SUOMEN SOODAKATTILAYHDISTYS
FINNISH RECOVERY BOILER COMMITTEE

Suomen Soodakattilayhdistys ry

Soodakattilapäivä 2019

Sokos hotelli Presidentti, Helsinki

31.10.2019

Raportti 4/2019

(16A0913-E0197)

Raportti 4/2019, Soodakattilapäivä 2019

SOODAKATTILAPÄIVÄ 31.10.2019
Sokos Hotel Presidentti, Helsinki
OHJELMA

09.30-09.55	Ilmoittautuminen ja aamukahvi *Sokos Hotel Presidentti, auditorio*
09.55-10.00	Tilaisuuden avaus
10.00-10.30	Suomen Soodakattilayhdistys, vuosikatsaus 2018-2019 *Markus Nieminen, Suomen Soodakattilayhdistys ry*
10.30-11.00	Non-process elements in the recovery cycle of six Finnish pulp mills *Camilla Karlemo, Valmet Technologies Oy*
11.00-11.30	Kahvitauko
11.30-12.00	Intelligent online analysis to better understand and optimize the recovery cycle *Pia Holmberg, Acosense AB*
12.00-12.30	Soodakattilan lämmönsiirtopintojen ajonaikainen likaantumisenhallinta – CBE räjäytyspuhdistukset *Vesa Railamaa, Clean Steel Oy*
12.30-13.30	Lounas *Presidentti-sali*
13.30-14.00	Possible to extend uninterrupted operation periods of kraft recovery boilers *Markku Lehtinen, ANDRITZ*
14.00-14.30	Recovery boiler technology trends in past and in future *Kari Haaga ja Timo Laurila, Valmet Technologies Oy*
14.30-15.00	Kahvitauko
15.00-15.20	Sodahuskommittén - Ruotsalais-norjalainen soodakattilakomitea, vuosikatsaus 2018 *Kristian Rosenqvist, Sodahuskommittén*
15.20-15.40	IAPWS (The International Association for the Properties of Water and Steam) Suomen osaston esittely, *Arja Lehikoinen, SIAPWS Suomi ry*
15.40-16.10	Yhdistyksen opinnäytetyöpalkintojen jako/esittely: Recovery Boiler Superheater Region Temperature Measurements for Fouling Prediction Development *Santeri Peltola, Tampereen yliopisto / Valmet Technologies Oy*
17.00-18.00	Cocktailtilaisuus *Tapahtumatila Forum Pressa*
19.00-	Päivällinen *Sylvi-sali*

SUOMEN SOODAKATTILAYHDISTYS RY
FINNISH RECOVERY BOILER COMMITTEE
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FIN-01621 VANTAA

Puhelin Telephone
+358 10 3311

Internet
http://www.soodakattilayhdistys.fi

SUOMEN SOODAKATTILAYHDISTYS, VUOSIKATSAUS 2018-2019

Markus Nieminen
Suomen Soodakattilayhdistys ry

SUOMEN SOODAKATTILAYHDISTYS
FINNISH RECOVERY BOILER COMMITTEE

Katsaus soodakattilayhdistyksen toimintaan 2018-2019

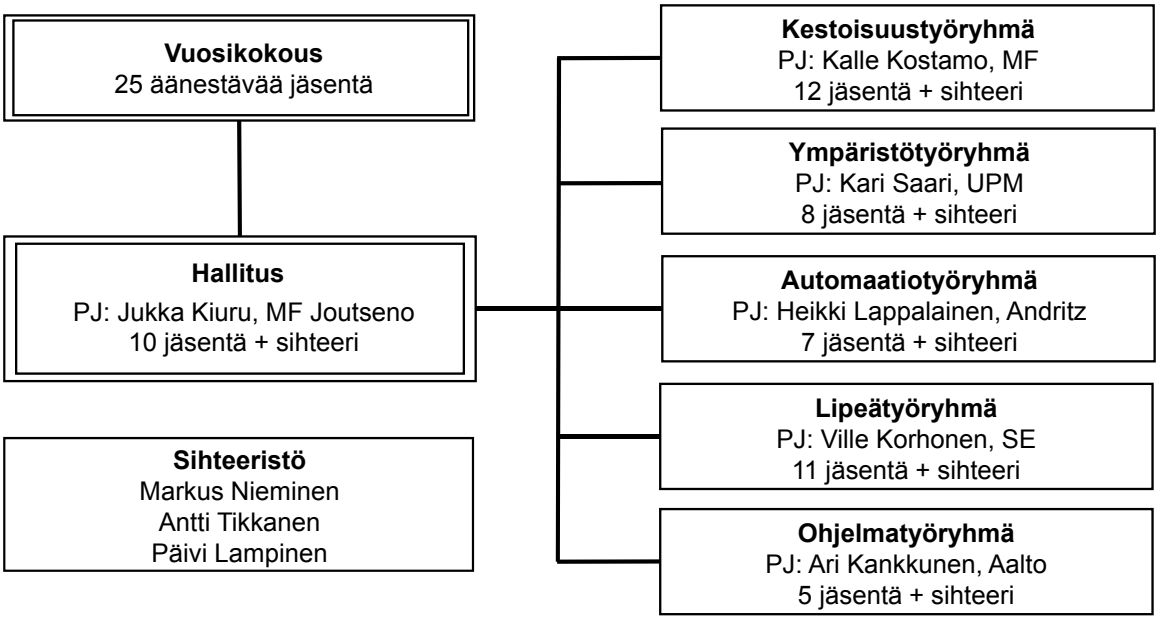
Soodakattilapäivä 31.10.2019
Sokos Hotel Presidentti, Helsinki

SUOMEN SOODAKATTILAYHDISTYS
FINNISH RECOVERY BOILER COMMITTEE

Sisältö

- SKY esittely / tapahtumat
- Suomen soodakattilat
- Projektit

SKY organisaatio 2019



Tulevia tapahtumia

- Konemestaripäivä 23.1.2020
  - Paikka: Sokos hotelli Lappee
  - Tehdasvierailu Kaukaan tehtaalle
  - Kutsu ja alustava ohjelma tulossa marraskuussa
- Soodakattilaoperaattoreiden kokemustenvaihtopäivä 2020
  - 12.-13.2.2020, paikkana Sokos hotelli Presidentti, Helsinki
  - Tilaisuuden kohderyhmänä on soodakattilan operaattoritason henkilöt
  - Käydään läpi käytännön esimerkkien avulla soodakattiloissa tapahtuneita vaurioita sekä ajossa syntyneitä ongelmatilanteita.
- Soodakattilapäivä 22.10.2020 Sokos Hotel Torni Tampere

Opinnäytetyöpalkinto

- Jaetaan vuosittain parhaasta maisterivaiheen opinnäytetyöstä (laajuus 30 op) sulfaattisellutehtaan talteenottoalueella
- Palkinto jaettiin ensimmäisen kerran vuonna 2009
- Palkinnon arvo on 2.000 €
- Palkintoa voi hakea Suomessa korkeakoulussa tai yliopistossa tutkintonsa suorittavat opiskelijat, joiden opinnäytetyö liittyy sulfaattisellutehtaan kemikaalien talteenottoon
- Tarkemmat tiedot yhdistyksen nettisivuilta
  - http://www.soodakattilayhdistys.fi/yhdistys/opinnaytetyopalkinto

SUOMEN SOODAKATTILAYHDISTYS
FINNISH RECOVERY BOILER COMMITTEE

Opinnäytetyöpalkinto

- Vuonna 2019 palkinto on päätetty jakaa kahdelle työlle:
  - Santeri Peltola: Recovery Boiler Superheater Region Temperature Measurements for Fouling Prediction Development
  - Kunal Kumar: Integrated Computational Fluid Dynamics and 1D Process Modelling for Superheater Region in Recovery Boiler

Suomen soodakattilat

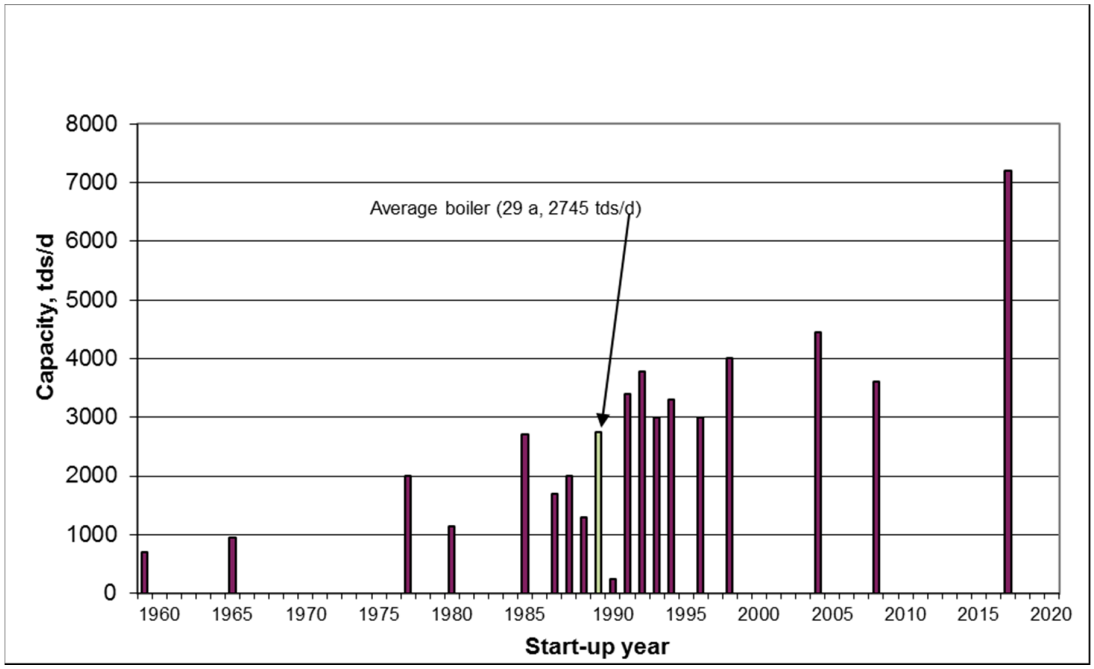
SUOMEN SOODAKATTILAYHDISTYS
FINNISH RECOVERY BOILER COMMITTEE

Suomen soodakattilat

- Kattiloita 17 kappaletta
  - Vanhin vuodelta 1959 (60 vuotta)
  - Uusin vuodelta 2017 ja suurin (7200 tka/vrk)
  - Pienin 250 tka/vrk

- Tehtaita 15 kappaletta
- Keskimääräinen kattilan ikä 29 vuotta (1989)
- Keskimääräinen kapasiteetti 2745 tka/vrk
- Yhdistetty kapasiteetti 46 660 tka/vrk

Suomen soodakattilat



Yhdistyksen projektit

3-vuotissuunnitelma

- Vuosikokouksessa päätettiin ottaa käyttöön tietyt teemat joita tullaan korostamaan seuraavat 3 vuotta (2018-2020). Näitä teemoja ovat:
  - pitkät ajojaksot (mm. sularännit, soodakattilan likaantuminen)
  - hajukaasut
- Teemoihin liittyvät projektiehdotukset ovat etusijalla rahoituksesta päätettäessä.

SUOMEN SOODAKATTILAYHDISTYS
FINNISH RECOVERY BOILER COMMITTEE

Projekteja 2018-2019

- Mustalipeän polttomenetelmät Suomen soodakattiloissa
- Soodakattila ja talteenottokierron vierasaineet
- Putken kuorinta ja S0-linjaus
- Selvitys sularännivaurioista
- Hajukaasusuosituksen päivitys

Mustalipeän polttomenetelmät Suomen soodakattiloissa 2018

- Soodakattilayhdistys teetti vuonna 2004 Teknillisessä korkeakoulussa diplomityön, joka on julkaistu yhdistyksen julkaisusarjassa nimellä "Mustalipeän polttomenetelmät Suomen soodakattiloissa"; raportti 3/2004, E0058"
- Raportissa päivitetty vertailu muun muassa lipeän ruiskutusparametreistä, käytetyistä ilmajaoista ja päästöistä

Soodakattilan ja talteenottokierron vierasaineet

- Jäsenistöltä tulleen palautteen perusteella toteutettu
  - Vierasaineet vaikuttaa haitallisesti prosessiin aiheuttaen mm. prosessilaitteiden likaantumista ja korroosiota
- Kerätty kuudelta tehtaalta näytteet seitsemästä kohtaa talteenottokiertoa analysointia varten sekä haastateltu henkilökuntaa
  - Analysoidaan pitoisuudet seuraaville alkuaineille: Na, S, Cl, K, Ca, P, Mg, Mn, Al, Si + polttolipeästä lisäksi F ja Hg
  - Tehtaat on valittiin siten että ne muodostavat keskenään kaksi vertailuryhmää puunkorjuualueen mukaan
- Työn tulokset esittely Soodakattilapäivässä 2019

Putken kuorinta ja S0-linjaus

- Muutamissa soodakattilan korjausprojekteissa on jouduttu keskustelemaan putken kuorinnasta ja S0-alueelle tunkeutumisesta.
- Tavoitteena muodostaa yhtenäinen linja eri osapuolten kesken:
  - Työssä teetetty standardisoidut menetelmäkokeet, tarkennettuna korotetun lämpötilan vetokokeilla seuraaville liitoksille:
    - 304 – kompound liitokselle 309 – lisäaineella
    - Normaalille sanicro 38 liitokselle
    - 304 – kompoundin liitokselle Sanicro – lisäineella
  - Menetelmäkokeita varten ajatettu kolmella hitsarilla kolme työkoetta

Selvitys sularännivaurioista

- Tarkoituksena on kerätä tietoa missä kunnossa rännit ovat ajojakson jälkeen ja mistä kohdista rännit vaurioituvat
- Projektin tavoitteet:
  - käyttäjille tarkempaa tietoa rännien kunnosta ja ajon vaikutuksesta ränneihin -> ovatko este pidemmille ajojaksoille
  - millä kattiloilla on haasteita, millä ei ole ->
  - suositukset käyttäjille lisäselvitysten tekemiseksi
- Projekti koostuu useasta eri osaprojektista:
  1. yhdistyksen sularännikyselyn päivittäminen mennessä
  2. käytetystä poistettujen sularännien VT&PT tarkastus
  3. valittujen sularännien metallurginen tutkimus -> VTT

Hajukaasusuosituksen päivitys

- Päivityksen pohjana on Kirsi Hovikorven selvitys
  - NCG-järjestelmien turvallisuusauditointi, tyypilliset onnettomuuteen johtavat syyt (esitys SKP 2017)
- Perustettu oma työryhmä, tehtaat/kattilatoimittajat
- Suosituksen uudet kappaleet (tähän mennessä):
  - soihdut ja hajukaasukattilat yhteistoiminta
  - vaaranarvioinnissa huomioitavaa
- Päivitystyö pyritään tekemään kevääseen 2020 mennessä

NON-PROCESS ELEMENTS IN THE RECOVERY CYCLE OF SIX FINNISH PULP MILLS

Camilla Karlemo
Valmet Technologies Oy

SUOMEN SOODAKATTILAYHDISTYS
FINNISH RECOVERY BOILER COMMITTEE

Åbo Akademi

Non-process elements in the recovery cycle of six Finnish Kraft pulp mills

Master's Thesis Presentation

Camilla Karlemo
camilla.karlemo@valmet.com

Soodakattilapäivä 2019

Åbo Akademi

Outline

- Thesis objective
- Background
- Experimental part
- Results
- Conclusions

Link to the thesis

Thesis objective

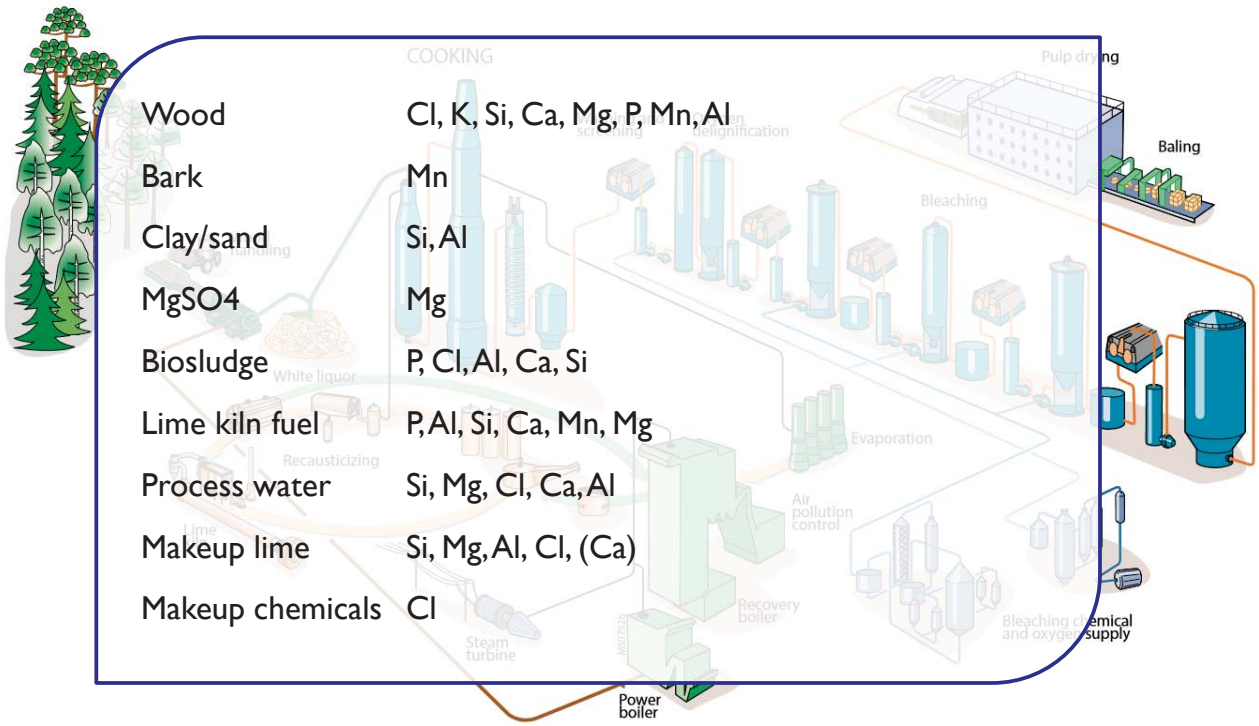
- Better understanding of NPE chemistry in todays Finnish pulp mills
- Will the NPE levels differ due to:
  - Geographical location differences North vs. East mills
  - Older vs. Present NPE results
  - *North and South American NPE results*
  - *Process equipment differences*

Background

- NPE = Non-process elements
  - Elements not actively participating in the pulping process
  - If let to accumulate → cause operational problems
- NPEs have different properties
  - T, pH, presence of other components → influence where the NPEs create problems and where they are to be purged most effectively

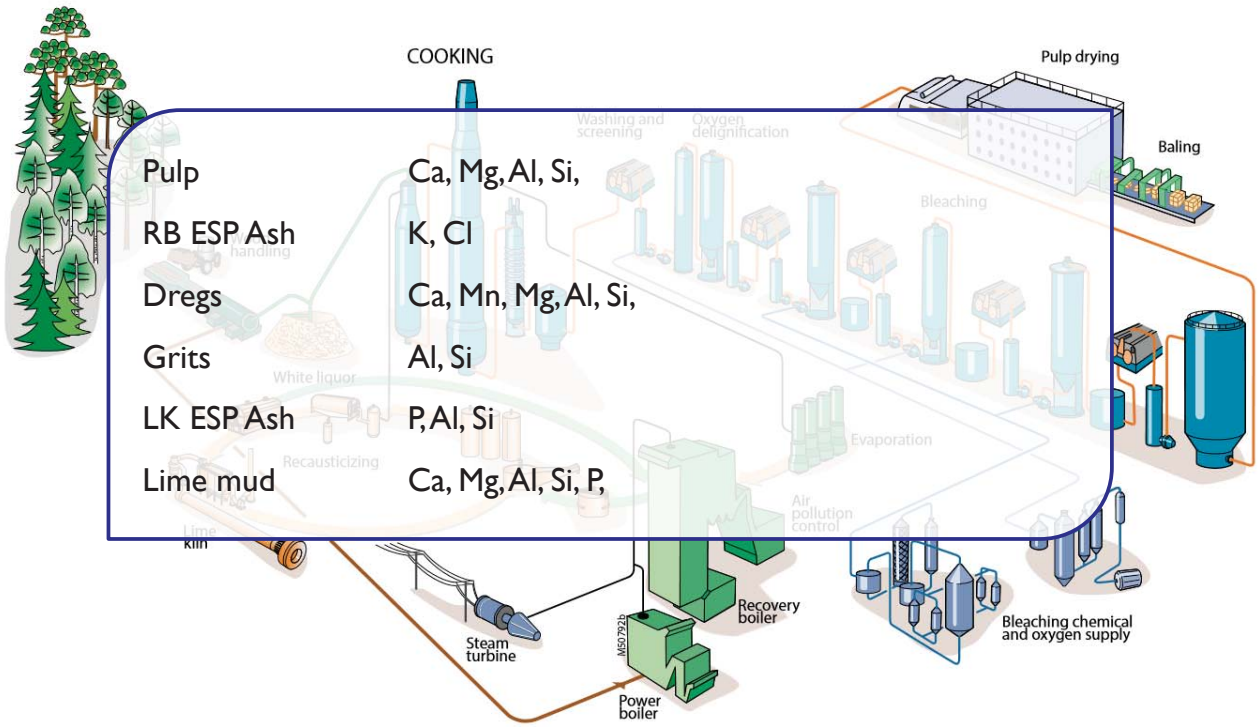
NPE input

Wood	Cl, K, Si, Ca, Mg, P, Mn, Al
Bark	Mn
Clay/sand	Si, Al
MgSO4	Mg
Biosludge	P, Cl, Al, Ca, Si
Lime kiln fuel	P, Al, Si, Ca, Mn, Mg
Process water	Si, Mg, Cl, Ca, Al
Makeup lime	Si, Mg, Al, Cl, (Ca)
Makeup chemicals	Cl

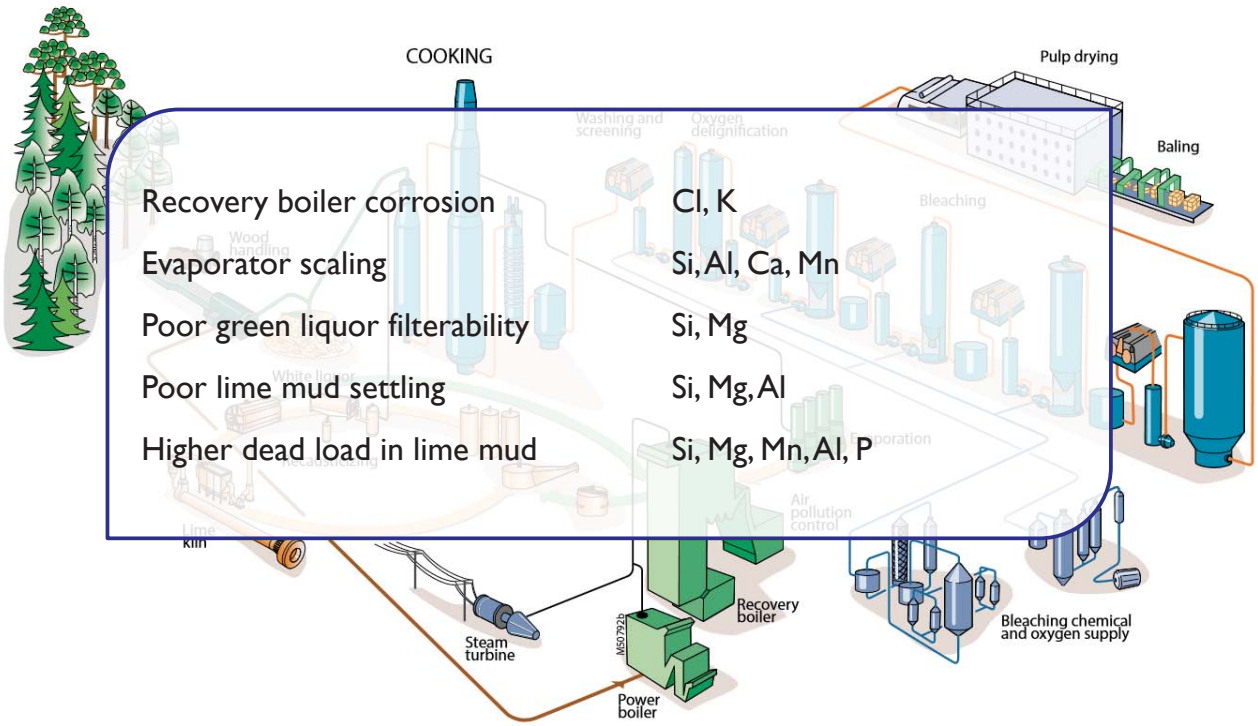


NPE output

Pulp	Ca, Mg, Al, Si,
RB ESP Ash	K, Cl
Dregs	Ca, Mn, Mg, Al, Si,
Grits	Al, Si
LK ESP Ash	P, Al, Si
Lime mud	Ca, Mg, Al, Si, P,



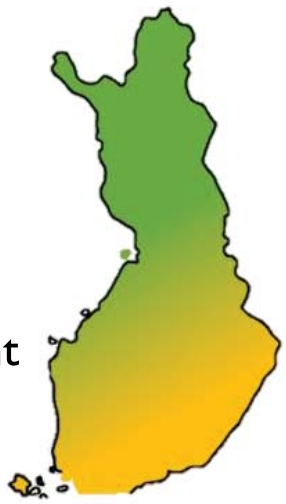
NPE problems



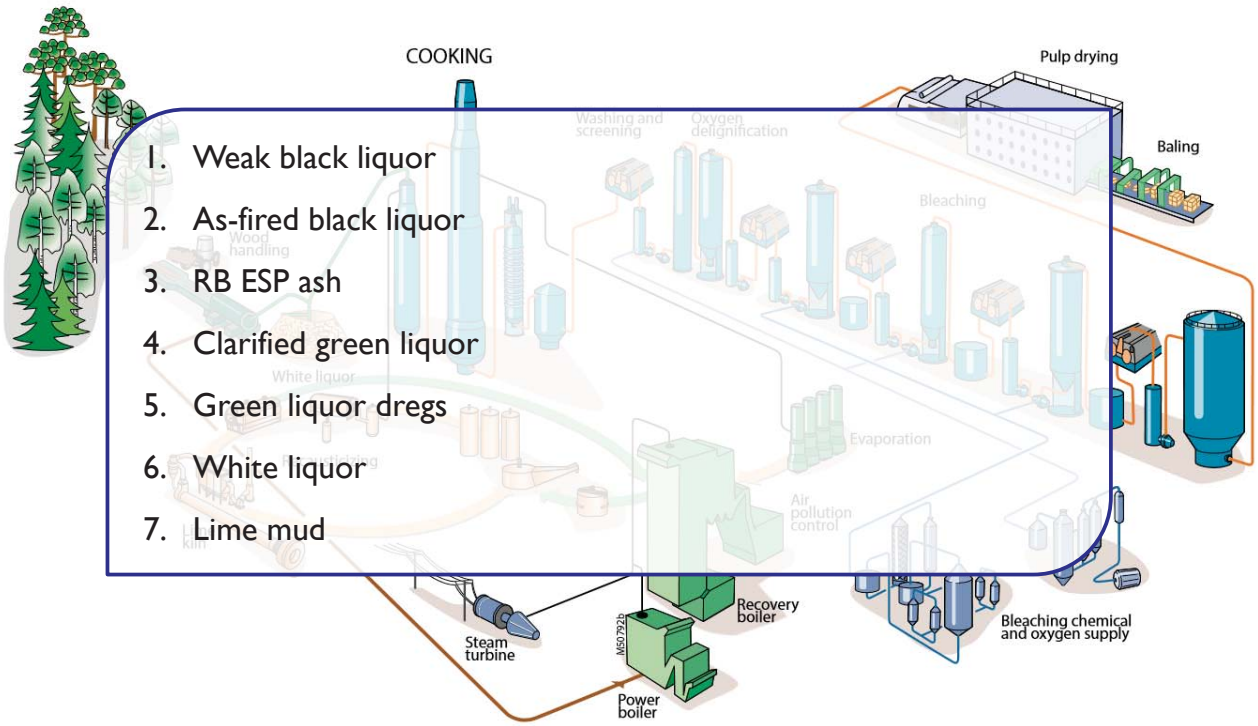
Recovery boiler corrosion	Cl, K
Evaporator scaling	Si, Al, Ca, Mn
Poor green liquor filterability	Si, Mg
Poor lime mud settling	Si, Mg, Al
Higher dead load in lime mud	Si, Mg, Mn, Al, P

Experimental part

- Six Finnish Kraft pulp mills
  - 3 North Finland
  - 3 East Finland
- 7 sampling points in the recovery cycle
- 10 elements were analyzed / sampling point
  - Na, S, Ca, Mg, Mn, Al, Si, P, Cl, K
- Interviews/visitations at all mills

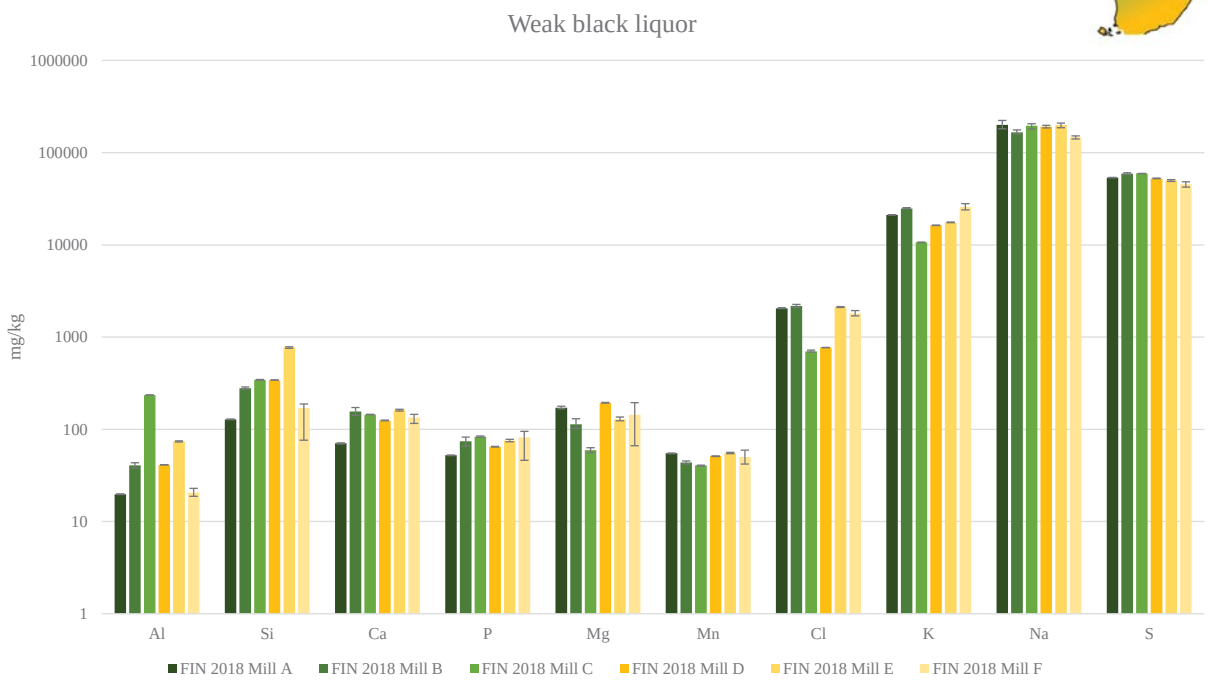


Sampling points

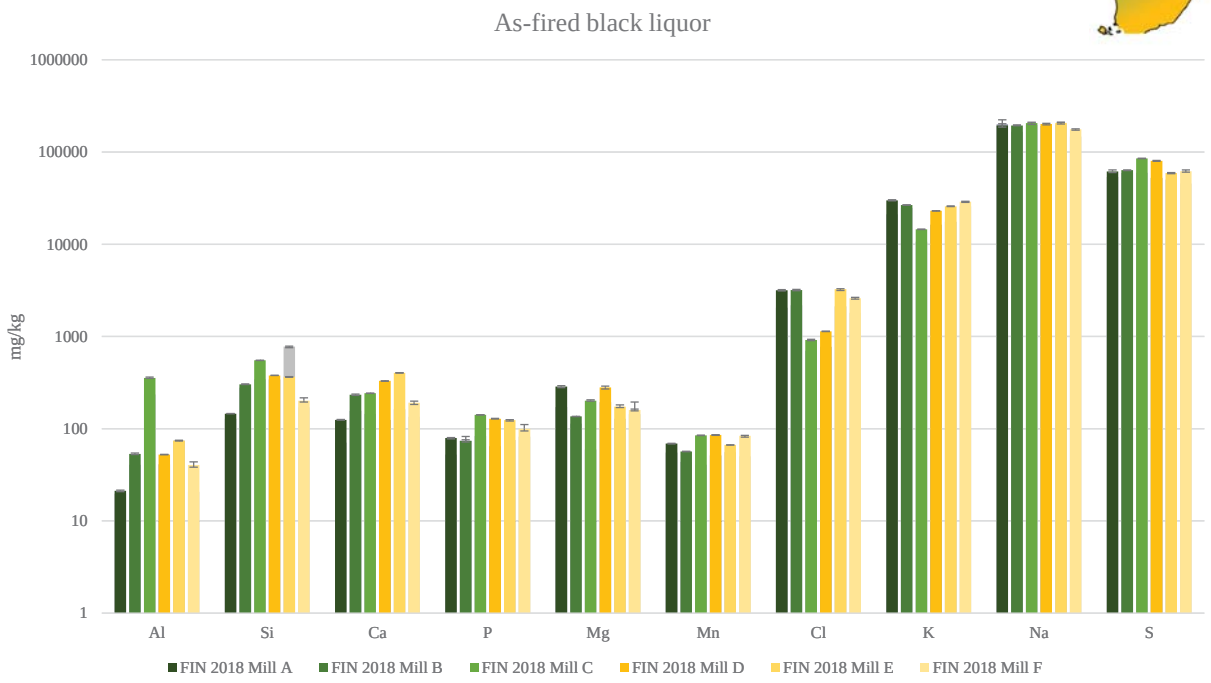


1. Weak black liquor
2. As-fired black liquor
3. RB ESP ash
4. Clarified green liquor
5. Green liquor dregs
6. White liquor
7. Lime mud

