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SMARTTRAN SOFTWARE FOR TRANSPORTATION OF OIL JSC KAZTRANSOIL

Abstract. Digital technology for monitoring, controlling and optimizing technological practices of oil and oil mixtures pumping through the sections of main pipelines, operating pumping units, preheaters, ground temperature, oil rheological properties and etc. has been created in a result of integration of a SmartTran software with of the Supervisory Control and Data Acquisition (SCADA) and the Automated Metering System (AMS) systems of the JSC "KazTransOil". The paper describes the main functionalities of the SmartTran software which was developed by the authors.

Thermohydraulic calculations of the sections of the main oil pipelines of JSC "KazTransOil" were carried out and compared with the actual data on the distribution of oil pressure, oil and ground temperature, power consumption of pumping equipment taken from SCADA and AMS.

The accordance of the calculated and actual data shows the applicability of the SmartTran software for the automation of calculations, planning and optimization of the technological modes of oil transportation through the main oil pipelines of JSC "KazTransOil".

Key words: software, integration, main oil pipeline, oil transportation, simulation, optimization.

Introduction. Automation of calculation [1-10], planning [11-16] and optimization [17-21] of the technological modes of oil transportation is in high importance in energy saving and energy efficiency issues of the oil and gas sector of economy. In consequence of the integration of SmartTran software, SCADA and AMS information systems of JSC "KazTransOil" has created an intelligent system for automating calculations and optimizing technological modes of oil and oil mixtures pumping in the sections of the main oil pipelines, pump units, preheaters operating, ground temperatures, rheological properties of oils etc.

Based on the historical data of the JSC "KazTransOil" SCADA system the following was carried out: 1) analysis of tags and industrial data by the operational pumping modes; 2) adaptation of head-capacity and energy characteristics of pumping units depending on their operational life; 3) adaptation of the pipelines' hydraulic resistance along main pipeline sections taking into account the rheological properties of the oil mixtures, changes in pipe roughness due to the asphaltene-resin-paraffin deposits; 4) adaptation of heat transfer coefficients between the "hot" oil and the ground, depending on changes in the ground thermal conductivity along main pipeline sections; 5) adaptation of the preheaters' characteristics depending on efficiency, pressure drop, etc.

According to the AMS and SCADA data the consumed power of pumping units, the cost of operating pumps and preheaters, the distribution of pressure and temperature of oil and oil mixtures in main pipelines sections, the change in ground temperature along the route can be found in real-time mode.

The SmartTran software has the following performance capabilities:

1. Heat-hydraulic calculations of stationary modes of high viscous and high pour point oil transportation for the safe operation of the main pipelines (taking into account associated pumping in and pumping out, pipe defects, loops and branches, pressure regulator and input of additives that reduce the hydraulic resistance of the pipeline, the pour point temperature of oil);

2. Heat-hydraulic calculations of non-stationary cooling and restart modes after short-term stops for the safe operation of the main oil pipelines;

3. Heat-hydraulic calculations of serial transfer of different varieties of high viscous and high pour point oils mixtures through the sections of the main pipelines;

4. Heat-hydraulic calculations of energy saving modes of main pumping units with detachable rotors and variable frequency drive for stationary operation regimes;

5. Determination of the optimum heating temperature of oil mixtures and energy-saving modes of preheaters for stationary "hot" operation modes;

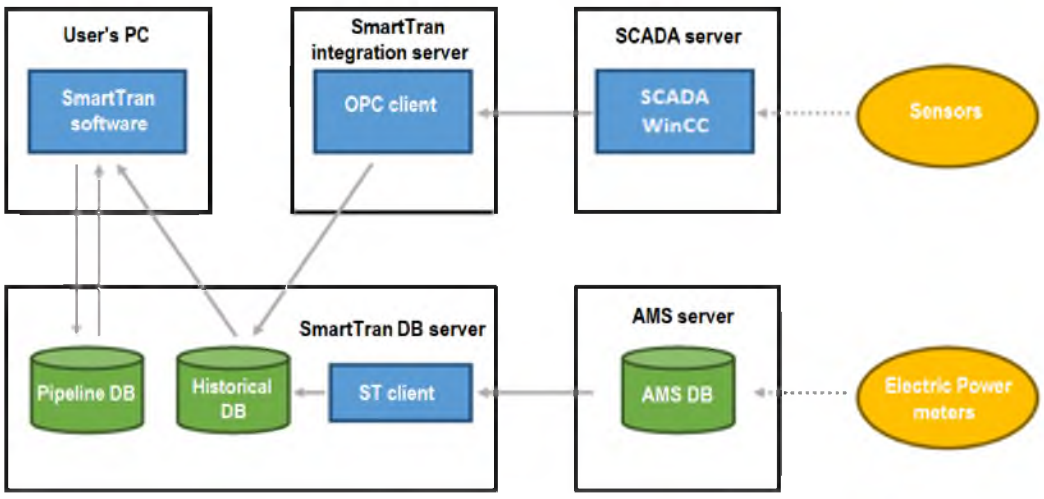
6. Selection of pumping equipment with detachable rotors and variable frequency drive for forecasting the maximum capacity of the pipeline in terms of the safe pumping conditions;

7. Adaptation of real characteristics of pumping equipment of the pumping stations (PS) according to the SCADA historical data;

8. Adaptation of the hydraulic characteristics of the pipe due to changes in wall roughness and heat transfer coefficient depending on the ground thermal conductivity of the main oil pipelines sections.

