Non-Intrusive Ultra-Sonic Flow Meters On Coker Feed
Presentation Agenda

- Coker Feed Challenge
- Coker Feed Issues & Economics
- Feed Measurement Options
- Clamp On USFM Technology & Examples
- Clamp-On Economics
- Diagnostics
Coker Feed Challenge

Coker feed liquid is

- Hot
- Viscous
- “Chunky”
- Dangerous
Accurate & reliable flow measurement is important

- Inaccuracy can trigger false (= costly) alarms
- Real flow drop-outs cause lines to cake up = costly cleaning
- Loss of signal to furnaces causes shut down for safety reasons = no room for error in safety matters
Coker Feed Issues
Health & Safety

Health & Safety must be top priority in any operation
Fire prevention is important

- Coker feed is a closed system
- But leaks can release liquids, vapors, gases
- In-line flow meters have flanges, gaskets = potential for leakage
- Leaks can cause fire, explosions
- Potential for fire is always present in coker operations
The issue as voiced by a refinery engineer in an online engineering discussion forum

Subject: Heater Feed Pass Flow Measurement
Category: Reliability / Maintenance expenses

>>We currently use orifices with purge for measuring heater pass flow. … We have reoccurring plugging problems and have been looking for an alternate technology. We looked at Vortex, but because we do get coke "chunks" occasionally in this service none of the vendors were comfortable with it. Any suggestion on what is the most reliable method for Htr Pass flow measurement?<<

Other case report:
>>.. Unstable readings…plugging lines and having to clean them…wasted labor…results in some $ 50,000 p.a. maintenance costs<<
Feed Measurement Option
Vortex Meter Technology

- Bluff body in flow stream causes vortices
- Frequency of vortices = measure for flow
Vortex Meter issues in coker feed

- Pressure drop (= energy destroyer = costs)
- Turn down max. 1:20 (does not start at “0” flow)
- Turn down decrease with higher viscosity
- Danger of leakage (Health and Safety)
- Danger of clogging (Process availability)
- Danger of wear of bluff body due to abrasion
- Danger of bluff body breaking
- Sensitive to vibrations
- Maintenance intense
Feed Measurement Option
Differential Pressure Meters

Common to all...(or some)

- Pressure loss = energy!
- Pressure lines = maintenance!
- Pressure lines = danger!
- Installation = shutting process down!
- Wear & tear = accuracy loss!
- Turn down limited
Feed Measurement Option
Ultra-Sonic Flow Meters (USFM)

Transit Time Operating Principle

... external measurement of internal flow
Clamp-On USFM
Operating Principle

Operational formula

\[ v_I = k_\alpha \frac{\Delta t}{2 t_F} \]

\[ k_\alpha = \frac{c_\alpha}{\sin \alpha} \]

Snell’s Law

\[ \frac{c_\alpha}{\sin \alpha} = \frac{c_\beta}{\sin \beta} = \frac{c_\gamma}{\sin \gamma} \]
Clamp-On USFM
Flow Profile Compensation

\[ Q = v_A \cdot A \]

\[ v_A = \frac{1}{A} \oint_A \mathbf{v} \cdot d\mathbf{A} \quad v_l = \frac{1}{l} \int_v \mathbf{v} \cdot d\mathbf{l} \]

\[ k_S = \frac{v_A}{v_l} \]

\[ Q = v_l \cdot A k_S \]

Fully developed flow profile:
\( k_S \) depends on Reynolds number and pipe roughness
Clamp-On USFM
Accuracy & Uncertainty

Meter Formular

\[ Q = K_{Re} \cdot A \cdot K_{\alpha} \frac{\Delta t}{2t_{fl}} \]

Error contributions

- fluid mechanics
- pipe geometry
- acoustics
- electronics & time measurement

(+ covariances)
Clamp-On USFM Applied to Hot Liquids

WavelInjector® Technology

- Temperature to 400°C/ 750°F
- No contact with liquid
- Never a leak
- No mechanical wear & tear
- Minimal maintenance
- Very high turndown
- High safety
- Line sizes > 1 ½”
USFM for Hot Liquids
WaveInjector® Technology

Typical Applications
- Coal Tar
- Bitumen / Pitch
- Feed Water
- Heat Oils
- Coker / FCC Feed
The toughest challenge …

… lies in Alberta Canada
...and the “largest” in everything...

