MEHAANIKATEADUSKONNA SOOJUSTEHNIKA INSTITUUDI
TEADUS- JA ARENDUSTEGEVUSE AASTAARUANNE 2011

1. Instituudi struktuur

Instituudi direktor Aadu Paist

- Soojusenergeetika õppetool, Chair of Thermal Power Engineering, Aadu Paist
- Soojusjõuseadmete õppetool, Chair of Thermal Power Equipment, Andres Siirde
- Tööstusliku soojustehnika õppetool, Chair of Heat Engineering, Ivan Klevtsov

2. Instituudi teadus- ja arendustegevuse (edaspidi T&A) iseloomustus

(NB! punktid 2.1- 2.6 täidab struktuuriüksus)

2.1 struktuuriüksuse koosseisu kuuluvate uurimisgruppide

2.1.1 teadustöö kirjeldus *(inglise keeles*);

Diagnostics and reliability of high pressure equipment of power plants

Availability of power plant equipment is directly connected to the power production safety, economy and power supply security of the republic. For that purpose inspection program, unique methodology and devices for the control of most sensitive parts of high pressure equipment of oil shale power plants (steam pipelines, boiler drums, turbine rotors etc.) are created. Regular investigations of high pressure equipment metal structure were performed by finding out weakest parts of the system with computer simulation of tenses at first. At next small metal samples for the detailed metallographic studies were taken. As a result of investigations pressure parts remaining lifetime is estimated and relevant measurers for avoiding breakdowns were proposed to the power plant operator.

Utilization of biomass and wastes

Biomass and wastes larger utilization is one of the Estonian energy policy aims. Fulfilment of this goal starts from screening of different biomass and wastes resources and properties. Related investigation includes topics of gasification behaviour and reactivity of different biomass chars, co-combustion of biomass and oil shale, operational problems of biomass fired large boilers related to heating surfaces fouling and deposit formation.

Larger utilization of biomass local resources is connected to compilation of regional energy supply masterplans also.

Air emissions

Mainly large combustion facilities (oil shale boilers) were studied with the purpose of reduction of air emissions by operational methods or by cleaning flue gases (semidry DeSOx) using high oil shale ash free lime content online in flue gas flow.

Dependence of DeSOx units efficiency on used fuel type and composition, boiler load and operation mode, furnace and gas pass temperature distribution was investigated.

Large scale tests on old PF boilers were performed for getting initial data for designing NOx reduction facilities for these boilers.

Processes at pulverized (PF) and circulated fluidized bed (CFB) fired boilers

With addition of irregular production loads to Estonian main power grid (windmills, co-generation plants) problem of compensation of these loads during breakouts with other existing power production units or sources arises. For that purpose load change dynamics, efficiency and emissions of oil shale PF power units are investigated.

Co-firing of oil shale and biomass in large CFB boilers changes heat and mass transfer terms in fluidizing bed. Ash composition and properties of mixed fuels is changed and it can have

unexpected effect to heating surfaces fouling and air emissions. Long term regular surveillance program and periodical tests on relevant CFB unit of Balti PP for the investigation of these problems are arranged.
Mineral matter behaviour at very different from conventional pulverized firing conditions in CFB boilers was investigated. Much lower temperatures and decomposition of carbonate minerals, high mixing efficiency of combustion products and longer residence times are resulting higher ash sulphation and HCl capture rates effecting also boiler thermal efficiency.

The basis of heat and mass transfer

Heat transfer augmentation possibilities (fouling, pressure drop, temperature distribution) of special construction turbulator inserts in air preheater (LUVO) of large oil shale boiler were investigated. The aim of the work is to raise thermal efficiency of the boilers.
First experiments at 100 MW power unit proved, that despite extremely high ash loads almost no deposits are formed.

Oil shale ash properties, ash fields technological problems and environmental impact

Drastically changed mineralogical properties of oil shale ash from CFB boilers in comparison with PF ash are causing problems at existing ash fields. Investigations of ash field layers by taking samples from different depths were performed.

