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A Mathematical Prediction Based on SAW Model

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Abstract: Artificial Lift is defined as any system that adds energy to the fluid column in a wellbore with the objective of initiating and enhancing production from the well. Artificial Lift is needed when reservoir drives do not sustain acceptable rates or cause fluids to flow at all in some cases. Artificial Lift Systems use a range of operating principles, including Pumping and Gas lifting. Simple Additive Weighting (SAW) model (method) is one of the most prevalent Multi Criteria Decision Making (MCDM) methods. MCDM is an approach employed to solve problems involving selection from among a finite number of criteria. An MCDM method specifies how attribute information is to be processed in order to arrive at a choice. The most studies in this field have been based on only them has been based on the scientific MCDM methods, itself implying one of the Artificial Lift Selection previous procedures major imperfections. In this paper, a novel expert computer method (by means of Visual Basic.net Code) based on SAW model has been presented for Artificial Lift Selection in oil industry validated with several certain oil fields such as the Iranian Kuh-E-Mond (MD-6) oil field data (that Progressive Cavity Pump (PCP) has been resulted as the best Artificial Lift System). experiential calculations by now despite the significant importance of this matter. As well, none of.

Key words: Artificial lift・Simple Additive Weighting・Multi Criteria Decision Making-SAW

INTRODUCTION

Any system adding energy to the fluid column in a wellbore to initiate or enhance production from the well is called as Artificial Lift. When a reservoir lacks sufficient energy for oil, gas and water to flow from wells at desired rates, supplemental production methods can help. Lift processes transfer energy down hole or decrease fluid density in wellbore to reduce the hydrostatic load on formation. Major types of Artificial Lift are Gas Lift (GL) design (Continuous Gas Lift, Intermittent Gas Lift) and Pumping (Electrical Submersible Pump (ESP), Progressive Cavity Pump (PCP), Sucker Rod Pump (SRP), Hydraulic jet type Pump (HP)).

As the well is produced, the potential energy is converted to kinetic energy associated with the fluid movement. This dissipates the potential energy of the reservoir, thereby causing the flow rate to decrease and the flow to eventually cease. It may be economical at any point in the life of a well to maintain or even to increase the production rate by the use of Artificial Lift to offset the dissipation of reservoir energy.

MCDM refers to making decisions in the presence of multiple, usually conflicting criteria. The problems of MCDM can be broadly classified into two categories: Multiple Attribute Decision Making (MADM) and Multiple Objective Decision Making (MODM), depending on whether the problem is a selection problem or a design problem. MODM methods have decision variable values that are determined in a continuous or integer domain, with either an infinitive or a large number of choices, the best of which should satisfy the decision maker's constraints and preference priorities. MADM methods, on the other hand, are generally discrete, with a limited number of predetermined alternatives.

By now, the usage of each of the Artificial Lift methods throughout of the world has been in a manner that for GL, ESP, SRP, PCP, HP as different Artificial Lift methods has been equal to 50%, 30%, 17%, >2% and <2% respectively.

The most studies in this field have been on the basis of only experiential calculations by now and not based on the scientific MCDM methods, despite its great importance which implies one of the Artificial Lift Selection previous procedures major imperfections.

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However, about the previous Artificial Lift selection procedures, it can be said that some researchers have studied on this matter briefly expressed as the following:

In Neely (1981) [1] considered the geographical and environmental circumstances as the dominant factors for Artificial Lift Selection.

In Valentine (1988) [2] used Optimal Pumping Unit Search (OPUS), a smart integrated system possessing the characteristics of Artificial Lift methods, for Artificial Lift Selection.

In Bucaram and Clegg (1993) [3] studied on some of the operational and designing factors based on Artificial Lift methods overall capability comparison and design.

In Espin (1994) [4] used SEDLA, a computer program possessing the characteristics of Artificial Lift methods, for Artificial Lift Selection. In Heinze (1995) [5] used "the Decision Tree" for Artificial Lift Selection, mostly based on a longtime economic analysis.

The paper objective is to specify SAW model as a predicted method for Artificial Lift Selection for different circumstances of oil fields.

MATERIALS AND METHODS

The usage of Artificial Lift methods throughout of the world by now has been recently reported (Figure 1), (Weatherford Com.).

It is necessary to mention that Sucker Rod Pump (SRP) is a positive displacement pump that compresses liquid by the motion of a piston. The piston is actuated by a string of sucker rods extending from the bottomhole pump to the pumping unit at the surface. The rod or structure may limit rate at depth [6].

