HEAT EXCHANGER WORLD
CONFERENCE & EXPO
AMERICAS

# Ultrasonic Cleaning Solution

Roberto Tomotaki, Heat Exchanger Advisor

CLEAN AS NEW
POWERED BY TECH SONIC

# Introductions

Roberto Tomotaki, Heat Transfer Specialist

- Career Heat Transfer Engineer (23 years)
- Former Americas Heat Exchanger Discipline Lead for ExxonMobil
- Current Heat Exchanger Advisor for Clean As New

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# The Fouling Challenge

- Fouling continues to be the biggest problem with Exchangers.
- Cost associated with exchanger fouling cost approximately 0.25% of GDP [ US $50 Billions] for industrialized countries. [*Stated in Fouling & Cleaning Conference 2019*]

# The Fouling Challenge – Different Perspectives

**Owner / Operator**

- Ability to monitor exchanger performance [*Large numbers to keep track*]
- Optimize HX Cleaning Program *[Evaluate Benefit to Cost]*
- Exchanger technology telection

**EPC**

- Account for fouling or % overdesign and HX isolation hardware
- Evaluate low fouling technologies
- Justify the cost for instrumentation for HX monitoring

# The Fouling Challenge – Different Perspectives

**Heat Exchanger Vendor Technology Provider**

- Compact Designs, Thermally Efficient
- Low Fouling - High Shear, Metallurgy, Coatings, On-Line Cleaning Technologies
- Cleanability

**Cleaning Technology**

- Safety / Minimize Waste
- Quality of Cleaning / Minimize HX Downtime

# Traditional Cleaning Technology - Safety / Environmental

## Safety

- Long Industry history of injuries during hydroblast cleaning *[Line of Fire]*

## Environmental

- Typical hydroblast methods consume approx. 55 k gallons of water which turns into an effluent waste
- Poor cleaning leads to less efficient exchangers requiring more fuel consumption and environmental emissions

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# Traditional Cleaning Technology - Quality of Cleaning / Time

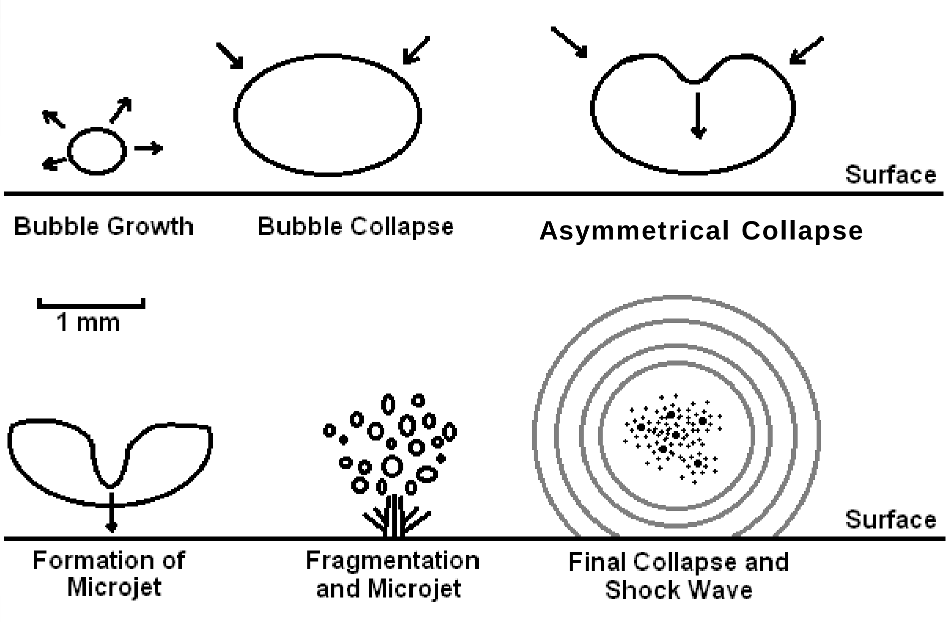
## Quality of Cleaning

- Difficulty to clean deep into the shellside of large exchangers
- Often inadequate for tubular inspection
- Require cleaning lanes, inadequate for compact HX designs

