

Introduction of the Novel Cross Vane Expander-Compressor Unit for Vapour Compression Cycle

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Background



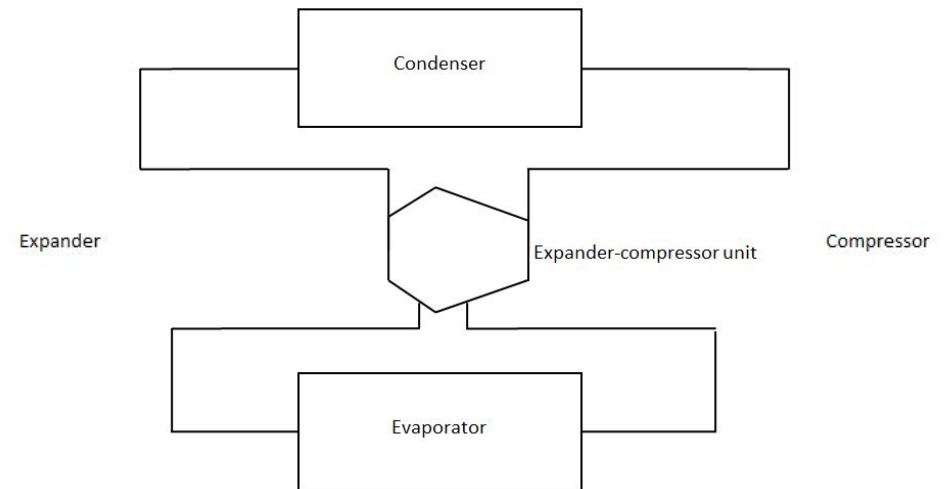
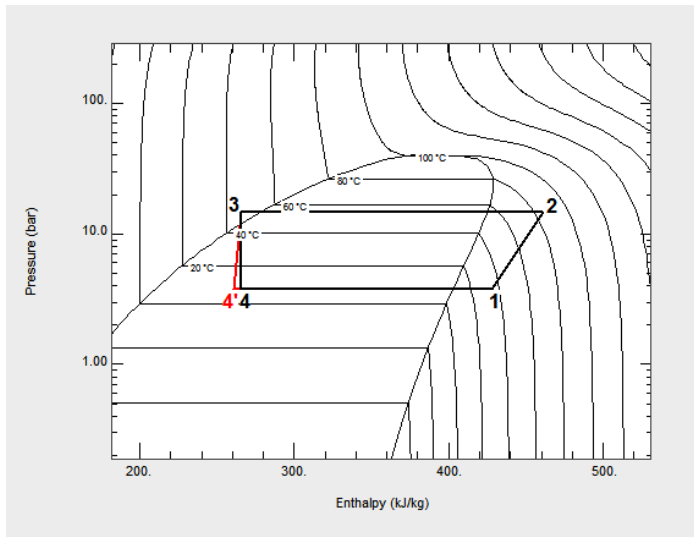
- Cooling & heating systems in houses, buildings & automobiles.
- Increase use of air-conditioning system:
 - » No. of household with air-conditioning rose by 56% between 1993 & 2009 in the US (Cox, 2012).
 - » No. of air-conditioned vehicles will increase > 50% from 2010 to 2015 in China (Cox, 2012).
- Increase use of electricity
 - » Household air-conditioning energy consumption doubled from 1993 to 2005 in the US (Cox, 2012).
- Electricity generated through burning fossil fuel → global warming.
- Energy efficient refrigeration systems are needed.



Solution?



- Replace expansion valve with expander.
- Advantages:
 - » Reduce power requirement.
 - » Increase cooling capacity.
 - » COP improvement from 10% to 40%.