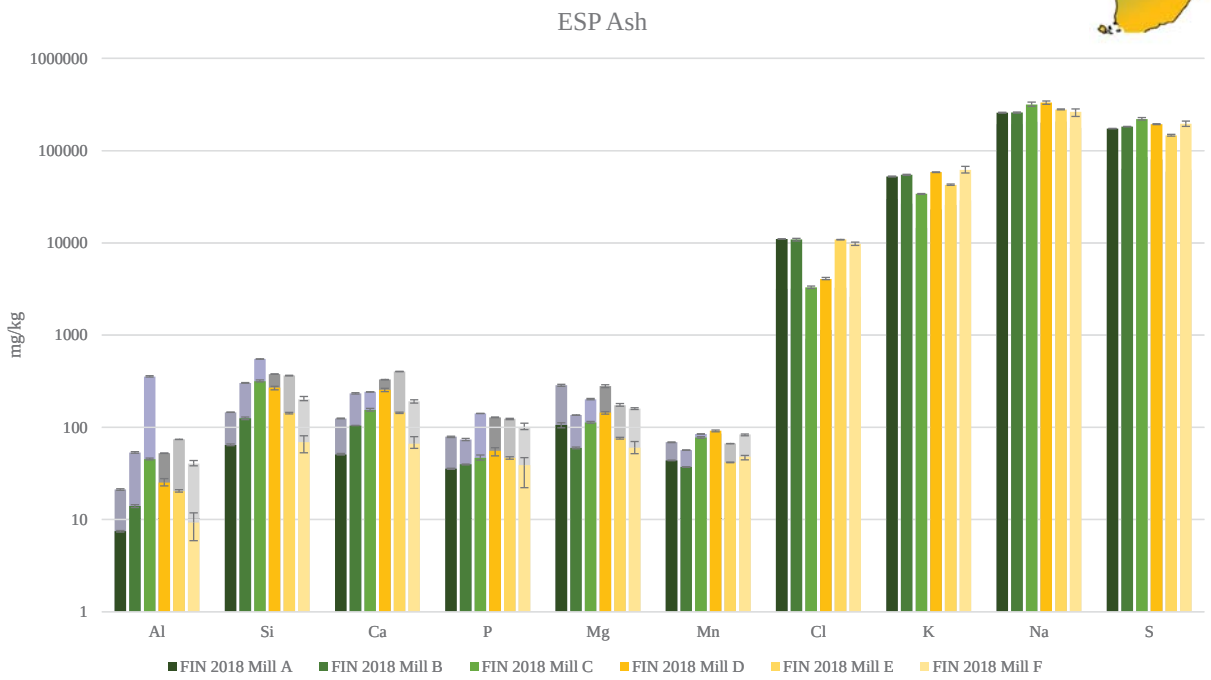
Weak black liquor



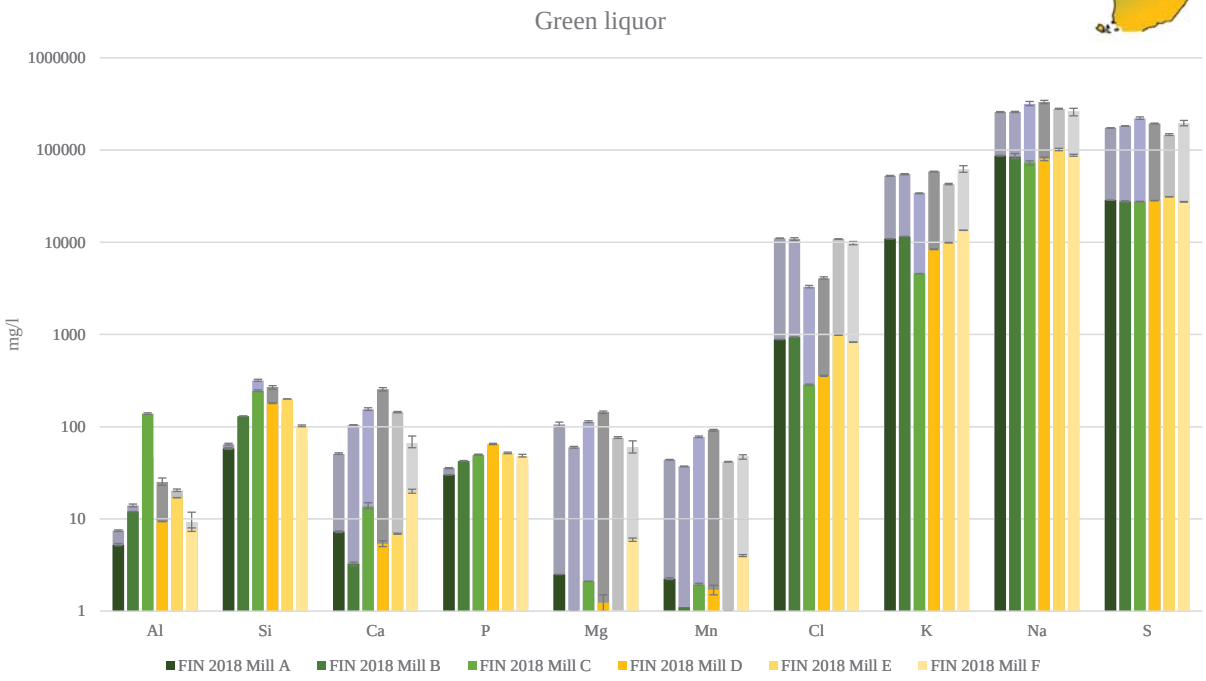
As-fired black liquor



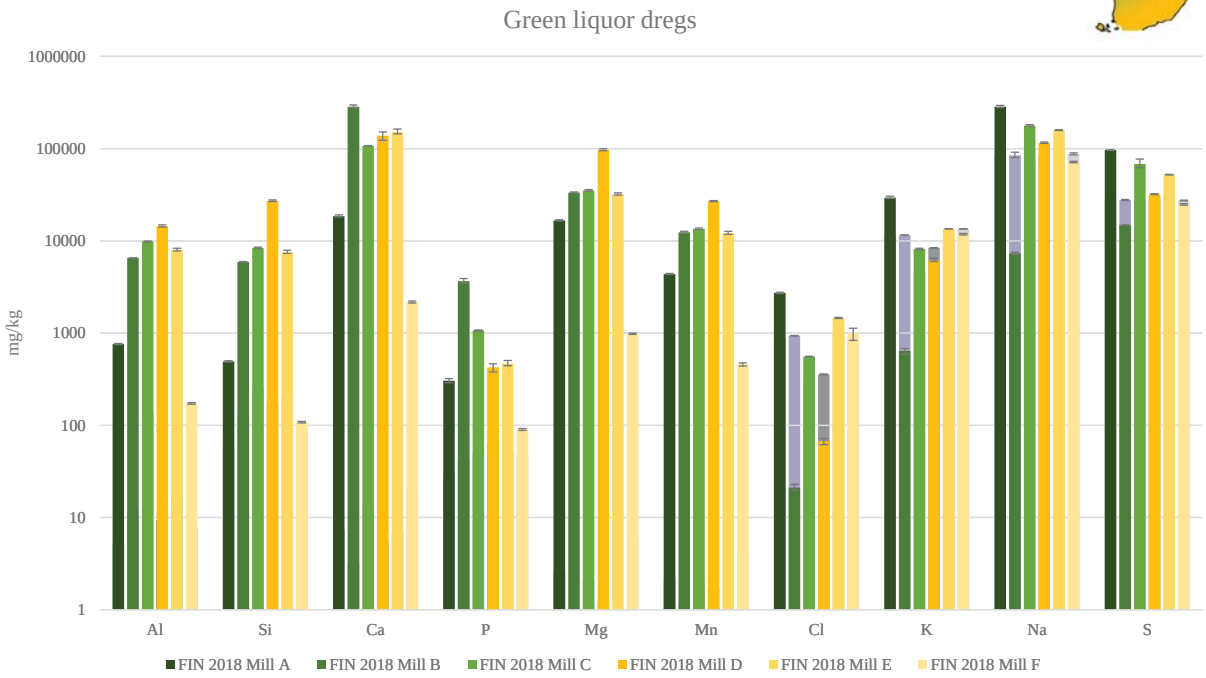
RB ESP ash



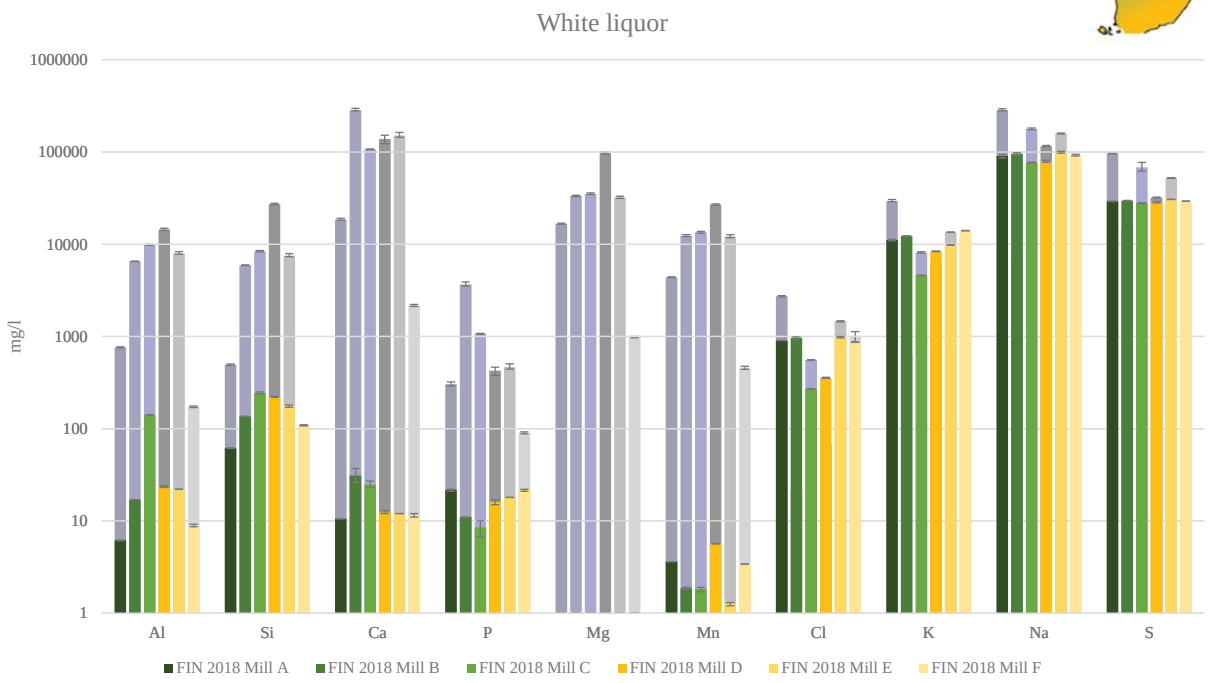
Clarified green liquor



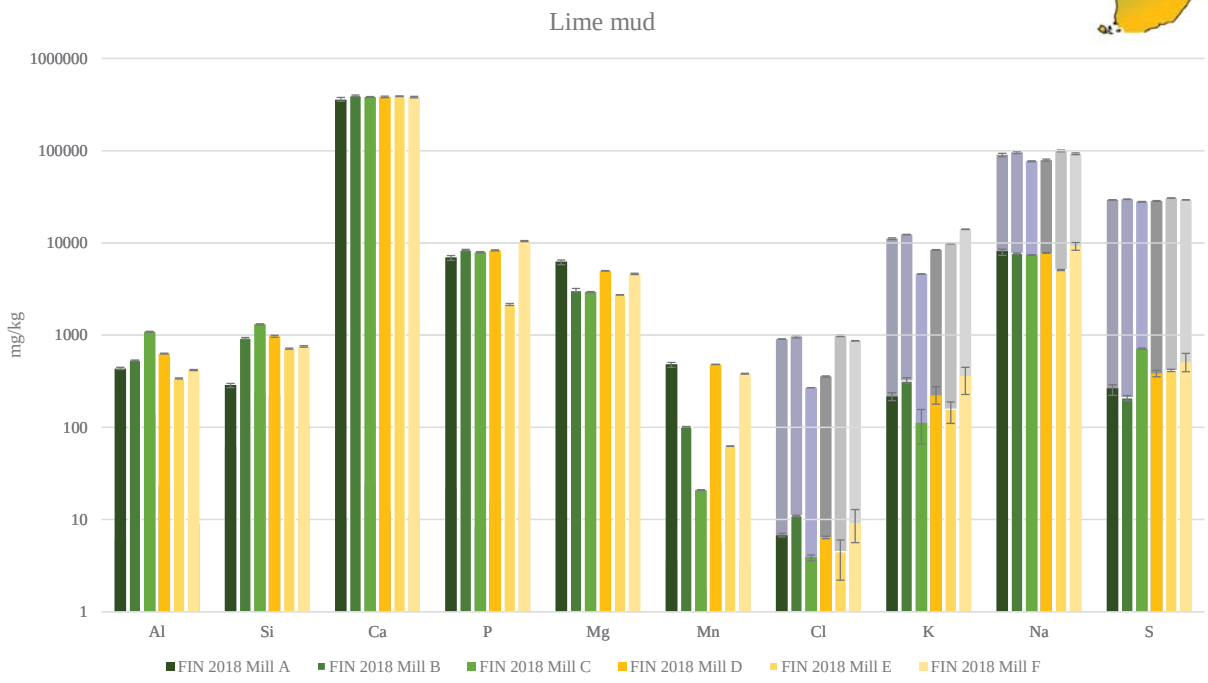
Green liquor dregs



White liquor



Lime mud



Results

AVG	Al	Si	Ca	P	Mg	Mn	Cl	K	Na	S
WBL mg/kg	*39	**230	132	72	135	49	1606	19359	183296	53367
ABL mg/kg	*48	**278	254	108	206	74	2376	24800	196417	68539
ESP Ash mg/kg	20	164	129	44	93	57	8316	50753	285083	185472
GL mg/l	32	152	9	48	2	2	711	9793	85739	28456
GLD mg/kg	6618	8265	***83409	1001	35937	11638	972	11616	136282	48189
WL mg/l	36	158	17	16	1	3	722	10052	89172	29211
LM mg/kg	573	827	382083	7366	4104	255	7	231	7566	415

* Mill C's Al result 235 mg/kg and 355 mg/kg is not included in WBL and ABL
** Mill C's and Mill E's Si results 344 and 775 mg/kg are not included in WBL and Mill C's Si result 550 mg/kg is not included in ABL
*** Mill B's Ca result is not included in GLD

Older vs. Present Finnish pulp mill results

Location	Author	Year	Sample point	Samples	Unit	Al	Si	Ca	P	Mg	Mn	Cl	K
FIN	Järvinen, Holamo	1995, 1999	WBL	42	mg/kg	32	277	156	84	129	68	2351	18969
FIN	Karlemo	2018	WBL	18	mg/kg	39	230	132	72	135	49	1606	19359
FIN	Salmenoja	2004	ABL	5	mg/kg	33	284	219	71	154		1600	27800
FIN	Karlemo	2018	ABL	18	mg/kg	48	278	254	108	206	74	2376	24800
FIN	Salmenoja	2004	ESP A	5	mg/kg	6	105	77	25	46		6800	47600
FIN	Karlemo	2018	ESP A	18	mg/kg	20	164	129	44	93	57	8316	50753
FIN	Holamo	1999	GL	9	mg/l	10	164	11	31	2	5		9788
FIN	Karlemo	2018	GL	18	mg/l	32	152	9	48	2	2	711	9793
FIN	Holamo	1999	GLD	9	mg/l	3881	6914	174667	2315	33812	16150		7013
FIN	Karlemo	2018	GLD	18	mg/l	6618	8265	117118	1001	35937	11638	972	11616
FIN	Järvinen, Holamo	1995, 1999	WL	37	mg/l	17	153	26	13	0,9	4	1250	8194
FIN	Karlemo	2018	WL	18	mg/l	36	158	17	16	0,6	3	722	10052
FIN	Holamo	1999	LM	9	mg/kg	287	1155	381889	6959	6987	379		378
FIN	Karlemo	2018	LM	18	mg/kg	573	827	382083	7366	4104	255	7	231

The result is marked with a color when $p < 0.05$

Conclusions

- North vs. East mills
  - No noticeable differences were found when comparing the location
- Differences are found when compared to older Finnish data
  - ESP A: NPE levels tend to be higher in present results
  - P seems to be higher in present results
- Waste (in wet mass) from pulp mills have decreased over 90 % from 1992
  - NPE levels have not increased remarkably

Conclusions

- Parameters that can affect the NPE accumulation:
  - Dregs handling
  - Lime mud dumping
  - Biosludge addition
  - RB and LK ESP ash dumping
  - Lime kiln fuel
  - Debarking
  - Tree species
  - Water quality
  - Stops and shut downs
  - New makeup chemicals

Conclusions

- According to the interviews: Mills have found ways to cope with NPEs
- **BUT**
- Process disturbances or process changes can be caused by:
  - Unpredictable high NPE levels from side streams e.g. biosludge
  - Using new makeup lime and makeup chemicals

The closure of the system increases the potential damage NPEs can cause → important to predict the NPEs in the system in order to prevent operational problems

INTELLIGENT ONLINE ANALYSIS TO BETTER UNDERSTANDING AND OPTIMIZE THE RECOVERY CYCLE

Pia Holmberg
Acosense AB

Intelligent online analysis to better understand and optimize the recovery cycle

Pia Holmberg
Finish recovery boiler conference
2109

ACOSENSE

ACOSENSE

SUOMEN SOODAKATTILAYHDISTYS
FINNISH RECOVERY BOILER COMMITTEE

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www.acosense.com

- All in all, demand for fiber-based products is set to increase globally, with some segments growing faster than others – *McKinsey&Company*
- The industry's raw material is renewable and recyclable – *Forest Sweden*

MEGATRENDS

Urbanization

Digitalization

Environmental & social responsibility

Sustainability

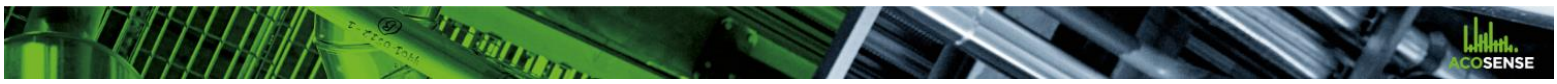
Climate change

Automation & AI

Demographic change

Security, surveillance & cyber security

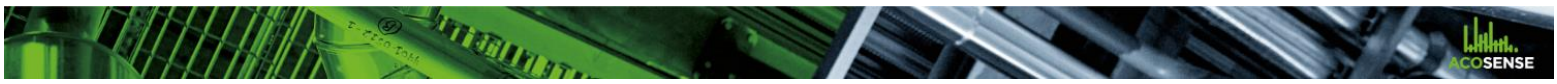
Globalization



- Fossil free future
- Waste to value
- New game changing products

SECURITY AND STABILITY - THE KEYS TO A SUSTAINABLE PRODUCTION

- PETRA EINARSSON, CEO BILLERUDKORSNÄS



COMPLEX PROCESS

Reduction rate

Fouling

Carry over

Effects the mills capacity and runnability

Green liquor quality

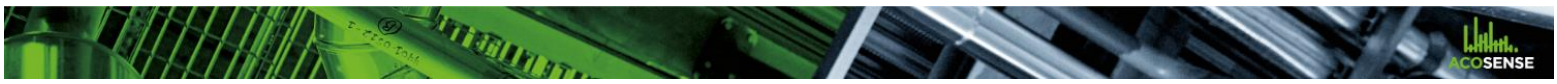
Droplet size

Varying fuel

Air emissions

IT IS HARD TO CONTROL WHAT YOU CAN'T SEE…

THE CHALLENGE OF AUTOMATION AND OPTIMIZATION

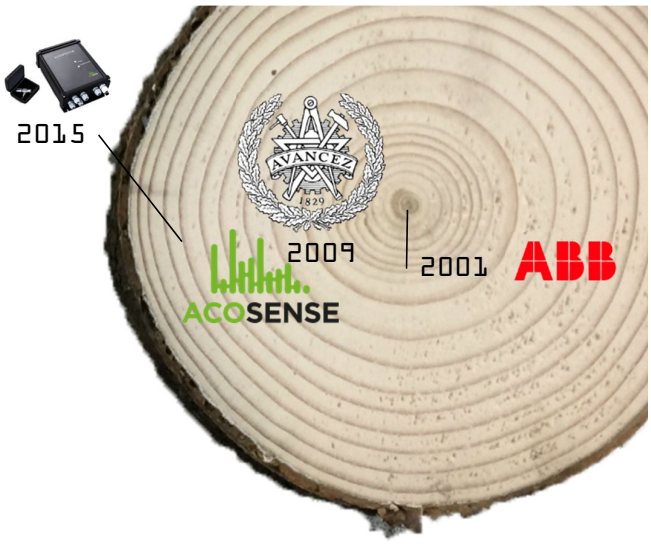


Process not working at its full capacity

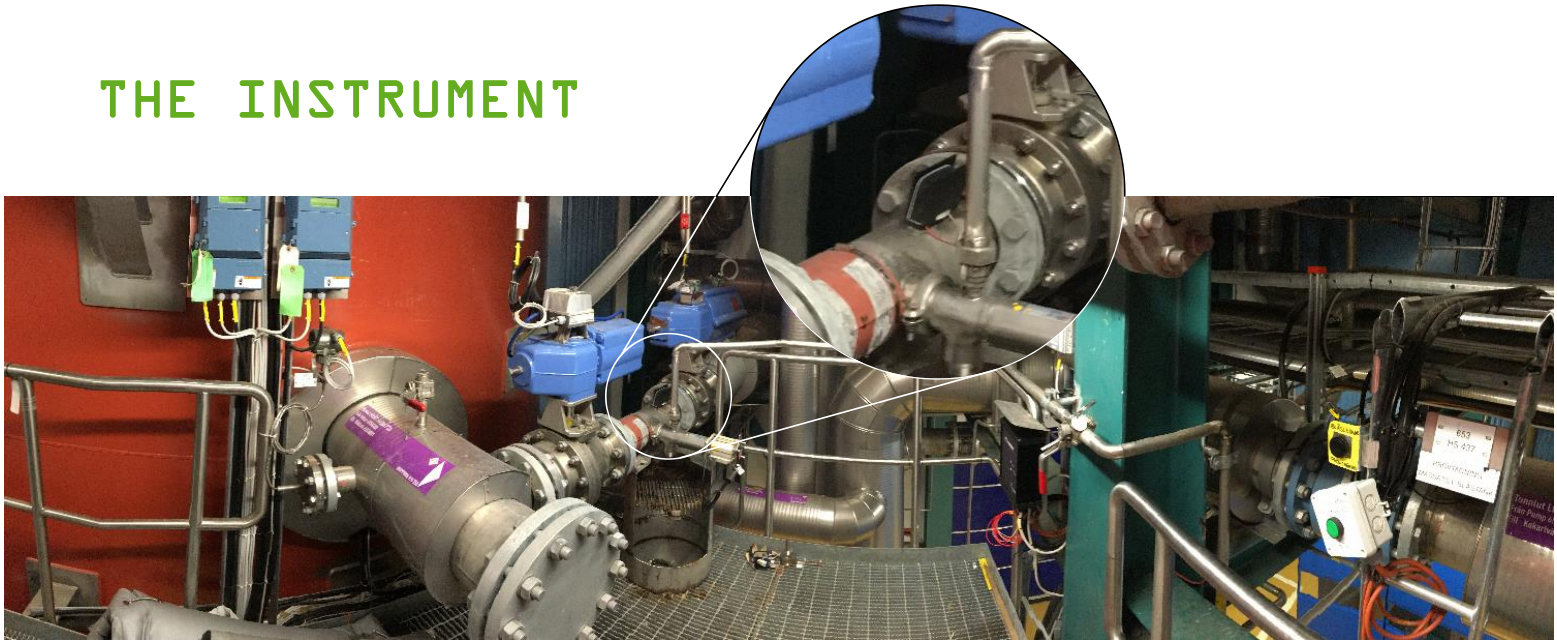
Lab samples can provide some information but the whole picture is not seen when using non-continuous and/or data with large errors and disturbances are often discovered and handled later than they should be.

Analyse complex fluids using active sound

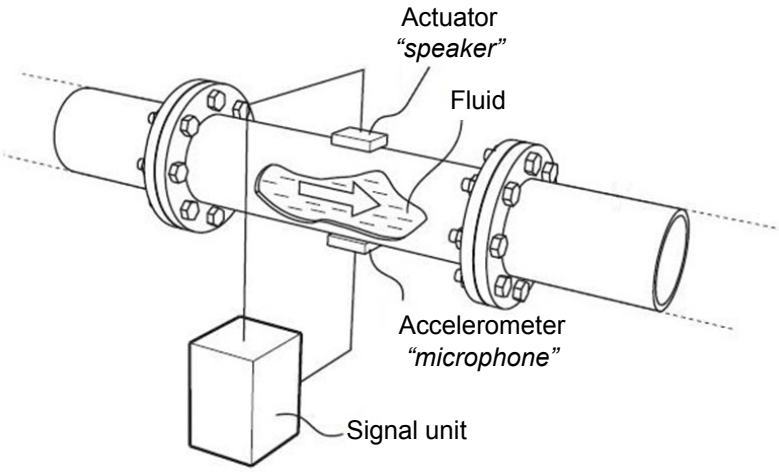
WHO WE ARE

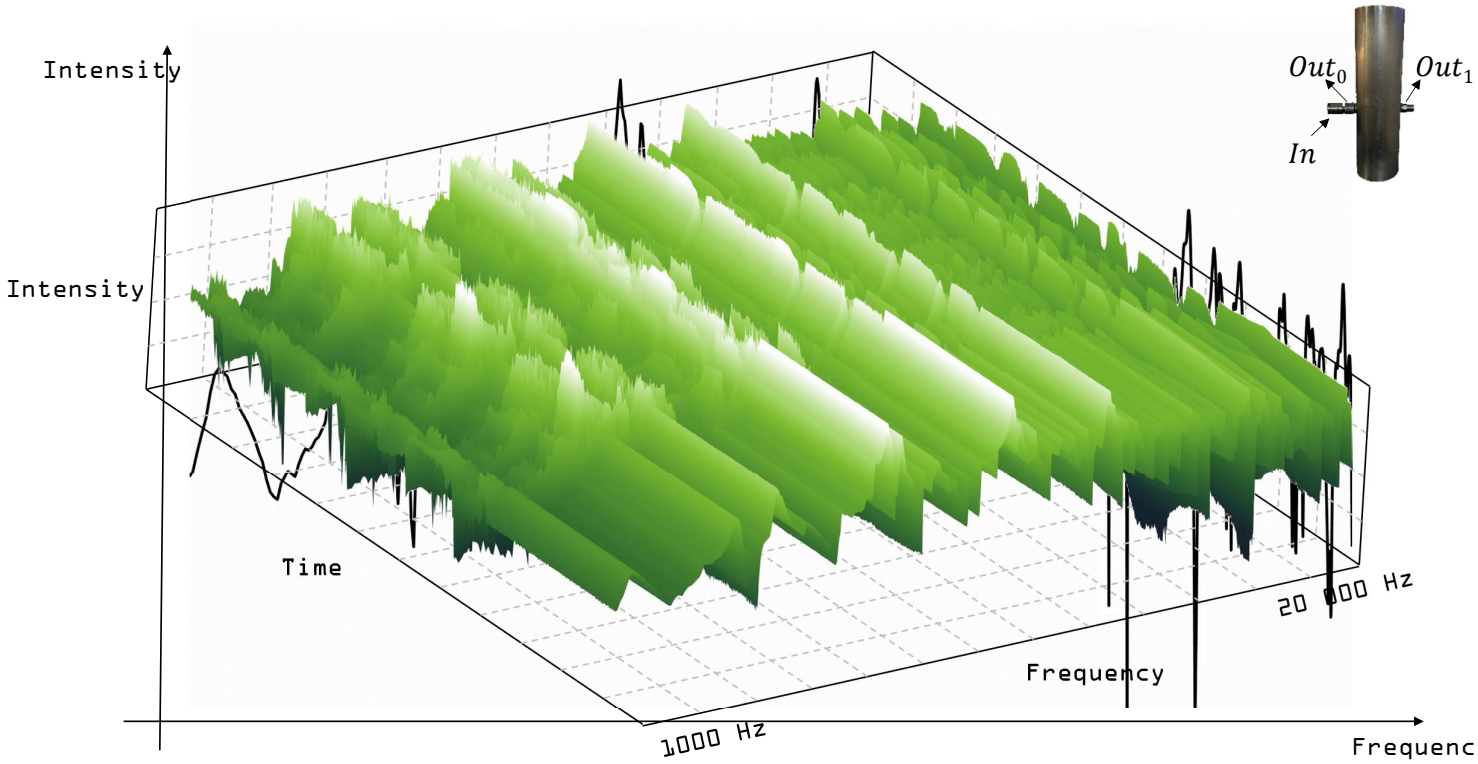


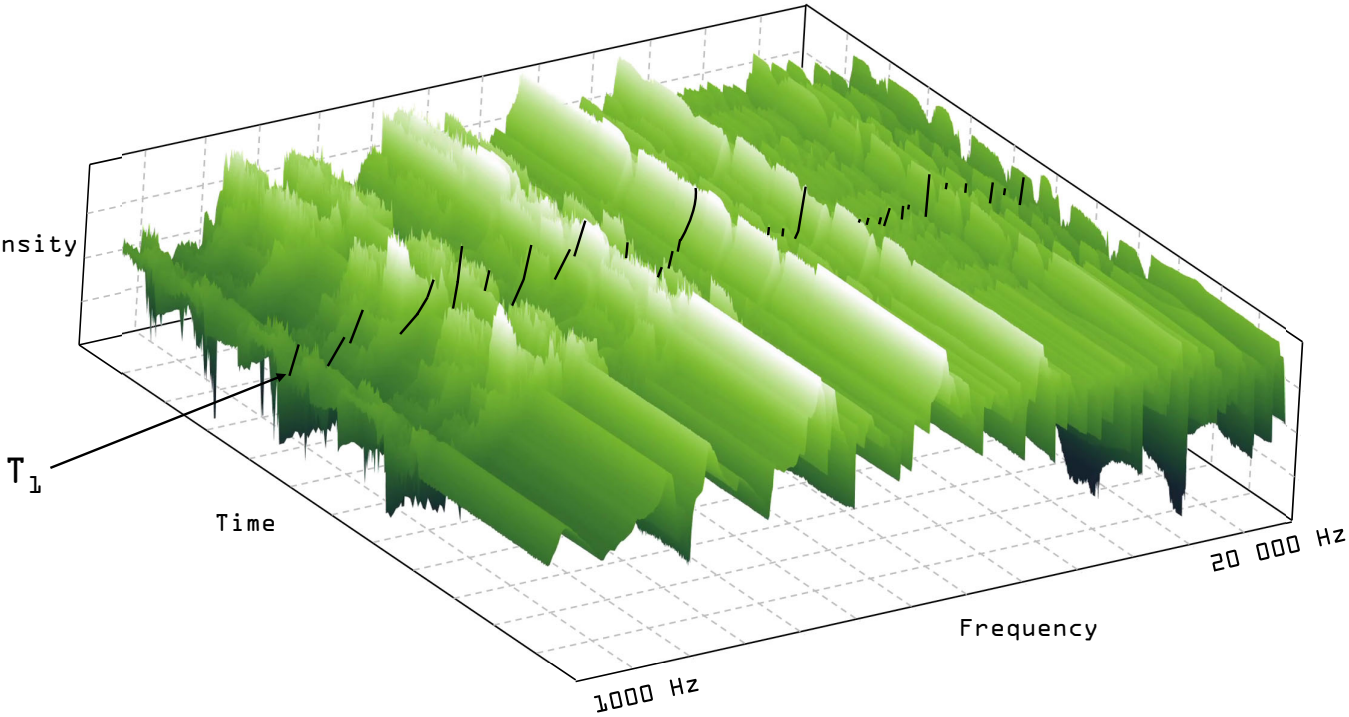
THE INSTRUMENT

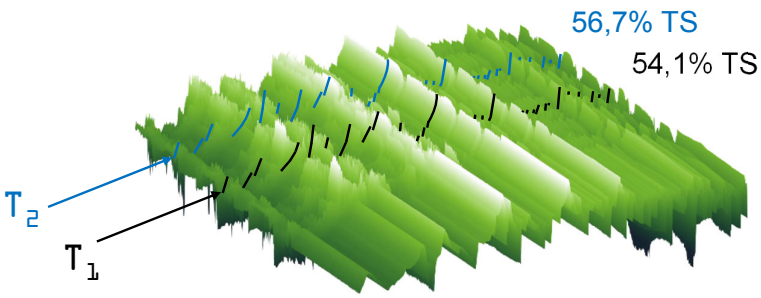


THE INSTRUMENT




Intensity
Intensity
Time
1000 Hz
Frequency
20 000 Hz
Frequency
Out_0
Out_1
In

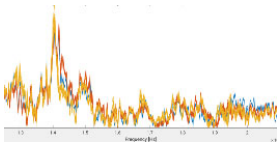

Intensity
T_1
Time
1000 Hz
Frequency
20 000 Hz



Spectrum

Property

Model

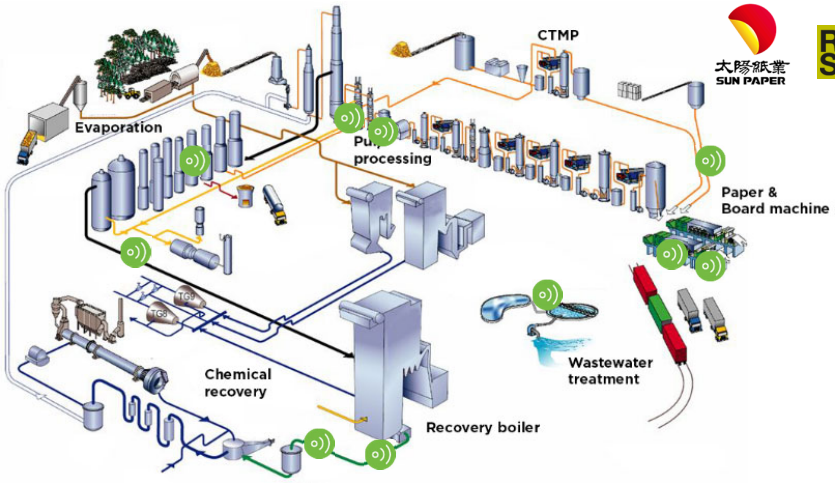


Process → Continuous spectrum → Model → Real time values

PULP & PAPER

Acosense can analyse fluids in most parts of the pulp and paper process.

