concept engineering

Heat Transfer. **Optimized.**

HTRI MEMBER

Widest Range of In-Tube and On-Tube Heat Transfer Solutions

www.conceptengg.com www.pinfintube.com www.allturbulators.com

About Us

Concept engineering is dedicated to reducing your heat transfer footprint, in size, cost and environmental impact. Proprietary research conducted at our Thermodynamics Research Division drives this.

Heat transfer optimization is balancing heat transfer inside and outside the tube. If the two sides are not balanced the side with the lower heat transfer coefficient is controlling. A small increase on the controlling side will give substantial results. Any increase on the other side is largely in vain. Since heat transfer comes at the cost of pressure drop, it is in our interest to balance the two sides to optimize costs. This is done with the use of our products—Turbulators and our range of Superfin Tubes—which have been optimized by plotting their performance parameters during development at our Thermodynamics Research Division.

Thermodynamics Research Division (TRD)

· All testing is controlled by a computerised SCADA (supervisory control and data acquisition) software which controls the testing through various steps through a PLC (programmable logic controller) controlling and recording aspects like fluid flow, temperatures, differential pressure and velocity in real-time through a range of actuators and sensors gathering data at preset intervals. Once a test is set up, the entire system of steps required through the test process are programmed into a recipe that is run by the SCADA and PLC. The recipe conducts the tests through a wide range of viscosities, flow rates, temperatures and Reynolds Numbers giving a complete profile of the specimen.

· All sensors, pumps, fans and flowmeters are of high sensitivity, respected brands, accurate and are calibrated.

· The rig has been subjected to a multi-level validation.

· The readings collected by the SCADA are uploaded to our cloud for posterity. The test specimen is preserved in our facility for physical verification.

· A single test run with over 2,000 discreet data collection points can be completed in a day in this sophisticated system.

TRD Highlights:

- Totally automated.
- Dedicated Exchanger Testing setup.
- 100+ Models tested.
- Data inputtable into software like HTRI and ASPEN. There are also usable forms for manual calculations.
- Can design and build sophisticated, accurate SCADA and PLC based test rigs as required.
- Data shared with clients after appropriate safeguards and NDAs.
- Multi-stage validation.
- Dedicated Wind Tunnel.
- 260,000+ data points tested.
- Can analyse data using advanced statistical and engineering techniques and models.
- Ongoing research and development of new solutions and products.

Turbulator Test Rig

1. Consists of a 3 meter long pipe-in-pipe or shell and tube exchanger with water on the shellside and hot oil on the tubeside. Oil currently used is MAK 220 hydraulic oil. There are 6 interchangable heat exchangers covering tube sizes 1.5”, 1.25”, 1”, 3/4”, 5/8” and 3/8”.

2. On the oilside, there is a 150 kg boiler, 300 litre insulated hot oil tank, 125 LPM gear pump, flowmeter, temperature sensors in the oil tank, at exchanger inlet and outlet as well as a differential pressure gauge to record pressure between inlet and outlet.

3. On the water side, there is a 2,000 litre ambient water tank, 500 LPM pump, flow meter as well as temperature sensors at the inlet and outlet.

