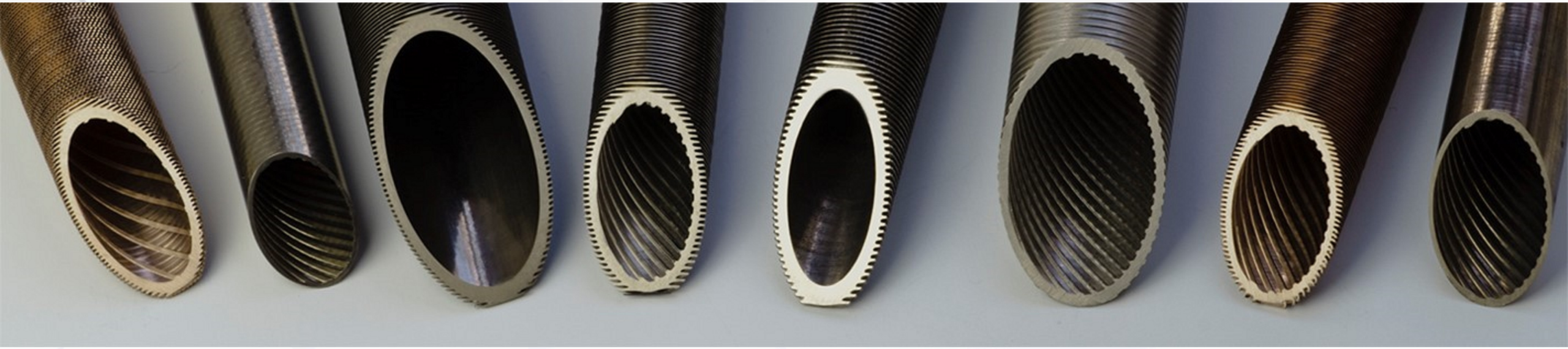
HEAT EXCHANGER WORLD
CONFERENCE & EXPO
AMERICAS

2022

Improving Heat Exchanger Efficiency with Internally Enhanced Heat Exchanger Tubing



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Craig Thomas - Neotiss

Types of Internal Tube Enhancements

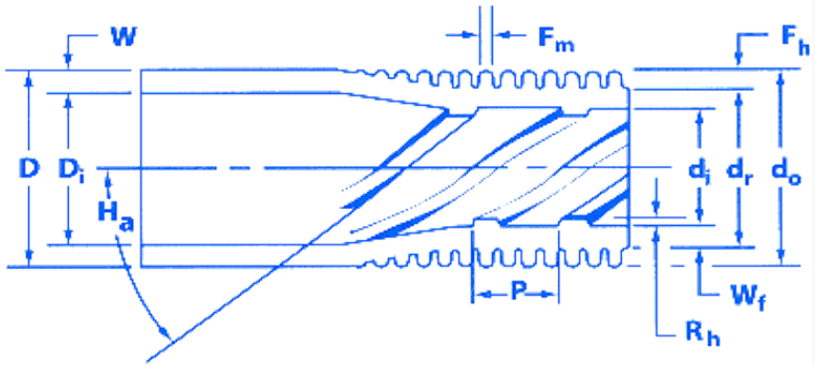
Turbulators / Inserts

Twisted

Spiral Grooved / Micro-fin

Indented / Corrugated

Internal Rib Geometry



<u>Micro-fin ID: 3 Main Parameters:</u>

No. Rib starts: 10 – 50

Rib Height: .010 - .016

Helix Angle: 20 – 45 degrees

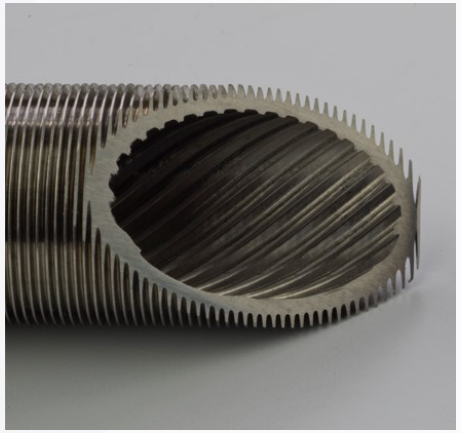
When to Consider ?

