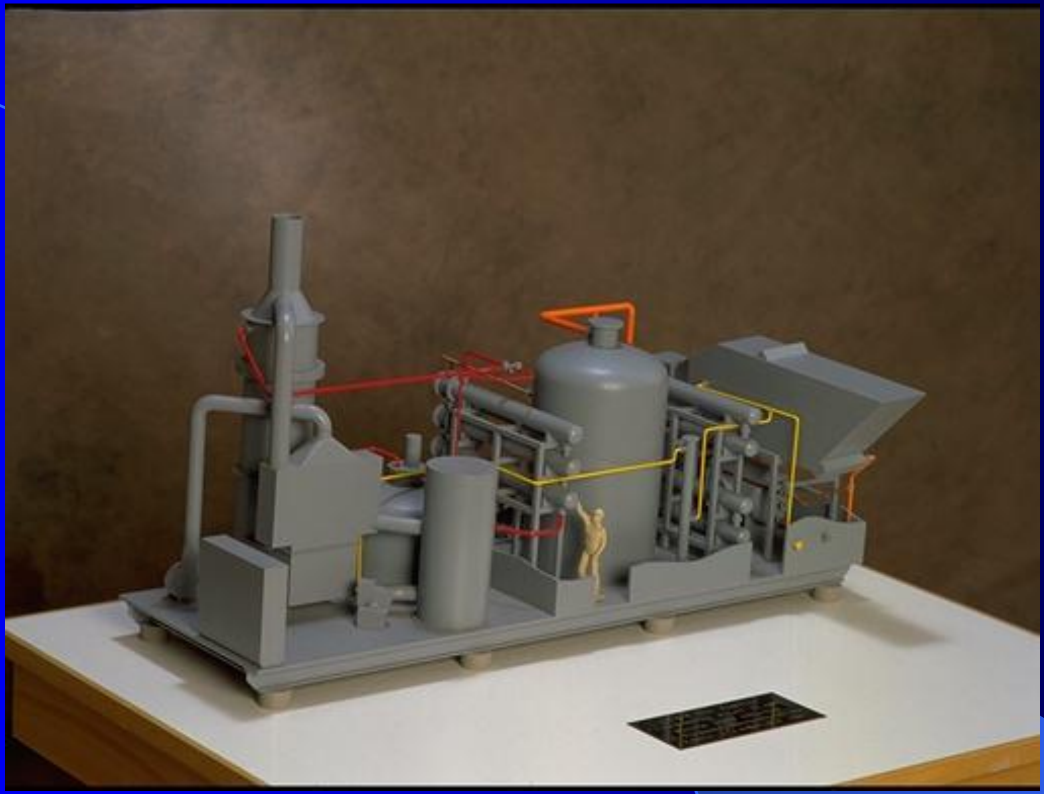
EADIEMAC Process for the Partial Upgrading of Heavy oil.



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Preamble

- Normally diluent is blended with heavy crude oil to meet pipeline viscosity specifications. By thermally changing the viscosity of the oil, near well sites, the oil may be transported with significantly less diluent. Where appropriate, the partially upgraded oil may be re-directed to a higher value product pipeline. Skid mounted units can be fabricated for higher volumes of say 10,000 bbls. per module.
- The **EADIEMAC Process** is a practical solution to the need for modular field upgrading units. The process is primarily engineered to thermally change heavy crude oil by visbreaking into a much lower viscosity higher value oil. Heavy oil producers may take advantage of the price differential between heavy and light crudes in the field and facilitate the transportation of heavy crude oil by pipeline locally and over long distances with less diluent in a cost effective plant.

Developers

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EADIEMAC Process Introduction

- Engineered to partially upgrade and reduce the viscosity of heavy oil/bitumen in field upgraders
- Reduces or eliminates the need for diluent to achieve pipeline viscosity specifications
- A low tech, relative to typical refinery processes, mini-refinery with low capital and operating costs
- More efficiently utilizes existing pipelines thus reducing the need for new pipelines both to markets and returning less diluent from markets
- Require a site for a demonstration plant

The Environmental Challenge

- As a practical consideration energy products, heavy oil/bitumen, will be required for the foreseeable future to maintain economic activity. The challenge is how to ship these products to market in a way that reduces or limits impacts to the environment, yet is economical for the energy producer.
- EADIEMAC partial upgrading plants make more efficient use of the existing field and national pipelines that ship energy products to market and return diluent via other pipelines to blending locations. Any reduction in the demand for pipeline capacity has a positive environmental outcome.
- Further, it is reported in studies that partial upgrading at or near the production source can reduce GHG emissions.
- The following technical presentation describes how existing product pipelines can move 20% or more heavy oil/bitumen economically while also reducing the need for diluent return pipelines.

