Optimization Energy Demand Models

Boiler/turbo-generator system keys:

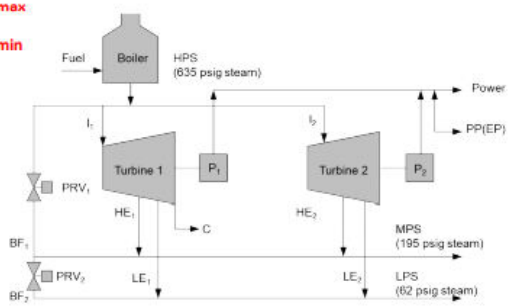
I_i : inlet flow rate for turbine i (lb/h)
HE_i : exit flow rate from turbine i to 195 psi header (lb/h)
LE_i : exit flow rate form turbine i to 62 psi header (lb/h)
C : condensate flow rate from turbine 1 (lb/h)
P_i : power generated by turbine i (kW)
BF_1 : bypass flow rate from 635 psi to 195 psi header (lb/h)
BF_2 : bypass flow rate from 195 psi to 62 psi header (lb/h)
HPS : flow rate through 635 psi header (lb/h)
MPS : flow rate through 195 psi header (lb/h)
LPS : flow rate through 62 psi header (lb/h)
PP : purchase power (kW)
EP : excess power (kW) different of purchased power from base power
PVR : pressure-reducing valve

Turbine data

	Turbine 1		Turbine 2		
$P_{1,max}$	Maximum generative capacity	6250 kW	Maximum generative capacity	9000 kW	$P_{2,max}$
$P_{1,min}$	Minimum Load	2500 kW	Minimum Load	3000 kW	$P_{2,min}$
I_1	Maximum inlet flow	192000 lb/h	Maximum inlet flow	244000 lb/h	I_2
C_1	Maximum condensate flow	62000 lb/h	Maximum 62 psi exhaust	142000 lb/h	LE_2
I_1-HE_1	Maximum internal flow	132000 lb/h	High-pressure extraction at	195 psig	
	High-pressure extraction at	195 psig	Low-pressure extraction at	62 psig	
	Low-pressure extraction at	62 psig			

Steam Header data

Header	Pressure (psig)	Temperature (F)	Enthalpy (Btu/lb)
High-pressure steam	635	720	1359.8
Medium-pressure steam	195	130 superheat	1267.8
Low-pressure steam	62	130 superheat	1251.4
Feed Water (condensate)			193



The system may be modeled as linear constraints and combined with linear objective function.

The objective is to minimize the operating cost of the system by choice of steam flow rates and power generated or purchased, subject to the demands and restrictions on the system.

Step 1) Objective function

Demand Penalty

$$Min\ f = 0.00261\,HPS + 0.0239\,PP + 0.00983\,EP$$

Steam cost — Electricity Price

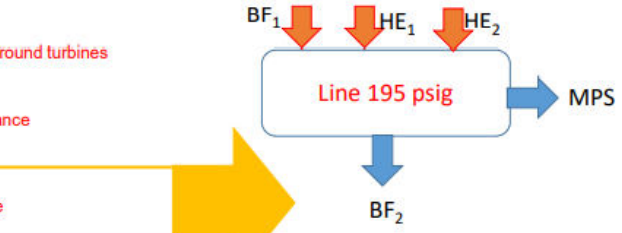
Material Balances

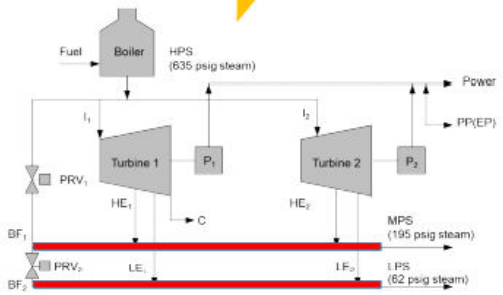
$$HPS - I_1 - I_2 - BF_1 = 0$$ Total Mass Balance

$$I_1 + I_2 + BF_1 - C - MPS - LPS = 0$$ Internal Mass Balance around turbines

$$I_1 - HE_1 - LE_1 - C = 0$$
$$I_2 - HE_2 - LE_2 = 0$$ Components Mass Balance

$$HE_1 + HE_2 + BF_1 - BF_2 - MPS = 0$$
$$LE_1 + LE_2 + BF_2 - LPS = 0$$ Addition Mass Balance





