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THE SUPERIOR MONO-MATERIAL INTEGRAL FINNED TUBE TECHNOLOGY

YOUR BEST INSURANCE TO LONG TERM RELIABILITY AND CORROSION RESISTANCE

The purpose of this technical paper is to highlight the advantages of the mono-material integral finned tube technology offered by Innergy tech. Completely made of a single 100% aluminum tube, this technology eliminates the usual tube-to-fin bond resistance encountered with other technologies. Its mono-material construction and extruded shape also prevent any corrosive liquids from seeping beneath the fins thus eliminating any risk of crevice or galvanic corrosion often encountered at the fin "root" with non-extruded or dual-material technologies.

HEAT TRANSFER AND AIR-TO-AIR HEAT PIPE EXCHANGERS:

When using an air-to-air heat pipe exchanger, several factors can affect the heat pipe thermal resistance:

1. Thermal conductivity of the refrigerant
2. External fouling resistance
3. In-tube "film" resistance
4. External "film" resistance
5. Thermal resistance of the tube metal
6. Thermal resistance of the fin metal
7. Tube-to-fin bond resistance

A drop in the exchanger's effectiveness usually means either modified airflows or an increase in one or many of the above thermal resistances. Due to the basic construction and closed loop circuits of a heat pipe exchanger, items 1, 3, 4, 5 and 6 are basically fixed characteristics not subject to change over time. However, items 2 and 7 can change throughout the exchanger's life.

ENERGY TRANSFER WITH OTHER TECHNOLOGIES:

In all systems which use the fin plates, wrap-on fins or embedded fins technologies, two factors, the external fouling resistance (item 2) and tube-to-fin bond resistance (item 7), can reduce the performance of the heat pipe over time. It should be noted that these problems are not likely to appear in a newly installed heat pipe exchanger regardless of the fin assembly.

Cleaning the heat pipe will help correct the external fouling resistance and reduce the aerodynamic resistance (pressure drop). On the other hand, there is no easy way to correct the tube-to-fin bond resistance. When performance degradation results from increased tube-to-fin bond resistance (item 7) there is no remedial solution for this progressive failure short of the complete exchanger replacement.

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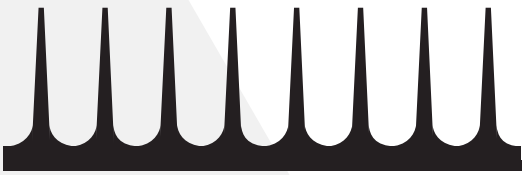
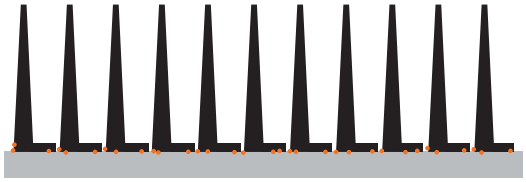
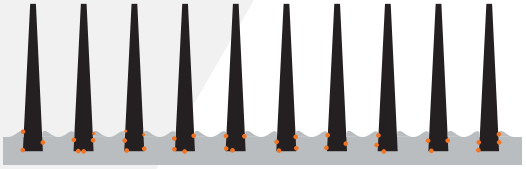


