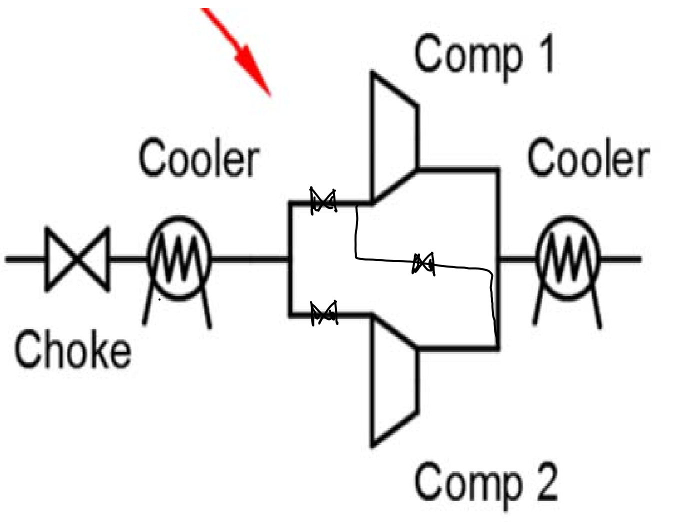
Help - comments for ex. 2 in Ex. set 5.

- choke at inlet reduce even more available pressure
- cool fluid upstream (30°C ΔT)
- cool fluid downstream (30°C ΔT)
- decide to use single or two compressors
- To reduce rate



204.9	82.0	78.6	30.0	6.7E+6	123															
196.8	82.0	78.6	30.0	6.7E+6	115															
188.8	82.0	78.6	30.0	6.7E+6	107															
180.9	82.0	78.6	30.0	6.7E+6	99															
173.1	82.0	78.6	30.0	6.7E+6	91															
165.4	82.0	78.6	30.0	6.7E+6	83															
157.8	82.0	78.6	30.0	6.7E+6	76															
150.2	82.0	78.6	30.0	6.7E+6	68															
142.6	82.0	78.6	30.0	6.7E+6	61						k	1.30								
135.1	82.0	78.6	30.0	6.7E+6	53						Polytropic effic	0.7								
127.5	82.0	78.6	30.0	6.7E+6	46						Mech. Effic	0.95								
119.9	82.0	78.6	30.0	6.7E+6	38															
112.2	82.0	78.6	30.0	6.7E+6	30															
104.4	82.0	78.6	30.0	6.7E+6	22															
96.5	82.0	78.6	30.0	6.7E+6	14															
88.4	82.0	78.6	30.0	6.7E+6	6	Pplem req	Δp cho	Psuc	Tsuc	rp	deltap	np	n	Tdis	zsuc	zdisc	Bg @suc	qg_local	Δhp	m
82.0	82.0	78.6	30.0	6.7E+6	0	[bara]	[bara]	[ba	[C]	[-]	[bar]	[-]	[-]	[C]			[m^3/Sm^3]	[m^3/d]	[J/kg]	[kg/s]
80.1	80.1	76.6	30.0	6.7E+6	0	78.6	0		67	1.03	1.94	0.70	1.49	69.81	0.93	0.93	14.5E-3	289.3E+3	4126.15	155.5
71.1	71.1	67.1	30.0	6.7E+6	0	78.6			67	1.17	11.43	0.70	1.49	85.05	0.94	0.94	16.7E-3	332.7E+3	26754.95	155.5
61.8	61.8	57.1	30.0	6.7E+6	0	78.6			67	1.38	21.45	0.70	1.49	104.60	0.94	0.95	19.8E-3	394.5E+3	56384.84	155.5
51.5	51.5	45.8	30.0	6.7E+6	0	78.6			67	1.71	32.75	0.70	1.49	133.02	0.95	0.97	24.9E-3	497.1E+3	100283.54	155.5
39.6	39.6	31.9	30.0	6.7E+6	0	78.6			67	2.46	46.68	0.70	1.49	184.44	0.97	0.99	36.3E-3	724.1E+3	181242.31	155.5
23.8	23.8	3.9	30.0	6.7E+6	0	78.6			67	20.06	74.65	0.70	1.49	638.81	1.00	1.02	304.1E-3	6.1E+6	908936.00	155.5
ALUE!	#VALUE!	#VALUE!	30.0	6.7E+6	#VALUE!	78.6			67	#VALUE!	#VALUE!	0.70	1.49	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	155.5
ALUE!	#VALUE!	#VALUE!	30.0	6.7E+6	#VALUE!	78.6			67	#VALUE!	#VALUE!	0.70	1.49	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	155.5

- Production optimization :
  - increase oil or gas production!
  - Reduce cost
  - by using cost effective measures

In the industry, typical activities performed in optimization are:

- Detect pipe section, component with high Δp. { · too small size · blockage · }

- verify design conditions of equipment vs actual operating conditions.

