Bioliquids-CHP

Power generation from Biomass

Engine and turbine fuelled with bioliquids for combined heat and power production

Enhancing strategic international cooperation between EC and Russia in the field of power generation from biomass

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- Project Objectives
- Project partners
- General Overview activities
- On going activities

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Project background

- Combined heat and power (CHP) is a very efficient way of using energy sources
- 2010 target: CHP to contribute 18% of European energy supply
- In Russia, many CHP units are used, in particular in remote areas.
- Implementation of smaller scale, direct biomass CHP systems has been limited for various reasons e.g. high investment and running costs, poor reliability, low acceptance by end-user.
- At the root of these reasons: presence of contaminants in biomass, non-uniform appearance of biomass, low energy density, complicated operation, difficulty to operate on varying load
- Using biomass derived liquids (in short: *bioliquids*) instead of direct biomass will overcome the main barriers hindering a wider use of biomass in smaller scale CHP systems.

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Project objectives

Main objective:

- To adapt engines/turbines to enable operation on a variety of bioliquids for CHP systems in the range of 50-1000 kW_e;

Specific objectives:

- To upgrade bioliquids or to prepare blends/emulsions of bioliquids to enable their use in engines/turbines;
- To find a technical and economic optimum between fuel upgrading and engine/turbine modification;
- To develop methods/techniques to control exhaust emissions (NO_x, CO, particulates);
- To evaluate the complete chain (sustainability, economics, technology, environment, market opportunities) for application in EU & Russia

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General Project Data

Full Title: Engine and turbine combustion for combined heat and power production

Acronym: Bioliquids - CHP

Call: Enhancing strategic international cooperation with Russia in the field of power generation from biomass

	EC - part	*Russian part*
Start-date	January 1, 2009	July, 2008
End-date	December 31, 2011	September 2011
Budget	1.6 MEur	~1.9 MEur
No of partners	4	3

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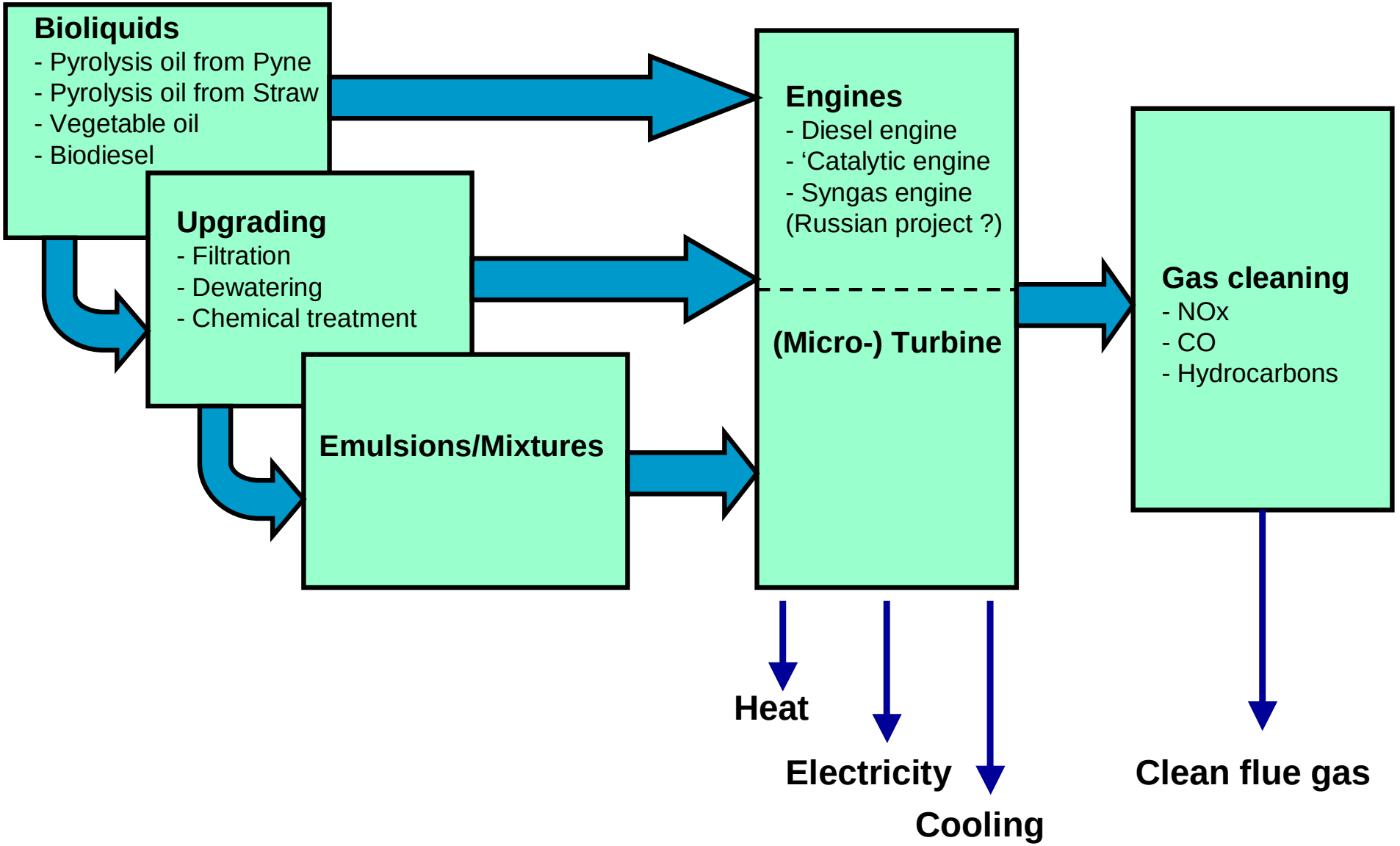
Project partnership

- BTG Biomass Technology Group BV (NL)
- EnConTech BV (NL)
- University of Florence, CREAR (Italy)
- Boreskov Institute of Catalysis, Siberian Branch of Russian Academy of Sciences (Russia)
- Federal State Unitary Enterprise 'Central Scientific Research Automobile and Automotive Engines Institute' - FSUE 'NAMI' (Russia)
- Aston University (United Kingdom)
- The Likhachev Plant (AMO ZIL) (Russia)

General Project overview– Work Packages



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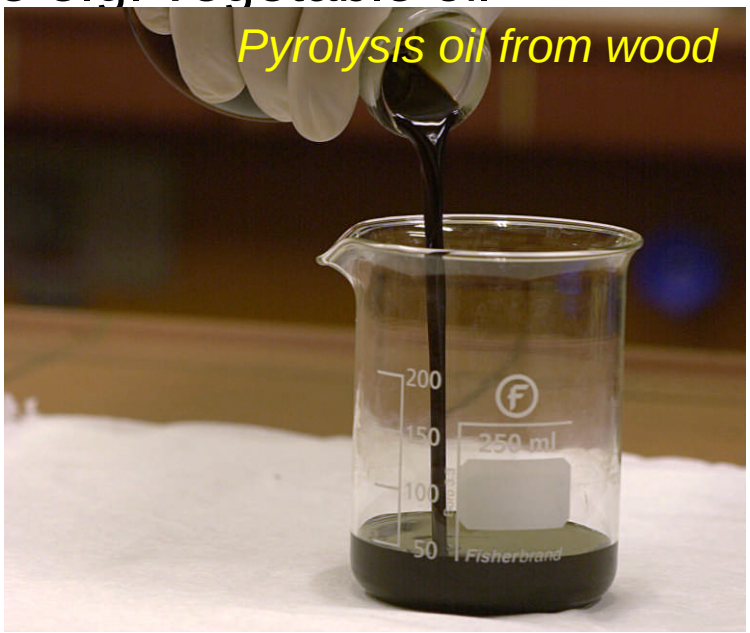
Bioliquid production, selection and analysis

- ***WP-leader:*** **BTG**
- ***Partners involved:*** **ECT, UFL, Aston, BIC, NAMI**
- ***Objectives - activities***
  - Production of pyrolysis oil from different biomass feedstocks
  - Selection/purchase of other bioliquids, like e.g. vegetable oil
  - Characterisation/analysis of bioliquids
  - Characterisation/analysis of products from WP2 (upgraded oil, blends and/or emulsions)



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Pyrolysis Oil Production

Pyrolysis oil production

- Feedstock: pine & wheat straw
- Production of 1,100 kg of pyrolysis oil from pine completed

