“Triple Win”

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Two options

A: “Single”

Water/mineral treatment

B: Integrated “ Triple” :

- Separation
- Oil viscosity decrease
- Water/minerals treatment

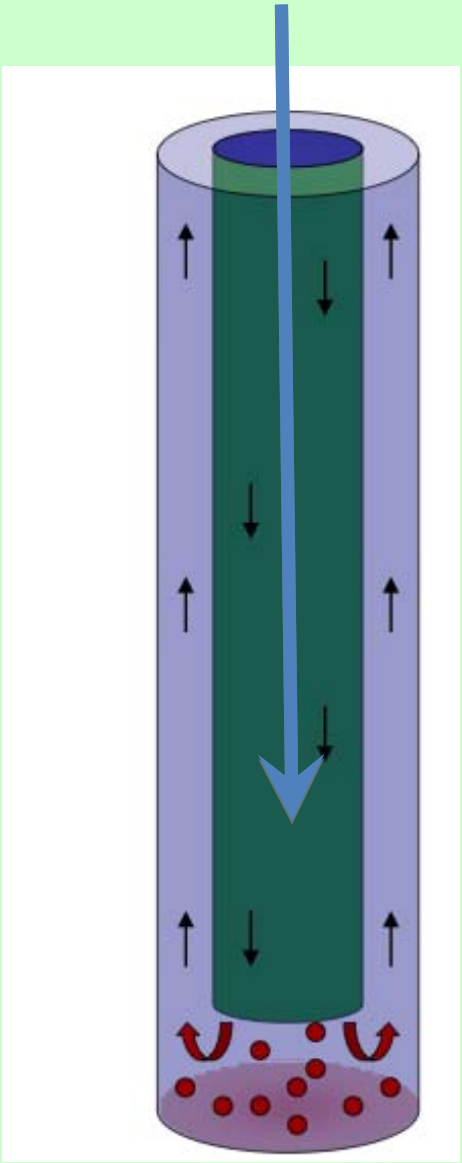
B: Residue treatment

Vertical Tube Reactor

- **Schematic**:
  - 0. Heat incoming residue
  - 1. Oxygen addition
  - 2. Oxidation
  - 3. Effluent

