

# Redesign of 2-stage Compressors for Small Centrifugal Chillers

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## Compressor Specification

- HFC-134a Refrigerant
- 90 USRT Capacity
- 2-stage Configuration
- Wide Operating Range
- Higher Efficiency
- 2 Design Points
- Minimal Changes of Geometry
- No Impeller-Cut
- No Changes of Impeller Blades
- No Changes of Volute

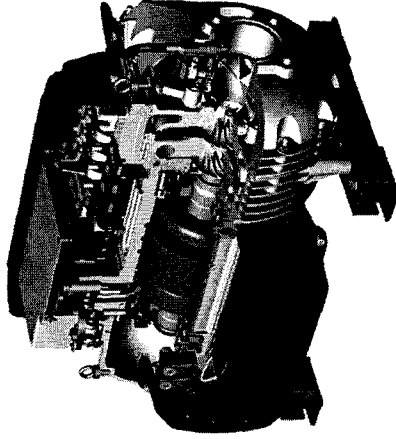
## Design Audit & Redesign

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# Small Centrifugal Chiller Compressor



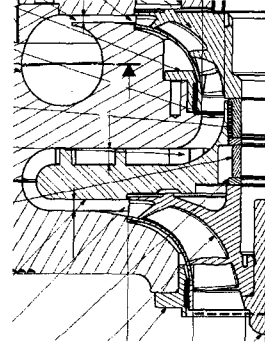
The TurboCOR TT300  
 compressor won an  
 Energy Innovation  
 Award at the 2003  
 AHR Expo in  
 Chicago for its  
 new technology.

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# Compressor -- Original Design



Performance Points	100% (100%)		75% (75%)		50% (50%)		25% (25%)		10% (10%)	
	Spec	Prod	Spec	Prod	Spec	Prod	Spec	Prod	Spec	Prod
Pressure ratio (P2/P1)	1.657	1.736	1.213	1.243	1.556	1.397	1.963	1.307	2.420	1.661
Specific Speed (1/S)	76	78	80	79	82	81	84	83	87	86
Impeller Efficiency (%)	89.5%	90.4%	91.8%	91.8%	93.2%	93.2%	94.6%	94.6%	96.0%	96.0%
Impeller Tip Speed (m/s)	16.53	16.53	16.53	16.53	16.53	16.53	16.53	16.53	16.53	16.53
Impeller Tip Speed (ft/min)	121.3	121.3	121.3	121.3	121.3	121.3	121.3	121.3	121.3	121.3
Tip Mach	0.840	0.840	0.840	0.840	0.840	0.840	0.840	0.840	0.840	0.840
Tip Mach	1.077	1.077	1.077	1.077	1.077	1.077	1.077	1.077	1.077	1.077
Tip Mach	1.324	1.324	1.324	1.324	1.324	1.324	1.324	1.324	1.324	1.324

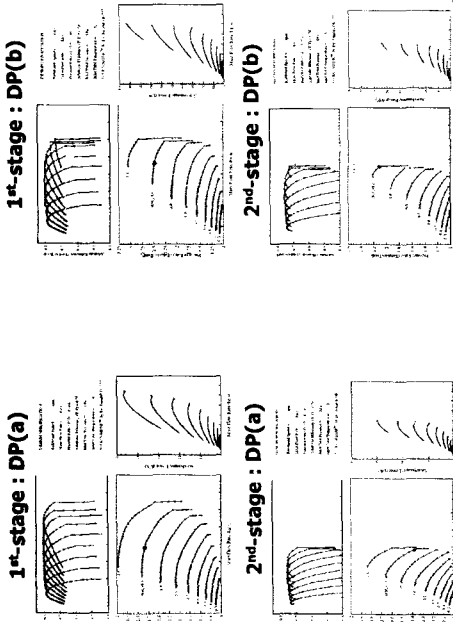
Notes: Spec = design conditions  
 100% = 100% of design conditions  
 75% = 75% of design conditions  
 50% = 50% of design conditions  
 25% = 25% of design conditions  
 10% = 10% of design conditions  
 P2/P1 = total pressure ratio  
 1/S = specific speed  
 Tip Mach = tip Mach number  
 Tip Mach = tip Mach number

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## Original Stage Performance Prediction