2.1.2 aruandeaastal saadud tähtsamad teadustulemused *(inglise keeles).*

- Large scale boiler tests at PF boiler revealed possibility of simultaneous reduction of SO_2 and NO_x emissions under certain combustion conditions (staged firing).
- Co-firing of biomass and Estonian oil shale in CFB boilers with biomass rates up to 20 % of heat does not cause any operational problems or effects to boiler availability and efficiency.
- In short term prospective turbulator inserts in air preheater (LUVO) of oil shale PF boiler are not causing additional fouling or corrosion problems.
- Handbook for biomass producers/users *Bioenergy Sytems Planning* was published.

Two PhD Theses were defended:
Reactivity of Woody and Herbaceous Biomass Chars, by Siim Link
Model for the Analysis of Combined Energy Production, by Eduard Latõšov

34 papers and conference presentations, 26 project reports were published.

2.2 Uurimisgrupi kuni 5 olulisemat publikatsiooni läinud aastal.

1. T. Pihu, H. Arro, A. Prikk, R. Rootamm, A. Konist K. Kirsimäe, M. Liira, R. Mõtlep. (2012) Oil Shale CFBC ash cementation properties in ash fields. The expected dispatch date of proofs 15-SEP-2011.
2. Plamus, K.; Ots, A.; Pihu, T.; Neshumayev, D. (2011). Firing Estonian oil shale in CFB boilers – ash balance and behaviour of carbonate minerals. Oil Shale, 28(1), 58 - 67.
3. Parve, T.; Loosaar, J.; Mahhov, M.; Konist, A. (2011). Emission of fine particulates from oil shale fired large boilers. Oil Shale, 28(1S), 152 - 161.

2.3 Loetelu struktuuriüksuse töötajate rahvusvahelistest tunnustustustest.

2.4 Loetelu struktuuriüksuse töötajatest, kes on välisakadeemiate või muude oluliste T&A-ga seotud välisorganisatsioonide liikmed.

Arvo Ots

Ameerika Mehaanikainseneride Assotsiatsiooni liige

Soome Tehnikateaduste Akadeemia Välisliige

Inge Roos, ÜRO Kliimasekretariaadi (UN FCCC, Climate Secretariat) /mittekoosseisuline ekspert kasvuhoonegaaside inventuuri alal

Andres Siirde

Euroopa Komisjoni Söe Nõuandva töögupi /liige

2010 - 2011 Rahvusvahelise Sümpoosiumi "International Conference of Young Scientists on Energy Issues", Lithuanian Energy Institute, Kaunas, Lithuania, teadusnõukogu liige

Sulev Soosaar, Eesti esindaja Euroopa Komisjoni Energeetika ja Transpordi Peadirektoraadi (DG TREN) nõuandvas energiamajanduse analüütikute (*Energy economic analysts*) töögrupis (alates 2009. aastast)/liige

2.5 Aruandeaasta tähtsamad T&A finantseerimise allikad.

1. T024, Energiaressursside säästlik kasutamine ja protsesside täiustamine põletusseadmetes, Ots Arvo
2. Lep10050, Põlevkivielektrijaamade käiduga seotud soojustehnilised ja keskkonnaalased probleemid, Pihu Tõnu
3. Lep7015, AS Narva elektrijaamade surveseadmete ohutu käitamise tagamise uuringud, Klevtsov Ivan

2.6 Soovi korral lisada aruandeaastal saadud T&A-ga seotud tunnustusi (va punktis 2.3 toodud tunnustused), ülevaate teaduskorralduslikust tegevusest, teadlasmobiilsusest ning anda hinnang oma teadustulemustele.

