DIESEL FUEL VIA THE CATALYTIC DEPOLYMERIZATION

Transformation of wastes material in Diesel, water and fertilizer

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1. **Introduction**  
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   1.2 Solution  

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1. INTRODUCTION

Inventor Dr.-Ing. Christian Koch
Born in 1940 since 1967 in Franken (germany). Studied Process/chemical engineering
3 years associate professor at the engineering school then Research center Siemens
Since 1973 KWU Erlangen (Brokdorf/Grohnde, Licensing and approval processes EVA), Development
New Energies from waste materials, Gasification and start of the oil transformation technology.
Since 2003 Alphakat GmbH with the „Frik tionsturbinen-Verö lungstechnik KDV“
Construction of the plants Mexiko, Kanada, Hoyerswerda and Constanti/Tarragona (KDV 1.000)
Since 2009 Development of new High performance turbines for a broad application spectrum (150 to 5.000 l/h Diesel)
1. INTRODUCTION
1.1 Problems

- More and more waste
- CO2 rise (burning)
- Methane rise (combustion)

Heat production rise

Example CO2 rise diagrams
1. INTRODUCTION
   1.1 Problems

Waste
CO2
Dioxines
Methane
Heat

Fuel problem
Energy
Consumption

Limited fossil fuel resources
Rising energy consumption
Rising relevance of alternative energy sources

Global Oil production

Energy by source

WEO 2006

OECD North America
Middle East
Africa
Latin America
Transition Economies
OECD Europe
OECD North America
1. INTRODUCTION
1.2 Solution

[19:43:10] Oliver Hartmann (TMT Factory): Accelerating 300 million years of the nature to 3 minutes with Alphakat
100% crystalline catalyst instead of minerals
280 – 330 °C max temperature instead of natures 4°C

BY NATURE:
300 Mill. years

BY ALPHAKAT:
3 minutes

Step1
Conversion organics to bitumen with minerals and extraction of oxygen in form of CO2

Step2
Depolymerization from bitumen to oil

Step3
Depolymerization from oil to Diesel

Step1
- Mixing: Catalyst mixed with material.
- Adsorption: Docking of the catalyst on material
- Reaction: New formation of hydrocarbons (diesel)

Step2
Splitting catalyst from diesel

Step3
Distillation of diesel and water from catalyst oil
1. INTRODUCTION

1.2 Solution

+ production of diesel or production of electric energy (peak power)
+ production of destilled water
Selfsufficient production process:
No additianal water needed
Uses aprox 10% of the diesel produced

- + no dioxins
+ no CO2 (CO2 is recycled except for the exhaust of the generator)
+ all waste can be converted (except for glass, metal, porcelan, stones)
+ low temperature/pressure process (low risk)
+ heat is re-entered in the dehydration process (no heat pollution)
The plant does not have a chimney
2. MAIN CHARACTERISTICS

Inputs – Material
MSW (municipal solid waste)
All Plastics
Animal waste
Mineral oils
Sewage Sludge
Agricultural waste
Biomass cut material

Output
Diesel fuel
Destilled water
Ash = fertilizer (1-3%)
CO2 (re-entered in the process)

Advantages:
• No emissions
• No usable material necessary for the input
• Efficiency (regarding the hydrocarbon content 65-90%)
  pending on the waterparts of the input material
• No temperature pollution with 300 degrees isolated in the production process

Application
• Fuel (diesel, cars, jet fuel)
• Generator fuel for electricity (Peak Load)
• Chemistry

Conclusion
Changes convertible material into non-convertible material as a energy storage medium
2. MAIN CHARACTERISTICS
2.1 Technology comparison

Conventional processes
- Waste combustion
- Waste gasification
- Pyrolysis

Chemical processes
- KDV (catalytic de-polymerization)
- Magnesium or aluminium silicate
## 2. MAIN CHARACTERISTICS
### 2.1 Technology by emissions 1<2

### Oil- and plastic residues

<table>
<thead>
<tr>
<th>Emissions</th>
<th>Combustion</th>
<th>Gasification</th>
<th>Pyrolysis</th>
<th>ALPHAKAT</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CO2</strong></td>
<td>100% - no firing added</td>
<td>80% - no FT-loss</td>
<td>50% - no methane consumption</td>
<td>10% - Own consumption</td>
</tr>
<tr>
<td><strong>remark</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Dioxin</strong></td>
<td>Allowable limit</td>
<td>Allowable limit</td>
<td>Exceeds allowable limit</td>
<td>No dioxins</td>
</tr>
<tr>
<td><strong>Resins</strong></td>
<td>none</td>
<td>Very problematic</td>
<td>Very problematic</td>
<td>None</td>
</tr>
</tbody>
</table>