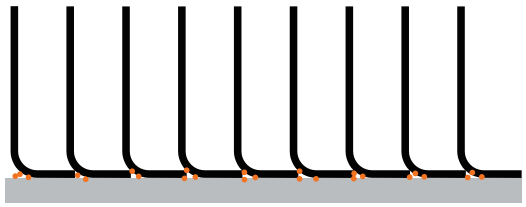
Mono-material finned tube technology



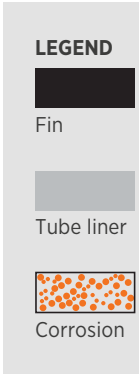
Wrap-on fins technology



Embedded fins technology



Fin plates technology



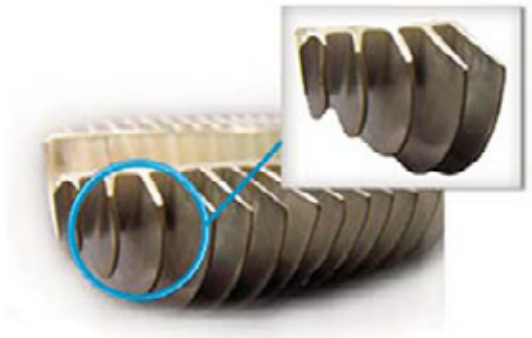
The loss of tube-to-fin contact or bond pressure occurs through the heat cycles of the heat pipe exchanger and will happen much more frequently and rapidly if different materials for the tubes and fins are used. For example, dual material assemblies are often made of aluminum for the fins and copper for the tubes. Due to the different thermal expansion coefficients of these materials, such assemblies result into a higher fins' thermal expansion (see table 1). This increased expansion in turn creates some stress at the fin's "root" and will, over time, reduce the tube-to-fin contact pressure and therefore heat transfer.

INTEGRAL FINNED TUBE TECHNOLOGY MEANS NO TUBE-TO-FIN BOND RESISTANCE AND GREATER FIN STRENGTH:

One of the greatest advantages of the mono-material integral finned tube technology is that there is simply no assembly and therefore no tube-to-fin bond resistance. All tubes are formed from a cold rotary extrusion process into the complete tube with fins end product (picture 1). Since all heat movement from the fins to the tubes and vice versa normally passes through the tube-to-fin bond resistance (located at the fin "root"), eliminating this resistance result is a much more stable performance over time. With the integral finned tube technology, you can be sure that the exchanger will perform as designed from the beginning all the way to the end of your ventilation unit's operating life. Another important advantage of the integral finned tube technology, this time related to the external fouling resistance, is the overall much greater strength of the fins when compared to other technologies like the fin plates or wrap-on fins (picture 2). This means that the exchanger will withstand much more severe cleaning methods like the use of pressure washers which will quickly clean the dirtiest exchangers. In addition, some environments with a high amount of contaminants susceptible to stick to the exchanger's surface simply can not be cleaned with conventional compressed air or vacuum cleaning methods. In these cases, the increased strength of the finned tube technology plainly becomes a must.

Table 1

COEFFICIENT OF THERMAL EXPENSION	
Metal	Coefficient x 10-6
Aluminum	13.5
Admiralty	10.0
Copper	9.6
Carbon Steel	6.7
Austenitic Stainless Steel	10.5



Picture 1: Mono-material finned tube technology close-up

Picture 2: Wrap-on fins (left) VS Innergy tech integral fins (right)

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GALVANIC AND CREVICE CORROSION:

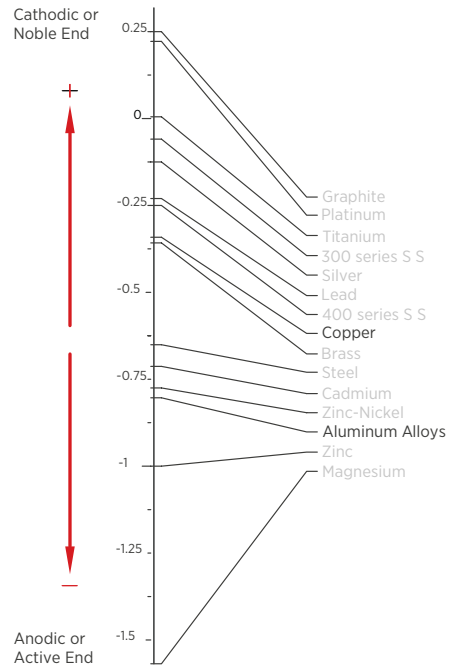
When different materials are used for the tubes and fins, galvanic corrosion can easily take place at the fin "root" and greatly contribute to the heat exchanger's irreversible performance degradation. Again, this kind of corrosion will be greatly