Detail reactor

0 m



1200 m

Length:
- Heat exchanger
  Pre heating input material

Oxygen:
- Energy production

Depth:
- Maximum pressure

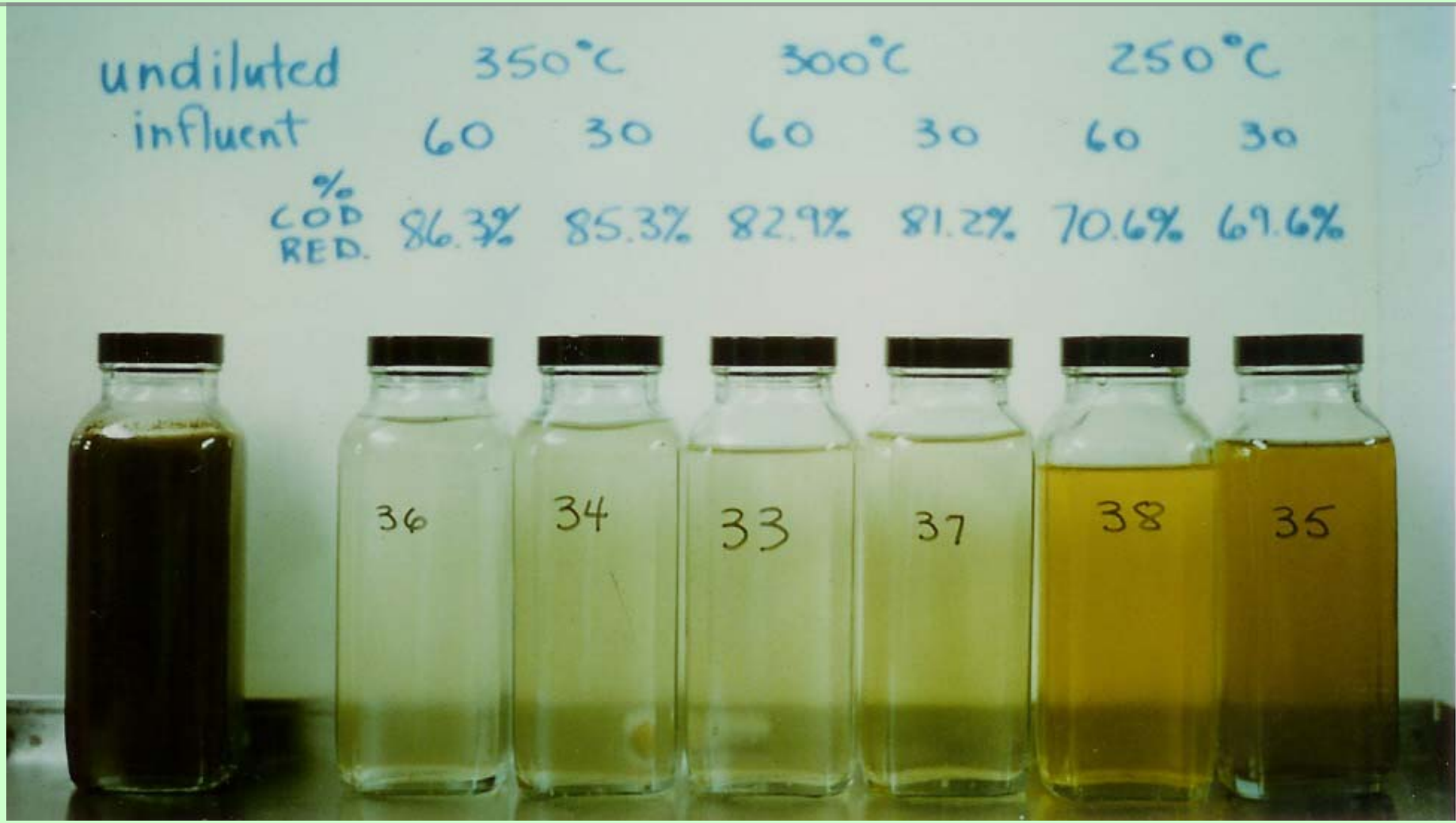
Upflow:
- Heatexchange
  incoming material