### Auto recycling material

<table>
<thead>
<tr>
<th>Emissions</th>
<th>Combustion</th>
<th>Gasification</th>
<th>Pyrolysis</th>
<th>ALPHAKAT</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CO2</strong></td>
<td>100% - no firing added</td>
<td>Not possible</td>
<td>50% - no methane consumption</td>
<td>10-20% - Own consumption</td>
</tr>
<tr>
<td><strong>remark</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Dioxin</strong></td>
<td>Allowable limit</td>
<td>n.a</td>
<td>Exceeds allowable limit</td>
<td>No dioxins</td>
</tr>
<tr>
<td><strong>Resins</strong></td>
<td>none</td>
<td>n.a.</td>
<td>Very problematic</td>
<td>none</td>
</tr>
</tbody>
</table>
Domestic waste predried (no metal, glass or ceramic)

<table>
<thead>
<tr>
<th>Emissions</th>
<th>Combustion</th>
<th>Gasification</th>
<th>Pyrolysis</th>
<th>ALPHAKAT</th>
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<tr>
<td>CO2 remark</td>
<td>100% - no firing added</td>
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</tr>
<tr>
<td>Dioxin</td>
<td>Allowable limit</td>
<td>Allowable limit</td>
<td>Exceeds allowable limit</td>
<td>No dioxins</td>
</tr>
<tr>
<td>Resins</td>
<td>none</td>
<td>Very problematic</td>
<td>Very problematic</td>
<td>none</td>
</tr>
</tbody>
</table>

General impact: Energy Consumption

<table>
<thead>
<tr>
<th>Emissions</th>
<th>Combustion</th>
<th>Gasification</th>
<th>Pyrolysis</th>
<th>ALPHAKAT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy consumption</td>
<td>800-1500°C Depending on input material</td>
<td>750-950°C Depending on input material</td>
<td>450-950°C Depending on input material</td>
<td>280-300°C</td>
</tr>
</tbody>
</table>
3. SYSTEM FUNCTIONALITY

3.1 Plant Summary

- SLUDGE PLANT
- KDV PLANT
- ASH PLANT
- GENSET PLANT
- OPTIONAL DESULPHURATION PLANT
3. SYSTEM FUNCTIONALITY

3.2 Inputs and feedstock

INPUTS
- MSW (municipal solid waste)
- All Plastics
- Animal waste
- Mineral oils
- Sewage Sludge
- Agricultural waste
- Biomass cut material

FEEDSTOCK
- Particle size: Max 25mm diameter
- Humidity: Max 20% weight
- Inorganics: Max 5% weight
- Calorific value
- Optimal mix (biomass content)
- Ash content

WASTE TREATMENT

OUTPUT
- Diesel quality 65 “Cetan” (20% more efficient compared to the diesel of a regular gas station)
- Lower freezing point aprox. -60 Cº
- Distilled Water
- 1-3% ash (fertilizer) binds hazardous materials

PRODUCTION:
- 1,2 t biological mass = aprox 500L diesel depending on the water saturation.
- NO chimney necessary
- NO heat pollution
- NO Methane / CO2
- NO Dioxine
3. SYSTEM FUNCTIONALITY

3.3 Production

PROCESS (after feedstock Input)

Process 1: Mixing, Adsorption, Reaction:
- Mixing: Catalyst mixed with material.
  - Motor (consumption 3-10% of production) a diesel or electric motor or a gas turbine is used (helicopter)
  - Turbine creates heat via friction of high speed revolutions
- Adsorption: Docking of the crystalized ion-exchanged catalyst on the molecular bindings of the material
- Reaction: Molecular bindings are broken and formed new into saturated hydrocarbon molecules without Oxygen

Process 2: Desorption
Hydration and splitting of the catalyst from the diesel, water and ash

Process 3: Evaporation
Destillation of the diesel and water.
- Diesel pumped in Tanks for quality control
- Catalyst refreshed

