their blends in air and oxyfuel firing conditions will be investigated using the non-isothermal thermogravimetric method (TGA/DSC) coupled with QMS. In this work a 60 kWth pilot CFBC will be used. The CFBC has been designed to allow fluidization with either air or O_2 mixed with recycled flue gas. The unit also enables sampling of flue gas such as trace metals and volatile organic compounds. FTIR and total organic content (TOC) analyzers will be used for determination of flue gas composition. To determine the chemical composition of the fuel used, the formed ash and fly ash, WDXRF, ICP-MS, an elemental analyzer, inductively coupled mass spectrometry (ICP), scanning electron microscopy-X-ray diffractometry (SEM-XRD) and a chemisorb analyzer will be used.

Based on the results obtained the sustainability of the proposed technologies will be evaluated.

Andres SIIRDE
Professor
Director of Department of Thermal Engineering
Tallinn University of Technology