2.7 Instituudi teadus- ja arendustegevuse teemade ja projektide nimetused *(Eesti Teadusinfosüsteemi, edaspidi ETIS, andmetel)*

- Haridus- ja Teadusministeerium

sihtfinantseeritavad teemad:

- T024, Energiaressursside säästlik kasutamine ja protsesside täiustamine põletusseadmetes, Ots Arvo

baasfinantseerimise toetusfondist rahastatud projektid (sh TTÜ tippkeskused):

- B10, Professor Ivan Klevtsovi poolt juhitava uurimisgrupi toetamine

riiklikud programmid:

- Teiste ministeeriumide poolt rahastatavad riiklikud programmid:
- Uurija-professori rahastamine:

- SA Eesti Teadusfond

grandid:

- ETF8782, Põlevkiviõli ja elektrienergia koostootmise mudelleerimine, Arvo Ots
- ETF8633, Soojusjõuseadmete metalli seisundi uuringud, Andrei Dedov

ühisgrandid välisriigiga:
järeldoktorite grandid (SA ETF ja Mobilitas):

- MJD10, Small-scale cogeneration plants in Estonian towns, Volkova Anna

tippteadlase grandid (Mobilitas):

- Ettevõtluse Arendamise SA

eeluuringud:
arendustoetused:

- SA Archimedesega sõlmitud lepingud

infrastruktuur (nn „mini-infra“, „asutuse infra“):

- AP024, Soojusseadmete efektiivsuse ja töökindluse uurimine ning selle suurendamise teed, Ots Arvo

Eesti tippkeskused:
riiklikud programmid:

- AR12003, CO2 heitme vähendamine põlemisõhu hapnikurikkamaks muutmisega keevkihtkatlas, Tõnu Pihu

muud T&A lepingud:

- SA Keskkonnainvesteeringute Keskusega sõlmitud lepingud:

- Siseriiklikud lepingud:

- Lep10034, Tuulemõõtmised Türisalus, Pertmann Indrek
- Lep10037, Sillamäe kaugküttevõrgu torustikulõikude soojuskadude mõõtmine ja arvutus, Kask Ülo
- Lep10050, Põlevkivielektrijaamade käiduga seotud soojustehnilised ja keskkonnaalased probleemid, Pihu Tõnu
- Lep11004, Turbulaatorite kasutamine soojusülekande intensiivistamiseks põlevkivikatelde õhueelsoojendis I, Ots Arvo
- Lep11017, Narva soojusvõrgu efektiivsuse muutuse hinnang aastatel 2006-2011, Narva soojusvõrgu efektiivsuse edasise tõstmise võimaluste analüüs ja soojusvõrgu rekonstrueerimise kava järgnevaks viieks aastaks, Paist Aadu
- Lep7015, AS Narva elektrijaamade surveseadmete ohutu käitamise tagamise uuringud, Klevtsov Ivan
- LMIN10119B, Energeetika ja põllumajanduse valdkondade Eesti riikliku kasvuhoonegaaside 2011. aasta inventuuri ja inventuuri aruande koostamine, Roos Inge
- LMIN11073B, Energeetika ja põllumajanduse valdkondade Eesti riikliku kasvuhoonegaaside 2012. aasta inventuuri ja inventuuriaruande koostamine, Roos Inge

- EL Raamprogrammi projektid:

- Välisriiklikud lepingud:

– VE512, NOx BASELINE TESTS FOR EEJ BOILER TP-101, Loosaar Jüri
– VIR417, The Baltic Sea Region Bioenergy Promotion Project, Roos Inge
– VIR442, From waste to traffic fuel, Kask Ülo
– VIR464, Concepts for using reed biomass as local bioenergy and building material, Kask Ülo
– VIR499, The Bioenergy Systems Planners Handbook - BISYPLAN, Kask Ülo

2.8 Struktuuriüksuse töötajate poolt avaldatud sihtfinantseeritava teadusteema taotlemisel arvestatavad eelretsenseeritavad teaduspublikatsioonid *(ETIS klassifikaatori alusel 1.1, 1.2, 1.3, 2.1, 2.2, 3.1, 3.2, 3.3, 4.1 ja 5.1).*

1.1

Suik, H; Pihu, T; Konist, A (2011). Catastrophic wastage of tubes in fluidized bed boiler. Oil Shale, 28(1S), 162 - 168.