9. Designing of new sites, the addition of pumping equipment at PS and input of rheological properties of oil mixtures.

The mechanisms for obtaining actual data on operation modes of oil pipeline, storing and uploading them to the user interface for analysis and processing have been developed in the SmartTran software. Figure 1 shows the interaction diagram of the SmartTran software with the SCADA and AMS. Data from the sensors (pressure, temperature, flow rate, network frequency measurements) are sent to the SCADA server from all sections of the JSC "KazTransOil" main pipelines. The special OPC client of the SmartTran integration server receives sensor data from the SCADA server via the WinCC system using the OPC protocol with a frequency of 30 minutes. The OPC client exports the actual data to the historical database in MySQL format of the SmartTran DB server. The use of an intermediate server (the SmartTran integration server) is dictated by the JSC "KazTransOil" security policy (figure 1).



Figue 1 – The SmartTran interaction diagram with SCADA and AMS systems of JSC "KazTransOil"

The electric energy data from various devices of JSC "KazTransOil" are transferred to a separate AMS server and stored in a MySQL-format DB. The special client application (ST-client) was developed on the SmartTran DB server, which receives new data of the active power consumption of JSC "KazTransOil" pumping units from the AMS DB and exports them to the historical data DB in the required format every 30 minutes.

In that way the actual data of the technological pumping modes parameters are stored as historical data in the SmartTran software DB.

The SmartTran applications only interact with the SmartTran DB server on users' computers. The users download data on the oil pipelines sections from the single pipeline DB, which provides data actuality. Individual users can also make changes to the pipeline DB (oil library, pump library, pipe parameters, etc.) if they have rights to edit various parameters of pipelines. In the same DB user-defined calculations are stored, for the analysis of which the historical data are used. The SmartTran software uses the historical data to adjust the parameters of pumps, pipes and grounds, which also lead to changes in the pipelines DB.

Analysis and discussion of the calculated data. The calculations results of technological pumping regimes of oil and oil mixtures along some oil pipeline routes of JSC "KazTransOil" are given below using data from the SCADA, AMS systems.

Figure 2 presents the comparison results of the calculated data (curves) with the actual SCADA values (points) of the Karazhanbas-Aktau pipeline section. The upper plot of the figure 2 shows the distribution of the hydraulic slope, the middle one shows the oil pressure distribution, and the lower plot presents the oil temperature distribution. The calculation results of the power consumption of pumping units and the pumping cost according to AMS are presented in a tabulated form (figure 2).

High-viscosity oil is pumped at the Karazhanbas-Aktau pipeline section. Hydraulic slope, oil pressure and temperature distributions show good agreement with the calculated lines with the actual SCADA data of JSC "KazTransOil" (figure 2).

