

Low Cost Desiccant Wheels AND Heat Pump Liquid Desiccant Regeneration

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Heat Pump Liquid Desiccant Regeneration

- NREL 3/01 RFP
- 7/02 – 12/02 schedule
- \$34,780 funding
- Project goal:
 - prototype designs via CFD
 - Primary COP ≥ 1.0
 - RSHI ≤ 1000 Btu/lb
- TAT & IES impact:
 - higher efficiency TAT
 - more cost effective IES
- Project team:
 - UIC/ERC
 - DryKor



Low Cost Desiccant Wheels

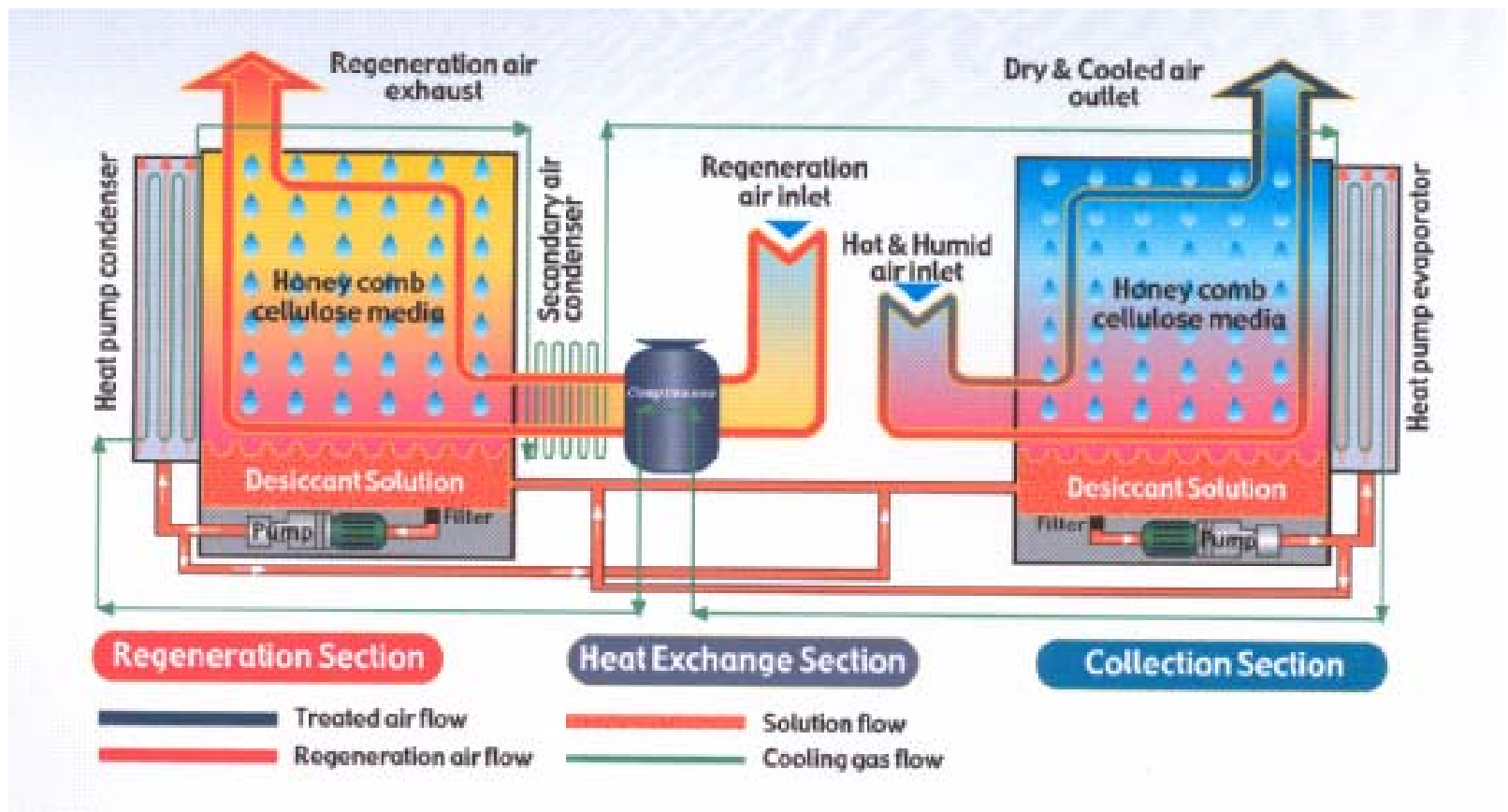
- NREL 4/01 RFP
- 7/02 – 4/03 schedule
- \$115,220 funding
- Project goal:
 - prototype rotor(s)
 - Δ gr/lb > 50 (@600 fpm)
 - 50% \$/cfm reduction
- TAT & IES impact:
 - lower cost TAT
 - more cost effective IES
- Project team:
 - UIC/ERC
 - RotorSource
 - ProFlute
 - IRE & NRG