The Development Strategy Stages #1 to # 10 are complete.

1. Concept creation and design piloting research plan
2. Design pilot plant and testing strategy
3. Secure samples of raw heavy oil-Cold Lake and Ft. Kent. Build pilot plant - ARC Nisku & Devon
4. Run a series of batch & continuous pilot tests up to 1.5 bbls/day
5. Analyse & report on batch & continuous test runs
6. Process Elk Point crude for a major energy company refinery test
7. Process/test in a 200 bbl/day #2 diesel plant, thermally cracked material, for a method to clean over cracked product (if required)
8. Translate pilot tests into a demonstration plant engineering design
9. Complete drawings of 1200-2000 bbl/day demonstration plant
10. Obtain final quotation from a fabricator to build the demo plant
11. Model process as a profitable commercial business (in progress)
12. Secure patent coverage for improvements to original patent
13. Build and test a field scale 2,000bbl/day demonstration plant

Topics

- **<u>Partial</u>** upgrading (no hydrogen, no coke)
- Viscosity objectives
- "Indirect" thermal reduction of viscosity
- Typical refinery equipment
- EADIEMAC Process flow diagram
- Value increase and cost reduction for site partial upgrading
- Partial upgrading v's diluent blending
- Project budget for a 1200-2000 bbl/day skid mounted unit
- Test results
- Breakeven analysis
- Key advantages – 1-3
- Current objectives

Partial upgrading (no hydrogen, no coke)

- No hydrogen thus low pressure - 50psi.
- H_2 is not required to achieve the objectives
- Focus on viscosity reduction with approx. 4 API change sufficient to meet viscosity objectives
- Simple system, low capital cost, ease of operation, minimal controls, low operating costs

Viscosity objectives

- ~350 Cp
- Depends on what you start with! 8 – 10 – 15 API
- 21 API not required if viscosity objectives met
- Viscosity has primary influence on pipeline power requirements

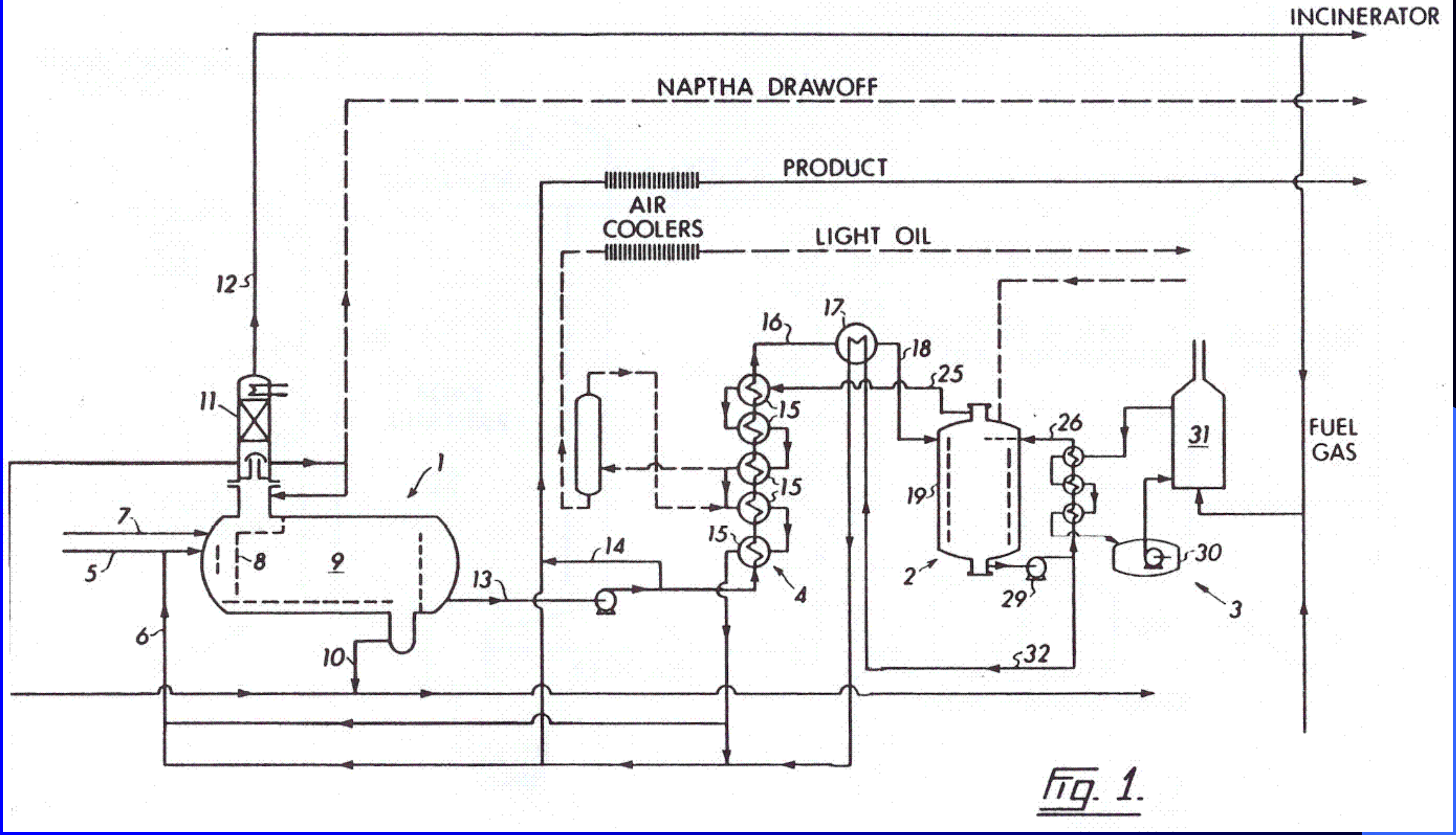
“Indirect” thermal reduction of viscosity