4. The SCADA system does the test typically in the following steps. These steps can be changed by changing the recipe.

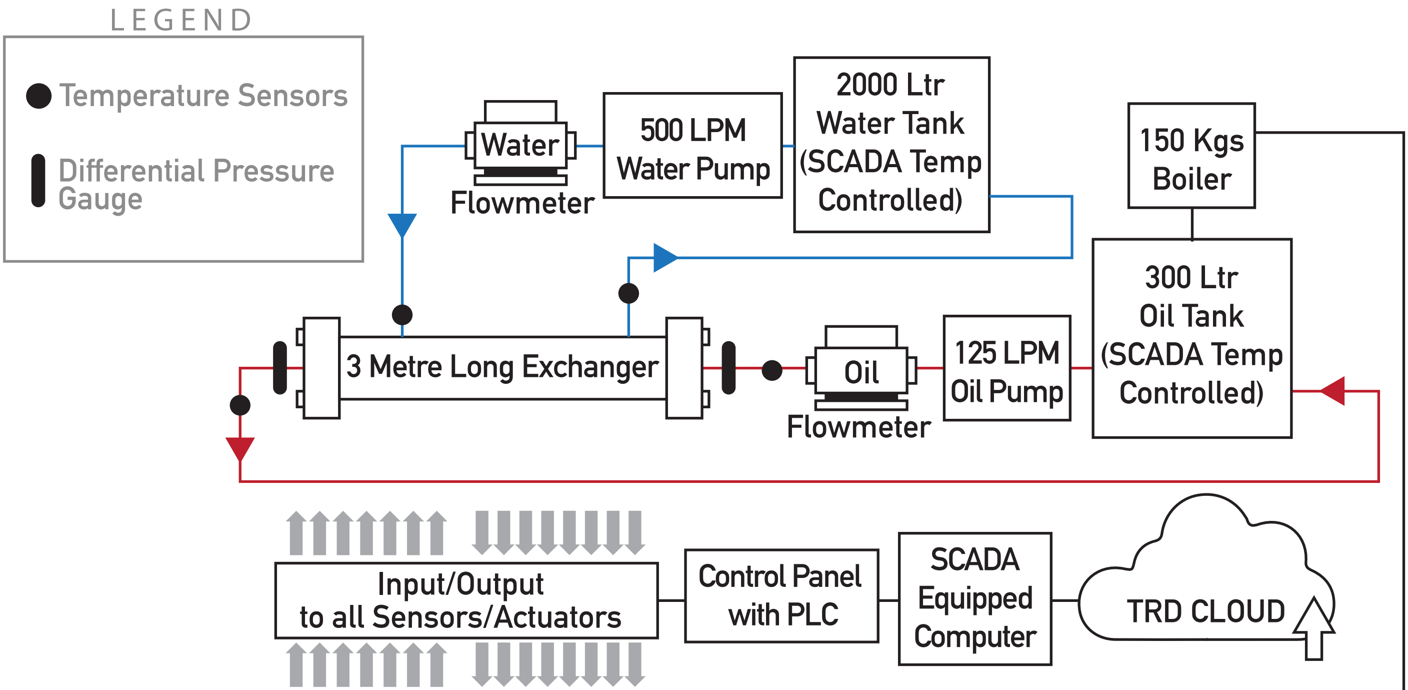
   a. Raise the oil temperature in 7 steps from 60 to 120 degrees in 10 degree increments.

   b. At each preset temperature raise the flowrate from 10 lpm to 90 lpm in 5 litre increments.

   c. At each combination of temperature and flow rate preset after stabilization of flow, take 60 readings at a preset time interval (say 5 seconds).

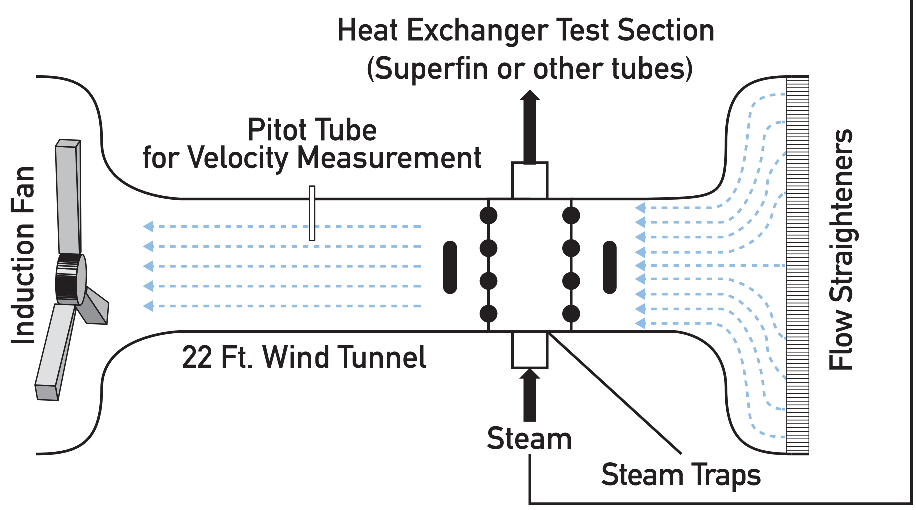
   d. Keep raising the flow rate and taking the readings till a pressure drop limit is reached.

5. This data is transferred to the Thermodynamics Research Division cloud. It is then analysed and the plots and power curves developed. These are made in a form inputable into major software like HTRI and ASPEN.



Wind Tunnel

The wind tunnel is 22 feet long and is induced draft. It also has the full complement of controls and sensors and records the data on temperature, pressure and velocity. The fluid on the tubeside is 3 bar steam. The fan speed is varied in increments and the temperature and pressure readings are taken.



Turbulators

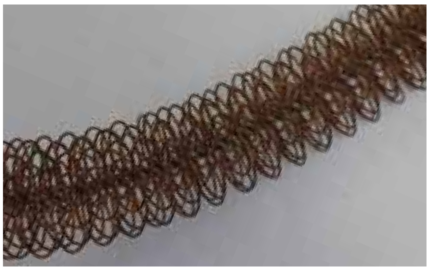
Our USP is we have a wide product range covering different applications. This allows us to be honest with our customers in offering them the ideal solution rather then trying to make their application suit our product. The range and the heat transfer tradeoffs form the rest of this brochure.

