

Degradation of Tar-water from Biomass gasification, DETAR

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**BIO-ENERGY
ENLARGED PERSPECTIVES**

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The DETAR partners:

- Babcock & Wilcox Volund R&D Centre (Co-ordinator) - DK (VRD)
- Kommunekemi - DK (KK)
- Napoli University - IT (UNINA)
- Institute of Wood Chemistry - DE (IWC)
- HGO Engineering - DK (HGO)

The DETAR execution period:

January 1st, 2003 - December 31st, 2005

Misc'l information:

- The overall project cost is 1.740.645 euro with an EU contribution of 1.066.425 euro
- Total R&D effort is 168 man-months
- The pilot-plant (to be used in DETAR) is being designed and built in an associated project with an overall project cost of 186.310 euro sponsored in part by the Danish Energy Authority with 93.960 euro
- A project web-site WWW.DETAR.DK will be active throughout the project period

DE TAR objective

To evaluate the full scale application of SCWO/G (Supercritical Wet Oxidation/Gasification) for gasification related tar-water cleaning

Expected results

- Characterisation of the chemical composition of waste water from updraft wood-gasification (in particular water soluble tar components)
- Application and optimisation of SCWO/G for such waste water at laboratory (1 kg/h) and pilot scale (50 kg/h)
- Formulation of kinetic and transport models for the SCWO/G process including validation and process simulation
- Characterisation of the chemical composition of the SCWO/G process effluent discharge water
- Based on literature information to extend the results of the analysis for 6MW_{TH} updraft wood-chips gasifier wet gas cleaning effluents to other gasifier configurations and gas cleaning technologies
- Provision of a full-scale evaluation of the SCWO/G process for both the technical (energetic/environmental) and the economic aspects

Methodology

- The Laboratory Scale Unit (LSU - already existing 1 kg/h system) will be used to establish parameters for the thermo-chemical mechanisms involved under various process conditions (retention times, temperature/pressure, influence of raw water acidity, added carbon powder catalyst)
- The Process Development Unit (PDU - financed in part by the Danish Energy Authority) will be used for correlation with the mathematical model and tools to be developed in the project, for optimisation of the SCWO/G process and as a basis for up-scaling the DETAR process for full scale application
- A full-scale implementation layout (about 1000 kg/h of waste water), which will be used to evaluate the capital/operational cost and environmental impact of the technology

Work Packages

- 0 **Design/build PDU**
- 1 **Chemical Characterisation**
- 2 **SCWO/G tests at lab/pilot scale**
- 3 **Kinetic and Mathematical modelling**
- 4 **Full scale implementation**
- 5 **Co-ordination and Reporting**

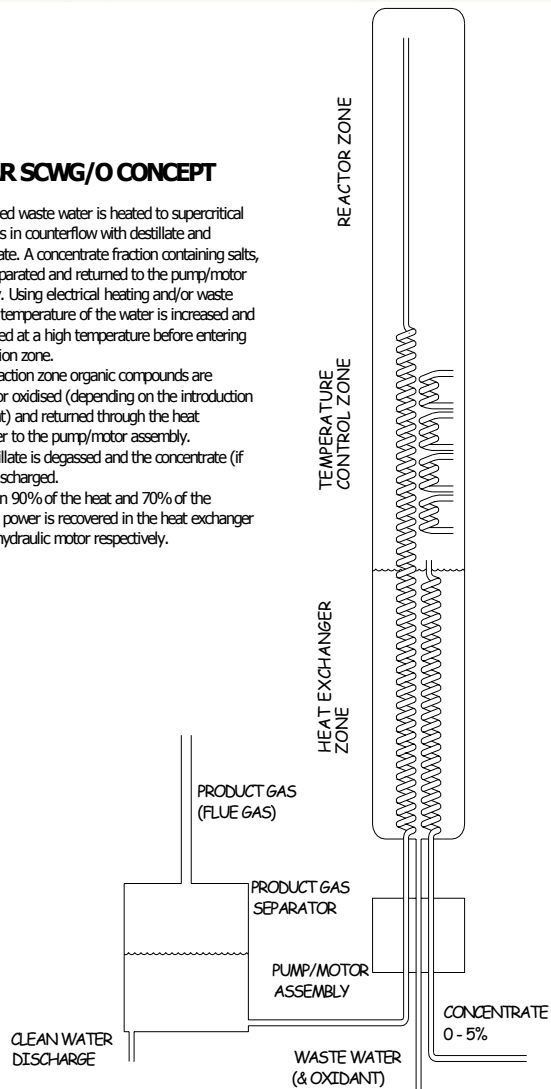
DETAR SCWG/O CONCEPT

Pressurised waste water is heated to supercritical conditions in counterflow with distillate and concentrate. A concentrate fraction containing salts, etc. is separated and returned to the pump/motor assembly. Using electrical heating and/or waste heat the temperature of the water is increased and maintained at a high temperature before entering the reaction zone.

In the reaction zone organic compounds are cracked or oxidised (depending on the introduction of oxidant) and returned through the heat exchanger to the pump/motor assembly.