- High temperature eutectic salt
- Standard heater to melt salt
- **Uniform** application of heat around heavy oil in tube of shell & tube exchangers
- Known refinery type equipment operation
- Visbreaking is a well-established process

Typical refinery equipment

- Built in shop on skid, modules shipped to site to suit various volumes of feedstock
- Standard fired heater, shell and tube exchangers, soak vessel
- Dual exchangers, quick clean feed line
- High temperature pump
- Pneumatic/electronic controls
- 50 psi. ASME

EADIEMAC Process flow diagram



Value increase and cost reduction for site partial upgrading

- Incremental sales value
- SAGD natural gas cost reduction
- Eliminate diluent transport to and from SAGD site (pipeline, tankage, operations)
- Reduction in diluent premium net cost
- Reduction in transport volume cost
- Reduced pipeline requirements for diluent

Partial Upgrading v's Diluent Blending

Analysis of partially upgraded bitumen/heavy oil v's diluted bitumen.

Diluted bitumen/heavy oil scenario	**C$'s**	**2022 projected prices**			
Price of dilbit at Hardisty equivalent to WCS:	$46.43	minus $4.00 differential =	$42.46	minus $3.00 shipping to Hardisty =	$39.46
Price of condensate	$58.98	postings $0.50 premium			
		plus $5.00 transportation =	$64.48	price at wellhead	
Assume a 30%/70% blend					
Cost of diluent =		$64.48x0.3 =	$19.34		
Net to operator =		$39.46 - $19.34 for 0.7 bbl. =	20.12	so on a barrel basis =	$28.74
Partially upgraded bitumen/heavy oil scenario with 50% of diluent replaced					
Price of dilbit at Hardisty equivalent to WCS:	$46.43	minus $4.00 differential =	$42.46	minus $3.00 shipping to Hardisty =	$39.46
Price of condensate	$58.98	postings $0.50 premium			
		plus $5.00 transportation =	$64.48	price at wellhead	
Assume a 15%/85% blend					
Cost of diluent =		$64.48x0.15 =	$9.67		
Net to operator =		$39.46 - $9.67 for 0.85 bbl. =	29.79	so on a barrel basis =	$35.05
				Savings = $35.05 - $28.74	$6.31
Partially upgraded bitumen/heavy oil scenario with 100% of diluent replaced					
Price of dilbit at Hardisty equivalent to WCS:	$46.43	minus $4.00 differential =	$42.46	minus $3.00 shipping to Hardisty =	$39.46
Price of condensate	$58.98	postings $0.50 premium			
		plus $5.00 transportation =	$64.48	price at wellhead	
Assume no blending					
Cost of diluent =			nil		
Net to operator =			$39.46	so on a barrel basis =	$39.46
				Savings = $39.46 - $28.74	$10.72

