CONCEPT

HTRI MEMBER

ENABLING APPLICATION SPECIFIC HEAT TRANSFER ENHANCEMENT IN

High Performance Falling Film Evaporation

VorTX Wire Turbulators

VorTX Spiral Turbulators

Twisted Tape Turbulators

Rigid Soldered Turbulators

Wire Wound Fin Tubes

Finding the right turbulator for an application is an exercise we are equipped to handle.

We make a bunch of different turbulator types and many different geometries within those types.

And it's because we make the entire spectrum of turbulator types and have data on where they stand that we can rank them in order of performance without letting bias creep in.

Rigid Soldered Turbulator

The highest performing turbulator there is as in addition to turbulation it also increases the internal surface area of the tube anywhere between 2x to 4x because of the solder bond effect. It makes drastic size (and cost) reduction in viscous fluid coolers possible.

It is also a gamechanger in gas coolers where the surface area extension is the dominant play other than simply turbulation as gas is naturally turbulent anyway. A 4x increase in internal surface area at 75% bond efficiency would still give a 3x bump in heat transfer coefficient.

Wire Turbulator

vortx enabled

Wire turbulators offer the flexibility of easy insertion and the second highest performance profile in our range. Second only to rigid soldered turbulators. Their performance and pressure drop correlations are mapped into our VorTX DLL. Wire Turbulators are ideal for cases where tubeside limitation is severe.

Spiral Turbulator

vortx enabled

Spiral Turbulators sit in between the performance of tight L/D Twisted Tape and Low Dense Wire Turbulators. A sweet spot in terms of pressure drop penalties. Spiral Turbulators also have their performance and pressure drop correlations mapped into our VorTX DLL. Spiral Turbulators are ideal for viscous and semi-viscous applications where pressure drop allowance is tight and twisted tapes can't give enough performance.

Twisted Tape

CEI Twisted Tapes have perfect L/D conformance and can be made in a wide range of materials and sizes. Even the L/D range that we can make these in is large giving a lot of flexibility in terms of design choices.

What VorTX is.

VorTX is Concept Engineering International's dynamic link library (DLL) developed by HTRI under proprietary contract with Concept Engineering International.

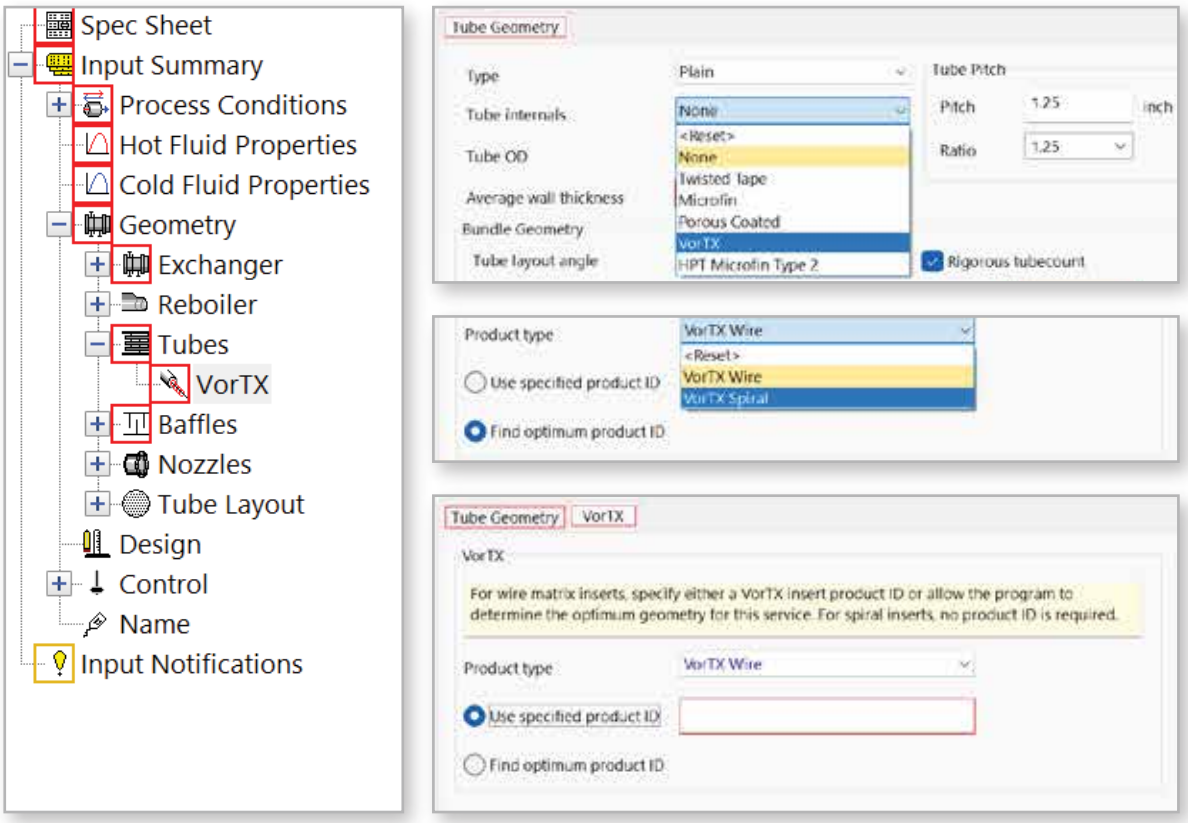
Multiple Concept Engineering International turbulators (wire and spiral tube inserts) were tested at HTRI's Research and Technology Center in Navasota, Texas, USA.