Process 4 (optional): Hydrofiner separates sulphur residues if necessary

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>SIZE</th>
<th>PLANT DIMENSIONS*</th>
</tr>
</thead>
<tbody>
<tr>
<td>PH9</td>
<td>150 l/h</td>
<td>500 l/h = 25 x 25 x 10 m</td>
</tr>
<tr>
<td>Depression 0,5 bar</td>
<td>500 l/h</td>
<td>2000 l/h = 50 x 50 x 30 m</td>
</tr>
<tr>
<td>Temp. Max 320 C°</td>
<td>1000 l/h</td>
<td>5000  l/h = 100 x 100 x 30 m</td>
</tr>
<tr>
<td>No chimney</td>
<td>2000 l/h</td>
<td>(*) without transport, storage or separation logistics</td>
</tr>
<tr>
<td></td>
<td>5000 l/h</td>
<td></td>
</tr>
<tr>
<td></td>
<td>modular</td>
<td></td>
</tr>
</tbody>
</table>
3. SYSTEM FUNCTIONALITY
3.4 Production benefits and highlights

**BENEFITS**

- The technological reproduction of the natural crude oil synthesis is *accomplished within minutes*
- Synthetic fuel can be produced at *competitive prices*
- The quality of ALPHAKAT-Diesel fuel is better than the EU-standards for conventional diesel fuel.
- No environmental pollution. The technology binds inorganic harmful substances in salt induced by the ionic changing characteristics of the catalyst.
- Environmental protection becomes a source of energy and jobs.

**HIGHLIGHTS**

- The ALPHAKAT process can use all materials containing hydrocarbons with reduced content of water and inorganics
- The efficiency is regarding to the low reaction temperature (280 – 320ºC), and high conversion rates (about 65 – 85 %)
- The plant does not produce coke and needs no cleaning system.
- The plant has not heating systems. The heat is coming from the friction in the turbine avoiding hot surfaces that can ignite materials.
- The vacuum controls the safety of the plant and the input system
- The residue is produced in solid form and offers the opportunity for the recycling of the catalyst
- The consumption of the catalyst is very low and the cost of the process is very competitive.
3. SYSTEM FUNCTIONALITY
3.5 Production Hoyersweda

Input: 1670 kg Müll
       35 kg Kathalysator
       150 kg Kalk

Output: 100 kg für Ascheanlage
         600 l Wasser
         1200 l Diesel

production 11.03.2009
4. SCENARIOS
4.1 Industrial installation MSW Tarragona

Characteristics:
• Recyclable plastics are separated and sold
• Organic waste is pre-composted (dehydrated)
• Diesel generators to create electricity to operate all components and vehicles of the plant
4. SCENARIOS

4.2 Example installation biomass waste

Characteristics:
- Modified feedstock preparation process
- Lower feedstock preparation cost

Examples:
- Sugar cane residues, sewer sludge, contaminated/oily soil/sand, “biofuel” plant mass, mineral oil residues, etc.

1. Plant building with control center and electricity generators
3. Alphakat Plan with connection to diesel tanks.
Biomass examples:

- Sewer sludge
- Forrest waste
- Agricultural waste
- Energy through photosynthesis
  "biofuel-" plants as source of feedstock
  ▫ Plant deserts and cities with new type of plants as “Jatropha” having roots up to 10 m.
  ▫ Harvest the plants without destruction and without implications on the food chain.
  ▫ Create new jobs in planting, harvesting and conversion in diesel
  ▫ Create social structures

4. SCENARIOS
4.2 Example installation biomass waste

- Jatropha
  - 1000 has.
  - 8,000 tons Diesel per year

- Sugar cane waste
  - 1000 has.
  - 9,000 tons Diesel per year

- Palm oil waste
  - 1000 has.
  - 7,000 tons Diesel per year
5. ECONOMICAL FIGURES

5.1 Break Even global

<table>
<thead>
<tr>
<th>TRESORY/DEBT</th>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
<th>Year 4</th>
<th>Year 5</th>
<th>Year 6</th>
<th>Year 7</th>
<th>Year 8</th>
<th>Year 9</th>
<th>Year 10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cash Flow period</td>
<td>2.261</td>
<td>2.244</td>
<td>2.226</td>
<td>2.207</td>
<td>2.186</td>
<td>2.165</td>
<td>2.142</td>
<td>2.118</td>
<td>2.093</td>
<td>2.066</td>
</tr>
<tr>
<td>Working capital</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Cash Flow accumulated

Long term loan Balance
5. ECONOMICAL FIGURES
5.2 Break Even per hour

Breakeven: 1,120 liters/hour (62% expected production)
APPENDICE A: CO2 CALCULATION

Chemistry of this process:

Nature formed the petroleum in 2 steps:

- CO2-Extraction from dead animals and plants to withdrawal the total oxygen content of the biomass and through that transfer or convert perishable matter to imperishable oils and

- Depolymerisation of long molecules to shorter molecules, also from Bitumen to Oils, Diesel and finally also to lighter hydrocarbons, like gasoline and natural gas.

