Adsorption Refrigeration

Orange Team B

Customer Needs

Need	Attribute	Metric	Number	
Spacious	Volume	Ft ³	5	
Cold	Temperature	٥F	33-40	
Low cost	Money	\$	<100	
Low maintenance	Time to maintenance	Years	5	
Easy refuel	Time	Minutes	10-15	
Safe	Health effects	Poisoning problems	0	

Market

- 80% of world's population lives in developing countries. In 1996 only 33% of the refrigerators went to meet their refrigeration needs.
- 31% of food in developing countries is perishable (only 1/5th of which is refrigerated)
- NGOs spend millions of dollars on refrigeration projects (Montreal Protocol spent \$780 million)
- UNDP, UNEP, and IIR have great interest
- No significant competition

Adsorption Fridge Concept



Actual Product Appearance



Scaling Calculations

A spread sheet was constructed to determine the parameters needed to make a scale model of the system. To convert a given mass of water into ice, it calculates:

- the amount of methanol
- the amount of charcoal
- •the minimum system volume
- •the length of the condenser

								safety fact
	Volume of water (cc)		8		Start temp methanol (C)		20	
	Weight of water (g)		8					
	Starting temperature (C)		20		Methanol mass (g)		2.99	5.973424
					Volume of liquid (cc)		3.78	7.551737
	Energy lost (J)		3340.96		Number of moles		0.093218	0.186436
					Volume of activated charc	oal (cc)	3.78	7.551737
	Max Temp (K)		373		Mass of activated charcoa	al (g)	1.89	3.775869
	Max Pressure acceptable	(atm)	3.4	500 psi		(0)		
					Velocity of methanol throu	ah condenser (r	m/s)	0.05
	Min Total Volume of syste	em (L)	0.839603	0.027987		Ŭ	,	
					Length of condenser (m)	0.000638843		
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Constants								
	Water :				Methanol:			
	Freezing Point (C)	0			Boiling Point (C)	64.6		
	c (J/g.K)	4.181			c_liquid (J/g.K)	2.48		
	latent heat of fusion (J/g)	334			Latent heat of vap. (J/g)	1008		
	beta (1/K)	0.000275			Density_vapor (g/cc)			
	Viscosity (kg/ms)	0.00091			Density_liquid (g/cc)	0.791		
	Density (kg/m3)	1000			Molecular weight (g/mol)	32.04		
	k (W/mK)	0.60548			Viscosity @ 82.5 (kg/ms)	0.000012		
	Pr	6.29			Density @ 82.5 (kg/m3)	0.73		
					c_p (J/kgK)	1375.16		
	R (L atm/mol.K)	0.0821			k (W/mK)	0.01407		
	g (m/s2)	9.81			mass flow rate (kg/s)	2.88981E-07		
					Temp inner wall (C)	82.5		
	Gr	0.036265			Temp outer wall (C)	30		
	Ra	0.228104			Temp in methanol (C)	100		
	Nu	2.195722						
	hc_o	209.3647	0.125	0.693147		2.041695401		
						0.000285798		
	Re	9.657292		UA/L	0.438325747	0.23942711		

Testing the Concept Feasibility



Critical Issues and Solutions

- methanol degeneration to formaldehyde within 12-18 months
 - flush the system once a year and replace methanol
 - formaldehyde oxidizes to water and carbon dioxide
 - disposal of formaldehyde relatively easy
- Not all the methanol adsorbs into the charcoal
 - seal the system better