## Downtime for Cleaning (Time)

- Relatively common for shellside cleaning to take several days for heavily fouled services
- Redo cleanings for inspection
- Extend outages, negatively impacting energy &

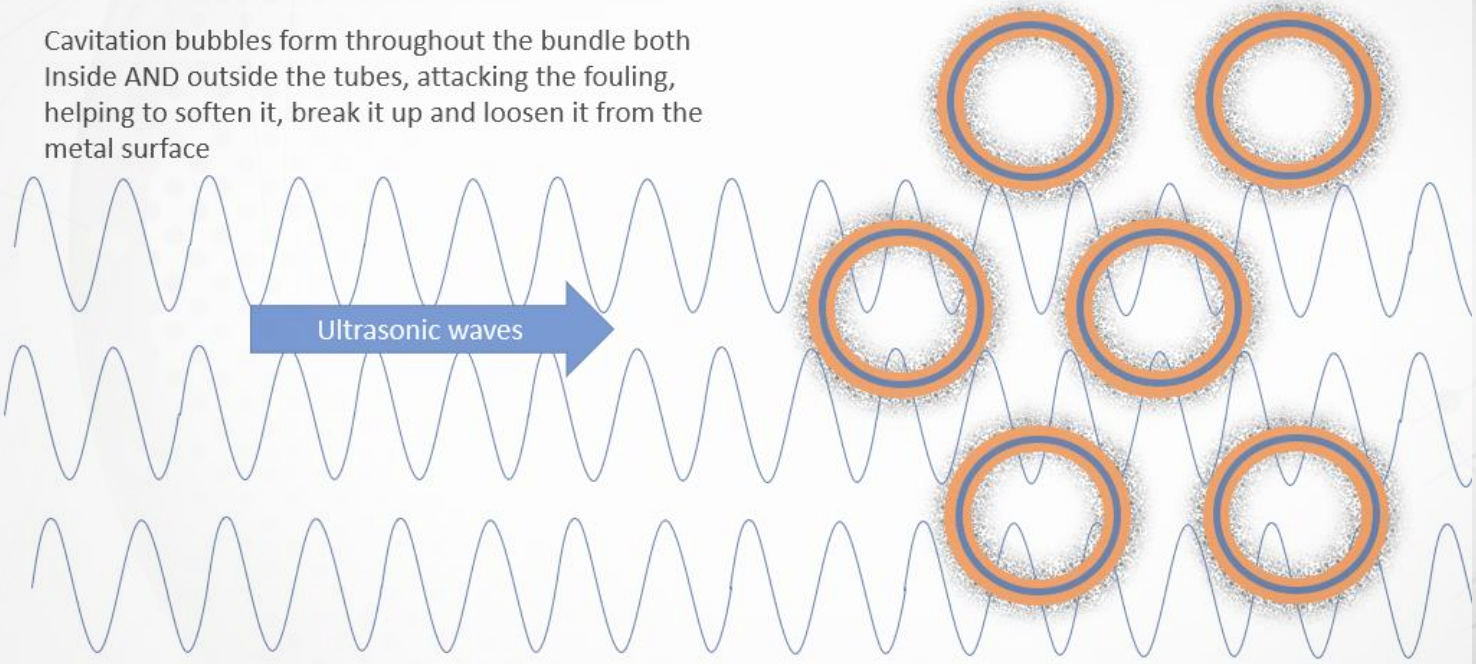
# The Alternative Technology




# How It Works

## Cleaning Heat Exchanger Tubes

Cavitation bubbles form throughout the bundle both Inside AND outside the tubes, attacking the fouling, helping to soften it, break it up and loosen it from the metal surface