- Wheat straw derived oil will be produced in 2010

BTG's Pilot-plant in Enschede

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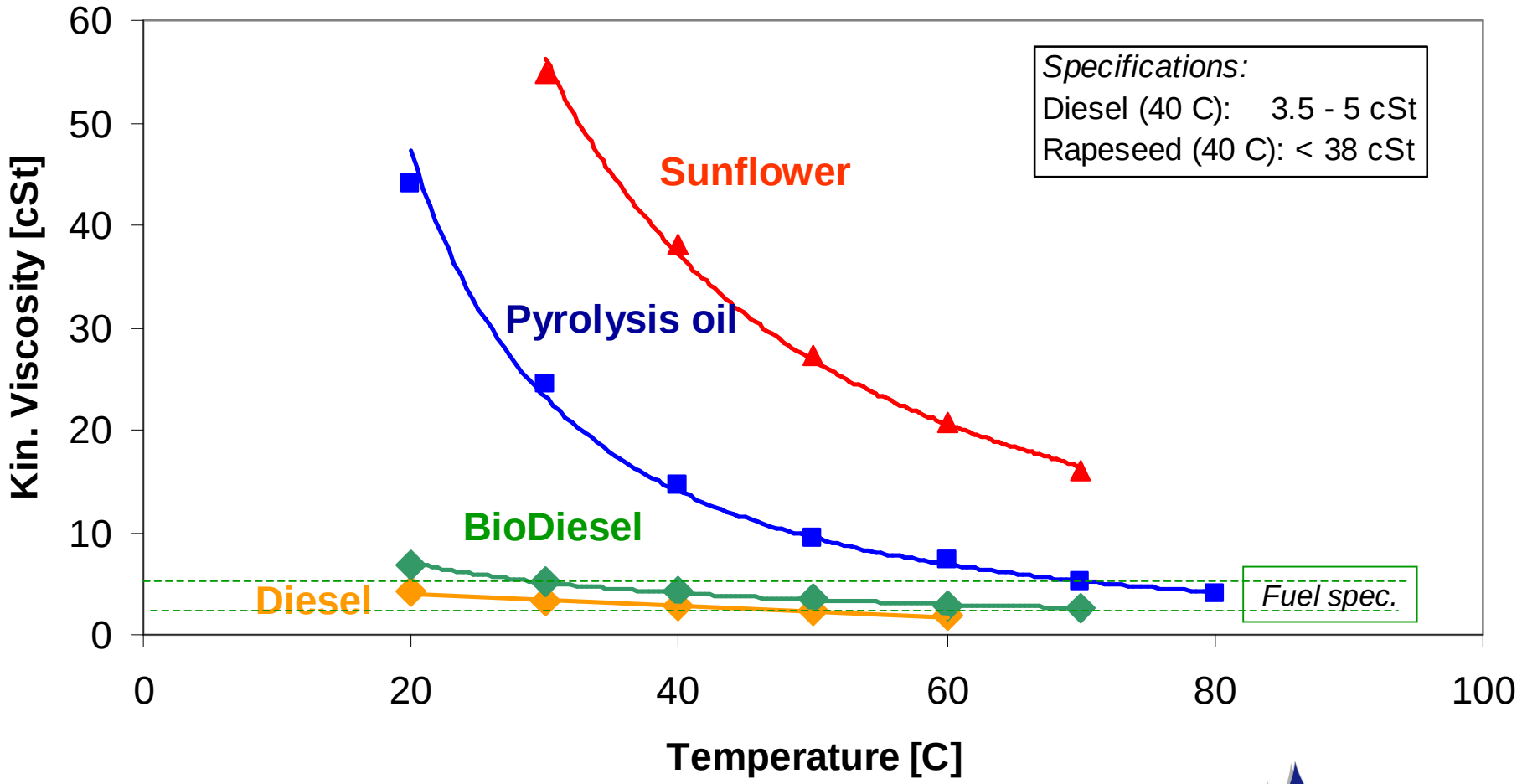
Selected Bioliquids

- Pyrolysis oil from pine
- Pyrolysis oil from straw
- Sunflower oil
- Biodiesel



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Bioliquids upgrading and blending

- ***WP-leader:*** **BTG**
- ***Partners involved:*** **BIC, NAMI**
- ***Objectives - activities***
  - Filtration of bio-oil (solids removal)
  - (Partial) dewatering of oil
  - Mild (catalytic) treatment of pyrolysis oil
  - Catalytic pyrolysis of pyrolysis oil
  - Blending and emulsification of pyrolysis oil with other bioliquids

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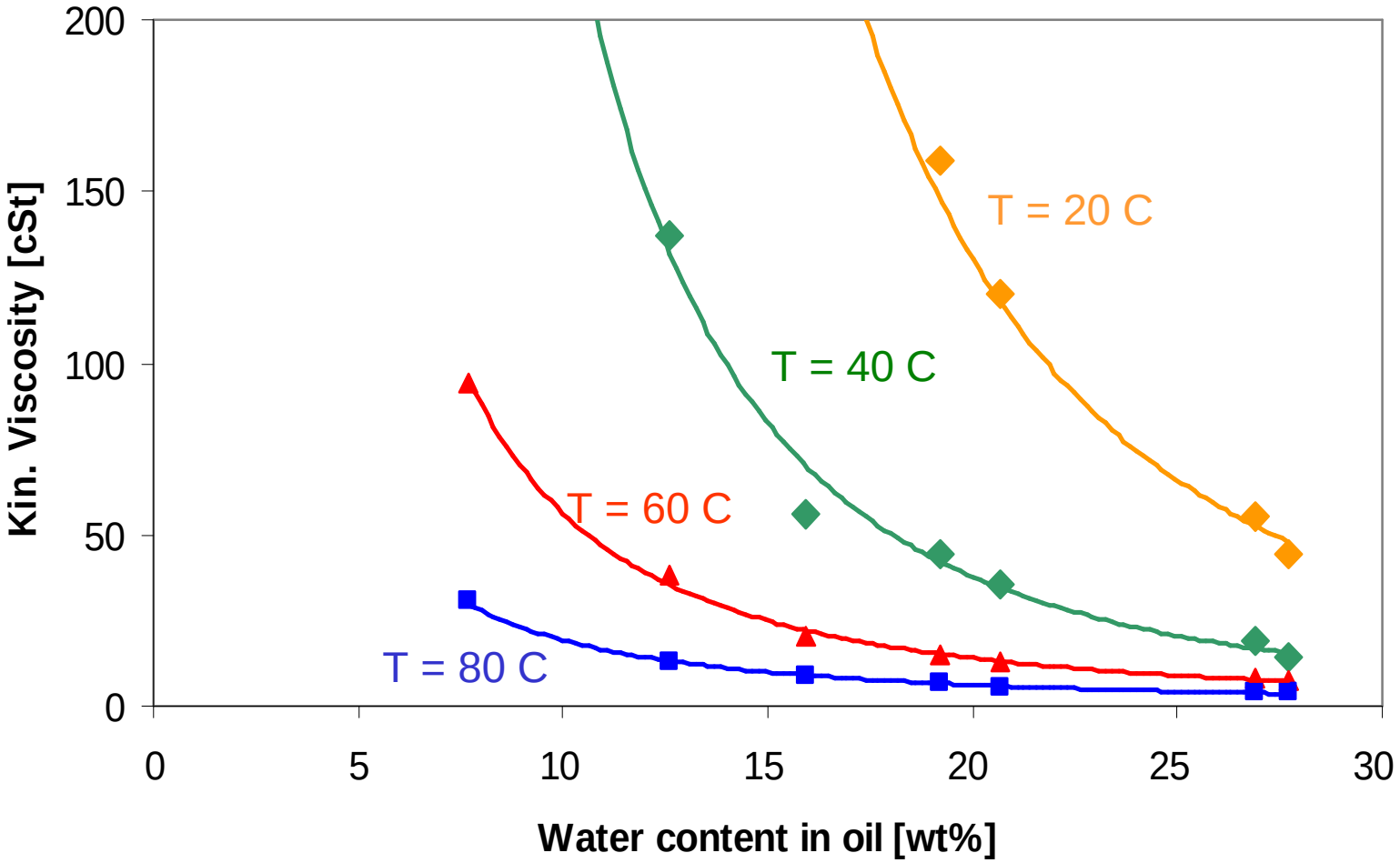
Filtration & partial dewatering of pyrolysis oil

- Different techniques are used for solids removal (filters, centrifuges, self-cleaning etc).
- Solids removal tested at labscale and pilot scale;
- Partial removal of water at low temperature and vacuum

