Tar decomposition by Novel Catalytic Hot Gas Cleaning methods

NOVACAT

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VTT Processes

BIO-ENERGY
ENLARGED PERSPECTIVES

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Project Consortium

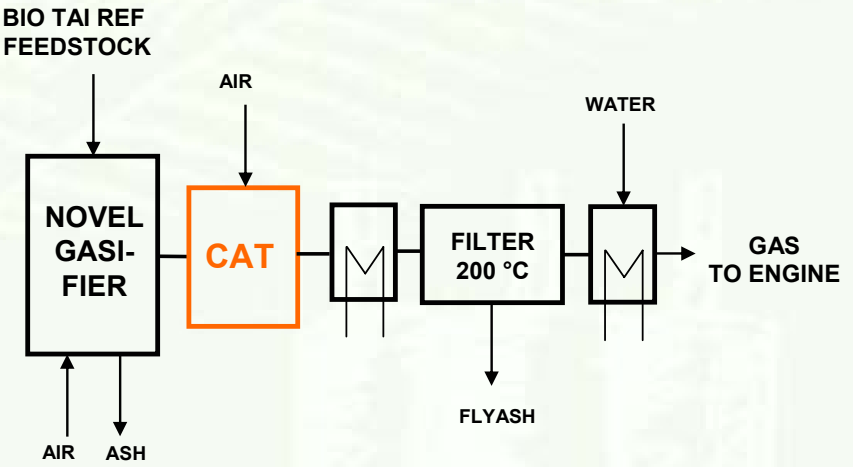
- VTT, Technical Research Centre of Finland *(Dr. Pekka Simell*)
- VUB, Vrije Universiteit Brussels (*Prof. Gino Baron*)
- UCM, Universidad Complutense de Madrid (*Prof. J. Corella*)
- Condens Oy, Finland (*Dr. Ilkka Haavisto*)
- Maridiana s.r.l., Italy (*Gianni Berna*)
- Sereco Biotets s.s, Italy (*Dr. Luca Poletti*)

Duration 27 months
1.1.2001 - 31.3.2003

Target gasification process

CHP/Engine power plant based on NOVEL fixed bed gasifier

- suitable for large variety of feedstocks
- low content of particulates
- relatively low tar content

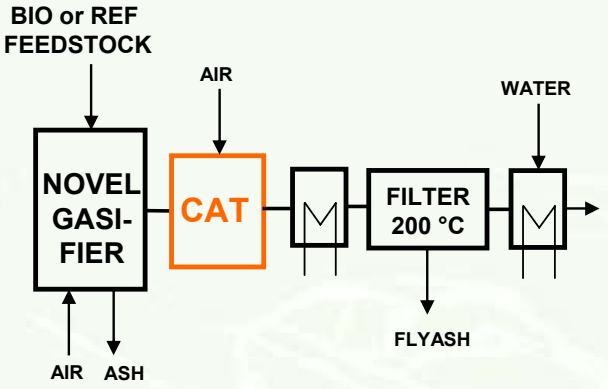


Gas cleaning for engine applications

- tar removal: no condensables, total tars < 100 mg/m3n
- ammonia removal: catalyst + scrubber, < 50 ppm-v
- dust removal by filtration < 10 mg/m3n

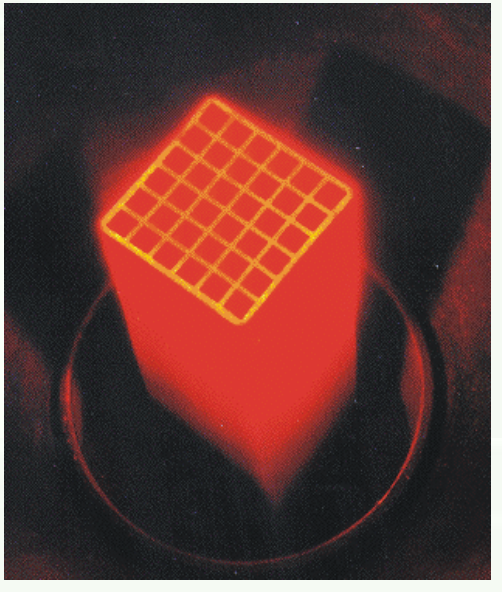
Challenges

- Power production by biomass & waste gasification
  - efficient and simple gas cleaning system
  - low cost, high availability
- Solution 1: Nickel monolith