A Progressive Cavity Pump (PCP) is a kind of pump which transfers fluid by means of a sequence of small, fixed shape, discrete cavities, that move through the pump as its rotor turns. The cavities taper down toward their ends and overlap with their neighbors, so that, in general, no flow pulsing is caused by the arrival of cavities at the outlet [6].

An Electrical Submersible Pump (ESP) is a dynamic displacement, multistage centrifugal turbine pump coupled by a short shaft to a downhole electrical motor. The motor is supplied with electrical power by a cable extending to the surface [6].

ESP systems have a wide range of applications and offer an efficient and economical lift method. Even if sand production, high Gas Oil Ratio (GOR) and viscosity are concerned, the right ESP for wells can be found to improve production. From onshore high water cut applications to complex offshore, deepwater, or subsea applications, there is a system to meet the important needs [6].

A Hydraulic jet type Pump (HP) is an ejector type dynamic displacement pump operated by a stream of high pressure power fluid converging into a jet in the nozzle of the pump. Downstream from the nozzle, the high velocity, low pressure jet is mixed with the well’s fluid. The stream of the mixture is then expanded in a diffuser and as the flow velocity is dropped, the pressure is built up. The fluid flow can carry some corrosive additives into wellbore and function as a maintenance material. The constraints to use HP are related to high GOR or contamination in the fluid flow bringing about low efficiency of pump at last [6].

As well, about Gas Lift (GL), gas is injected into the tubing string to lighten the fluid column and allow the well to flow when it does not flow naturally. The injected gas is mixed with the produced fluid, decreases the flowing gradient in the production string and thus lowers the bottomhole flowing pressure. The basic objective of gas lift design is to equip wells in such a manner as to compress a minimum amount of gas to produce a maximum amount of oil [6].

Previous Artificial Lift Selection Procedures:

- In Neely (1981) [1] designated some Artificial Lift methods such as: SRP, ESP, HP, GL and studied about the application circumstances, advantages,

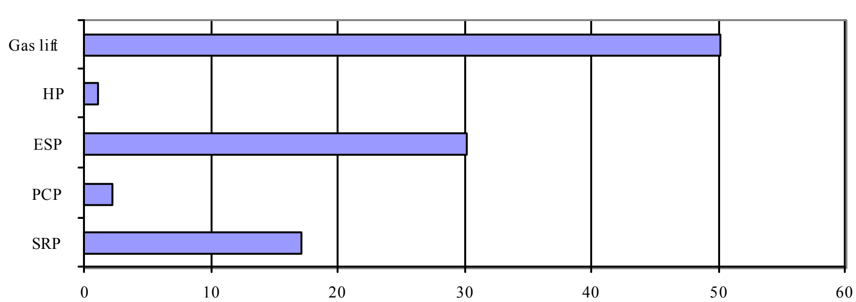

Fig. 1: The usage of Artificial Lift methods throughout of the world,

disadvantages and constraints of each method. The geographical and environmental circumstances as the dominant factors for Artificial Lift Selection and also some other subordinate factors such as: reservoir pressure, productivity index, reservoir fluid properties and inflow performance relationship were considered by him (Neely, B., *et al*., 1981).

- In Valentine (1988) [2] used Optimal Pumping Unit Search (OPUS) for Artificial Lift Selection. Indeed OPUS was a smart integrated system possessing the characteristics of Artificial Lift methods. OPUS had the capability to control the technical and financial aspects of Artificial Lift methods. It can be said that the production system was consisted of the downhole pump up to the surface facilities (stock tank). The technical and financial evaluation of this procedure was done by means of some specific computer algorithms. Therefore, knowing the primary required investment value, costs (maintenance, equipment) and technical ability of each Artificial Lift method, Artificial Lift Selection was done (Valentine, E.P., *et al*., 1988).
- Also in Clegg (1988) [7] mentioned some economic factors such as: revenue, operational and investment costs as the basis for Artificial Lift Selection. He believed that the selected Artificial Lift method could have the best production rate with the least value of operational costs [7].
- In Bucaram and Clegg (1993) [2] studied on some of the operational and designing characteristics of Artificial Lift methods categorized into 3 types. They were based on Artificial Lift methods overall capability comparison and design, some specific operational factors and Artificial Lift methods factors probably causing some specific problems respectively [2].
- In Espin (1994) [3] used SEDLA for Artificial Lift Selection. Indeed SEDLA was a computer program possessing the characteristics of Artificial Lift methods. It was composed of 3 modules based on an information bank of human activities, the theoretical knowledge of Artificial Lift methods and the economic evaluation of Artificial Lift methods respectively. Therefore, the Artificial Lift Selection was done on the basis of profit value [3].
- In Heinze (1995) [5] used "the Decision Tree" for Artificial Lift Selection. The most major factor in it was based on a longtime economic analysis. Also, the Artificial Lift methods evaluation was based on operational costs, primary investment, lifetime cost and energy efficiency. Ultimately, considering these factors besides the decision maker, the Artificial Lift Selection was done [5].

