Building an El-Cheapo Compressed Air Dryer

One of the problems with running an air compressor for air tools etc is the buildup of water in the compressor tank. This water is bad for several reasons: First, it causes the interior of the air tank to rust, which eventually can become the cause of a catastrophic tank failure; second, the water is not good for air tools; and third the water can actually prevent some tools/processes from working correctly, like a plasma cutter or a sandblaster.

So, we want to remove as much water as possible from the compressed air and from the tank. Leaving water in the tank is simply ensuring that the stored compressed air is saturated with moisture.

There are several ways to remove moisture from air, but the easiest way is to cool it. When you compress air, it's temperature rises, when you let it expand, it cools. That's why the compressor gets so hot when its working, not from internal friction of the compressor itself (which does contribute heat) but from the simple act of increasing the air.

For those engineer geeks out there, the equation is called the Ideal Gas Law. (Air is not actually an "ideal gas" but its darn close, so the equation is a good approximation.)

$PV = NRT$

Where P= Pressure, V = Volume, N is the amount of molecules of gas (in our case, air), R is the gas constant (it's a value you look up in a reference book for whatever gas you are working with) and T is the temperature. Its fairly easy to see that if we increase the pressure, with everything else remaining constant, the temperature must rise.

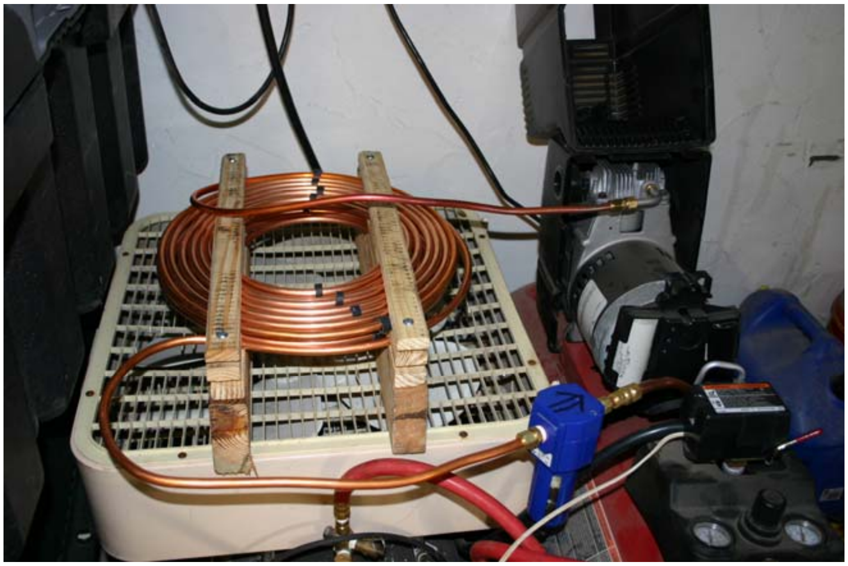

Figure 1 - the assembled dryer and cooling fan

So, we want to reduce the temperature of the compressed air to well below its Dew Point so that the water will precipitate out (like rain) as a liquid.

Usually, modern air compressors have a short run of tubing from the compressor to a check-valve at the point where it enters the tank. On my compressor, I simply diverted this tubing into a long coil where I can blow air over it to cool it. See Figure 1. All of the parts used to build this cooler were obtained from my local Lowe's plumbing department, except the blue air filter assembly which came from Tractor Supply. The fan came from Walmart.

The air exiting the compressor, entering the coil (upper right of the picture in Figure 1) is very hot, and moisture laden. The pipe here will be plenty hot enough to burn you, so don't touch it when the compressor is running. The air exiting the cooler at the bottom of the picture is cool to the touch.

Note that the coil is oriented so that as the air flows from the compressor through the coil, it is always flowing downhill. This way, any liquid will be pushed along not only by the flow of air, but by gravity also, and will wind up in the blue separator. Figure 2 shows a side view of the coil, and you can see how the inlet is at the highest point, the coils are approximately level and the outlet is the lowest point. Note also just barely visible between the coils is the section that goes from the upper coil to the lower coil in the rear, always slanting downward for the condensed liquid to flow. I did almost nothing to shape these coils except to separate them to allow the air to flow; their dual flat coil shape is how the pipe is shipped.

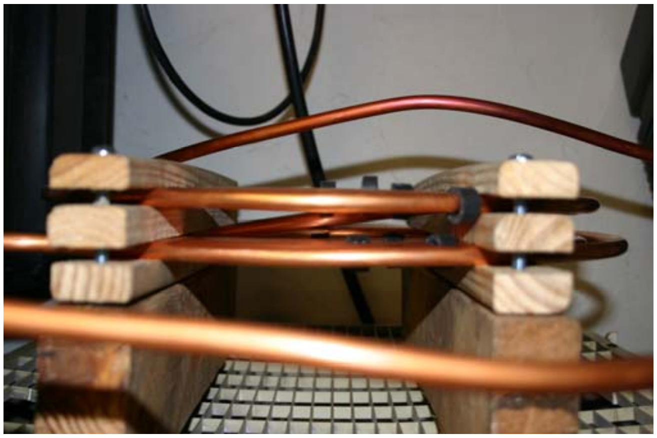

Figure 2 – Side view of the cooling coils

Figure 3 – tube separators

Figure 3 shows the separations of the tubing to allow better airflow. This is one place where my setup could have been done better – I did not think about the need for airflow between the windings of each coil until after I had assembled the coil rig, and once you get to that point its truly difficult to wrestle the tubing about to get gaps between the tube – so, do this part first when you pull the coil out of the box. Get the automotive tubing and use these separators throughout the coil, probably like at 90deg or perhaps at 120deg separations to ensure the tubes allow air to flow between them – this will dramatically increase the efficiency of the coil heat transfer.