We always like to evaluate Turbulators by using a measure called the heat transfer purchase factor. This is nothing but the increase in heat transfer divided by the increase in pressure drop.

$$\text{Purchase factor} = \frac{\text{Increase in heat transfer}}{\text{Increase in pressure drop}}$$

Keeping an eye on this allows us to make sensible tradeoffs.

Flexible Turbulators



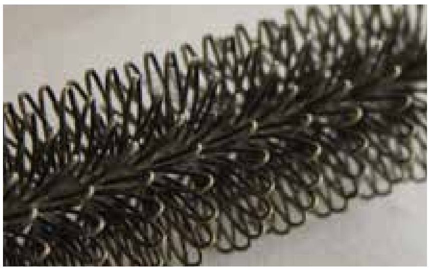
Being easy to install, cost effective and with a good performance this is a star product for us. We have thouroughly tested these and have made the data inputtable into HTRI and ASPEN. They are used very widely in air cooled heat exchangers and shell and tube exchangers. Other applications are found in heat sinks, liquid cooled motors, falling film evaporators and static mixers.

Twisted Tape Turbulators

These are great for relatively higher Reynold Number applications. They have a comparatively lower pressure drop at higher flow rates. Designing is easy and is part of all major software suites like HTRI and ASPEN. Having a low pressure drop profile, it is very suitable for retrofitting existing exchangers where a higher velocity is already utilizing available pressure drop.

We have found that retrofitting refinery exchangers with these considerably reduces pressure drop while increasing heat transfer.

Rigid Soldered Turbulators



In performance these are really a star product. This is because they are soldered inside the tube and increase heat transfer by both turbulation and an increase in surface area. They are perfect for compact oil coolers where the tubeside heat transfer is also suitably enhanced using our super fin tubes.

Disadvantages are that since they are soldered inside tubes the process has to be done in our factory, the fluid in the tube has to be clean and non fouling as the turbulator cannot be removed. Also, there is a temperature limitation of 260 degrees as beyond that the solder will melt. They are also expensive due to the soldering involved and thus suitable for compact coolers for machinery.

Hollow Rod Turbulators

This is a specialized turbulator similar to the rigid turbulator where the loops are soldered to a small central tube whose ends are sealed making a light-weight hollow rod. This is useful where the tube OD is large and by blocking the centre we are moving the fluid to the periphery where the heat transfer is taking place.

Spiral / Spring Turbulators


These are shaped like a spring or coil. Their advantage is by functioning near the boundary layer they expedite heat transfer while minimizing pressure drop. They are suitable where low multiplication of heat transfer is required or where allowable pressure drop is low.

Selection Assistance

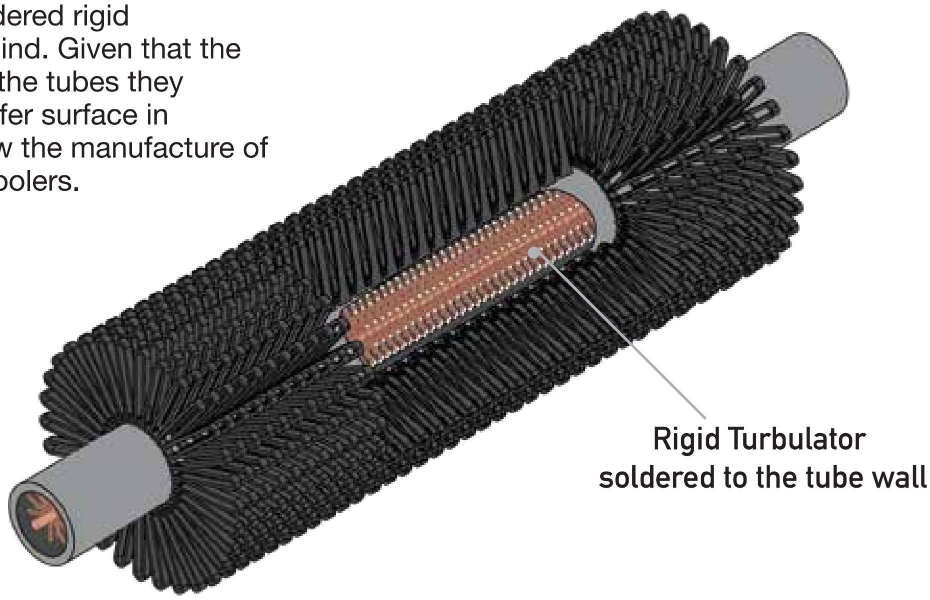
As stated before we can recommend the right turbulator type for your needs. We can also assist in equipment sizing.

Superfin Tubes (stainless steel or copper fins)

Superfin Tubes are made of Stainless Steel 304 or 316 wire loops soldered to a Stainless Steel bare tube giving perfect bonding and high strength. The wire loops turbulate the air increasing greatly the airside heat transfer. The airside heat transfer can be raised about 3 times as compared to the 10 FPI Aluminium L Fin. Since water at a speed of 6 FPS has twice the linear coefficient of a 1" L Fin tube and steam has 3 to 4 times the linear coefficient, we can optimize our fin tubes for water or steam making the heat exchanger size much smaller.