- Study and analyze maintenance, installation, testing logistics, defect defficiencies, problems and take measures.

- identify sources with non attractive characteristics (H_2S, WC), and limit their production

- review failure data and detect patterns

- identification and address of operational constraints or bottleneck.

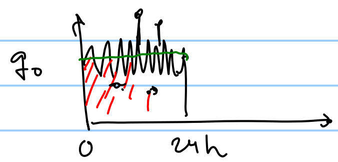
- calibration of instrumentation

- identifying and monitoring $\underbrace{\text{KPIs}}_{\text{key performance indicators}}$

① → find settings of adjustable elements that give the maximum revenue and satisfy the multiple operational constraints.

mathematical procedure that can guarantee optimality.

tools used to perform optimization:
- historic data (reported)
- look at more frequent data



- instrumentation
- experience from field operators.
- numerical models.

> 1000 sensors

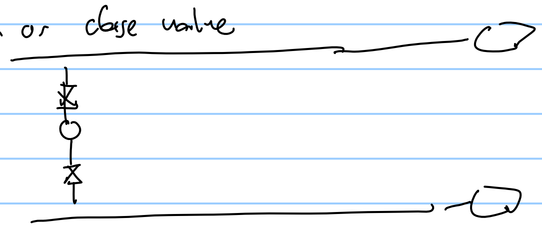
Formal - mathematical → Production optimization

short term

- min → weeks

(is neglects time effect, steady state)

- real-time production optimization
- gas-lift allocation ← gas lift rate
- routing ← open or close valve



- ESP systems (change f)
- processing opt.

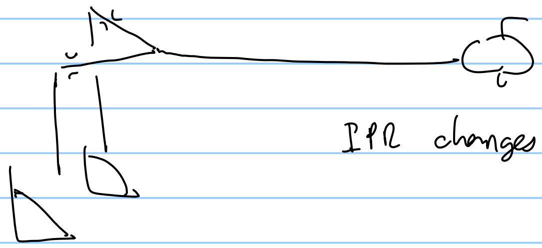
long-term

month → years

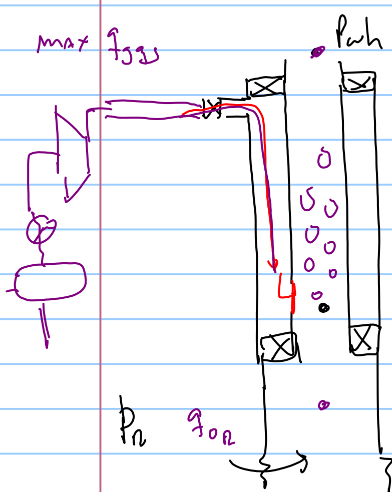
- reservoir control { find $q_o(t)$ ← i-nº well; that gives max NPV, max RF

considering the time effect in a long time scale

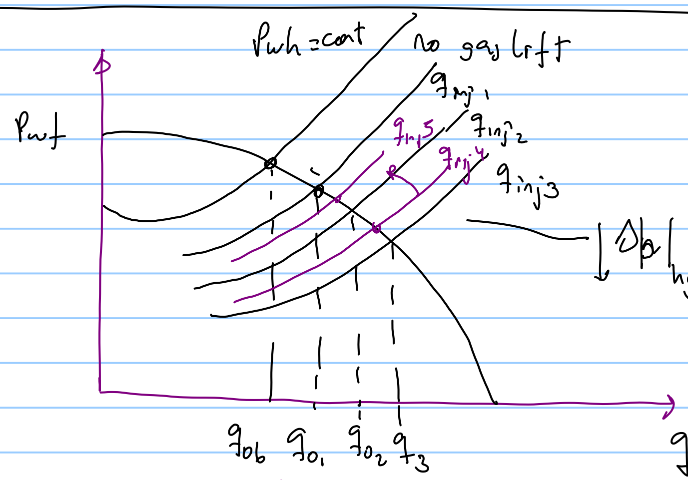
- well placement



IPR changes with time



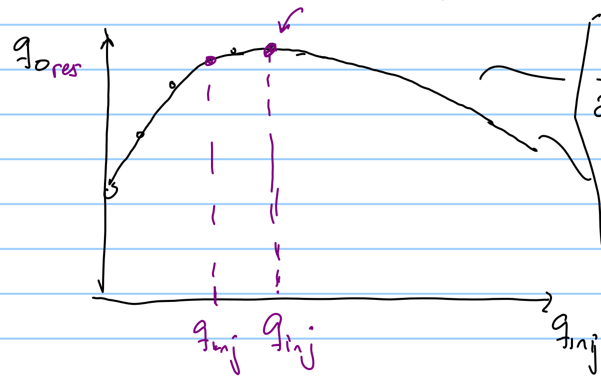
↓ ρ_{mix} tub



$\downarrow \Delta p|_{hy} + \Delta p|_f \uparrow$

operational constrains have to be taken into account when performing optimization!

