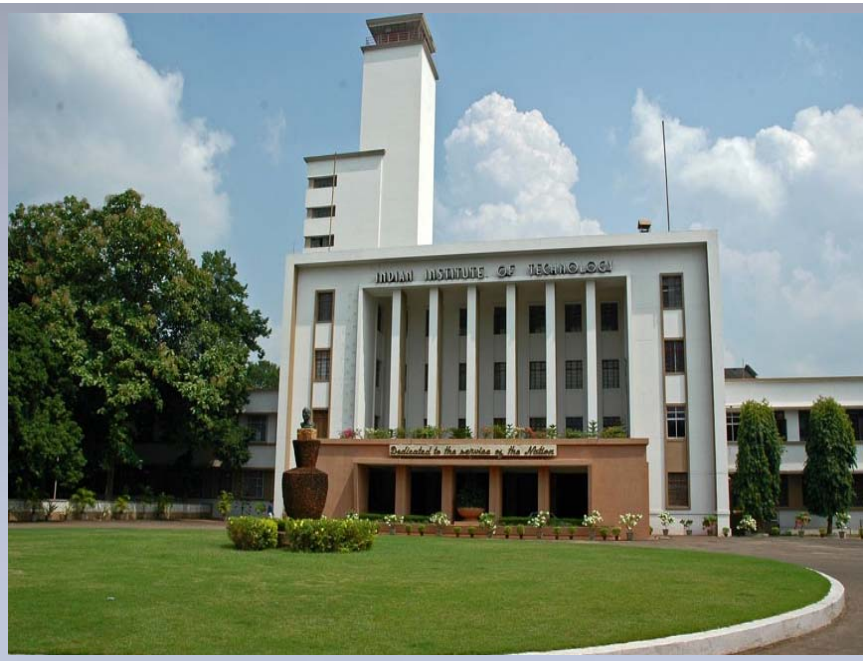
NATURAL REFRIGERANTS – The Indian Perspective



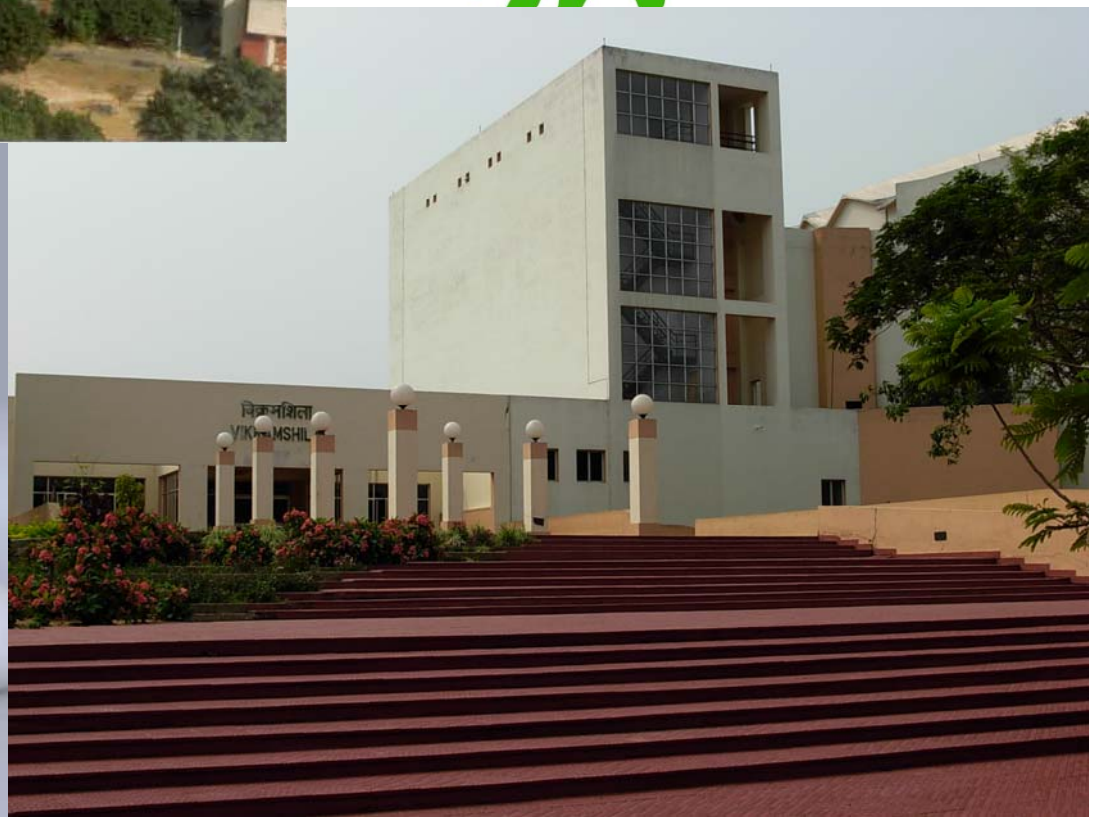
Souvik Bhattacharyya
Dean (SA) & Professor of Mechanical Engineering
Faculty Advisor, ASHRAE Student Branch
Indian Institute of Technology (IIT) Kharagpur
India

