International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878 (Online), Volume-8 Issue-4, November 2019

Multi-Objective Gas Lift Optimization using Elitist Non-Dominated Sorting Genetic Algorithm (NSGA-II)

V Sreeharsha, Pulak Jawaria, M Ragavendra, B Madhuri, Vishesh Bhadaria

Abstract**:** ***In petroleum industry, gas lift optimization is the most important for evaluating the reservoir. By improving the gas lift operation we can save money and time which we spend on the reservoir for effective production. The mainly accepted scenario of gas lift is to maximize production by using minimized cost infrastructure. If the production rate is increased, then the cost of oil production also increases due to the increase in surface facilities and increase in cost of gas compression to higher pressures. The production rate and production cost during gas lift are mutually conflicting in nature i.e., if anyone desires to increase the oil production rate, then at the same time it is difficult to minimize the cost of production. Therefore, this is an ideal candidate for multi-objective optimization study, where production rate needs to maximized while minimizing the cost of production. The oil production rate is calculated using nodal analysis of inflow performance and outflow performance curve while the production cost is calculated using the brake horsepower requirement of the compressor. Oil production rate during a gas lift operation can be defined as a function of various factors like (i) depth of gas injection, (ii) gas injection rate (iii) gas lift injection pressure, (iv) wellhead pressures, (v) bottom hole pressure, (vi) tubing size, (vii) surface choke size/wellhead pressure. Production cost mainly depends on the cost of gas compression which further depends on the pressure up to which gas has to be compressed in the annulus so that the gas lift valve at the bottom of the well opens. The opening of gas lift valve depends on the bottom hole pressure in the tubing i.e. the density of mixture present inside the tubing. The multi-objective gas lift optimization is carried out using multi-objective evolutionary algorithms (EAs) that use non-dominated sorting called elitist non-dominated sorting genetic algorithm (NSGA-II). In this project, we aim to find the optimum values of the decision parameters i.e. gas injection rate and wellhead pressure, for which oil production rate would be maximized while minimizing the cost of oil production.***

Keywords: gas lift, nodal analysis, multi-objective optimization, pareto-optimal solutions, genetic algorithms.

Manuscript published on November 30, 2019.
* Correspondence Author

V Sreeharsha have position of asst. professor in vignan's foundation for science, technology and research. He has done his master degree from IIT Dhanbad.

Pulak jawaria has done master degree from IIT Dhanbad.

Vishesh Bhadaria, has master degree from IIT Dhanbad.

I. INTRODUCTION

The production system of oil well contains a part of the reservoir, the system sending oil to the wellhead, and also the initial separation process at surface in certain time intervals.

A lot of careful characterization of the system parts would consist: the part of formation between the location of the geographic region and also the wellbore site, wells completion, i.e. perforations, gravel pack, screens etc., vertical or inclined tube string, any down hole limitations present within the tube, like down hole safety valves, etc., artificial elevate by means of supportive mechanical equipment, if needed for recovery of oil to the top surface, the choke assembly present at the wellhead, the flow line with its supporting mechanical equipment, the centrifuge useful for initial separation of oil is formed. Assume a straight forward flowing well with just some of the parts discussed earlier. Design for this modified case. Oil present in the formation fluids to the well from as way because the boundary of the geographic location,1. When coming into the well by the sand portion, straight flow within the tube starts at well bottom part, 2. Inside the tubing pipe string vertical or directional tube the flow will reach to the well top, 3. A well head choke closure is present at that four points is adding the lifting purpose to the flow line. Horizontal or directional flow within the flow line goes to the centrifuge. The flowing well consists of points which are denoted by nodes system to easily understand the flowing condition of fluid at the different node points. They will categorize the several parts in the reservoir: The formation zone, the tubing string, the flow line, etc. Between any 2 node points, Decreasing in the fluid flow in any direction of the tube is characterized by respective nodes present in that particular flow direction. The direction of the flow with respect to change in pressure drop within the flowing tube also we can be analyzed and determined. For various types of hydraulic parts we will consider different pressure drop models and which will result in our prime motive assumption. Two node points are separate case evaluation: The extent of the geographic area and also centrifuge. Those points will gives us the 2 endpoints of the gathering reservoir and pressure is maintained at constant for loner period of times.

Hydrocarbon zone pressure at the primary condition of the geographic area of the well, as well, depletion in the reservoir except the production related operations related to short term, medium term will be neglected. Centrifuge pressure, typically maintained at the constant sphere conditions for effective operation of the reservoir. Thus, the two different pressures mainly the pressure difference and centrifugal pressures maintained at constant rate which leads smooth analysis.