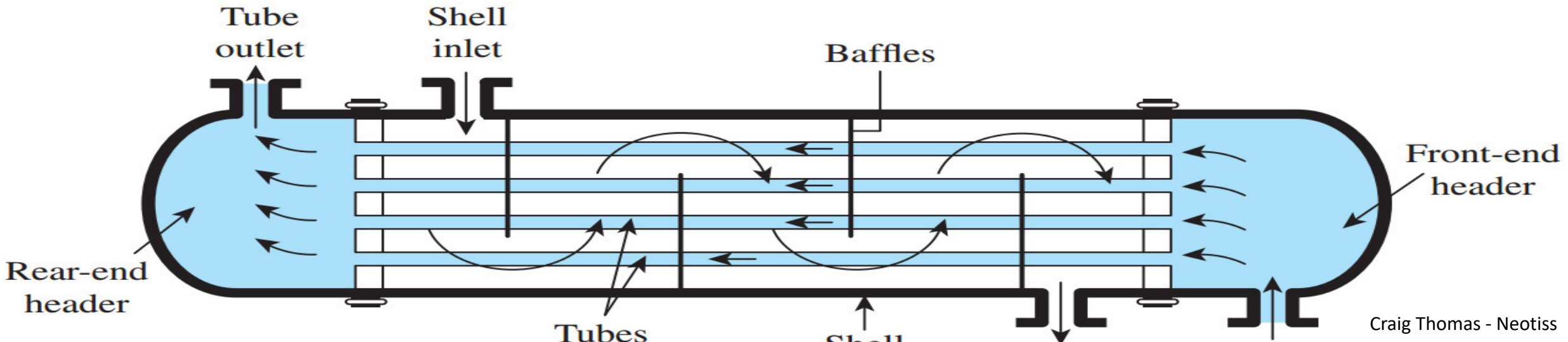
Tube-side controlling heat transfer

Space / weight restricted

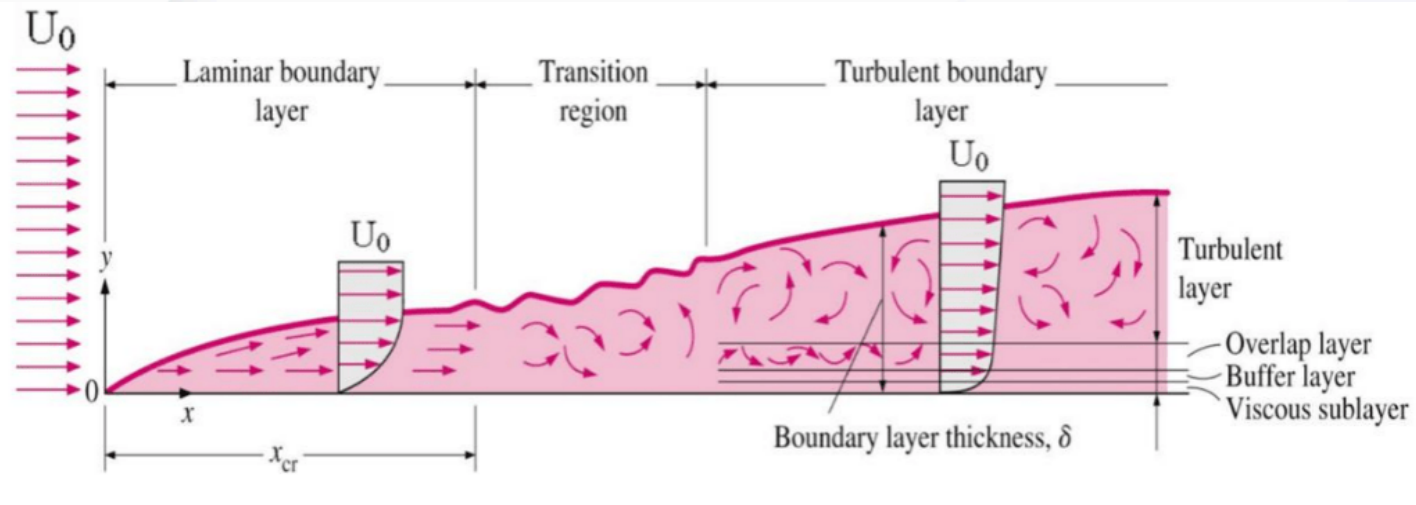
Unused tube-side pressure drop