Project Budget for a 1200 – 2000 bbl/day skid mounted unit

✓ $9m based on 2021 estimates and CESSCO/ALTEX quotes for the major equipment

- Notes:
- Incinerator not included
- Tankage and site not included
- Throughput varies with feed type – heavy oil or bitumen

Test Results

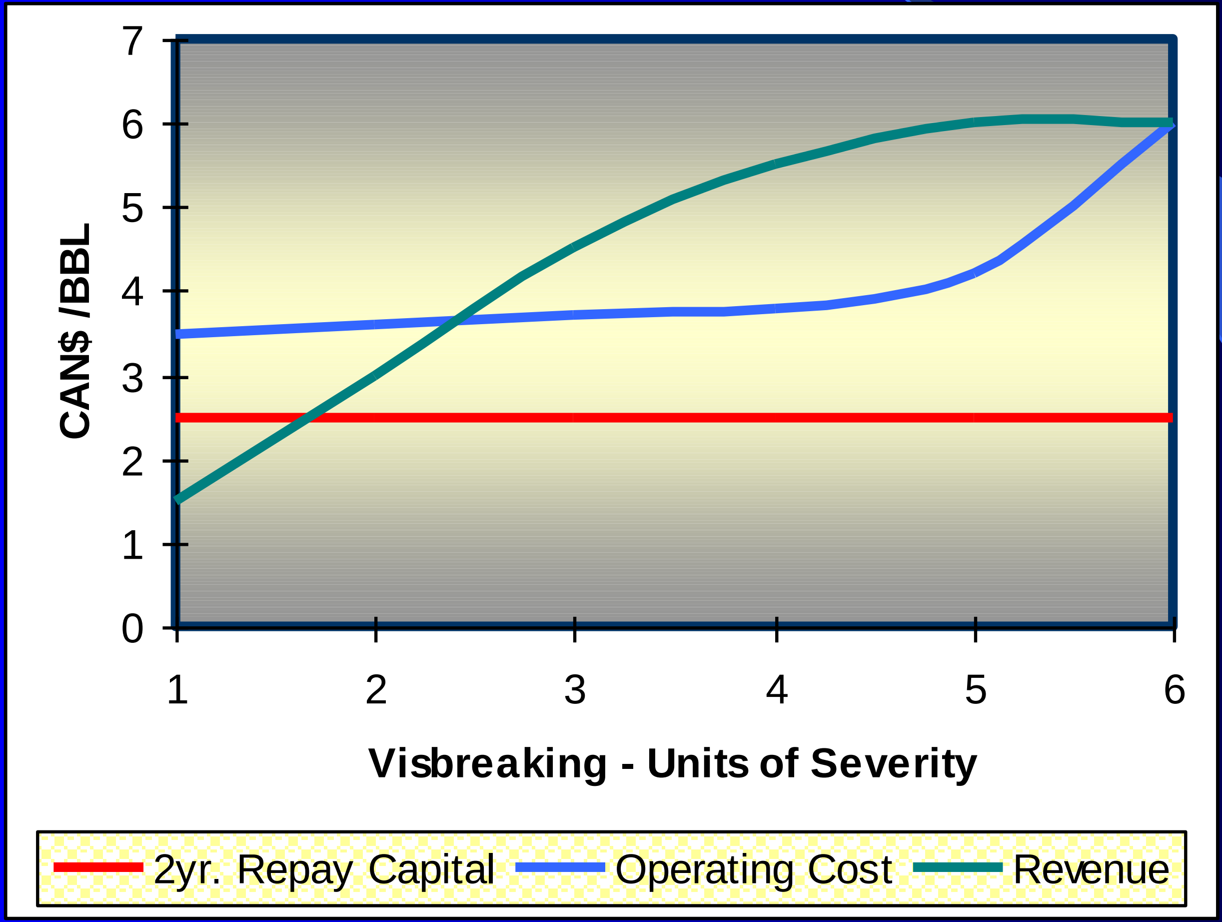
- Alberta Research Council tests.
- 200 bbl/day diesel plant second stage process result.

Fort Kent heavy oil test results

(Note: Click on link above to view.)

Breakeven Analysis

(Conceptual only – will vary by site. Revenue levels off and operating costs increase at highest severity as coke precursors start to form.)