II. METHODOLOGY

We aim to define two objective functions for optimization

1. Oil production rate during gas lift which should be maximized, as a function of various factors like (i) depth of gas injection, (ii) gas lift injection rate (iii) gas lift injection pressure, (iv) wellhead pressure, (v) bottom hole pressure, (vi) tubing size, (vii) surface choke size/wellhead pressure.
2. Production cost is the main aspect while we are considering about the gas compression methods for recovery through well. Gas lift valves usage in the production purpose which leads to the operating cost. The flow of fluids through porous media to the annulus and annulus to the tubing string is determined by using the appropriate actions. So the recovery of hydrocarbons depends on the factors which impact the well bore conditions also. The criteria of selection are useful for amount of injection fluid needed for EOR process.

A. Workflow Procedure

After defining the two objective functions we aim to find the threshold values of the decision variables, i.e. gas injection rate and wellhead pressure, for which oil production rate would be maximized while minimizing the cost of oil production using Elitist Non-dominated Sorting Genetic Algorithm (NSGA-II) In this paper, we use the gas lift method to recover the oil from the wells. So, for that we have different approaches to enable it but non-linear function of gas lift is taken into consideration for better results. When we using the gas upto particular level there will be no pressure loss, once it reached the below bubble point pressure then there is decrease in the production. Above this point there is no matter how much gas you sent it will be negligible effect on the pressure maintenance. For particular gas amount, when we are using the gas injection in the wells will not entertain properly. So, we consider the single objective gas lift process for problem optimization is to give a less amount of gas to a number of wells present in the reservoir while improving the production on a regular basis. The main basis is to maintain it on regular basis. One dedicated team present to monitor the system always. In such cases we will recommend bi-objective optimization to control the problem. It is more helpful in eliminating the problem condition.

B. Input Parameter

First Objective Function-Liquid Production Rate (Buyon Guo et al., 2007)

The various input variables required for the calculation of liquid recovery rate are as follows:

Parameter	***Conditions***
Average Reservoir Pressure	$\bar{P}$*(psia) = 5000 psia*
Reservoir Permeability	k (md) = 60 mD
Reservoir Pay thickness	h (ft) = 100 ft
Oil Viscosity	μ_o (cP) = 3.5 cP
Oil Formation Volume Factor	B_O (rb/stb) = 1.2 rb/stb
Reservoir Drainage Radius	re (ft) = 3000 ft
Wellbore Radius	r_W (ft) = 1.5 ft
Skin Factor	$S = 0$
Water Cut	WC (fraction) =0.25
Oil API Gravity	(°API) = 30 °API
Gas Specific Gravity	$\gamma_g = 0.65$
Produced water specific gravity	γ_w =1.05
Formation GLR	$GLRform$ (scf/stb) = 700 scf/stb
Wellhead Temperature	Twh (^oF) = 80 ^oF
Bottom Hole Temperature	Tbh (^oF) = 180 ^oF
Tubing Shoe Depth	H (ft) = 5000 ft
Tubing Inner Diameter	D (in) = 2 inch

Second Objective Function-Recovery Cost (K.E.Brown, 1980)

The various input variables required for the calculation of cost of gas injection are as follows:

1. Bellow/Dome pressure	Pd (psia) = 900 psia
2. Spring tension	St (psia) = 0 psia
3. Area of port	Ap (sq inch) = 0.3 sq inch
4. Area of bellow	Ab (sq inch) = 1.5 sq inch
5. Compressor suction pressure	$Psuct$ (psia) = 30 psia
6. Compression cost	x ($/day per BHP) = 800 $/day per BHP

DECISION PARAMETERS

The decision variables which need to be optimized and which can be changed during gas lift operation are as follows:

1. Gas injection rate, Qg injected (scf/d)
2. Well Head Pressure, Pwh (psia)

III. OVERVIEW OF PROGRAM

PROGRAM CODE:

Setting Decision Parameters and Generation Size

In this sub-routine function, the following values are entered:

The number of decision parameters involved in the objective functions, in our case it is

1) *nparam=2.*

The generation size is chosen, the more the generation size, the more accurate the result. In our case, we have chosen different **maxgen** for testing purpose.

- i. **maxgen** = 5
- ii. **maxgen** = 50
- iii. **maxgen** = 100
- iv. **maxgen** = 500
- v. **maxgen** = 10

IV RESULTS AND DISCUSSION

After recording the last 100 values for both the objective functions and both the decision parameters in separate worksheets for each of the value of maxgen, graphs were plotted between Liquid Recovery rate on x-axis and the recovery cost on y-axis. The plot (pareto optimal solution) between them should come as an increasing trend in which cost of production increasing with increasing liquid production rate.