Nickel monolith catalyst

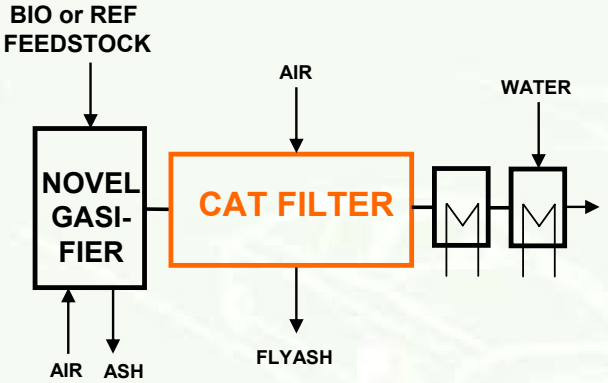
- low pressure drop
- suitable for clean biofuels (low Cl and S)
- high efficiency on tars and ammonia
- operation at 900 ^{o}C



Challenges

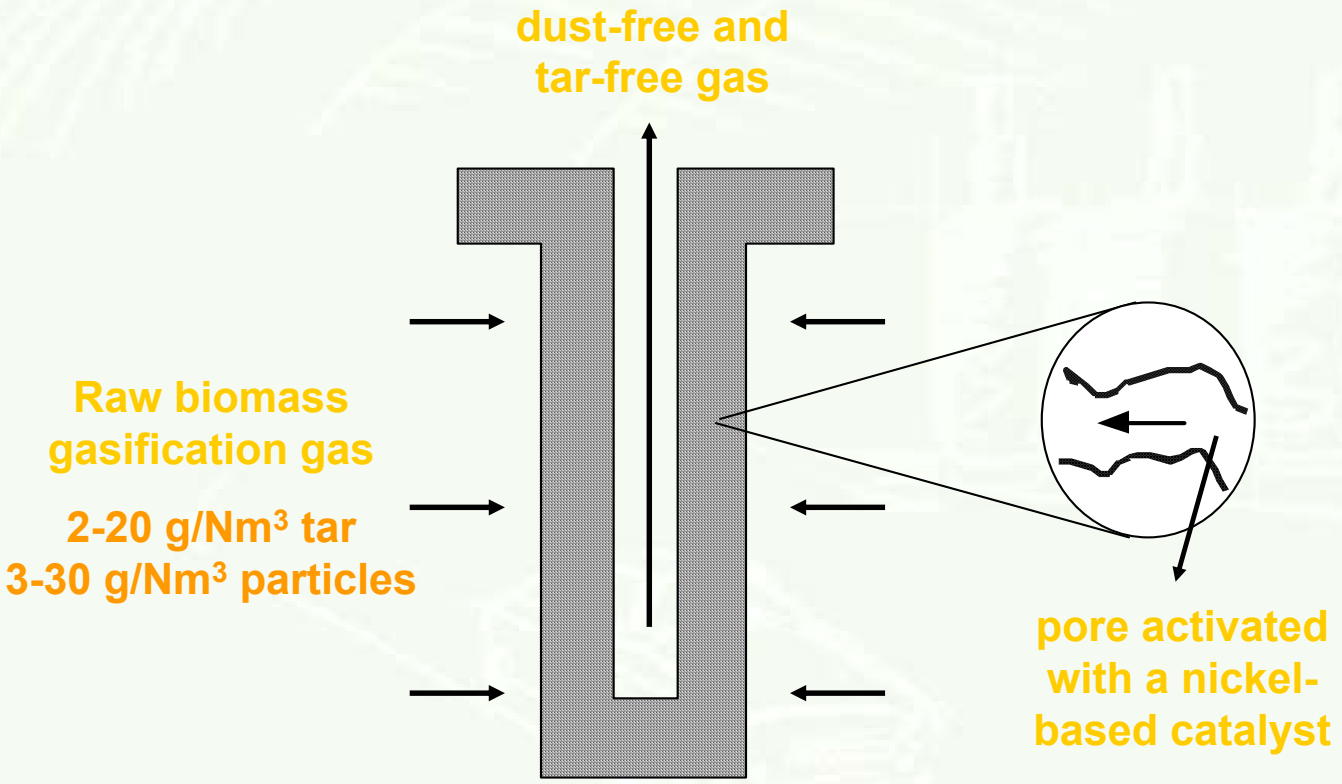
- **Power production by biomass & waste gasification**
  - **efficient and simple gas cleaning system**
  - **low cost, high availability**