Liquid Desiccant Heat Pump (LDHP)

NREL testing

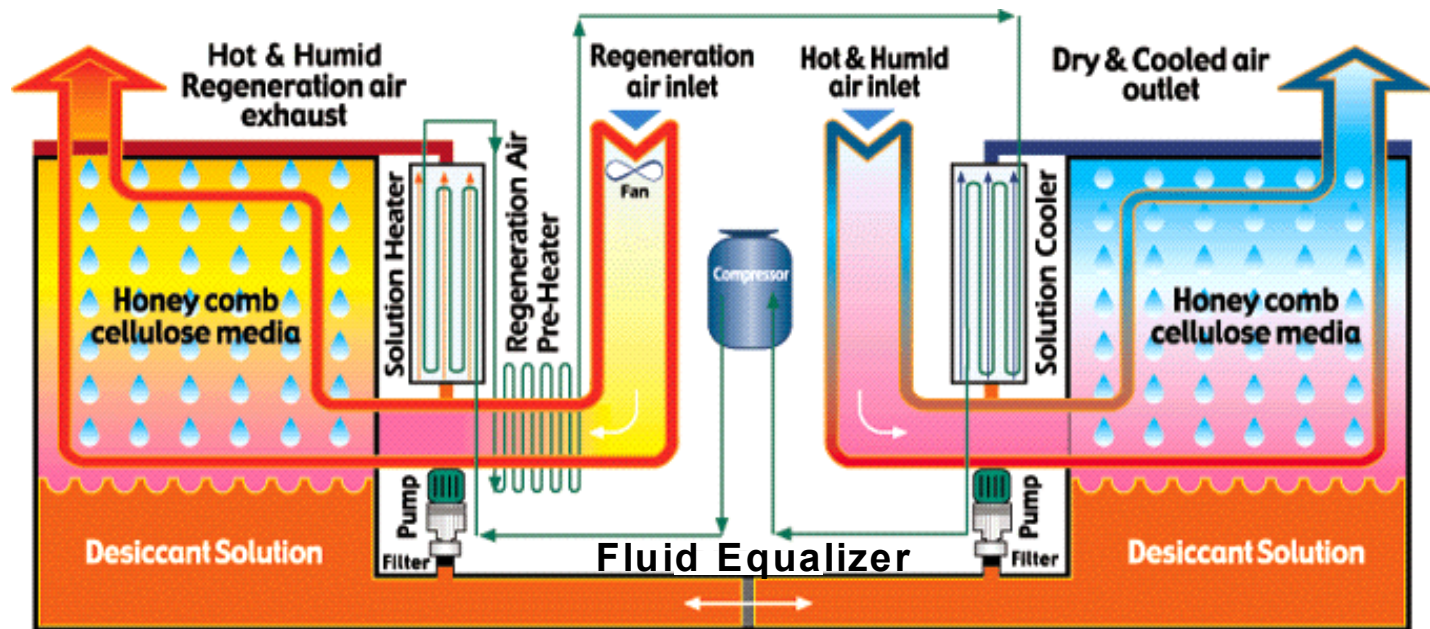
- COPs up to 3.0 (0.84 PCOPs)
- Energy efficiency promising/potential for high COP



Advanced LDHP

Theoretical COPs up to 7.0

- 1 unit of energy into compressor
- 3 units of heat into evaporator
- 4 units of heat out of condenser (into regenerator)



Regeneration Section

Heat Pump Section

Collection Section

- Treated air flow
- Desiccant flow
- Regeneration air flow
- Heat Exchange Fluid

Advanced LDHP “Fluid Equalizer”