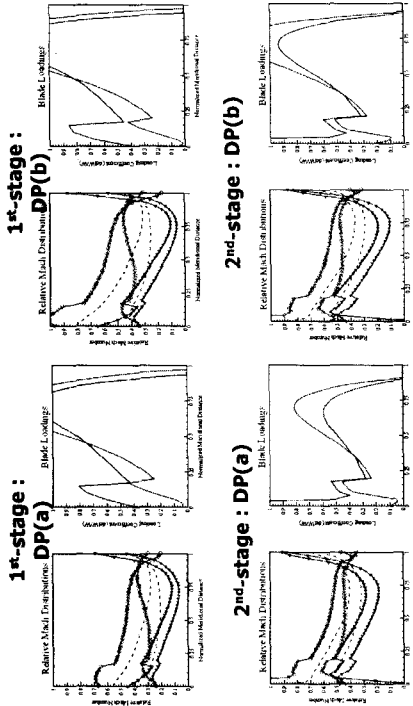


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## Original Impeller Performance



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## Redesign Results

DP(a) DP(b)

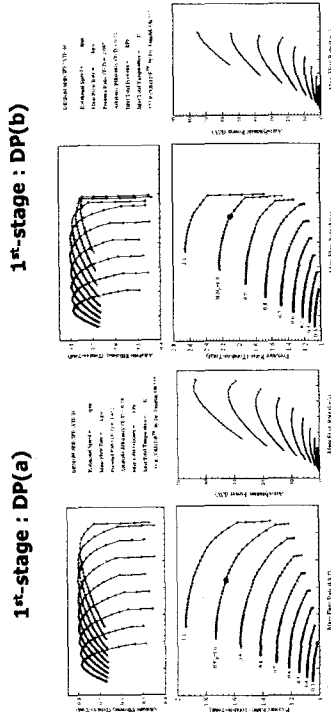
Redesigned Parameter for DP(a)	1st stage		2nd stage		1st stage		2nd stage	
	Original	Redesign	Original	Redesign	Original	Redesign	Original	Redesign
Impeller exit radius (mm)	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged
Impeller blade exit angle (deg)	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged
Impeller exit mean thickness (mm)	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged
Impeller exit width (mm)	100%	141%	100%	141%	100%	141%	100%	141%
Deswirl vane inlet angle (deg)	100%	85%	100%	85%	100%	85%	100%	85%
Impeller inlet shroud radius (mm)	100%	113%	100%	113%	100%	113%	100%	113%
Passage height at volute inlet (mm)	100%	140%	100%	140%	100%	140%	100%	140%
Passage height at volute exit (mm)	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged
Cross section area at volute exit (mm <sup>2</sup> )	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged
Cross section area at volute flange (mm <sup>2</sup> )	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged
Shroud radius at return channel exit (mm)	100%	113%	100%	113%	100%	113%	100%	113%
Shroud radius at return channel exit (mm)	100%	111%	100%	111%	100%	110%	100%	110%
Mass flow rate (kg/s)	100%	111%	100%	111%	100%	110%	100%	110%
Rotational speed (rpm)	98%							

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## Redesigned Compressor Performance



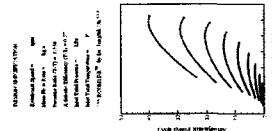
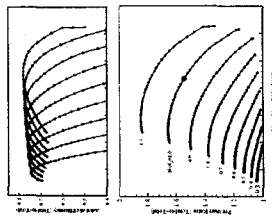
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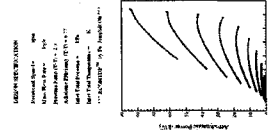
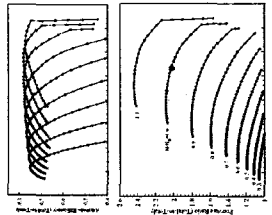
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## Redesigned Compressor Performance

2nd-stage : DP(a)



2nd-stage : DP(b)



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## Impeller CFD Performance 1st-stage : DP(a)

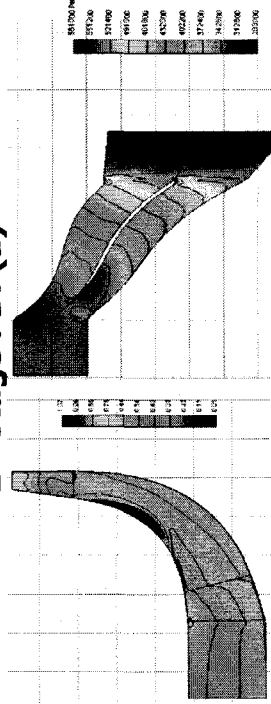


Table 4.3 Some important performance parameters

Parameter	CFD	Measuring	Remarks
Pressure ratio (Total-to-total)	1.983	1.795	10.5% higher
Isentropic efficiency (Total-to-total)	0.921	0.954	3.6% lower
Absolute flow angle at exit (deg)	19.65	23.40	higher pressure
Absolute Mach number at exit	0.75	0.66	lower efficiency
Total temperature at exit (K)	313.42	309.41	lower efficiency

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