Use of Nanoparticles In Refrigeration Systems: A Literature Review Paper

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Presentation Overview

- Historical Developments
- Nanofluids vs Normal Suspensions
- Nanoparticles & Production Techniques
- Nanoparticle Selection
- Nanofluid Preparation
- Nanofluids for Refrigeration & Benefits
- Limitations of Nanofluids
- Literature Review
- Limitations of Literature Review & Literature
- Future Directions & Publication Checklist
- Conclusion
Historical Development

Thermal Conductivity (K)

\[ K_{(\text{Metal & Metal Oxides})} > K_{(\text{Liquids})} \]

For Heat Transfer Improvement

Maxwell : (1873)  
Normal Suspensions  
(Metal particles + Liquid)  
‘mm’ size particles

Choi : (1995)  
Nanofluids  
(Nano particles + Liquid)  
‘nm’ size particles

(2016)  
Many paper are published every year

July 11-14, 2016  
Purdue Conferences  
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Nanofluids have

- Higher heat transfer rates
- Better dispersion stability
- Reduced particle clogging
- Reduced pumping power
Nanoparticles

(1 nm < NP Size < 100 nm)

Length scale & some related examples
Nanoparticles Production Techniques

- Mechanical attrition
- Pyrolysis
- Gas condensation
- Chemical precipitation
Nanoparticle Selection

Carbon Nano Tubes: $1800 < K_{\text{CNT}} < 6600 \text{ (W/m k)}$

Diamond: $2200 < K_{\text{Diamond}} < 2300 \text{ (W/m k)}$
Thermal Conductivity Increase

Thermal conductivity of nanofluid ($K_{nf}$) & Pure fluid ($K_f$)
Nanofluid Preparation

Preparation Methods

One Step Method / Two Step Method: Nanoparticle Production & Dispersion in one/two steps respectively.

Guidelines for nanofluid preparation

• Dispersability of nanoparticles
• Stability of nanoparticles
• Chemical compatibility of nanoparticles
• Thermal stability of nanofluids.
Nanofluids For Refrigeration Systems

Nanoparticles + Lubricant = Nanolubricant

Nanoparticles + Refrigerant = Nanorefrigerant

Nanolubricant + Refrigerant = Nanolubricant _refrigerant
Nanofluid Benefits In Refrigeration

Nanolubricant
- Improved tribological characteristics (Friction & viscosity)
- Improved compressor performance

Nanorefrigerant
- Improved thermo-physical properties (H/T Coefficient)
- Improved refrigerating effect

Nanolubricant-refrigerant
- Enhanced solubility between oil & refrigerant
- More oil returns back to the compressor
Limitations of Nanofluids

- Poor long term stability
- High pressure drop
- High pumping power
- Low specific heat
- Particle settling
- Fouling
- High production cost

Time
Literature Review

Section one: Basic research
Properties studied are
- Thermal conductivity
- Viscosity
- Heat transfer coefficient
- Friction factor

Section two: Applied research in refrigeration system
Literature Review

With use of nanoparticles most papers show

- Increase in heat transfer coefficient & thermal conductivity
- Reduction in friction factor
- Increase in viscosity & pressure drop
- Improvement in coefficient of performance

With use of nanoparticles small number of papers show

- Decrease in heat transfer coefficient
Literature Review

Comments

- Research is in its primitive stage, large research is possible
- Synchronization between basic & applied research is needed
- Publication checklist is needed to compare different results
- Mixed (Positive & Negative) results are observed.
- Most of the literature shows improvement in heat transfer & coefficient of performance with use of nanoparticles
Limitations of Literature Review

- Need to find nanofluid with continuous dispersion stability throughout refrigeration system.
- Nanofluid preparation method, sonication time durations needs to be specifically mentioned in the papers.
- Nanoparticle migration studies in evaporator are limited & no such study in condenser is yet published.
- Basic properties of nanofluids like latent heat, specific heat, density, surface tension, dielectric strength, miscibility, & solubility also needs to be investigated.
Limitations of Literature

- Nanofluid containing mixture of different types of nanoparticles is not published yet.
- Industrial refrigeration systems are not yet studied.
- Screw & centrifugal compressors, shell & tube and plate type heat exchangers are not yet studied.
- Flooded evaporators are not yet studied.
- Natural refrigerants like ammonia are not yet studied.
- More focus also needs to be given on flow boiling with and without lubricants.
Future Research Directions

- Cover the limitations of literature & literature review
- Data base with number of investigations needs to be created
- Checklist while publishing research is provided to compare results between different papers
- Interdisciplinary study approach may help to develop better prediction methods useful for basic research
Checklist For Publications

- Nanoparticle/s
- Size (dry & in fluid)
- Base fluid (refrigerant/ lubricating oil/ other)
- Nanoparticle concentration (in mass/ volume basis in lubricant, refrigerant & in refrigerant-lubricant)
- Nanofluid preparation method
- Dispersion stability duration
- Are experimental tests performed with stable dispersion?
- Details (name, type, quantity) of surfactants/ dispersants
- Details of sonication time and dispersion method used
- Experimental/test conditions.
## Conclusion

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<tr>
<th>Opportunities</th>
<th>Challenges</th>
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<tr>
<td>• High heat transfer rate</td>
<td>• Poor long term stability</td>
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<td>• High coefficient of performance</td>
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<td>• Small refrigeration systems</td>
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For use of nanofluids in refrigeration more research is needed.
Thank You!

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