The VorTX DLL contains tube side single phase heat transfer and pressure drop correlations for modeling Concept Engineering International's products which were developed under proprietary contract with HTRI using Concept Engineering International's proprietary data.

HTRI used laminar flow CFD results to supplement empirical testing measurements at Reynolds numbers under 500.

The VorTX DLL can be used with HTRI Software for the following purposes:

1. Identifying an optimal Concept Engineering International product from those supported by the VorTX DLL based on utilizing the maximum amount of pressure drop allowed.
2. Evaluating the performance of a Concept Engineering International product supported by the VorTX DLL that resembles the geometry of those tested by HTRI.



What VorTX enables.

Data really drives every enhancement decision we make.

We're looking for the best operating window for our products from a Reynolds standpoint.

We're diving deep into wall correction factor impact of our geometries in software outputs.

We're looking at the additional hydraulic load of each geometry. Small tweaks in angles of attack.

How much the shear stress is when you pit turbulator vs bare tube.

What the impact on fouling is likely to be because of that additional wall sheer stress.

How we can disrupt film boiling to move over to nucleate boiling, arrest mist flow and reduce bubbles down to size.

These are questions that only data has the answer for.

Our turbulator range (multiple geometries) has been tested for a hard data mining operation.

Post that, the data has been analyzed and curve fitted and then modeled into correlations along with a test report for each insert geometry.

We've also done supplemental CFD work via a proprietary contract to home in on more accuracy.

To completely integrate into software platforms, we've also had developed the **VorTX.DLL** plugin that will hold this data and allow you, the user, to design your exchangers using our products in a matter of seconds if you're using compatible software.

If you're an end-user like a refinery who uses a performance monitoring software, we're also looking at hard coding our mined data in software such as this to see the impact we can have on refinery exchangers to mitigate fouling by looking at shear stress increases and what that will mean for overall CO2 emissions reduction.

High-Performance Falling Film Evaporation:

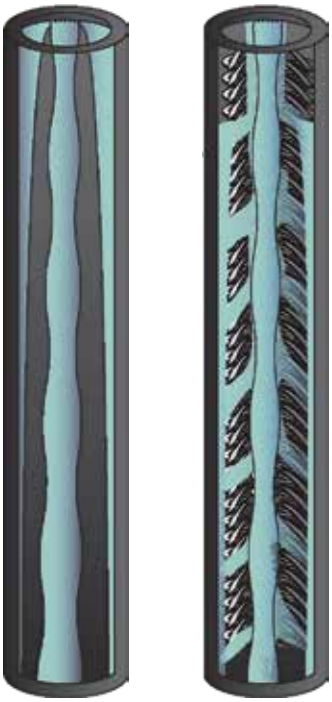
Advanced Film Redistribution

In falling film evaporators, the efficiency of the entire process is dictated by the uniformity and thickness of the liquid film as it descends the internal tube wall. Traditional gravity-fed systems often suffer from "dry spots" or film breakdown, leading to reduced thermal performance and potential product degradation. Concept Engineering has engineered a specialized solution: the Outward-Directional Wire Turbulator.

The Science of Wall-Side Redistribution

Unlike standard inserts, our specialized falling film turbulators feature a geometry where the wire loops are precision-angled, sloping downward and outward toward the tube wall. This design creates a critical mechanical advantage for evaporation:

- **Continuous Film Wetting:** Gravity pulls the liquid down the center and across the loops, which act as "distributors," constantly pushing the liquid back toward the tube wall. This prevents the formation of dry patches even at low flow rates.
- **Boundary Layer Thinning & Turbulence:** The contact points of the loops disrupt the falling film, inducing turbulence and thinning the liquid layer. This drastically reduces thermal resistance and accelerates the evaporation rate.
- **Enhanced Vapor Release:** The open wire matrix provides a clear path for the generated vapor to escape toward the tube center, preventing "vapor entrainment" and maintaining high-velocity throughput.