Partial dewatering of pyrolysis oil



Kinematic viscosity as a function of the water content in the oil for different temperatures

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Development of Micro turbines

- ***WP-leader:*** **UFL**
- ***Partners involved:*** **BIC, NAMI**
- ***Objectives - activities***
  - Modification of Micro Gas Turbines (MGT)
  - Supporting CFD simulations
  - MGT testing programme / MGT performance
  - Evaluation and assessment of MGT for bioliquids fuelled CHP systems

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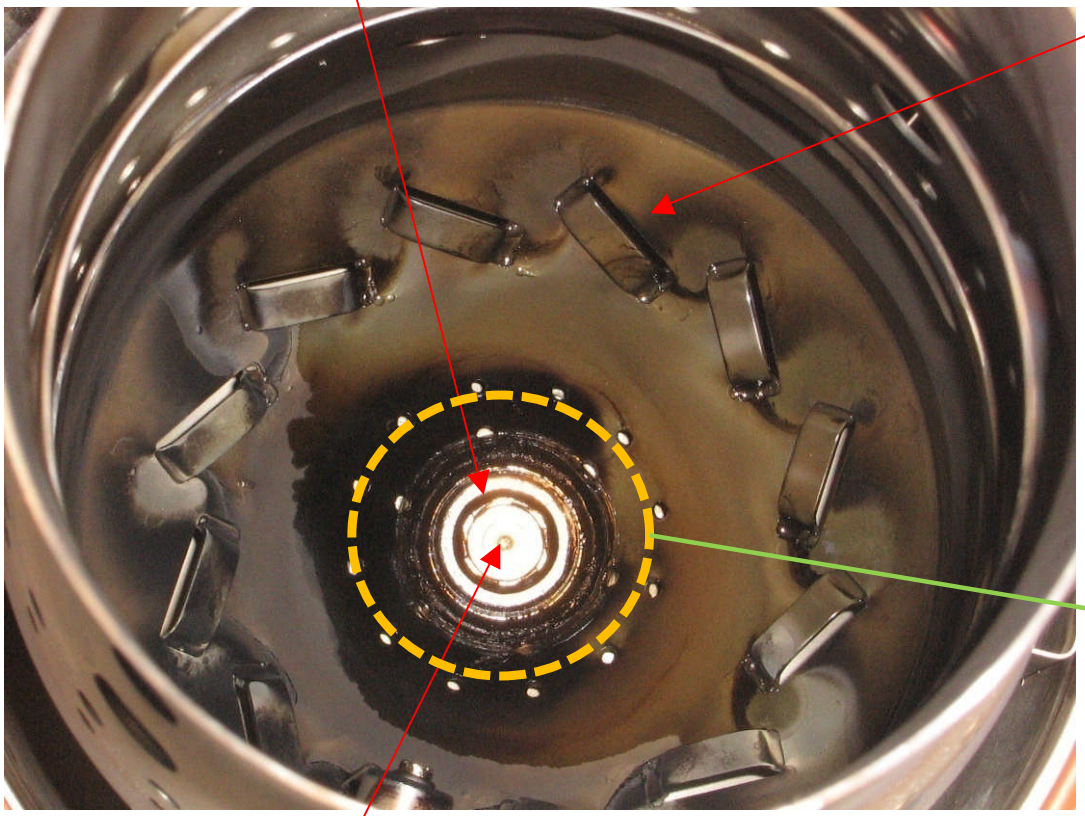
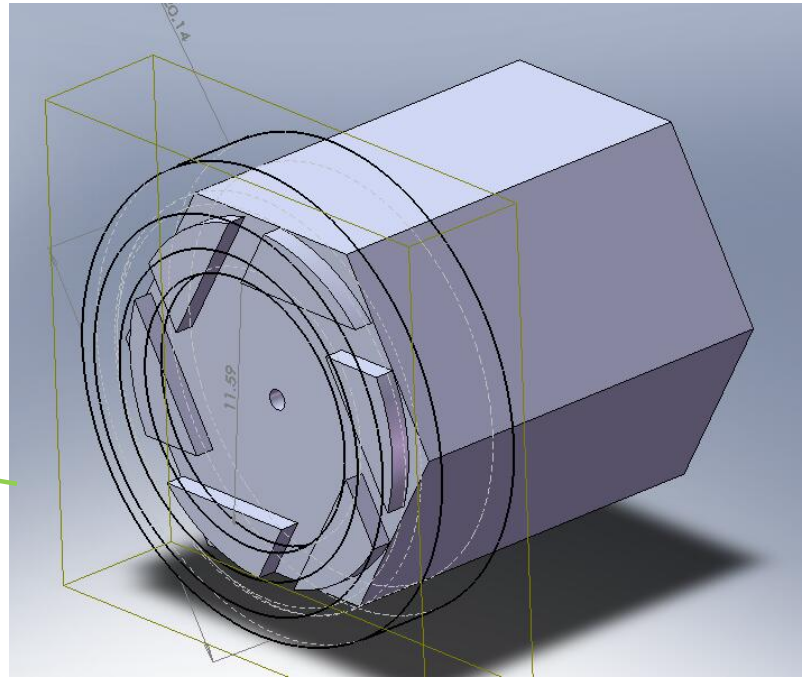
Micro turbines - combustor

INJECTOR
SWIRLER

DEFLECTORS





INJECTOR

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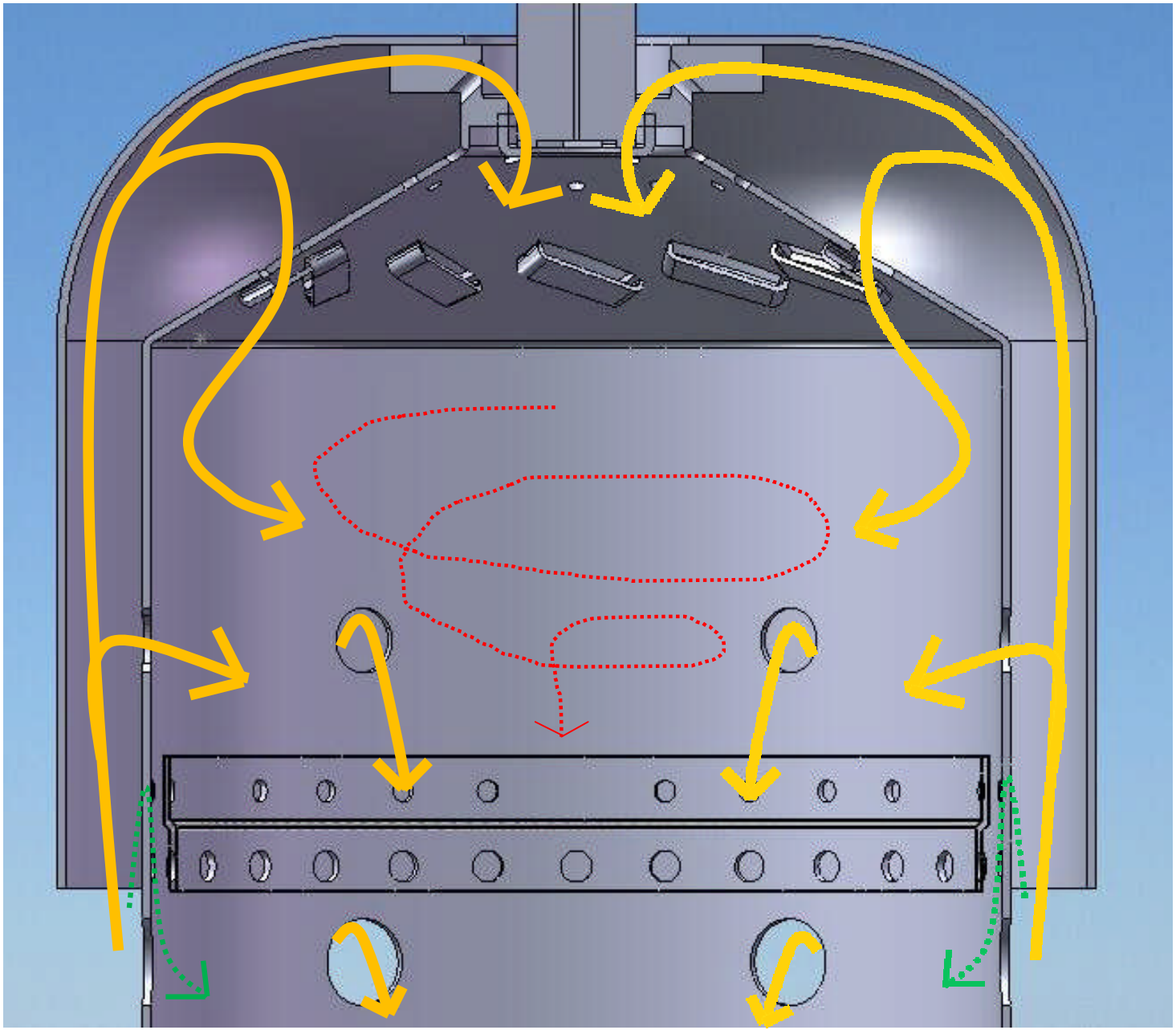
Micro turbines - combustor