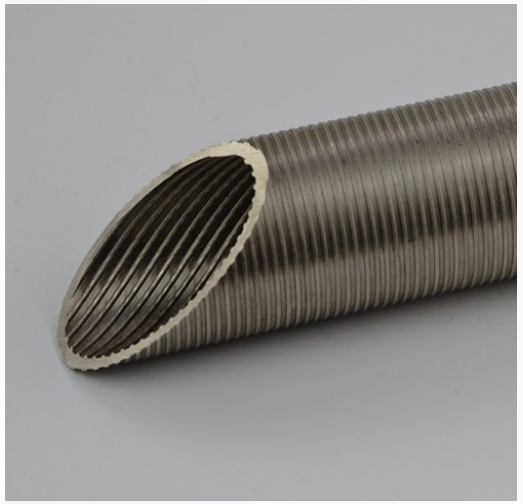
Debottlenecking / Retrofit





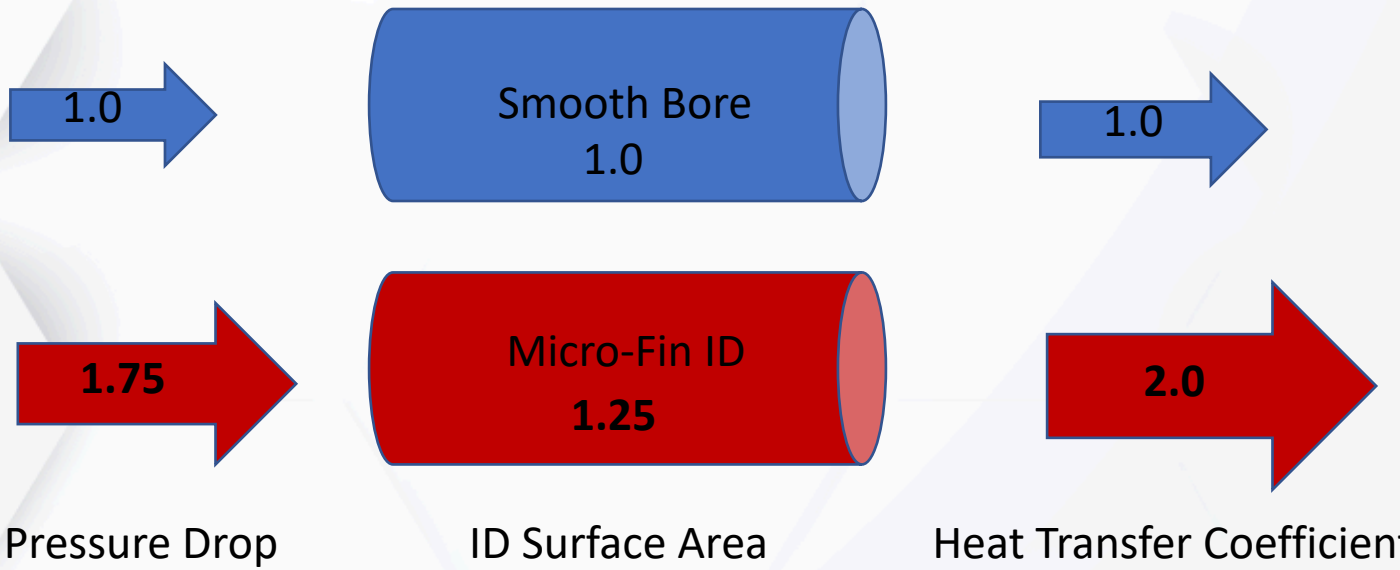
The Fluid Dynamics of Micro-fin ID Surface





