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Fuzzy rule base model for oil wells efficiency estimation

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Abstract

In this paper a fuzzy expert system is used for determining amount of efficiency of the oil wells from energy consumption point of view. Knowledgebase is extracted from data by using Fuzzy C-means method based clustering. Knowledgebase is realized in environment Expert system shell ESPLAN. Experimental results have demonstrated efficiency of the proposed method and its advantages as compared to the existing classical methods.

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Keywords: Fuzzy expert system; fuzzy c-means clustering method; oil-water factor

1. Introduction

In oil exploration, one challenging problem is estimation of efficiency of oil wells determined by set of criteria such as amount of mining oil, amount of water and energy consumption. In practice of oil exploration, working oil wells may be into two groups. In the first group, there are oil wells for which effectiveness obtained from mining oil is higher than energy consumption. In the second group, effectiveness getting from exploration is significantly lower than energy consumption. There is no problem with oil wells in the first group. But it is necessary to have economic investigation of oil wells included into the second group. The problem requires decision or to stop exploration ofthese oil wells or to involve additional capital for increasing of effectiveness of such type oil wells. It is obvious that this problem solving requires mathematical model of relationship between factors and affected efficiency of oil wells. Here difficulties arise related to high level of uncertainty in estimation of these factors.

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In this paper we investigate if-then rule based on the model described relationship between amount of mining oil, water amount and energy consumption as independent variables, and overall efficiency of oil wells taking into account fuzzy uncertainty of oil exploration environment.

The paper is structured as follows. In Section II we give some preliminaries that will be used for modeling of oil wells efficiency. Section III includes statement of the problem, solving procedures and computer simulation. Section IV concludes.

2. Preliminaries

Aliev's Fuzzy Inference Method[1,2].

Advantages of the Aliev's method is given below:

1. It is intuitive.
2. It has widespread acceptance.
3. It is well suited to human input.
4. Modeling under second-order uncertainty using the possibility-probability measure
5. Computing with word

The basic steps of the method are given below:

1. The truth degree of the rule is computed as:

$$r_{jk} = Poss(v_k / a_{jk}) \cdot cf_k$$
$$\tau_j = \min(r_{jk})$$

2. First the objects are evaluated, i.e. every w_i object has appropriate linguistic value defined as (v_i, cf_i) . where v_i is linguistic value, $c_{f_k} \in]0,100]$ is confidence degree of the value v_i . v_k - linguistic value of the rule object, a_{jk} - current linguistic value (j is index of the rule, k is index of relation) value(for example , A_ir)

3. For each rule, calculate $R_j = (\min_j r_{jk}) * CF_j / 100$, where CF is the confidence degree of the rule.

4. The user or the creator of the rule defines the firing level (π), and $R_j \geq \pi$ is checked. If the condition holds true, then the consequent part of the rule is calculated.

5. The evaluated w_i objects have S_i value: $w_i, (v_i^1, cf_i^1), \ldots., \ldots, (v_i^{S_i}, cf_i^{S_i})$ S_i is the number of the rules in fuzzy inference process

6. The average value is determined as follows:

$$\overline{v}_i = \frac{\sum_{n=1}^{S_i} v_i^n \cdot cf_i^n}{\sum_{n=1}^{S_i} cf_i^n}$$

Algorithm is realized by ESPLAN expert system shell.

The shell of ESPLAN ensures :

- - creation of expert systems for various applications;
- - building module-oriented structures and segmentation of knowledge bases;
- - representation of fuzzy values;
- - compositional inference with possibility measures;
- - arithmetic operations with fuzzy numbers;
- - realization of simple question-ask dialogue by using special functions;
- - set of confidence degree for any rule (in per cent);
- - call of external programs;