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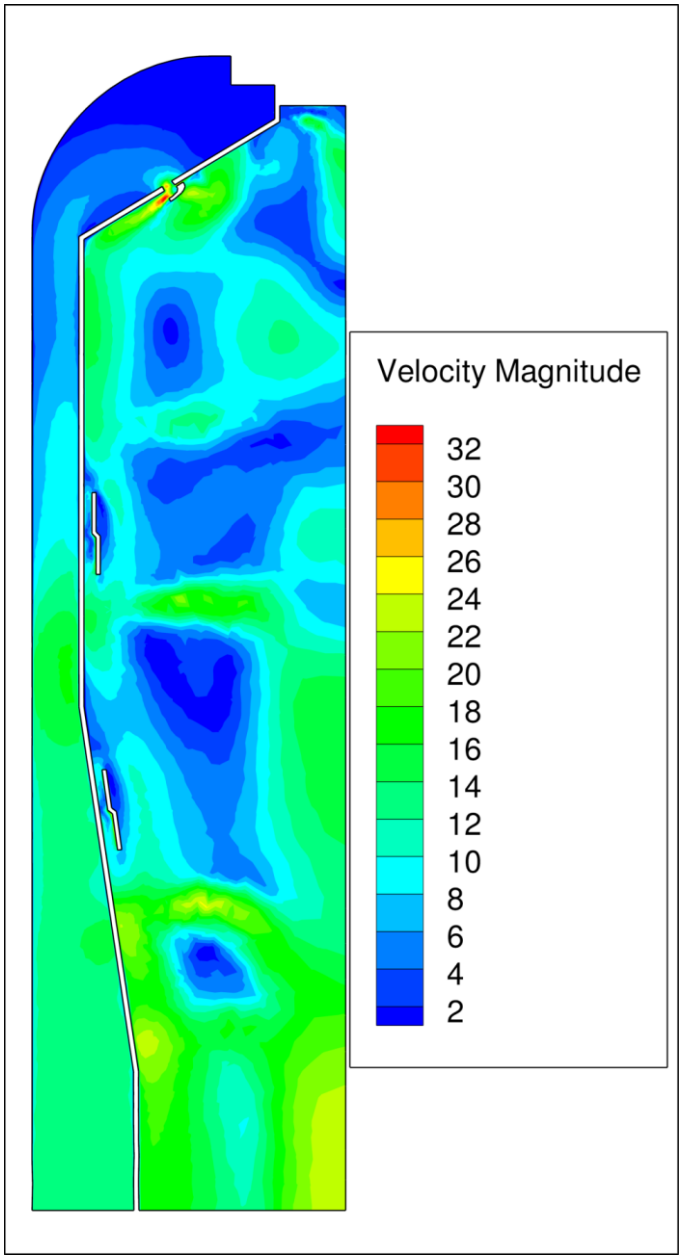
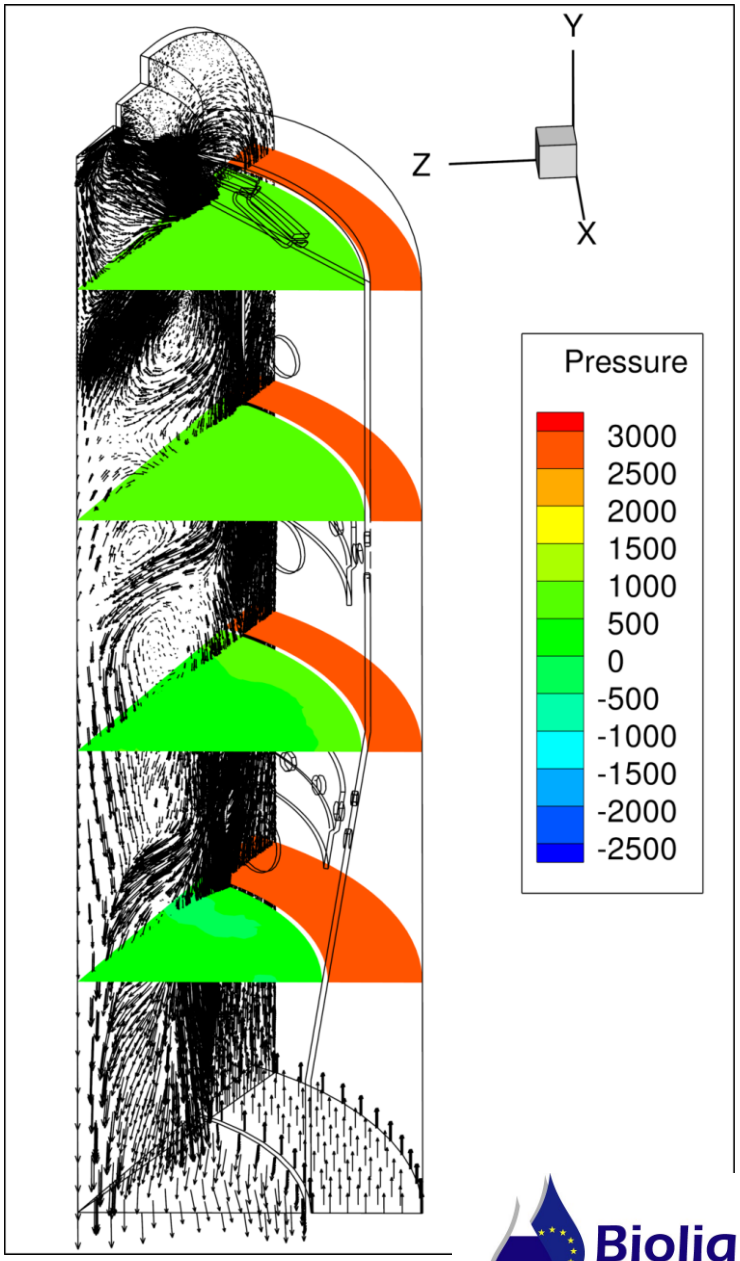
Micro turbines - cold flow CFD