Online and real time measurements can vastly increase the possibility to optimise the process.



ACOSENSE

FLUIDS

- **Coating** – Viscosity, Solid content
- **Sludge** – Sludge content
- **Pulp** – Pulp consistency
- **Green Liquor** – Density
- **Black Liquor** – Total solid content, Density

FUNCTIONS

- **Online in real time measuremen**
- **Process status visualization**
- **Alarm**
- **Prestudy**
- **Process analysis**

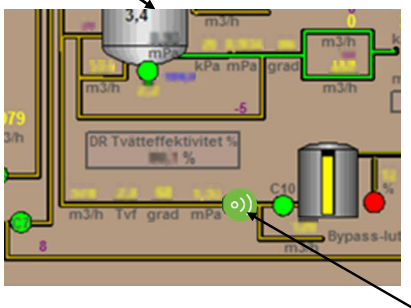
SCA

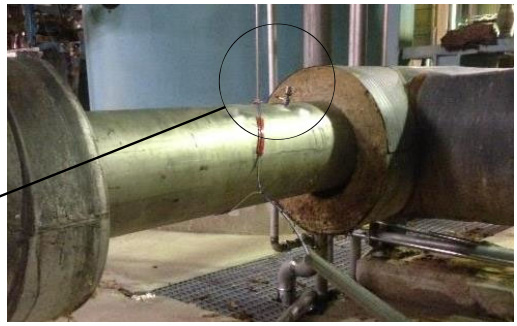
Washing Liquor

Total solid content 8-15%

Analysing the dry content in the washing liquor to minimize the amount of water and at the same time ensure digester efficiency.

Digester

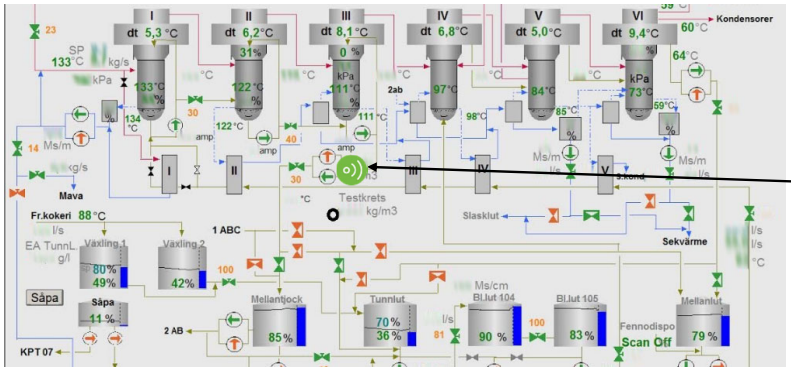


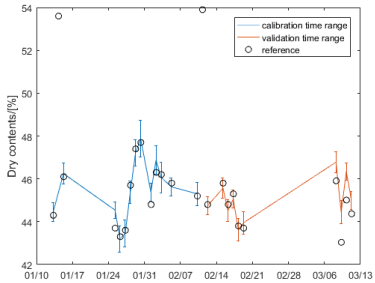


Black liquor
Total solid content

BILLERUDKORSNÄS

Analyse black liquor (intermediate) dry content in the evaporation process to avoid fouling/scaling and optimize the process.

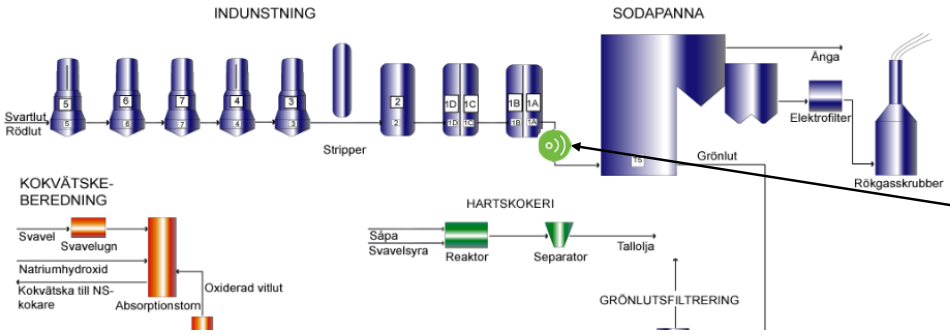




Black liquor
Total solid content

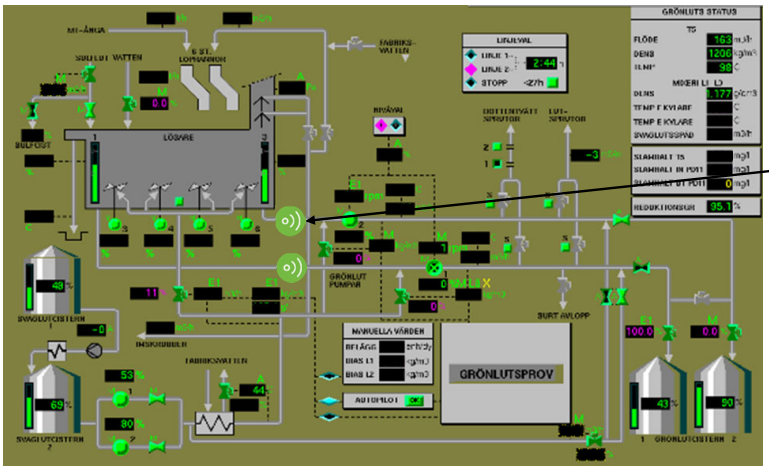
BILLERUDKORSNÄS

Keep track on the dry content of heavy black liquor leaving the evaporation for the recovery boiler, to increase efficiency.



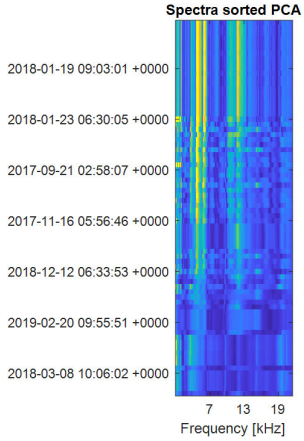
Green liquor
Density (TTA)

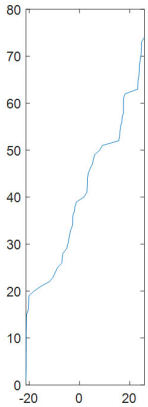
Two instruments to analyse the density in green liquor to keep track on the alkali content.



One step further …

Using the raw signal for scaling detection





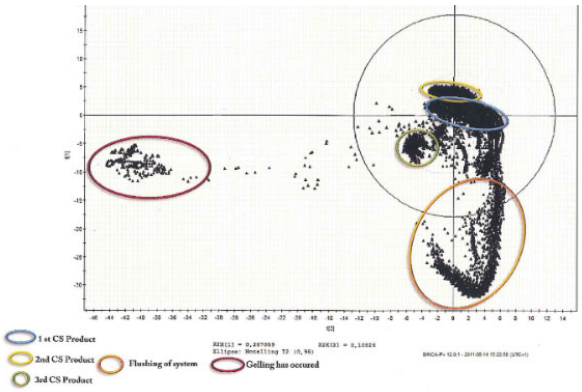
- Detect scaling
- Optimize washing

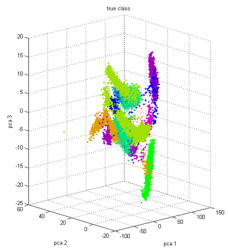
Alarm & Process control

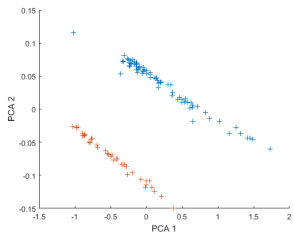
Acosense can also listen to the process and establish a “fingerprint” of *e.g.* a normal process or a certain quality or product.

- Alarm
  - Deviation from normal process
  - Detect unwanted substances

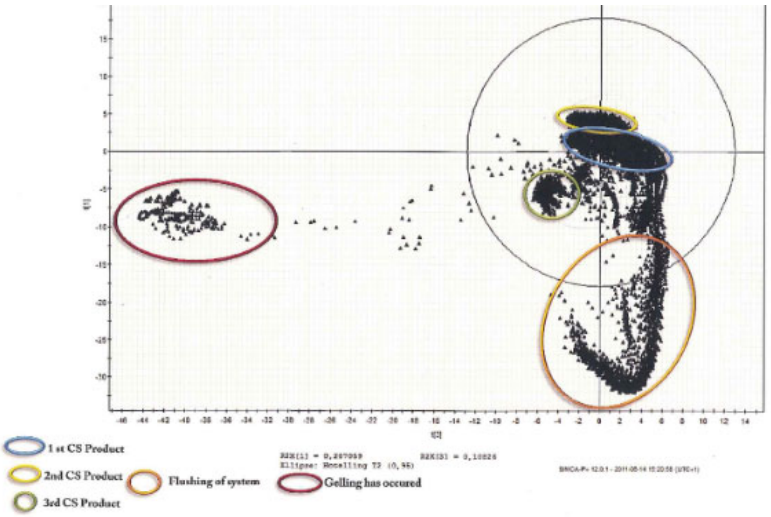
- Process control
  - Observe and verify quality change
  - Monitor process drift
  - Process optimisation

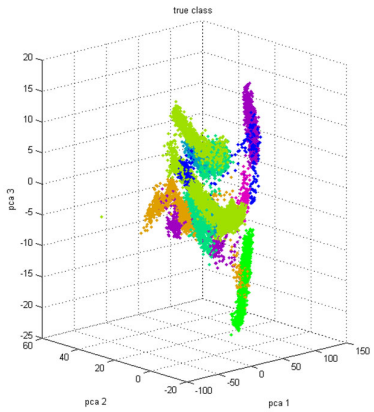


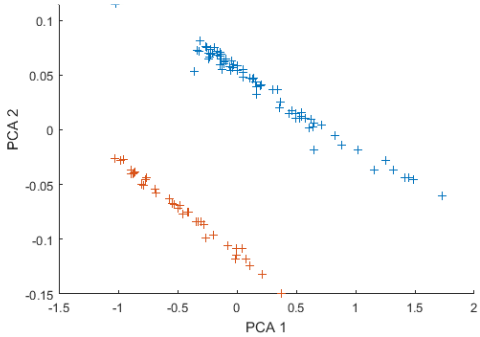




Alarm & Process control







Digitalization of the recovery boiler

NORDICPAPER

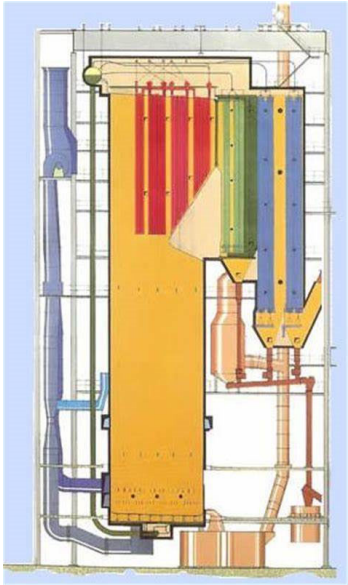
ACOSENSE

PiA
Process Industrial IT and Automation

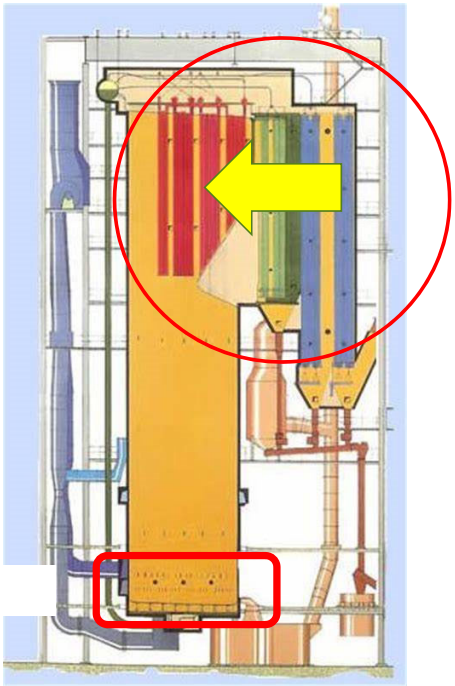
PAPER PROVINCE

Focus Areas For Increased Capacity

- # 1 Plugging
- #2 Smelt spout stability



Plugging



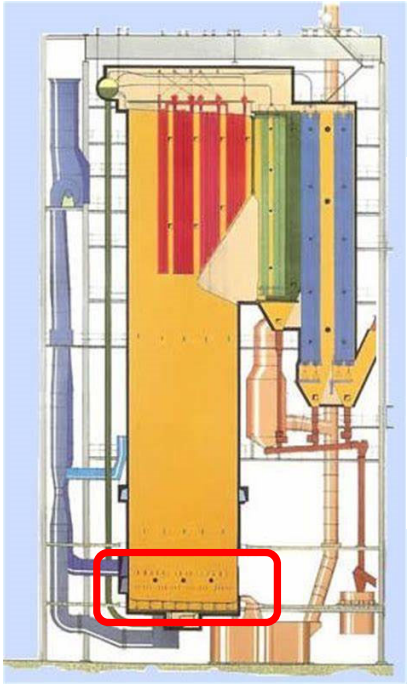
Sootblowing – effective ash removal

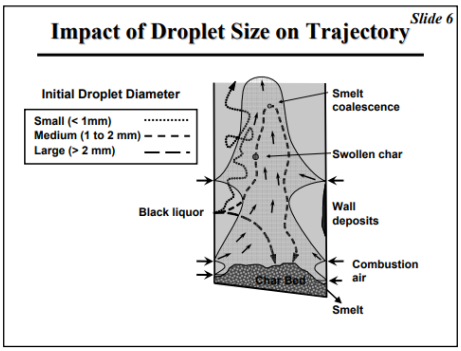
Lower furnace control

Lower Furnace

Increased availability through
Lower furnace control

- Medium char temp = easy removable ash
  Not carbonates (High temp), not sticky (SO2, low temp)
- Minimize carry over
  - Stability (Time to find best settings)
  - Reduced fluegas flow/speed (Pri and Sec-air)
  - Droplet formation (sprayers, temp, pressure)

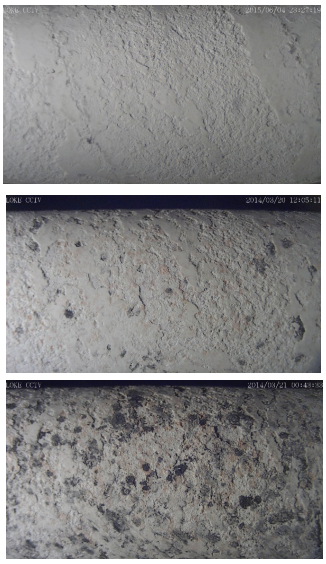


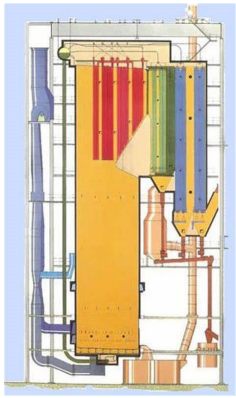


Good/medium char bed temperature

- Too High Temp
  - Carbonates
  - Hard ash
  - High Ash Ph
- Too Low Temp
  - SO2
  - Sticky
  - Low Ash pH

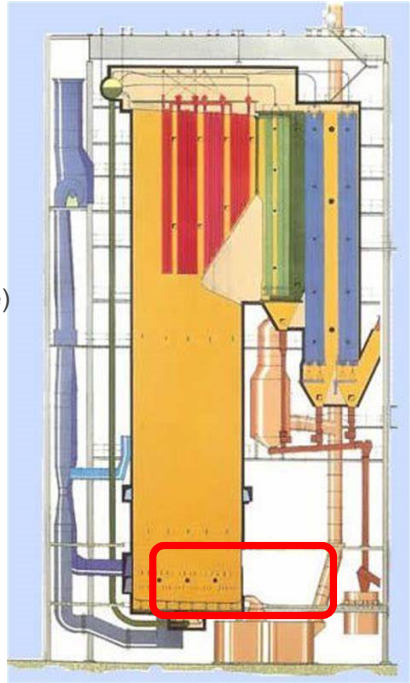
Sootblower lance images

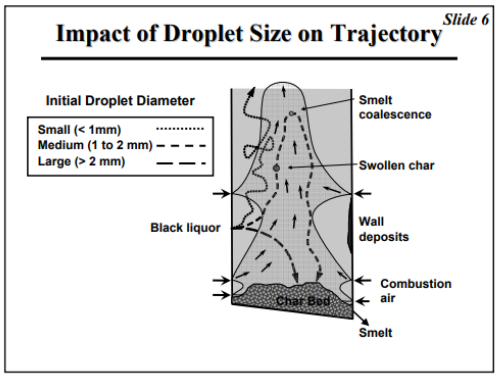




Carry Over & Lower furnace control

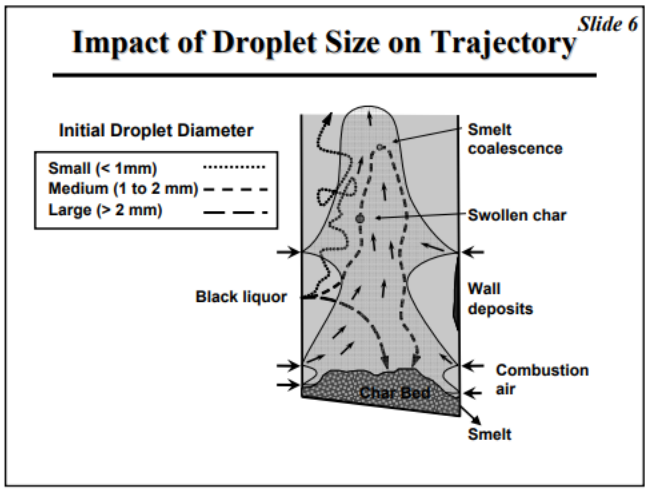
- Stability (Time to find best settings)
- Fluegas flow/speed (Pri and Sec-air)
- Droplet formation (sprayers, temp, pressure)

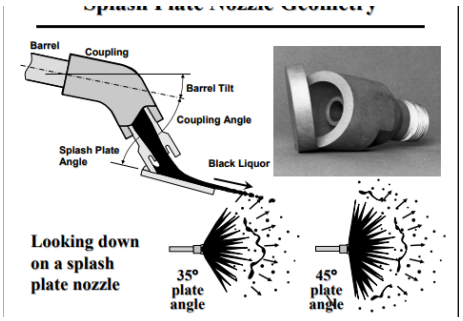


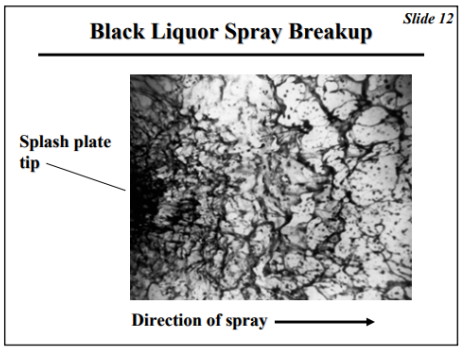


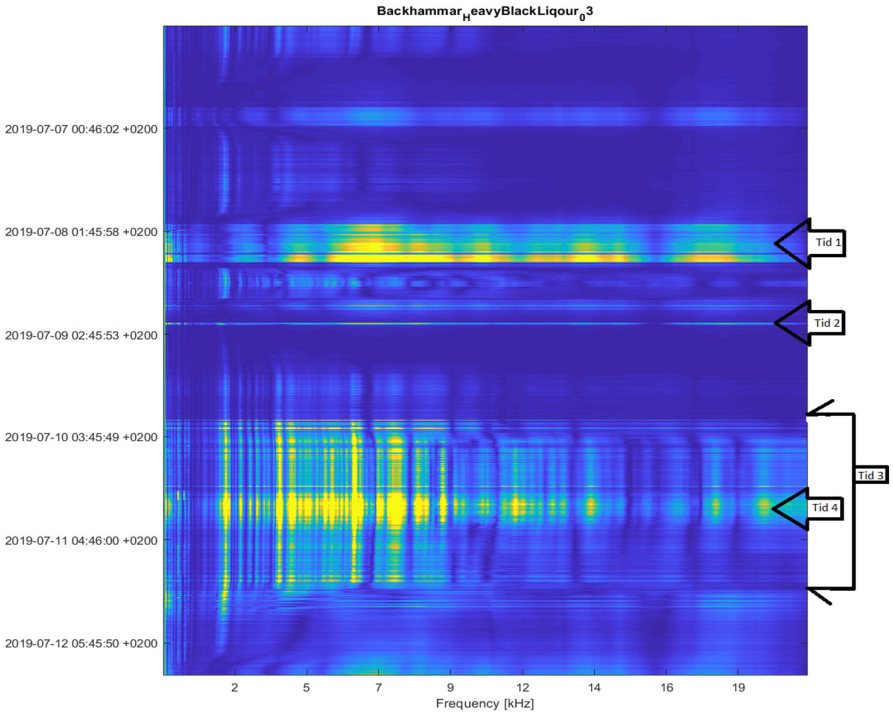
Sprayers and droplet formation

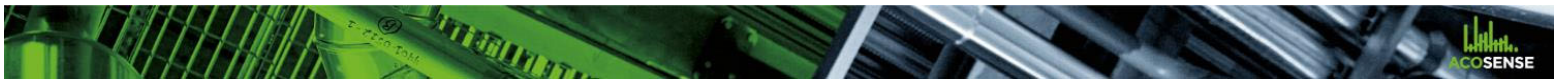
predictability of droplet generation



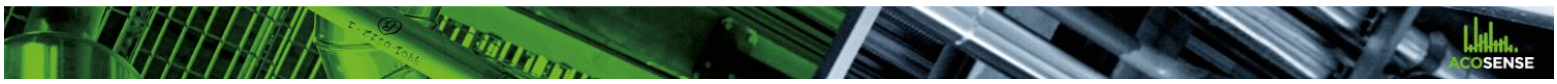





Backhammar_HeavyBlackLiqour_03
2019-07-07 00:46:02 +0200
2019-07-08 01:45:58 +0200
2019-07-09 02:45:53 +0200
2019-07-10 03:45:49 +0200
2019-07-11 04:46:00 +0200
2019-07-12 05:45:50 +0200
Tid 1
Tid 2
Tid 3
Tid 4
2
5
7
9
12
14
16
19
Frequency [kHz]


ACOSENSE

1 st CS Product
2nd CS Product
3rd CS Product
Flushing of system
Gelling has occured


ACOSENSE

THANK YOU FOR LISTENING

PIA.HOLMBERG@ACOSENSE.COM

ACOSENSE +46 (0)31 763 26 12 or +46 (0)70 733 26 76
Stampgatan 20A, SE 411 01 Göteborg, Sweden

ACOSENSE

acosense.com

SOODAKATTILAN LÄMMÖNSIIRTOPINTOJEN AJONAIKAINEN LIKAANTUMISENHALLINTA – CBE RÄJÄYTYSPUHDISTUKSET

Vesa Railamaa
Clean Steel Oy

Clean Steel

Maximising boiler performance

CBE –räjäytyspuhdistukset osana soodakattiloiden lämmönsiirtopintojen ennakoivaa likaantumisenhallinntaa

Vesa Railamaa 30.10.2019

Yritys

Clean Steel on likaantuvien lämmönsiirtopintojen tehokkaaseen puhdistukseen ja kattiloiden moitteettoman toiminnan varmistamiseen keskittyvä palveluyritys.

- Perustettu vuonna 2011. Perustaja / Tj. Hannu Laitomaalla yli 40 vuoden kokemus erilaisista laitos- ja kattilatyypeistä sekä niiden kunnossapidosta
- Clean Steel syntyi markkinoiden tarpeesta ja asiakkaiden kriittisyydestä perinteisiä puhdistusmenetelmiä kohtaan
- Tyytyväiset asiakkaat vauhdittavat kasvuamme.
- Laajentuminen Europpaan ja Etelä-Amerikkaan

Etsimme ja tutkimme intohimoisesti tapoja kehittää lämmönsiirtopintojen likaantumisen hallintaa ja parantaa kattiloiden käytettävyyttä.

Tausta

Likaantumisenhallinta tärkeämpää kuin koskaan, miksi?

- Halu parantaa / tehostaa läsnä kaikkialla
- Haasteelliset polttoaineyhdistelmät

Soodakattiloiden suorituskyvyn kasvaminen on edellyttänyt polttoainekuorman nousua

- kasvattanut savukaasujen lämpötilaa
- kasvattanut lentotuhkan määrää
- ja siten lisännyt likakerroksen muodostumista.

Vaikka ilmansyöttöjärjestelmän ja nuohouksen kehittyminen ovat selvästi vähentäneet soodakattilan likaantumisongelmia viime vuosina, aiheuttaa **kuorman kasvattaminen merkittäviä haasteita likaantumisen hallinnassa. Erityisesti ajonaikaisten toimenpiteiden merkitys on kasvanut.**

Tyypillisimmät haasteet

Yleisesti ottaen käytettävyyteen liittyvät soodakattilan likaantumisongelmat **mielletään erityisesti ajokauden loppupuolen ongelmiksi.**

1. **Heikentynyt lämmönsiirron tehokkuus**
2. **Savukaasukanavan virtauspoikkipinnan tukkeentuminen**
3. **Mahdolliset rakenneviat lämpöpinnoilla (epätasainen lämpövirta)**
4. **Painehäviöiden nousu ja virtausnopeusten haitallinen kasvu**

Likaantumiseen / tukkeentumiseen liittyvällä lentotuhkan kemialla on tukkeentumisen lisäksi **myös yhteys korroosioon**.

- Kasvaneet materiaalikulut/ kunnossapitokulut
- Turvallisuusriski

Likaantumisen syiden tiedostaminen ja niihin puuttuminen ajoissa

Likaantumisen havainnointi ja reagointi

Perinteiset havainnointitavat edelleen relevantteja

- Savukaasukanavan painehäviöt
- Höyryntuotannon, tuorehöyryn ja jäähdytysveden määrä
- Tulistimien, keittopinnan ja savukaasukanavan ulostulolämpötila
- Savukaasupuhaltimen nopeuden muutokset

Tyypillinen reagointi

- Ennakoivat toimenpiteet:
  - nuohouksen tehostaminen,
  - palamisen optimointi,
  - aktiivinen pH:n seuranta ja alkalimetallien poistaminen kierrosta
- Reaktiiviset toimenpiteet: räjäytyspuhdistus, vesipesu

Lämmönsiirtopintojen räjäytyspuhdistukset, CBE

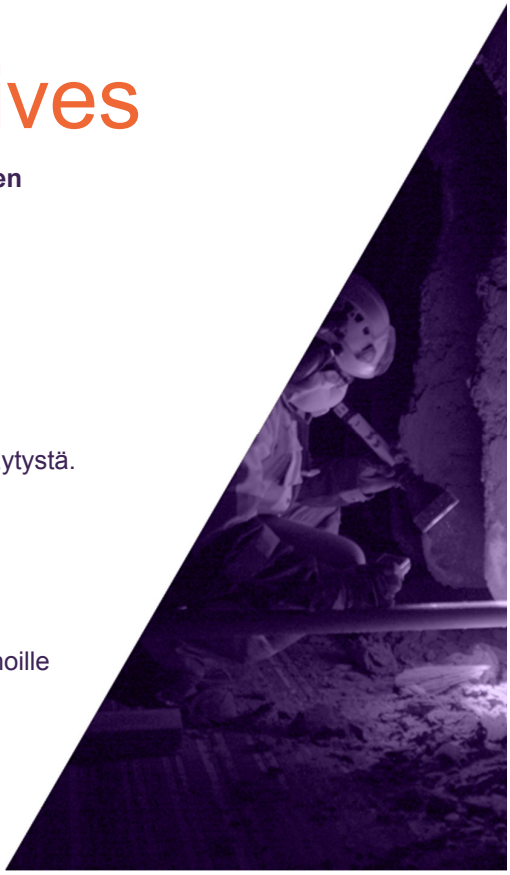
Käytettävyyden ja tehokkaan lämmönsiirron varmistaja

CBE – Clean By Explosives

- **Kattilan lämmönsiirtopinnoille palamisen yhteydessä tarttuvan lian poistaminen räjäyttämällä**
  - tehokas ratkaisu lämmönsiirtopintojen ajonaikaiseen likaantumisen hallintaan
  - Soveltuu jätteenpoltto-, bio- ja soodakattiloiden puhdistamiseen
  - Turvaräjäytykset ennen huoltoseisokkia huoltotöiden mahdollistamiseksi

- **Käytössä laajasti mm. Ruotsissa ja Yhdysvalloissa.**
  - Suomessa käytetty vuoden 2018 loppuun asti lähes pelkästään kaasuseosräjäytystä.

- **Turvallinen & Tehokas & Nopea**
  - Ei vahingoita kattilaa
  - Luvanvaraista toimintaa, jossa turvallisuus on kaiken keskiössä
  - Perustuu räjähdyksessä syntyvään paineaaltoon, joka irrottaa lämmönsiirtopinnoille kertyneen lian.
  - Emulsiopohjainen räjähde, josta ei jää kattilaan mitään jäämiä
  - Nopeuttaa puhdistusta huoltoseisokin yhteydessä



CBE - palveluprosessi

- **1. Valmistelevat työt**
  - Kohteeseen tutustuminen & Räjäytyssuunnitelman laatiminen
    - Räjäytyspuhdistettavat alueet
    - Käytettävät aineet & määrät
    - Tarvittavien räjäytysten lukumäärä
    - Ajankäyttösuunnitelma / miehitys
    - Tuhkanpoistosuunnitelma

- **2. Toteutus**
  - Toteutuksen esivalmistelu kohteessa (ilmoittautuminen valvomossa n. 90 min ennen vars töiden aloittamista, panosten rakentaminen, alueen rajaaminen)
  - Ajokuorman alentaminen ei välttämätöntä (joskin osa asiakkaista toimii näin)
  - Räjäyttäminen suunnitelman mukaisesti

- **3. Jälkihoito**
  - Kirjallinen raportointi suoritetuista räjäytyksistä & havainnoista sekä suositus seuraavasta räjäytyspuhdistuksesta

Turvallisesti & Ammattitaidolla

- CBE palvelukehitys toteutettu yhteistyössä Fortumin kanssa.
- Kaikilla CBE räjäytyspuhdistuksia tekevillä nuoremman panostajan tai panostajan koulutus
- Käytettävät panoskoot suunnitellaan likakertymien määrän ja koostumuksen mukaan.
- Syntyvä paineaalto ei vahingoita kattilaa

Case Metsä Fibre Oy, Äänekoski, BTT

Ennakoiva CBE räjäytyspuhdistus osana laitoksen käytettävyyttä

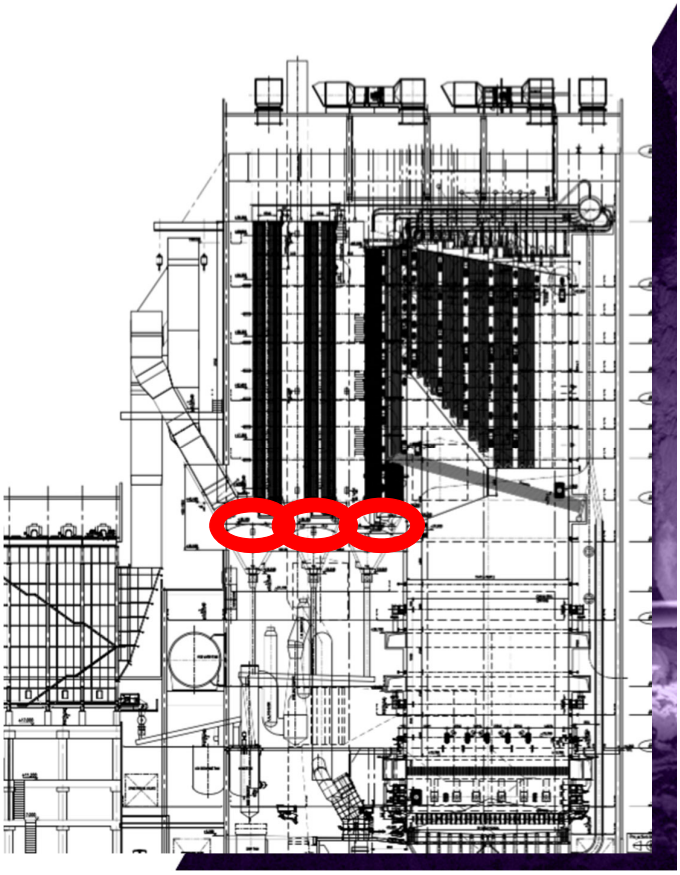
Kattilan käytettävyyteen vaikuttavaa likaantumisongelmaa lähinnä ekonomaiserien alueella.

