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ILMAR ÖPIK AND OIL-SHALE-FIRED BOILERS

My contacts with **Ilmar Öpik**, an intelligent engineer and a distinguished scientist, began in 1956, when I worked as an assistant of the head of Boiler Department in Kohtla-Järve Power Plant.

I. Öpik's career as a scientist began immediately after the start-up of the first *Relay-Stokers* and CKTI 75-39-F-type boilers in Kohtla-Järve and Ahtme power plants fired with pulverized oil shale when it had become evident that these boilers were not fit to work on pulverized oil shale. No preliminary studies were made before designing these boilers. The main reason why these boilers could not attain the designed parameters was the fouling of all heating surfaces with ash deposits and, first of all, the erosion wear of economizers. The fouling of boiler bundle and the second stage of air preheater in *Relay-Stokers* type boilers was most catastrophic. Three big institutes of the former U.S.S.R. were dealing with reconstruction of operating oil shale fired boilers in this time:

- All-Union Heat Engineering Institute, now Russian Heat Engineering Institute
- Scientific & Development Association on Research and Design of Power Equipment
- *Orgenergostroi*

Their studies were directed mostly towards improving the design of heating surfaces in order to achieve the operation of boilers at designed parameters.

I. Öpik tried to solve the problem in another way, to find out the basic laws of fouling process. He built a pilot boiler for researching the behaviour of oil shale mineral matter in the combustion process. In this boiler the mixture of pulverized oil shale (25 %) and oil shale gas was burned.

Studies on chemical composition and structure of deposits on heating surfaces in operating boilers continued parallel to the experiments on the pilot boiler. In spring 1953 I. Öpik defended his candidate's dissertation "Sintering of Fly Ash Deposits on Heating Surfaces in Oil Shale-Kukersite Fired Boilers" on the basis of these results. I, then a third-course student, still remember a comment. A well-known chief engineer expressed his regrettable opinion that he could not see any perspective for this study in his power plant. Unfortunately, there were no talks yet about high-pressure pulverized oil shale fired boilers in 1953. The building of the new boiler was decided in the end of 1955.

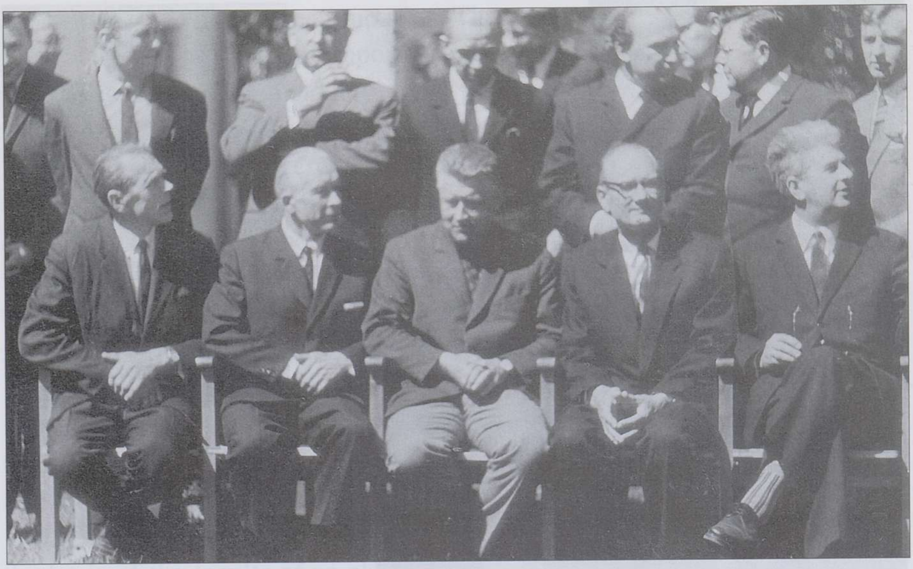
At the next stage of research (together with post-graduate student Ilmar Mikk and engineer Endel Ratnik) the formation mechanism of loose and dense sulfate deposits at the co-action of mechanical and chemical processes was studied under controllable conditions (the temperature and velocity of flue gases, the temperature of probe). The experiments were carried out in a gas channel built between superheater and flue-gas exhauster in Kohtla-Järve Power Plant boiler No. 1. I. Mikk composed his candidate's dissertation "Oil Shale-Kukersite's Fly-Ash Hardening on Tubes" on the basis of the research results. He defended the dissertation at the Academy of Sciences of the Estonian SSR in 1957. It was the first candidate dissertation supervised by I. Öpik. Later I. Mikk continued his research in the field of radiative heat transfer.