P & V fields, vectors of V





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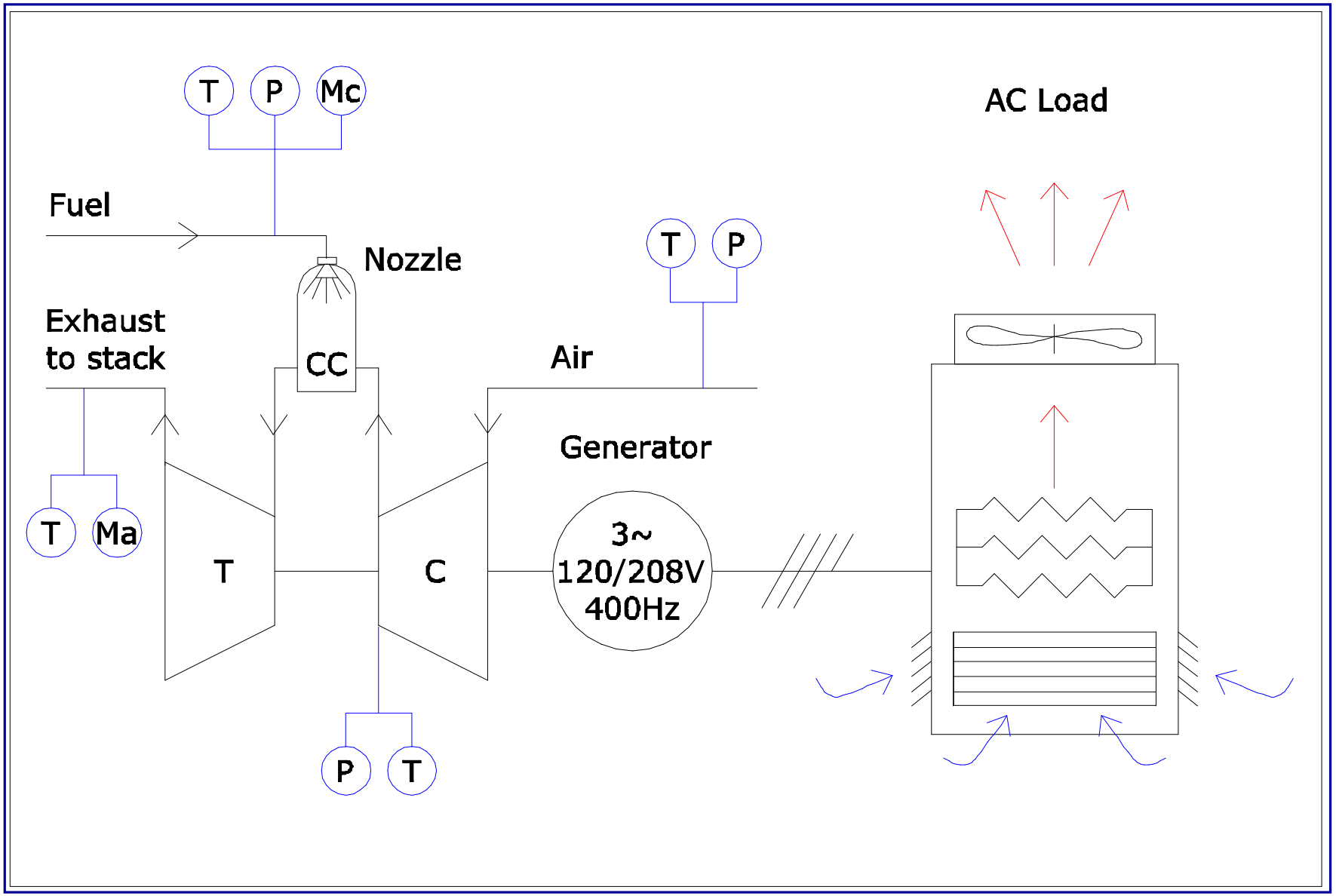
Micro Turbine - test bench



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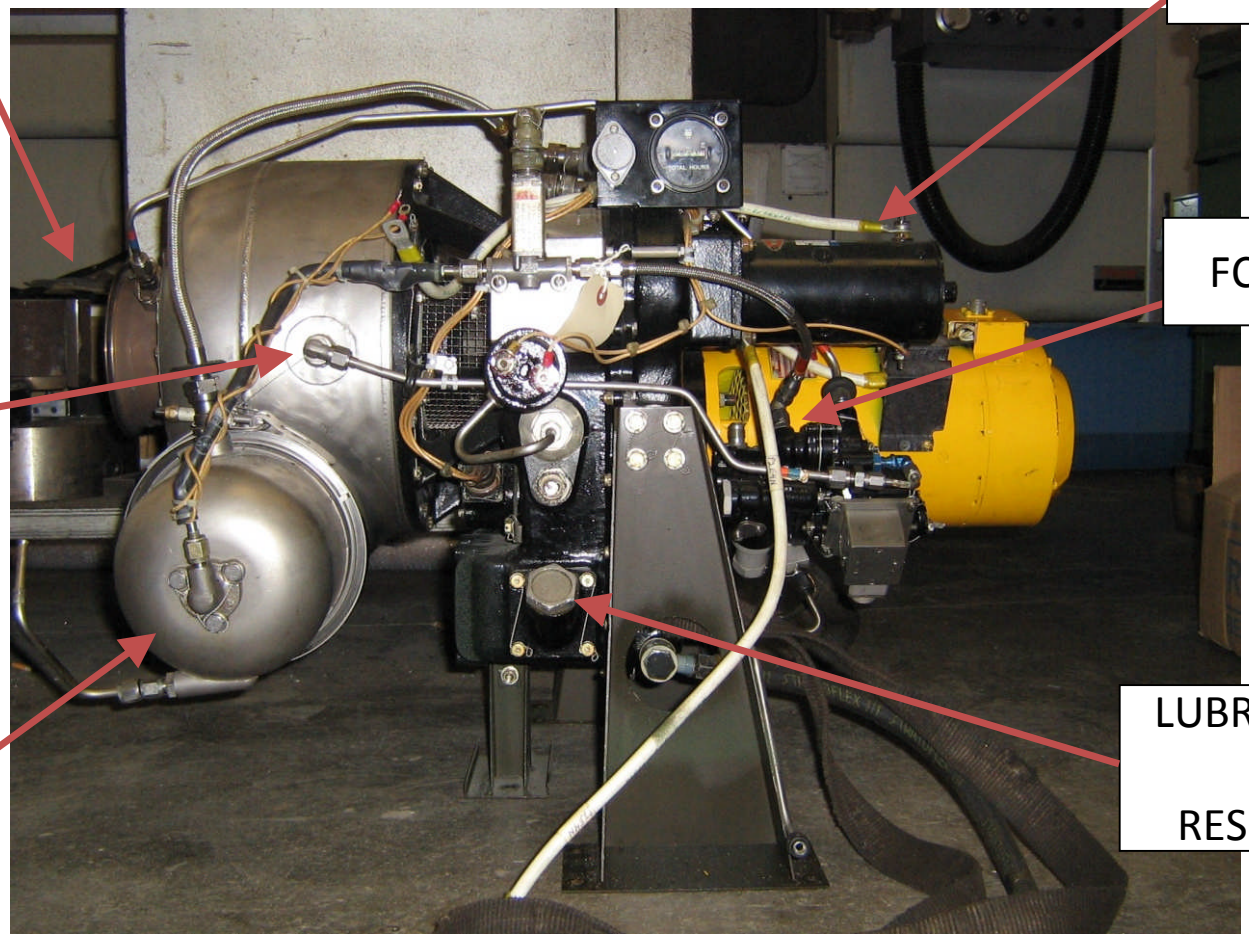
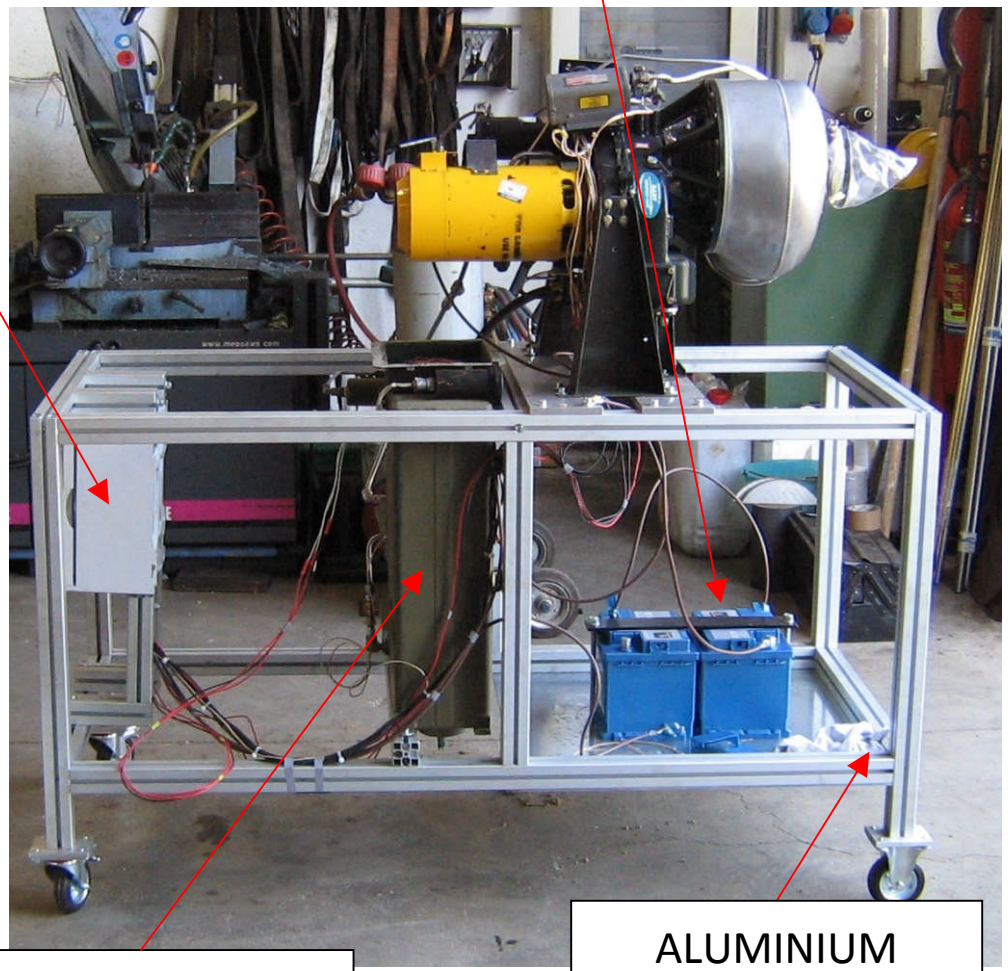
Micro Turbine - test bench