Some other certain scientific programs based on MCDM models (methods) are listed as below, but because SAW model has been validated with several certain oil fields Artificial Lift Selection operational results (such as the Iranian Kuh-E-Mond (MD-6) oil field data (that Progressive Cavity Pump (PCP) has been resulted as the best Artificial Lift System), SPE Paper#99912 (2006) [8], a considerable accordance between the designed SAW model program final results and the fields operational results has been found, So in this paper, SAW model has been chosen for Artificial Lift Selection.

- Simple Additive Weighting (SAW) model
- Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) model
- ELimination Et Choix Traduisant la REalité (ELECTRE) model
- Weighted Product Model (WPM)
- VIšekriterijumsko KOmpromisno Rangiranje (VIKOR), Compromise Ranking model

DISCUSSION

It was essential to mention to the mathematical and logical strategy of the novel expert computer method (by means of Visual Basic.net Code) based on SAW model.

Simple Additive Weighting (SAW) Method: This model is also called as Weighted Sum Method and is the simplest and still the widest used MADM method [9], [10].

The main procedure of SAW model for the selection of the best alternative from among those available has been described as below:

At first, it was required to allocate suitable quantities (a_{ij}) scaled from 0 through 10 for the alternative relative to the criteria qualities, (higher each of their qualities, more its value out of 10), the number of the alternatives and the number of the criteria have been considered as the number of matrix rows (i) and matrix columns (j) in the alternatives relative to the criteria quantities matrix (decision matrix) respectively [11]. The relative scores of different methods relative to Production, Reservoir and Well constraints as well as Produced fluid properties and Surface infrastructure constraints (all the criteria) have been based on Schlumberger Company certain practical reports (Figure 2), (Schlumberger Com.).
(Recently reported by Weatherford Com.)

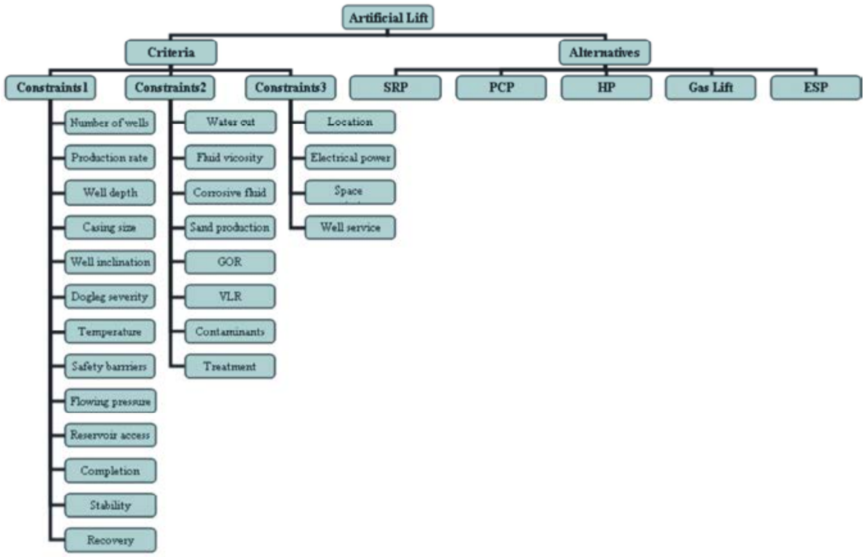

Fig. 2: The Alternatives versus the Criteria for Artificial Lift Selection, (Schlumberger Com.)