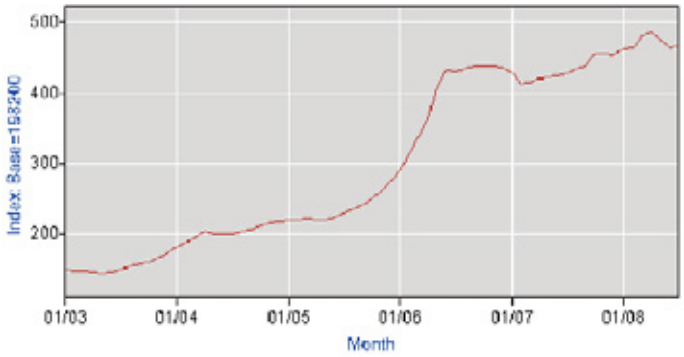
accelerated when using metals with important electrolytic potential differences such as copper (-0.35V) and aluminum (-0.8V). In this case, water condensing on the heat pipe exchanger, along with contaminants or salts in marine environments,

will find its way over time and seeps between the tube and fin assembly where it will corrode the anodic metal (in this case the aluminum fin). The decomposed fin "root" will turn into metallic salts and oxides that will create a thermal insulation

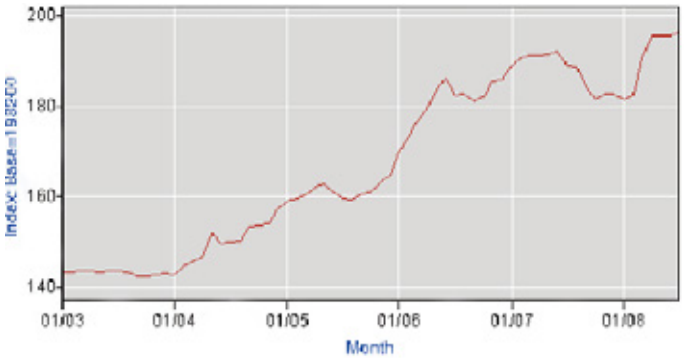
between the tube and "root" of the fin. The result will be a permanently damaged exchanger with gradually reduced performances and no repair possibility short of the entire unit remplacement. Crevice corrosion is another factor which can damage some assemblies like the fin plates or wrap-on fins if a corrosive liquid ever seeps beneath the fins anywhere along the tube's length. Again, with time, the crevice corrosion will spread thus leading to the permanent failure of the tube-to-fin bond. For the above reasons, for any assemblies using copper and aluminum, expensive protection coatings like electro-coatings will have to be used in order to extend the exchanger life to acceptable levels.

Galvanic Series In Flowing Seawater





Aluminum mill shapes price index



Copper alloyed and unalloyed price index

THE MONO-MATERIAL INTEGRAL FINNED TUBE DIFFERENCE:

The mono-material integral finned tube technology address these corrosion threats with its 100% aluminum tubes and formed construction thus completely eliminating any risk of galvanic or crevice corrosion. In this case, a protective coating becomes required only in the presence of chemicals known to directly attack aluminum like aluminum chloride, ammonia or chlorine water. A pool application with susceptible high amount of condensation is a good example where a protective coating is advised.

INITIAL SYSTEM COSTS, A CHANGE IN THE OVERALL PICTURE:

In the past decades, while nearly everyone agreed that the extruded fin technology was the best solution to the long term reliability of heat exchangers, the thicker tubes required to correctly extrude the fins were responsible for an overall higher initial cost compared to plate fins, wrap-on fins or embedded fin assemblies.

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In the past five years or so however, the situation quickly changed with the great price increase of copper in response to China's ever increasing demand for this non-ferrous metal. The situation can be easily shown with the below graphs from the U.S. Department of Labor's database. As shown below, just between 2003 and 2008, the copper index suffered from a dramatic increase of approximately 310% (from 150.5 to 467.2) while aluminum increased by 37% only (from 143.4 to 196.4) for the same time period. The end result is that the situation has changed and now, the mono-material integral fin technology can be offered at a much better price compared to all conventional technologies using aluminum/copper assemblies.

CONCLUSION:

The need for protective coatings as well as an appreciable increased tube-to-fin bond resistance due to thermal cycling has been proved experimentally with tube assemblies.* The mono-material integral finned tube technology offered by Innergy tech is not subject to the above limitations and will result in the most reliable and best corrosion resistant exchangers. Furthermore, the recent copper base price increases and improved manufacturing techniques now make the mono-material integral finned tube technology the most affordable in the industry.

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A SUPERIOR TECHNOLOGY FOR SUPERIOR PRODUCTS.

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2. S. McHugh & S. E. Chapple, "Specify the right fin type for air-cooled heat exchangers", Hydrocarbon Processing September 1999.
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