DEEP Coil Series

DEEP Coil for 50% Reduction

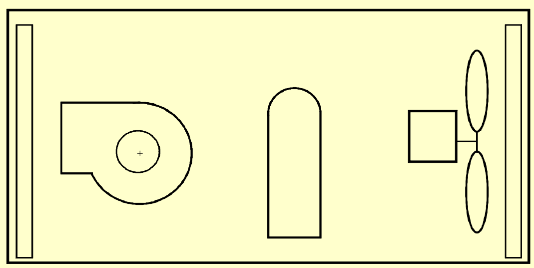
Both cost & energy input, concurrently!

THERMORISE INC.

www.thermorisecoil.com

Hemant D Kale, PE

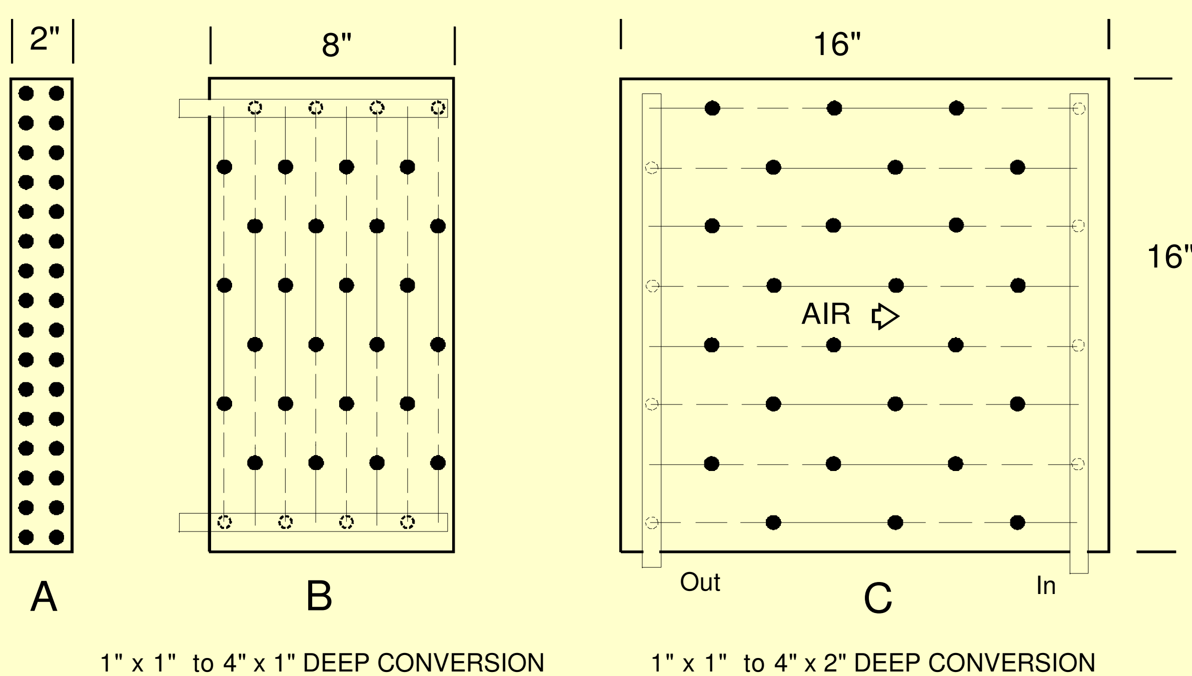
NOW YOU CAN BOTH REDUCE POWER INPUT AND COST OF AN AIR CONDITIONER UP TO 50%!



This is how:

In an air-cooled vapor compression air conditioner there are 3 major energy consuming components, namely compressor, condenser fan motor(s) and blower (indoor) motor. The total power consumption by these components can be reduced considerably, to nearly 50% in some cases, concurrent with proportional material cost savings.

Coil A below is a typical representative outdoor condenser coil. It is a 2 row, 16 x 16" face area, 3/8" 1x1" tube, and 16 fins per inch. Coil B is representation of the Coil A when transformed to 4x1" tube pattern. The coil B has same face area (16x16"), same tubes (3/8"), but the fin density is only 4 fpi. Both coils use 42.66' of tube length in the air stream, and 56.88 sq.ft of total fin surface.



The main differences in the coil A and B are: tube spacing of 1 x 1” vs. 4 x 1”, fin density of 16 vs. 4 fpi, and hairpins and return bends of 1” dia. vs. 4” dia.

Coil B has 4 times as long an air path. Being same face area, velocity remains the same at given cfm in both coils. Therefore, Coil B provides 4 times as long a real-time contact between two heat exchanging media allowing more complete heat exchange. Given the extreme low fin density of 4 fpi, Coil B will also provide considerable air resistance (static pressure, S.P.) reduction. According to our test data, it will be in the range of 80%-90%. The combined effect is same heat transfer, but with enormous reduction in air resistance. The fan BHP varies according to following formula:

New BHP = Old BHP x (New S.P/Old S.P.)^1.5

Accordingly, the new fan BHP for the same CFM will be $1/10^{th}$ of the original – whopping 90% savings. The propeller fans routinely used in condensers are most efficient in low air resistance (low static pressure) conditions. The large static pressure reduction provided by Coil B, while maintaining the same heat transfer, will be very favorable to condenser propeller fans.

Similar considerations apply to indoor blower motor except for one. The blower motor is designed to overcome the resistance created by unit cabinet, the coil and the duct work external to the unit. The typical values for a residential unit are, respectively, 0.1”, 0.4” and 0.2” of w.g. Therefore, the 80% - 90% reduction in the coil resistance will amount to smaller reduction in total air resistance, relative to condenser coil. Yet, it can be up to 50% from prior level and will result in proportionate horse power reduction.

