Efficiency increase of the technologic electric plant on oil-pumping stations of the main oil pipe line

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Abstract. Promising method of operation efficiency increase of the oil pumping stations along with their energy supply from their own gas turbine energy plant is considered. This methods allows to increase durability of the oil pumping system and allow to effectively control operation regimes of the oil pumps by means of frequency regulation of the electric motors. Utilization of the associated petroleum gas (APG) as a fuel in gas turbine energy plants allows decrease of the exploitation costs. Influence of the APG composition on power and economic efficiency of the gas turbine energy plants was analysed.

1. Introduction
Efficiency of the gas turbine energy plant utilization in their own electric plants in industrial companies is determined by decrease of the electricity cost provided by centralized electric network. Companies participating in technological process of hydrocarbons (oil, natural and associated petroleum gas) piping are related to a first category of the electric supply.

Oil pumps of the oil pumping stations (OPS) of the main pipelines are driven by electric motors with power capacity up to 6 MW. Total electric power capacity of large OPS can reach 30-35 MW. Consumed electric power is usually equal to 25-30 MW. Today, there is a necessity to explore new oil deposits in the areas of Far North, North-West Siberia, European North and shields of Pacific and Arctic oceans. Electric energy losses during its transport by long power lines are especially high for energy supply in these regions and often surpass 12–14%. Durability of the oil transport system is decreased during emergency shutdown of the pipelines. It is discovered that 90% of all faults during OPS operation are caused by external energy supply.

Creation of own electric plants allows to provide durable and economic energy supply of company needs in the field of hydrocarbons transport without or with significant decrease of the electricity consumption from external electric networks. Generated electricity is also technological product and do not belong to taxing which cause further increase of economic efficiency.

2. Associated petroleum gas utilization proposal
Russian engine corporations are capable to manufacture gas turbine energy plants which utilize converted aviation gas turbine engines as drive for electricity generators. Application of the own technological electric plants with gas-turbine engines on OPS and utilization of the cheap APG will promote decrease of the exploitation costs of the hydrocarbons transport. Dependency on electricity supply from external network will be neutralized and electricity costs will be decreased.
Oil pumping costs are constantly increasing due to increase of the electricity cost. Plc ‘GRASIS” developed a technology of the APG cleaning on modular membrane hydrocarbon plants. Prepared APG is compressed on modular compression stations (MCS) and transported to consumer by special gas pipe lines and can be used as a fuel for gas turbine plants. Utilization of the converted aircraft engines with COP reaching 34–36% [1] is appropriate in energy plants. Heat of the exhaust gases of the engine can be used for oil heating which allows to decrease power consumed by oil pumps up to 20%. Composition of APG must be considered during analysis of gas-turbine efficiency on OPS. As an example, composition of the APG produced on different deposits of Plc “Samaraneftegaz” company.

Table 1. APG composition.

| Deposit            | CH4 | C2H6 | C3H8 | C4H10 | C5H12 higher | CO2 | N2 | O2 | H2 | S | H |
|--------------------|-----|------|------|-------|--------------|-----|----|----|----|---|---|
| Utevskaya          | 33.38 | 17.01 | 16.01 | 6.63 | 2.49 | 0 | 24.48 | 0 | 0 | 0 |
| Evgenievskaya      | 33.78 | 18.68 | 19.33 | 7.86 | 2.78 | 2.47 | 14.19 | 0 | 0.91 | 0 |
| Barinovskaya       | 29.16 | 16.09 | 16.06 | 6.79 | 4.51 | 1.83 | 22.87 | 0 | 2.69 | 0 |
| Parfenovskaya      | 22.27 | 10.50 | 15.42 | 7.29 | 3.72 | 2.54 | 34.63 | 0 | 3.62 | 0.01 |
| Kudinovskaya       | 47.08 | 21.79 | 14.23 | 4.57 | 2.05 | 1.06 | 9.18 | 0 | 0.04 | 0 |
| Natural gas, Yamburg | 98.20 | 0.66  | 0.22  | 0.08 | 0.03 | 0 | 0.78 | 0.02 | 0 | 0 |

Plc “Samaraneftegaz” plans to create united system of APG with its purification and refinement in technological gas which can be used as raw material or fuel on chemical factories. APG differs from natural gas which mainly consists of methane. Applied analysis [2] of APG utilization as a fuel showed that in all range of the values of the gas temperature before turbine, change of the air ratio does not surpass 1.5% for different compositions of APG. Largest deviation in comparison with natural gas is equal to 4%. Thermodynamic calculations allow to estimate influence of the APG composition on change of the gas turbine engine (GTE) characteristics.

APG composition is mostly influence specific fuel rate of the GTE. For different types of the APG, change of the fuel rate on operation regimes of GTE can achieve 40%. Main influence is caused by the calorific value change of the fuel. It is shown, that application of converted GTE operation on APG is appropriate for their utilization within own technological gas turbine electric plant of OPS.

3. Method for OPS oil pump control

New method of OPS oil pumps control with application of the electric motor frequency control was suggested in [3].
Let’s consider set up of the technological gas turbine energy plant for OPS. Main pipe line pumps driven by electricity are suggested to split on 2 groups. Gas turbine energy plant of the first group generate electricity for electric motors of first group and energy plant, and energy plant of the second group provides electricity for electric motors of the second group of oil pumps at constant current frequency as well as generates electricity for OPS own needs.

Principal scheme of the technological gas turbine energy plant for OPS is presented on figure 1 and includes: module of APG preparation 1, first group with energy plant 2, electric generators 3, main line pumps of the first group 4, electric engines of the main line pumps of the first group 5, electric engines of the main line pumps of the first group 6, main line pumps of the second group 7, APG pipe line 8, second group with gas turbine energy plant 9, oil heater 10, electric engines switchers 11, main oil pipe line 12, electric switcher 13, external power line 14, systems of own needs 15. Prepared APG is charged in combustion chambers of the gas turbine energy plants as a fuel and heat of the exhausted gases is utilized for heating of the transported oil and heat supply of the OPS itself.

Electric generator of gas turbine unit of the first group is connected through electric switchers with electric engines of the first group of the main line pumps, and electric generator of gas turbine unit of the second group is connected through electric switchers with electric engines of the second group of the main line pumps as well as with systems of the OPS own needs and through electric switcher to external power line of high voltage. Exhaust duct of the gas turbine units is connected with atmosphere through heat exchangers suited for oil heating. Heat exchanger input is connected with charging side of the main pipe line and heat exchanger output is connected with charging side of the oil pumps. If oil flow rate in main pipe line is changed, fuel rate in the combustion chamber is changed in the gas turbine unit of the first group, thus, changing electric motor frequency of the oil pumps.

Electric engines of the second group of oil pumps are charged by electric energy with constant frequency. If oil flow rate in main pipe line is changed, gas turbine unit electric generator frequency is changed for the first group and frequency control of the electric engines for the first group is performed. If oil rate is significantly decreased, one oil pump is stopped and excess power from electric generator is delivered at constant frequency to external power line with high voltage.

This method allows to decrease cost of consumed electricity, increase durability and economic efficiency of the OPS on both nominal and variable operation regimes and decrease oil transport cost at main pipe line.
4. Conclusions
Suggested method of the operation of OPS equipped by gas turbine energy units allows its exploitation at different oil fuel rates in main pipe lines. Possibility of frequency control of oil pumps at decrease of the oil flow rate allows to decrease exploitation cost. Refuse to use expensive electricity from external power lines with high voltage, application of the APG as a fuel for gas turbine unit allow to significantly decrease oil transport cost.

References
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