Superfin Tubes with Soldered Turbulators

These tubes are married to soldered rigid turbulators with oil cooling in mind. Given that the turbulators are soldered inside the tubes they provide an extended heat transfer surface in addition to turbulation and allow the manufacture of light-weight, strong compact coolers.



Performance / Physical Characteristics

· About half the weight of an SS Fins L Fin Tube and about the same weight as an Aluminium L Fin Tube.

· Very high performance. Air side coefficient is three times that of same length 10 FPI L Fin Tubes at same air flow rate.

· Much smaller footprint.

· Greatly lowers power consumption.

· High corrosion resistance as full SS construction.

· Strong. Loops are solder bonded to tube so fins are more durable as compared to Aluminium fins. Can be cleaned by low pressure water jet.

Prime Enhancement Case:
Air Cooled Heat Exchangers (ACHE)

An average L Fin Tube is about 6 times the cost of a bare tube. The footprint of an ACHE is also very large and offers real benefits in its reduction. A large ACHE is also a power guzzler. All this makes ACHEs the number 1 case for optimization. Let us study this case a bit more in depth.

Typical fluids in a fin tube exchanger with their linear tubeside coeficients at maximum typical flowrates (water 6 FPS, oil 5 FPS) are:

Sr. No	Fluid	Tubeside Coefficient	Airside Coefficient	Percentage of Airside Coefficient
1	Water	75	54	138%
2	Oil (5 cst)	20	54	37%
3	Oil (15 cst)	7	54	13%
4	Oil (25 cst)	5	54	9%
5	Steam	202	54	374%

A typical 1” 10 FPI L Fin has a linear tubeside heat transfer coefficient at 800 FPM of 54 BTU per hour.

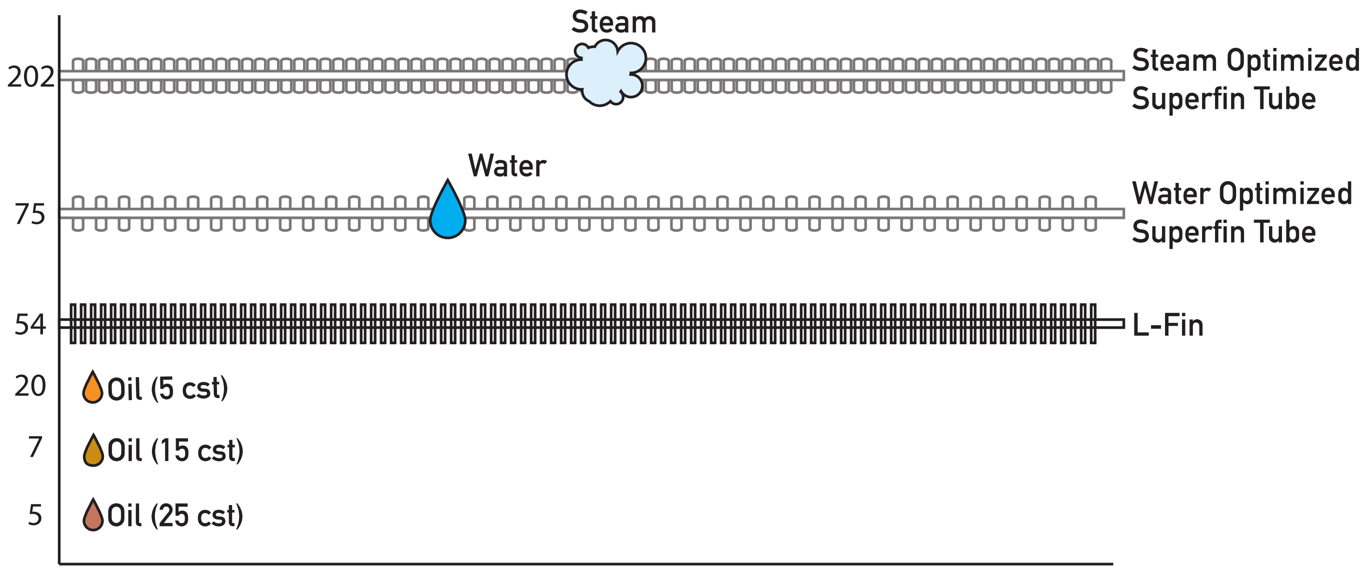
Given the high cost of fin tubes, it is a good strategy to have the tubeside coefficient 20% higher than the airside coefficient.

In the case of oil, if fouling is taking place then further allowances need to be made for performance loss due to fouling.

From the above one can see that:

L Fin Tubes have a much higher heat transfer than oil and would benefit if we are able to bump up the tubeside coefficient and it is possible to thus reduce the size substantially with its consequent capital and operating cost reductions.