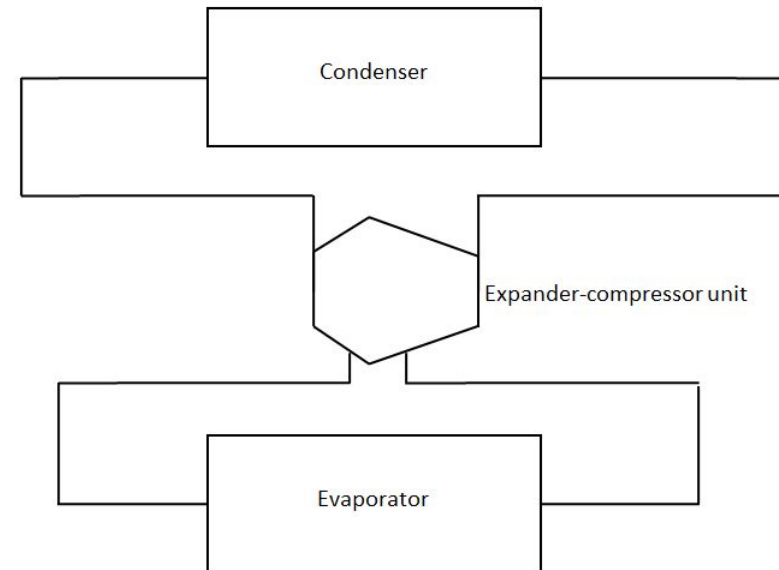




Expander-Compressor Systems



- Expander-compressor systems in the literature:
 - » **Reciprocating** (Heyl and Quack 1999)
 - » **Sliding vane** (Henderson et al. 2000)
 - » **Screw** (Stosic et al. 2002)
 - » **Scroll** (Kim et al. 2008)
 - » **Rolling piston + Scroll** (Matsui et al. 2009)

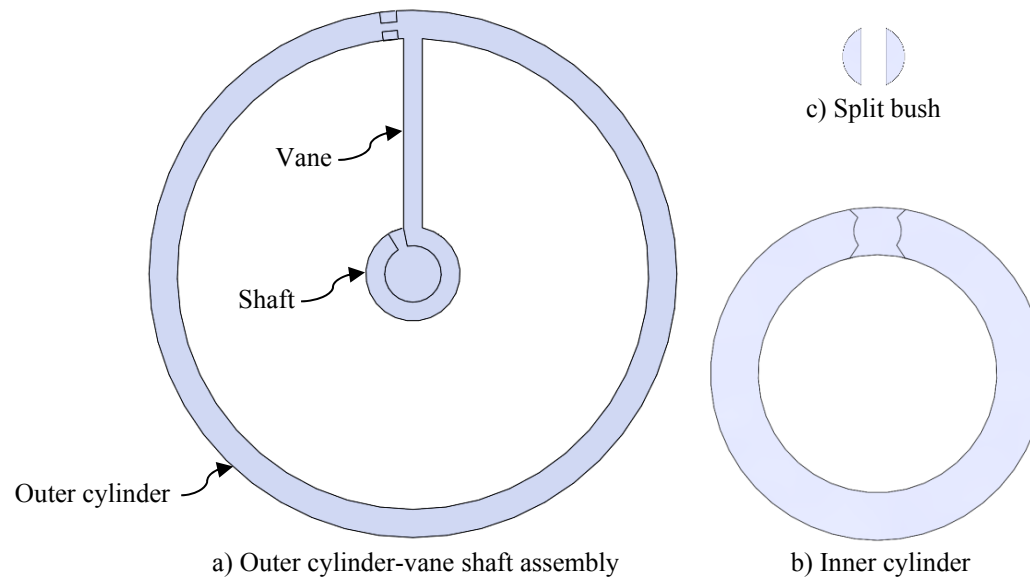




Cross Vane Expander-Compressor (CVEC)



- New design currently filled for patent.
- 3 Components: outer cylinder-vane-shaft assembly, inner cylinder, and split bush.

