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Publication date:
2017

Document Version
Publisher's PDF, also known as Version of record

Numerical routine for magnetic heat pump cascading

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Motivation

The possibility of magnetic heat pumps (HPs) industrialization depends on their ability to provide sufficient heating power with competitive COP. Conventional HPs provide from few to tens of kW. To make it achievable with magnetic HPs, we proposed cascading [1], which also may reduce losses, Fig. 1. Here the *more practical cascading design* is studied: we develop a general numerical routine to model cascading and apply it to a three-heat pump cascade, Fig. 2.

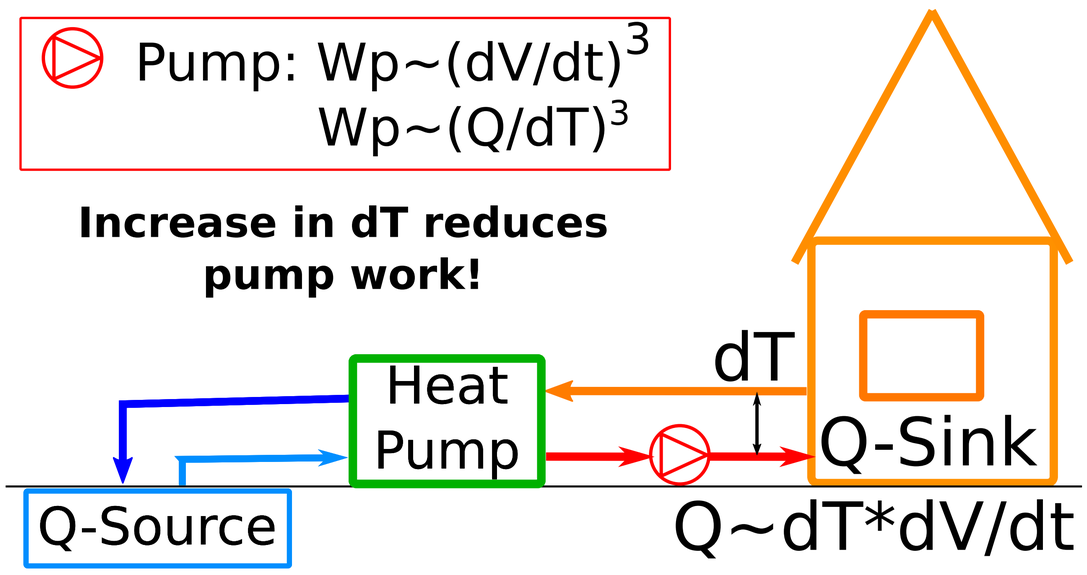

Figure 1. Motivation: magnetic HP for building heating.

Design

1. The total HP system (Fig. 1): 12 Active Magnetic Regenerator beds (AMRs) on a platform inside a rotating magnet.
2. No cascading: AMRs are connected in parallel to the same pump
3. Cascading: 6 pumps are now connected to each other
4. Transfer from no cascading to cascading is shown in figures

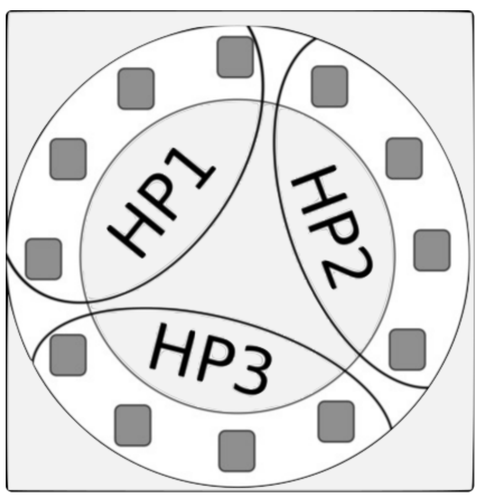

Figure 2. Magnetic HP reconnected into a three-HP cascade.