Spiral grooves disrupt boundary layer
Increased shear stress at tube wall

Performance Comparison in Cooling Water



Predicting Performance

Typical Screening Design Multipliers

Service / Test Case	ID Heat Transfer	ID Pressure Drop	ID Area
Smooth bore reference standard	1	1	1
Single Phase (Cooling Water)	2.0	1.7	1.25
Two phase Condensing (N-Pentane)	1.5 to 2.3	1.4 to 1.8	1.25
Two Phase condensing mixture (n-Pentane / Paraxylene)	1.7 to 2.5	1.4 to 1.8	1.25

Industry Experience with Micro-fin ID tubing

Commercial Chiller Machine

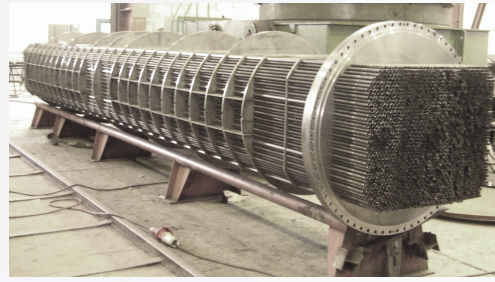
- Refrigerant Evaporator
- Refrigerant Condenser

LNG Liquefaction Process

- C4/MR Evaporator
- C4 Condenser

Chem & Petrochem Pro

- Methanol Vaporizer
- C2 Splitter
- Recuperator



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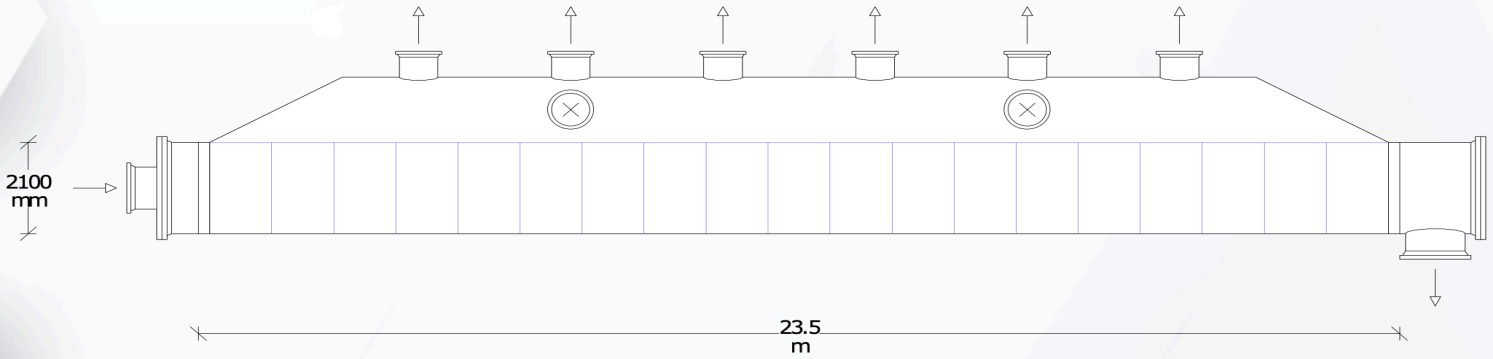
Commercial Water Chiller Experience
Micro-fin ID tubing

- 25+ Years of installation experience in all types of cooling water
- Over 200,000 Installations with cooling tower water since 1990
- **Over 200 installations with sea, river, brackish waters since 1999**
- 90% of all installations today use both OD and ID enhanced tubing

LNG Case Study

Precooling Section APCI Process
Propane Evaporating Shell-side / Mixed Refrigerant condensing Tube-side

