S1–07

New Mathematical Method for Solving Cuttings Transport Problem in Horizontal Wells by Using GA and ACA

Choe Kum Hyok *, *Ryu Kum Song*

Faculty of Resources Exploration, Kim Chaek University of Technology, Pyongyang, DPRK

*Corresponding author: Email: cgh881224@star–co. net. kp

Cuttings transport has been one of the difficulties in drilling horizontal and inclined wells, and the models in cuttings transport research are usually formulated with highly nonlinear equations set. Many researchers developed various models to investigate this problem, among which the two–layer model is one of the analytical research models and is formulated with highly nonlinear equations set. Nevertheless, solving the complicated highly nonlinear model to get a reasonable and stable solution has been a challenge to researchers for a long time. Usually, the Newton methods are widely used in solving nonlinear equations set. However, the solution obtained by the Newton methods highly depends on the initial values, and finding proper initial values for nonlinear equations set is not an easy job. Meanwhile, since the gradient or the Jacobian matrix has to be calculated and updated in the iteration, singularity problem of Jacobian matrix often occurs in the computation, and this problem will probably make the iteration prematurely terminated. Obviously, the dependence of result on initial values, Jacobian matrix singularity, and variable outflow of its definition domain in iterations are three of the often encountered difficulties when using Newton methods to solve real engineering problems.

In this paper, the ant colony algorithm combined with genetic algorithm is applied to solve the two–layer cuttings transport model with highly nonlinear equations set. Analyzing the results of the example, it can be concluded that ant colony algorithm can be used to solve the highly nonlinear cuttings transport model with good solution accuracy; transforming the solution–searching process of solving nonlinear equations set into an optimization process of searching the minimum value of the objective function is necessary; the real engineering problem should be simplified as much as possible to decrease the number of unknown variables and facilitate the use of genetic ant colony algorithm.

Objective function

$$\min F = \left|A_S v_S - Q\right| + \left|C_S - \frac{C_b}{A_S}\int_{A_S} \exp\left[\frac{v_{hin}\sin\alpha}{\varepsilon_p}(y - h_b)\right]\right\|_S$$

Fitness value: 2–F

Variables: h_b, v_S

Variables: $h_b \in (0,\ D), v_S > 0$

Solution–Searching Procedure

ⅰ) Set the numbers of ants and iteration generations

ⅱ) Set the scopes of optimization parameters

ⅲ) Conduct the optimization and obtain the optimum cuttings bed height and suspension layer velocity.

When the 550 generations pass, all the ants stay at around (1.330 3m/s, 0.007 0m), where the fitness value is the highest (i.e., 1.999 9). The highest fitness value means that objective function value reaches the lowest, very close to zero (i.e., 0.000 063), which mathematically corresponds to the solution of the nonlinear equations set. Therefore, the value (1.330 3m/s, 0.007 0m) can be taken as the solution of nonlinear equation in two–layer.

So, the genetic ant colony algorithm can be used to solve cuttings transport model with highly nonlinear equations set, and the solutions solved by genetic ant colony algorithm and Discrete Newton method show good agreement with each other.