... can also be found in Alberta Canada
The Mother-Of-All Bitumen Coker Feed Lines

... is of course also in Alberta Canada

Coker feed flow 16” line @ 675°F
Customer states the issues for the test

The common method of flow measurement in bitumen service with high temperatures and pipe sizes > 8 inches is the DP / orifice plate transmitter…

The reliability of the DP instrument for this service is low because …the instrument typically fails because of these impulse line problems

- Impulse line plugging
- Impulse line freezing
- Impulse line fluid-voiding, which subsequently gets filled with bitumen
WaveInjector® Installation done easily…

- Done in 1 hour
- No process shut down
- Installation outside of pipe
- No special tools
First Try: Flow Signal on 16” Bitumen Line

Signal quality with M transducers produce on-the-edge and unreliable readings for customer.
Flow Signal on 16” Bitumen Line
Getting It Right!

Renewed test with G transducers (lower frequency = improved result on large pipe with high dampening media) produce stable signals
Signal Quality
Examined & Compared

.. Test results confirmed by customer. Red = Flexim, Blue and Green : DP

The red line is the Ultrasonic flow Meter. Very nice..
Signal reliability confirmed in winter performance

- Test results for period March 15th to April 15th
- Flow signal of orifice plates (red & green) improved on April 2nd due to > freezing temperatures
- The USFM (blue) was more stable regardless of the temperature conditions
WaveInjector® Design
Heat Tracing Issues

Coker feed: heat tracing lines stay intact
WaveInjector® Design
Pipe Insulation Issues

Insulation stays intact
Reading the manual is important!

... an example of how NOT to do it...

Installation manual not read $\rightarrow$ disaster strikes
The challenge:
Replace 44 DP meters on “resid” feed to coker @650F

Reason:
- DP maintenance issues
- DP reliability issues

Measurement purpose:
- safety
- reliable monitoring
Case: ExxonMobil
Signal Reliability & Accuracy
Clamp-On USFM Economics ... vs in-line flow meters

**Competitor G**
inline / wetted USFM  
special material for pipe and sensors  
cost per meter appr. $35 K  
plus: process shut down expenses for installation

**Competitor K**
inline / wetted USFM  
special material for pipe and sensors  
cost per meter appr. $44 K  
plus: process shut down expenses for installation

**Flexim  WaveInjector**
clamp on  USFM  
all standard materials and models  
cost per meter appr. $12 K  
no process shut down / installation done in 1 hour  
no maintenance
FLEXIM – WaveInjector®
Some Users

SUNCOR
Flying J
ExxonMobil
BP
TOTAL
Shell
Valero
Chevron
LUKOIL
Husky Energy
Moose Jaw Refinery
DEVON
Marathon
Diagnostics & Evaluation of Clamp-On USFM Flow Measurements
USFM Diagnostic Tools

All diagnostic values
- are displayed and stored
- can drive process interface

Data logger
- stores signal related and application diagnostic values for offline analysis
To monitor and analyze:
- Fluid sonic velocity
- Signal amplitude
- Fluid flow

Flow
Channel A: blue
B: black

Sonic Velocity
Channel A: green
B: black
Diagnostics: Signal Analysis Software

Signal parameters

- SNR
- SCNR
- Pipe signal
- Signal amplitude
- Gain
- Correlation
Multi channel flow application
.. time & time difference variation are indicators for flow fluctuations such as turbulence, flow disturbances
- Average => main result
- Standard deviation as an indicator of fluctuation
Thank You!

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