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Automation of oil production

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ABSTRACT

At present, oil production and refining are the main source of energy. However, due to environmental issues related to the use of oil, the hunt is on the alternative sources of energy. To become more competitive on the market of the so-called renewable energy sources, a theoretical analysis of oil recovery using centrifugal pumps is strongly required to reveal the hidden reserves. Such an analysis could provide insights on the ways of improving the economic performance of this oil production method. Besides, this analysis can be carried out by application of the laws of thermodynamics during pumping of multi-phase mixtures with centrifugal pumps. It's worth mentioning that such an approach has never been adopted by anyone.

Keywords: Oil Field, Electric Centrifugal Pumps, Pump Thermodynamics, Thermal Mode

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INTRODUCTION

The solution of the thermodynamics problem of pumping multi-phase mixtures with centrifugal pumps, led to discovery of a series of formerly unknown phenomena, taking place during oil well operation. It was found that salt deposition in a centrifugal pump was a result of a thermal behavior, previously not taken into account. The ways of oil recovery cost reduction have been determined. It was revealed that application of acids and other chemical

mixtures to stop salt deposition had basically no effect. Finally, it was found out that only by solving the problem of the centrifugal pump thermal behavior during pumping of multi-phase mixtures, the oil production process control could be automated and a smart oil field could be obtained. Transition from an automatic installation to an automated oil field is the only right path forward to reduce the cost of oil production.

1. The current status of production and national economy development is largely driven by extraction and processing of natural resources, oil and gas being the key ones. As a result of the use of oil, gas and other minerals, the waste in the form of carbon dioxide, methane and some other chemical mixtures is produced, adversely affecting our noosphere - the habitat of all living beings, including us, humans. The negative impact of oil production makes people think about a gradual transition from oil to other energy sources. However, in the foreseeable future, oil will remain the primary source of energy and a raw material for chemical and machine-building industries.

2. Therefore, further improvement of economic and ecological parameters of oil production is required. Here with, there are three interrelated approaches: in the first place, it is the improvement of economic and technical parameters of oil production equipment, represented by electric centrifugal pumps. The second approach deals with reduction and, at the best, elimination of the use of chemical reagents during centrifugal pump's operation. The third trend is the geological improvement of oil well energy characteristics per se and better handling of oil beds.

3. The study of the methods of improving the economic parameters of centrifugal pumps are under way: they are focused on the increase of the equipment efficiency factor. Unfortunately, despite numerous attempts, no significant results have been gained so far. The second approach has also given no breakthrough. Such situations always occur, when a theoretical tenor of an oil production method plays out, as in our case, due to the lack of theoretical studies and analyses of centrifugal pump operation during pumping of multi-phase mixtures. Oil recovery using centrifugal pumps, is based on empirical formulas, i.e. not on a profound feasibility study. Thus, there is an urgent demand for a scientific approach to centrifugal pump operation on the basis of the general laws of thermodynamics and thermophysics, since the mechanic energy delivered to the pump is converted into heat. The solution of the approximating problem of the centrifugal pump thermodynamics is described in the works.[1-12] Let us get down to discussion of the obtained results.

4. Application of the laws of thermodynamics[1-5] during pumping of gas-cut mixtures, triggers the assessment of the operating modes of a centrifugal pump. For the first time it was revealed that the centrifugal pump is characterized by a thermal behavior,[6] which strongly influences the duration of a faultless operation of the pump. The heating temperature may reach hundreds of centigrades. The pump gets hot due to substantial drop of its efficiency, which may lead to the "heat shock",[3] casting light on a sudden death of the equipment in some cases.

5. The real cause of salt deposition[9-12] in centrifugal pump diffusers was revealed. It was proved that oil-production enterprises try to control salt deposition in the wrong way, namely by the use of chemicals and acids. Whereas salt deposition must be controlled by selection and application of process flow patterns[12] or centrifugal pump's operating modes - from continuous to periodic. The use of acids to control salt deposition is ineffective and leads to the loss of tightness of a production string and to contamination of oil beds with chemical reagents.

6. Practical implementation of the results, obtained due to the application of the laws of thermodynamics in the centrifugal pump operation, will provide for:

a) Increase of the service life of centrifugal pumps;

b) Decrease of the number of the pumps used over the well operation period;

c) Reduction of well work overs;

d) Reduction of oil production losses thanks to lesser downtime before work over;

e) Non-use of chemical mixtures to control salt deposition;

f) Elimination of production string damages;

g) Protection of subsurface resources from contamination with chemical reagents.

7. It was proved that by applying the laws of thermodynamics to centrifugal pump operation,[13] a robotic system for oil well operation control can be created.

8. Development of the automatic control system will allow for a transition from an automatic pumping installation to an automated oil field.

9. Application of IT-solutions and implementation of automatic centrifugal pumping units allow for an easy way of running the whole oil field in the automatic mode. Herewith, it is possible to set up different automatic modes not only for one well, but also for the whole filed: starting from the energy-saving mode[13] and ending up with the maximum oil recovery mode, etc.

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