ATMO sphere 2010
faster to market
natural refrigerants

INDIAN INSTITUTE OF TECHNOLOGY KHARAGPUR
भारतीय प्रौद्योगिकी संस्थान खड़गपुर
19 51
योगः कर्मसु कौशलम्

IIT Kharagpur (1951)

- 2200 Acres
- 9000 Students
- 20,000 in Campus



People/Collaborators

- Dr M Ramgopal, Associate Professor

  IIT Kharagpur ramg@mech.iitkgp.ernet.in
- Dr N Agrawal, Assistant Professor, BATU Univ, Lonere, MH neeraj.titan@gmail.com
- Dr J Sarkar, Asst. Professor, BHU-IT, Benaras

  js_iitkgp@yahoo.co.in

IIT Kharagpur: NatRef Research Initiatives

- 2003 – got started, 32 J papers incldg 13 in IJR
- Application: simultaneous heating and cooling
- Precision property code development
- Thermodynamic modelling and optimization
- System simulation: heat transfer and fluid flow effects
- Optimal parameter correlation development
- Prototype development, Capillary tube based system
- Tube dimension optimization, 2-phase flow model
- Performance comparison vis-à-vis controllable valve
- Developed design nomograms

CONCLUSIONS

- Optimal CapTube based system behaves almost like having optimal pressure control
- System performance is close to the optimum with CT
- Capillary tube system is quite flexible regarding changes in ambient temperature
- CapTube: appears to be a competitive solution in small transcritical systems

Also Studied: N_2O (240 GWP, -80 deg C)

Single-stage & Two-stage transcritical N_2O cycles

Novel N_2O-CO_2 cascade system for refrigeration and heat

CO_2-C_3H_8 cascade refrigeration-heat pump system

2-stage CO_2 heat pump cycle with flash intercooling

Market Size: India

RAC industry, 2008-09 Total US$3.0 billion market

Air-conditioning	**77.5%**	
Refrigeration	**14%**	
Service	**8.5%**	
Air-conditioning:	**Room A/C**	**36%**
	Central Plants	**22.5%**
	Duct/Package	**13%**

Present penetration level is barely 3%

INSTALLED TONNAGE (approx.)