Ratkaisu:

- n. 8 viikon välein suoritettava CBE räjäytyspuhdistus läpi ajokauden (+vesipesu huoltoseisokissa)

Hyödyt?

- Mahdollistaa tehokkaan ajon läpi ajokauden
- Likaantuisongelma kontrollissa koko ajan
- CBE menetelmänä hellävaraisempi kuin aiemmin käytetty menetelmä.
- CBE:stä ei jäämiä prosessiin



Ennen & Jälkeen

Noin. 40 räjäytystä, Operaation kesto n. 6 tuntia

Yhteenveto

Lämmönsiirtopintojen likaantumisen hallinnan merkitystä saatetaan vähätellä jos laitos toimii ”normaalisti”.

- Likaantumisen hallintaan liittyvä toiminta usein reaktiivista
- Hyvin toimivaakin voidaan ja kannattaa parantaa

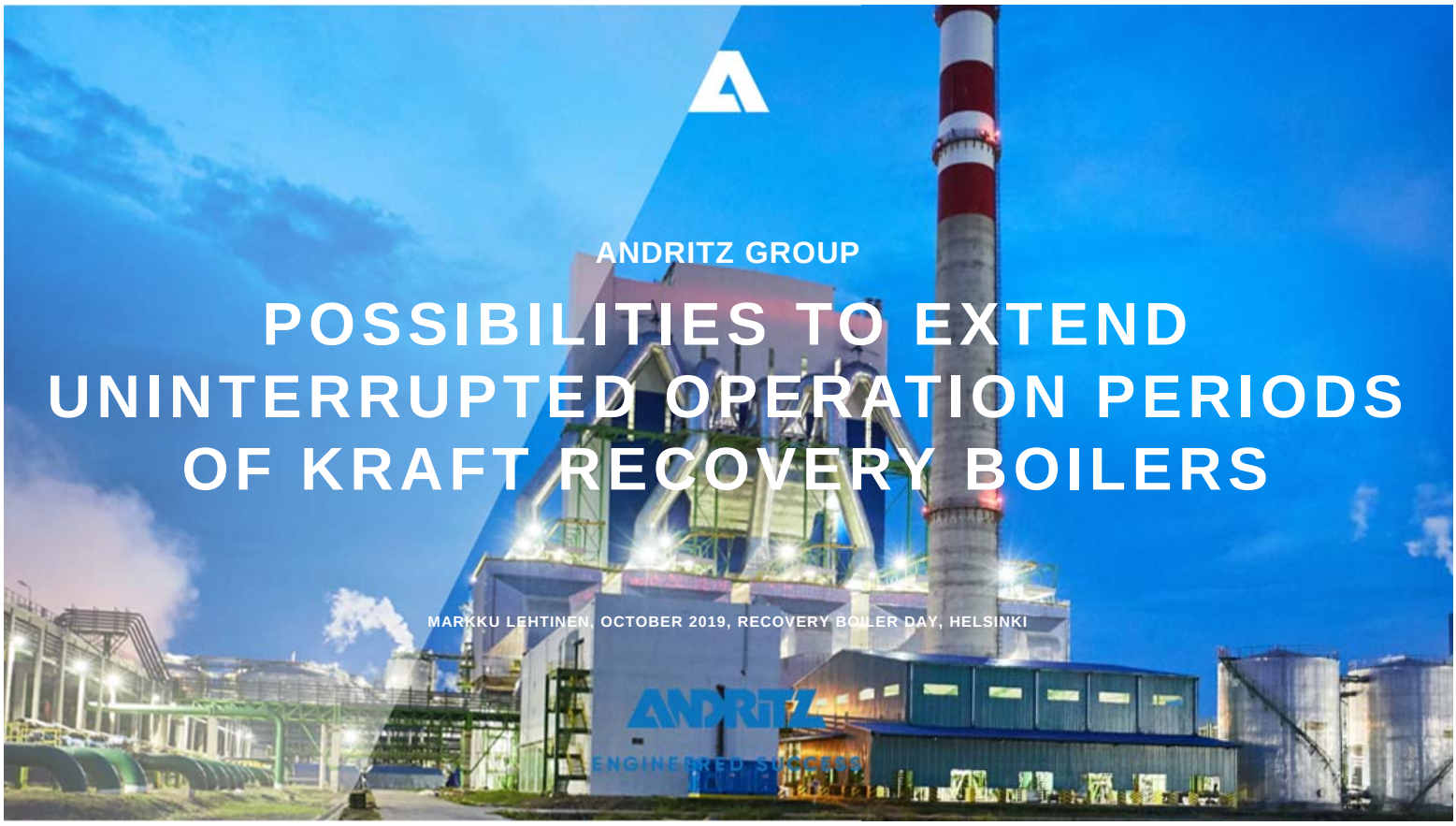
CBE Räjäytyspuhdistus on turvallista ja tehokasta

- Jo nyt säännöllinen osa usean laitoksen arkea, yleistyy jatkossa vauhdilla.
- Ei korvaa vuosihuollossa tehtävää pesua mutta tehostaa sitä
- Turvallisuus on meille prioriteetti nro yksi

- **Laitoskohtaiset erot likaantumisessa voivat olla suuria niinpä ratkaisujenkin tulee räätälöityä**
  - Säännöllisen räjäytyspuhdistusrytmin määrittäminen
  - Räjäytyspuhdistettavat kohteet ja panoskoot vaihtelevat

POSSIBLE TO EXTEND UNINTERRUPTED OPERATION PERIODS OF KRAFT RECOVERY BOILERS

Markku Lehtinen
ANDRITZ



ANDRITZ GROUP

POSSIBILITIES TO EXTEND UNINTERRUPTED OPERATION PERIODS OF KRAFT RECOVERY BOILERS

MARKKU LEHTINEN, OCTOBER 2019, RECOVERY BOILER DAY, HELSINKI

CHAPTER OVERVIEW

01 INTRODUCTION
02 RECOMMENDATIONS
03 LEGISLATION
04 MECHANICAL CONSTRAINTS
05 PROCESS CONSTRAINTS
06 TOOLS TO EXTEND OPERATION PERIODS
07 SUMMARY

POSSIBILITIES TO EXTEND UNINTERRUPTED OPERATION PERIODS OF KRAFT RECOVERY BOILERS

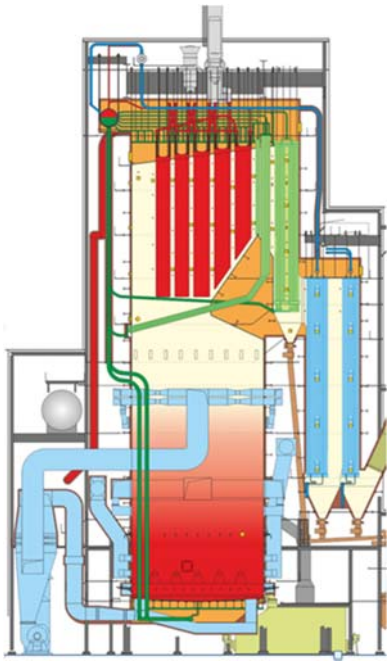
Introduction

- All the pulp mills are looking for ways to push the production towards higher numbers
- One of the most important operating factors to reach this target is the mill's total availability
- Although, the capacity of kraft recovery boilers has increased rapidly during recent years and the nominal furnace loading has increased significantly, the availability of recovery boilers has always been very high
- If the availability cannot be increased, then another possibility to raise pulp production is to increase the number of operation days

References of HERB availability over operation period

RB label	tds/d	Availability %
OB	1,000	99
MR	1,800	99.5
MF	1,200	100
MS	2,300	98.1
MP	5,700	99.9
FB	4,500	99.5
WF	4,500	99.9
FJ	3,500	99.8
Average		**99.6**

Totally 670 000 operation hours



POSSIBILITIES TO EXTEND UNINTERRUPTED OPERATION PERIODS OF KRAFT RECOVERY BOILERS

Introduction

- Increased production can be in the long-run achieved by increasing the operation periods between scheduled shutdowns
- Traditionally, 12 months of operation between scheduled shutdowns has been the standard in the pulping industry
- Encouraged by the high availability numbers of modern recovery boilers, mills are pushing the boiler suppliers to extended operation periods up to 18 months
- Some mills are even targeting at 24-month long operation periods

POSSIBILITIES TO EXTEND UNINTERRUPTED OPERATION PERIODS OF KRAFT RECOVERY BOILERS

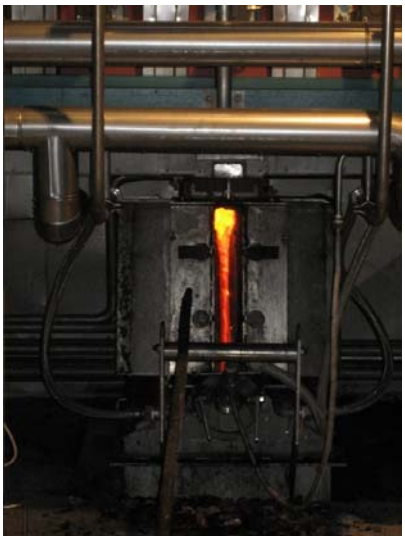
Introduction

- What is actually limiting the length of the recovery boiler operation periods between shutdowns?
- Are the limiting factors related to safety, perceptions, mechanical constraints, process issues, fouling and plugging, corrosion, local legislation, or recommendations from recovery boiler committees?
- What are the possibilities to extend uninterrupted operation periods of kraft recovery boilers without unscheduled shutdowns

POSSIBILITIES TO EXTEND UNINTERRUPTED OPERATION PERIODS OF KRAFT RECOVERY BOILERS

Recommendations

- BRLBAC & SKY
  - Smelt spouts should change every 12 months
- Sodahus committee
  - Smelt spouts must be inspected during every planned shut down



POSSIBILITIES TO EXTEND UNINTERRUPTED OPERATION PERIODS OF KRAFT RECOVERY BOILERS

Legislation

- Brazil
  - Standard inspection period is 12 months
  - Inspection period of 15 months is possible, but requires “inspection auditions” during the operation period
- Sweden
  - Recovery boilers are to be inspected every calendar, but there is six months transition period, that gives possibility to maximize with special application to 18 months.
- Finland & EU
  - Operation inspection interval is 24 months.
  - Internal pressure part inspection every four years.

POSSIBILITIES TO EXTEND UNINTERRUPTED OPERATION PERIODS OF KRAFT RECOVERY BOILERS

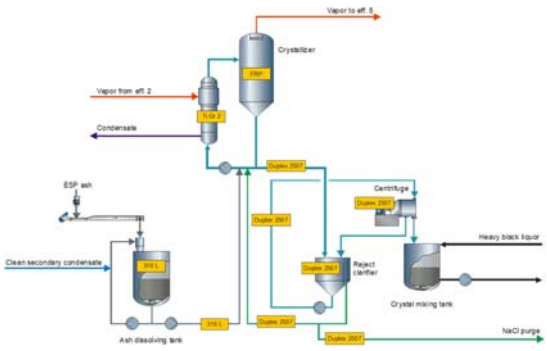
Constraints

- Mechanical
  - Life time of smelt spouts
  - Furnace and superheaters life time
  - Leaks, critical and non-critical
- Process
  - Fouling of the heating surfaces
  - Carry over – Large dropping lumps
  - Electrostatic precipitator plugging – Temporary load reduction
  - Smelt spout plugging

POSSIBILITIES TO EXTEND UNINTERRUPTED OPERATION PERIODS OF KRAFT RECOVERY BOILERS

Tools to extend operation periods

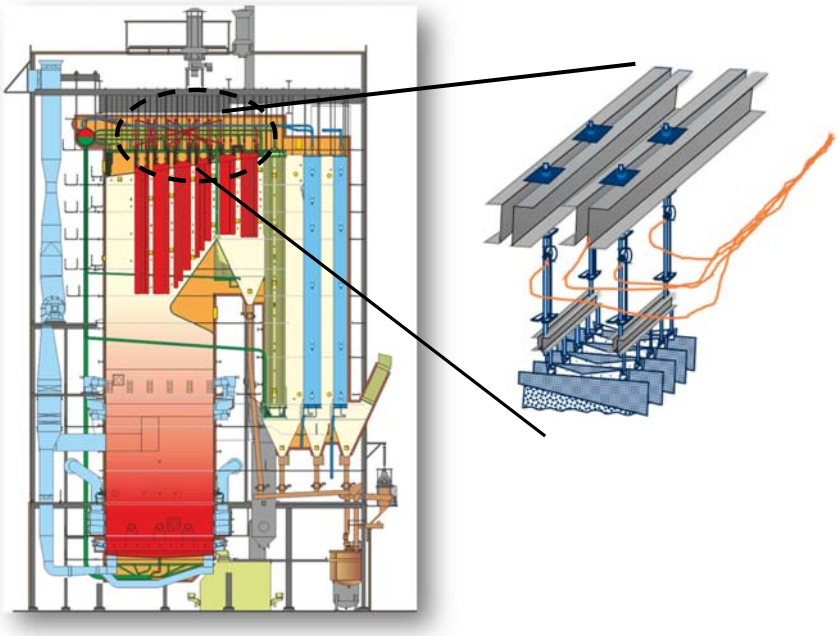
- Controlling of Cl and K content of black liquor
  - HERB cleanability
  - Superheater corrosion



POSSIBILITIES TO EXTEND UNINTERRUPTED OPERATION PERIODS OF KRAFT RECOVERY BOILERS

Tools to extend operation periods

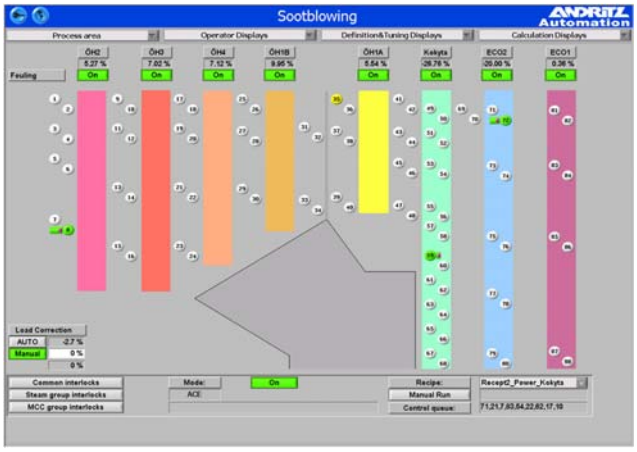
- HEWI & Sootblowing ACE
  - is a system with measurement sensors that includes supporting parts to hanging rods and signal connection for the stress gauge implementation.
  - measurement value CHANGEs are followed in order to see fouling and then act accordingly in process control (sootblowing)
  - information is valuable without DCS but best benefits achieved when combined with DCS information



POSSIBILITIES TO EXTEND UNINTERRUPTED OPERATION PERIODS OF KRAFT RECOVERY BOILERS

Tools to extend operation periods

- HEWI & Sootblowing ACE



On-line process calculations
- Furnace temperature profile
- Heat transfer
- Firing liquor properties
- Ash properties
- Ash melting temperature and density

Soft sensors

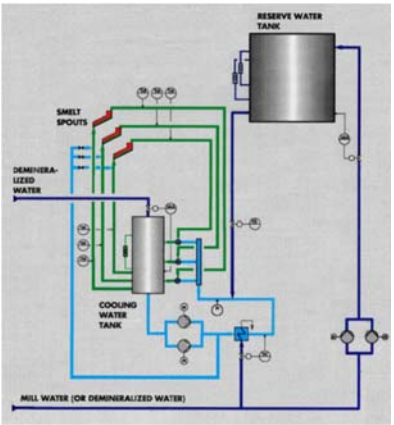
1. Fouling control
- Fouling calculations (dP, Heat transfer, SO_2, HEWI)
- Sticky area prediction

2. Dynamic Sequence Sootblowing
- Dynamic queue based on Run Intervals
- SB's steam pressure and speed profiles
- Boiler load adaptive sooting power
- Configurable sootblowing system structure

POSSIBILITIES TO EXTEND UNINTERRUPTED OPERATION PERIODS OF KRAFT RECOVERY BOILERS

Tools to extend operation periods

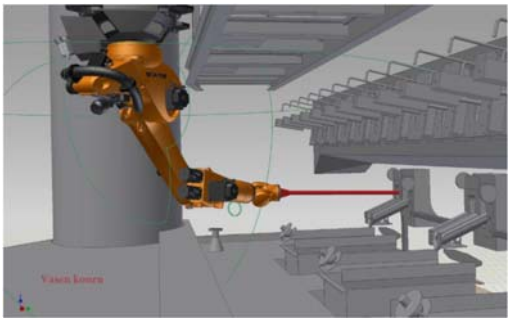
- Smelt Spout Durability
  - Laser Weld Overlay spouts
  - Effective cooling



POSSIBILITIES TO EXTEND UNINTERRUPTED OPERATION PERIODS OF KRAFT RECOVERY BOILERS

Tools to extend operation periods

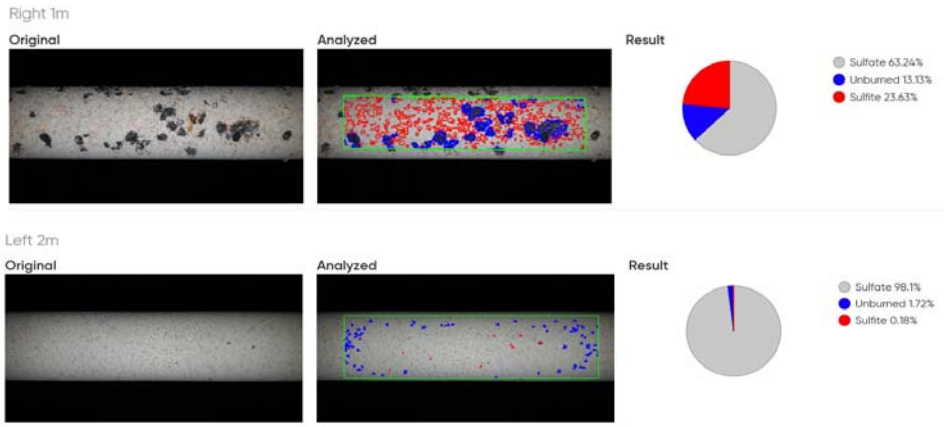
- Smelt spout robot
  - Available for tight layouts, Cleans 3 spouts / robot
  - Gently cleaning
  - Boiler movement tracking with laser sensors
    - Accurate positioning for cleaning movements



POSSIBILITIES TO EXTEND UNINTERRUPTED OPERATION PERIODS OF KRAFT RECOVERY BOILERS

Tools to extend operation periods

- AVA – ANDRITZ visual analysis
  - Carry over



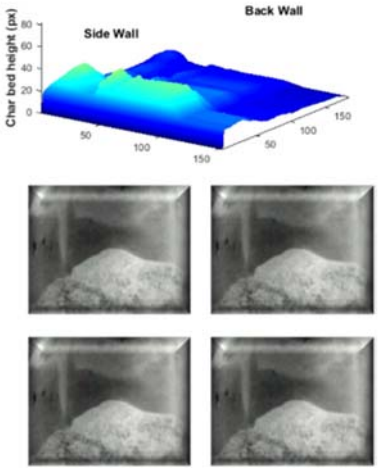
Poor

Good

POSSIBILITIES TO EXTEND UNINTERRUPTED OPERATION PERIODS OF KRAFT RECOVERY BOILERS

Tools to extend operation periods

- AVA – ANDRITZ visual analysis - Char bed
- The charbed is typically a black box inside the furnace
- Charbed events are hard to predict or simulate
- Some boilers are operating with low char bed, some with high char bed
- Every RB is equipped with at least one char bed camera
- Visually used for estimating the bed height and events in the lower furnace
- Four char bed cameras gives optimum imaging and has higher availability
- At least one cha rbed camera should be equipped with temperature readings
- The system produces digitalized images from the char bed cameras views
    - Triggering information to the smelt spout rodding system
- The ANDRITZ Charbed monitoring system enables bed height, location, movement, and inventory (volume and mass) recording on-line to achieve
    - Better combustion and reduction rate control



POSSIBILITIES TO EXTEND UNINTERRUPTED OPERATION PERIODS OF KRAFT RECOVERY BOILERS

Summary

- Recovery boiler combustion is a chaotic event
- There is no single medicine to control the chaos
- Multiple channels to collect process information is required
- Based on data analysis optimum operational can be executed

- Outcome =>
    - Longer operation periods
    - Optimum combustion
    - Stable operation

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RECOVERY BOILER TECHNOLOGY TRENDS IN PAST AND IN FUTURE

Kari Haaga ja Timo Laurila
Valmet Technologies Oy

Soodakattiloiden ja automaation teknologiset trendit viimeisten vuosikymmenten aikana

Recovery Boiler Technology trends in past and in future

Soodakattilapäivät 2019

31.10.2019 Helsinki

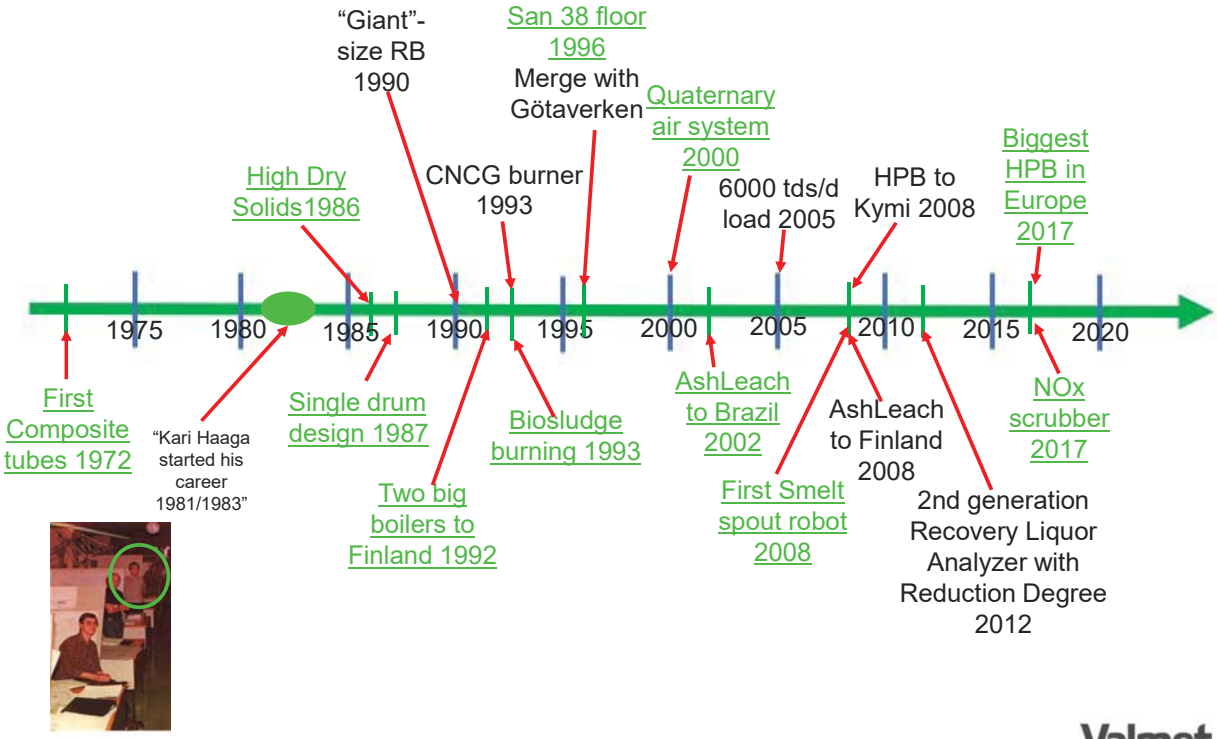
Kari Haaga

Timo Laurila

Valmet

Recovery Boiler Technology trends in past and in future

Most “interesting” developments in RB technology



Valmet

1972 Composite tubes

Membrane wall designs

Corrosion of tubes in the lower section of recovery boiler furnaces is a well-known problem. Corrosion has been found to be especially rapid in boilers where the steam pressure is over 64 bar. The quality of liquor and smelt also affects the speed of corrosion.

We have carried out extensive research in this field and have solved corrosion problems connected with high pressure and temperature.

The pictures on the right show the three alternatives used for tube protection. The top picture shows tube studding. This is the cheapest solution and gives a tube service life of 3 to 6 years.

Tampella has also clad tubes in the lower section of furnaces by welding with stainless steel electrodes (middle picture). This gives a service life of over ten years. The most modern method, shown in the bottom picture, is to use composite tubes with a stainless steel external layer. A useful service life of over twenty years is achieved this way. To further reduce the risk of corrosion caused by over-heating and thermal stress, Tampella uses narrow fins in membrane walls.

Power Lines in the beginning of 1991

Valmet

1972 Composite tubes

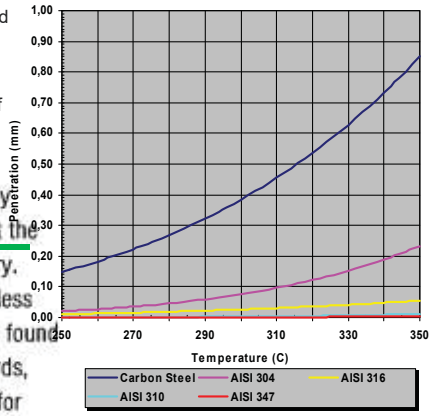
Corrosion in furnace tubes

CORROSION-RESISTANCE OF STAINLESS STEEL

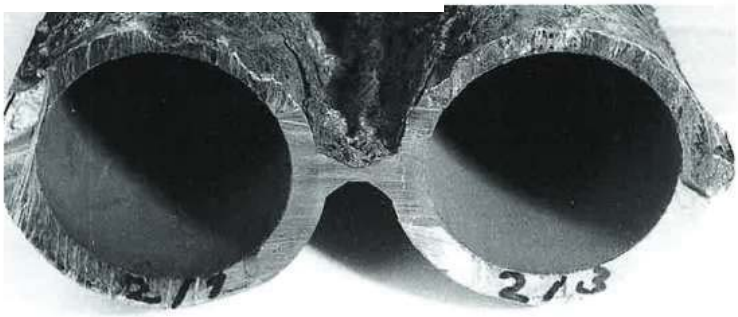
Extensive field experiments were conducted on test panels of various materials in a Finnish recovery boiler during a six year period in the late 1960s and early 1970s. At the end of the test series, it was evident that the composite tubes with stainless steel AISI 304 cladding had remained totally intact. This was a clear message to the boiler manufacturer that this material would be a good substitute for carbon steel tubes in the most critical part of the boiler.

Encouraged by these findings, Tampella Power Inc. was the first company to build a black liquor recovery boiler using composite tubes in the lower part of the boiler (1973). This boiler appeared to be huge success from the standpoint of corrosion. It is no wonder that many boilers have since been built using composite tubes.

- When boiler steam pressures increased then also furnace tubes surface temperatures increased ➔ risk of corrosion



The results were confirmed in laboratory tests conducted in severe test conditions at the Finnish Pulp and Paper Research Laboratory. The critical corrosion temperature for stainless steel AISI 304 in sulfidizing conditions was found to be around 500 °C (932 °F), in other words, far above the operating temperature, even for high pressure boilers. Figure 3 gives the original results.



Wall tube corrosion caused by an excessive temperature.

Power Lines 1991

Valmet

1972 Composite tubes

First composite 304L installation

The Tampella Power boiler at Assi, Lövholmen, Sweden. The composite tubes were initially installed to a height of 6 meters (19.68 feet) in 1972. Twenty years later, they were still undamaged. In May 1991, the composite level was raised by 4 meters (13.1. feet) and newly designed air ports were installed by Tampella Power.

Power Lines in the beginning of 1991

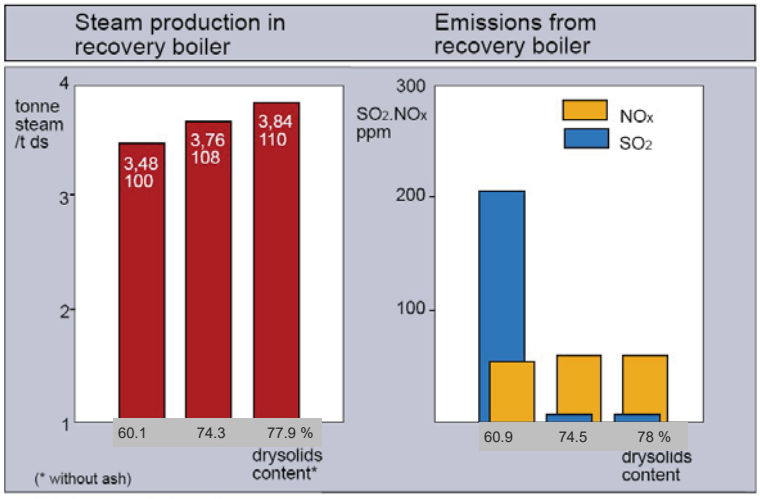
Valmet

1986 High dry solids firing

Super combustion system

Tampella Power's Super Combustion system, based on the super concentrator, has been functioning on a plant scale for a full five years with excellent results.

The first full scale production super concentrator was actually installed in March 1986. It was retrofitted to the recovery boiler (775,000 lb/h – 350 tds/24 h) at Pori Paper's Aittaluoto sulfate pulp mill in Pori, Finland. Pori Paper is part of United Paper Mills; its experience with Super Combustion has been overwhelmingly positive.



Data from consultant report

Valmet

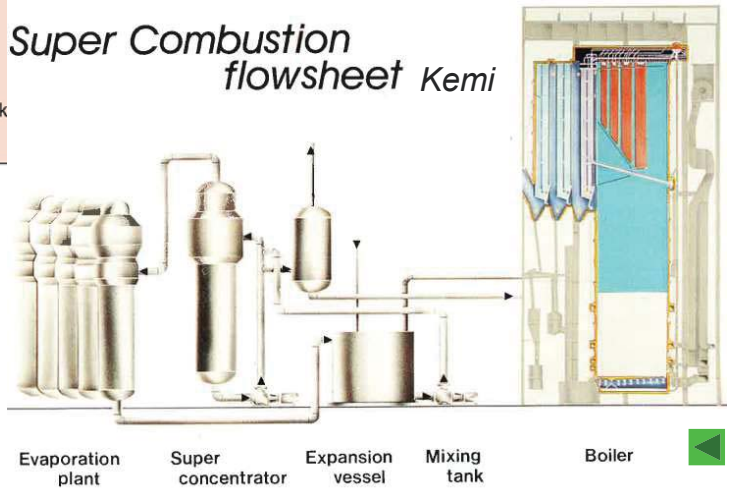
1986 High dry solids firing

First Super Concentrator

Experience of Super Combustion at Rosenlew, Pori, Finland

Increased dry solids content 61% ➔ 80%

- Reduction efficiency 95% ➔ 97%
- SO_2 100-400 ppm ➔~0
- Na_2CO_3 in ash 5% ➔ 15-20%
- H_2S 5-10 ppm ➔~0
- Recovery boiler steam production increased by 10%
- Availability of the boiler improved - less plugging
- Sootblowing steam consumption decreased
- Super concentrator availability good - boil-out once a week



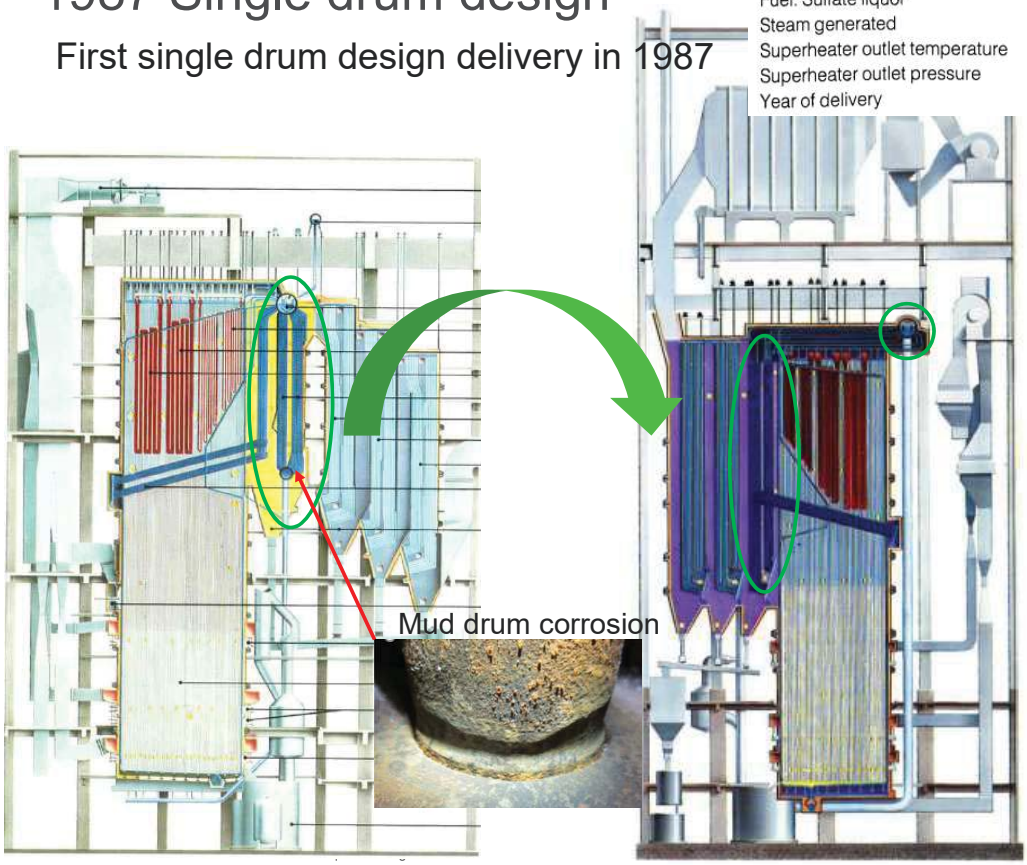
Valmet

1987 Single drum design

First single drum design delivery in 1987

Korsnäs-Marma Aktiebolag, Swe

Fuel: Sulfate liquor	1550 tds/24h
Steam generated	245 t/h
Superheater outlet temperature	450 °C
Superheater outlet pressure	64 bar
Year of delivery	1987



Wider side spacing of elements ➔ less fouling.