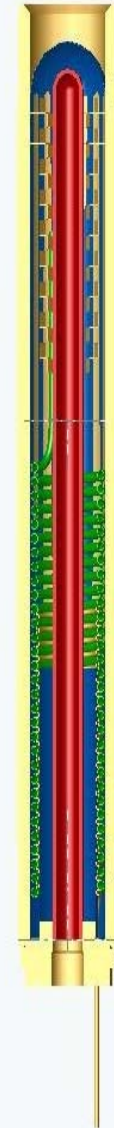
The distillate is degassed and the concentrate (if any) is discharged.

More than 90% of the heat and 70% of the pumping power is recovered in the heat exchanger and the hydraulic motor respectively.



WP0: Design/build PDU

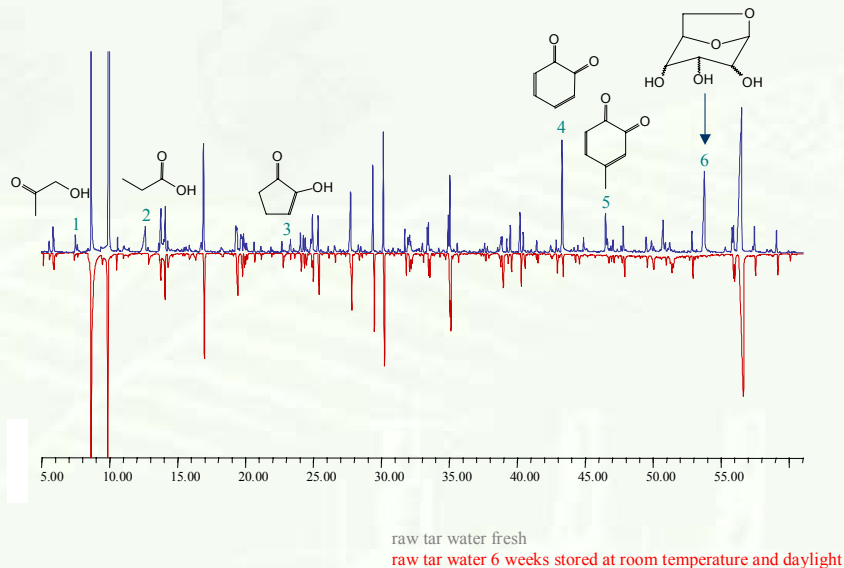
- The tests carried out with the LSU has led to several design changes - specifically in the reactor part of the system (improvement of isothermal stability and mixing)
- The Reactor/Heat-exchanger design is the responsibility of VRD, the Pump/Motor design is the responsibility of HGO and the Auxiliary support systems is the responsibility of KK
- The 50 (kg/h) PDU system will be built and assembled during the fall of 2003 and "test-firing" will take place immediately after Christmas 2003
- Actual testing of the system will be carried out during the rest of the DETAR project at the partner KK



WP1: Chemical characterisation

- A methodology for analysing the raw tar water and waste water, which has been subject to both SCWO and SCWG has been developed at IWC, using waste water from the VRD operated Harboore (DK) Wood-chips Updraft Gasifier based CHP plant

- 56 characteristic GC/MS peaks have been observed, which are reduced differently at increasing reaction temperature. The temperature influence is markedly different for reducing and oxidising conditions



- Also storage of the waste water will influence the composition (on the GC graph above fresh water and 6 weeks old are depicted)

- 1:Hydroxyacetaldehyde
- 2:Propanoic acid
- 3:2-Hydroxy-2-Cyclopenten-1-one
- 4:1,2-Benzenediol
- 5:4-Methylcatechol
- 6:unknown anhydrosugar

WP2: SCWO/G tests at lab/pilot scale

- At the 1 (kg/h) LSU experiments have been carried out at 24-25 MPa pressure and temperatures in the range 400°C-550°C
- 4 interim reports describing the experiments (before and after modifications) have been issued to the partners
- During the next 2 months supplementary LSU tests with catalysts (Carbon powder and Potassium Hydroxide) will be carried out at HGO



Laboratory Scale Unit
Front View

WP3: Kinetic and Mathematical Modelling

- A review of the State of the Art on kinetic modelling of supercritical gasification/oxidation of tar and tar components has been carried out by UNINA. A list of relevant references has been made available to the project partners
- A Mathematical Model - based on the assumption of plug flow - is currently under development at UNINA to interpret the data from the LSU experiments. In connection with the design of the PDU preliminary work has been carried out at VRD on a Mathematical Tool (PC based) to establish preliminary thermal design and performance. The kinetics has not as yet been included in the (Visual Basic) tool - only assumptions regarding reduction zone heat requirement are used
- Work on the Mathematical Model and the Mathematical Tool will proceed during the next period as data from the LSU experiments are consolidated

WP4: Full scale implementation

No activities are scheduled as yet for this Work-Package - which awaits more information from the PDU experiments

WP5: Co-ordination and Reporting

- The central forum for DETAR project decisions - the EXCO (Executive Committee) meeting - has carried out 2 meetings (at VRD and HGO) and issued minutes of meeting
- There has been contribution from a participant (external to DETAR and financed by VRD) related to use of Carbon Powder and Potassium Hydroxide catalysts
- 2 PhD studies - at UNINA and IWC - are associated with the DETAR project
- A Consortium Agreement has been drafted and is expected to be signed by the partners at the IWC EXCO meeting December 2003
- A Web-site has been created (WWW.DETAR.DK) and will be updated late October 2003