1. Domestic Unitary Units :

Room ACs + Splits : 2.8 Million Units =	4.2 M TR
Refrigerators : 5.5 Million Units =	2.75 M TR
Packaged AC Units (5-25 TR) =	0.44 M TR
VRF Systems =	0.125 M TR

2. Central Plants :

Reciprocating Chillers : 2120 units x 75 TR =	0.15 M TR
Screw Chillers : 1100 units x 300 TR =	0.330 M TR
Centrifugal Chillers : 200 units x 600 TR =	0.12 M TR

3. Cold Chain :

Bottle Coolers, Deep Freezers, Ice Cubers, Water Coolers etc. ~ 750,000 units	1.0 M TR

Total: ~ 9.2 M TR **ANNUAL GROWTH : 20-30%**

Barriers Survey

- Conducted by IIT Kharagpur among leading consultants, experts
- Researchers/Professors from the IITs researching in Refrigeration
- Response: Industry: 35%, Academia: 65%

Are you aware of the fact that we need to switch to Natural Refrigerant based systems (e.g. CO_2 based systems) because of the environmental issues? Yes: 100% No: Zero

Are you aware that such technology is available & a host of mfgrs. exists globally to supply such green systems? Yes: 81% No: 19%

Are you interested in knowing more about such systems and technology? Yes: 100% No: Zero

CO_2 based systems in Supermarkets are becoming a reality in Europe, Australia, etc. Do you think they are acceptable solutions for India?

Yes 62% No 24% Not able to answer 14%

Survey (contd.)

General category of the barrier to introduction of NatRefs in India?

Technical (refrigeration engineering)	72%
Technical (safety engineering)	72%
Supply and availability (materials, eqpt, components, fluids)	72%
Commercial (investment, profit, financial incentives)	62%
Information resources (know-how, guidance, technical data)	48%
Regulatory and quasi-regulatory (legislation, standards)	30%
Psychological and sociological aspects	30%
Market (customer, consumer, competing products)	25%

Jump from HCFCs to safer refrigerants for India should skip the HFC route and go straight to a natural refrigerant? YES 72% NO 28%

Survey Opinions

What is the anticipated potential for such systems in India (particularly in Supermarket applications)?

- ❑ **Food Supermarkets are yet to take off in India. In the mostly family owned small food retail stores, initial cost weighs heavily on buying decisions. But big players viz. Coca Cola, can pursue their global philosophy on NatRefs.**
- ❑ **Great potential in hotel industry and supermarkets.**
- ❑ **Modest potential; we just graduated to *shopping mall* concept from *corner stores*, however not for produce selling. Most perishables are directly from the farms & not from cold storages.**
- ❑ **Cascaded systems with NH_3 have not still taken root. Problems are anticipated for high ambient CO_2 system performance.**
- ❑ **Potential for A/C in supermarket is strong.**
- ❑ **Capital Intensive. Not much use for Heat Recovery.**
- ❑ **Supermarkets with foreign tie-ups will follow global technology.**
- ❑ **Serviceability, technical knowhow to maintain & operate is poor.**

BARRIERS

Barriers to use of NatRefs are the biggest ones in India, across all applications? 1 – highest barrier; 7 – lowest barrier.

1. Legislation (policies, standards)
2. Funding & Support (CDM/JI mechanisms, grants, subsidies, tax credits, direct investment)
3. Technology & Safety (technical challenges, safety issues)
4. Supply & Availability (materials, equipment, components, fluids)
5. Training & Know-how (engineers education/certification, technical data, meetings, information campaigns)
6. Markets & Marketing (advertising, competition by chemical refrigerants, profitability, demand structure)
7. Psychology (consumer acceptance, public perceptions, rumors, influence of peer groups)

END USE

	NH_3	HC	CO_2
Hot water heating			
Space heating			
Room Air-Conditioning			
MAC (car, train, bus, airplane)			
Water Cooling			
Ind. Refrign (food storage, production)			
Supermarket Refrigeration	cascade		cascade
Transport Refrigeration (food cooling, perishable goods, etc.)			
Home Fridges & Freezers			
Bottle Coolers & Vending Machines			

HOW TO ……..

- Demonstration project: UN agencies, global suppliers
- Training, sector-wise: involve local expertise
- Awareness campaigns, academia, societies
- Introduce NAtRef content in Syllabus
- Consumer market: NatRef products, major brands
- Govt. Regulation to favour green refrigeration
- Fiscal incentives from govt. (viz. HCFC Phaseout)