- **Solution 1: Nickel monolith**
- **Solution 2: Catalytic filter**



Catalytic candle filter

Compact, simple, low-cost and high-performance gas cleaning system



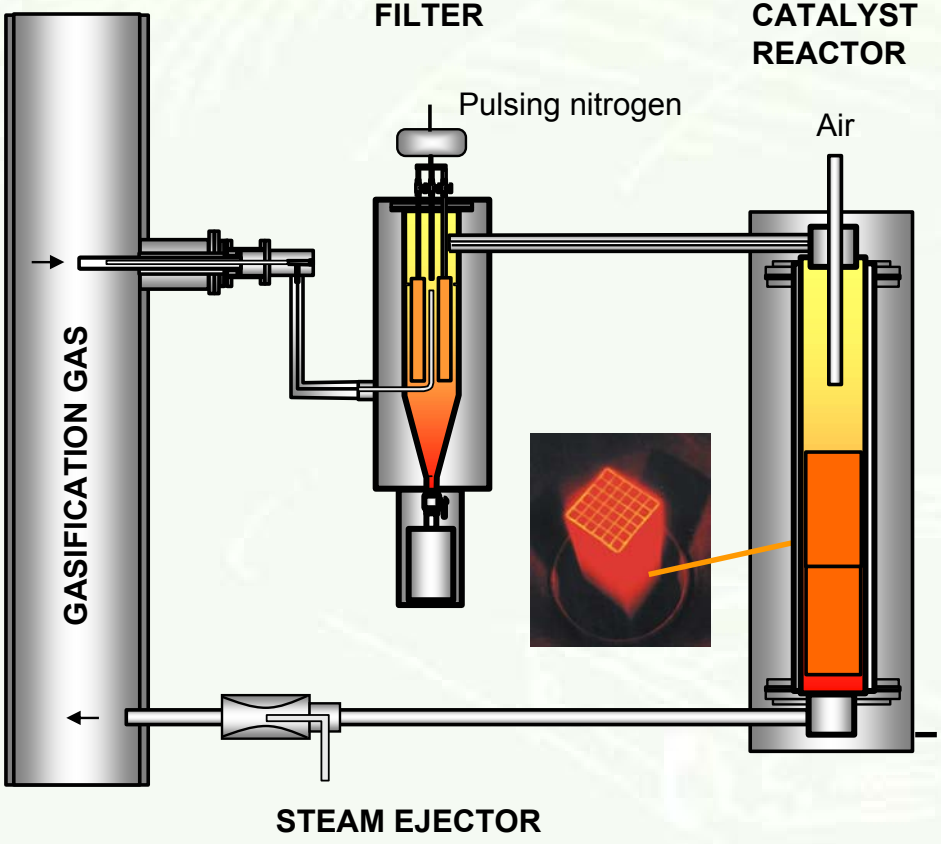
Key questions
monolith

- What is the lifetime of the nickel monolith?

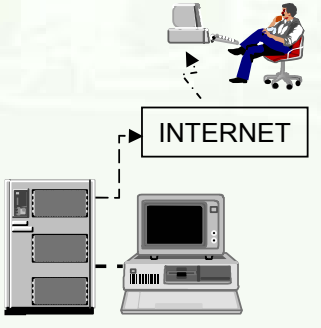
  ⇒ test in slip-stream
  ⇒ high activity after 2300 h on-stream
  ⇒ probable that will remain active for much longer periods of time
  ⇒ no fouling