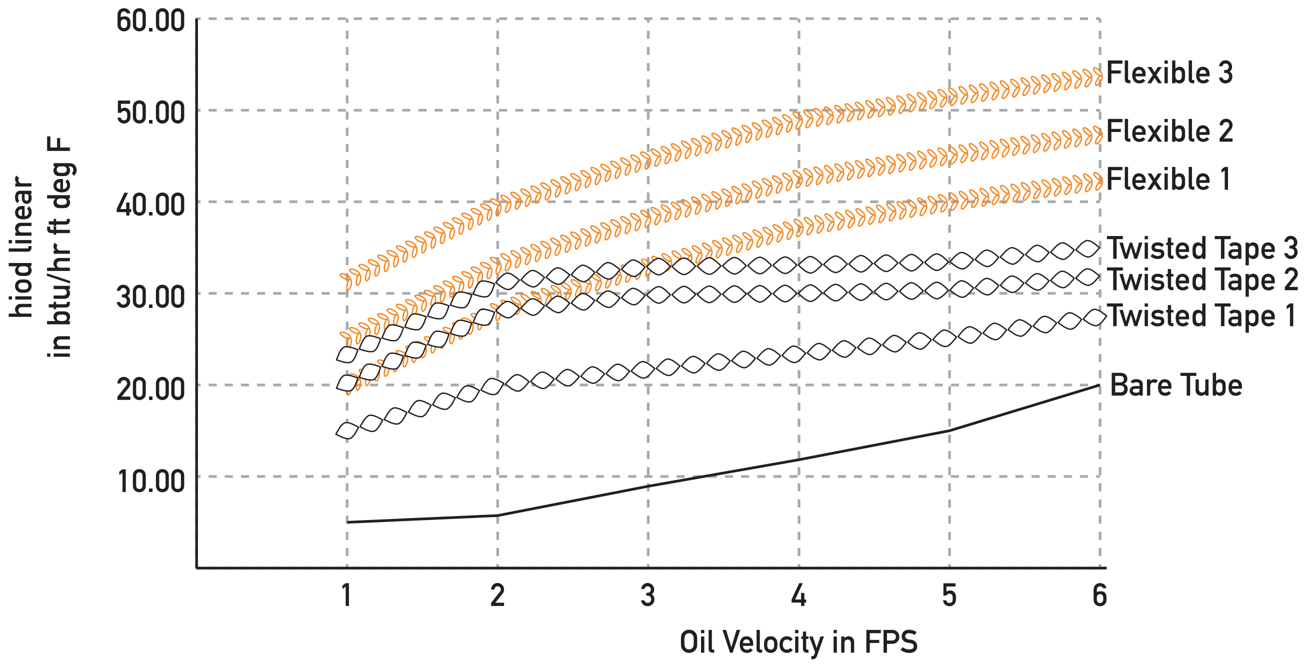
The Graph below illustrates this point lucidly.



Tubeside Optimization in Air Cooled Oil Coolers

Flexible Turbulators are able to raise the tubeside coefficient depending on the viscosity to match the airside coefficient of an L Fin Tube, greatly reducing cooler size. In the case of compact coolers where the super tubes are combined with soldered turbulators the size reduction is even greater.

The graph below shows how turbulators will affect the tubeside heat transfer. For the sake of perspective we have taken a ¾" tube this time , the other popular tube size.



Optimization of Steam / Water Air Coolers

Water

Here the ACHE can be reduced to about 75% of the size by using a water optimized Stainless Steel Superfin Tube in place of an Aluminium fin tube. The Superfin Tube being made of Stainless Steel will also last much longer and withstand corrosion much better having a longer life.

Steam

An L Fin is hopeless in harnessing the power of steam. Using a steam optimized Superfin Stainless Steel tube the steam heater can be made with a panel 33% in size but with higher efficiency. Again the Stainless Steel will give it the necessary strength and corrosion resistance.

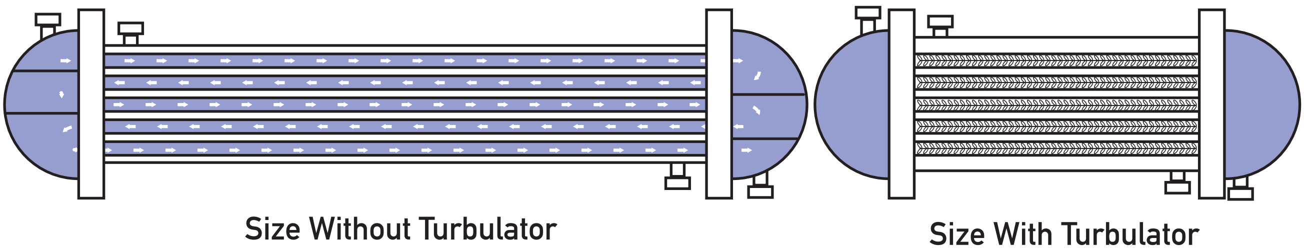
Use Case 2: Shell and Tube Exchangers

A shell and tube exchanger gives a designer many options as he is able to switch the fluids around, vary tube passes as well as baffle arrangements to achieve the desired goal of balancing the heat transfer on the two sides. That said, turbulators can greatly reduce the size of exchangers. It is a very useful tool in the following cases.