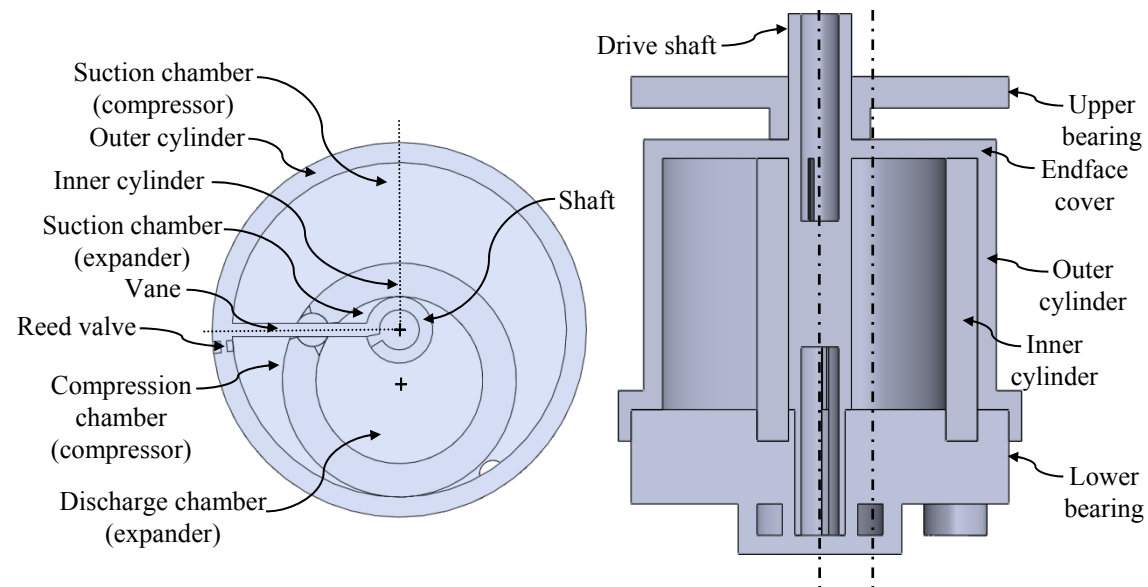




Cross Vane Expander-Compressor (CVEC)



- The assembly.



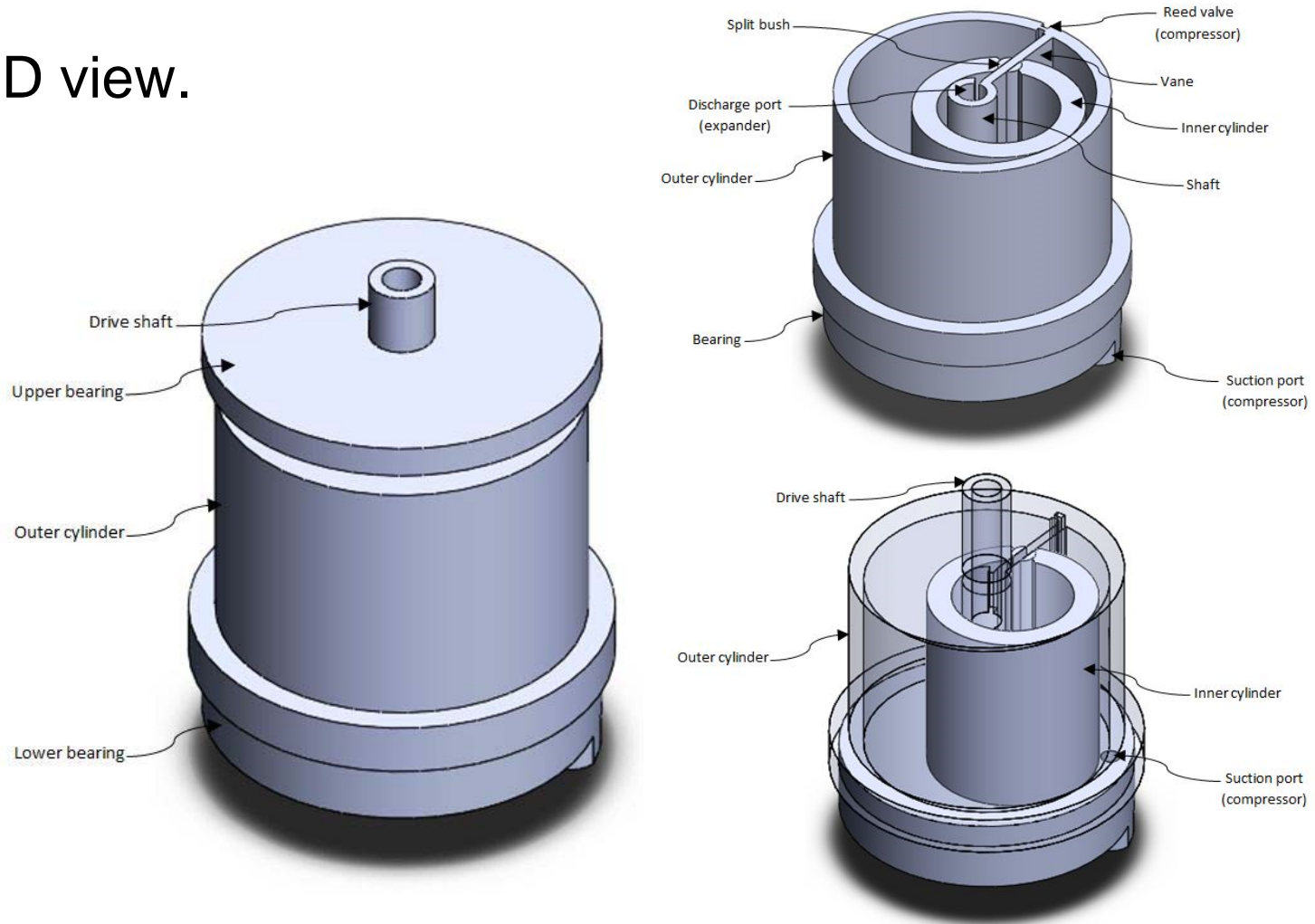
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Cross Vane Expander-Compressor (CVEC)



- 3D view.