Plant Apeldoorn

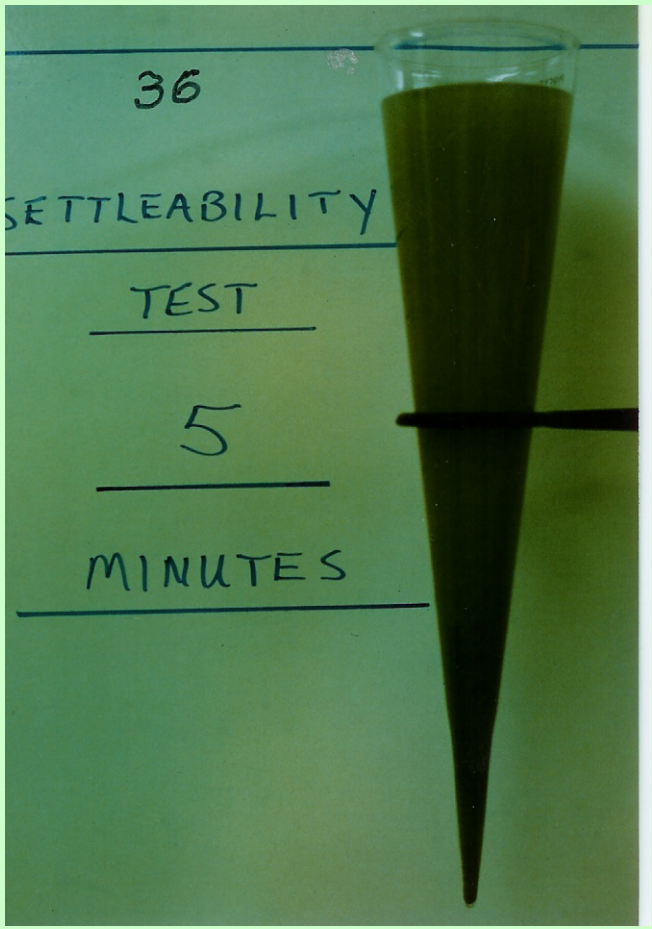
Vertical Tube Reactor

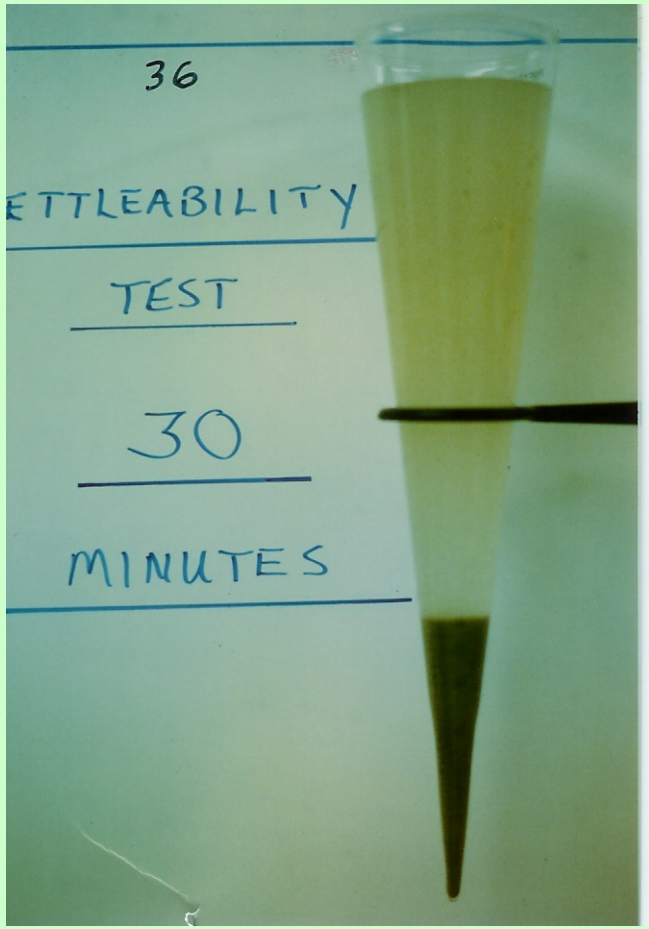
- Experience:
  - Sewage sludge:
    120 m3/hr, 5% DS, 50% TVS
    Yearly 550.000 m3/yr, 10 years
  - Chemical waste
  - Harbour sludge
    160 m3/hr (organics, settlement)
- Tested:
  - Various streams
  - Oil sand residue

3. Residue treatment



3. Residue treatment





Capacity

- Proven up to 140 m3/hr (for 7 5/8”)
- Upscaling possible, up to 1.000 m3/hr
  (est. diameter DownComer 16”)
  Total well bore: 40”

- Costs depending on:
  - Scale, COD load, final treatment, energy price etc.
- Estimated price t.b.d.

