As a manuscript

Alexander E. Tretyakov

A METHOD OF DECREASING THE LOAD ON ELECTRICAL CIRCUITS IN OILFIELDS

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Research supervisor:
Candidate of Sciences (Engineering),
Associate Professor at the Department
of Chemistry and Technology of Natural
Energy Carries and Carbon Materials Marianna-K. Shaikhutdinova

Reviewer:
Head of the Sector of
Efficiency and Energy Saving
OOO «RN-Vankor» Eldar-R. Galimov

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Master Programme Leader:
Candidate of Sciences (Chemistry),
Associate Professor at the Department of
Chemistry and Technology of Natural
Energy Carries and Carbon Materials Fedor A. Buryukin

INTRODUCTION

The current vision of energy production and oil price trends push oil companies to actively seek for more innovative ways to reduce operating costs and to extend the life of their ageing fields. Nowadays, oilfields are provided with energy from different sources such as diesel generators, gas turbine stations, cogeneration units etc. However, oilfields are characterized by a large amount of produced water stored in reservoirs that must be treated and reinjected in the underground reservoirs. Using these water to produce electrical energy is an interesting option.

Humans have used the power of water for thousands of years. Hydropower the energy generated by damming a river and using turbine systems to generate electrical power. Hydroelectric power is currently the least expensive source of electrical power and is much cleaner than the power generated using fossil fuels. Flowing and falling water has potential energy. Hydropower comes from converting the energy in flowing water by means of the water wheel or through the turbine into mechanical power. This power is converted into electricity using the electric generator. Potential energy of water may be used directly in an oilfield because there are many sources of produced water streams at tank farms.

The Government of Russian Federation approved the "Energy Strategy of Russian Federation” for the period until 2030. In this document energy efficiency and energy saving trends prevail. They are recognized as one of the main directions of the country's economic development and the most important strategic principles. These trends are especially relevant in the regions of Eastern Siberia and the Far East, where large deposits will be developed under severe natural conditions. That will require new approaches to energy and heat supply systems on using the maximum amount of local energy sources including the sources of renewable energy.

One of the most promising areas in alternative energy production is using the energy of technological processes of the produced water with the help of micro-hydroelectric power stations (micro-HPP). Due to considerable energy potential of such water streams and comparatively simple technology, on the one hand, and, the requirements of the technological process on the other hand, such systems could be implemented in oilfields.

This paper focuses on application of micro-HPPs in produced water streams in oilfields and has the following objectives:

1) To examine traditional and alternative energy supply sources in oilfields
2) To identify the best micro-HPP installation locations
3) To calculatethe optimal pipeline diameter and determine water flow and net head losses.
4) To select the hydroturbine type to meet the requirements of calculated parameters.
5) To make hydraulic calculation of the pipeline and hydroturbine.
6) To vindicate the installation cost and energy effectiveness of a micro-HPP

Traditional and alternative energy supply sources in oilfields

In oilfields natural gas is often burnt off as a fuel and electricity generation source. Nowadays, there are several types of engines where gas can be used:

- The turboshaft engine

  Conceptually, turboshaft engines are very similar to turbojets, with additional turbine expansion to extract heat energy from the exhaust and convert it into output shaft power.
- The reciprocating engine

  It is typically a heat engine that uses one or more reciprocating pistons to convert pressure into rotating motion.
- The diesel generator

  It is a combination of a diesel engine with an electric generator to generate electric energy.

Apart from those sources, combined heat and power energy (cogeneration) is used in some of the earliest oilfields due to the high cost of early purchased power. Moreover, cogeneration is a more thermally efficient use of fuel than electricity generation alone. In conventional production of electricity some energy must be rejected as waste heat, but in cogeneration this thermal energy is put to good use.

As an alternative, fuel cells could be applied. The fuel cell is a device that converts chemical energy from ~~a~~ fuel into electricity through the chemical reaction of positively charged hydrogen ions with oxygen or another oxidizing agent. Fuel cells can produce electricity continuously as long as these inputs are supplied. However, the use of fuel cells is very new, and quite a bit of advancement and research is still needed before it can be used on a wide scale. Its applicability is not even fully known yet.

In view of the fact that there is still a great disparity between urban and isolated rural zones, with a consequent imbalance in the accessibility of energy micro-HPPs provide an alternative solution to electric grid extension that could serve to power widely scattered and remote communities in the nearest future, as a high efficiency power supplement in urban areas, small industries and for domestic purposes.

Micro-HPPs in oilfields

In the process of oil treatment, when produced water is separated, the pressure drops due to the stop valves. Subsequently, this water flows into the process tanks or injection sites. The essence of the suggested technology is using the micro-HPP, which is installed in the flow of produced water (first separation stage) and produces electricity alongside with simultaneous technological pressure drop. Figure 1 shows the scheme of oil preparation at the oilfield, as well as the place where it is possible to install a micro- HPP.