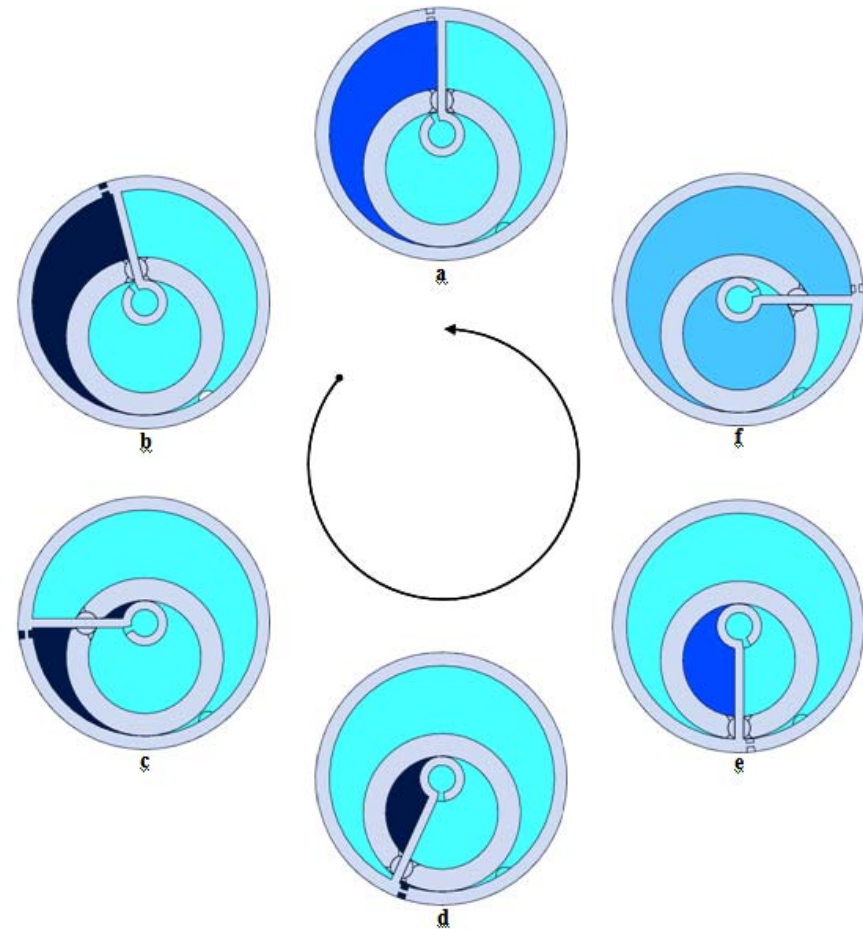




Working Principle of CVEC



- Expander located at inner chambers.
- Compressor located at outer chambers.
- Compressor driven by:
 - » Prime mover
 - » Expander





Discussion of the Design



Feature	Screw-screw	Scroll-scroll	Scroll-rolling piston	CVEC
No. of components	3	5	8	3
Simplicity of component geometry	Helical profile	Spiral profile	Spiral, cylindrical & concentric profile	Cylindrical & concentric profile
Moment of inertia	High	Low	High	Low
Capacity	Low	Low	Low	High
Mechanical efficiency	Low	Low	Low	High
Torque matching	Cannot be matched easily	Can be matched easily	Can be matched easily	Cannot be matched easily
Configuration of suction and discharge ports	Less complicated	Less complicated	Less complicated	More complicated



Preliminary Theoretical Investigation



- Working fluid: **R-134a**.
- Mechanical efficiency of CVEC: **96.5%**
- Energy saving of up to **18.0%** is achievable.



Conclusions

- The novel Cross Vane Expander-compressor (CVEC) is designed.
- 3 components: outer cylinder-vane-shaft assembly, inner cylinder, & split bush.
- Additional advantages of CVEC as compared to other types of rotary expander-compressor systems are:
 - » Fewer major components.
 - » Simplicity of component geometry.
 - » Lower moment of inertia of rotating components.
 - » Higher working fluid capacity given the same size.
- However, the disadvantages associated with CVEC are:
 - » Challenge in torque matching.
 - » Complexity and space limitation in the design of suction and discharge ports.



References

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