- gas capacity
- water processing capacity
- gas processing capacity



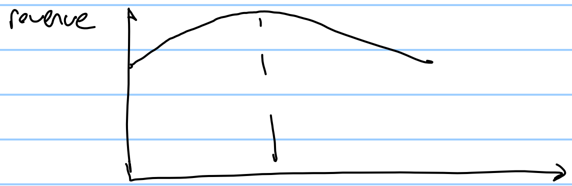
$$\frac{\partial q_o}{\partial q_{inj}} = 0 \quad q_{inj} = ?$$

$$\frac{\partial^2 q_o}{\partial q_{inj}^2} < 0$$

make this optimization on revenue

- gas coning
- water coning
- sand production
- power consumption
- erosion

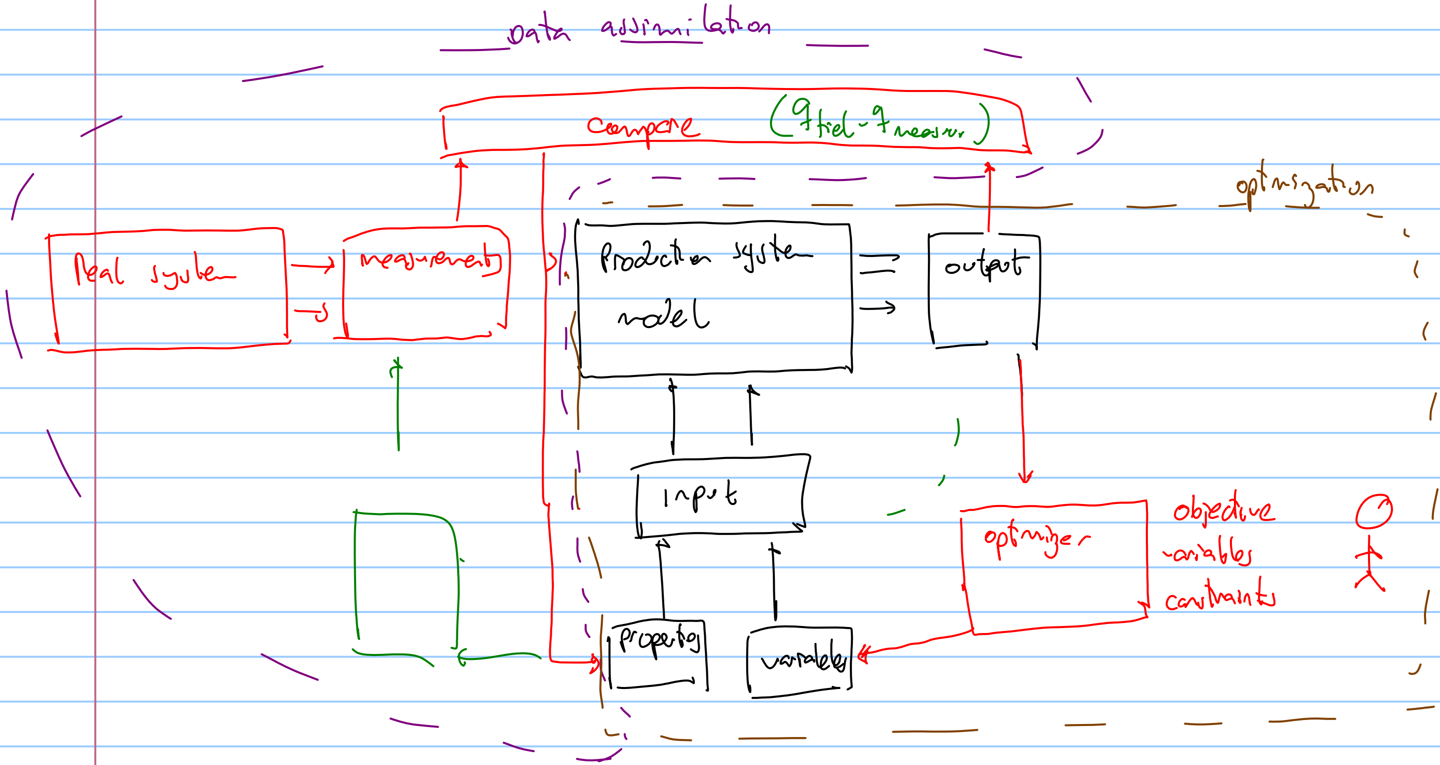
$\text{revenue} = q_o \cdot P_o - q_g \cdot P_w$ or $\text{revenue} = q_o \cdot P_o - \frac{\text{kwh}}{\text{USD}} \cdot \text{Power}$