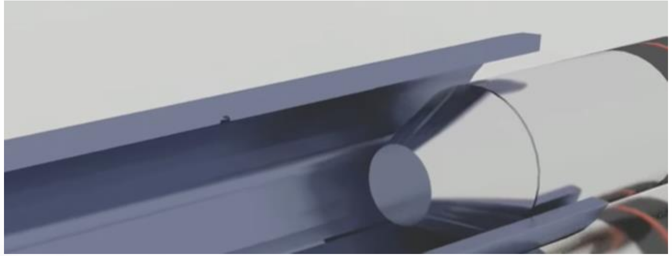
# Cleaning Validation – Measured Trial

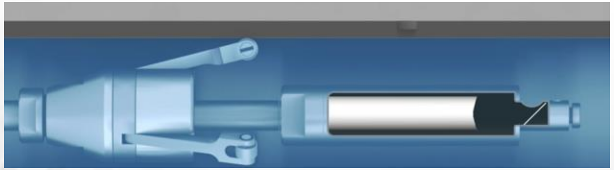
## Visual

- Borescope

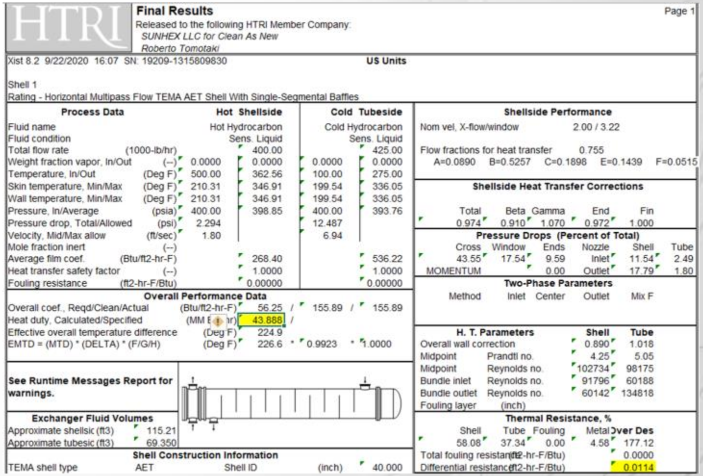
## Suitability for Inspection

- Eddy Current
- IRIS





## Heat Transfer Evaluation



HTRI **Final Results** Page 1

Released to the following HTRI Member Company:
*SUNHEX LLC for Clean As New*
*Roberto Tomotaki*

Xist 8.2 9/22/2020 16:07 SN: 19209-1315809830 **US Units**

Shell 1
Rating - Horizontal Multipass Flow TEMA AET Shell With Single-Segmental Baffles

| Process Data | | Hot Shellside | | Cold Tubeside | |
|---|---|---|---|---|---|
| Fluid name | | | Hot Hydrocarbon | | Cold Hydrocarbon |
| Fluid condition | | | Sens. Liquid | | Sens. Liquid |
| Total flow rate | (1000-lb/hr) | | 400.00 | | 425.00 |
| Weight fraction vapor, In/Out | (--) | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Temperature, In/Out | (Deg F) | 500.00 | 362.56 | 100.00 | 275.00 |
| Skin temperature, Min/Max | (Deg F) | 210.31 | 346.91 | 199.54 | 336.05 |
| Wall temperature, Min/Max | (Deg F) | 210.31 | 346.91 | 199.54 | 336.05 |
| Pressure, In/Average | (psia) | 400.00 | 398.85 | 400.00 | 393.76 |
| Pressure drop, Total/Allowed | (psi) | 2.294 | | 12.487 | |
| Velocity, Mid/Max allow | (ft/sec) | 1.80 | | 6.94 | |
| Mole fraction inert | (--) | | | | |
| Average film coef. | (Btu/ft2-hr-F) | | 268.40 | | 536.22 |
| Heat transfer safety factor | (--) | | 1.0000 | | 1.0000 |
| Fouling resistance | (ft2-hr-F/Btu) | | 0.00000 | | 0.00000 |