Neshumayev, D.; Ots, A.; Parve, T.; Pihu, T.; Plamus, K.; Prikk, A. (2011). Combustion of Baltic Oil Shale in Boilers with Fluidized Bed Combustion. Power Technology and Engineering, 44(5), 382 - 385.

Parve, T.; Loosaar, J.; Mahhov, M.; Konist, A. (2011). Emission of fine particulates from oil shale fired large boilers. Oil Shale, 28(1S), 152 - 161.

Siirde, A.; Roos, I.; Martins, A. (2011). Estimation of Carbon Emission Factors for the Estonian Shale Oil Industry. Oil Shale, 28(1S), 127 - 139.

Pertmann, I. (2011). Estonian Wind Farms Need for Full Balance Power. Oil Shale, 28(1S), 193 - 202.

Plamus, K.; Ots, A.; Pihu, T.; Neshumayev, D. (2011). Firing Estonian oil shale in CFB boilers – ash balance and behaviour of carbonate minerals. Oil Shale, 28(1), 58 - 67.

Plamus, K.; Soosaar, S.; Ots, A.; Neshumayev, D. (2011). Firing Estonian oil shale of higher quality in CFB boilers – environmental and economic impact. Oil Shale, 28(1S), 113 - 126.

Kartushinsky, A.; Siirde, A.; Rudi, Ü.; Shablinsky, A. (2011). Mathematical model of two-phase flows loaded with light and heavy particles to analyze cfb processes. Oil Shale, 28(1s), 169 - 180.

Kask, Ü.; Loosaar, J.; Parve, T.; Kask, L.; Paist, A.; Muiste, P.; Padari, A.; Astover, A. (2011). Potential of biomass in Narva region regarding oil shale and biomass co-firing. Oil Shale, 28(1s), 181 - 192.

Paist, A. (2011). Present and future of oil shale based energy production in Estonia. Oil Shale, 28(1S), 85 - 88.

Ots, A.; Poobus, A.; Lausmaa, T. (2011). Technical and ecological aspects of shale oil and power generation. Oil Shale, 28(1S), 101 - 112.

Latõsov, E.; Volkova, A.; Siirde, A. (2011). The impact of subsidy mechanisms for biomass and oil shale based electricity cost prices. Oil Shale, 28(1S), 140 - 151.

T. Pihu, H. Arro, A. Prikk, R. Rootamm, A. Konist K. Kirsimäe, M. Liira, R. Mõtlep. (2011) Oil Shale CFBC ash cementation properties in ash fields. // Fuel, The expected dispatch date of proofs 15-SEP-2011.

1.2

Volkova, A.; Hlebnikov, A.; Siirde, A. (2011). Methodology for defining of eligible capacity for wood fuel based cogeneration plants in small towns in Estonia. Journal of Energy and Power Engineering, 5(6), 481 - 489.

Мисенёв, С.И.; Сийрде, А.Э.; Юркин, С.В.; Якутов, В.В. (2011). Опыт внедрения систем пневмообрушения на базе устройств «ИСТА-4» в бункерах сырого сланца . Электрические станции, 11, 52 - 55.

Križan, P.; Matúš, M.; Šooš, L.; Kers, J.; Peetsalu, P.; Kask, Ü.; Menind, A. (2011). Briquetting of municipal wastes by different technologies for quality and properties evaluation . Agronomy Research, 19, 115 - 123.

1.3

Kask, Ü.; Andrijevskaja, J. (2011). Pilliroo kasutamise kontseptsioon kohaliku energiaallika ja ehitusmaterjalina. Eesti põlevloodusvarad ja -jäätmed = Estonian combustible natural resources and wastes, 2011, 18 - 19.

2.1

2.2

3.1

Volkova, A.; Roos, I.; Soosaar, S.; Siirde, A. (2011). Competitiveness of wood fuel in the conditions of open electricity market in Post-Kyoto period: case study for Estonia. In: Proceedings of International Conference on Clean Electrical Power: 3rd International Conference on Clean Electrical Power, Renewable Energy Resources Impact, Ischia, Italy, 14th-16th June, 2011. IEEE, 2011, 660 - 667.

