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Improved Oil Production Optimization Applying Particle Swarm Optimization

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Abstract:

General oil field-optimization algorithm is proposed in this paper for improved asset optimization techniques using Particle Swarm Optimization (PSO). The proposal consists of the swarm behavior model. The PSO algorithm proposes a set of potential solutions to the optimization problem.

A large amount of work has been done for well optimization in which multiple optimization methods were used. In gradient-based optimization methods, the derivative of the objective function with respect to the decision variables is used. In gradient-free optimization, multiple algorithms classified as global or stochastic algorithms - such as the genetic algorithm, simulated annealing, and particle swarm optimization. These optimization strategies can be applied individually or can be used in complementary to maximize the different objectives in an oil field.

In this paper, we review Particle Swarm Optimization (PSO) and its application to optimize the critical variables. In this work, we address the significance of different methods and highlight their limitations. We also discuss the challenges associated in applying, extending these methods, and their potential in the future.

Keywords — **Oil Field Optimization, Particle Swarm Optimization, Asset Optimization**

I. INTRODUCTION

Model-based oil field production optimization is often full of uncertainties and is computationally intensive.
Oil field optimization is an important factor in field development strategies targeted to maximizing the hydrocarbon recovery, and economic feasibility of new field development projects. Particularly, considering shortage in new oil field discoveries, maximizing oil production has become very important in Oil and Gas industry.

As a result, field optimization techniques are being considered as separate research field. Recently there are many attempts made by researchers and commercial operators to create efficient asset optimization models that can predict strategies for managing the existing oil and gas field's potential for maximizing the critical variables. Important elements in field development and optimization include well type, well lift type and production methodologies. Recently, a lot of work has been done for asset optimization using both gradient based and gradient-free optimization methods.

II. LITERATURE SURVEY

A. PSO: Constraints Formation [1]

In this work [1], we focus on developing constraint formulations to enforce various realistic field development considerations. Furthermore, we use the Particle Swarm Optimization (PSO) algorithm to solve an optimization case with given constraints.

B. Review Current optimization techniques[2]

In this paper [2], we review several of the current optimization techniques, and their application to maximize the critical factors. In the process, we address the significance of different methods and highlight their limitations. We discuss as well the challenges associated in extending these methods, and their potential in the future.

C. PSO Evaluation and Field Development [3]

In this study [3], oil field development strategies are evaluated based on decision variables, uncertainties and optimization methods. The study proposes reservoir models considering the subsurface uncertainties. Hydrocarbon recovery objective is modelled for maximization of the total recovery and Net Present Value (NPV).

D. Analysis of PSO and its application for real time problems. [4]

General PSO analysis, trends and real time issues are analysed in this study [4].

E. Analysis of general oil field development problems [5]

In this paper [5] the field development problem is considered with an optimization objective to determine type of new wells and their respective drilling sequence. The objective includes determining well locations and time varying controls.

III. PROPOSED METHODOLOGY

In this project, the Particle Swarm Optimization
In this project, the Particle Swarm Optimization (PSO) based asset optimization technique is proposed for the improved optimization results in terms of data accuracy and time complexities and implementation complexities.

A. Architecture:

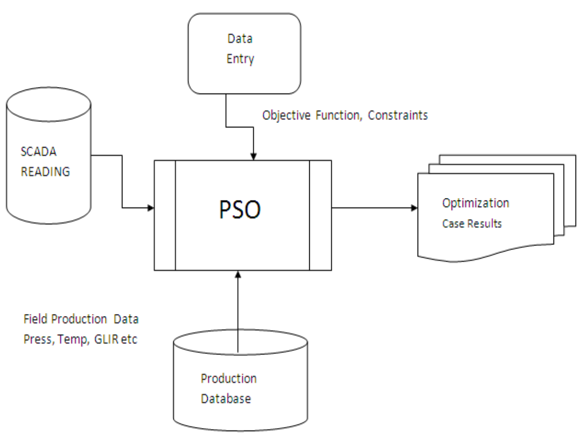


Fig 1.Oil Field Optimization using PSO architecture

Data Collection:
Daily Production data is capture through any Production Data Management System (PDMS). It captures the meter readings and any other field equipment or asset data.

Supervisory control and data acquisition (SCADA) Readings:
It is the High Frequency Data received from different equipment's like meters, sensors etc

Data Entry:
The field operator can input the if scenarios in terms of objectives and constraints.