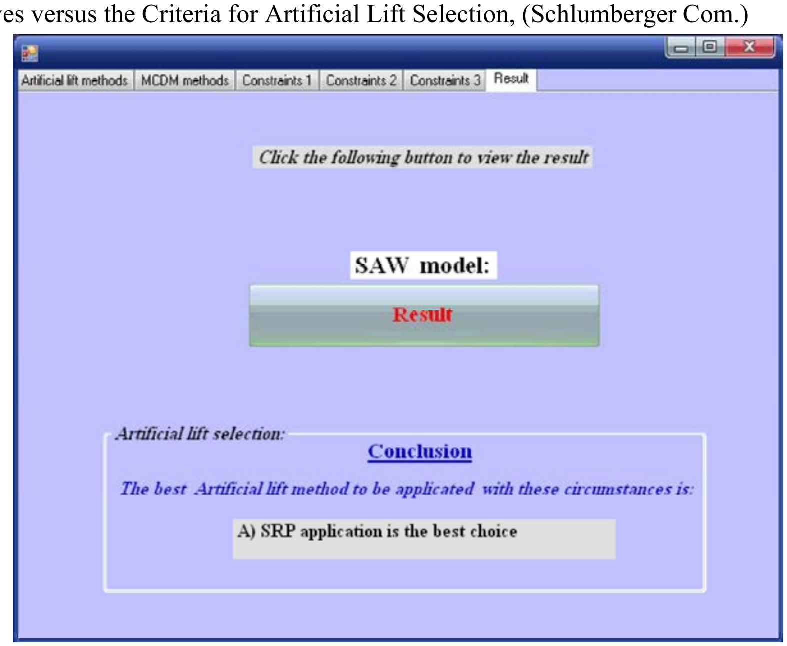

Fig. 3: Artificial Lift Selection result by the designed computer program, (According to Figure 6)

The value of 1 (good to excellent) has been considered as 7 out of 10, the value of 2 (fair to good) has been considered as 5 out of 10 and the value of 3 (not recommended and poor) has been considered as 3 out of 10 in the following.

Then, the linearly normalizing of the resulted alternatives relative to the criteria quantities matrix had to be done by equations (1), if the criteria had positive aspects, or (2), if the criteria had negative aspects [11]:

$$n_{ij} = a_{ij} / Max(a_{ij}) \tag{1}$$

$$n_{ij} = 1 - a_{ij} / Max(a_{ij}) \tag{2}$$

Meanwhile, if the criteria both with positive and negative aspects were available, it was required to convert the negative ones to positive by reversing the negative ones.

Then, the criteria quantities had to be weighted by means of the Entropy method, by equations (3) through (6), (Figure 4), [11].