No numerous tubes welding to drum(s)

No thick drum wall thickness ➔ faster start-ups

Better supports of tubes and elements

No near mud drum corrosion

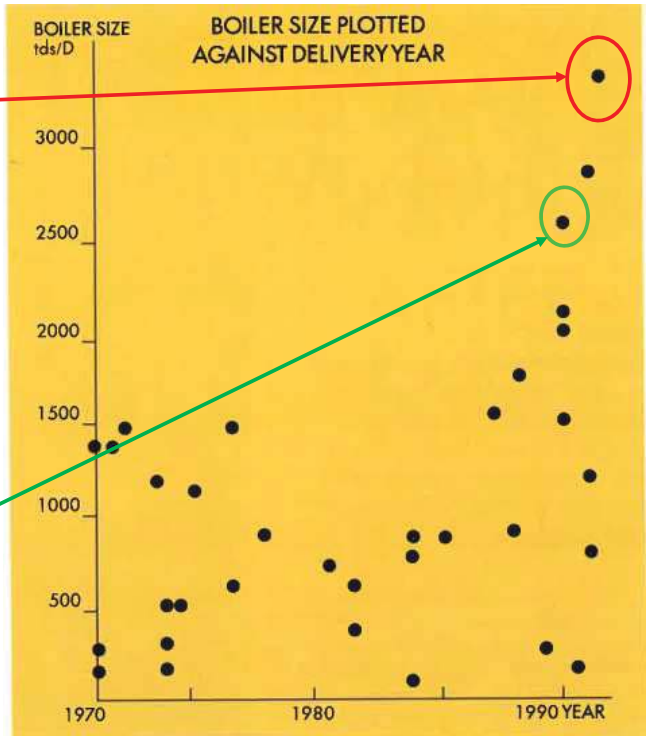
Valmet

1990, 1994, 2005 Capacity increase of RB

One of the two recovery boilers will be the largest in the world. It will be delivered to Enso's Kaukopää Mills in 1992 and it puts Tampella Power Industry top of the world league as far as large recovery boilers are concerned.

The Kaukopää pulp mill produces 500,000 tons of pulp a year, yet the boiler, which has a maximum capacity of 3,300 tonnes d.s./24h (7,275,000 lb/h), will alone be sufficient to meet its needs.

As part of Metsä-Botnia's investment program, Tampella Power delivered a giant-size (2600 t ds/24 h - 5,750,000 lb ds/24 h) recovery boiler to the Kemi Mills in 1990. The design features of this large boiler, including the multi-level air system, were important technological advances.

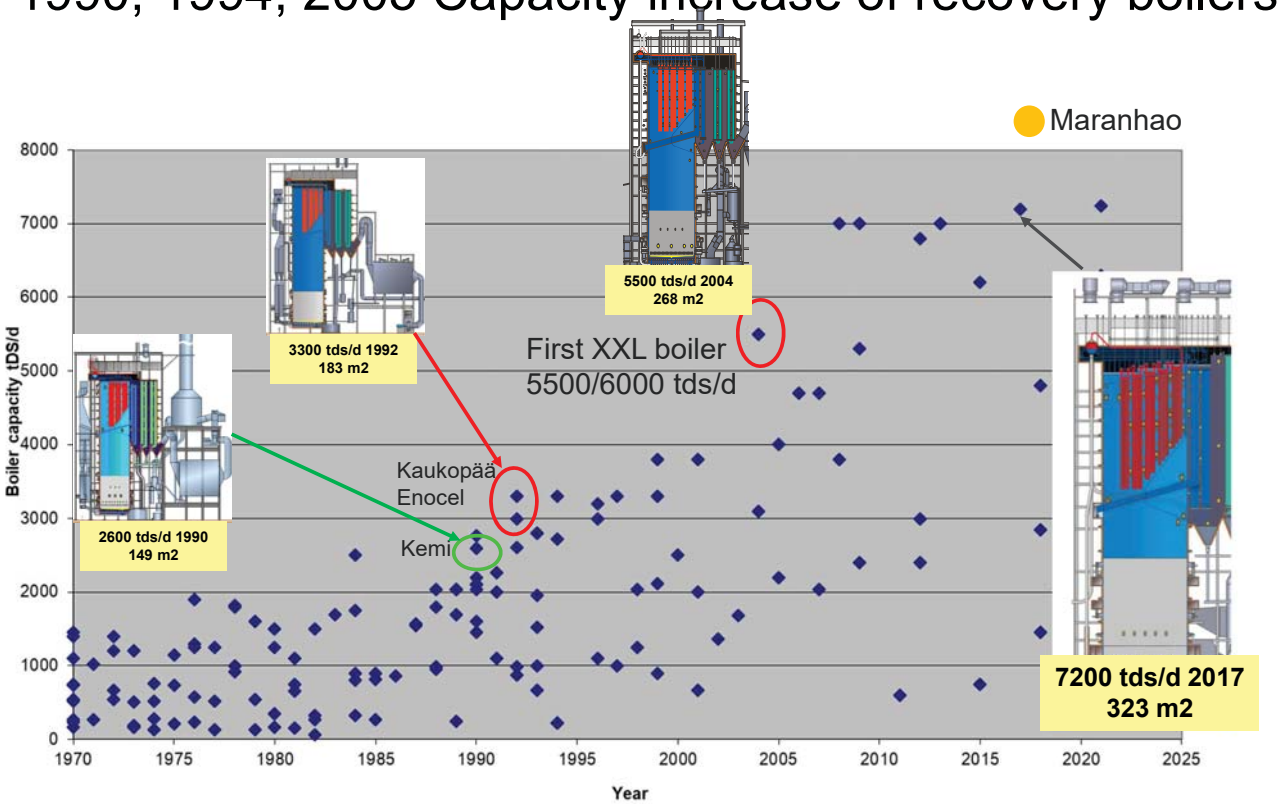


Power Lines 2/1990, 1993

Valmet

~ Other supplier

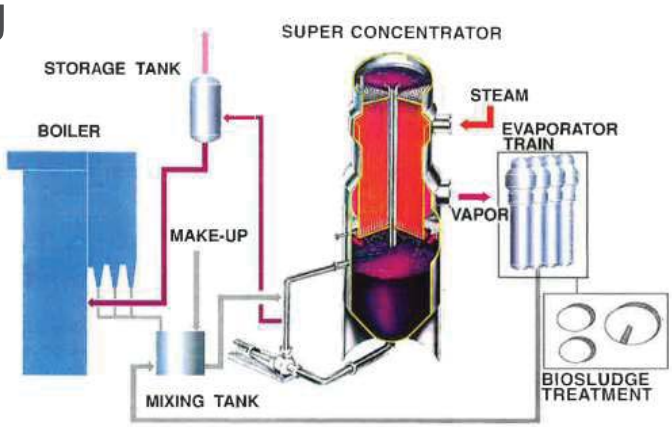
1990, 1994, 2005 Capacity increase of recovery boilers



Valmet

1993 Biosludge burning

- The Metsä-Botnia Kemi Pulp Mill was the first mill in the world to burn biosludge in a recovery boiler.
- Mechanically dewatered biosludge is mixed with weak black liquor and concentrated in a conventional evaporation plant equipped with a pressurized Super Concentrator unit.
- Disposal of biosludge in a recovery boiler offers an economically and environmentally attractive alternative



BENEFITS OF BIOSLUDGE SUPER COMBUSTION

- Extremely high dry solids
- Less need for additional fuels
  → significant drop in CO_2 emissions
- 4-5 % increase in energy generation
- Minimum emissions
- Stable burning conditions
- Better heat ratio in recovery boiler
- Less corrosion
- High boiler availability

Tampella Power also supplied a super concentrator for concentrating the mixture of black liquor and biosludge. The high dry solids content mixture (1 % biosludge, 99 % black liquor) is burned in the recovery boiler. The delivery also included an odor control system for the highly concentrated gases released from the chemical recovery lines and the super concentrator.

Power Lines 1993

1993 CNCG burner

- CNCG burning started in recovery boilers in the beginning of 1990 at MB Kemi mill
- After that CNCG burning has become a standard in new boiler deliveries
- CNCG burning has proved be safe way for controlling odorous emissions of the pulp mills and recovering sulfur chemicals. However, back-up burning places are needed; separate incinerators, torch, Power Boiler,….
- During last years mostly it has been discussed when those gases can be started to burn in recovery boilers
  - CNCG, (Methanol, DNCG and vents)

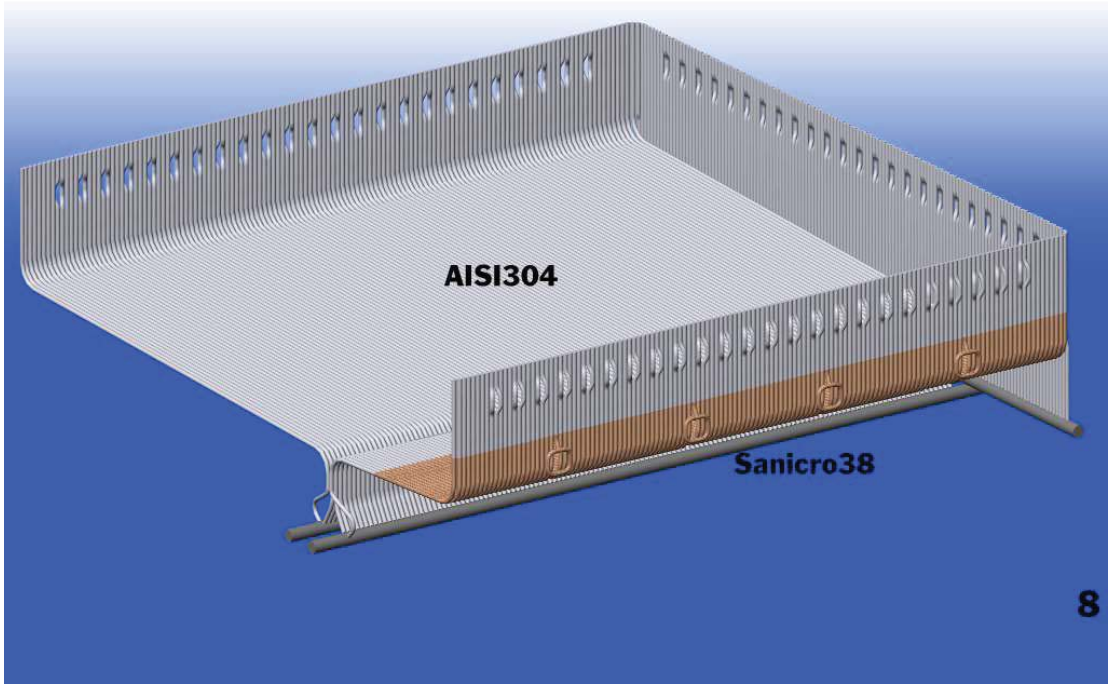
1996 Sanicro 38 floor

Floor made totally with Sanicro 38 material in Rauma RB

Sanicro 38 floor has now been in operation for 23 years with extremely good results

1995 Sanicro 38 floor at the front of spouts

Floor made partially with Sanicro 38 material in one boiler in Sweden

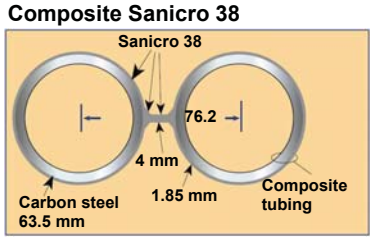


2008 Sanicro 38 floor

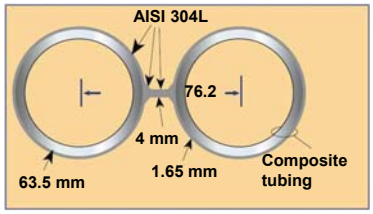
Lower part of furnace made totally with Sanicro 38 material

1996 Sanicro 38 floor

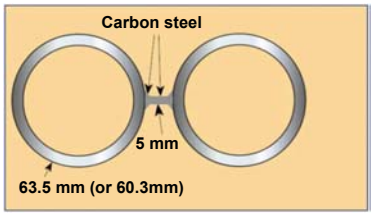
Composite Sanicro 38



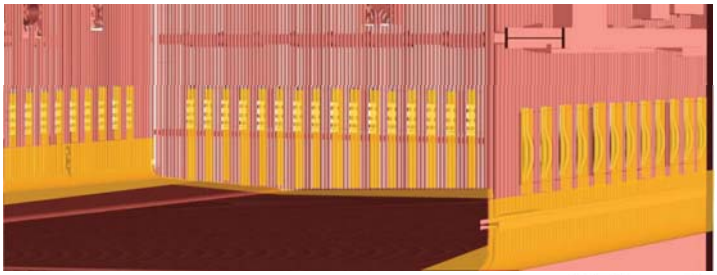
Composite tube AISI 304L



Carbon steel tube

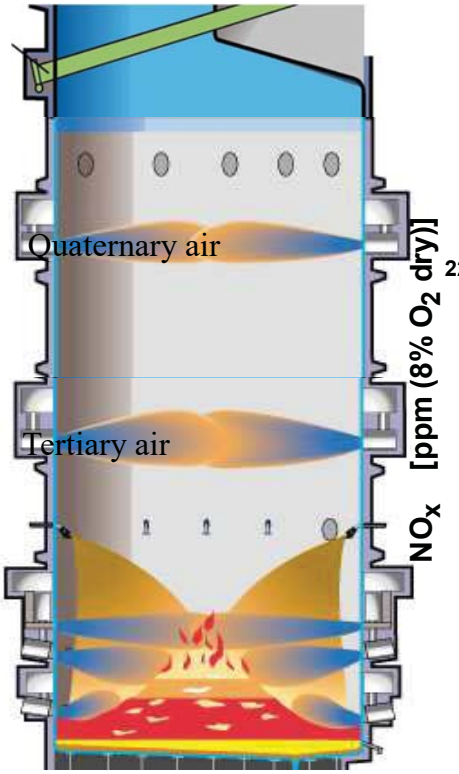


- Nowadays very common material selection in lower part of recovery boilers' furnace is:
  - Middle part of floor is carbon steel (SA/A-210 A-1)
  - Front and rear wall corners are Sanicro 38 material
  - Bended tubes in primary air ports are made by Sanicro 38 material
  - Rest part of furnace up to highest combustion air level is made by AISI 304L composite tubes
- Also totally Sanicro 38 floors have been delivered to some boilers. Then Sanicro cut point has been above primary air ports on all walls.
- Sanicro 67 material has been tested mainly in primary air port openings in some boilers

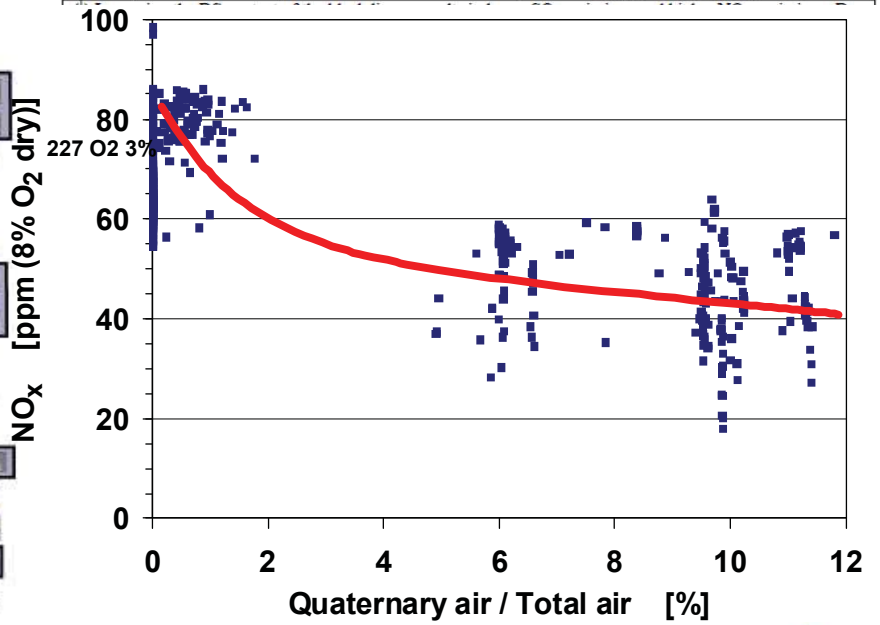


2000 Quaternary Air System

Primary method: Air staging with Quaternary air



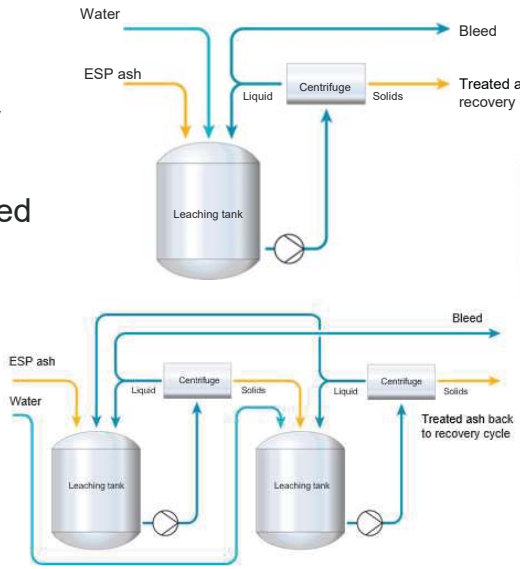
Parameter		Yearly average (1) mg/Nm³ at 6 % O_2	Yearly average (1) kg NO_X/ADt
NO_X	Softwood	120 – 200 (2)	DS <75 %: 0.8 – 1.4 DS 75 – 83 % (3): 1.0 – 1.6
	Hardwood	120 – 200 (2)	DS <75 %: 0.8 – 1.4 DS 75 – 83 % (3): 1.0 – 1.7



2002 Ash treatment systems

Ash Leaching and crystallization

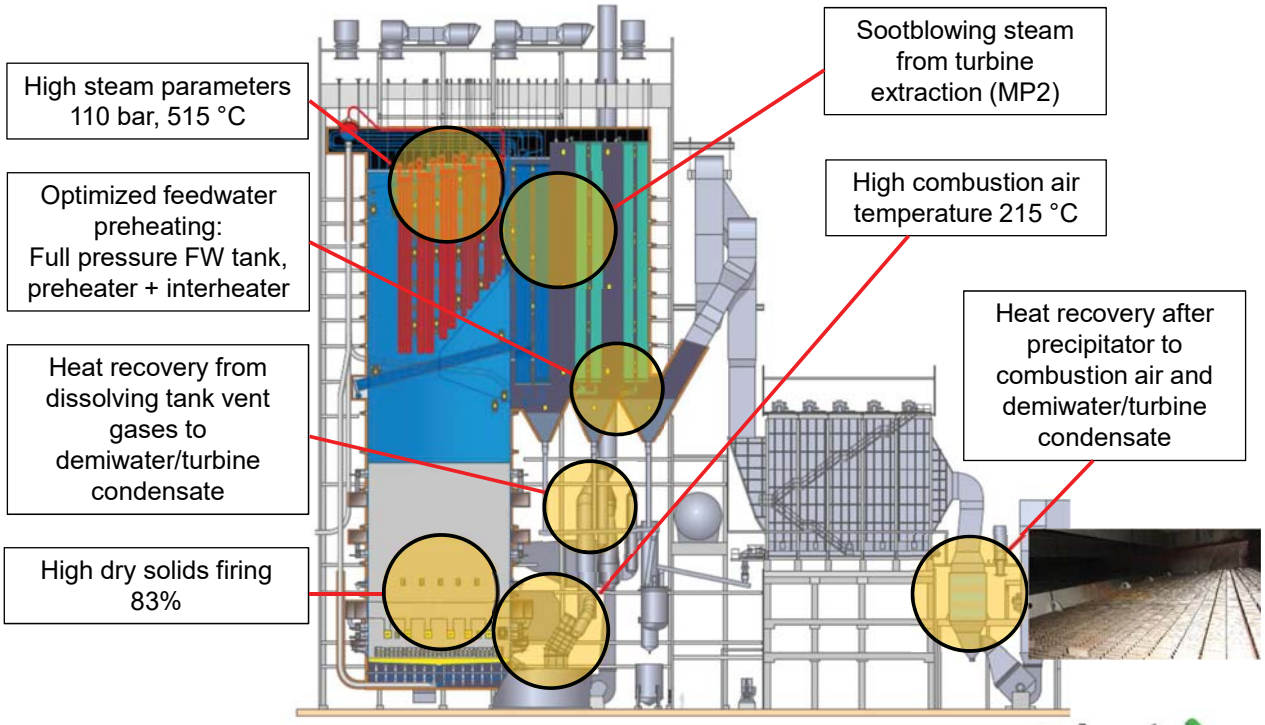
- Non-process elements like chlorine (Cl) and potassium (K) accumulate in the liquor cycle of a pulp mill
- Cl and K concentrations need to be controlled to avoid excessive fouling and corrosion of boiler's heat transfer surfaces
- Ash treatment processes have been developed for purging of Cl and K with minimum losses of cooking chemicals



2008 First Smelt Spout robot to Kymi

- Safety – less manual work close to the spouts **decreases risk of personal injuries**
- Stable smelt flow and trouble-free operation
- Saves money - Cleans spouts regardless of operator workload
- Persistent 24 hours careful cleaning
- Hinders the boiler spout openings from plugging
- Splendid observation Cameras from robot tip too area coverage
- Extends the lifetime of the spout
- 10 robots in operation and one in delivery

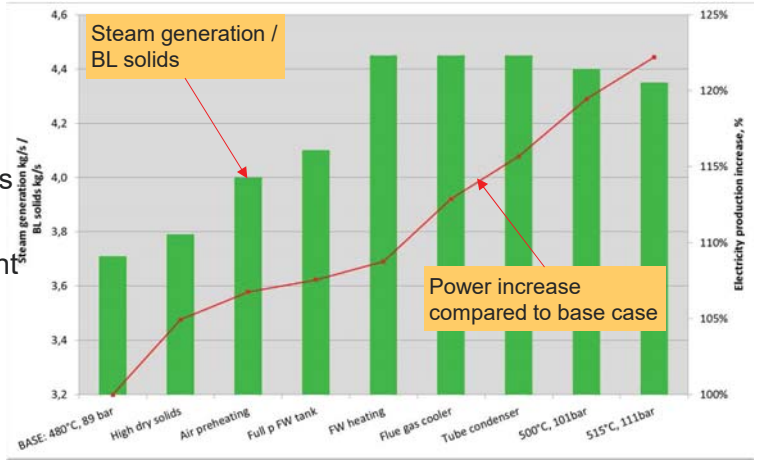
2017 Biggest High Power Boiler in Europe



2017 Biggest High Power Boiler in Europe

Effect of high power features on steam and electricity production

- Black liquor dry solids 83%
- Main steam parameters 110 bar, 515°C
- Combustion air temperature 215 °C
- Flue gas outlet temperature optimized together with feedwater preheating concept; after flue gas cleaning (ESP) further cooling to 130-135°C in flue gas coolers
- Heat recovery from dissolving tank vent gas
- Feedwater preheating
  - full LP pressure feedwater tank 143°C
  - preheater before economizer (MP1 steam) ➔ feedwater into the economizer I 185°C
  - interheater between economizers (MP2 steam)



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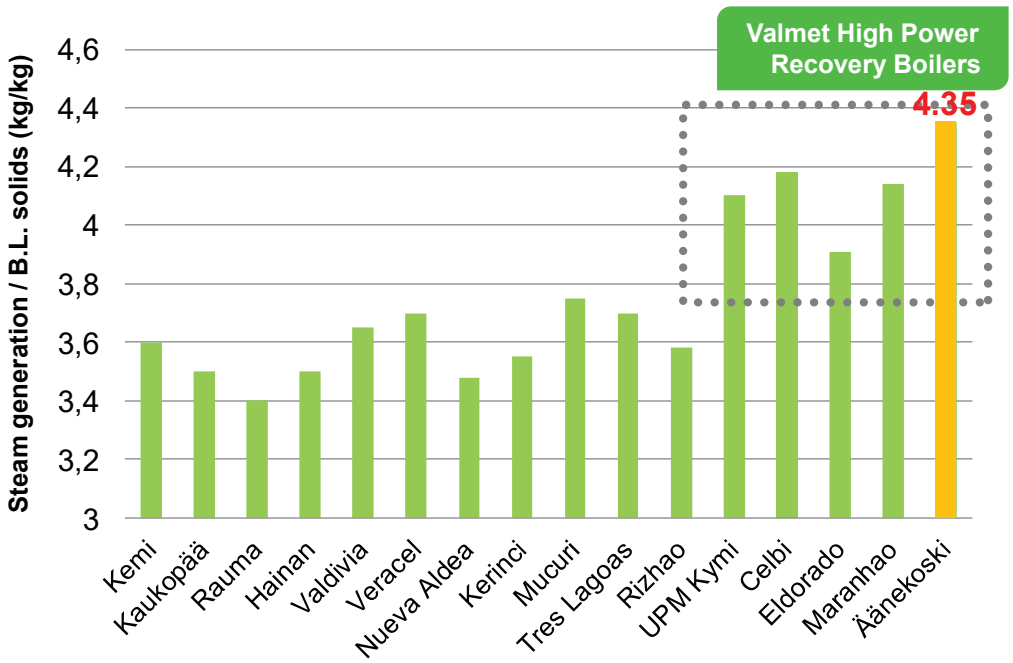
2017 Biggest High Power Boiler in Europe



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2017 NOx scrubbers, Recovery Boilers

Tightening NO_x emission limits

NO_x	Typical emissions	Europe BAT* Emission limit	China Emmission limit 2020
mg/Nm^3 @ 6% O_2 dry gas	120-250	120-200	100

*Industrial Emissions Directive 2010/75/EU

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2017 NOx Scrubber

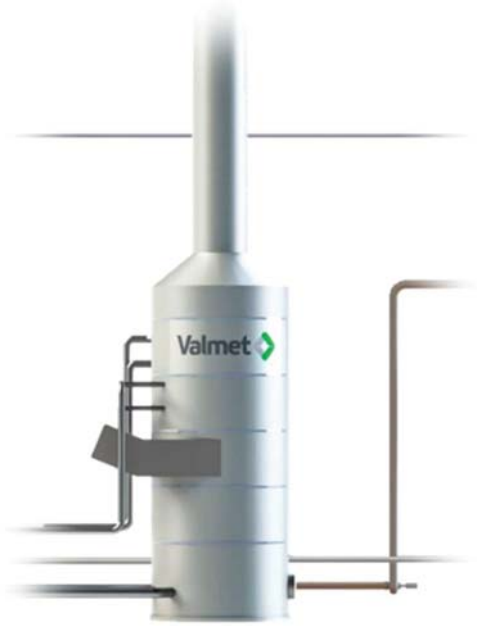
ClO_2 or O_3 as oxidation agent in deNOx scrubbers For Recovery boilers and Lime Kilns

ClO_2 is available in most pulp mills. Its used in bleaching

- Low energy consumption compared to the Ozone NOx process
- High selectivity , (NO to NO_2/N_2O_5 Oxidizes in milliseconds)
- Oxidized NO_2 will easily dissolve in scrubber liquor
- Easy start-up of ClO_2 based NOx scrubber, reliable

O_3/O_2 gas mixture is used for NO_x oxidation

- O_3/O_2 mixture is blown with carrier air to scrubber inlet
  - Rapid NO oxidation to NO_2
- NO_2 washed into scrubbing liquid
- O_3/O_2 gas mixture produced in special ozone generator
- Already commercial technology used in power boilers



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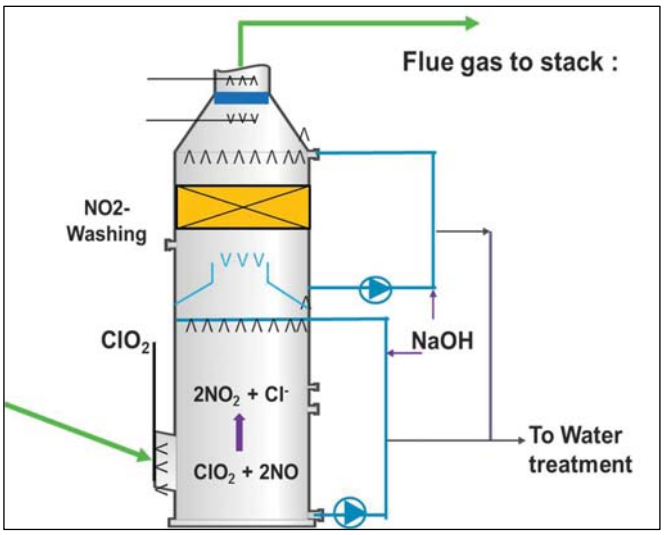
2017 NOx Scrubber

World's first recovery boiler with DeNOx scrubber

Sun Paper RB 450 t/d, Yanzhou, China



Test results have proven even NO_x 95% reduction rate

Nine NOx scrubbers are in operation or under delivery.
In all cases emission max 100 mg/Nm3

2017 NOx Scrubber

Valmet Scrubber NOx References

Eleven scrubbers under construction or delivery

Customer	NOX scrubber Application	Delivery status	Start-up	NOx limit
Sun Paper Yanzhou	RB 450 tDS ClO_2 DeNOx scrubber	Delivered In operation	2017	100 mg/m3n
Sun Paper Yanzhou	RB 1000 tDS ClO_2 DeNOx scrubber	Delivered In operation	2018	100 mg/m3n
Sun Paper Yanzhou	RB 900 tDS ClO_2 DeNOx scrubber	Delivered In operation	2019	100 mg/m3n
Asia Symbol (Shandong) Pulp and Paper Co. Rizhao	NCG Incinerator O_3 DeNOx scrubber	Under construction	2019	100 mg/m3n
Asia Symbol (Shandong) Pulp and Paper Co. Rizhao	RB7500 tDS/d ClO_2 DeNOX scrubber	Under construction	2019	100 mg/m3n
Asia Symbol (Shandong) Pulp and Paper Co. Rizhao	RB7500 tDS/d ClO_2 DeNOX scrubber	Under construction	2019	100 mg/m3n
Asia Symbol (Shandong) Pulp and Paper Co. Rizhao	Lime Kiln ClO_2 DeNOX scrubbers (2 scrubbers)	Under construction	2019	100 mg/m3n
Asia Symbol (Shandong) Pulp and Paper Co. Rizhao	Lime Kiln ClO_2 DeNOX scrubbers (2 scrubbers)	Under construction	2019	100 mg/m3n
Sun Paper Zoucheng	RB 1600 tDS/d ClO_2 DeNOX scrubber	LOI	2019	100 mg/m3n

Valmet Recox+ Automation

Path to maximum sustainable performance

Timo Laurila

Soodakattilapäivät 2019 Helsinki

Recovery Boiler Automation and Optimization

Contents

1 Long History in Automation

2 Recovery Boiler Optimization and Monitoring

3 Mass and Chemical balance example

4 Recox+ Automation

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Long history in the Recovery Boiler Automation

Recovery Boiler Automation Forerunners and Developers

THANK YOU!

