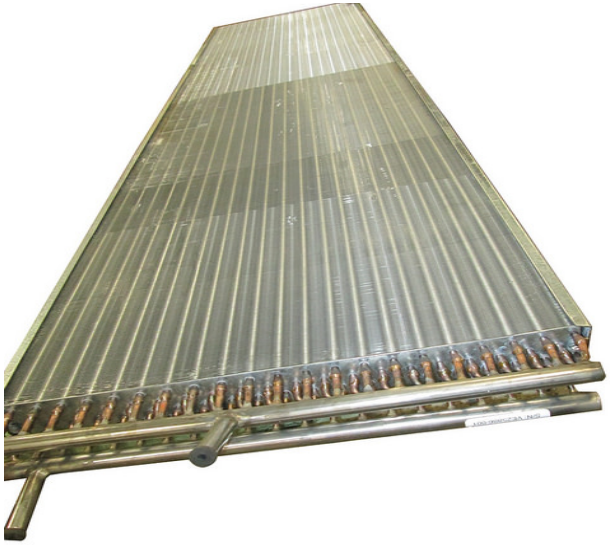
New copper-tube technologies for heat exchangers:

R290 condenser Coil and R744 gas cooler

Y. Shabtay, Dr. Jian Yu, N. Cotton

Case studies

10” x 13” condenser coil



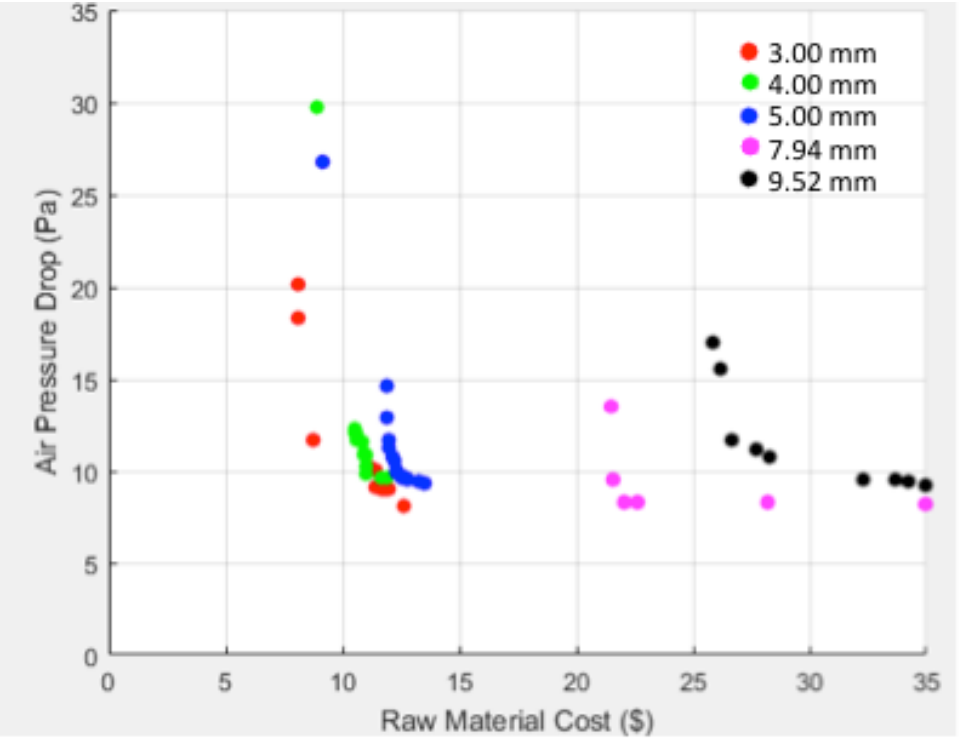
18” x 37” CO_2 gas cooler

Requirements

- R290 condenser:
  - Limit on refrigerant charge amount
  - Safety concerns
  - Minimize cost
- R744 gas cooler:
  - High-pressure with thin wall
  - Minimize cost

Design software

- Gives user the option to choose a tube diameter, inner groove tube geometry, fin design and refrigerant type
- Optimizes entire system of compressor, evaporator, and condenser with a cost analysis
- Simulates all key technical parameters needed to optimize the performance and cost of small diameter copper tube heat exchangers and total system



Slit fin HX simulation

Manufacturing

- Pressure expansion allows:
  - Expansion of small tubes
  - Expansion of long coils
  - Maintains inner grooving
  - Low tool wear

Case 1 comparison

Super Radiator Coils

Heat Transfer Technologies

R290 Condenser	Unit	5 mm Tube	3/8" Tube	5/16" Tube
Capacity	BTUH	4715	4426	4477
Design Pressure	PSIA	250	250	250
Coil Size	in	10.5 X 13.25	10x13.25	10x13.25
Row		5	3	4
Fin Density	FPI	8	8	8
Tube Pattern	in	0.75 x 0.449	1.0 x 0.866	1.0x0.625
Tube Material		Cu	Cu	Cu
Tube OD	in	0.197	0.375	0.3125
Tube Wall	in	0.010	0.016	0.013
Tube Weight	Lbs.	2.05 (82% of 5/16)	2.77	2.50
Fin Material		AL	AL	AL
Fin Thickness	in	0.0075	0.0075	0.0075
Fin Weight	Lbs.	1.72 (97.7% of 5/16)	1.82	1.76
Total Internal Volume	Liter	**0.55** (65.5% of 5/16)	0.90	0.84

Case 2 comparison

Super Radiator Coils

Heat Transfer Technologies

CO2 Gas Cooler	Unit	5mm tube	5/16" tube	Ratio
Capacity	BTUH	43,000	43,000	
Design Pressure	PSIA	1,005	1,005	
Coil Size	in	18 x 37	18 x 37	
Row		4	4	
Fin Density	FPI	16	12.5	
Tube Pattern	in	0.75 x 0.449	1.0 x 0.625	
Tube Material		Cu	Cu	
Tube OD	in	0.197	0.3125	
Tube Wall	in	0.040	0.049	
Tube Weight	Lbs.	24.5	37.7	**65%**
Fin Material		AL	AL	
Fin Thickness	in	0.0039	0.0045	
Fin Weight	Lbs.	7.5	9.5	**79%**
Total Internal Volume	Liter	1.2	2.2	**54.5%**

Lessons / plans

- Higher pressure capable, Lower refrigerant charge, Compact design
- High-strength copper alloy (CuFe2P) available for even higher pressure
- Expanding use of 5mm Microgroove tubes