Key Advantages - 1

- Accurately control salt temperature
- Uniform heat transfer through shell and tube exchangers
- Slowly raise temperature to achieve the degree of visbreaking required
- A higher bulk temperature can be used thus producing greater quantities of gas oil
- Uniform film coefficient to avoid coking
- Control oil pumping rate through tubes
- Easily control level, time and temperature in soak vessel to adjust to changes in feedstock quality

Key Advantages - 2

- Low pressure distillation of feed in the annular compartment of soak vessel thus saving a flasher unit and utilizing energy from visbreaking action
- Use of a soaker drum helps produce a stable residue product
- Incorporates quench of vapours from cracking exchangers
- No equipment internals in the high temperature flash zone
- Delays quench of liquid effluent until it approaches the perimeter of the soak vessel
- Good energy utilization

Key Advantages - 3

- Can incorporate dual high temperature salt/heavy oil exchangers and switch to avoid shutdowns for cleaning
- Can incorporate dual liquid/vapour effluent lines into soaker vessel with removable stainless steel liners to avoid shutdowns and ease of cleaning

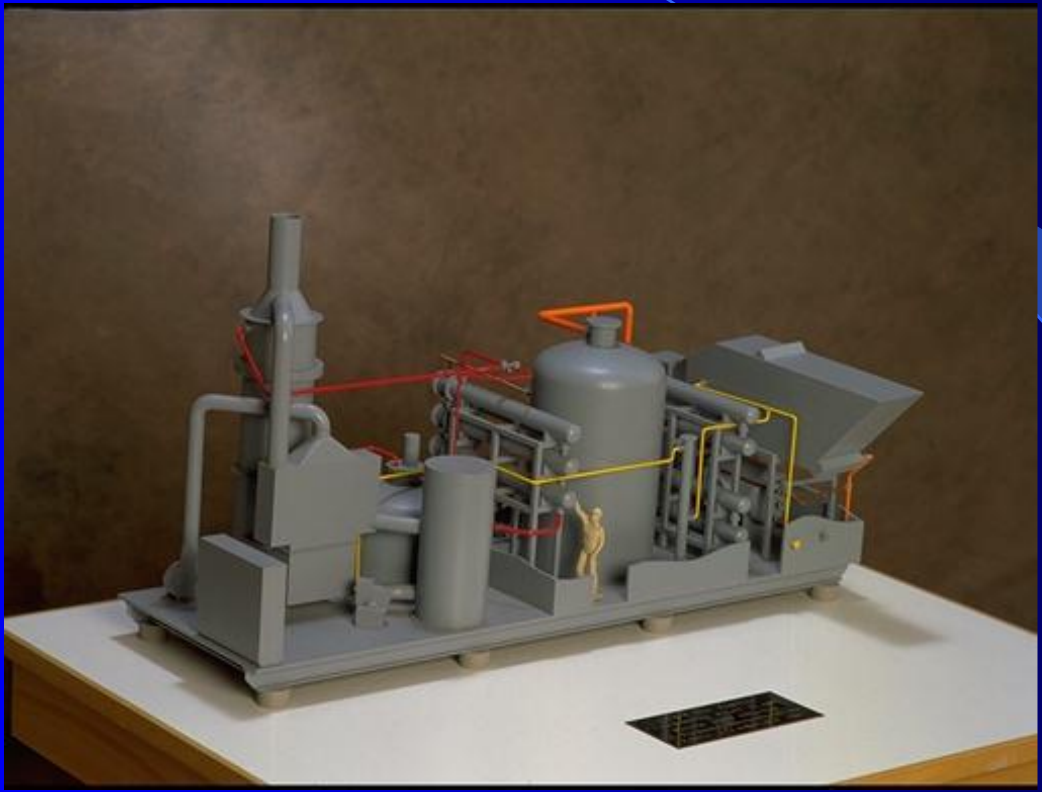
Current objectives

- To secure a site for a demonstration pilot plant
- To obtain feedback from operators
- To “fine tune” the engineering design to obtain the optimum upgrading of a variety of feed stocks
- To reduce capital & operating costs

Summary

- ✓ Partial upgrading, viscosity reduction and reduced diluent
- ✓ Low capital and operating costs
- ✓ Typical refinery/oilfield visbreaking modular equipment
- ✓ Environmental advantages through more efficient utilization of existing pipelines
- ❑ Secure patents for improvements to the original patent
- ❑ Construct and operate a 2000 bbl/day demonstration plant
- ❑ Construct and operate a 10,000 bbl/day modular unit

2,000 bbl/day Plant Model



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