Micro Turbine - test bench

START-UP AND SHUT-DOWN CONTROL PANEL

BATTERY PACK



LOAD CONTROL PANEL

FUEL TEMPORARY TANK

ALUMINIUM SKID

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Development of Engines & components

- ***WP-leader:*** **ECT / NAMI**
- ***Partners involved:*** **BTG, BIC**
- ***Objectives - activities***
  - to develop engine components that are tolerant towards the bio-liquids including fast-pyrolysis oils or mixtures.
  - Construction of experimental facilities
  - Lab-scale experiments
  - Engine modifications
  - Engine testing and emission measurement

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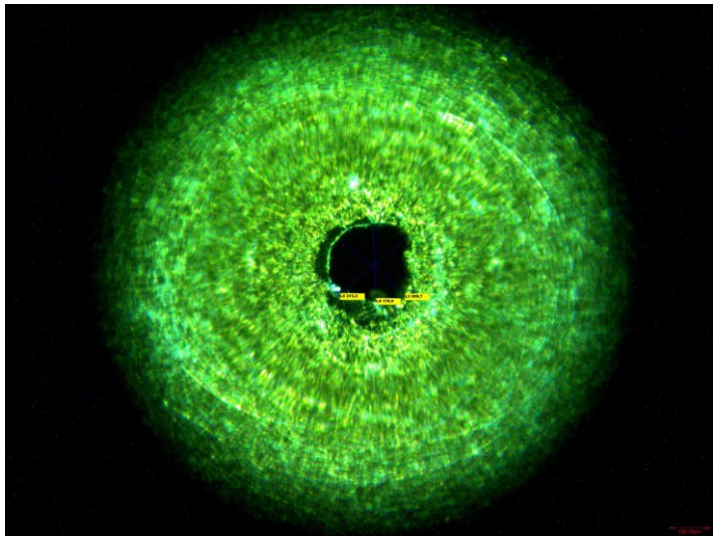
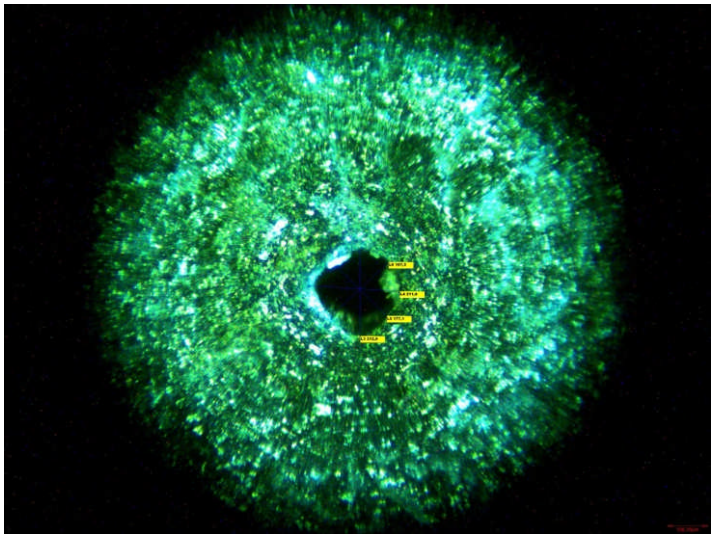
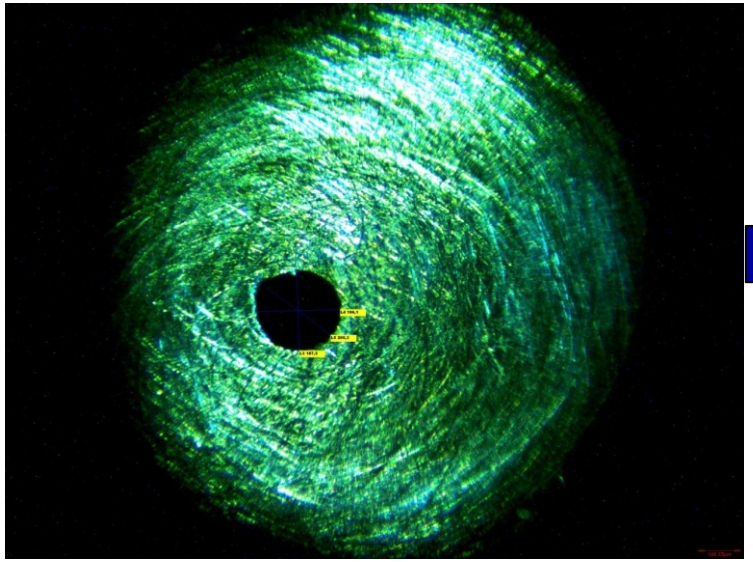
Material testing – corrosion / abrasive wear



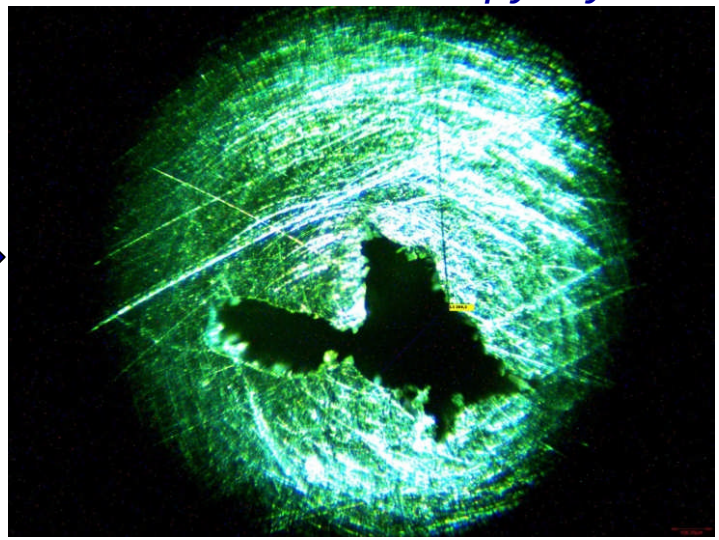
Material No 2 - New



After 400 hrs contact with pyrolysis oil



Material No 1 - New



After 27 hrs injection with water/diamond powder;

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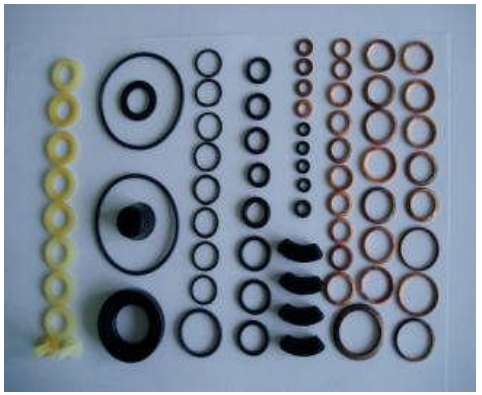
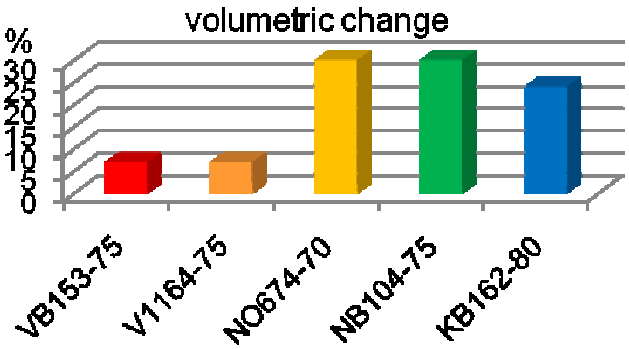
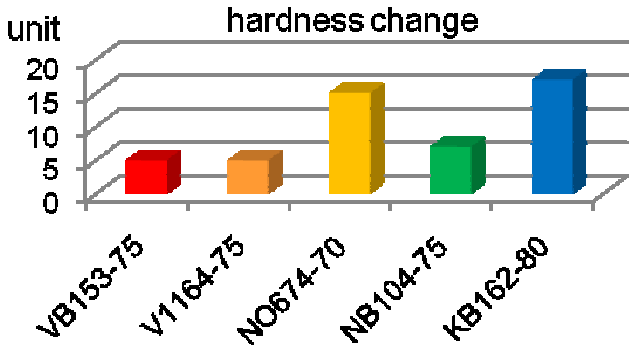
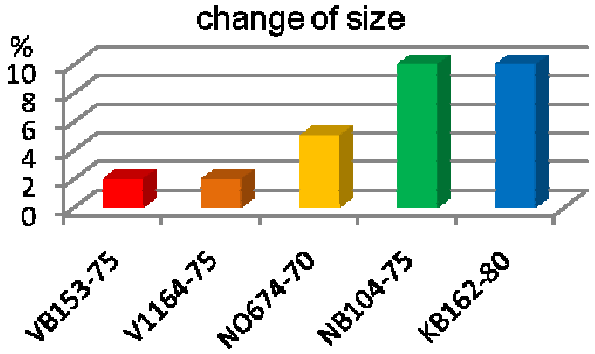
Material testing for for sealings