$$P_{ij} = a_{ij} / \sum_{i=1}^{m} a_{ij} \tag{3}$$

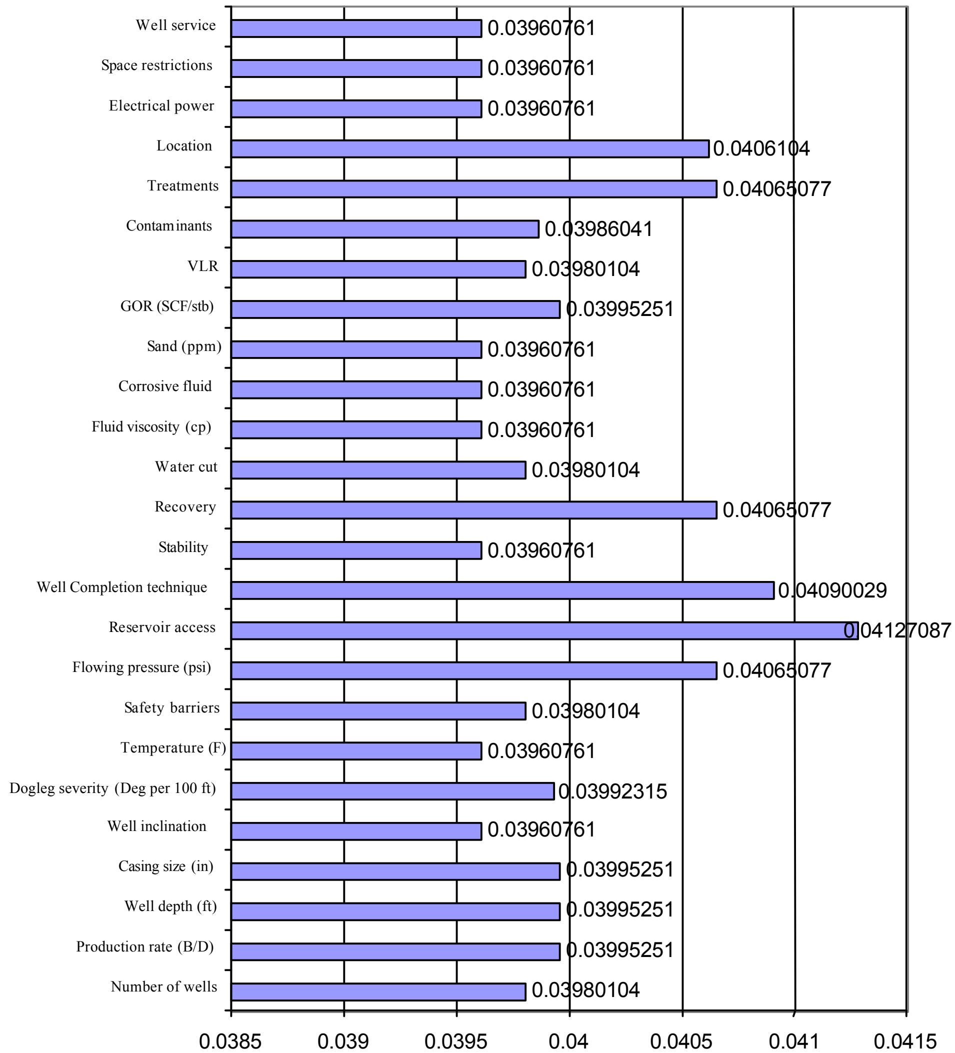

Fig. 4: The resulted weights of the alternatives relative to the criteria all quantities, (According to Figure 6)

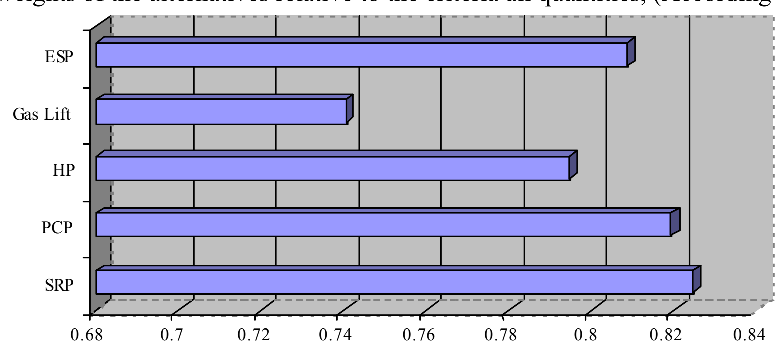

Fig. 5: Artificial Lift Selection result, (According to Figure 6)

$$d_j = 1 - E_j \quad (4)$$

$$E_j = -k\sum_{i=1}^{m}[p_{ij} Lnp_{ij}] \quad (5)$$

$$W_j = d_j / \sum_{j=1}^{n} d_j \quad (6)$$

At last, multiplying the normalized matrix by the resulted criteria weights matrix and sorting the final resulted values, the highest value in the final resulted matrix has showed the best alternative for selection (Figure 5), [11].

Condition	Example oil field input data (the designed program default input data)
Number of wells	Single
Production rate	56000 STB
Well depth	2000 ft
Casing size	7"
Well inclination	All of cases
Dogleg severity	0-10 per feet
Temperature	180-210 F
Safety barriers	1
Flowing pressure	Less than 100 psi
Reservoir access	Required
Completion	Dual
Stability	Stable
Recovery	Secondary waterflood
Water cut	50%
Fluid viscosity	Less than 100 cp
Corrosive fluid	No
Sand and abrasives	Less than 10 ppm
GOR	650
VLR	Less than 0.1
Contaminants	Asphaltene
Treatment	Solvent
Location	Offshore
Electrical power	Utility
Space restriction	Yes
Well service	Workover rig

Fig. 6: Example oil field input data chart (The designed program default input data)

On the whole, it has been believed that the related calculations results and the related figures shown as (Figure 3) through (Figure 5) vary in different circumstances of oil fields. But here, as an example oil field input data (The designed program default input data) (Figure 6), (Figure 3) through (Figure 5) results have been shown.

CONCLUSIONS

- In this paper, a novel expert computer method (by means of Visual Basic.net Code) based on SAW model has been presented for Artificial Lift Selection in oil industry.
- The designed SAW model computer program has been validated with several certain oil fields data (such as the Iranian Kuh-E-Mond (MD-6) oil field data (that Progressive Cavity Pump (PCP) has been resulted as the best Artificial Lift System), SPE Paper#99912 (2006) [10] and finally, a considerable accordance between the program final results and the fields operational results has been found.

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