SE Kotka 1980	MF Kemi 1990	ZP Rosenthal 1999	SE Kemi 2001	MF Rauma 2005	SE Kemi 2012	SE Kemi 2016
Damatic 1st Recovery Boiler Distributed Control System	**Combustion Optimizer** 1st Combustion and Sootblowing Optimization	**SIS** 1st Safety Integrated System (HIMA)	**Performance Contract** 1st Recovery Line Performance Contract	**Dissolving Tank** 1st Dissolving tank TTA Optimization	**Leak Detector** 1st Recovery Boiler Water/Steam leak detection	**Reduction Degree** 1st Reduction Degree Optimization

1960
The Airmatic a pneumatic measurement and control system

1970's
Elmatic-100 system, electronic instrumentation
Damatic, the first Distributed Control System (DCS)

1980's
Sensodec Condition Monitoring System
Damatic XD, modular second generation DCS

1990's
metsoDNA, Dynamic Network of Applications
SIS, Safety Integrated System

2000
Performance Contracts

2012
2nd generation Recovery Liquor Analyzer with Reduction Degree

2015
Valmet Process and Automation Technology company

2018
Valmet Boiler Diagnostics Systems

2018
Valmet Performance Centers

- Single loops
- To Distributed Control Systems

- Digitalization
- Large mill information systems

- Value added services
- Multivariable controls

- Advanced diagnostics and KPI's
- Millwide performance development and optimization

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Valmet Recovery Boiler Optimizer

By far most comprehensive offering on the market

Valmet DNA

Valmet DNA based APC-platform can also connect to any other DCS

IR Bed Camera

Acoustic Pyrometer

Recovery Liquor Analyzer

Options marked with *

Combustion optimization

Combustion Symmetry and Emission management

- Air distribution
- Boiler load
- Liquor droplet size
- Bed management
- Reduction Efficiency (add-on) *
- Superheated steam temperature (add-on)
- Leak detector (add-on)

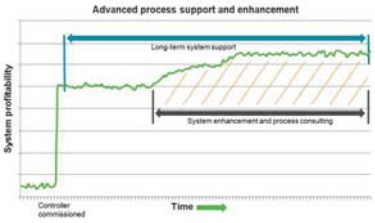
Dissolving tank optimization

- Valmet Alkali-R recovery liquor analyzer
- Na_2CO_3 solubility calculation *
- TTA-control *
- Dissolving tank mass balance stabilization (add-on)

Sootblowing optimization

- Fouling indicators
- Sootblowing efficiency indexing
- Adaptive intervals

Performance Services



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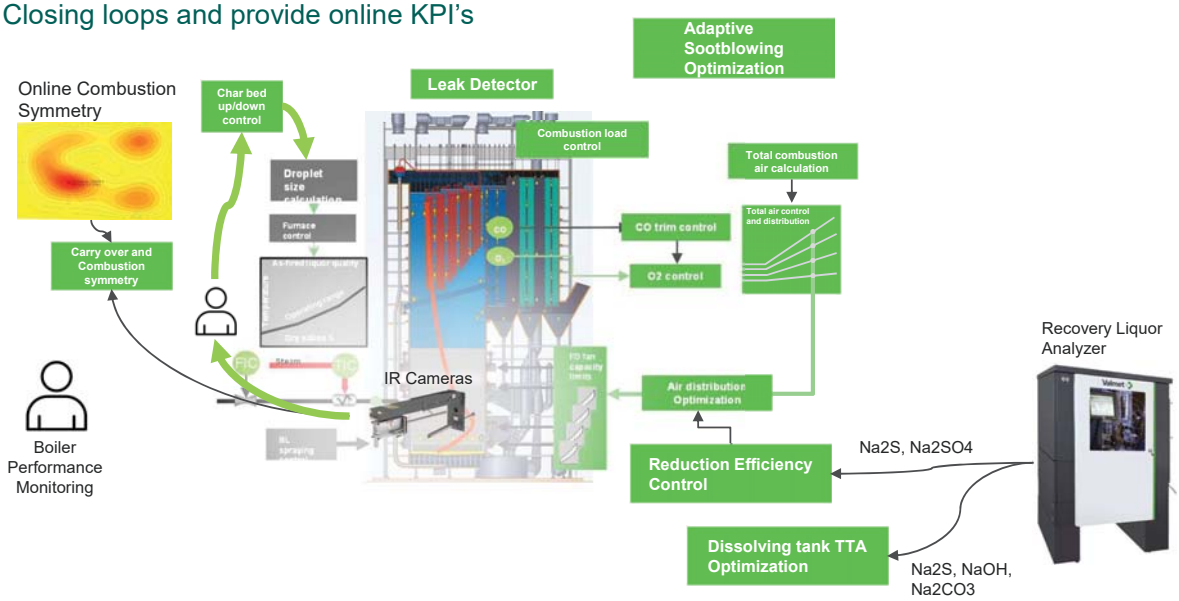
Recovery Boiler Optimization

Closing loops and provide online KPI's



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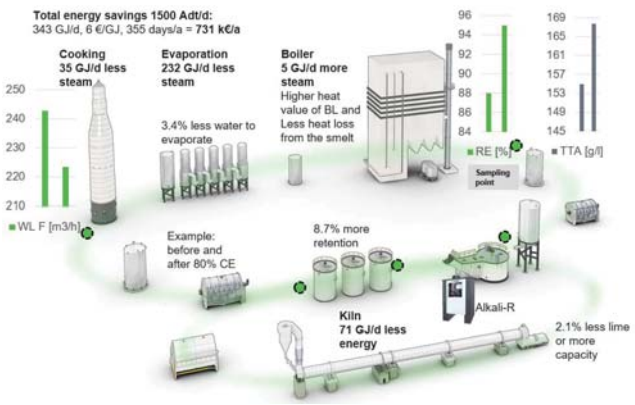
Recovery Boiler Automation and Optimization

- Maximum cleanability
- Maximum steaming
- Efficient sootblowing
- Minimum carryover
- Low emissions
- High and steady superheated steam temperature
- Maximum operational safety

- Optimized Chemical Recovery from Black to Green liquor



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Valmet
FORWARD

SODAHUSKOMMITTÉN - RUOTSALAIS-NORJALAINEN SOODAKATTILAKOMITEA, VUOSIKATSAUS 2018

Kristian Rosenqvist
Sodahuskommittén

Sodahuskommittén

Report from the Swedish-Norwegian Recovery Boiler Committee

Soodakattilapäivä 31/10 2019

Kristian Rosenqvist, ÅF Pöyry
Secretary of the Swedish-Norwegian Recovery Boiler Committee (SNRBC)

Sodahuskommittén

Topics

- Members and organization
- Recovery Boilers in Sweden and Norway
- Reported incidents
- Standardization
- Recommendations and standardization
- Certification of operators
- Experience sharing day
- Recovery Boiler meeting
- Prioritized projects

Members

- All mills producing kraft pulp and Domsjö in Sweden (22 mills), and Borregaard in Norway
- Recovery boiler manufacturers (Andritz and Valmet)
- 3rd party (Dekra, Force and Kiwa Inspecta)
- Swedish Paper Industry Workers' Union

Organization

The Board of the SNRBC
Chairman: Hans Holm, Ahlström Munksjö Aspa mill
Secretary: Kristian Rosenqvist, ÅF
19 members (12 voting)

- Recommendations Subcommittee
  Secretary: Lars Andersson, ÅF
  Additional 4 members
- Incidents Subcommittee
  Secretary: David Good, Dekra
  Additional 13 members
- Education Subcommittee
  Secretary: Björn Lundgren, Kiwa Inspecta
  Additional 5 members
- EIA Subcommittee
  (Electricity, Instrumentation, Automation)
  Secretary: Kristian Rosenqvist, ÅF
  Additional 8 members

Recovery Boilers in Sweden and Norway

Spring 2019
- Increased capacity Smurfit Kappa Piteå

Autumn 2018
- Increased capacity recovery boiler SCA Östrand

Autumn 2016
- Increased capacity recovery boiler Södra Cell Värö

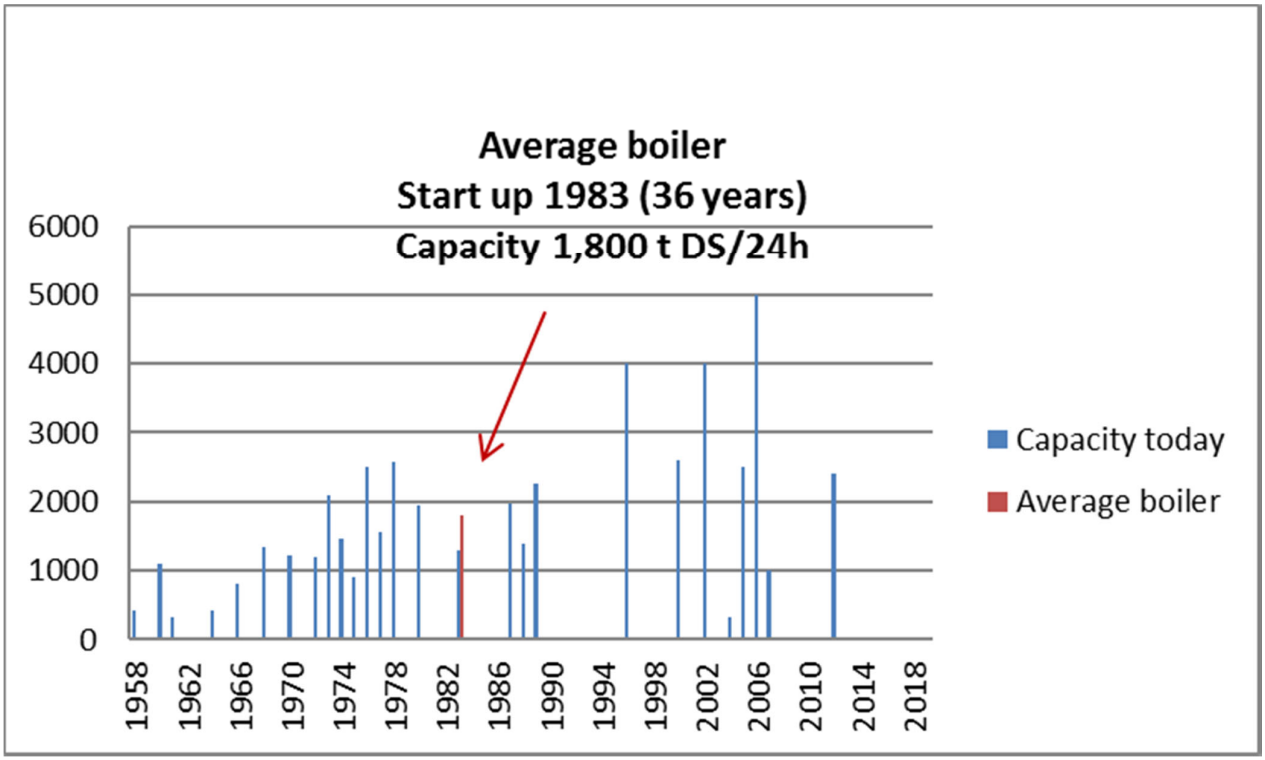
Autumn 2013
- The boiler in SCA Munksund was converted to single drum
- New evaporator line in BillerudKorsnäs Skärblacka

Summer 2013
- Closure of Södra Cell Tofte, Norway

Summer 2012
- Start up of a new boiler in Holmen Iggesund (the two old boilers were shut)

Sodahuskommittén

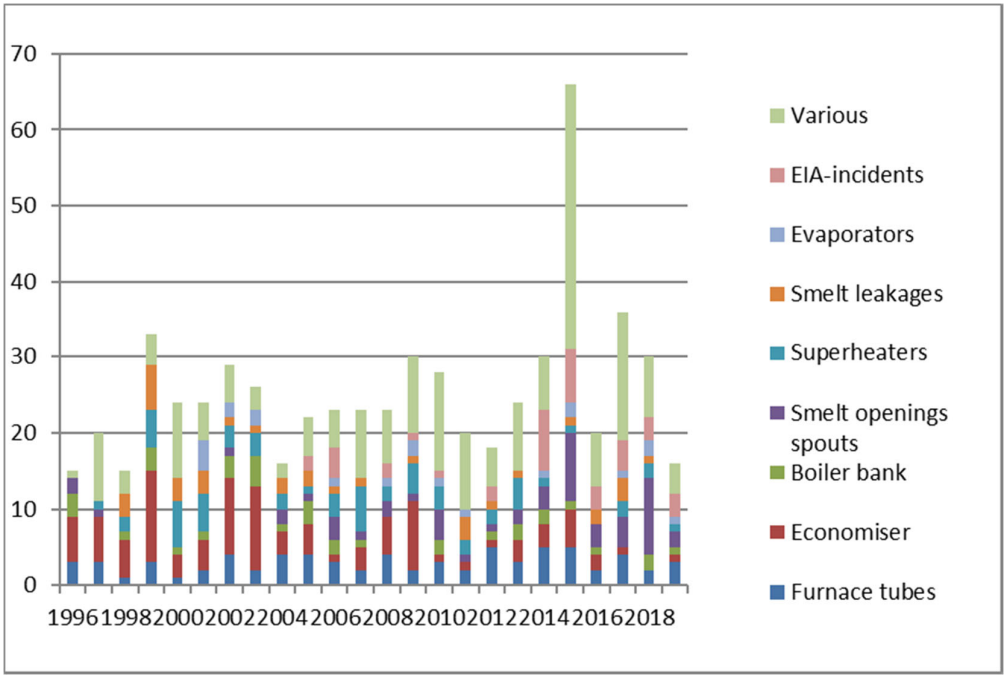
Recovery Boilers in Sweden and Norway



Sodahuskommittén

Reported incidents

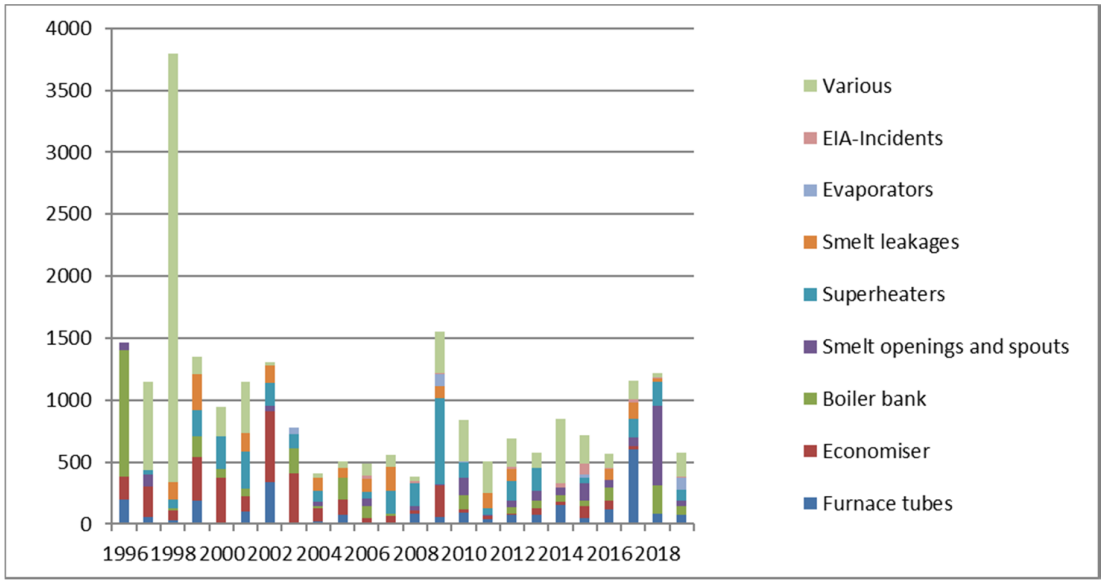
- Amount of incidents (until October 2019)



Sodahuskommittén

Reported incidents

- Down time [h] (until October 2019)

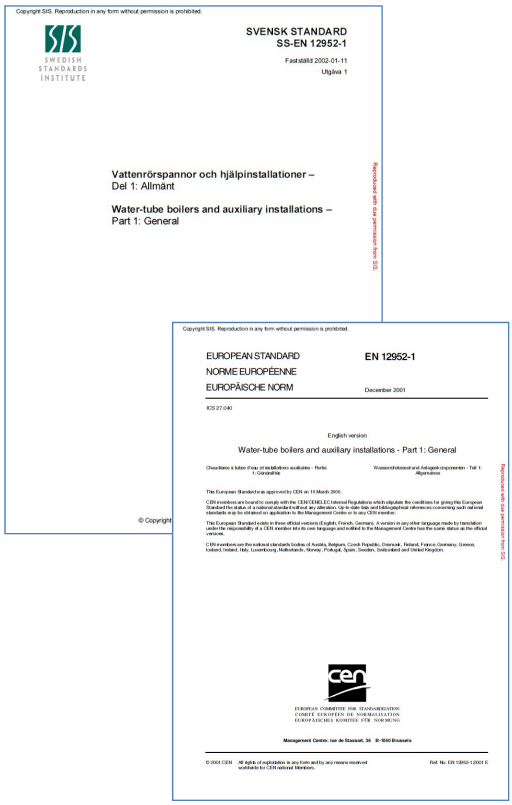


Standardization

- We are members in the Swedish Standardization, SIS

- We are represented in the Swedish Working Group TK285, Boilers

- We take part in the CEN Standardization work for the boiler standard: EN 12952, “Water tube boilers”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SVENSK STANDARD
SS-EN 12952-1

Fastställd 2002-01-11
Utgåva 1

Vattenrörspannor och hjälpinstallationer –
Del 1: Allmänt

Water-tube boilers and auxiliary installations –
Part 1: General

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EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

EN 12952-1

December 2001

ICS 27.040

English version

Water-tube boilers and auxiliary installations - Part 1: General

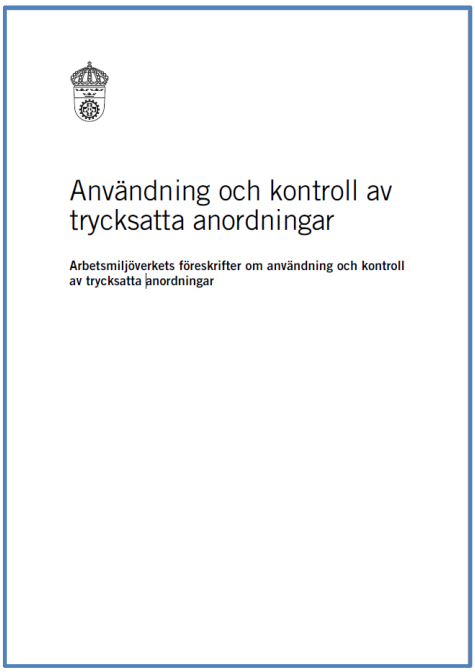
Sodahuskommittén

Standardization

Since november 2017 Sweden has a new regulation för pressurized devices (AFS 2017:3)

Important changes, relevant to recovery boilers are:

- Inspection of boilers
- Assessment of remaining lifetime, routines, journal keeping
- Certification of boiler operators


Användning och kontroll av trycksatta anordningar

Arbetsmiljöverkets föreskrifter om användning och kontroll av trycksatta anordningar

Recommendations

The SNRBC has 40 recommendations, divided in areas like:

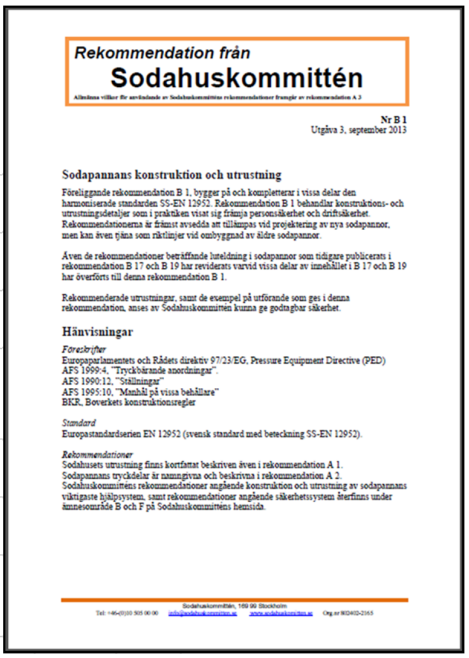
B: Construction and equipment
C: Operation and operational disturbances

B: Konstruktion och utrustning

Nr.	Titel
B1	Sodapannors konstruktion och utrustning
B2	Säkerhet i sodahusbyggnader

C: Drift och driftstörningar

Nr.	Titel
C1	Information om kritiska tillstånd och händelser i sodahuset.
C2	Information om sodapannedrift samt förebyggande och åtgärdande av driftstörningar.



Rekommendation från
Sodahuskommittén

Allmänna villkor för användande av Sodahuskommitténs rekommendationer framgår av rekommendation A 2

Nr B 1
Utgåva 3, september 2013

Sodapannans konstruktion och utrustning

Föreliggande rekommendation B 1, bygger på och kompletterar i vissa delar den harmoniserande standarden SS-EN 12952. Rekommendation B 1 behandlar konstruktions- och utrustningsdetaljer som i praktiken visat sig främja personsäkerhet och driftsäkerhet. Rekommendationerna är främst avsedda att tillämpas vid projektering av nya sodapannor, men kan även tjäna som riktlinjer vid ombyggnad av äldre sodapannor.

Även de rekommendationer beträffande luteldning i sodapannor som tidigare publicerats i rekommendation B 17 och B 19 har reviderats varvid vissa delar av innehållet i B 17 och B 19 har överförts till denna rekommendation B 1.

Rekommenderade utrustningar, samt de exempel på utförande som ges i denna rekommendation, anses av Sodahuskommittén kunna ge godtagbar säkerhet.

Hänvisningar

Föreskrifter
Europaparlamentets och Rådets direktiv 97/23/EG, Pressure Equipment Directive (PED)
AFS 1999:4, "Tryckbärande anordningar".
AFS 1990:12, "Ställningar"
AFS 1995:10, "Manhål på vissa behållare"
BKR, Boverkets konstruktionsregler

Standard
Europastandardserien EN 12952 (svensk standard med beteckning SS-EN 12952).

Rekommendationer
Sodahusets utrustning finns kortfattat beskriven även i rekommendation A 1.
Sodapannans tryckdelar är namngivna och beskrivna i rekommendation A 2.
Sodahuskommitténs rekommendationer angående konstruktion och utrustning av sodapannans vårtgaste hjälpsystem, samt rekommendationer angående säkerhetssystem återfinns under ämnesområde B och F på Sodahuskommitténs hemsida.

Sodahuskommittén, 100 00 Stockholm
Tel: +46-(0)10 505 00 00 info@sodahuskommitten.se www.sodahuskommitten.se Org.nr 802402-2165

Updating of the recommendations every third year

Recommendations approved 2018/2019

B1 Recovery boiler construction and equipment (2019)
B8 Emergency shutdown and rapid drainage of recovery boiler (2018)
B12 Electric power supply in recovery boilers (2018)
B13 Combustion of oil and gas in recovery boilers - equipment and safety systems (2018)
B14 Arrangement of alarms and indications for recovery boilers
B16 Firing of NCG and auxilliary fuels in recovery boilers

C4 Quality of makeup water, condensate, feed water, boiler water and steam (2018)

D2 Inspection of recovery boilers (2018)
D5 High temperature deformation of superheaters in recovery boilers (new recommendation, 2018)
D6 Continuous inspections and documentation

F1 Monitoring of recovery boilers (2018)

Certification of recovery boiler operators

The minimum accepted recovery boiler experience until examination and certification is 2 years

All certificates need to be updated/renewed each 7th year

The "re-examination test" is web-based and divided into three main parts:

- Recovery boiler design
- Combustion optimization
- Safety

Education adopted to also suit the knowledge requirements for boiler operators in the renewed Swedish regulation of pressurized devices

Sodahuskommittén

Certification of recovery boiler operators

Knowledge requirements in the renewed Swedish regulation of pressurized devices (AFS 2017:3):

- Knowledge of the regulation for pressurized devices
- Boiler principles: thermodynamics, superheated steam, phase transitions
- Boiler construction
- Risks during start and stop of boiler
- Monitoring and safety system of boiler
- Emergency situations and how the operator should act
- Properties of steam, water and oil at temperatures exceeding 110C
- Special risks in boilers where heat can be accumulated and how to prevent these risks
- Boiler control system
- Boiler alarms related to safety and critical to safety

	Kategori			
Färdighet eller kunskap	1	2	3	4
Ha kunskaper om kraven för pannor i dessa föreskrifter: – Fortlöpande tillsyn – Pannans livslängd – Kontroll – Övervakning	X	X	X	X
Känna till de grundläggande principerna bakom pannor: termodynamik, överhettning och fasomvandling.	X	X	X	X
Kunna ISO-standardenheter för temperatur, tryck, massa, densitet och energi.	X	X	X	X
Kunna beskriva hur pannan och de huvudkomponenter som är förbundna med pannan fungerar.	X	X	X	X
Ha grundläggande kunskaper om de risker som finns vid start och stopp av en panna.	X	X	X	X
Ha grundläggande kunskaper om de risker som finns med eldning av olika bränslen.	X	X	X	X
Kunna beskriva och förstå en pannas övervakning- och säkerhetsutrustning, varför de finns, hur de fungerar och vilka åtgärder som ska vidtas när de aktiveras.	X	X	X	X
Ha kunskaper om de nödsituationer som kan uppkomma vid användning av pannor och hur en [pann-operatör] ska agera vid dessa nödsituationer.	X	X	X	X
Känna till krav vid ständig och periodisk övervakning.	X	X	X	X
Ha kunskaper om egenskaper hos ånga samt vatten och olja som hanteras över 110°C.	X		X	
Veta vilka särskilda risker som finns vid eldning av pannor där restvärme kan ackumuleras i farlig mängd och hur dessa risker förebyggs.	X	X		
Veta hur de styr- och reglersystem som säkerställer att pannan hålls inom tillåtna värden fungerar.	X	X		
Känna till vad som skiljer säkerhetsrelaterade och säkerhetskritiska larm från övriga larm.	X	X		

Sodahuskommittén

Certification of recovery boiler operators

Phase 1, 4 days	Phase 2, 4 days	Phase 3, 4 days	Phase 4, 4 days
Introduction Introduction to pulp production and chemical recovery Environmental technologies Process- and production economy Project Homework	Process control, phase 1 Energy technology Feed- and boiler water Boiler circulation and steam formation Combustion technology Presentation of project, part	Process control, phase 2 Regulations Safety systems Fuel, hot water and hot oil boilers Material and damages Site visit Presentation of project, part	Process control, phase 3 Critical conditions Operation and operational disturbances Safety aspects of operation, case study Final presentation of project

Sodahuskommittén

Experience sharing day

Operators and other persons from member companies meet and discuss important topics.

2019 the topic was

” Experience of weak gases, strong gases, dissolving tank gases and methanol in the recovery boiler”

- How does it look in our home mills
  - Recent situations, routines, instructions
- Regulations, norms, recommendations
- Discussions

Next Experience sharing day January 2020 on topic:
”**Safe operation of the dissolving tank**”

Recovery Boiler Meeting 2019

…was hosted by SCA Östrand! Participants went on a tour in Östrand mill after the HELIOS expansion project, listened to presentations – and last but not least, new recovery boiler operators received their certificates!

Prioritized projects 2019

Risk Analysis Recovery Boiler (continuation) – SIL classification
Guidelines on risk analysis of recovery boiler incl

- required safety functions in a recovery boiler
- by SNRBC recommended SIL-level (Safety Integrity Level) for each safety function

Projects 2019/2020, Åforsk
- Is high pressure testing relevant after circular welding of boiler tubes or are other test methods needed to identify weaknesses in the welding?

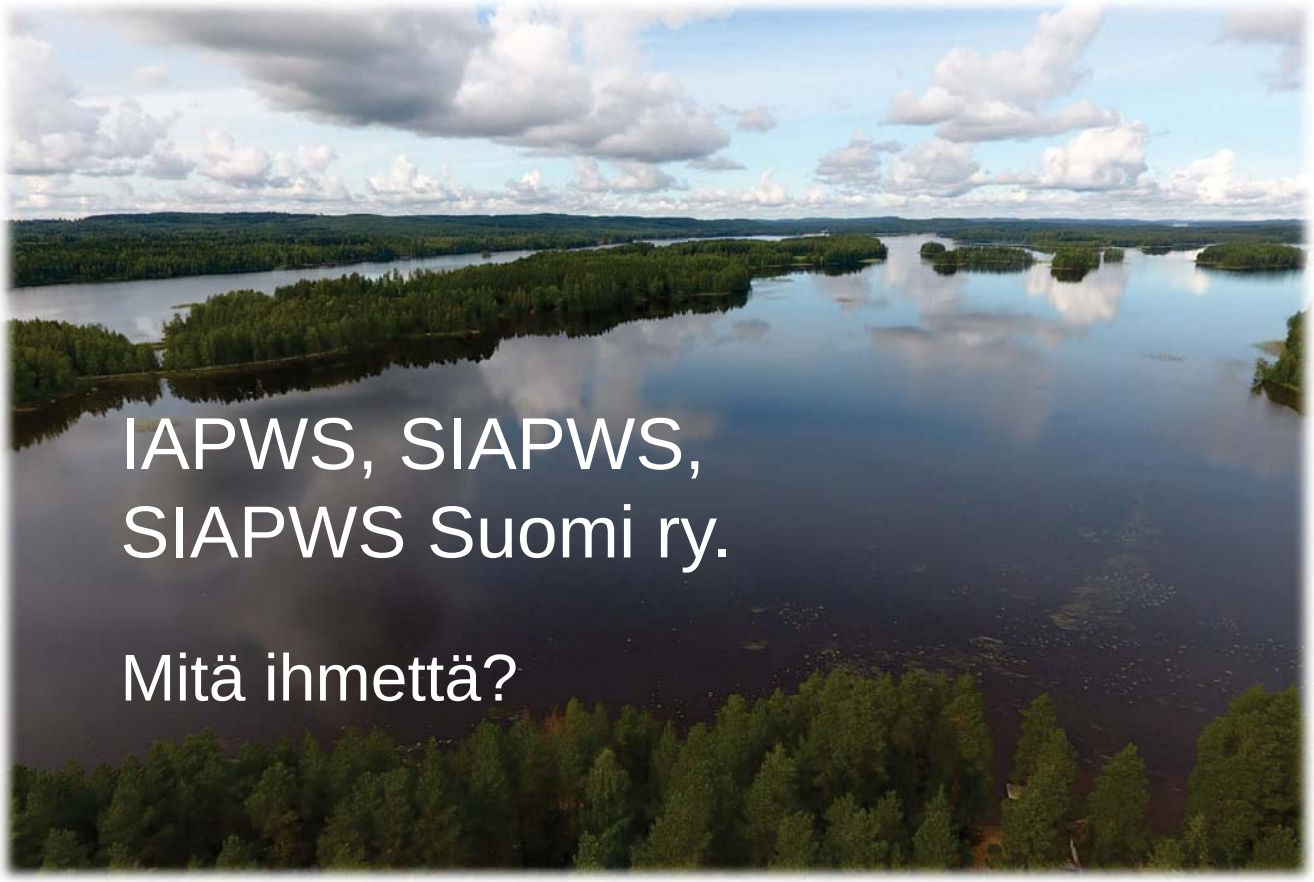
- Smelt runoffs – Analysis of process data from 6 mills

Thank You!

Förbättrar personsäkerheten och
driftsäkerheten för sodahusprocessen

IAPWS (THE INTERNATIONAL ASSOCIATION FOR THE PROPERTIES OF WATER AND STEAM) SUOMEN OSASTON ESITTELY

Arja Lehikoinen
SIAPWS Suomi ry



IAPWS, SIAPWS, SIAPWS Suomi ry.

Mitä ihmettä?

Arja Lehikoinen 18.10.2019
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International Association for the Properties of water and Steam

- IAPWS:n toiminta aloitettiin vuonna 1929 Lontoossa höyry-taulukko-konferenssin yhteydessä. Höyrytaulukko IAPWS IF-97 on nykyisin käytetyn materiaalin pohjana.
  www.iapws.org
- Yhdistyksen tavoitteena on edistää veden, höyryn sekä vesisysteemien ominaisuuksien tuntemusta suunnittelijoiden, käyttäjien ja tiedemiesten keskuudessa maailmanlaajuisesti painopisteen ollessa teollisuuden sovelluksissa.
- Pohjoismainen panos on ollut työryhmässä Power Cycle Chemistry (PCC), joka tuottaa muun muassa vesi-höyry –kierron kemian ohjearvosuosituksia (Technical Guidance Documents).
- Toiminnassa on mukana jäsenyhdistyksiä ympäri maailmaa.

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International Association for the Properties of water and Steam

- Yhdistyksen julkaisemat standardit (Technical Guidance Document, TGD) ovat nettisivuilla kaikkien saatavilla
- http://www.iapws.org/techguide.html

IAPWS Technical Guidance Documents:
Cycle Chemistry Guidelines for Fossil and Combined Cycle Plants

Cycle chemistry guidelines in the form of Technical Guidance Documents have been developed by IAPWS to provide truly international cycle chemistry guidance for fossil and combined cycle plants. They represent the accumulated experience of members of the IAPWS Power Cycle Chemistry (PCC) Working Group with expertise from 21 countries.

All current IAPWS Technical Guidance Documents are listed and described below and are downloadable as PDF files.

Identifier	Title	Year of last revision	Description
TGD11-19	Application of Film Forming Substances in Industrial Steam Generators	2019	Guidelines and Processes for the application of film forming substances (FFS) in industrial steam generation.
TGD10-19	Chemistry Management in Generator Water Cooling during Operation and Shutdown	2019	Guidelines for cooling water chemistry during operation and layup for water-cooled generators.
TGD9-18	Air In-leakage in Steam-Water Cycles	2018	Guidelines on the detection and measurement of air in-leakage (AIL) in reference to the optimum cycle chemistry control and maximum thermal cycle efficiency in a wide range of generating plants. Contains special guidance on how plant operators can recognize and control AIL.
TGD8-16(2019)	Application of Film Forming Substances in Fossil, Combined Cycle, and Biomass Power Plants	2019	Cycle Chemistry Guidelines and Processes for the application of film forming amines (FFA) and Film Forming Amine Products (FFAP) in fossil and combined cycle / HRSG power plants.
TGD7-16	HRSG High Pressure Evaporator Sampling for Internal Deposit Identification and Determining the Need to Chemical Clean	2016	Cycle Chemistry Guidance and Processes for sampling and analyzing the internal deposits on HRSG high pressure (HP) evaporator tubing. New guidance is included on assessing whether an HRSG needs chemical cleaning to avoid under-deposit corrosion.
TGD6-13(2014)	Corrosion Product Sampling and Analysis for Fossil and Combined Cycle Plants	2013	Cycle Chemistry Guidelines on sampling and analysis for the monitoring of iron and copper corrosion products in the steam and water cycles of fossil and combined cycle / HRSG power plants. Key sampling locations and achievable levels are provided.