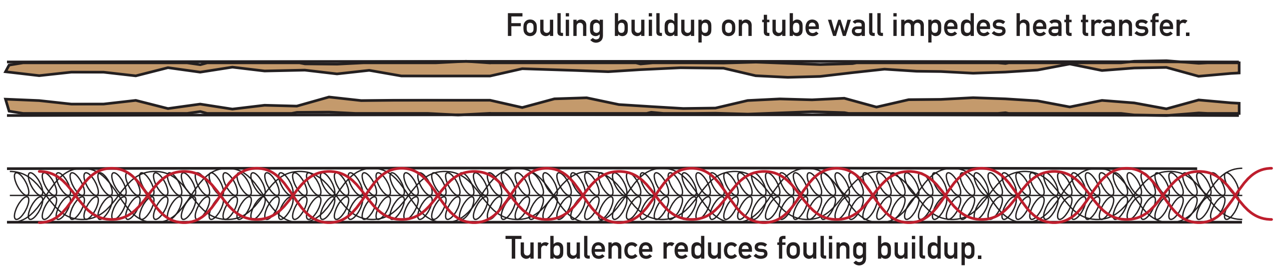
1. Where the tubeside coefficient is lower than the shell side coefficient. Using turbulators will greatly reduce equipment size.

2. Where though initially the tubeside coefficient is higher, with fouling it drops below the shellside performance. Here the tubeside performance is boosted and provides a fouling buffer. Our experience with retrofitting at refineries has showed that due to turbulation the fouling rate and resulting fouling thickness is substantially reduced by using turbulators. This increases exchanger performance as well as time between cleanings. In one case where an equipment was required to be cleaned every 2 months after retrofitting it was running continuously for 2 years at a higher performance level then before.

3. Where the velocity is at its recommended limit and increasing tube passes is not possible. Here one can reduce the passes/velocity by installing turbulators which increase the heat transfer substantially reducing the exchanger size and cost.



Use in Fouling Reduction



Fouling happens when:

1. The temperature difference at the tube wall leads to changes in the fluid which cause fouling compounds to separate and deposit on tube walls. This can be similar to milk solids sticking to the bottom of a pan of heated milk which has not been stirred while heating.

2. A laminar flow allows particles separated from the fluid to settle on a tube wall.

With a turbulent flow the particles are whisked away before they can form or settle on a tube wall. Hence the fouling reduction caused by turbulators.

Other Applications:

Liquid Cooled Heat Sinks for Power Electronics

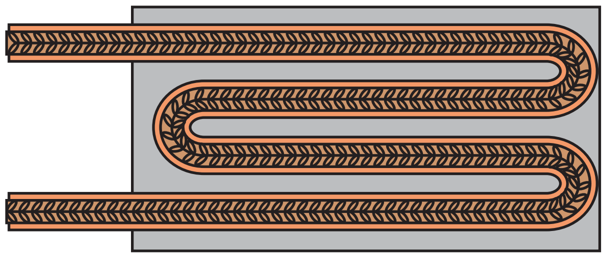
When cooling IGBT modules and high-powered semiconductors, air cooling is often inadequate and liquid cooling is the order of the day. This is because water's thermal conductivity is about 24x of air.

Cold plates are a way to implement localized cooling of power electronics by transferring heat from the device to a liquid that flows to a remote heat exchanger and dissipates into either the ambient or to another liquid in a secondary cooling system.

The application of turbulators increases the rate of heat transfer further, leading to even more heat dissipation than the industry standard and the enhancement is on trend with many thermal solutions' companies looking to capitalize on the improvements in liquid cooling and the customer perception that it's now more reliable and leakproof than ever before.