Comparable processes

Process	Wet Air Oxidation	CO2 Energy Reactor	Oil sand tailings
Application	Slurry waste treatment	CO2 sequestration	-Residue treatment
Depth	1200 meter	≈ 1200 meter	≈ 1200
Diameter	24 inch	24 inch	40 inch
Energy	10 MW(th)	11.8 MW(th)	100 MW(th)
Capacity	100 m3/hr	100 m3/hr	1000 m3/hr

Status processes

Process	**Wet Air Oxidation**	**CO2 Energy Reactor**	**Oil sand residue**
Experience	3 reactors > 10 years	Testing autoclave	Harbor sludge **Autoclave tests**
Patent	Due	Granted	Pending
Research	Private parties	University of Leuven (B)	Innovation Concepts
Test equipment	Available	Built	Available

“ Triple Win”

Integrated process

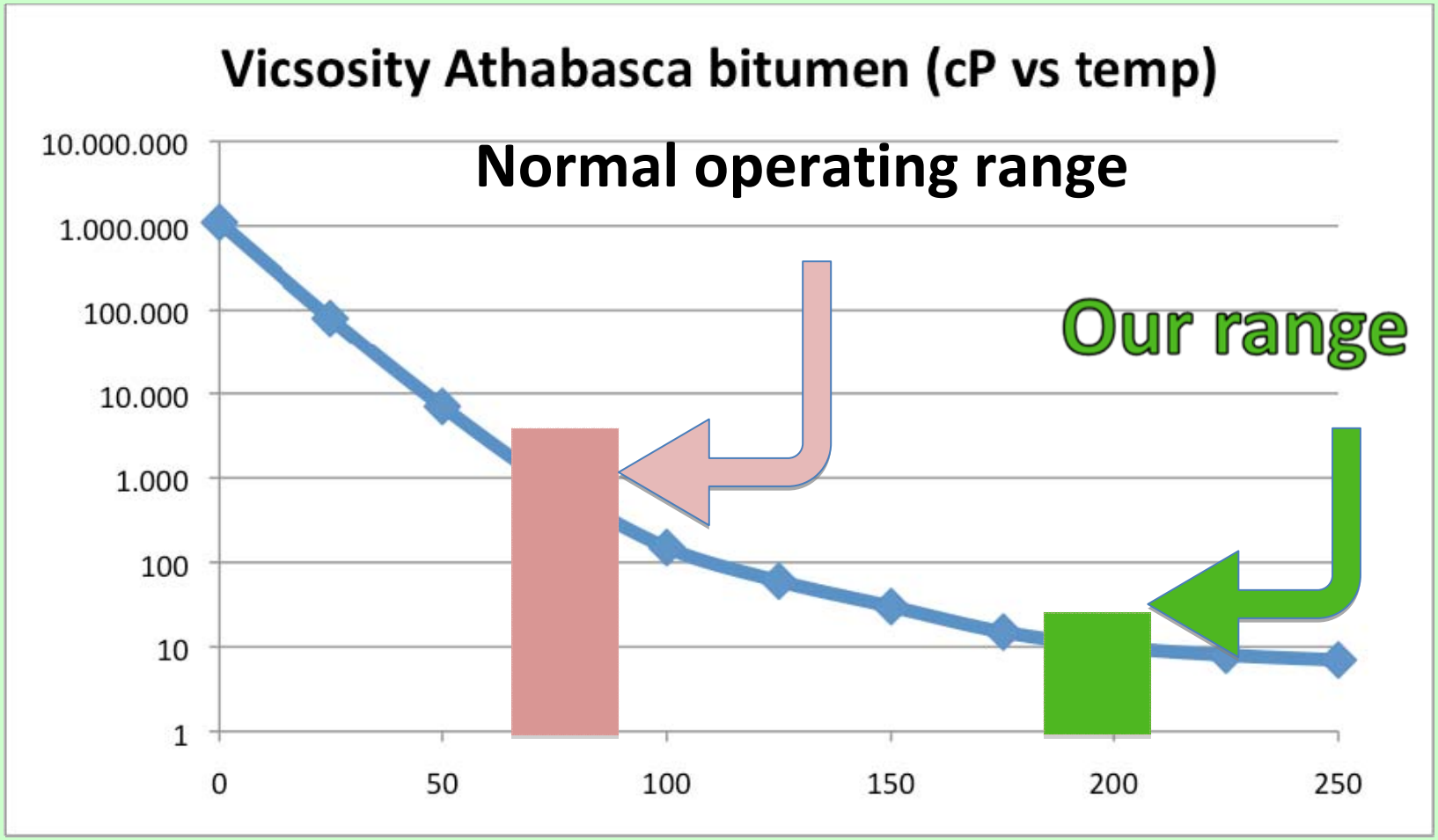
- Proposed process
  - Mining
  - Water addition
  - Mixing into slurry
  - Heating slurry
  - Separation
  - Residue treatment
  - Water reclamation
  - Disposal cleaner residue
  - Oil
  - Oil viscosity reduction