Arja Lehikoinen 18.10.2019
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SIAPWS Suomi ry.

- Suomi kuuluu IAPWS:ään pohjoismaisen jäsenyhdistyksen kautta
  - SIAPWS = Scandinavian IAPWS
- Jokaisesta jäsenistöön kuuluvasta pohjoismaasta valitaan vuosikokouksessa kaksi edustajaa SIAPWS:n hallitukseen
  - Suomesta Arja Lehikoinen ja Jere Espo
- Keväällä 2018 SIAPWS hallitus päätti järjestää SIAPWS:n toiminnan maakohtaisesti, jotta kyettäisiin järjestämään toimintaa kussakin maassa lähellä jäsenistöä helposti saavutettavissa olevalla tavalla, myös kunkin maan omalla kielellä.
- Vuoden 2018 marraskuussa järjestettiin SIAPWS Suomen perustamiskokous
- Myös Tanskaan perustettiin samaan aikaan SIAPWS Danmark
- Ruotsissa on toiminut jo pitkään Matarvattensektionen, joka on nyt SIAPWS:n jäsen, ”SIAPWS Ruotsi”

Arja Lehikoinen 18.10.2019
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SIAPWS Suomi ry.

SIAPWS visio

Vesikemia-alan koulutuksen tarjoaminen
- teemapäivät
- työpajat
- online-kurssit

Kotimaisten kokemustenvaihtotapaamisten järjestäminen

SIAPWS-seminaarien järjestäminen

Tietojenvaihdon mahdollistaminen energia- ja tutkimussektorin välillä

Kaupallisesti riippumaton toimija

Osallistuminen kansainvälisen IAPWS:n toimintaan
- tutkimus ja kehitys
- ohjearvot
- kokemustenvaihto

Pohjoismaisen vesikemiaverkoston luominen
- yhteistyö ja kokemustenvaihto pohjoismaiden energiasektorin sisällä

Suomalaisen vesikemia- ja vedenkäsittelyverkoston luominen
- yhteistyö ja kokemustenvaihto kotimaassa
- alusta kansainväliselle yhteistyölle

Arja Lehikoinen 18.10.2019
arja.lehikoinen@valmet.com

SIAPWS Suomi ry.

Hallituksen jäsenet

- Arja Lehikoinen, Valmet (puheenjohtaja)
- Jere Espo, Maintpartner (varapuheenjohtaja)
- Jani Vuorinen, Vesi-Ihminen (rahastonhoitaja)
- Susanna Vähäsarja, Elomatic (sihteeri)
- Nuutti Lehtikuja, Teollisuuden Vesi (tiedotusvastaava)
- Martti Ikonen, Endress+Hauser (jäsen)
- Mira Ketola, Tampereen Sähkölaitos (varajäsen)
- Salla Paajanen, Metrohm Nordic (varajäsen)
- Sami Huhtiniemi, Solenis (varajäsen)

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SIAPWS Suomi ry.

Jäseniä noin 30 yritystä tai henkilöjäsentä

Suomessa tähän mennessä järjestettyä toimintaa:

- Perustamiskokous Suomenojan voimalaitoksella 11/18, laitoskäynti
  - Yhdistyksen rekisteröinti
- 1. vuosikokous 02/19 Riihimäellä Fortumilla, esitelmä + laitoskäynti
- Pohjoismainen SIAPWS-vuosikokous 03/19 Helsingissä, seminaari + illallinen + laitoskäynti Vantaan hyötyvoimalaitoksella
- Opintokäynti Endress+Hauserilla 09/19 Tampereella + laitoskäynti Viinikanlahden jätevedenpuhdistamolla
- LinkedIn-ryhmä SIAPWS Suomi -jäsenet

Arja Lehikoinen 18.10.2019
arja.lehikoinen@valmet.com

SIAPWS Suomi ry.

Suomessa tulevaa toimintaa 2020:

- 2. vuosikokous 2/20, seminaari + mahd. laitoskäynti
- Opintokäynti
- Nettisivut
- Jäsenkysely
- Koulutuksia
- ….?

Arja Lehikoinen 18.10.2019
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SIAPWS Suomi ry.

Kansainvälistä toimintaa:

- IAPWS vuosikokous Banffissa Kanadassa 10/20, työryhmien kokoukset + seminaari
- Osallistuminen standardien (TGD) laadintaan ja päivittämiseen
  - Savukaasulauhteenkäsittely
  - Demilaitokset
  - Älykkäät hälytykset
- Matarvattenkonferensen Tukholmassa 11/20
- SIAPWS vuosikokous Kööpenhaminassa 03/20 (1½ päivää) , seminaari + laitoskäynti
- IAPWS vuosikokous Torinossa 09/20, työryhmien kokoukset + seminaari

Arja Lehikoinen 18.10.2019
arja.lehikoinen@valmet.com

SIAPWS Suomi ry.

Yhdistyksen toiminnan tarkoituksena on

- järjestää toimintaa mahdollisimman edullisesti kotimaisilla kielillä
- toimia alustana kansainväliselle yhteistyölle

Vuoden 2019 jäsenmaksut olivat:

Jäsenmaksuluokat	Henkilömäärä	Liikevaihto	Osallistujat	Jäsenmaksu €
1. Henkilöjäsen	1		vain jäsen	60
2. Pieni yritys tai yhdistys tai instituutio	≤ 50	< 10 M€	max 3	300
3. Suuri yritys	>50	> 10 M€	ei rajoitusta	600
4. Kannatusjäsen				2000

Lisätietoja voi kysellä ja jäsenyyttä hakea lähettämällä sähköpostia

- Puheenjohtajalle arja.lehikoinen@valmet.com tai
- Rahastonhoitajalle jani.vuorinen@vesi-ihminen.fi

Arja Lehikoinen 18.10.2019
arja.lehikoinen@valmet.com

YHDISTYKSEN OPINNÄYTETYÖPALKINNON ESITTELY: RECOVERY BOILER SUPERHEATER REGION TEMPERATURE MEASUREMENTS FOR FOULING PREDICTION DEVELOPMENT

Santeri Peltola
Tampereen yliopisto / Valmet Technologies Oy

RECOVERY BOILER SUPERHEATER REGION TEMPERATURE MEASUREMENTS FOR FOULING PREDICTION DEVELOPMENT

SANTERI PELTOLA

Soodakattilapäivät 31.10.2019

SISÄLTÖ

1. Hankkeen taustaa ja tavoitteet
2. Mittalaitteet
3. Mittauskampanja
4. Kerätty aineisto
5. Analyysi
6. Tulokset
7. Johtopäätökset

1. HANKKEEN TAUSTAA JA TAVOITTEET

1. HANKKEEN TAUSTAA JA TAVOITTEET

Diplomityöhankkeeseen osallistuneet

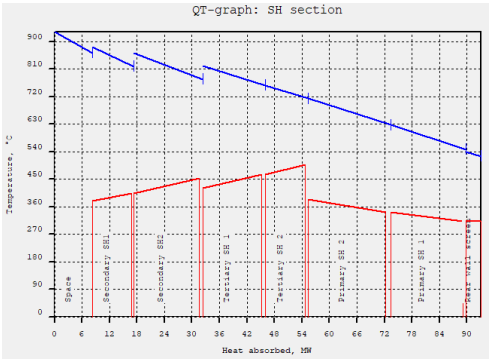
- Diplomityön tekijä
- Diplomityön ohjaaja Valmetilla: Jarmo Mansikkasalo
- Diplomityön ohjaaja TTY:llä: Henrik Tolvanen
- Hankkeen kannalta keskeisiä muita henkilöitä
  - Mike Anna (akustinen pyrometri)
  - Tarmo Toivonen (mittalaitteet, mittauskampanjan suunnittelu)
  - Aino Vettenranta (akateeminen ohjaus)

RECOVERY BOILER SUPERHEATER REGION TEMPERATURE MEASUREMENTS FOR FOULING PREDICTION DEVELOPMENT, SOODAKATTILAPÄIVÄT 31.10.2019

1. HANKKEEN TAUSTAA JA TAVOITTEET

Lähtötilanne (1/2)

- Soodakattilan tulistinalueen savukaasujen lämpötilakenttä ei ole tarkasti tiedossa
  - Ei jatkuvatoimisia mittauksia
  - Arvioidaan kattilamitoitus- ja CFD-mallinnustyökaluilla
  - Mittakampanjat

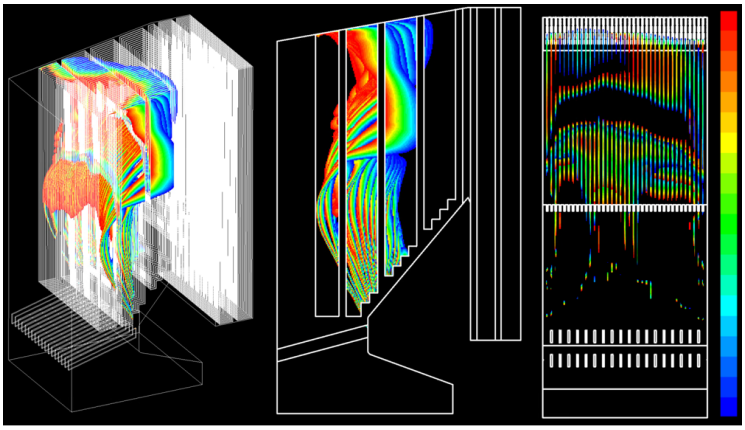


Aineisto: Valmet Technologies

1. HANKKEEN TAUSTAA JA TAVOITTEET

Lähtötilanne (2/2)

- Lämpötila vaikuttaa
  - Tuhkan sulamiskäyttäytymiseen
  - Tulistinalueen suunnitteluun ja mitoitukseen



Isometric View Side View Rear View

1. HANKKEEN TAUSTAA JA TAVOITTEET

Tavoitteet

- Kerätä tarkkaa lämpötiladataa
  - Määritellä moniulotteinen lämpötilakenttä
  - Likaantumiskertoimien tarkastaminen laskentatyökaluissa
  - Suovanpolton vaikutus savukaasujen lämpötilaan
- Akustisen pyrometrin ensimmäinen referenssi soodakattilassa
- Lisätä ymmärrystä savukaasuvirtauksen luonteesta
  - Pyörteet
  - Nuohoimien vaikutus

2. MITTALAITTEET

2. MITTALAITTEET

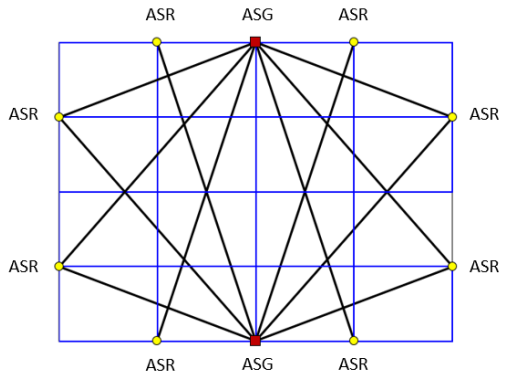
Mittalaitteet – termoelementti ja imupyrometri

- Yksinkertaisia mittausmenetelmiä
- Paikallinen mittaus seinän vierestä
- Ei kerro kattilan keskiosien lämpötilaa
- Riippuvainen savukaasuvirtauksen heilahteluista
  - Pyörteet ja heilahtelut
  - Nuohoimet

2. MITTALAITTEET

Mittalaitteet – akustinen pyrometri

- Uusi mittausmenetelmä soodakattilassa
- Äänennopeus on riippuvainen väliaineen lämpötilasta
- Akustinen lähetin (ASG) tuottaa ääniaallon
- Vastaanotin (ASR) mittaa läpäisyajan ja laskee keskiarvolämpötilan äänisignaalin reitille
- Kaksiulotteinen lämpötilamatriisi
- Jatkuva-aikasta mittaustietoa
- Tässä diplomityöhankkeessa asennettiin 1 lähetin ja 3 vastaanotinta
  - Matriisia ei tässä työssä rakennettu

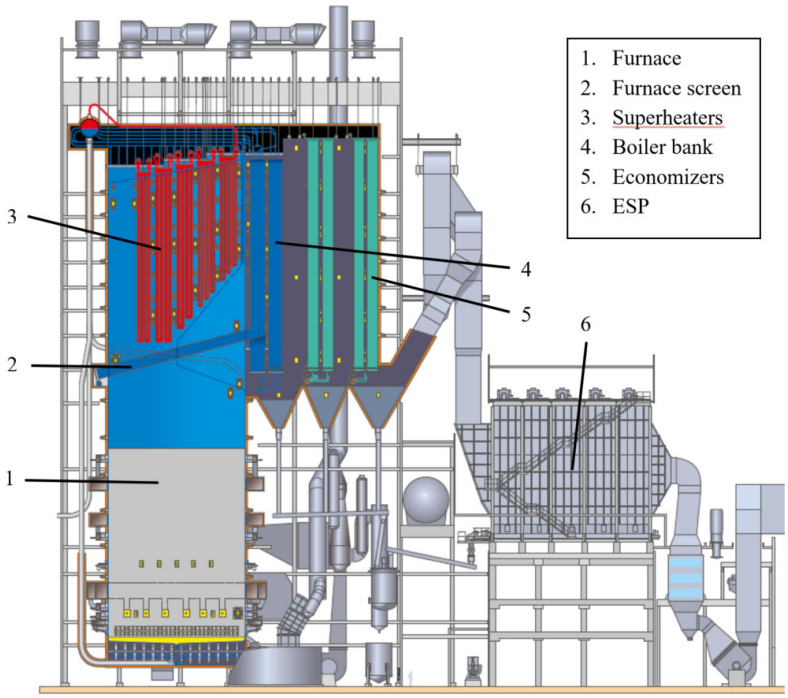


3. MITTAUSKAMPANJA

3. MITTAUSKAMPANJA

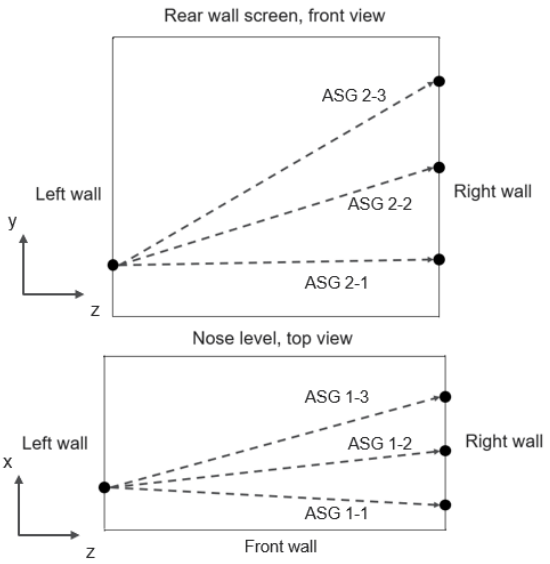
Yleiskuva

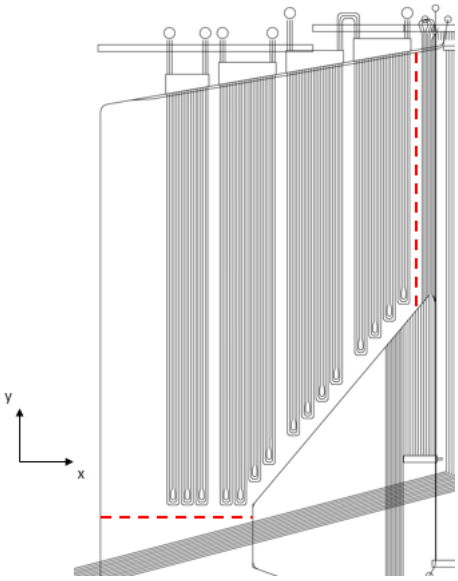
- Perinteiset mittausmenetelmät
  - Termoelementti
  - Imupyrometri
- Akustinen pyrometri



3. MITTAUSKAMPANJA

Mittauspaikat – akustinen pyrometri



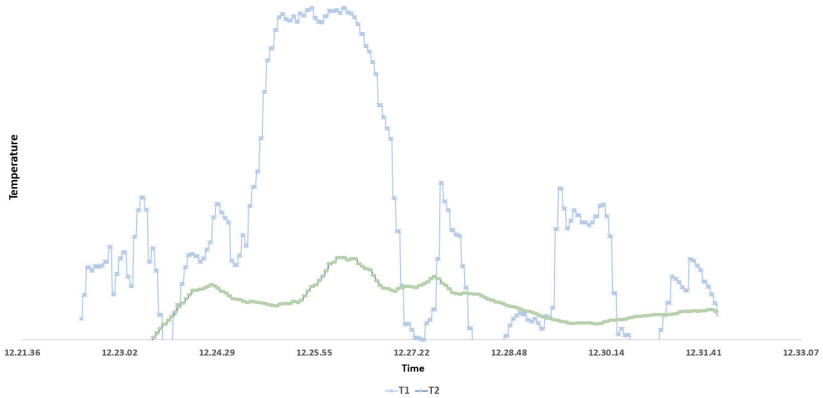


4. KERÄTTY AINEISTO

4. KERÄTTY AINEISTO

Aineiston tulkintaa

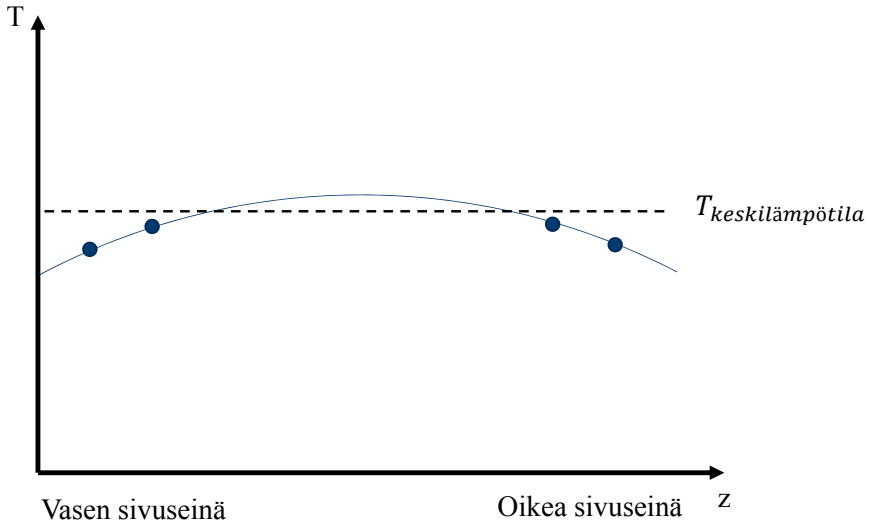
- Termoelementti- ja imupyrometrilukemissa suurta heiluntaa
- Termoelementin kesto rajoittaa mittausaikaa
- Rajallinen mittaushenkilöstön määrä rajoittaa yhdellä kertaa mitattavien pisteiden määrää
- Lämpötilan määrittelyssä käytettiin keskiarvoistusta
- Lämpötilahuippuja yhdistettiin nuohoimien toimintaan



5. ANALYYSI

5. ANALYYSI

Lämpötilajakauma sivuseinältä sivuseinälle

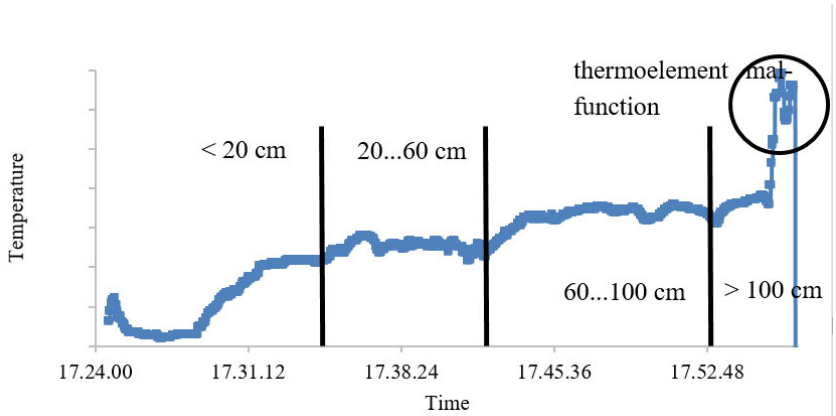


- Pisteet: mitattuja lämpötilapisteitä
- Katkoviiva: akustisen pyrometrin mittaama keskilämpötila

5. ANALYYSI

Rajakerroksen lämpötila

- Savukaasuvirtauksen rajakerrosta mitattiin termoelementillä
  - Vähän toistoja
  - Ei yksiselitteisiä havaintoja



5. ANALYYSI

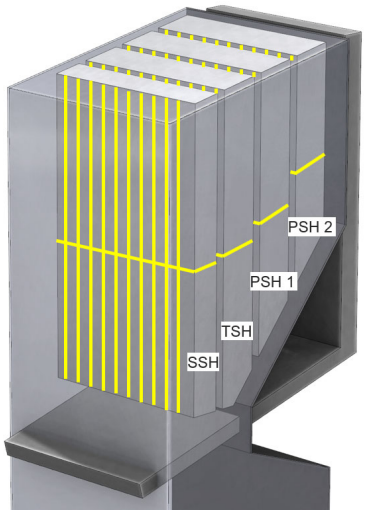
Mitoitustyökalu ja CFD-mallinnus

- Mitatut lämpötilat syötettiin mitoitus- ja CFD-mallinnustyökaluihin
- Mitoitustyökalussa takaperinlaskenta
  - Likakertoimien vertailu vakiintuneisiin arvoihin
- CFD-mallinnuksessa määriteltiin mallin likakertoimet
  - Uutta tietoa CFD-mallinnukseen
- Herkkyystarkastelu
- Keskinäinen vertailu menetelmien välillä

5. ANALYYSI

Excel-laskenta tulistimien likaantumisesta

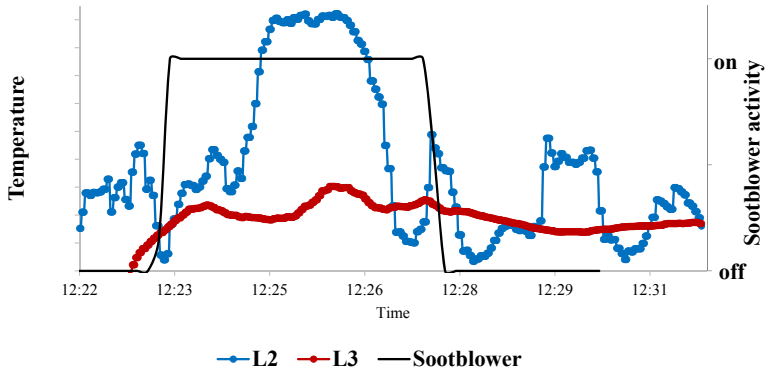
- Laskenta tulistimien likakerroksen paksuudesta
  - Lämpötilajakaumat lähtötietoina
  - Laskenta perustuu lämmönsiirron teoriaan
  - Tuloksena kaksiulotteinen kerrostumajakauma jokaiselle tulistimelle
- Herkkyystarkastelu
- Vertailu mitoitustyökalun ja CFD-mallinnuksen tuloksiin



5. ANALYYSI

Kriittinen nuohoin - vaikutus savukaasun lämpötilaan

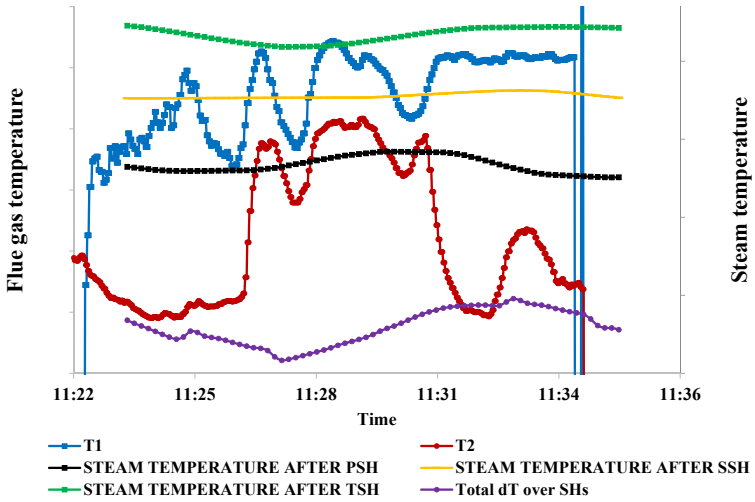
- Kriittiset nuohoimet vaikuttavat savukaasun lämpötilaan merkittävästi
  - Jäähdyttävää vaikutusta ei havaittu
  - Lämpötilaa nostava vaikutus oli selkeä



5. ANALYYSI

Kriittinen nuohoin - vaikutus höyryn lämpötilaan

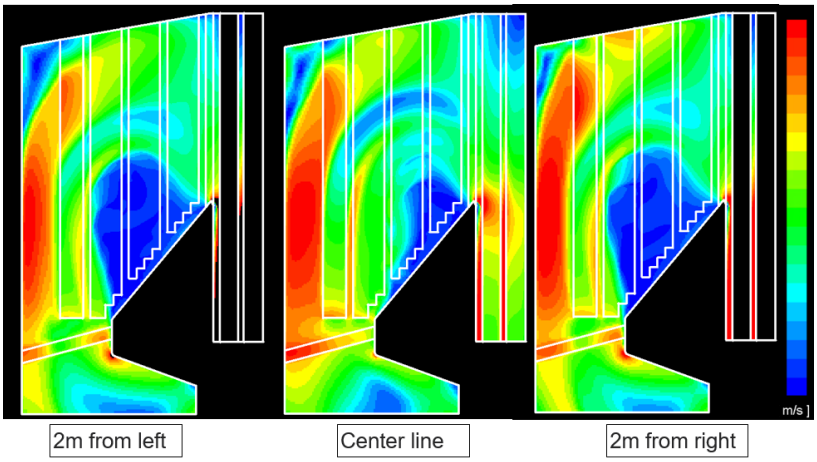
- Nuohoimet nostavat myös tulistetun höyryn lämpötilaa



5. ANALYYSI

Kriittinen nuohoin – miksi kriittiset nuohoimet parantavat lämmönsiirtoa

- Savukaasuvirtauksessa on häiriöitä
  - Pyörteet
  - Virtauksen kanavoituminen
  - Epäsymmetrisyys
- Kriittinen nuohoin voi rikkoa savukaasupyörteen
  - Kylmä alue savukaasuissa häviää
  - Lämmönsiirto paranee



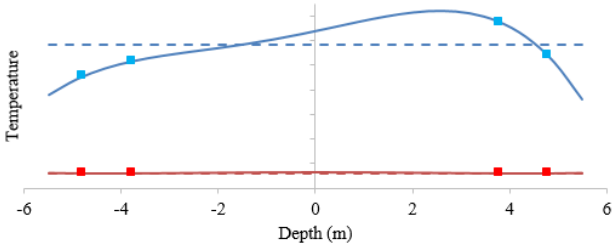
Tyypillinen savukaasujen virtauskenttä

6. TULOKSET

6. TULOKSET

Lämpötilajakauma sivuseinältä sivuseinälle

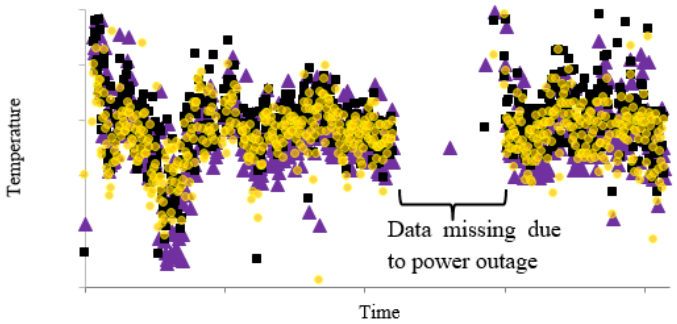
- Akustisen pyrometrin lukemat ja pistemittaukset yhteneväisiä
- Mittauksiin perustuva laskennallinen lämpötilajakauma uskottava
  - Yhteneväisyys CFD-mallinnuksen kanssa kohtuullinen
- Tulokset korostavat savukaasujen lämpötilakentän epäsymmetrisyyttä
- Lämpötilaero seinän ja savukaasujen välillä vähenee tulistinalueen ulosmenoa kohti



6. TULOKSET

Akustinen pyrometri

- Akustisen pyrometrin tarkkuus oli hyvä
- Mittausaineiston yhtenäisyys oli hyvä
- Laitteiston luotettavuus ja aukipysyvyys olivat hyvät



6. TULOKSET

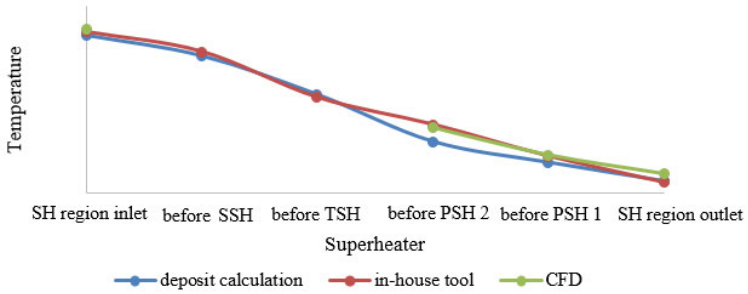
Suovanpolton vaikutus savukaasujen lämpötilaan

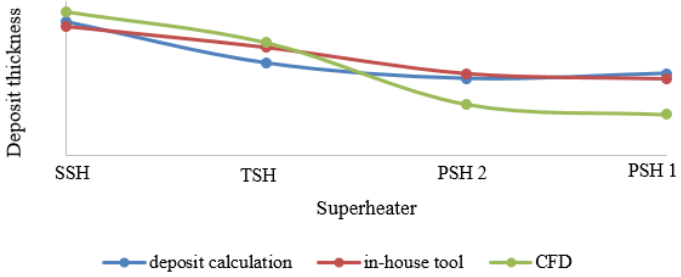
- Savukaasujen lämpötilaheilahtelut suuria
- Suovan määrä oli matala
  - Noin 1 % mustalipeän lämpömäärästä
- Suovan vaikutusta ei kyetty tunnistamaan

6. TULOKSET

Laskentamenetelmät

- Menetelmät
  - Kirjoittajan Excel-laskenta
  - Taselaskentaan perustuva kattilamitoitustyökalu
  - CFD-mallinnus
- Mitattu ja mallinnettu savukaasun lämpötila
- Mallinnettu tulistimien likaantuminen





7. YHTEENVETO

7. YHTEENVETO

- Kampanjan aikana kerättiin aiempaa tarkempaa lämpötilatietoa
  - Akustisella pyrometrillä täysin uutta mittaustietoa
  - Perinteisten mittausmenetelmien epätarkkuus ja ajasta riippuvuus korostui
- Kerättyä tietoa pystyttiin hyödyntämään etenkin CFD-mallinnuksessa
  - Mallinnuksen ongelmana on kuitenkin rajallinen likaantumisen resoluutio
- Akustinen pyrometri osoitettiin toimivaksi, tarkaksi ja luotettavaksi
- Kriittisten nuohointen vaikutus savukaasujen virtauskenttään ja tulistukseen
  - Hypoteesi esitetty ilmiön selittämiseksi
  - Mittausaineistoa kerätty hypoteesin tueksi

Tämän diplomityöhankkeen myötä ymmärrys soodakattilan tulistinalueen lämpötilakentästä on edistynyt.

Kuvat ja lähde

Recovery Boiler Superheater Region Temperature Measurements for Fouling Prediction Development, Santeri Peltola, Tampereen Teknillinen yliopisto, 2019

KIITOS

YHDISTYKSEN OPINNÄYTETYÖPALKINNON ESITTELY: INTEGRATED COMPUTATIONAL FLUID DYNAMICS AND 1D PROCESS MODELLING FOR SUPERHEATER REGION IN RECOVERY BOILER

Kunal Kumar
Aalto-yliopisto / Andritz Oy

ANDRITZ GROUP

INTEGRATED COMPUTATIONAL FLUID DYNAMICS AND 1D PROCESS MODELLING FOR SUPERHEATER REGION IN RECOVERY BOILER

KUNAL KUMAR

OCTOBER 31ST, 2019

ANDRITZ

ENGINEERED SUCCESS

CHAPTER OVERVIEW

01 INTRODUCTION

02 MOTIVATION

03 MODELLING APPROACH

04 INTEGRATED CFD/1D-PM SIMULATIONS

05 RESULTS AND DISCUSSION

06 CONCLUSIONS

07

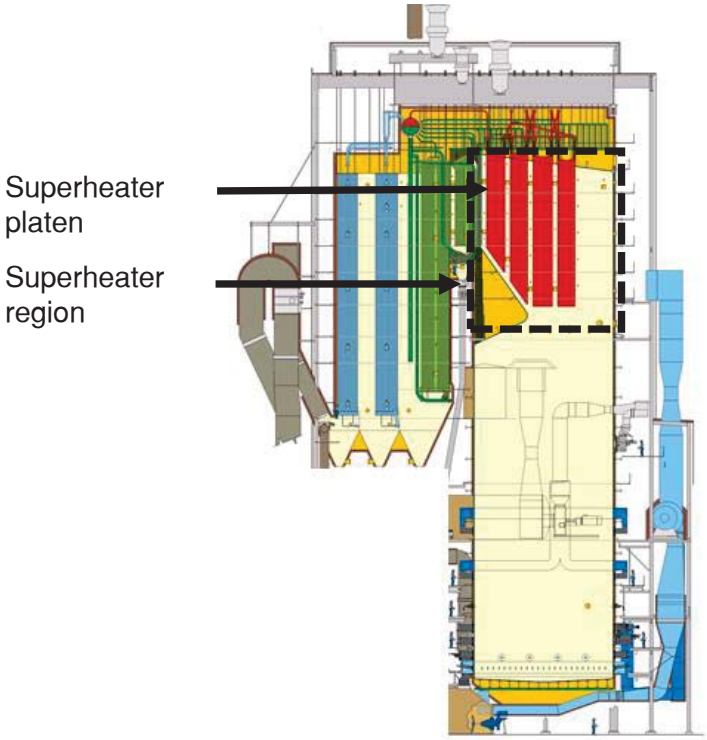
08

09

10

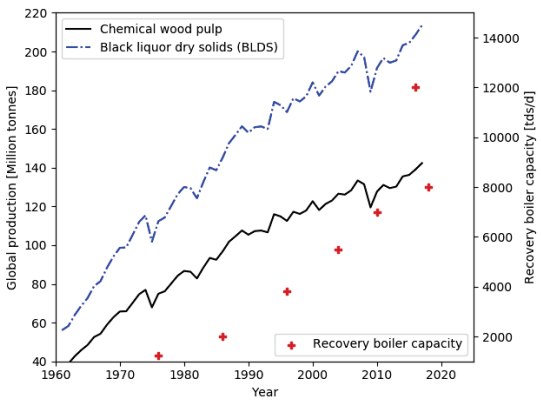
INTRODUCTION

- **Superheater region** is the focus of this work. They are the key components and capture around 30% heat from hot flue gas.
- **In Finland**, in 2017, approximately 8% of total electricity and 18% of total renewable electricity were generated using black liquor combustion in recovery boilers. (Statistics Finland, 2018)



MOTIVATION

- **Continuous** increment in black liquor dry solids production.
- **Increase** recovery boiler´s availability to support continuous pulp production.
- **Obtain** detailed knowledge about :-
  a) Platen-wise superheated steam distribution. It has not been done before.
  b) Platen-wise superheater material temperature distribution.
- **Unlike** fossil fuel boilers or BFB boilers, detailed analysis of recovery boiler's superheater region is explored less.
- **Improve** future design, safety, energy efficiency and cost efficiency of recovery boilers.