**Overall Performance Data**

| | | | | |
|---|---|---|---|---|
| Overall coef., Reqd/Clean/Actual | (Btu/ft2-hr-F) | 56.25 / | 155.89 / | 155.89 |
| Heat duty, Calculated/Specified | (MM Btu/hr) | 43.888 / | | |
| Effective overall temperature difference | (Deg F) | 224.9 | | |
| EMTD = (MTD) * (DELTA) * (F/G/H) | (Deg F) | 226.6 * | 0.9923 * | 1.0000 |

**See Runtime Messages Report for warnings.**

**Exchanger Fluid Volumes**

| | |
|---|---|
| Approximate shellsic (ft3) | 115.21 |
| Approximate tubesic (ft3) | 69.350 |

**Shell Construction Information**

| | | | | |
|---|---|---|---|---|
| TEMA shell type | AET | Shell ID | (inch) | 40.000 |

**Shellside Performance**

Nom vel, X-flow/window 2.00 / 3.22

Flow fractions for heat transfer 0.755
A=0.0890 B=0.5257 C=0.1898 E=0.1439 F=0.0515

**Shellside Heat Transfer Corrections**

| Total | Beta | Gamma | End | Fin |
|---|---|---|---|---|
| 0.974 | 0.910 | 1.070 | 0.972 | 1.000 |

**Pressure Drops (Percent of Total)**

| | Cross | Window | Ends | Nozzle | Shell | Tube |
|---|---|---|---|---|---|---|
| | 43.55 | 17.54 | 9.59 | Inlet | 11.54 | 2.49 |
| MOMENTUM | | | 0.00 | Outlet | 17.79 | 1.80 |

**Two-Phase Parameters**

| Method | Inlet | Center | Outlet | Mix F |
|---|---|---|---|---|

| H. T. Parameters | | Shell | Tube |
|---|---|---|---|
| Overall wall correction | | 0.890 | 1.018 |
| Midpoint | Prandtl no. | 4.25 | 5.05 |
| Midpoint | Reynolds no. | 102734 | 98175 |
| Bundle inlet | Reynolds no. | 91796 | 60188 |
| Bundle outlet | Reynolds no. | 60142 | 134818 |
| Fouling layer | (inch) | | |

**Thermal Resistance, %**

| Shell | Tube | Fouling | Metal | Over Des |
|---|---|---|---|---|
| 58.08 | 37.34 | 0.00 | 4.58 | 177.12 |

| | | |
|---|---|---|
| Total fouling resistance | (ft2-hr-F/Btu) | 0.0000 |
| Differential resistance | (ft2-hr-F/Btu) | 0.0114 |