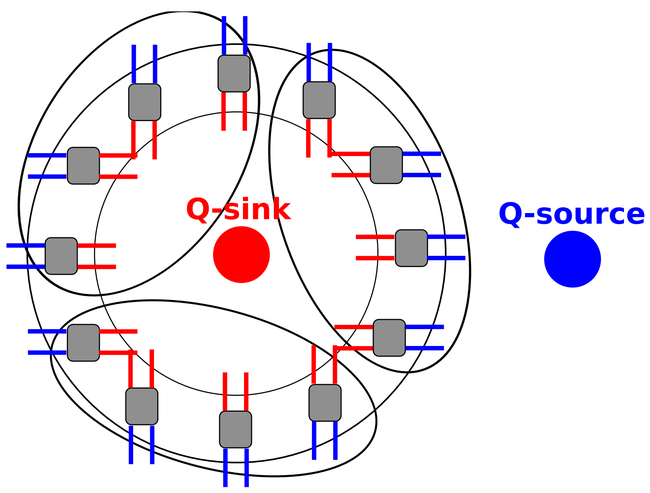

Figure 3. Configuration without cascading

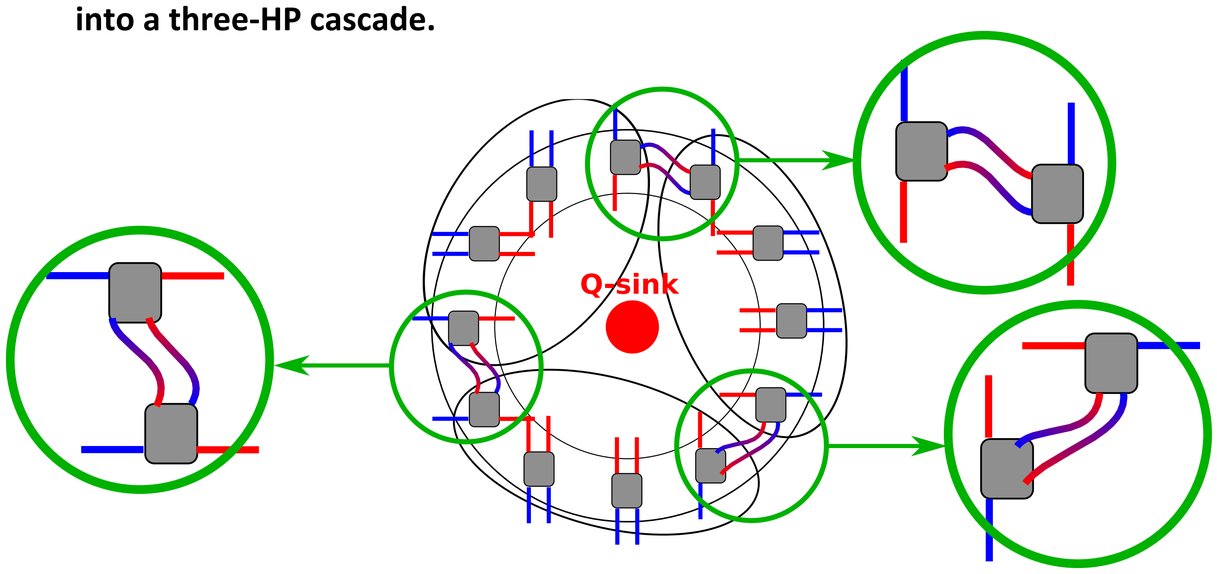

Figure 4. Configuration with cascading

Numerical routine

1. MATLAB code calculates thermodynamic properties from a single AMR data precalculated using 1D transient model
2. Different types of connections can be accounted for
3. Modular: components can be integrated into energy models, substituted and scaled