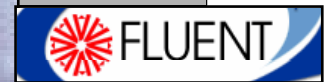
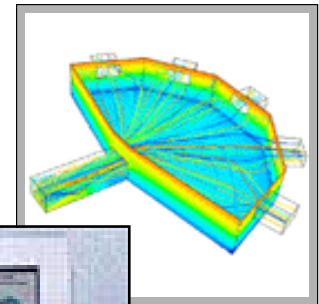
Double Diffusion (DD)

- Solute (LiCl) diffusion and solvent (water) osmosis
- Reductions in thermal mass of liquid desiccant solution cycled between collector and regenerator

Thermal Mass Reductions (%)	Equipment COP	Primary COP	Equipment RSHI (Btu/lb)	Comments
0	3.40	0.95	1413	DryKor catalog data for Model DL 4.0. Power plant to site efficiency = 28%. Prototype targets: Primary COP = 1.0 RSHI = 1000 Btu/lb NREL targets: Primary COP = 1.4 RSHI = 700 Btu/lb
10	3.67	1.03	1271	
20	3.94	1.10	1130	
30	4.22	1.18	989	
40	4.49	1.26	848	
50	4.76	1.33	707	
60	5.03	1.41	565	

Advanced LDHP Project Team

- ERC at UIC
 - 40 years desiccant experience
 - Fluent CFD modeling
 - www.erc.uic.edu



- DryKor
 - Israeli based
 - Atlanta distribution
 - 500 systems installed
 - schools, hotels, QSRs
 - supermarkets, hospitals, industries, etc.
 - www.drykor.com



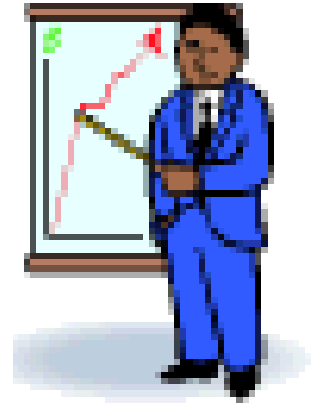
Advanced LDHP Tasks & Milestones

- 7-12/02: Task 1 High Efficiency System Design
 - Modeling Algorithms (including but not limited to DD)
 - Fluent CFD Simulations and Evaluations
 - DryKor Feedback
- 12/02: Deliverable from Single Task Phase 1
 - High Efficiency LDHP Design Report
 - 0.5 inch ΔP , 1.0 ARI PCOP, & 1000 Btu/lb ARI RSHI
- 1/03: Phase 2 Go/No-Go Decision
 - Task 2 Advanced Regeneration Bench-Scale Experiments
 - Task 3 Manufacturing Cost Analysis
 - Task 4 High Efficiency Full Scale Prototype

Advanced LDHP Summary

noting Technical Approach & Barriers/Risks

- Potential advancement in LDHP energy efficiency using double diffusion (DD) reductions in amount of solution regenerated
- Much scientific debate with multiple DD theories in play that presents barriers/risks
- UIC Chemistry Department faculty expertise in diffusion and osmosis theory will overcome barriers and minimize risk during CFD modeling project