SLIP-STREAM TESTING UNIT AT LAHTI CFB-GASIFICATION PLANT

- nickel catalyst long-term testing
- SCO testing



Lahti Kymijärvi Power Plant



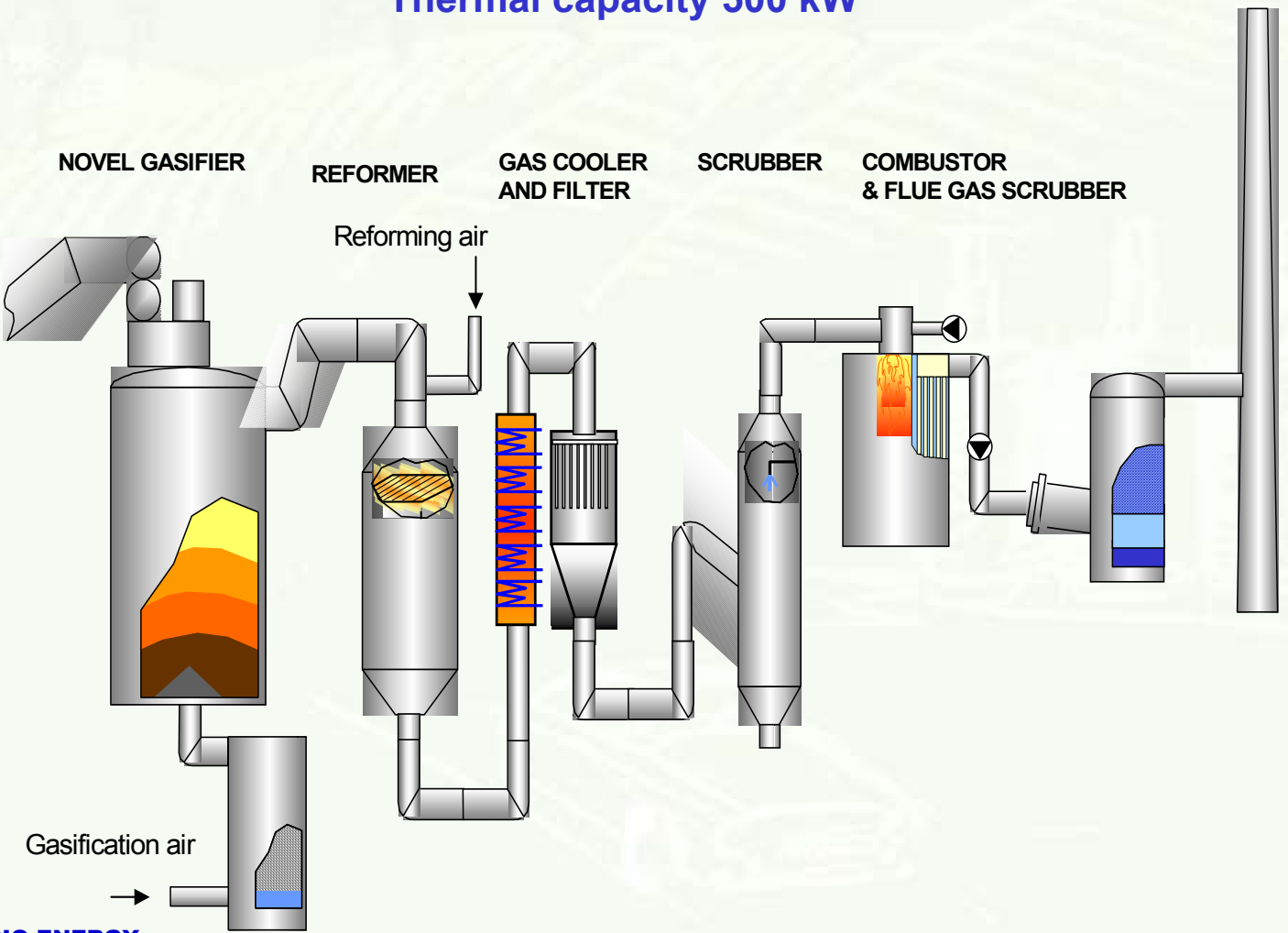
Data acquisition via internet

Key questions
monolith

- Will the nickel process work also in larger scale?
- Is the gas clean enough for modern turbo-charged engines?

$\Rightarrow$ NOVEL-process modified and tested at pilot scale

NOVEL-FIXED-BED GASIFICATION PILOT PLANT OF VTT AND CONDENS OY, Espoo, Finland Thermal capacity 500 kW



Gas impurities after the gas cleanup train

Feedstock	Benzene mg/m^3_n	Tar mg/m^3_n	NH3 mg/m^3_n	Particulates mg/m^3_n
Coppice wood	200	40	20	<5
Olive residues	230	10	20	<5
Demolition wood	400	70	<10	<5

Key questions
monolith

- Will the nickel process work also in larger scale?
- Is the gas clean enough for modern turbo-charged engines?