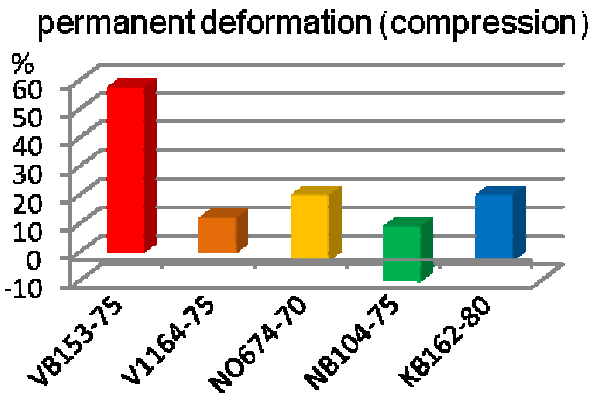
Influence of biofuel on various elastomers

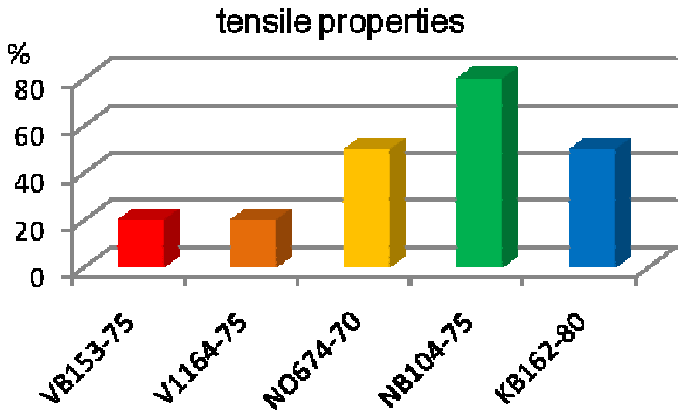












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Engine development

Tested Engine at NAMI with an electric power generator.

View of the 120 kWt load testing bench for testing the engine with the generator

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Emission reduction and control

- ***WP-leader:*** **BIC**
- ***Partners involved:*** **NAMI, ZIL**
- ***Objectives - activities***
  - Development of catalysts and a system for emission reduction and control – in particular NOx – for exhaust gases from engines and turbine for CHP units in the capacity range of 50 – 1000 kWe
  - Catalysts screening
  - Catalysts testing & selection
  - Catalyst manufacturing and system development

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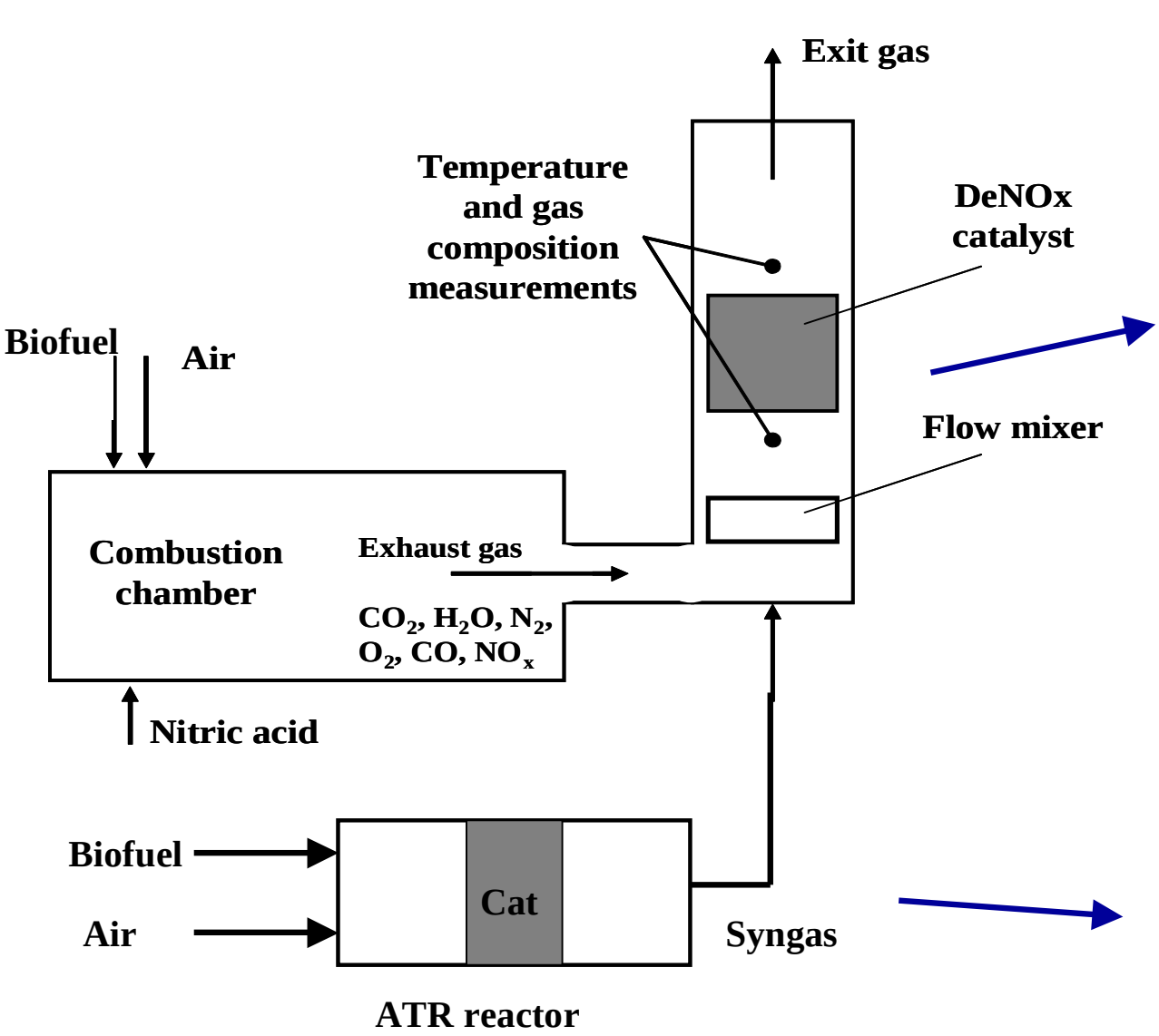
Schematic diagram and photo of NO_x SCR reactor