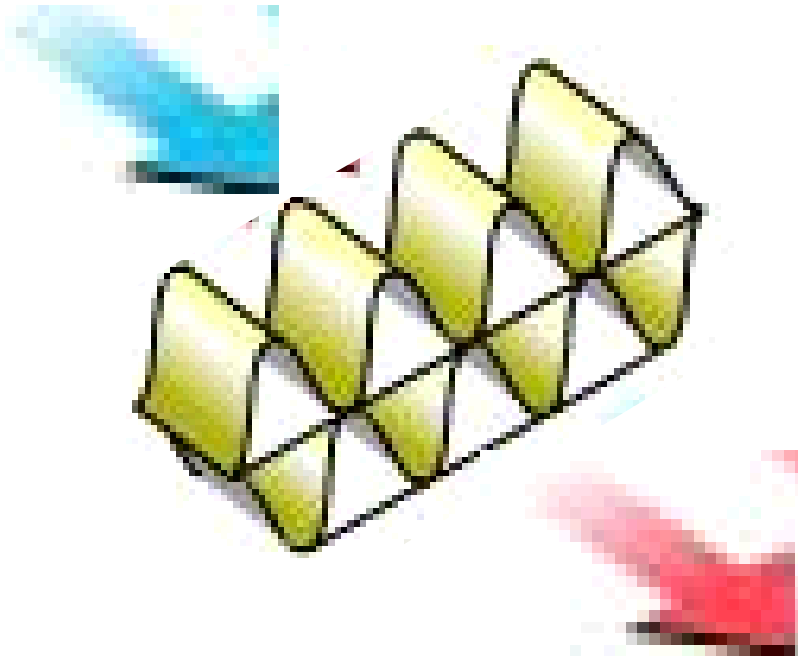
SOA Desiccant Wheel Media



<u>SOA Rotor Costs</u>	<u>\$/cfm</u>
• Formed Matrix @ \$18/lb (\$0.50 to \$14/lb materials)	\$0.06
• Desiccant in Matrix @ \$9/lb (\$0.50 to \$10/lb materials)	\$0.12
• Hub/Spoke/Rim/Face	\$0.06
<hr/>	
• Total Cost of Rotor	\$0.24
Specification: 8 inches deep @ 15 lb/ft ³ density 600 80% desiccant fpm	

Low Cost Desiccant Wheels (LCDW)

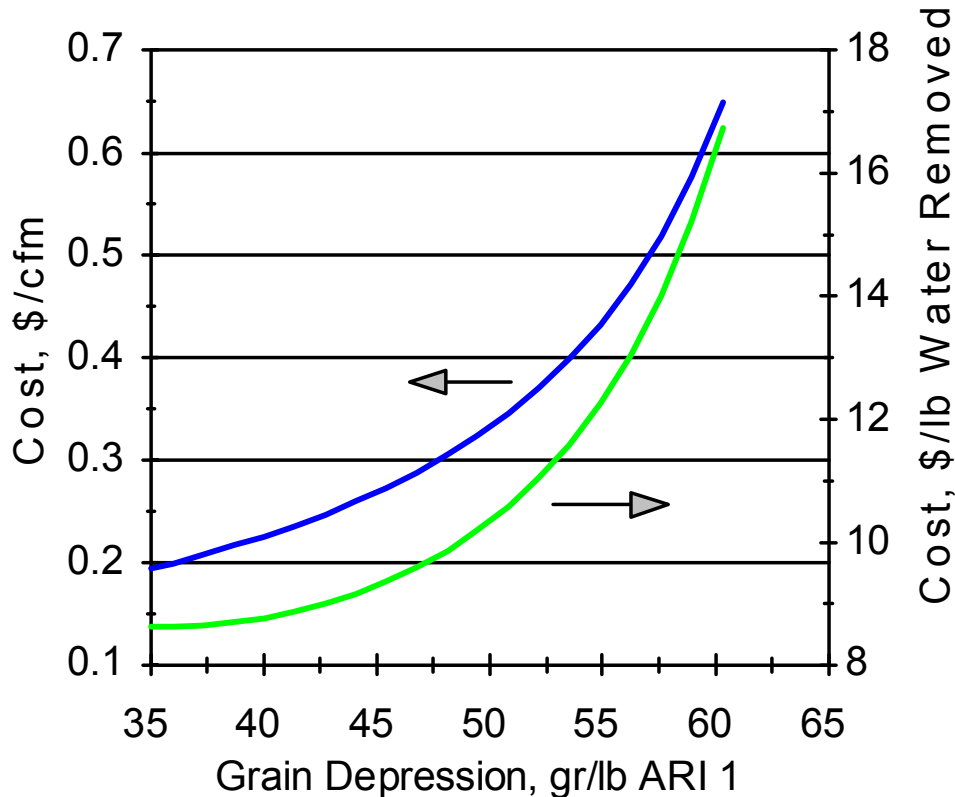
Design Parameters



- Flute size
 - NTUs
 - Pressure drop
- Media Depth
- Media density
 - Matrix wall thickness
 - Desiccant type
 - Desiccant loading
 - Binder level
- Media strength/stability
 - Manufacturing stress
 - Thermal cycling