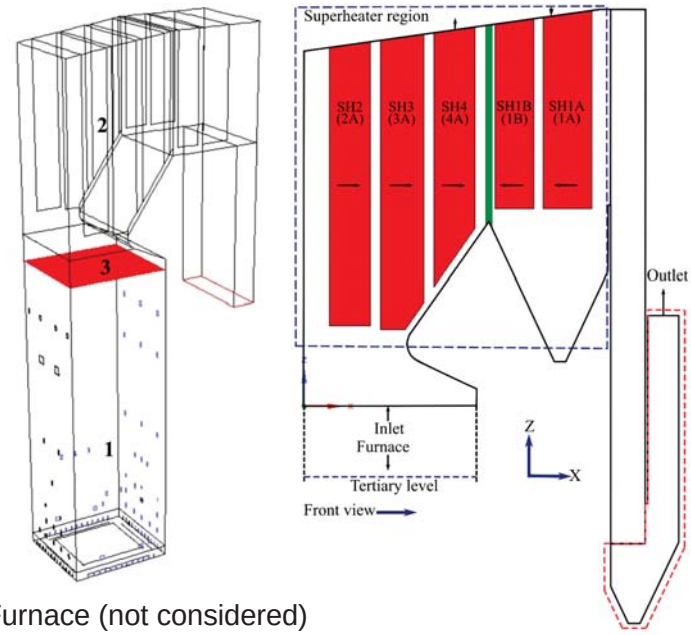
Chemical wood pulp data is taken from Food and Agricultural Organization of United Nations (FAO)

MODELLING APPROACH

Description of the case

Main operating parameters

Parameters	Values
Boiler type	Kraft recovery boiler
Black liquor capacity, tds/d	1000
Black liquor HHV, MJ/(kgds)	15
BLDS, %	74
Main steam flow, kg/s	49
Main steam temperature, °C	505
Main steam pressure, bar	110

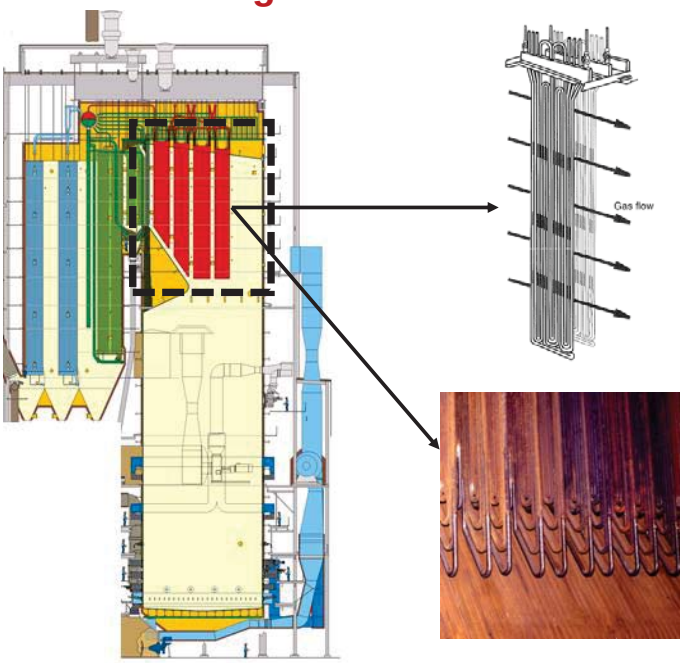


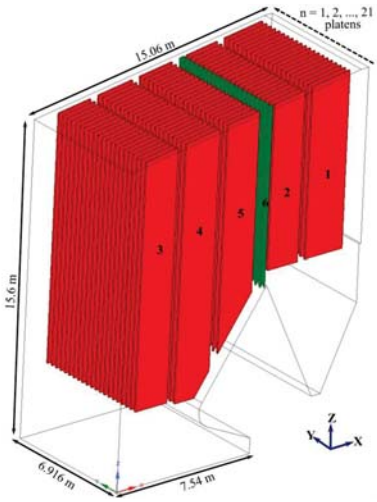
Reference Data: Mass and energy balance calculations, and measurement. It is based on 80% of boiler capacity.

1. Furnace (not considered)
2. Superheater region
3. Inlet for the present work

MODELLING APPROACH

CFD side: Flue gas- CAD Model

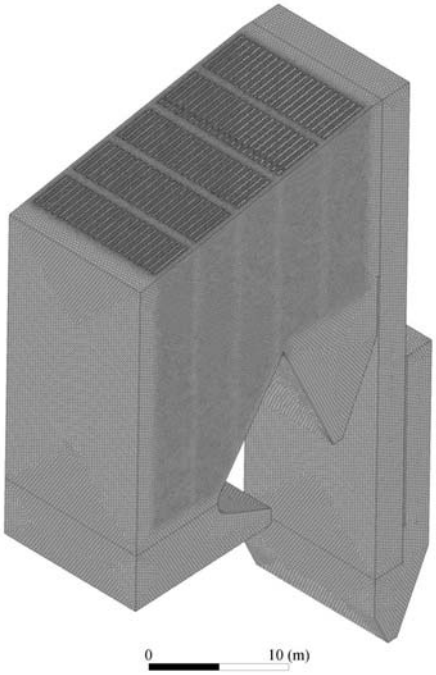


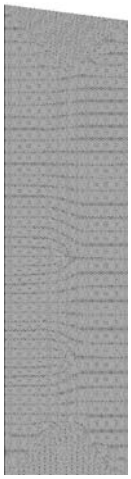


Developed CAD model, where all platens are considered as flat plates. For platen-wise steam flow, a 1D-process model (1D-PM) has been developed.

MODELLING APPROACH

CFD side: Flue gas- Meshing



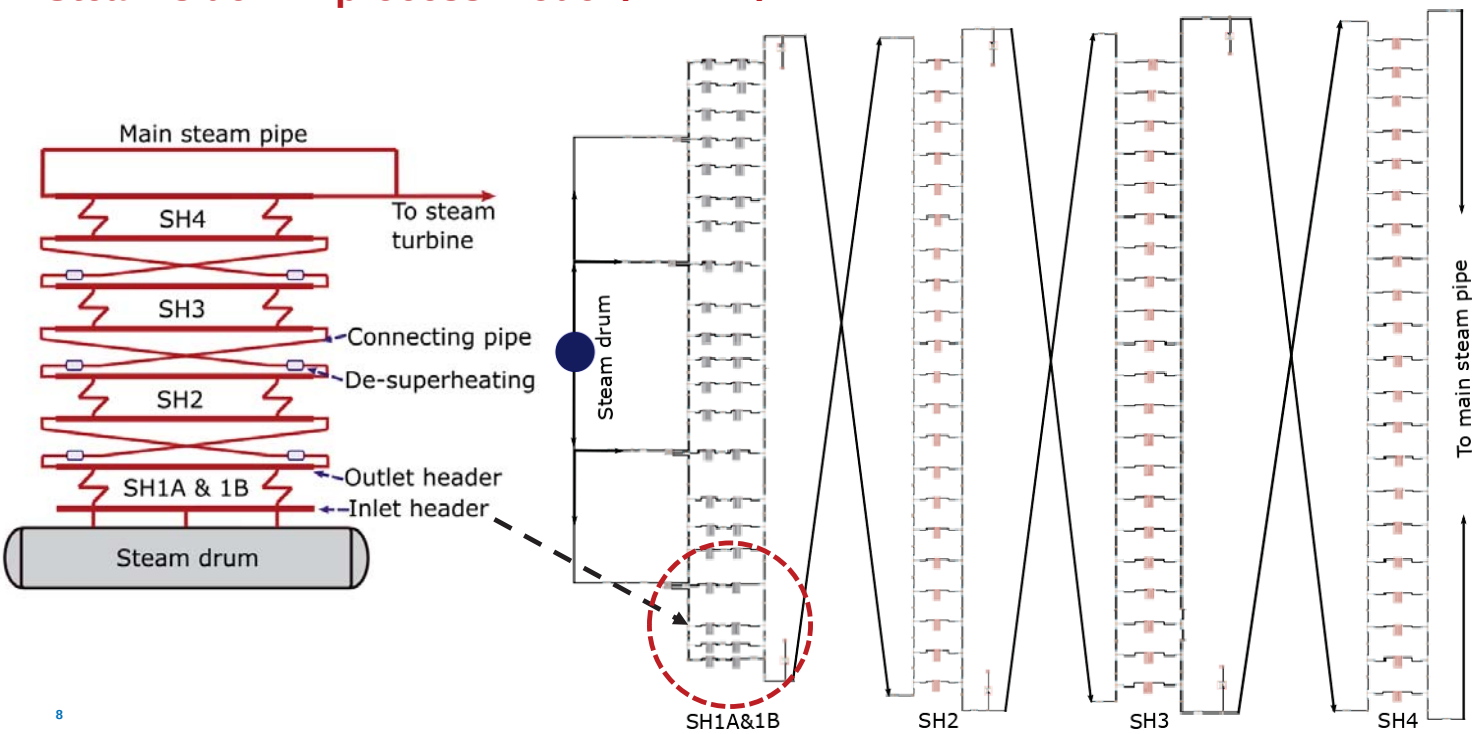


Meshed platen wall

- **Meshed** with **Polyhedral** meshing approach, which is an unstructured meshing method.
- **Total** number of Polyhedral cells- **13M**.
- **Mesh** quality is measured with various methods.

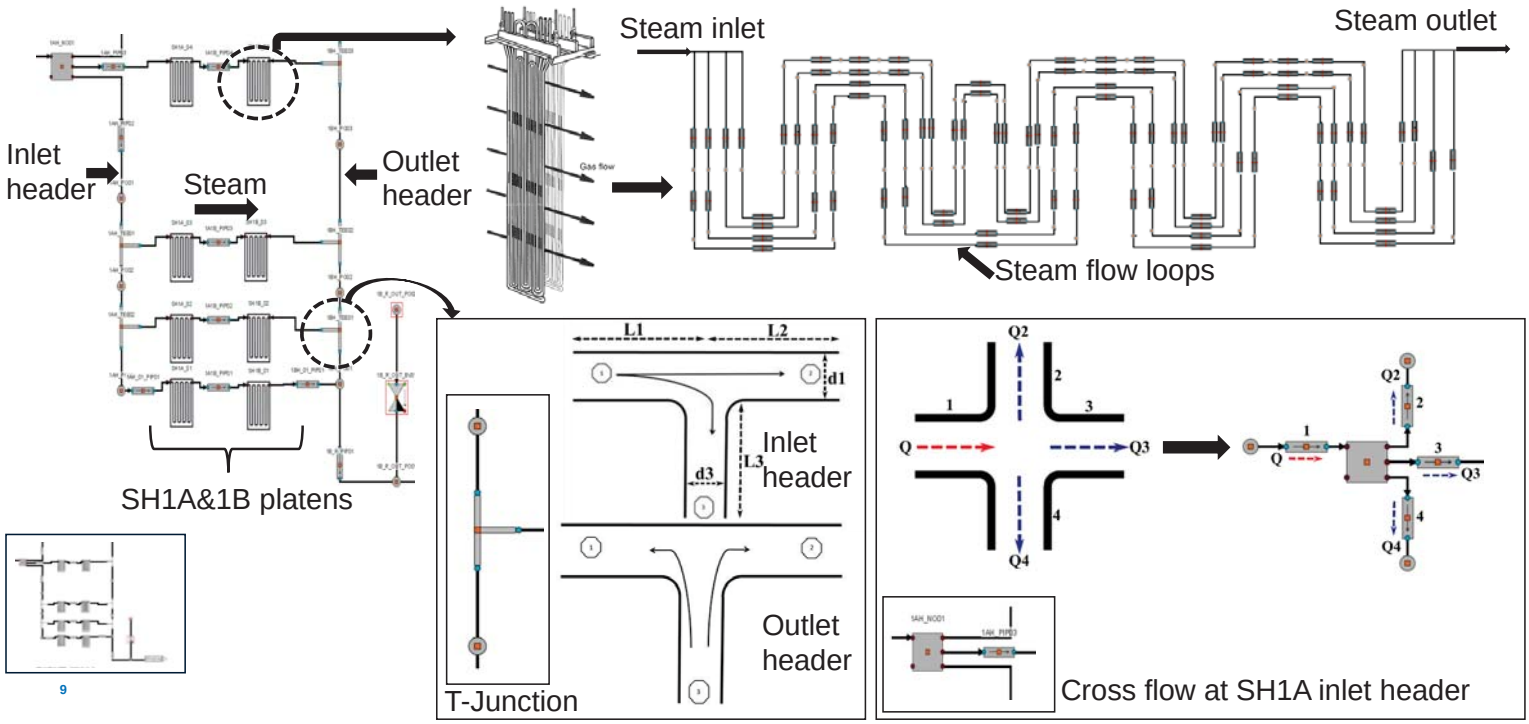
MODELLING APPROACH

Steam side: 1D-process model (1D-PM)

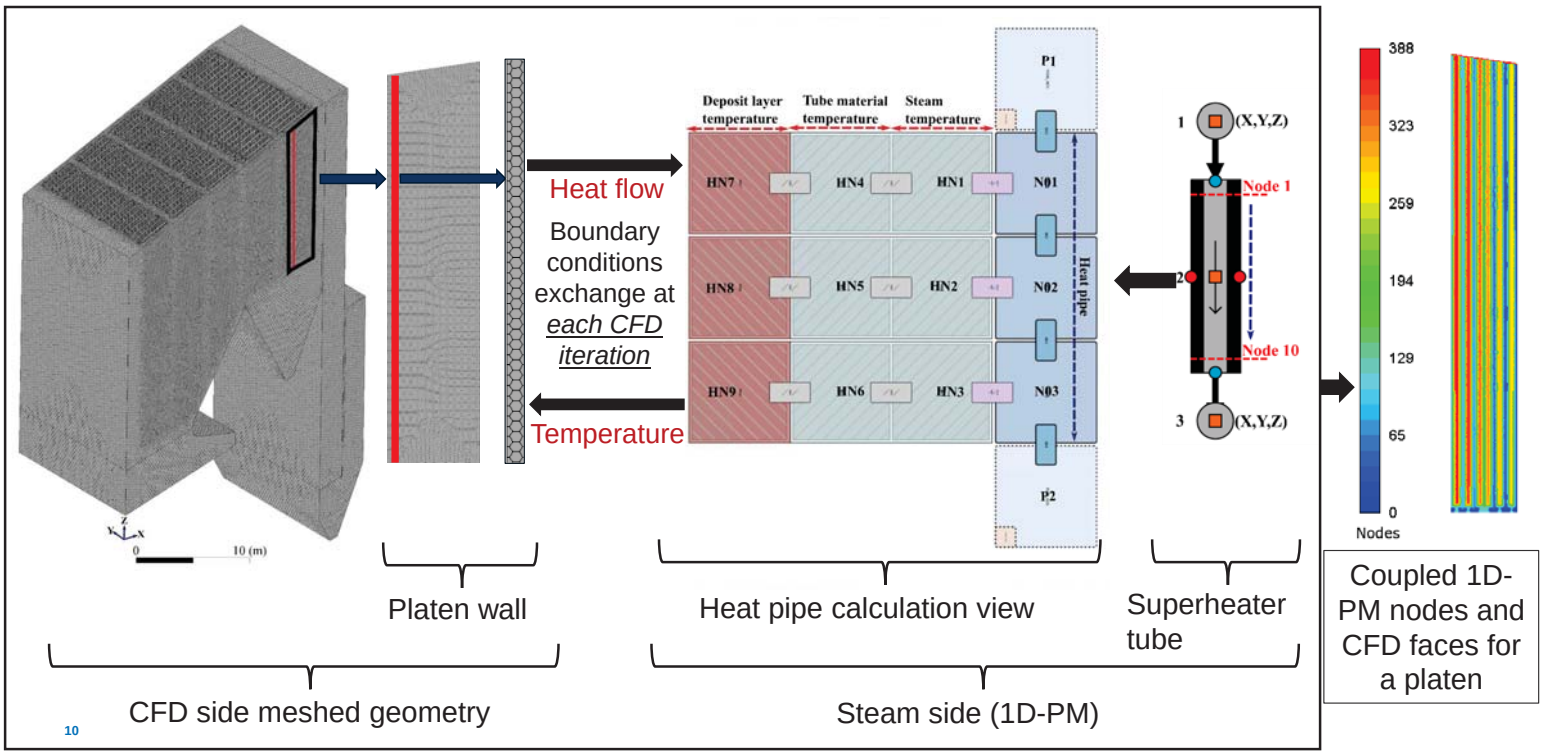


MODELLING APPROACH

Steam side: 1D-PM



INTEGRATED CFD/1D-PM SIMULATIONS



INTEGRATED CFD/1D-PM SIMULATIONS

Methods and boundary conditions

- **Integrated modelling approach solves:**
  - a) Turbulence and radiation.
  - b) Flue gas species transport.
  - c) Heat transfer.
  - d) Thermal-hydraulics of superheated steam.
- **Flow boundary conditions:**
  - a) CFD side (Flue gas): Taken from previously performed furnace CFD simulation.
  - b) Steam side (1D-PM): Based on Reference Data.

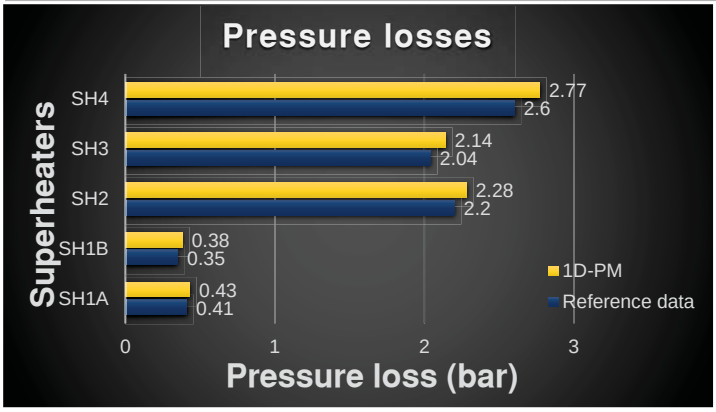
RESULTS AND DISCUSSION

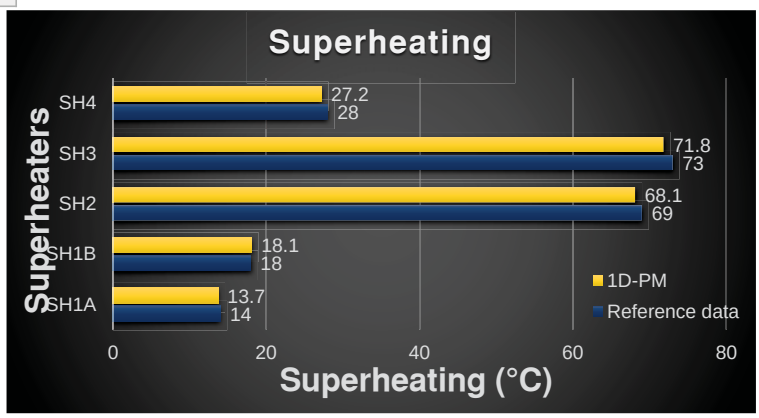
1D-PM validation with Reference Data

Main steam values

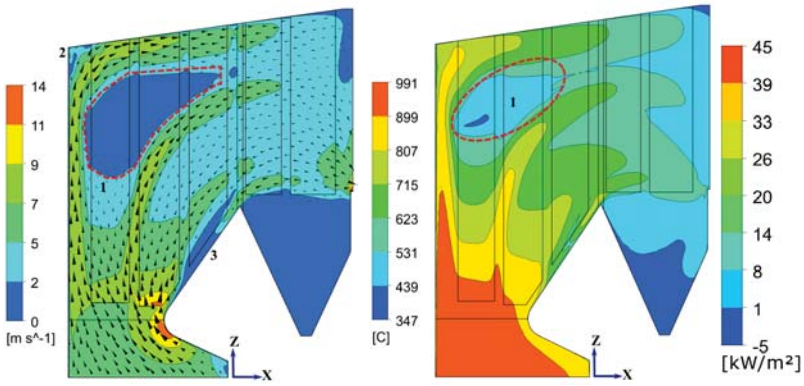
	Reference Data	1D-PM	Error (%)
P, bar	111.9	110.29	1.4
T, °C	506	501.3	1.0
ṁ, kg/s	38.2	38.2	0

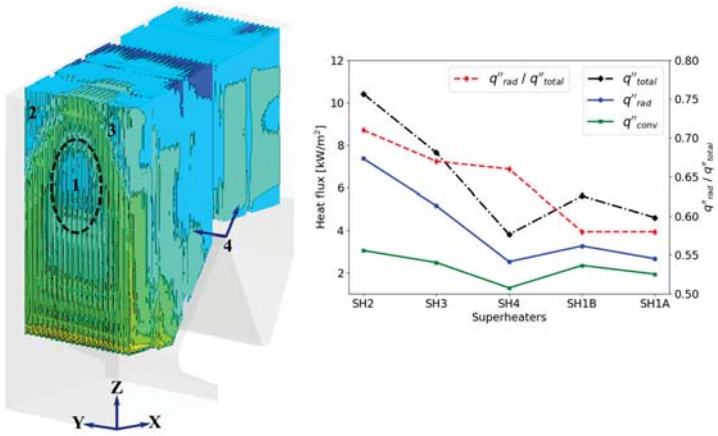
- Uniform platen-wise heat flux distribution is applied, which is based on Reference Data.





RESULTS AND DISCUSSION
Integrated simulations: Flue gas side





Flue gas flow and temperature fields in the middle of the boiler.

Heat transfer to superheaters.

1- Large recirculation zone
2&3- Small vortices

Non-uniform flue gas flow field, because of

1. Partial boiler load (80%).
2. Non-uniform inlet boundary conditions.

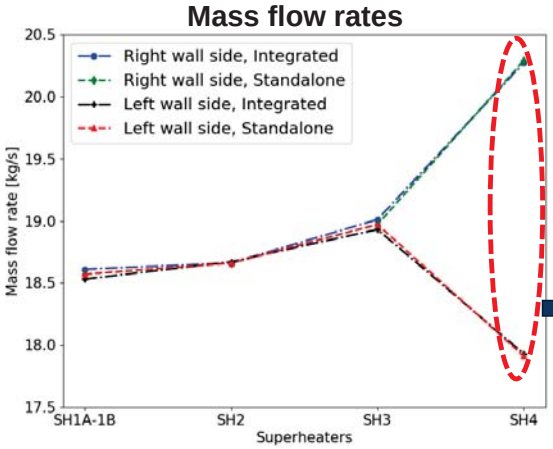
RESULTS AND DISCUSSION
Integrated simulations: Steam side
Main steam values

Main steam values

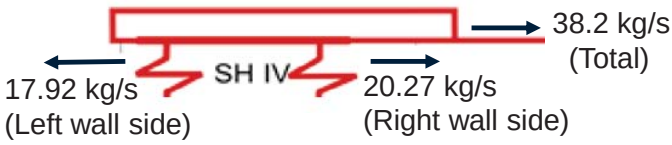
	Integrated	Standalone 1D-PM
P, bar	110.17	110.24
T, °C	504	504.1
ṁ, kg/s	38.2	38.2

Heat Flux for **Standalone 1D-PM** approach is taken from integrated simulations and uniformly distributed among the platens. It is a commonly used approach.

Mass flow rates



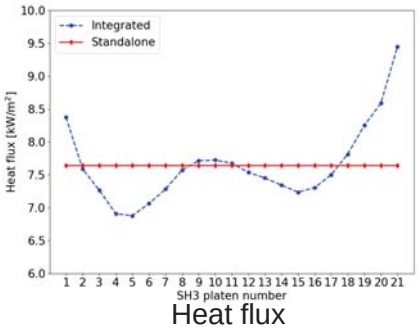
Variation due to main steam pipe geometry plus associated friction and form losses.



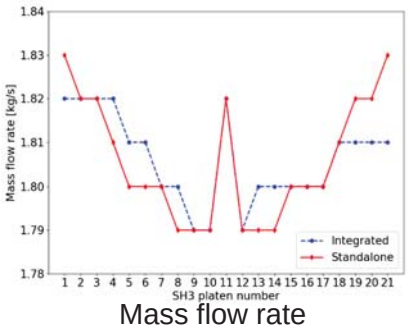
RESULTS AND DISCUSSION

Integrated simulations: Steam side

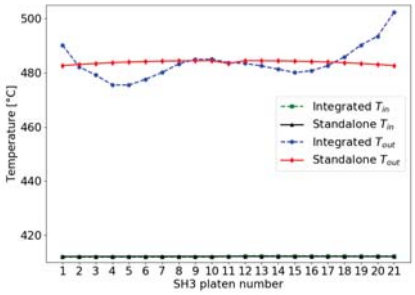
SH3: Heat flux, mass flow rate and steam superheating



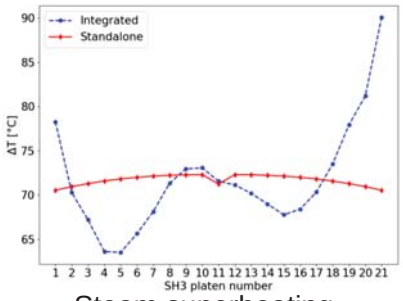
Heat flux



Mass flow rate



Steam temperature



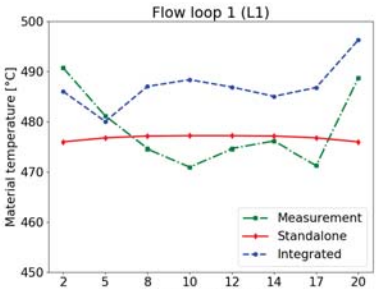
Steam superheating

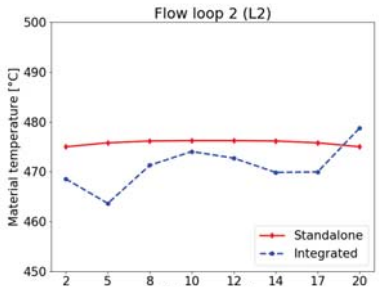
- In **Integrated**, largest differences for heat flux among platens near side walls and middle region are SH4(83%) and SH1A (80%)
- In **Standalone**, the steam flow distribution in different platens is only affected by geometry. While in **Integrated**, the effect of heat transfer on steam flow in different platens is also taken into account.
- For mass flow rates, platen-wise differences between **Integrated** and **Standalone** are 0.6- 2.5%, which can be significant in small capacity boiler.
- For all superheaters in **Integrated**, the variation in platen-wise superheating was 45-122%.
- **Inlet headers** distribute the steam with almost uniform temperatures, which shows their mixing effects.
- In **Standalone**, platen-wise superheating is almost similar, which is not accurate from real recovery boiler's operation point of view.

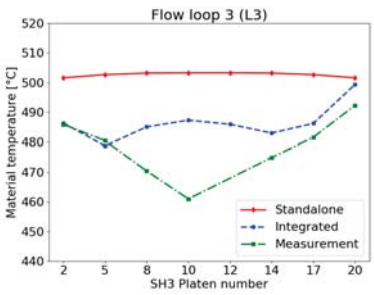
RESULTS AND DISCUSSION

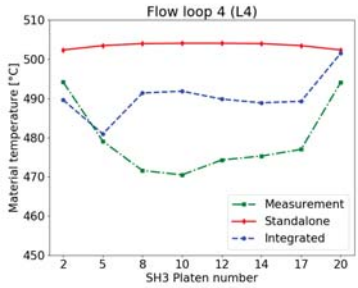
Integrated simulations: Steam side

SH3: Superheater material temperature distribution



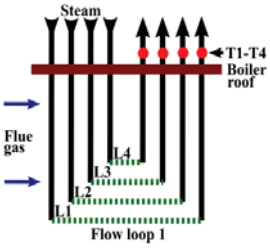






Measurements vs Integrated

Superheaters	Avg. diff. (%)
SH1A	0.7
SH1B	1.0
SH2	1.5
SH3	2.2
SH4	2.6



L1≈L2< L3 ≈ L4

- **Total 93 thermocouple** measurements in all the superheaters.
- The **Standalone** did not catch the temperature differences between platens and provided unrealistic results.
- The **Integrated** CFD/1D-PM approach provides detailed information about these complex phenomena.

CONCLUSIONS

- This novel Integrated CFD/1D-PM modelling approach is complex, comprehensive and advantageous.
- Its feasibility depends on preprocessing/set-up, computational resources and available computational time.
- Advantages:
  a) Able to solve complex heat transfer phenomena in superheater region of a recovery boiler.
  b) Aid for trouble shooting and optimizing the future design of superheaters.
  c) Relevant to study rapid load change situations in recovery boilers.
  d) It could also be applied to other energy production units such as biomass-fired boilers.

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1/2018 Suomen Soodakattilayhdistys ry
Konemestaripäivä 25.1.2018, esitelmät
Park hotel Tornio, Stora Enso Oyj, Veitsiluodon tehdas
(16A0913-E0184) 25.1.2018

2/2018 Suomen Soodakattilayhdistys ry
Soodakattila-alan yhteistoiminta
Vuosikertomus 2017
(16A0913-E0185) 26.4.2018

3/2018 Suomen Soodakattilayhdistys ry
Soodakattila-alan yhteistoiminta
Pöytäkirja. Vuosikokous 26.4.2018, Helsinki Congress Paasitorni
(16A0913-E0186) 26.4.2018

4/2018 Suomen Soodakattilayhdistys ry
Soodakattilapäivä 25.10.2018
Sokos hotelli Torni, Tampere, (16A0913-E0187) 25.10.2018

5/2018 Suomen Soodakattilayhdistys ry
Black Liquor Evaporation Book
Jim Frederick and Niko DeMartini
(16A0913-E0188) 25.10.2018

6/2018 Suomen Soodakattilayhdistys ry
Sularännisuositus
(16A0913-E0189) 10.12.2018

7/2018 Suomen Soodakattilayhdistys ry
Soodakattilan päästömittausten menetelmät
Paula Juuti, Pöyry Finland Oy
(16A0913-E0190) 10.12.2018

8/2018 Suomen Soodakattilayhdistys ry
NCG-järjestelmien turvallisuusauditointi, syntyvät hajukaasumäärät ja koostumukset, tyypilliset onnettomuuteen johtavat syyt – prosessikonseptitarkastelut
Kirsi S. Hovikorpi, Esa Vakkilainen, Lappeenrannan Teknillinen Yliopisto
(16A0913-E0191) 10.12.2018

9/2018 Suomen Soodakattilayhdistys ry
Pulp mill deposit formation and aging – role of intra-deposit alkali chloride transport
Roland Balint, Markus Engblom, Åbo Akademi
(16A0913-E0192) 10.12.2018

10/2018 Suomen Soodakattilayhdistys ry
Nitrogen in wood and its fate in kraft pulping – a review
Klaus Niemelä, VTT
(16A0913-E0193) 17.12.2018

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1/2019 Suomen Soodakattilayhdistys ry
Konemestaripäivä 24.1.2019, esitelmät
Scandic Laajavuori, Jyväskylä, Metsä Fibre Oy, Äänekosken Biotuotetehdas
(16A0913-E0194) 24.1.2019

2/2019 Suomen Soodakattilayhdistys ry
Soodakattila-alan yhteistoiminta
Vuosikertomus 2018
(16A0913-E0195) 11.4.2019

3/2019 Suomen Soodakattilayhdistys ry
Soodakattila-alan yhteistoiminta
Pöytäkirja. Vuosikokous 11.4.2019, Lapland Hotels Bulevardi, Helsinki
(16A0913-E0196) 11.4.2019

4/2019 Suomen Soodakattilayhdistys ry
Soodakattilapäivä 31.10.2019
Sokos hotelli Presidentti, Helsinki (16A0913-E0197) 31.10.2019