Applications that call out for liquid cooling further enhanced by our turbulators would be:

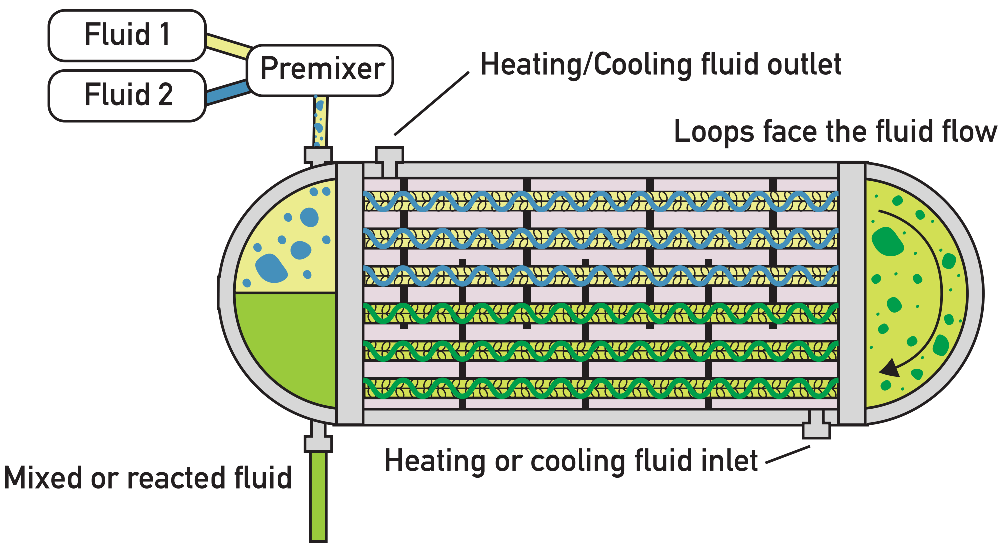
High-powered Electronics
IGBT Modules.
Lasers.
Wind Turbines.
Motor Devices.
Automotive Components.
Medical Equipment.



Inline Static Mixer Reactors

Agitated vessels for mixing or reactions can be replaced by passing the fluids to be mixed through a set of turbulated tubes.

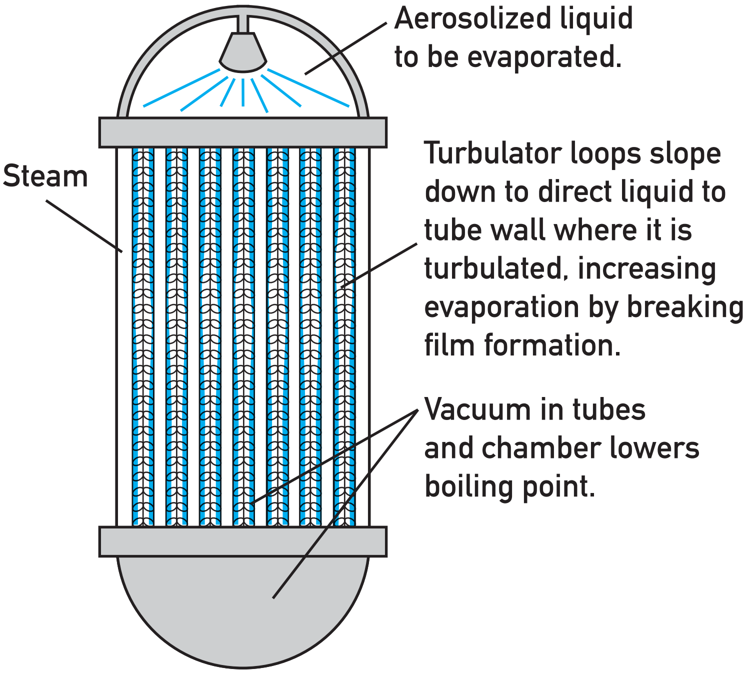
By this in-tube micromixing it is possible to achieve:
1. Online vs batch mixing and reactions.
2. Significantly lower equipment size.
3. Significantly lower power consumption.
4. Significantly lower mixing time.
5. For reactions it is possible to coat turbulators with catalysts or make them from catalyzing metals.
6. For reactions it is possible to add or remove heat by housing the turbulated tubes within an exchanger where the heat transfer fluid (either heating or cooling) can be passed through the shell. (steam, hot/cold water, thermic oil).
7. Turbulators are also very useful when fluids need to be mixed in the feed pipe itself before entering a process chamber.



Falling Film Evaporators

When placed correctly in the tubes of a falling film evaporator, the loops direct the falling liquid to the wall of the tube and also turbulate the film of liquid increasing heat transfer and evaporation.

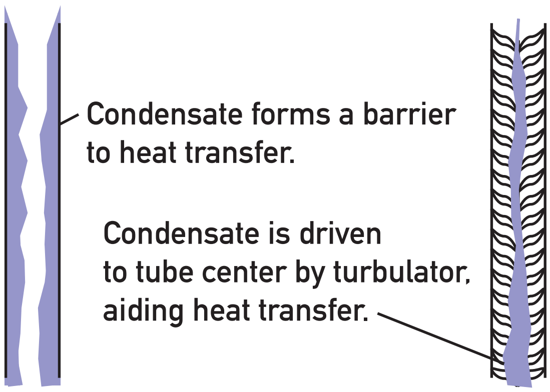
The turbulators also provide additional surface area for the evaporation to take place.