LCDW with High Performance

Cost vs. Performance Tradeoffs

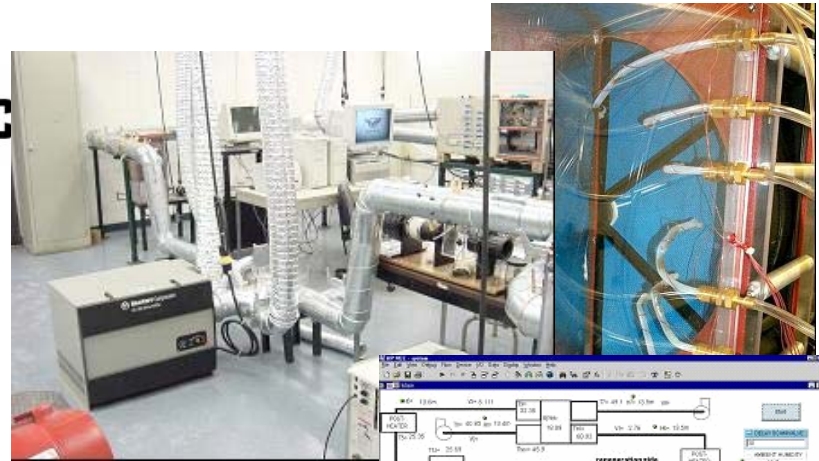


From 40 to 45 gr/lb: 23% increase in cost
From 45 to 50 gr/lb: 26% increase in cost
From 50 to 55 gr/lb: 30% increase in cost

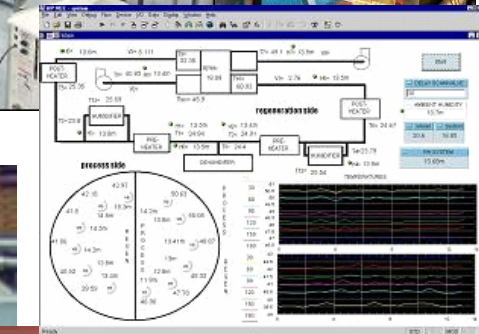
- NREL Goals
 - Δ gr/lb > 50 (@600 fpm)
 - 50% \$/cfm reduction from SOA wheels
- Incremental improvements in grain depression are costly in the 50 gr/lb range

LCDW Project Team

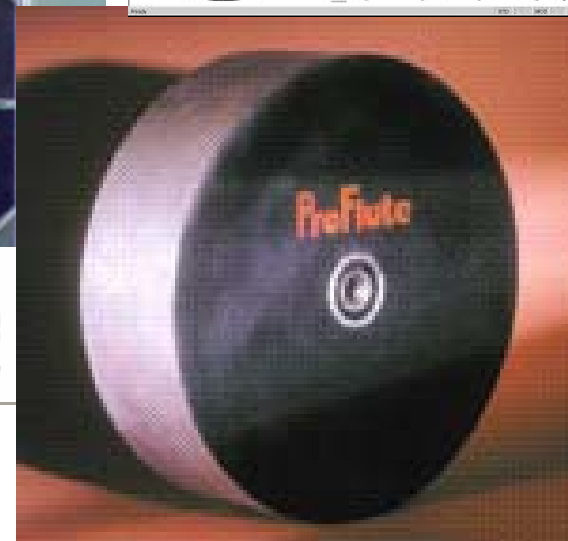
- ERC at UIC
 - 40 years desiccant experience (14 testing)
 - Sorption Test Facility
 - www.erc.uic.edu



- Rotor Source
 - US cassette & unit manufacturer
 - www.rotorsource.com



- ProFlute
 - Swedish supplier to RS
 - www.proflute.se



- Consultants
 - NRG/Dr. Collier
 - IRE/Dr. Belding



LCDW Tasks & Milestones

- 7-9/02: Task 1 SOA Review/Advanced Modeling
- 9-12/02: Task 2 Media/Rotor Experiments
- 1/03: Task 3 Manufacturing Cost Analysis
- 2/03: Task 4 Low Cost/High Performance Design
- 3-4/03: Task 5 Rotor Prototype
 - NREL test of prototype in 4/03
 - Summary report/presentation deliverable in 4/03
- 4/03: Phase 2 Go/No-Go Decision
 - Cassette cost reduction tasks
 - Seals, drives, frames, etc.

LCDW Summary

noting Technical Approach & Barriers/Risks

- Potential low cost/high performance rotor with
 - Shorter depth wheel
 - Smaller height flute
 - Thinner paper matrix
 - Higher performance desiccant/binder
- 50% SOA cost reduction very challenging at
 - Grain depression of 50 gr/lb
 - Face velocity of 600 fpm
 - ARI 940 Rating #1 of 95Fdb/75Fwb (99 gr/lb)
- Possible, but at what
 - Pressure drop?
 - Regeneration Sensible Heat Input (RSHI)?