An optimization problem consists on 3 things

- objective → max → q_o, q_g, RF, NPV
  - → min → cost, q_w, downtime, etc
- variable { choke position, well placement; gas lift rate; pump frequency; well routing } only the essential
- constraint {

for optimization we use numerical models

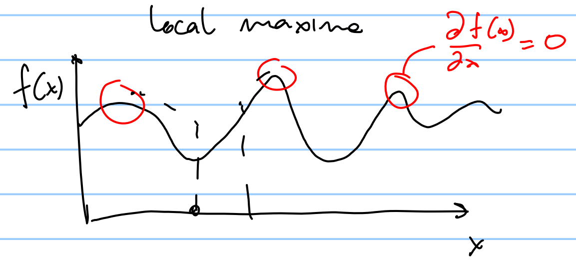


How is optimization performed ?

- perform single or multiple evaluations of model for different input conditions
- estimating the next set of input conditions that you want to evaluate (algorithm).
- checking if the stopping criteria is met.

there are different types of optimization problems

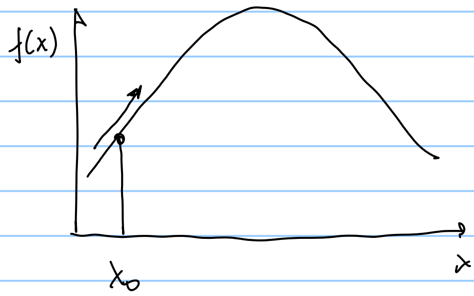
- variable type → continuous
  → integer
- constraints: constrained
  un constrained
- linear vs non linear



run multiple starting points and verify that the solution doesn't change.

there are different methods to perform optimization:

- gradient based (derivative based)

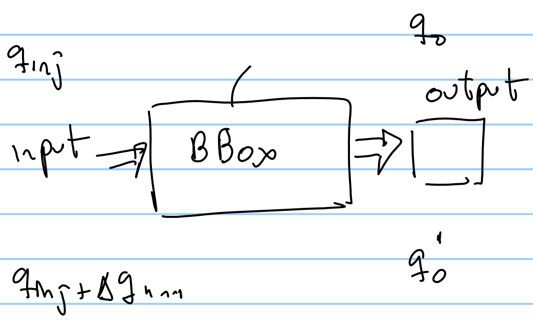


- move in the direction of gradient

Newton-Raphson type method

$$\underbrace{\left\{ \frac{\partial f}{\partial x} \right\}} \quad \left\{ \frac{\partial^2 f}{\partial x^2} \right\}$$

$$F(x_1, x_2, x_3, \ldots x_n)$$



for black box models — no access to equations

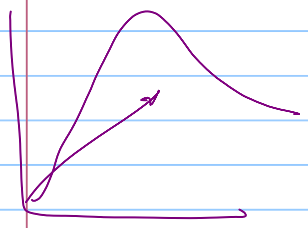
$\frac{\partial f}{\partial x}$ is estimated numerically

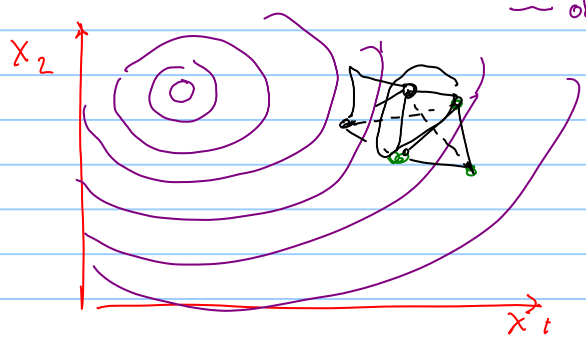
$$\frac{\partial f}{\partial x} \approx \frac{f(x+\Delta x) - f(x)}{\Delta x}$$

- for many variables is a prohibitive approach

- quick convergence

- heuristic methods. Some logic to chose the next point from the existing evaluations





Nelder-Mead

✓ Black box models

- Evolutionary methods. evaluate a group of individuals. Select those who performed best and estimate new set of individuals

genetic algorith

to evaluate a whole population.