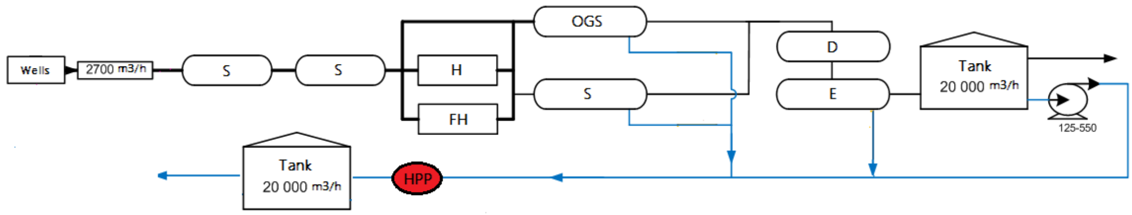

Figure 1– The scheme of oil preparation at the oilfield, where:
S – separator; H – heater; FH –fired heater; OGS– oil and gas separator; D – degasser;
E – electric coagulator; HPP – micro-hydroelectric power station.

Power generation depends upon a combination of the net head and flow. Both must be available to produce electricity. Water is diverted from the stream into the pipeline, where it is directed downhill and then through the turbine. The vertical drop (net head) creates pressure at the bottom end of the pipeline. The pressurized water emerging from the end of the pipe creates a force that drives the turbine. The turbine, in its turn, drives the generator where electrical power is produced. More flow or more net head produces more electricity. The electrical power output will always be slightly less than the water power input due to the turbine's and the rest of the system's inefficiencies. The water pressure or net head is created by the difference in the elevation between the water intake and the turbine. Net head can be expressed as the vertical distance (feet or meters), or as pressure, such as kilograms per square meter. Pipeline diameter also has an effect on net head. Flow is a quantity of water available, and is expressed as 'volume per unit of time', for example cubic meters per second, or liters per minute. The theoretical power (N) available from a given net head of water is proportional to the net head and the quantity of water available.

Hydroturbine types. Hydraulic calculation of the pipeline and hydroturbine.

There are several types of hydro turbines:

– Pelton
– Cross-Flow
– Bulb

– Straflo

– Tube

– Kaplan

– Francis

– Kinetic

Kaplan turbines are widely used throughout the world for electrical power production. They cover the lowest head hydro sites and are especially suited for high flow conditions. That is why according to the present, feasibility study the Kaplan turbine type was chosen to conduct further calculations.

To determine the exact model of Kaplan, turbine hydraulic calculations of pipeline and turbine were conducted are presented in Table 1.

Table 1 – Calculated results

Calculated results	
Discharge ($Q_{max\ hour}$)	$662{,}380\ m^3/h$
Pipeline diameter(D_n)	$530\ mm$
Velocity of produced water stream (ϑ_n)	$0{,}932\ m/sec$
Head losses (H_l)	$9{,}807\ m$
Stream-power (N)	$14{,}3\ kW$

According to Table 1 two turbine models were chosen for further vindication of the cost and energy-effectiveness of a micro-HPP.

Cost and energy-effectiveness of a micro-HPP

The final decision on whether a micro-HPP should be installed or not, or on the choice among alternative design solutions is generally based on the comparison of the expected costs and benefits, which determine a useful life of the project, using economic analysis criteria. This analysis was performed to show the advantages from the economic point of view.

It should be pointed out that effectiveness of an economic analysis as a decision-making tool of a small hydro investor depends on the accuracy of the project cost and benefits estimates. These estimates are difficult to make, especially at the early stages of design when some of the scheme characteristics are only preliminarily defined. The results of the present economic analysis are presented in Table 2.

Table 2– Results of economic analysis

Calculated results Micro-HPP (INSET)		Calculated results Micro-HPP (WESWEN)	
Price of micro-HPP	205 000 rub	Price of micro-HPP	220 000 rub
Annual costs per 1 kW	23 769 rub	Annual costs per 1 kW	25 030 rub
Construction and installation expenses	6000 rub	Construction and installation expenses	6000 rub
Total amount of energy produced by micro-HPP per year	136100kW	Total amount of energy produced by micro-HPP per year	136100kW
Cost price of energy	2,6 rub per kW hour		2,9 rub per kW hour
Recoupment of ~~the~~ project	1,9 year	—	

According to Table 2, Micro-HPP (INSET) is more cost and energy-effective. That is why this model was chosen to be recommended for installation.

Conclusion

This paper confirms that micro-HPPs can be used in produced water streams in oilfields for energy production. To prove that the following steps were made:

– Traditional and alternative energy supply sources at oilfield were examined.

– The exact place where micro-HPP could be installed was identified.

- Calculation of the pipeline’s diameter was conducted and water flow and net head losses were determined.
- A hydroturbine type was selected.
- Hydraulic calculations of the pipeline and hydroturbine were conducted.
- The cost of Micro-HPP and its energy-effectiveness was vindicated.

The analysis performed shows that such micro-HPP in-pipe systems can offer many advantages in terms of quantity of energy produced and supply continuity without facing problems of architectural integration and dependence on weather conditions.