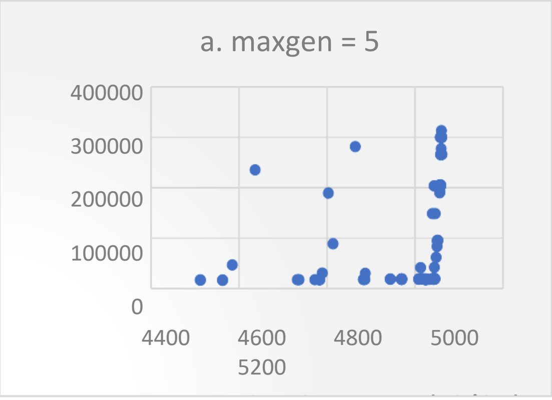

Figure 1: Production cost vs Liquid production rate

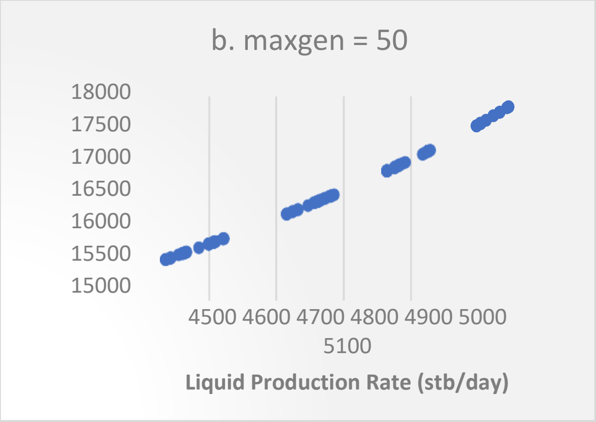

Figure 2: Production cost vs Liquid production rate

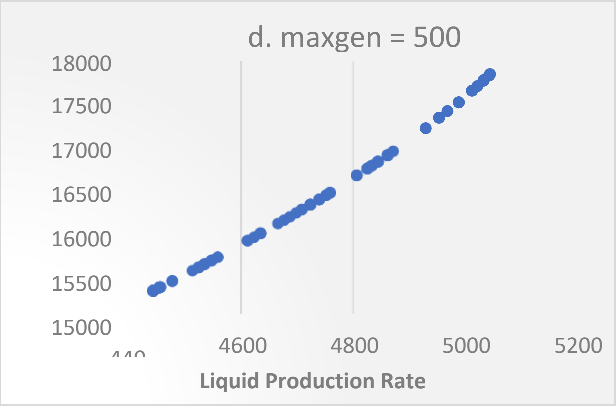

Figure 3: Production cost vs Liquid production rate

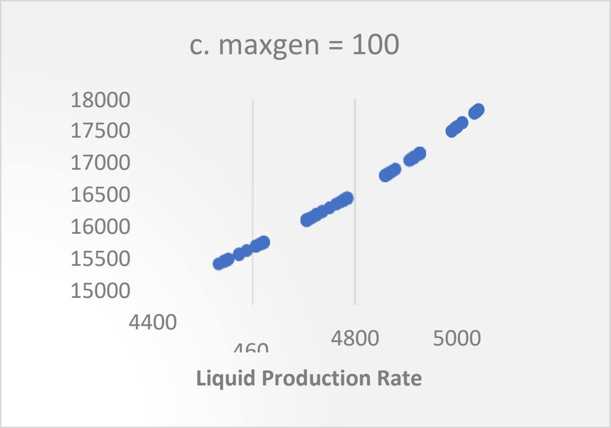

Figure 4: Production cost vs Liquid production rate

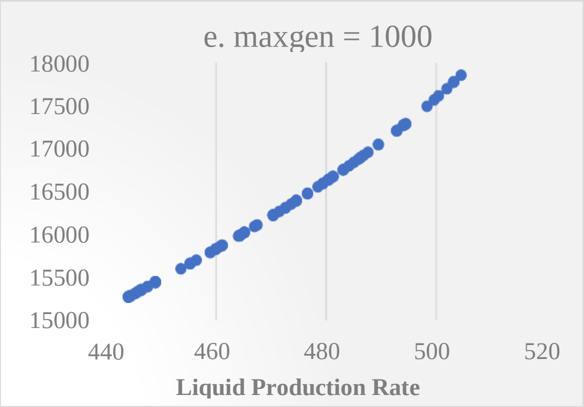

Figure 5: Production cost vs Liquid production rate

IV. CONCLUSION

The optimization is performed using non-dominated sorting genetic algorithm (NSGA-II) in FORTRAN, developed by Kalyanmoy Deb. The NSGA-II requires input of two objective functions. In our case, the first objective function is the liquid production rate during gas lift operation which mainly depends on the gas injection pressure and rate which also depends on wellhead pressure. The liquid production rate is determined using nodal analysis of inflow performance and tubing performance curve. The second objective function is the cost of gas compression or production cost, which depends on the pressure up to which gas has to be compressed. The pressure up to which gas has to be compressed depends on wellhead pressure and average mixture density present in the tubing. The average mixture density further depends on the gas injection rate. Both the functions depend on gas injection rate and wellhead pressure. So, these variables are considered as decision parameters. A relevant range of values is selected for both the decision parameters and entered in the program. The programs of objective functions are also entered in the NSGA-II program. On observing the results of the program, we can make the following conclusions. The gas injection rate is maintained at minimum value of its range to maintain optimum liquid production rate and production cost. The wellhead pressure is optimized to a certain value in its range to maintain optimum liquid production rate and production cost.

The following deductions can be made from sensitivity analysis of liquid production rate: the liquid production rate increases with increase in gas injection rate up to a certain level only and the liquid production rate decreases with increase in wellhead pressure.The following deductions can be made from sensitivity analysis of production cost: the production cost increases with increase in gas injection rate due to increase in power requirement of compressor and the production cost decreases with increase in wellhead pressure. The gas lift performance curve is plotted between liquid production rate and gas injection rate which justifies that the liquid production rate starts to decline in case of excessive gas injection rate.