Integrated process

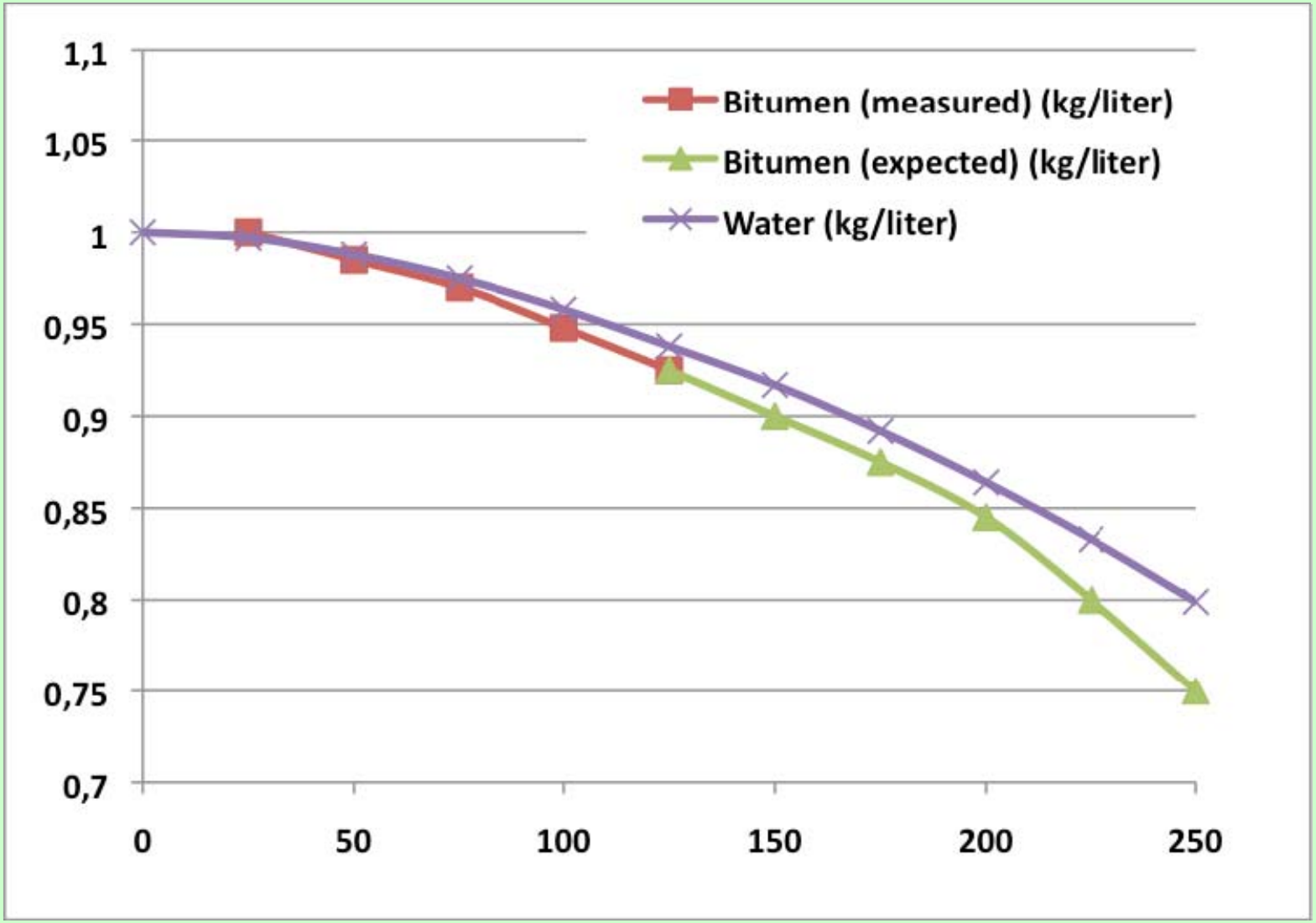
Vertical Tube Reactor

- Schematic:
  - 0. Heat incoming slurry
  - 1. Separation
  - 2. Oil:
    - Viscosity reduction
  - 3. Residue:
    - Oxidation

Viscosity temperature dependance



Density


1,1
1,05
1
0,95
0,9
0,85
0,8
0,75
0,7
0
50
100
150
200
250
Bitumen (measured) (kg/liter)
Bitumen (expected) (kg/liter)
Water (kg/liter)
Density (kg/liter)
Temperature (degrees Celsius)

1. Separation

- Using a hydro cyclone
  - Using difference in density
  - Higher temperature more pronounced
  - Higher temperature lower viscosity
- Experience comparable sizes
- Application (under higher temperatures and pressures) new

2. Oil Treatment

- Vis breaking
- Available literature
  - Literature & experience:
    breaking down long, cyclic chains