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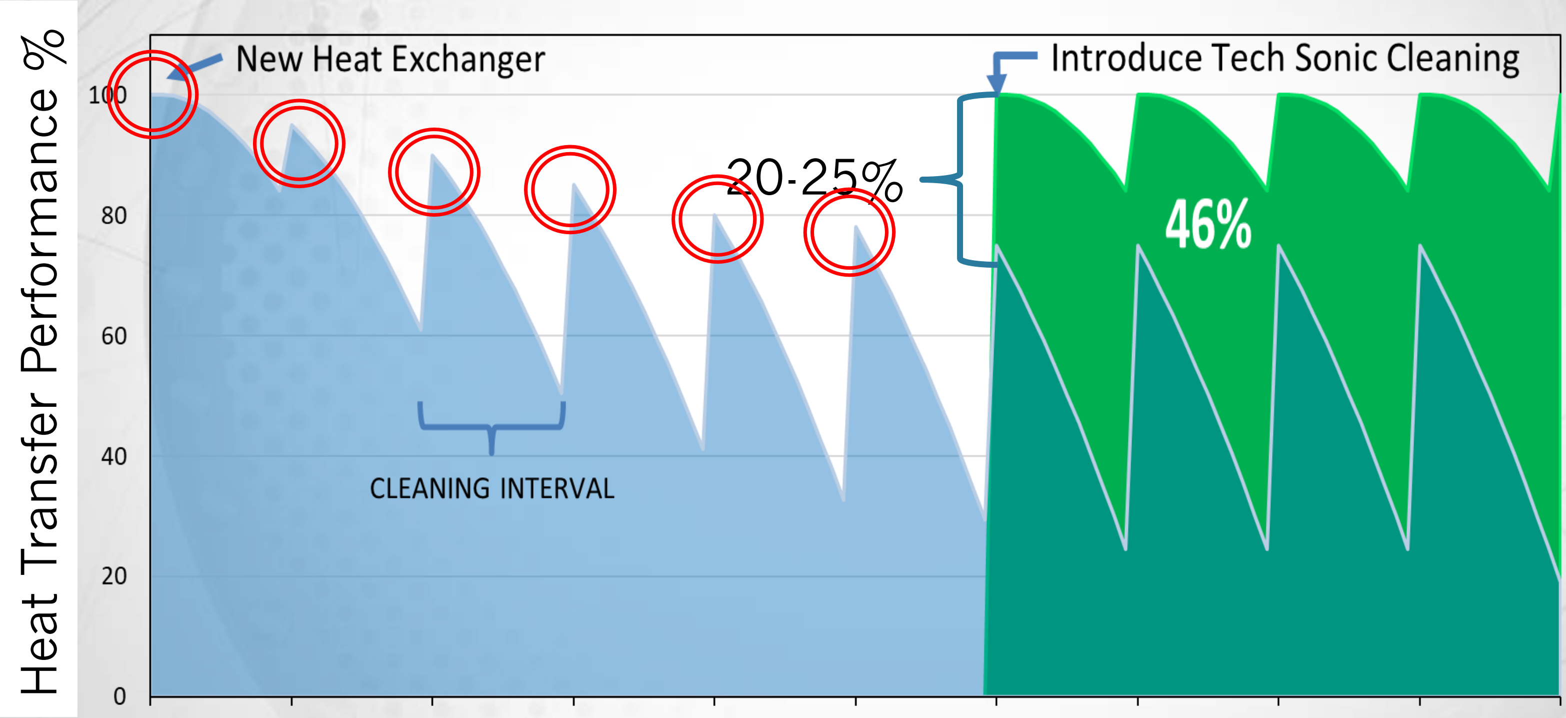
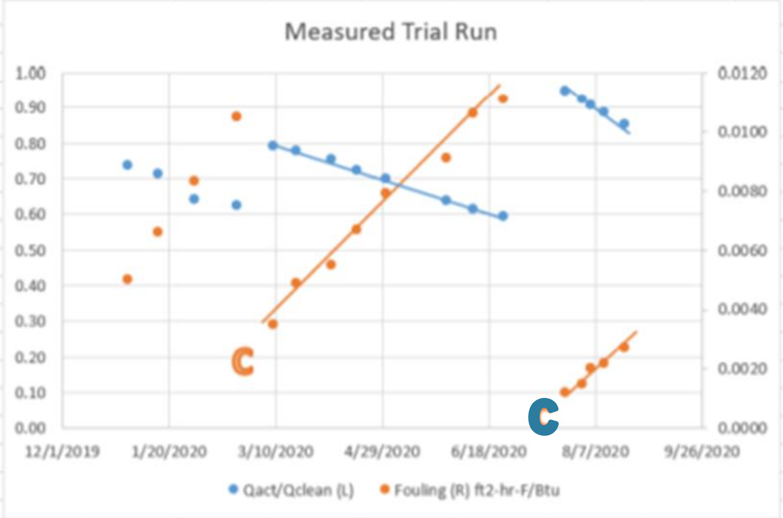
# Improved Heat Transfer Performance



# Measured Trial – Heat Transfer Evaluation

The example below indicates a 20% [0.79 to 0.95] improvement in Q-actual/Q-clean between the two methods.