⇒ NOVEL-process modified and tested at pilot scale

⇒ specifications set by engine manufacturers were met

⇒ suitable for various feedstocks, low density is not a problem:

⇒ **Italian agrobiofules: olive prunings, coppice wood**

⇒ **forest waste wood and demolition wood**

Key questions
monolith

- Optimal operation conditions?
- Operation limits?

⇒ operations with monolith are demanding

⇒ **skilled plant personnel required**

⇒ main operational parameters studied

- **H2O/C* ratio**
- **air feeding**
- **gas superficial velocity**
- **space velocity**

⇒ start-up and shut-down operations studied

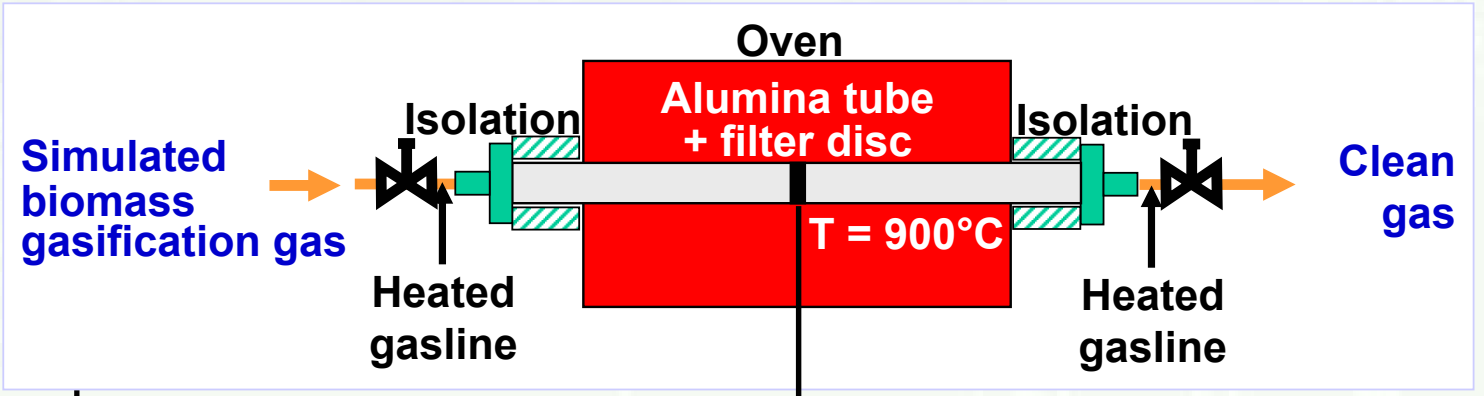
⇒ optimised operation window found

Key questions
catalytic filter

- Can sulphur resistance of the catalytic filter be improved?
- Will the catalytic filter work with real gases?

$\Rightarrow$ Tests with lab and real gases

Experimental Setup



Model for catalytic candle filter:
catalytic filter disc

50 % N_2, 10 % H_2,
12 % CO, 11 % CO_2,
12 % H_2O, 5 % CH_4

H_2S content: 0-200 ppm

Tar model compounds:
15 g/Nm^3 (4300 ppmv) benzene
5 g/Nm^3 (875 ppmv) naphthalene

Gas velocity: 2.5 or 4 cm/s

Analysis gases and tars:
on-line gas chromatography
+ on-line mass spectrometry

Key questions
catalytic filter

- Can sulphur resistance of the catalytic filter be improved?
- Will the catalytic filter work with real gases?

⇒ modified new Ni-activated alumina filter substrates developed
⇒ improved resistance to sulphur poisoning
⇒ laboratory conditions 99.9% conversion at 900°C
⇒ target tar conversion, > 95 %, achieved with real gases
⇒ rapid carbon fouling of filter (no filter cleaning to remove carbon!)
⇒ combined filtration / conversion to be tested in future studies

Key questions
both solutions

- What is the technical & economical feasibility of the both catalytic gas cleaning systems developed in the project?

  ⇒ Case studies: NOVEL CHP in Finland & Italy, 2 - 5 MWth

  ⇒ electricity price plays a major role

  ⇒ **pay-back time 10 - 13 years in low el. price countries (30 e/MWh)**

  ⇒ **pay-back time 3 - 6 years in high el. price countries (120 e/MWh)**

  ⇒ use of the catalytic filter cuts the costs

  ⇒ REF fuels economically attractive

Conclusion

- NOVEL-process commercialised as a direct follow up
- the first NOVEL-plant to town Kokemäki in Finland