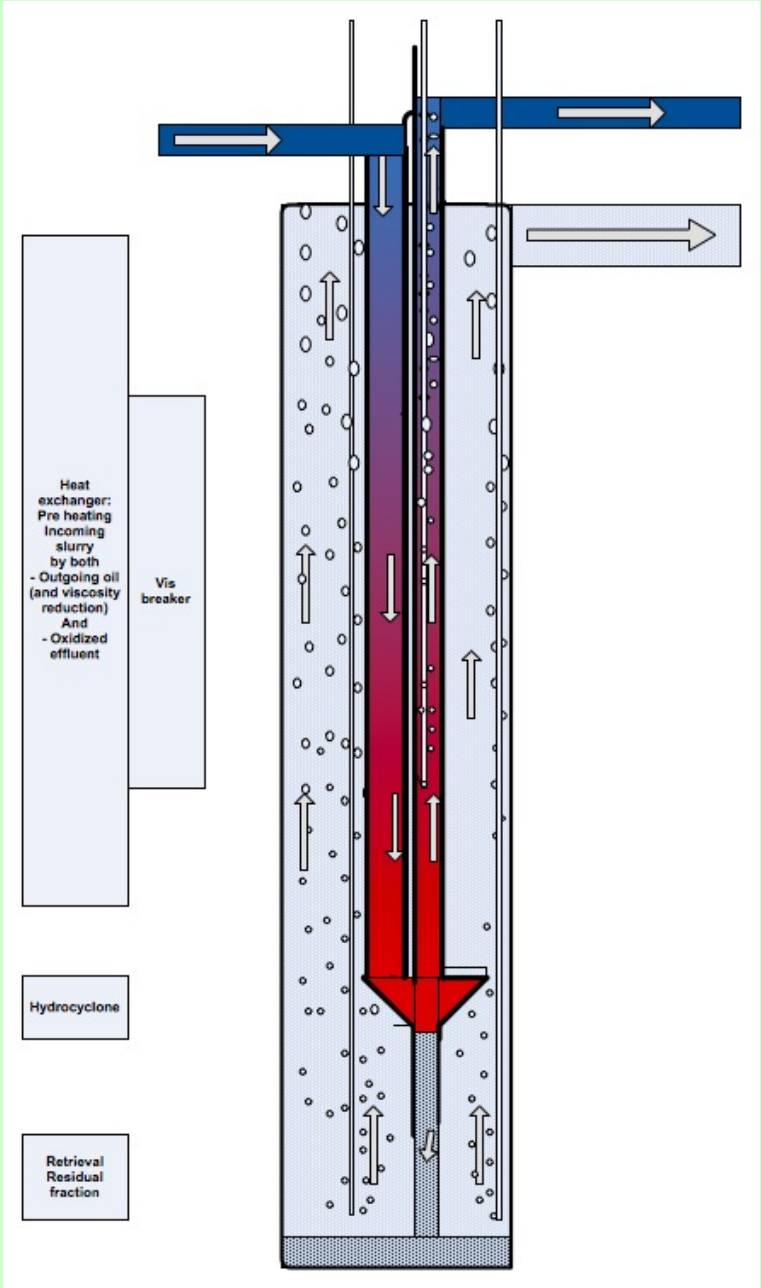
3. Residue treatment

- Currently “Tailings” sent to pond
- Addition extra oxygen
- Aim:
  - Energy production for maintaining the process
  - Oxidation of the residues (oil, metallic faction)
  - Settling residue fraction
- Tested in special autoclave

Vertical Tube Reactor

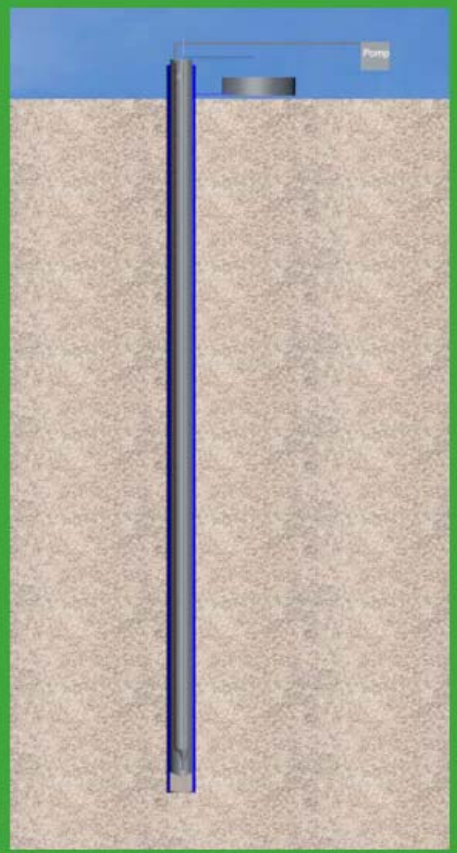
- Schematic:
  - Heat incoming slurry
  - Separation
  - Oil:
    - Viscosity reduction
  - Residue:
    - Oxidation
    - Settlement

Drawing


Heat exchanger: Pre heating Incoming slurry by both - Outgoing oil (and viscosity reduction) And - Oxidized effluent
Vis breaker
Hydrocyclone
Retrieval Residual fraction

Movie

Vertical Oil Sand Reactor®



Application for oil-sand industry:
Triple win:
- efficient extraction oil
- reduced viscosity
- cleaner residue

Innovation Concepts

Energy balance

- Assumptions:
  - 400 m3/hr, 25% TS, 10% oil sand, recovery oil: 90%
- Temperatures
  - inlet: 20° Celsius, separation 200° Celsius
  - **Energy required 66 MW(th)**
- Energy production: 7.4 MW(th)
  - Heat exchanger recovery: 90%
- CO2 emission: ≈ 40 kg/barrel

Advantages

- 1. Separation at much higher temperatures:

  Higher yields

  No chemicals
- 2. Integrated “Vis breaking” effect
  - To some degree
- 3. Integrated residue treatment
  - Cleaner effluent
  - No external energy
  - Effluent settles in solid fraction
- **Lower CO2 emissions**

Questions ?

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