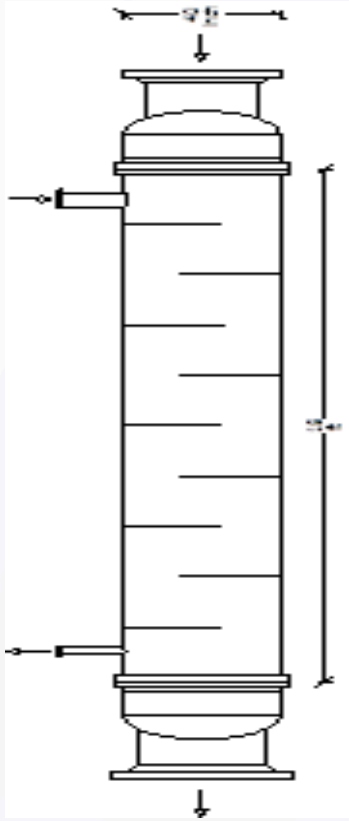


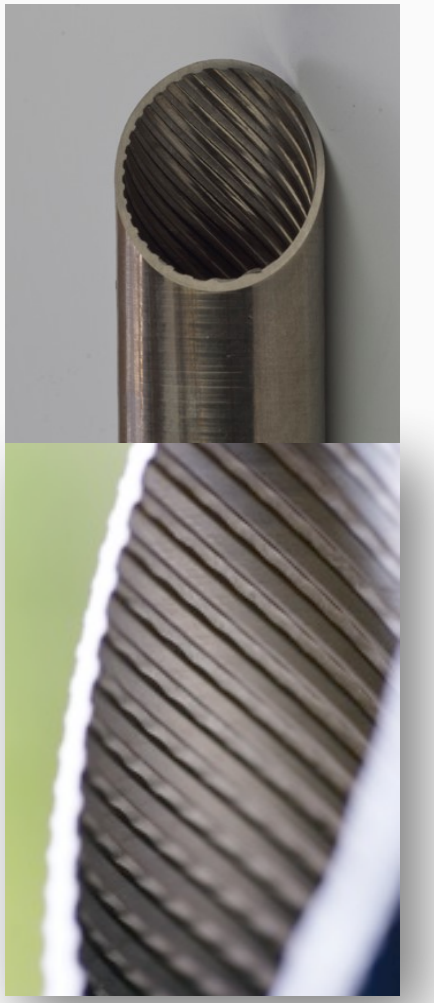
TEMA type	NKN		Total tube inlet nozzles	1	Stream ID	Shellside		Tubeside	
Shell diameter	2100	mm	Total tube outlet nozzles	1	Stream name	Propane		Mixed Refrigerant	
Kettle diameter	3599.99	mm	Total shell inlet nozzles	2	Flow, kg/s	98.7330		411.849	
Tube length	23.5	m	Total shell outlet nozzles	6	Pressure drop, kPa	0.311		14.956	
Dry weight	206081	kg/shell			Temperature, C	-34.02	-34.06	-14.00	-31.00
Wet weight	430205	kg/shell			Wt. fraction vapor	0.10000	1.00000	0.44340	0.22896
Bundle weight	127515	kg/shell			Pressure, kPa	143.198	142.888	5750.00	5735.04

Tube Type	Plain	OD Fin / Smooth Bore	Dual Enhanced
Tube Length Required (to meet Duty)	23.5M	16M	12.5M

Case Study: Methanol Vaporizer

Application: (Spray)	SS Steam / TS gas + Methanol liquid
	Vertical down flow
Problem:	Corrosion of CS tubes
	Not achieving 100% vaporization
Solution:	Replace CS with SS Tubes
	Use ID Enhanced Tubes
Results:	No issues after 10 years service.
	Same practice repeated in all their plants





Fouling and Spiral Grooved ID Tubing Research

Main principle: Higher shear stress at tube wall can lower fouling rate compared to smooth surface (however this is dependent upon many variables including fouling type, fluid velocity, and surface geometry)

R. Webb: In cooling tower water the lower the rib density (wider rib spacing)= lower fouling rate.

P. Thor: In cooling tower water the ratio of rib pitch / rib height of 3.5 is optimal to reduce fouling

H. Joshi: In crude oil the ID ribbed tube reduced fouling by 57% with HTFR + 21% and PD + 63%

C.B. Panchal: In seawater the shear stress in spiral fluted tubes can lift oxidized film from wall to prevent deposition.

ASHRAE Summary: Most significant variable in fouling rate is water quality not surface geometry. Next variable is water velocity. Then surface enhancement type. In cases where internal enhanced tubes do foul, they tend to maintain their performance advantage over smooth surface. Spiral grooved tubes can be cleaned with similar methods to smooth tubes.

Thank You!

Craig Thomas
NEOTISS, Inc.