B. Approaches:

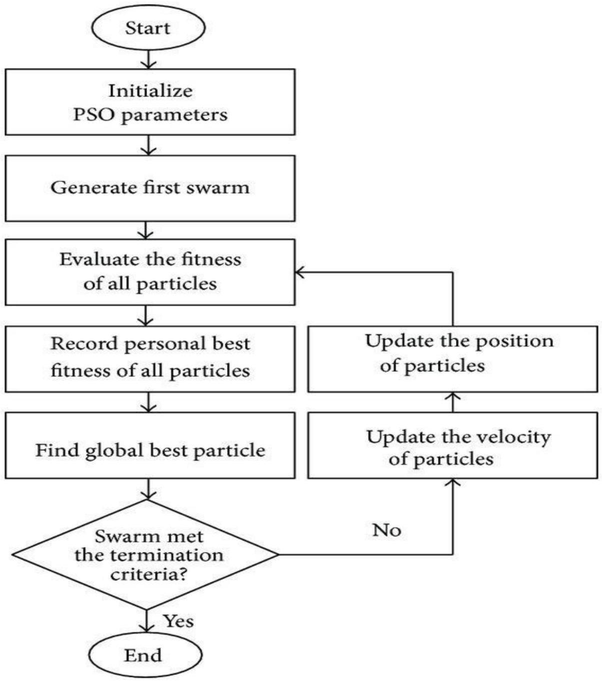
Particle Swarm Optimization (PSO) solves complex optimization problems with the inspiration from bird flocking and fish schooling.

Each bird or fish is mapped as a particle in the swarm and the target is observed. The particle closest to the target is considered as the best solution and all other particles in the group adjust their values as close as possible to the best solution. This behaviour is executed in iterations unless and until all the particles have reached to their best solution and the overall target of the group.

The procedure focus on following factors:

- Objective or Target
- Global best – Determines which particle has a solution nearest to the objective or target.
- Termination condition depending on the group objective or target has been achieved or not

- ***Algorithm***



.Fig. 2. Generic Particle swarm optimization algorithm

Every particle has following identities:

- Current data which can be a potential solution
- The value of the Velocity which determines how much data can be changed or needs to be changed
- Personal best value of the particle determining its nearest value to the target in the successive iterations

In the Oil field optimization problem, every well inside the field will be considered as a Particle.

Every well has its own producing status and artificial lift type at any specific time. Based on the lift type, total available supply will be mapped as constraint value. For example, for Gas Lifted wells, total available gas for the field will be one constraint and similarly for the Electrical Submersible Pump (ESP) wells, the total available power supply will be mapped as a constraint.

The velocity value is mapped as the individual wells production. The well's individual best production will be treated as the local best. However the target is the global best which will be summation of all the wells of the field. The particle's velocity will be compared with its local best and global best values and will be adjusted as per the objective function or the target.
The global best value changes whenever the local best of any of the well moves closer to the target.

The particles' data could be anything. In the flocking birds theory, the data would be the X, Y, Z coordinates of each bird. The individual coordinates of each bird would try to move closer to the coordinates of the bird which is closer to the food's coordinates (gBest). If the data is a pattern or sequence, then individual pieces of the data would be manipulated until the pattern matches the target pattern.

C. Swarm Modelling Functions

Velocity Function:

V (t) = w V (t-1) + C1R1 [X (Local Best) (t-1) –
X (t-1)] C2R2 [X (Global Best) (t-1) – X (t-

1)] X (t) = X (t-1) +V (t)

V: Velocity of a particle
w: inertia weight
t: time
C1: Constant
C2: Constant
Particle's Position at time t.

R1: Random Variable within range [0, 1]
R2: Random Variable within range [0, 1]

X (Local Best): Particle's best fitness value X
(Global Best): Groups best fitness value

Fitness Value Function:
z = Z(X)
X* = arg min Z(X)

IV. RESULT AND DISCUSSIONS

Field Optimization offers incremental potential to significantly increase ultimate hydrocarbon recovery by generating an affirmative picture for development plans with the virtue of many alternatives being evaluated.

The optimization algorithm can be based on traditional derivative based algorithms for initial field development. Once the field is matured, the optimization techniques can be extended to use the Particle swarm optimization.

Success of the optimization will be based upon:

1. Choice of appropriate design variables
2. Inclusion of uncertainty of important variables
3. Objective Function(s)
4. Design constraints based on operational conditions

V. CONCLUSIONS

This project proposes an improved production optimization algorithm utilizing the bio inspires optimization techniques such as PSO.

The proposed approach can provide an important element for future planning and optimization of the production operations of gas fields.

The proposed approach will help the field operators in terms of:

1. Reduced implementation complexity
2. Reduced time
3. Improved accuracy
4. Simpler maintenance

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