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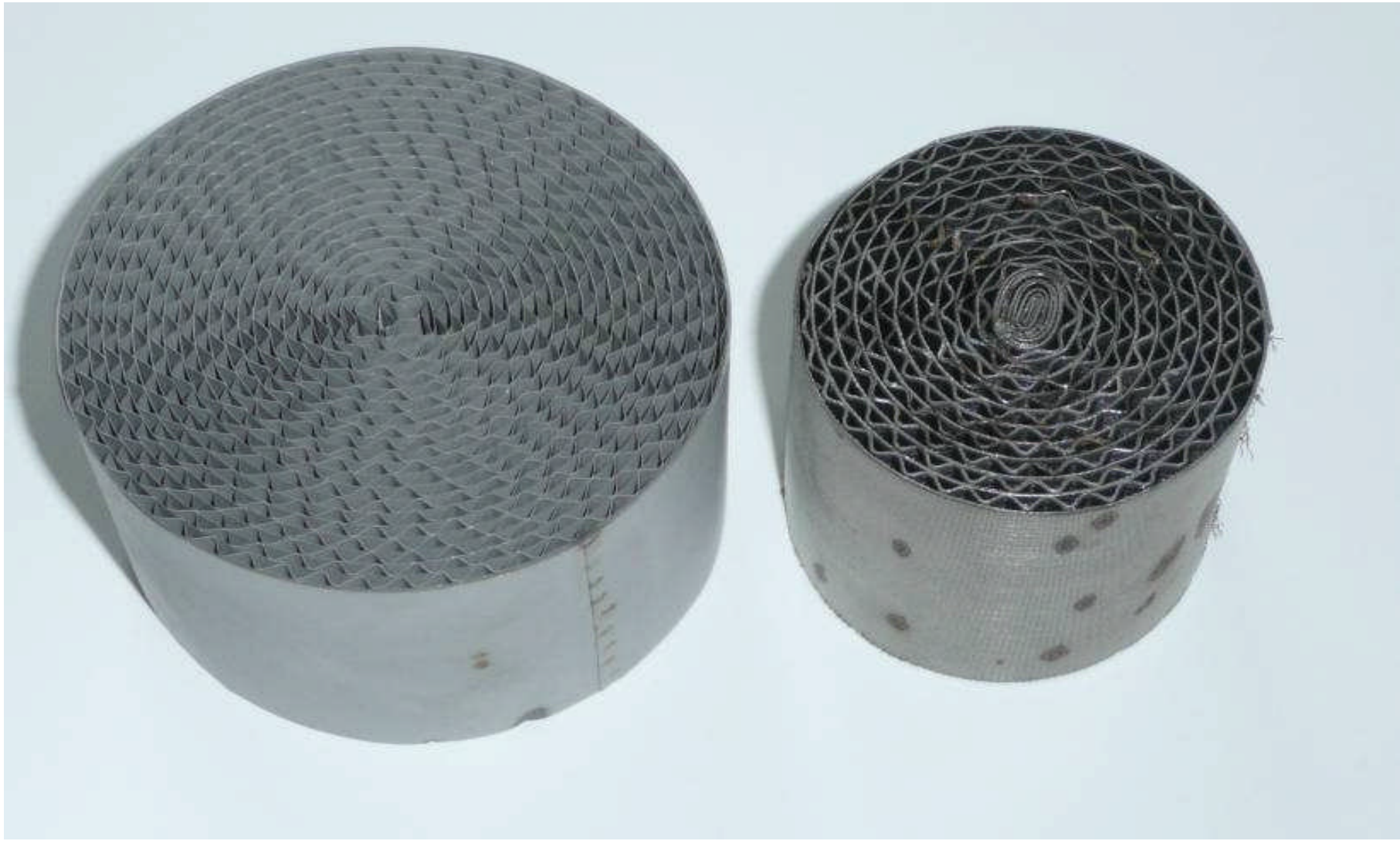
Samples of Monolith Catalyts for ATR of Biofuel



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DeNOx Catalyst (Ag/Al2O3)

Name of Parameters	Standard
Catalyst outwards: - color - form	 cream Spherical
Diameter, mm	2,5 - 2,8
Internal surface area, m^2/g	190 - 210
Pore volume, sm^3/g	0,55 - 0,70
Ag concentration, %	1,5 - 2,3
Density, g/l	500-600
GHSV	15 000 h^{-1}
Volume of catalyst preparation	40 liters

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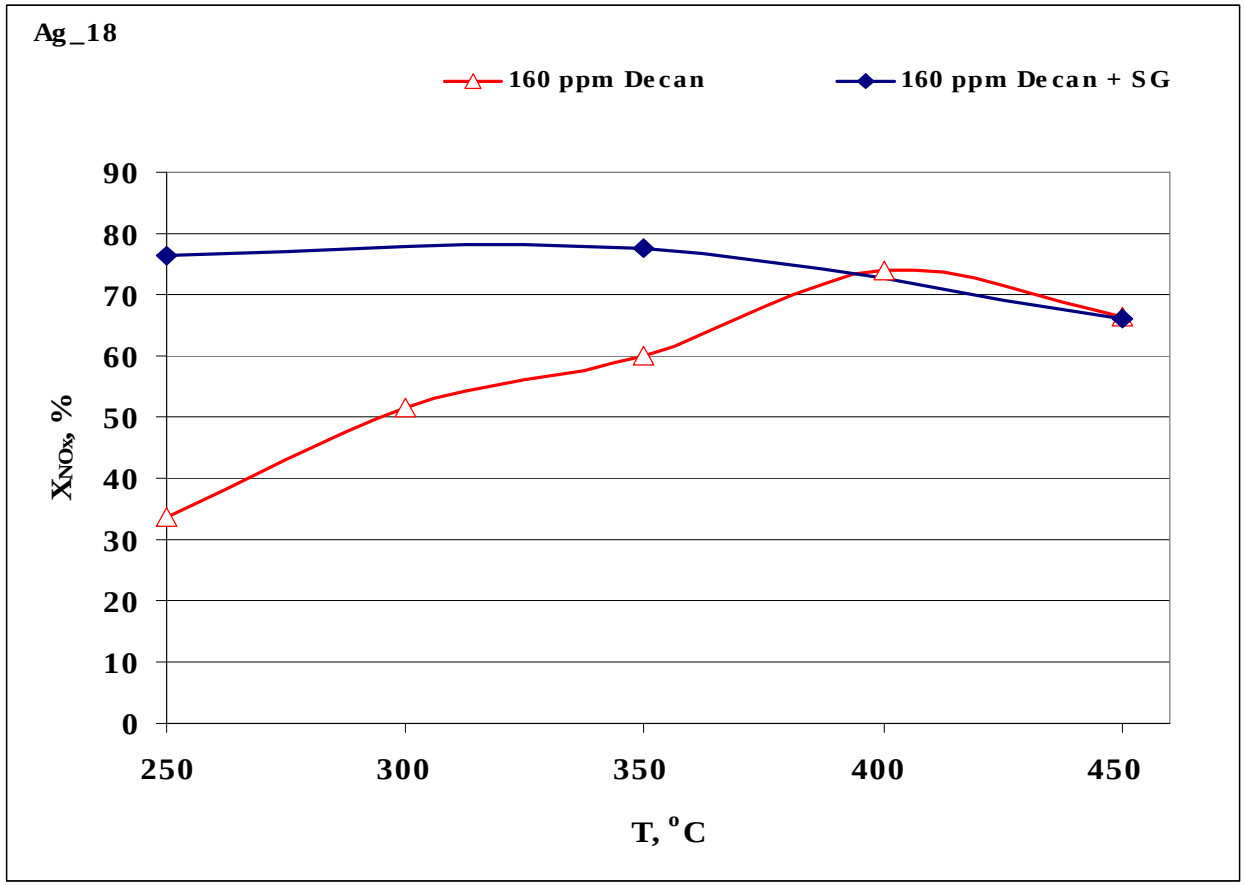
Conversion of NOx *vs temperature* during reduction by decane, and decane+syn.gas mixture.



Conditions of lab scale testing: catalyst Ag-18, GHSV = 13300 h-1, [NOx]o = 460 ppm, [O2]=10%, [CO]o= 930 ppm, [H2]o = 3200 ppm, [H2O]o = 2 %, [C10H22]o = 160 ppm,

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Techno-economic assessments and market opportunities

- ***WP-leader:*** **Aston**
- ***Partners involved:*** **BIC, NAMI, ZIL**
- ***Objectives - activities***
  - Techno-economic and environmental assessment of CHP-units fuelled with bioliquids, and identification of market opportunities
  - State-Of-The-Art review on CHP-units in Europe and Russia
  - Performance and cost assessment
  - Environmental assessment
  - Identification of market opportunities for CHP-units in the capacity range of 50-1000 kW_e for both Europe and Russia

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Summary - Conclusions

- ✓ The project is exploring the production, upgrading and use of PO in engines an turbines through an International (EU-Russia) collaboration
- ✓ Preliminary results have already given first insights on the topics
- ✓ Larger batches of PO are under preparation, and technologies are currently being converted to biofuels (biodiesel, pure VO, PO)
- ✓ The next year full tests will be carried out

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Acknowledgement

This co-operative research project is financially supported by the Seventh Framework Programme (FP7) of the European Commission & the Russian Federal Agency of Science and Innovation (FASI).

SEVENTH FRAMEWORK PROGRAMME

Ministry of Education and Science of the Russian Federation

Federal Agency of Science and Innovation


Thanks for your attention !
www.bioliquids-chp.eu