REFERENCES

1. Abdalsadig, MA, Nourian, A, Nasr, GG and Babaie. "Gas lift optimization to improve well performance", International journal of mechanical, aerospace, industrial, mechatronic and manufacturing engineering; 2016, **10** (3), pp. 427-435.
2. Aguilar, M. A. L. and M. R.A. Monarrez, "Gas Lift with Nitrogen Injection Generated in Situ." Paper SPE 59028 presented at the International Petroleum Conference and Exhibition in Mexico, held in Villahermosa, February 1-3, 2000.
3. Ali Hernández. *Fundamentals of Gas Lift Engineering: Well Design and Troubleshooting*. Oxford, OX5 1GB, UK: Gulf Professional Publishing, 2016, pp: 151-182, 296-299
4. Ansari, A.M., Sylvester, N.D., Sarica, C., Shoham, O., and Brill, J.P. A comprehensive mechanistic model for upward two-phase flow in wellbores. SPE Production and Facilities (May 1994) 143, Trans. AIME 1994; May:297.
5. Narsimulu D., Rao B.N., Venkateswarlu M., Srinadhu E.S., Satyanarayana N. Electrical and electrochemical studies of nanocrystalline mesoporous MgFe2O4 as anode material for lithium battery applications, (2016) Ceramics International: Vol. 42.
6. Hari Prasad K., Naresh N., Nageswara Rao B., Venkateswarlu M., Satyanarayana N. Preparation of LiMn2O4Nanorods and Nanoparticles for Lithium-ion Battery Applications, (2016) Materials Today: Proceedings: Vol. 3.
7. Kumar P.R., Madhusudhan Rao V., Nageswararao B., Venkateswarlu M., Satyanarayana N. Enhanced electrochemical performance of carbon-coated LiMPO 4 (M = Co and Ni) nanoparticles as cathodes for high-voltage lithium-ion battery, (2016) Journal of Solid State Electrochemistry:Vol. 20.
8. Sudhir M.S., Mohan P.M., Nadh R.V. Simple and validated ultraviolet spectrophotometric method for the estimation of Febuxostat in bulk and pharmaceutical dosage forms. (2013) Oriental Journal of Chemistry: Vol. 29.
9. Suresh G., Venkata Nadh R., Srinivasu N., Kaushal K. Novel coumarin isoxazoline derivatives: Synthesis and study of antibacterial activities.(2016) Synthetic Communications: Vol. 46.

AUTHORS PROFILE

V Sreeharsha have position of asst. professor in vignan's foundation for science, technology and research. He has done his master degree from IIT Dhanbad. The following work has done during the last one year time period.

Pulak jawaria has done master degree from IIT Dhanbad. he has done deep study on the topic and worked on this project.

Vishesh Bhadaria, has master degree from IIT Dhanbad. he has sound knowledge in petroleum modeling and simulation topics.