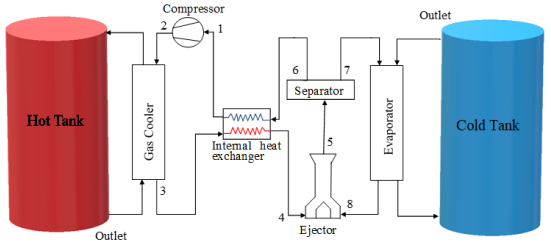
Structure and Control Co-Optimization for a CO_2 Heat Pump with Thermal Storages

Jiaxin Deng, Fang Liu*, Qiu Mo
College of Energy and Mechanical Engineering
Shanghai University of Electric Power, Shanghai, China
*fangliu@shiep.edu.cn

MOTIVATION

In order to solve the structure and control co-optimization problem of a heat pump with thermal storages, a coupled dynamic optimization method was developed based on the nonlinear dynamic system model.



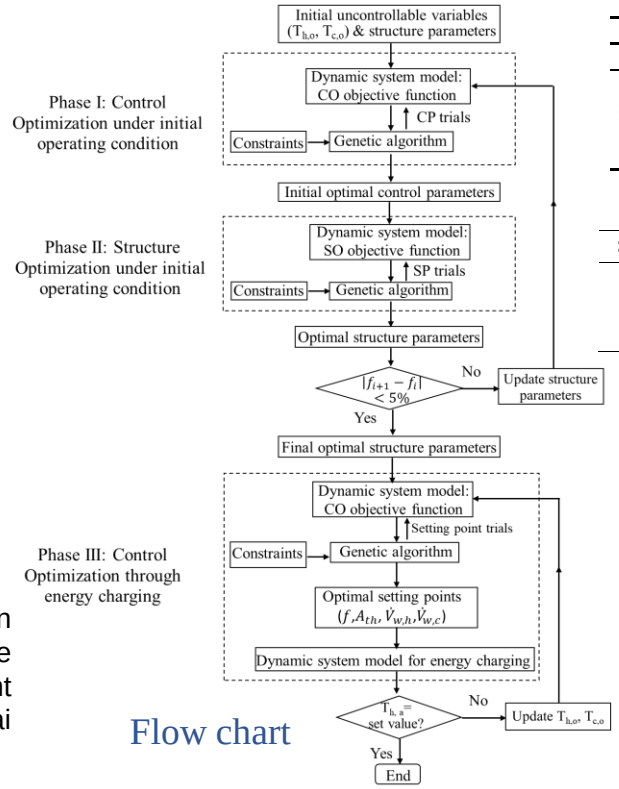
Ejector expansion CO_2 heat pump coupled with thermal storages

ACKNOWLEDGMENT

Natural Science Foundation of Shanghai in China (19ZR1420400, 15ZR1417700), the Program for Professor of Special Appointment (Eastern Scholar) supported by Shanghai Institutions of Higher Learning (2013-66)

Applied Energy Symposium
MIT A+B
Co-organized with Harvard

STRUCTURE AND CONTROL CO-OPTIMIZATION



Flow chart

RESULTS AND DISCUSSIONS

Optimal structures

	Gas cooler		Evaporator		Thermal storage tanks	
	Parameters	Value	Parameters	Value	Parameters	Value
Structure	N_{gc} (-)	15	L_{ev} (m)	6.64	D_h (m)	0.47
	$L_{gc,pl}$ (m)	0.39	$D_{ev,i}$ (mm)	12	H_h (m)	1.55
	$W_{gc,pl}$ (m)	0.089	$D_{ev,o}$ (mm)	24	D_c (m)	0.36
	$\varphi_{gc,pl}$ (°)	40			H_c (m)	1.56

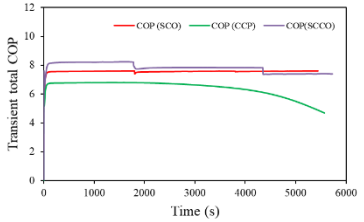
Dynamic optimal control strategy during energy charging

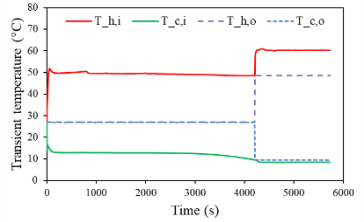
Stage no.	Charging time(s)	f (Hz)	A_{th}(mm^2)	$V_{w,c}$(m^3/h)	$V_{w,h}$(m^3/h)
1	0 - 1785	30	0.303	0.2	0.120
2	1785 - 4210	34	0.298	0.3	0.108
3	4210 - 5730	35	0.390	0.3	0.250

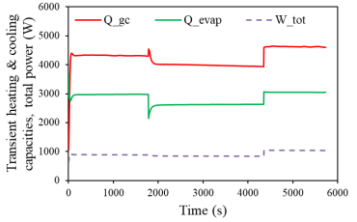
Structure and control co-optimization constraints

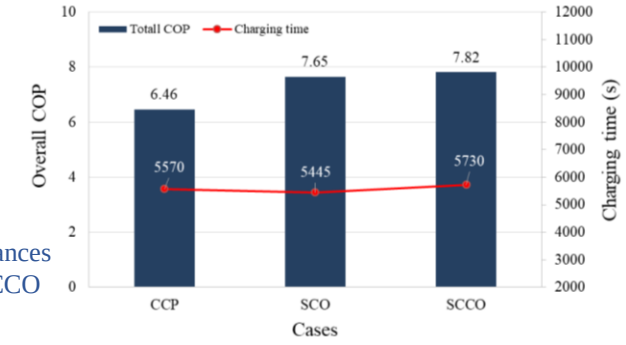
	Parameters	start	min	max
Structure	N_{gc} (-)	10	3	20
	$L_{gc,pl}$ (m)	0.329	0.2	0.5
	$W_{gc,pl}$ (m)	0.072	0.05	0.1
	$\varphi_{gc,pl}$ (°)	35	15	80
	L_{ev} (m)	5.47	2	10
	$D_{ev,i}$ (mm)	12.7	0	30
	$D_{ev,o}$ (mm)	22.2	0	30
	D_h (m)	0.4	0.25	0.8
	H_h (m)	1.4	0.8	2.2
	D_c (m)	0.4	0.25	0.8
	H_c (m)	1.3	0.8	2.2
Control	f	40	30	50
	$\dot{V}_{w,c}$	0.18	0.10	0.50
	$\dot{V}_{w,h}$	0.18	0.10	0.50
	A_{th}	0.5	0.2	0.70

Transient charging performances









Comparisons of overall charging performances of an ejector expansion systems using SCCO with CCP and SCO control strategies