| | Date | Duty Actual | Duty Clean | Qact/Qclean (L) | Fouling (R) |
|---|---|---|---|---|---|
| | | MBtu/hr | MBtu/hr | | ft2-hr-F/Btu |
| | 1/1/2020 | 92.0 | 125.0 | 0.74 | 0.0050 |
| | 01/15/20 | 86.0 | 120.6 | 0.71 | 0.0066 |
| | 02/01/20 | 98.0 | 152.4 | 0.64 | 0.0083 |
| | 02/21/20 | 85.0 | 136.1 | 0.62 | 0.0105 |
| Hydroblast | 03/09/20 | 117.0 | 148.0 | 0.79 | 0.0035 |
| | 03/20/20 | 87.0 | 111.8 | 0.78 | 0.0049 |
| | 04/05/20 | 84.0 | 111.2 | 0.76 | 0.0055 |
| | 04/17/20 | 105.2 | 145.2 | 0.72 | 0.0067 |
| | 05/01/20 | 83.0 | 118.7 | 0.70 | 0.0079 |
| | 05/29/20 | 93.0 | 145.4 | 0.64 | 0.0091 |
| | 06/11/20 | 89.5 | 145.8 | 0.61 | 0.0106 |
| | 06/25/20 | 87.4 | 147.0 | 0.59 | 0.0111 |
| Ultrasonic | 07/24/20 | 133.0 | 140.0 | 0.95 | 0.0012 |
| | 08/01/20 | 125.0 | 135.0 | 0.93 | 0.0015 |
| | 08/05/20 | 118.0 | 130.0 | 0.91 | 0.0020 |
| | 08/11/20 | 120.0 | 135.0 | 0.89 | 0.0022 |
| | 08/21/20 | 115.0 | 135.0 | 0.85 | 0.0027 |

Duty Improvement from better cleaning = 20 MBtu/hr

# Cleaner/Faster Example Calculation

| *Shorter Oil Out to Oil In* | **Traditional On-Site Hydroblast** | **Ultrasonic Clean As New** |
|---|---|---|
| | Days | Days |
| HX Process Prep  Isolation | 1 | 1 |
| HX Disassembly and Pulling | 1 | 1 |
| Transport HX Washpad | 0.125 | 0.375 |
| Shelside Clean | 2 | 0.5 |
| Tubeside Clean | 1 | 1 |
| HX Inspection/Repair | 1 | 1 |
| Transport HX to Unit | 0.125 | 0.375 |
| HX Assembly , Leak test and Onstream | 1 | 1 |
| Total Oil Out Oil In | 7.25 | 6.25 |
| **Oil Out to Oil In Reduction** | | 1 |
| | | |
| Oil out Oil in margin credit $k | | 15 |
| Oil out Oil in energy credit $k | | 3.24 |
| **Total Oil out Oil In credit $k** | | **$18.2** |

| *Improved Duty from Better Quality Cleaning* | **Traditional On-Site Hydroblast** | **Ultrasonic Clean As New** |
|---|---|---|
| HX Duty Day 1 After Cleaning MBtu/hr | 25 | 30 |
| HX Duty Day 365 After Cleaning MBtu/hr | 15 | 18 |
| Sinple Median HX Duty | 20 | 24 |
| Yearly Energy Benefit $k | | $105.1 |
| Yearly Margin Benefit $k | | $100.0 |
| Yearly Margin +  Energy Benefit $k | | **$205.1** |

# Cleaning Effectiveness Enables Acceptance of Compact HX

Having the ability to effectively clean compact exchanger technology in heavily fouling services enables its broader application


Welded Plate

Spiral

# Summary Advantages of Using Ultrasound

- Provides cleaning action on surfaces not accessible by a direct water jet
- Allows cleaning multiple surfaces simultaneously
- Reduction of hydroblast duration
- Less water required





- Enables the use of compact HX designs in fouling services – less capital
- Higher Heat Transfer – Lower Emissions

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