Condensate Drains

Where condensation happens inside vertical tubes, significant performance enhancement is achieved using flexible wire petal turbulators inserted with the loops facing upwards. This is because the condensate film forms a laminar layer impeding heat transfer. The turbulator breaks the film and increases heat transfer and hence condensation. The condensate is diverted to the center of the tube removing its barrier-forming potential significantly increasing the heat transfer at the tube wall. The contact points of the turbulator and tube encourages drop formation at those points. These drops of condensate are drained away towards the center of the tube by the wire loops.

This system is superior to putting the tubes horizontally as in such an arrangement the condensate settles at the floor of the tube reducing effective heat transfer area and in the case of steam condensate can cause knocking.



Further Use Cases

Bearing Oil Coolers
Glycol Coolers
Many others

We can consult with you on your applications. You can also draw on the more extensive data found on our website.

Heat Transfer.
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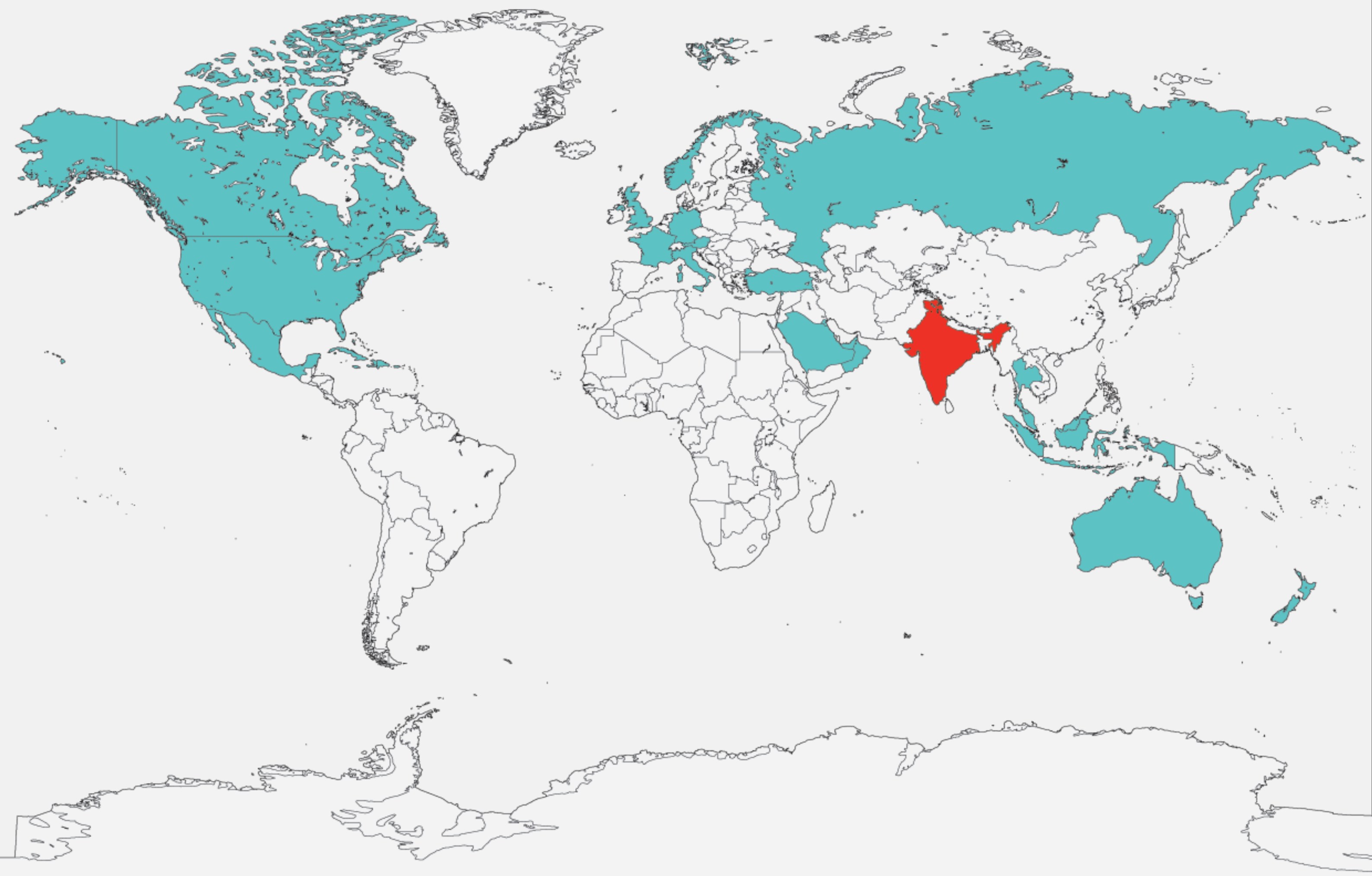
Globally.



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