Indus Engineering

Heat Exchanger Design Case Study
Condenser for Medical Device Cooling System

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Customer Requirement

- Development of condenser coil of medical device cooling system

- Use of next generation low GWP refrigerant gas to reduce environmental impact of HFC

- Reduction of material cost and refrigerant charge

Task

- ❑ **Design of condenser coil with low GWP refrigerant R290**

- ❑ **Task is to achieve:**
  - **Maximum performance keeping low refrigerant charge within safety limit**
  - **Minimum pressure drop both air side and refrigerant side**
  - **Lower superheating and subcooling values**
  - **Mounting of condenser within existing coil envelope**

Actions

- Indus Engineering team took up the challenge and with our software simulation program and HVAC/ refrigeration system knowledge, condenser design were carried out

CONDENSING COIL - 20 x 17.32 x 5mm IG x LF 13T 2NR 336A 1.5P 1NC

Geometry	20 x 17.32 x 5mm IG x LF	Coil Length	336.0 mm		
Nr of Tubes per Row	13	Fin Pitch	1.50 mm		
Nr of Rows	2	Nr of Circuits	1	Tube Shape	Circular

Capacity	2066	Btu/h
Exchange Surface	42.446	ft²
Global Exchange Coefficient	8.76	Btu/(h ft² °F)
DTML	3.1	K
Fins Material / Tubes Material	Aluminium / Copper	
Fin Thickness	0.00472	in
Coil Internal Volume	0.005	ft³
Tubes External Diameter	0.1969	in
Tubes Internal Diameter	0.1748	in
Number of skipped tube	0	
AIR SIDE		
Atmospheric Pressure / Altitude	14.70 / 0.00	psi / ft
Volumetric Air Flow	390.0	cft/min
Mass Air Flow	1674.78	lb/h
Face Velocity on the Coil	2.11	m/s
Inlet Air Density	0.071572	lb/ft³
Inlet Air Temperature	32.0	°C
Inlet Air Relative Humidity	50.00	%
Inlet Air Specific Humidity	103.30	gr/lb AS
Inlet Air Enthalpy	37.73917	Btu / lb
Outlet Air Temperature	34.8	°C
Outlet Air Relative Humidity	42.79	%
Outlet Air Specific Humidity	103.30	gr/lb AS
Outlet Air Enthalpy	38.97263	Btu / lb
Pressure Drop	28	Pa
Partial Exchange Coefficient	12.25	Btu/(h ft² °F)
Fouling Factor	0.0000	(ftq h °F)/Btu
REFRIGERANT SIDE		
Fluid	PROPANE	
Mass Fluid Flow	11.93	lb/h
Fluid Velocity (Gaseous Phase)	3.47	m/s
Fluid Velocity (Liquid Phase)	0.21	m/s
Mass velocity	97	kg/(m² s)
SubCooling	1.5	K
Desuperheating	40.0	K
Condensing Temperature	37.0	°C
Fluid Pressure Drop	22.34	kPa
Manifold Pressure Drop	0	kPa
Total Pressure Drop Fluid Side	22.34	kPa
Partial Exchange Coefficient	594.86	Btu/(h ft² °F)
Fouling Factor	0.0000	(ftq h °F)/Btu

- Tube diameter selection:
  - Simulation with different tube diameter to minimize internal volume of coil
  - Minimisation of refrigerant charge of R290 refrigerant
  - Keeping desired performance of coil at different ambient conditions

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Actions

- **Fin Selection:**
  - **Pperformance simulation carried out with different fin geometry**

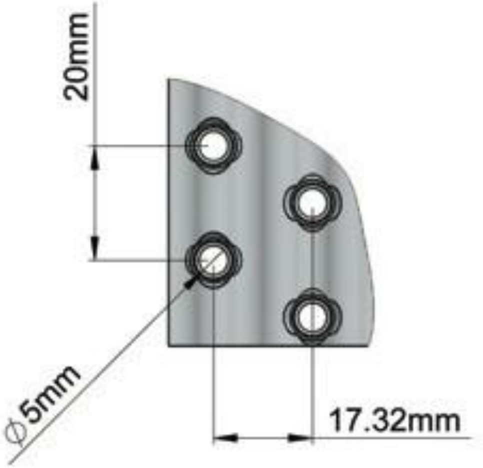
  - **Keeping wide fin spacing**

  - **Meet low air side pressure drop**

Solution

- Based on various iterations, we choose two geometries:
  1. Mini-channel tube of 5mm OD and compact fin geometry pattern 20 x 17.32mm and sine wave type fin
  2. Tube of 7mm OD and fin geometry pattern 25 x 21.65mm and sine wave type fin

5MM DIA TUBES



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Solution

- ❑ **Compressor flow rate design:**
  - Refrigerant flow rate is designed for a certain level of superheating and subcooling

- ❑ **A complete matrix of simulation results was prepared with various options**

- ❑ **After deliberation, optimum performance and cost viable option is selected with 5mm OD tube**

Solution

- Coil circuit designed to keep refrigerant side pressure drop optimum

- Sampling and testing were carried out at customer end and coils performed as per desired target

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Benefits

- **Achieved targeted performance of condenser keeping refrigerant charge within safety limit**

- **Cost Effective Solution:**
  - Reduction in material weight by 12% and cost reduction by 15%
  - Low refrigerant charge

- **Meeting EU f-gas regulations of low GWP refrigerant using R290 compared to R410a**