Looking at the fluid side, the Coil B has 4 times as large hairpins and return bends. Both coils will have smooth semicircular hairpins and return bends. The larger bends will reduce the fluid resistance within the bends by inverse proportion of the diameter. Four times as large a diameter will reduce the fluid resistance within the bends to $1/4^{th}$ of the original. Ideally, the condenser face height to width ratio should be 1 to 1, which makes it a square. The square face area provides uniform and even air flow over the heat transfer surface for a propeller fan to be most effective.

For the purpose of estimating the fluid side resistance, the 180 degree, 3/8” diameter tube bends will add about 2’ of equivalent straight tubing. The fluid side resistance for each tube for Coil A and B can be estimated as follow:

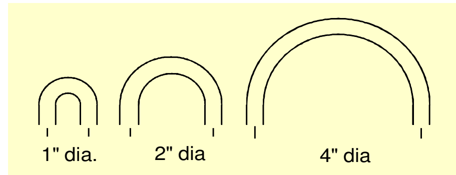
Coil A = 16”/12 + 2 = 3.33’ of equivalent tubing per tube
Coil B =16”/12 + (2 x ¼) = 1.83’ of equivalent tubing per tube
Which is 1.83/3.33 = 0.55, 45% reduction in fluid side resistance in each tube.

This ratio will get smaller as the face area increases, but remains same for any number of rows. For example, for 4 x 4’ face area this ratio will be 0.7, which is 30% reduction in fluid resistance in the condenser.

The compressor needs energy to compress the gas, push the mixture of vapor/liquid through the condenser, expansion valve, distributor and evaporator. The portion downstream from the expansion valve is a low density liquid mist and vapor. This portion is a much small work load on the compressor. So, the 45% reduction mentioned above will certainly become lesser component in the overall compressor load. How much is not known.

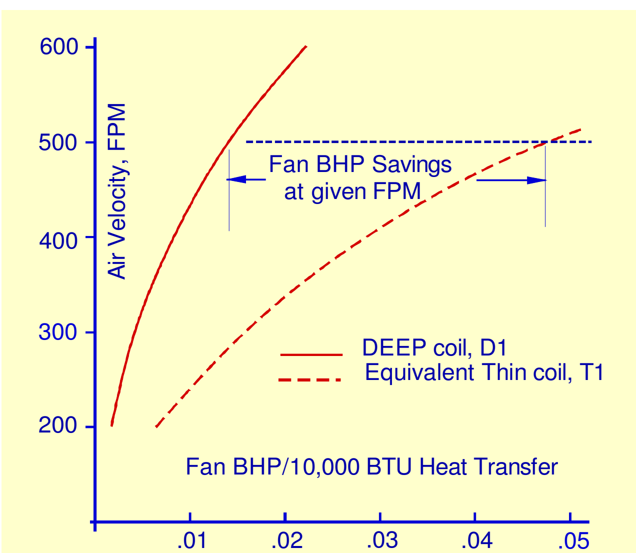
For chilled water and hot water coils, the fluid pump power will reduce in same proportion as the reduction in the tubes since there is no compression involved.

When the above power reduction in the compressor and the two motors is added, it can amount to 30-35% overall reduction from the prior levels. Not quite 50%. Still, substantial and at levels previously unaccomplished. And, most important, these savings are concurrent with similar savings in the product manufacturing cost. The proportionate operating cost savings to the consumer are for the 20-25 years life span of the product. By comparison, scroll compressor provides between 5%-10% higher efficiency with 10% price premium.



Is it possible to accomplish 50% power reduction? It is a stretch, but feasible with some out-of-the-box engineering.   Consider coil C which is a transformation of 1 x1” to 4 x 2”. The tube length in the air stream is the same, but the fin surface at 4 fpi is twice as much. The coil provides 8 times the real-time contact between two heat exchange media. This will increase the heat transfer as well as air resistance. However, given the low fin density of 4 fpi, the heat transfer gain will be higher than the air resistance, providing a net gain. Testing may reveal that the fin density can be further reduced to 3 fpi. The Coil C configuration affords effective thermal counter flow relative to both Coil A and B.   The thermal counter flow will provide up to 15%+/- additional heat transfer, which will result in some more reduction in the compressor h.p. Counter flow provides the most heat transfer with the minimum CFM. The higher the heat transfer, lesser will be the demand on the compressor load. The combined effect of large reduction in the static pressure due to reduced fin density, large tube spacing, and fluid side reduction due to 4 times as large return bends/hairpins can be substantial. On machines using reciprocating compressor, instead of scroll, the reduction can approach 50%. All this with net OEM cost savings in similar proportion!

Another attribute of the DEEP coil is that it has higher velocity threshold point. In conventional tight tube spacing coils, 550 fpm is the threshold velocity. Any increase in velocity beyond 550 fpm provides marginal heat transfer gain, but the fan h.p. climbs disproportionately. The same velocity threshold point for DEEP coil is much higher - about 750-800 fpm. In some cases this can reduce the size of the compressor needed.



Source: Empirical data

Combining 4x2” tube spacing, 3 fpi fin density, counter flow and higher velocity is likely to get you very close to 50% power reduction.

The above estimates of power reductions in compressor, fan motor and blower motor are based on empirical ETL comparison tests on true prototypes of 2x1” tube spacing as well as numerous other exploratory tests on many different tube spacing and patterns. Fin-dies for 2 x 1” are currently available.

The DEEP coil attributes hold good in any fluid-to-air heat transfer (absorb or reject). It works just as good on any refrigerant, chilled/hot water, steam or oils. It should also hold just as good whether reciprocating, scroll or centrifugal compressor as well as different tube diameters.

So much hue and cry over energy, green tech, climate change………….

………so little action!