Power purchased

$$EP + PP \geq 12000$$

Optimization Energy Demand Models

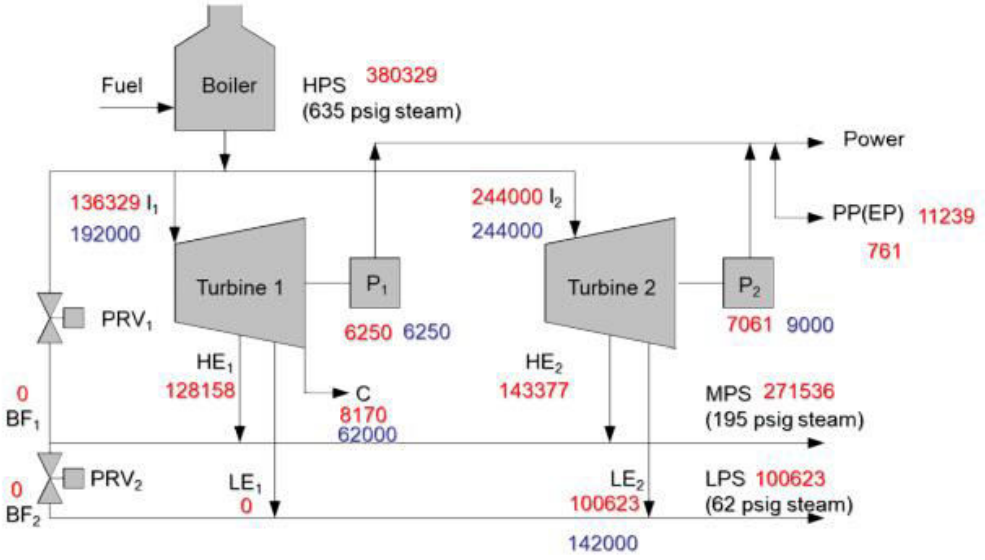
Optimal solution of model

Variable	Name	Value
1	I_1	136329
2	I_2	244000
3	HE_1	128158
4	HE_2	143377
5	LE_1	0
6	LE_2	100623
7	C	8170
8	BF_1	0
9	BF_2	0
10	HPS	380329
11	MPS	271536
12	LPS	100623
13	P_1	6250
14	P_2	7061
15	PP	11239
16	EP	761

Value of objective function is **1268.75 $/h**

Optimization Energy Demand Models

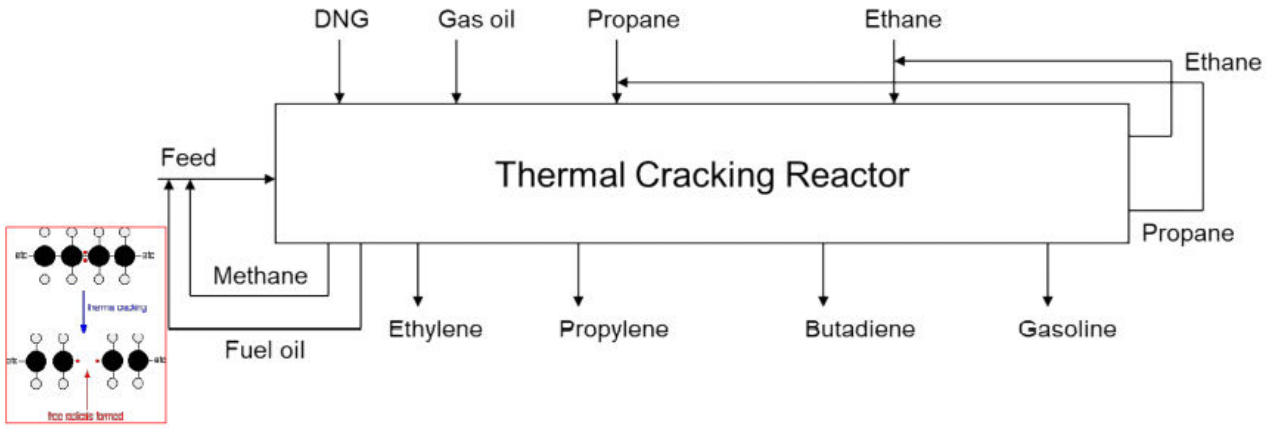
Optimal solution of model



Optimization Energy Demand Models

Thermal cracking system energy demand model

When multiple reactants are employed, it is desirable to optimize the amounts of each reactant so that the products satisfy flow and demand constraints.



Optimization Energy Demand Models

The capacity of run gas feeds through the cracker is 200000 lb/stream hour (total flow based on an average mixture).

Ethane uses the equivalent of 1.1 lb of capacity per pound of ethane.

Propane 0.9 lb/h, gas oil 0.9 lb/h and DNG 1 lb/h.

Down stream processing limits exist of 50000 lb/stream hour on the ethylene and 20000 lb/stream hour on the propylene.

The fuel requirements to run the cracking system for each feedstock type are as follow:

Feedstock type	Fuel requirement (Btu/lb)
Ethane	8364
Propane	5016
Gas oil	3900
DNG	4553