Advanced Process Optimisation
Project description

October 2019

The Kigali amendment[1] was agreed in October 2016, committing signatory nations to phase out hydrofluorocarbons (HFCs) as refrigerants, in order to prevent an excessive rise in global temperatures by the end of the century. In this project, your task is to identify a replacement refrigerant for a common HFC, R134a (tetrafluoroethane), that meets the following process conditions[2,3]:

(a) evaporating temperature, $T_e = 272$ K; condensing temperature, $T_c = 316$ K; and average process temperature $T_m = (T_e + T_c)/2$;

(b) vapour pressure at evaporating temperature is greater than atmospheric, i.e., $P_{v,e} \geq 1.1$ bar; and vapour pressure at condensing temperature is less than or equal to 14 bar, i.e., $P_{v,c} \leq 14$ bar;

(c) heat of vaporisation at evaporating temperature of the designed refrigerant, H_{v,T_e}, should be greater than or equal to heat of vaporisation of the HFC refrigerant, $H_{v,T_e,R134a}$;

(d) liquid heat capacity of at average process temperature , C_{p,T_m}, should be less than or equal to liquid heat capacity of the HFC refrigerant,$C_{p,T_m,R134a}$.

In a pair, complete the following tasks:

1. Propose a mathematical formulation for the design problem, implement it in GAMS and identify an optimal refrigerant, using a local or global solver.

2. Using integer cuts, identify 10 possible refrigerants that should be investigated further, commenting on the suitability of the compounds you have found.

3. Propose three additional constraints that you could use to improve the mathematical formulation. Do not implement them.

4. Write a report of no more than 8 pages on your findings. Use margins of 2.5 cm throughout, a line spacing of 1.2 and 11 point Arial font.

Submit your report (one report per pair) on Blackboard by 4.30pm on Thursday 12 December 2019. Send your GAMS file to mohamed.maher18@imperial.ac.uk by the same deadline.

[1] http://www.unep.org/africa/news/kigali-amendment-montreal-protocol-another-global-commitment-stop-climate-change.

[2] Duvedi, A. and Achenie, L. (1996). Designing environmentally safe refrigerants using mathematical programming. Chemical Engineering Science, 51, pp.3727-3739.

[3] Sahinidis, N., Tawarmalani, M. and Yu, M. (2003). Design of alternative refrigerants via global optimization. AIChE Journal, 49, pp.1761-1775.

Marking scheme (out of 25)

Question	Key criteria	Marks
1	Is the mathematical formulation correct and explained clearly? Does it address the design problem?	7
2	Are 10 solutions reported? Does the discussion of the results demonstrate an understanding of optimisation and refrigerant design	5
3	Are the three constraints relevant and explained clearly?	6
4	Are the conclusions sound and insightful? Is the report presented well?	3 4