Exmpl: heating power of three-HP cascade and comparison to single HP

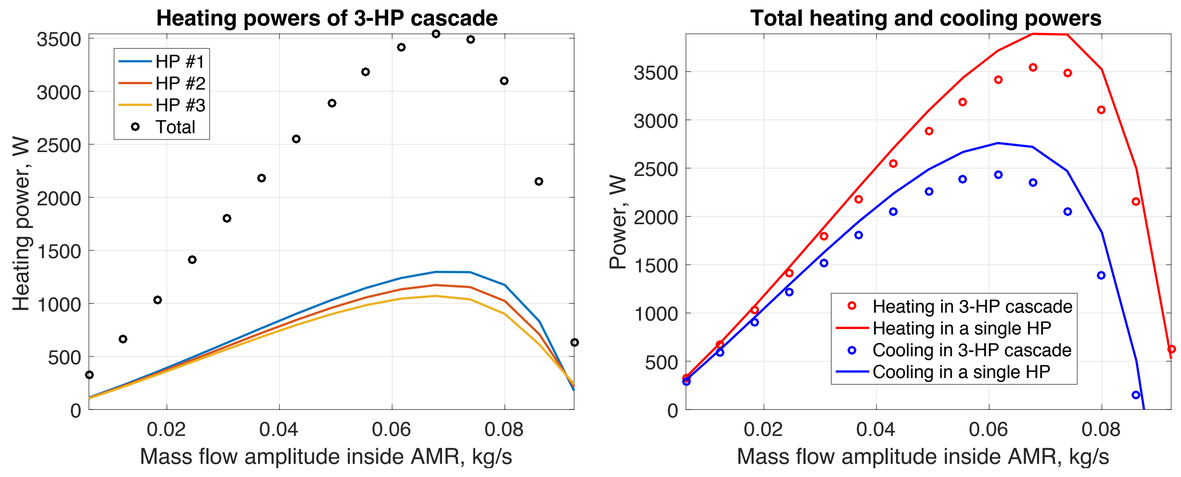

Figure 5. Routine results for 3-HP cascade total powers (points), single HP (solid, right) and individual HPs inside 3-HP (solid, left)

Three-HP cascading system performance

1. Temperature difference at the HP hot outlet increases approx. 3 times compared to the case with no cascading
2. COP is slightly less than without cascading
3. Heating and cooling powers slightly degrade

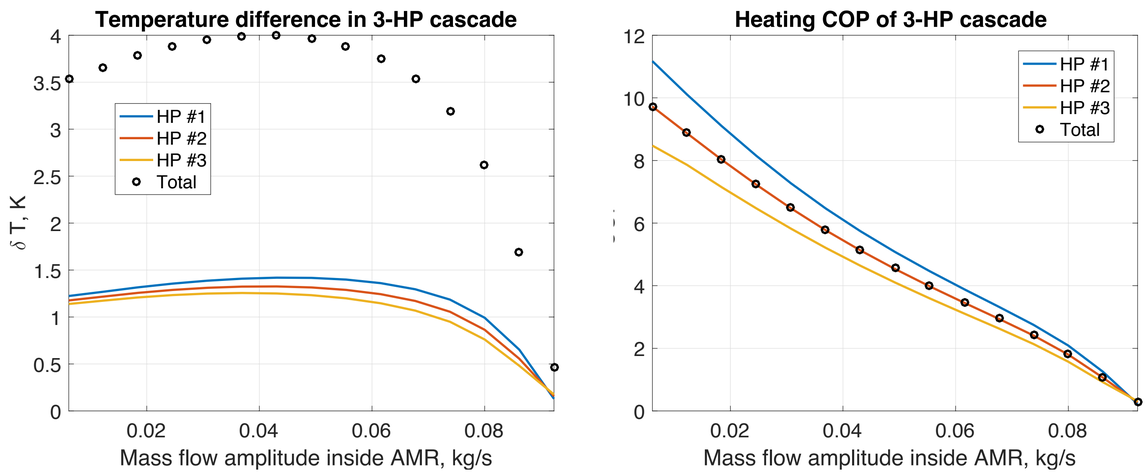

Figure 6. Performance of the three-HP cascading system

Conclusion

Calculated increase in temperature difference (3-4 K) is an argument in favor of a magnetic heat pump cascades as possible residential heating systems. Developed numerical routine can be useful in modelling magnetic HPs operation inside target buildings.

Acknowledgments

We are grateful for financial support provided by the ENOVHEAT project funded by Innovation Fund Denmark (contract no 12-132673).

References

[1] M. Tahavori, K. Filonenko, C. T. Veje, T. Lei, K. Engelbrecht, C. R. H. Bahl, "A Cascading Model Of An Active Magnetic Regenerator System", In *Proceedings of the 7th International Conference on Magnetic Refrigeration at Room Temperature*, 248-251 (2016)