The removal of the oxygen content in form of CO2 and not H2O, as it happens in thermal technical processes, is given through the low conversion temperature of the natural process. This is being realized in the complete temperature range during the formation of the petroleum till the conversion temperatures of the KDV technology which are below 300°C. Due to this process, not only complicated biological matter, as for instants the cellulose structure into Alkanstructure, transferred, but rather a hydrogen excess is produced, which is technically utilized in the KDV.

Cellulose can for example for the hydration of technical, unsaturated hydrocarbons, as technical oils, plastics and rubber deliver the nascent hydrogen after the reaction:

\[
\text{Cellulose} + \text{technical oils} = \text{saturated hydrocarbons, therefore } 4 \times \text{C6H11O5 (cellulose)} + \text{C50 H92 (unsaturated technical oil)} = 4 \times \text{C16H34 (diesel/kerosene)} + 10 \text{ CO2S. this example from 1 ton celluloses } + 1.06 \text{ tons of starkly unsaturated oils} = 675 \text{ kg of CO2} + 1,385 \text{ tons of high-value Alkandiesel shows the need for the input matter, namely}
\]

- for the feeding of technical waste from plastics, rubber and technical oils or oil wastes is the addition of nascent hydrogen from biomass necessary. There nature helps us because all biomasses in the KDV reaction releases more or less hydrogen.

- In feeding only biomass one gets a high great product of satiated hydrocarbons of the middle distillate area (shortly call diesel). The during this process produced hydrogen reacts with a part of the oxygen to reaction-water and the CO2 production is lesser for that amount.
APPENDICE A: CO2 CALCULATION

The KDV reaction is therefore always
1. a diffusion catalytic new formation of the molecule structure
2. with the extract ions of the oxygen content as a CO2,
3. adsorption of the molecular fine catalyst through Antransport with the catalyst oil at the brought hydrocarbon mass
4. without Koksablagerung
5. without Dehydrierung
6. without resin material development
7. in a continuous process
8. under development of satiated hydrocarbons
9. under avoidance of Olefinen
10. under avoidance of aromas and therewith the possibility of dioxin or Furanbildung
11. in the ion exchange removing of the acids halogens and sulfur and
12. regeneration of the catalyst with chalk

In the reaction steps of the KDV
1. entry systems
2. before process technology of the transformation of the festival materials into a pulp under complete draining (PN200 - 220°C)
3. KDV process with "friction turbine" under release of the hydrocarbons as a means distillate and the remaining CO2-Menge and
4. ash plant to the Limitierung of the salt salary and the not marketable inorganic materials in the KDV (metal, glass, ceramics, stones) and
5. in request after desulfurization (Hydrofiner)
**APPENDICE A: CO2 CALCULATION**

**Example cellulose:**

KDV: \( \text{C}_6\text{H}_{11}\text{O}_5 = 2\ \text{CO}_2 + 1\ \text{H}_2\text{O} + \text{C}_4\text{H}_9 \), therefore 163 kg of cellulose = 88 kg of CO2 + 18 kg of water + 57 kg of satiated hydrocarbons

Combustion of 57 kg KWS = 176 kg of CO2 + 81 kg of water,

therefore

1 t cellulose = 539 kg of CO2 (275 M3 CO2) + 111 kg of water + 350 kg of diesel

Combustion:

1 t cellulose = 1860 kg of CO2 (948 M3 CO2) + 610.5 kg of steam

KDV: 1 ton of cellulose + 1.06 rubber or strongly unsaturated oils = 675 kg of CO2 + 1,385 tons of Alkandiesel

Combustion of this mixture: = 5,028 tons of CO2 + 1,781 tons of steam

**Tabular comparison of KDV and Combustion:**

<table>
<thead>
<tr>
<th>Material</th>
<th>CO₂ KDV</th>
<th>Water KDV</th>
<th>CO₂ Combustion</th>
<th>Steam of Combustion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cellulose</td>
<td>29 %</td>
<td>18 %</td>
<td>100 %</td>
<td>100 %</td>
</tr>
<tr>
<td>Cellulose + Rubber or Bitumen</td>
<td>13,4 %</td>
<td>0 %</td>
<td>100 %</td>
<td>100 %</td>
</tr>
</tbody>
</table>