Comprehensive studies of elaboration of high-pressure boiler design started in 1955 when it was decided to establish a pulverized oil shale fired power plant near Narva. Taganrog Boiler Manufacturing Factory had to design and build the new boiler. Ilmar Öpik, who was already highly acknowledged by two Moscow ministries, was appointed the Estonian side supervisor of the design and building of the new boilers. Boris Mgalobelov, the chief engineer of *Estonian Energy* of that time, a man with great knowledge and persuasive force pushed through I. Öpik's ideas. It was known from the experience of the five-year operation that:

- Common cross-flow convection superheater with small pitch is incapable of operation because of intensive fouling
- Heating surface of superheater must have maximum longitudinal flow in order to reduce fouling
- Location of air preheater under the economizer is inadmissible
- It is practical to locate the economizer in the ascending gas flow in order to reduce wear
- Sufficient number of cleaning facilities must be provided for periodical cleaning of heating surfaces

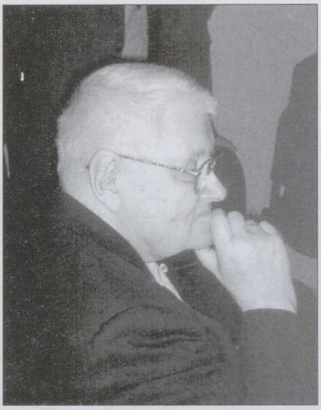
BKZ-75-39-type boiler No. 5 in Kohtla-Järve Power Plant was reconstructed for solving the problems concerning design of the above-mentioned new boiler. The pilot platen superheater tubes were in longitudinal gas flow in the extent of around 84 % and the economizer was in ascending flue gas flow in this boiler. The pilot platen superheater was provided with fixed steam nozzles for periodical cleaning.

Heat Power Men

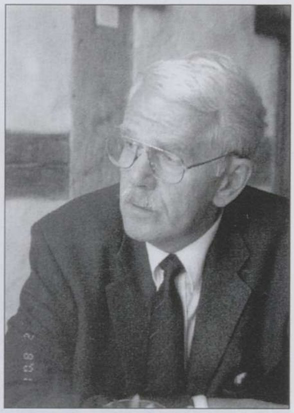


At Püssi, 1968

In Tallinn, 1960



I. Öpik with his colleagues at the Thermal Engineering Department of TTU, December 21, 2000



A. Prikk

Standing from left: J. Raidma, A. Paist, Ü. Kask, A. Ots, A. Veski, sitting on the right: H. Arro

Standing from left: I. Viilman, A. Hlebnikov and H. Arro

Parallel to the studies on heat absorption and fouling of longitudinal flow platen superheater tubes, analogical experiments were carried out on cross-flow convection superheater which was periodically cleaned with stationary OPK-7-type soot blowers. The rotating pipes of these soot blowers were assembled with Ø 4 mm steam nozzles. The research on cross-flow platen superheaters was of practical importance, because the longitudinal-flow platen superheaters have unavoidably some cross-flow areas, and there was no method for calculating them.

These experiments were short-term ones (~900 hours) and planned only to study the mechanism of deposit formation under conditions of periodical cleaning; the high-temperature corrosion-scouring wear was not directly studied. However, this type of wear was found both on pilot platen superheater tubes and on boiler superheaters cleaned with steam soot blowers. This phenomenon was not studied because of the lack of time. However, I remember Ilmar Öpik's warning: "We shall face serious problems with cleaning and wear of superheater. We have nothing but long-travel steam soot blowers for their cleaning, and without cleaning the superheating temperature 540 °C cannot be achieved". His words have come true.

I. Öpik presented a concept of new high-pressure oil-shale-fired boiler on the basis of the results of an almost three-year research. Constructors of Taganrog Boiler Manufacturing Factory approved his concept, despite of the criticism of ministries in Moscow because of too great metal content of the boiler with four passes. The new boiler was named TP-17. The political start-up of the boiler took place in the end of 1959.

In the beginning of the 1960s the laboratory research on resistance of various boiler steels to high-temperature corrosion began under the supervision of I. Öpik. Engineers Hendrik Arro and Elvi Tomann carried out the experiments with the purpose to assess corrosion resistance of various-grade boiler steels in the presence of oil shale ash and flue gases and to reveal corrosion accelerating compounds in oil shale ash and deposits. Various methods showed that KCl is the main compound responsible for acceleration of high-temperature corrosion of steels.

It was found that the ash deposits on cooled probes located in gas channel contain 17 % Cl. It was a great surprise for all of us but at the same time also the explanation of intensive wear of superheater tubes in TP-17-type boilers. Under I. Öpik's supervision H. Arro composed his candidate's dissertation based on the results of studies of ash deposits in boilers fired with oil shale and Nazarovo brown coal. He defended this dissertation in 1968. In the same year Arvo Ots, the future head of Thermal Engineering Department of Tallinn Technical University and a member of the Academy of Sciences defended his doctor's dissertation.

A new boiler with the capacity of 100 MW (320 t/h) was designed for Baltic Power Plant 200 MW unit in Taganrog Boiler Manufacturing Factory. This boiler was designed with three passes to reduce the costs, but this design required the use of cross-flow platen superheaters. Taganrog Boiler Manufacturing Factory made four pilot platen superheaters to study the problems of fouling, cleaning and wear. In 1961 the author of this paper, employed at this time in *Energoremont*, took part in the mounting of these platen superheaters in boiler No. 1. We succeeded in performing only 50 % of planned experiments because of the failure of superheaters due to inappropriate operation.

I. Öpik's scientific activity was directed to solve the problems arising from practice. In the last years, being already a professor emeritus, he took an active part in designing new circulating fluidized-bed oil-shale-fired boilers as well as in discussing new projects presented by boiler manufacturing factories.

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Harri Tallermo by I. Öpik's grave at *Metsakalmistu* cemetery

Biographical and bibliographical lists were compiled basing on the following sources:

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