Priss, J.; Klevtsov, I. (2011). Strength calculations of slurry disposal pipeline. THE 22ND DAAAM WORLD SYMPOSIUM, 23-26th November 2011, Austria Center Vienna, Vienna, Austria. DAAAM International Vienna, 2011, 1175 - 1176.

Volkova, A.; Siirde, A. (2011). The Use of Thermal Energy Storage for Energy System based on Cogeneration plant. In: Recent Researches in Geograpjy, Geology, Energy, Environment and Biomedicine: The 5th International Conference on Energy and Development-Environment-Biomedicine 2011 (EDEB'11), Corfu Island, Greece, July 14-16, 2011. North Atlantic University Union: WSEAS, 2011, 71 - 75.

3.2

Kartushinsky, A.; Siirde, A. (2011). Mathematical Modelling of the Motion of Dust-Laden Gases in the Freeboard of CFB Using the Two-Fluid Approach. Jianping Zhu (Toim.). Computational Simulations and Applications (143 - 158).INTECH

Lausmaa, T. (2011). Correlation of the fire resistance time of fire doors and the structure of the doors. In: Extended Abstracts 2011 Baltic Heat Transfer Conference: 6-th BHTC, August 24-26, Tampere, Finland. , 2011, 52 - 52.

Neshumayev, D.; Ots, A.; Poobus, A. (2011). Full scale experiments on application of compound heat transfer enhancement technique in fire-tube boilers. 6th Baltic Heat Transfer Conference, August 24-26, 2011, Tampere, Finland. Tampere University of Technology, 2011.

Ots, A. (2011). Thermophysical properties of ash deposit on boiler heat exchange surfaces. Heat Exchanger Fouling and Cleaning, Crete, 06-10.06.2011. , 2011.

Priss, J.; Klevtsov, I. (2011). The Programs for Strength Calculation in Pipelines . Rain Lahtmets (Toim.). 10th International Symposium "Topical problems in the field of electrical and power engineering. Doctoral school of energy and geotechnology". II : Pärnu, Estonia, January 10-15, 2011 (209 - 212). Tallinn: Estonian Society of Moritz Hermann Jacobi

Latõšov, E. ; Siirde, A. (2011). Competitiveness Of Combined Heat And Power Plant Technologies In Estonian Conditions. In: 12th International Symposium on District Heating and Cooling September 5th–September 7th, 2010 Tallinn, ESTONIA: Tallinna Tehnikaülikool, 2011. [ilmumas]

3.3

4.1

5.1

2.9 Struktuuriüksuses kaitstud doktoriväitekirjade loetelu *(NB! struktuuriüksus lisab struktuuriüksuse töötaja juhendamisel mujal kaitstud doktoriväitekirjade loetelu)*

Siim Link, soojustehnika instituut
Teema: *Reactivity of Woody and Herbaceous Biomass Chars* (Puit- ja rohtbiomassi kokside reageerimisvõime)
Juhendaja: prof Aadu Paist
Kaasjuhendaja: Dr Stelios Arvelakis
Kaitses: 20.12.2011
Omistatud kraad: filosoofiadoktor (soojusenergeetika)

Eduard Latõšov, soojustehnika instituut
Teema: *Model for the Analysis of Combined Energy Production* (Koostootmise analüüsi mudel)
Juhendaja: prof Andres Siirde
Kaitses: 17.03.2011
Omistatud kraad: filosoofiadoktor (soojusenergeetika)

2.10 Struktuuriüksuses järeldoktorina T&A-s osalenud isikute loetelu *(ETIS-e kaudu esitatud taotluste alusel)*

MJD10, Small-scale cogeneration plants in Estonian towns, Volkova Anna

2.11 Struktuuriüksuses loodud tööstusomandi loetelu

3. Struktuuriüksuse infrastruktuuri uuendamise loetelu

- 38DLP Ultraheli paksusemõõtja,28.06.2011, 3 023 €
- Tuhasulatus analüsaator,5.10.2011, 46 828 €
- Tõmbekatsestend LabTest,20.12.2011, 22 404 €