If your compressor is electric, it will have a pressure operated switch which turns the electricity on to the compressor motor at a low pressure setting and turns it off at a high pressure setting. This is the black box at lower right of fig 1 where the large black and small white electrical cords end. I opened up this switch (after unplugging the compressor from the wall, of course) and wired the fan so that it comes on whenever the compressor comes on. My compressor is a relatively small 110V rig – if yours is a 220V setup, this same thing can be accomplished but your wiring would be different for the 220V setup. You should still be able to use a 110V box fan like mine for this – they only cost about $20 from WalMart.

How well does it work? Its not perfect, and it wont remove 100% of the water from the air. Some of the effectiveness of this rig is driven by the ability of the filter/separator device to remove the condensed water. Mine is a very cheap chinese-made Campbell-Hausfeld device – you probably could find a much better one if you tried, but it will cost quite a bit more.

Figure 4 – One compressor cycle worth of removed water

I emptied my compressor entirely and then emptied the water trap from the separator. I then ran the compressor to shutoff at 120PSI. ***Figure 4 shows the amount of water which was removed by this setup in just this one cycle of the compressor!*** So this darn thing does indeed work.

The coil is the expensive part. The copper tubing was purchased from Lowes, and I used 3/8" tubing. 50 feet cost about $50. The tubing will come in a coil just like you see in figure 1. I got about 1 foot of ½" automotive hose, split it lengthwise, and cut it into small sections like little C shapes that I could slide over the tube to ensure that the tubes remain separated to allow the air to flow through between the tubes. You can see these little black things on the coil in Figure 1. I used 3 pieces of wood, about 1.5" wide, by ½" thick, and about 18" long on each side of the coil, with a long screw through all three at each end GENTLY tightened down to sandwich the coil in shape and to keep it from vibrating. These three slats are sitting on two 2X4s in Figure 1, on top of the fan. These two 2X4s just hold the coil at the correct height to allow the coil not to have any low point which will hold liquid.

Safety concerns:

- The coil will get very hot, at the input end.
- Copper pipe used for plumbing, like you will find at Lowes and HomeDepot, is generally type L. The internal working pressure for this type of pipe varies with diameter, and generally the larger the diameter, the lower the pressure limit. For maximum heat transfer, you want the smallest diameter possible, but that's offset by having sufficient flow through the pipe. For the 3/8" pipe that I used, my research via the internet led me to the conclusion that the pipe is rated at a maximum working pressure that is several times what my compressor can develop, so I believe its safe. One such reference is *http://coppercanada.ca/pdfs/28e.pdf* page 17. There are many others which lead me to the same conclusion. Your mileage may vary, professional typist on a closed keyboard, yada yada yada.
- Make sure your connections are tight and secure. Ferrule (or swage collar) fittings like you will have to use with copper pipe will blow off if you don't have them tight. It shouldn't do anything more than scare you half to death the first time it happens, but you don't want to risk something else getting damaged.
- Your compressor SHOULD be designed with a pressure relief that will dump the pressure in the pipe from the compressor to the tank when the pressure switch shuts it off. This is called an unloader valve, and is intended to prevent the compressor from having to start-up against a high pressure. This will also vent the pressure from the coil.

The water separator is http://www.mytscstore.com/detail.asp?pcID=1&paID=1010&sonID=464&productID=1669 at Tractor Supply for about $24. Another way to accomplish this, suggested by Al Dolney, is to simply build a short vertical section of pipe, right angle outflow at the top to the air tank, and inflow from the cool end of the coil about halfway down, and a ball or other sealed valve at the bottom. This would trap the liquid water in the lower part of the pipe. Ideally, you would want to use a clear pipe so you could see the water level. Figure 5 depicts a notional design. I have not tried this, but it certainly should work.

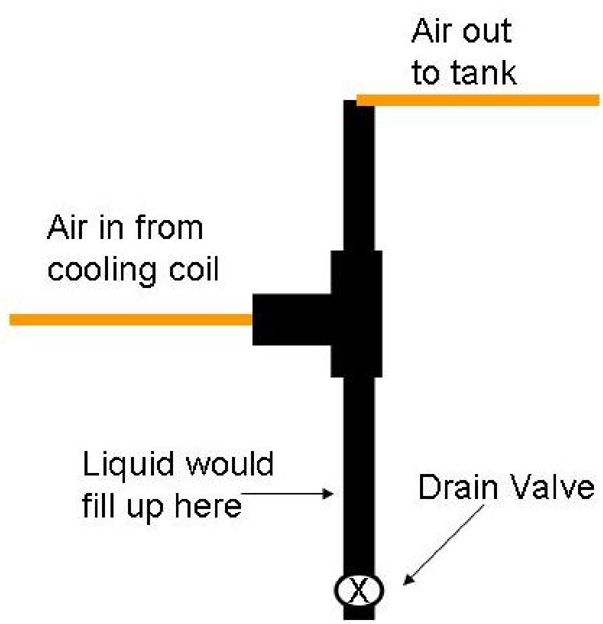

Figure 5 – Notional design for homebrew liquid water separator