Turbulators direct all the liquid to the tube wall improving heat transfer as more fluid is in contact with the wall. It also agitates the film along the tube wall and the zig-zag pattern created increases dwell time and thickens the film layer. This also reduces fouling and increases the interval between cleanings.

Industry-Proven Applications

Based on our extensive experience in process enhancement, the following five products see transformative improvements when processed using our wall-sloping directional turbulators:

1. Ammonia (R717) Evaporators

In industrial refrigeration and large-scale chillers, maintaining a consistent ammonia film is vital for high COP. Our inserts ensure the entire tube surface stays wetted, allowing for compact, low-charge evaporator designs.

2. LNG (Liquefied Natural Gas)

For standardized LNG regasification units, managing the rapid phase change from liquid to gas is critical. The directional loops stabilize the film, preventing "mist flow" and ensuring predictable vaporization rates.

3. Caustic Soda (NaOH) Concentration

Highly viscous and temperature-sensitive, caustic solutions require uniform heating. Our "wall-pushing" geometry prevents localized overheating and scales, extending the period between acid washes.

4. Fruit Juices & Purees

In the food industry, falling film evaporators must operate at low Delta T to preserve flavor and color. By thinning the film, our turbulators allow for high evaporation rates at lower temperatures, protecting the product's sensory profile.

5. Pharmaceutical Intermediates

For heat-sensitive organic solvents, reducing residence time on the hot tube wall is essential. The active redistribution ensures the fluid moves quickly and evenly, preventing thermal degradation of high-value active ingredients.

Technical Performance Summary

Parameter	**Bare Tube (Falling Film)**	**Outward-Directional Turbulator**
Film Uniformity	Risk of Dry Spots / Channeling	**100% Surface Wetting Guaranteed**
Heat Transfer	Baseline	**40% Improvement Minimum**
Vapor Separation	Potential Entrainment	**Rapid Vapor Release to Center**
Residence Time	Inconsistent	**Controlled & Uniform**
Overall Footprint	Large / Tall Columns	**Ultra-Compact / Reduced Height**

Engineering & Material Resilience

Falling film evaporators often handle corrosive or high-purity fluids. We manufacture our directional turbulators in robust, process-compatible metallurgy:

- **Stainless Steel (316L, 321, 347)** for general food and chemical service.
- **Duplex & Super Duplex** for aggressive brine or caustic service.

The NexTherm Advantage: Efficiency By Design

By integrating our outward-directional enhancement, you can achieve a radical reduction in equipment size. For modular skids or tall evaporation columns, this translates to lower structural costs, reduced pumping power, and superior product quality.

Products Utilizing Falling Film Technology

The hallmark of falling film evaporation is the short residence time and low temperature difference, which prevents thermal degradation in the following categories:

Food & Beverage (Dairy & Nutrition)

- **Dairy:** Whole and skim milk, whey protein concentrates, baby food, and condensed milk.
- **Juices:** Concentration of orange, apple, grape, and tropical fruit juices (preserving aroma and Vitamin C).
- **Sweeteners:** Glucose, fructose, maltose, corn syrup, and beet/cane sugar juices.
- **Extracts:** Coffee and tea concentrates, malt extracts, and herbal infusions.

Chemical & Petrochemical

- **Organics:** Urea, phosphoric acid, and various monomers (e.g., acrylic acid) where polymerization must be avoided.
- **Chlor-Alkali:** Concentration of Caustic Soda (NaOH) and Potassium Hydroxide (KOH).
- **Solvents:** Recovery of ethanol, methanol, and hexane from process streams.
- **Polymers:** Pre-condensation of resins and polycarbonates.

Pharmaceutical & Biotech

- **API Production:** Concentration of active pharmaceutical ingredients and antibiotics.
- **Blood Plasma:** Processing of sensitive proteins and albumin.
- **Fermentation Broths:** Concentration of amino acids, enzymes, and vitamins.

Environmental & Energy

- **Wastewater:** Zero Liquid Discharge (ZLD) systems, landfill leachate treatment, and refinery spent wash.
- **Biofuels:** Concentration of bio-ethanol and biodiesel glycerin.
- **Desalination:** High-efficiency water recovery from brine.

The NexTherm Advantage in FFE

As you look toward the use of turbulators in FFEs, remember that our Outward-Directional Wire Turbulators can be retrofitted into any of these shell-and-tube designs to:

- **Eliminate Dry Spots:** Ensuring the film stays pinned to the wall even as it thins toward the bottom.
- **Increase Throughput:** Allowing a GEA or BMA unit to process 20–30% more volume without increasing the physical height of the column.

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