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Apêndice

O algoritmo adotado para a solução numérica do sistema de equações referente ao sistema indireto de refrigeração é detalhado a seguir:

- 1) Ler os dados de entrada ao programa
- 2) Calcular ciclo de referência para o fluido-base
 - 2.1) Leitura de parâmetros empíricos:
 $\Delta T_{EVA}; \Delta T_{CON}; G_{sf,EVA}; N_{s,COMP}$
 - 2.2) Calcular parâmetros de referência: temperatura de evaporação, pressão de evaporação, temperatura de condensação, pressão e temperatura de condensação, temperatura do refrigerante na saída do condensador, relação de compressão, eficiência isentrópica do compressor, entalpia real de saída do compressor, área transversal do canal de fluido secundário no evaporador
 - 2.3) Calcular a vazão de fluido secundário no evaporador, $\dot{m}_{sf}$
 - 2.4) Calcular calor trocado no evaporador, $\dot{Q}_{EVA}$
 - 2.5) Calcular efetividade, condutância, NTU e UA, do evaporador
 - 2.6) Calcular números Reynolds e Prandtl e coeficiente de troca pelo lado do fluido secundário, no evaporador
 - 2.7) Calcular U do evaporador, considerando o coeficiente pelo lado do refrigerante desprezível.
 - 2.8) Calcular área de troca de calor do evaporador, $A_{L,EVA}$
 - 2.9) Calcular comprimento do evaporador, $L_{tub,EVA}$
 - 2.10) Calcular a vazão de refrigerante, $\dot{m}_{ref}$
 - 2.11) Calcular o trabalho de compressão adiabática
 - 2.12) Calcular consumo de potência elétrica

- 2.13) Calcular o volume deslocado do compressor, V_c
- 2.14) Entrar com dados para a sub-rotina que calcula o ciclo de amônia

- 3) Calcular parâmetros do circuito primário
 - 3.1) Calcular área transversal do tubo
 - 3.2) Calcular área lateral do tubo
 - 3.3) Calcular temperatura de saída do refrigerante do condensador
 - 3.4) Calcular temperatura de condensação
 - 3.5) Calcular pressão de condensação
 - 3.6) Calcular propriedades do refrigerante à saída do condensador:
 - 3.7) Calcular propriedades à temperatura e pressão de entrada do fluido secundário no evaporador
 - 3.8) Calcular números de Re e Pr para as condições de entrada do fluido secundário no evaporador
 - 3.9) Calcular coeficiente de transferência de calor para o fluido secundário no evaporador
 - 3.10) Inicializar a variável de controle $dif(\alpha) = 10000$
 - 3.11) Inicializar o coeficiente de troca de calor do refrigerante $\alpha_{ref,app} = 10000$
 - 3.12) Repetir (3.12) enquanto $|dif(\alpha)| > 0.001$
 - 3.12.1) Calcular UA, NTU e efetividade do evaporador
 - 3.12.2) Calcular temperatura de evaporação
 - 3.12.3) Calcular pressão de evaporação
 - 3.12.4) Calcular temperatura de saída do evaporador
 - 3.12.5) Calcular queda de pressão no evaporador
 - 3.12.6) Calcular propriedades do refrigerante à saída do evaporador
 - 3.12.7) Calcular propriedades do refrigerante à entrada do evaporador
 - 3.12.8) Calcular vazão de refrigerante
 - 3.12.9) Calcular coeficiente de transferência de calor evaporador pelo lado do refrigerante
 - 3.12.10) Atualizar $dif(\alpha)$

- 3.12.11) Atualizar $\alpha_{ref,app}$
- 3.13) Fim da repetição
- 3.14) Calcular a queda de pressão no condensador
- 3.15) Calcular a pressão de condensação
- 3.16) Calcular a razão de compressão
- 3.17) Calcular eficiência isentrópica do compressor
- 3.18) Calcular a entalpia de saída da compressão isentrópica
- 3.19) Calcular a entalpia real de saída do compressor
- 3.20) Calcular as propriedades do refrigerante à saída do compressor
- 3.21) Calcular a velocidade do compressor
- 3.22) Calcular a eficiência mecânica para um compressor de pistão
- 3.23) Calcular o trabalho de compressão adiabática
- 3.24) Calcular consumo de potência elétrica
- 3.25) Calcular coeficiente de desempenho, COP

- 4) Calcular circuito secundário de referência
 - 4.1) Leitura de parâmetros empíricos locais: ΔT_{SEC} ; $T_{fw,SEC}$
 - 4.2) Calcular a área de escoamento: transversal do anel no secundário
 - 4.3) Calcular a área de troca: lateral do tubo interior no secundário
 - 4.4) Propriedades do fluido refrigerado para a temperatura média
 - 4.5) Calcular a taxa de calor trocado entre fluido refrigerado e fluido secundário
 - 4.6) Calcular a vazão do fluido do meio refrigerado
 - 4.7) Dados de entrada para a sub-rotina do circuito secundário

- 5) Calcular circuito secundário
 - 5.1) Calcular a queda de pressão no evaporador pelo lado do fluido secundário
 - 5.2) Calcular a queda de pressão do fluido no trocador secundário
 - 5.3) Calcular a queda de pressão na tubulação
 - 5.4) Calcular a pressão elevada pela bomba
 - 5.5) Pressão de saída do trocador secundário
 - 5.6) Calcular o trabalho da bomba

- 5.7) Calcular estado termodinâmico do fluido secundário à entrada do trocador secundário
- 5.8) Calcular a temperatura de saída do fluido secundário do trocador secundário
- 5.9) Calcular as condições médias do fluido secundário no evaporador
- 5.10) Calcular as variações de entropia e entalpia do fluido secundário no evaporador
- 5.11) Calcular as condições médias do fluido secundário no trocador secundário
- 5.12) Calcular números de Reynolds e Prandtl do fluido secundário no trocador secundário
- 5.13) Calcular coeficiente de troca pelo lado do fluido secundário no trocador secundário
- 5.14) Calcular coeficiente de troca pelo lado do fluido refrigerado no trocador secundário
- 5.15) Calcular efetividade do trocador secundário
- 5.16) Calcular temperatura de saída do fluido refrigerado

- 6) Calcular coeficiente estrutural
 - 6.1) Calcular irreversibilidade do compressor
 - 6.2) Calcular irreversibilidade do condensador
 - 6.3) Calcular irreversibilidade da válvula de expansão
 - 6.4) Calcular irreversibilidade do evaporador
 - 6.5) Calcular irreversibilidade do trocador secundário
 - 6.6) Calcular irreversibilidade da bomba
 - 6.7) Calcular irreversibilidade total
 - 6.8) Calcular coeficiente estrutural
 - 6.9) Calcular eficiência racional

- 7) Repetir para cada nanofluido, para cada critério e para cada concentração volumétrica:
 - 7.1) Calcular a vazão mássica do fluido secundário
 - 7.2) Calcular o parâmetro constante segundo o critério de comparação
 - 7.3) Calcular circuito primário: como no ponto (3)

- 7.4) Calcular circuito secundário: como no ponto (5)
- 7.5) Calcular coeficiente estrutural: como no ponto (6)
- 7.6) Fim da repetição

- 8) Mostrar Resultados

- 9) Fim