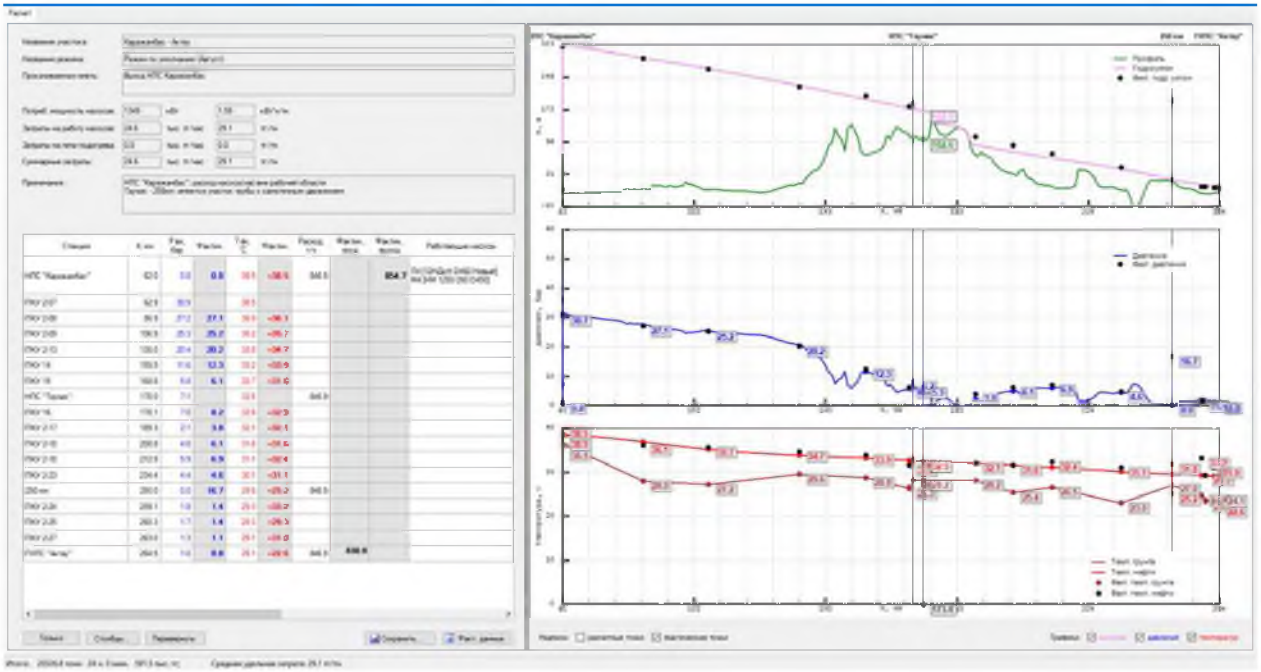


Figure 2 – Comparison of calculated (lines) data with experimental points of the Karazhanbas-Aktau section

Figure 3 presents the comparison results of the Aktau - Zhetybai pipeline section. The graphical data shows the hydraulic slope distribution (upper plot), oil pressure distribution (middle plot), and oil and ground temperature distribution (lower plot). In the left side of figure 3, the calculations of the power consumption of the pumps and the oil pumping cost according to the AMS data are shown in the table form. Comparison of hydraulic slope, pressure and temperature distributions shows good agreement between calculated data and the actual SCADA values.

Figure 4 shows the results of comparing the calculated data of the Kasymov–Bolshoi Chagan pipeline section with the SCADA data.

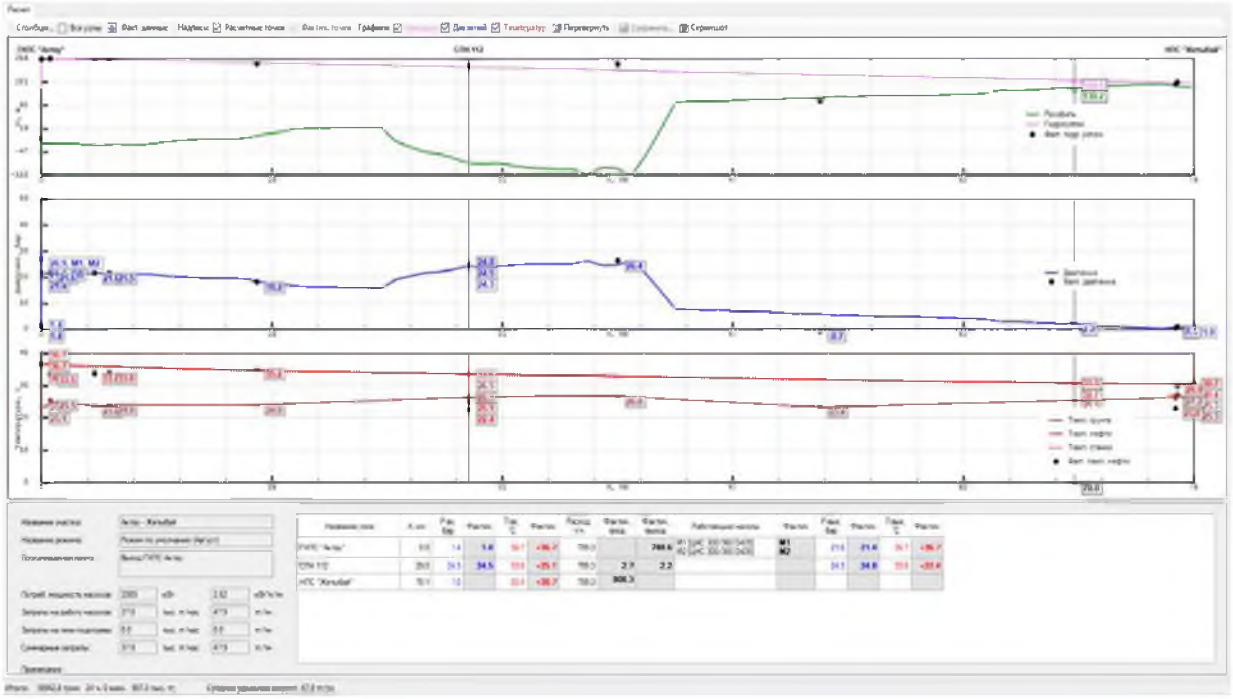


Figure 3 – Comparison of calculated (lines) data with experimental points of the Aktau - Zhetybai section

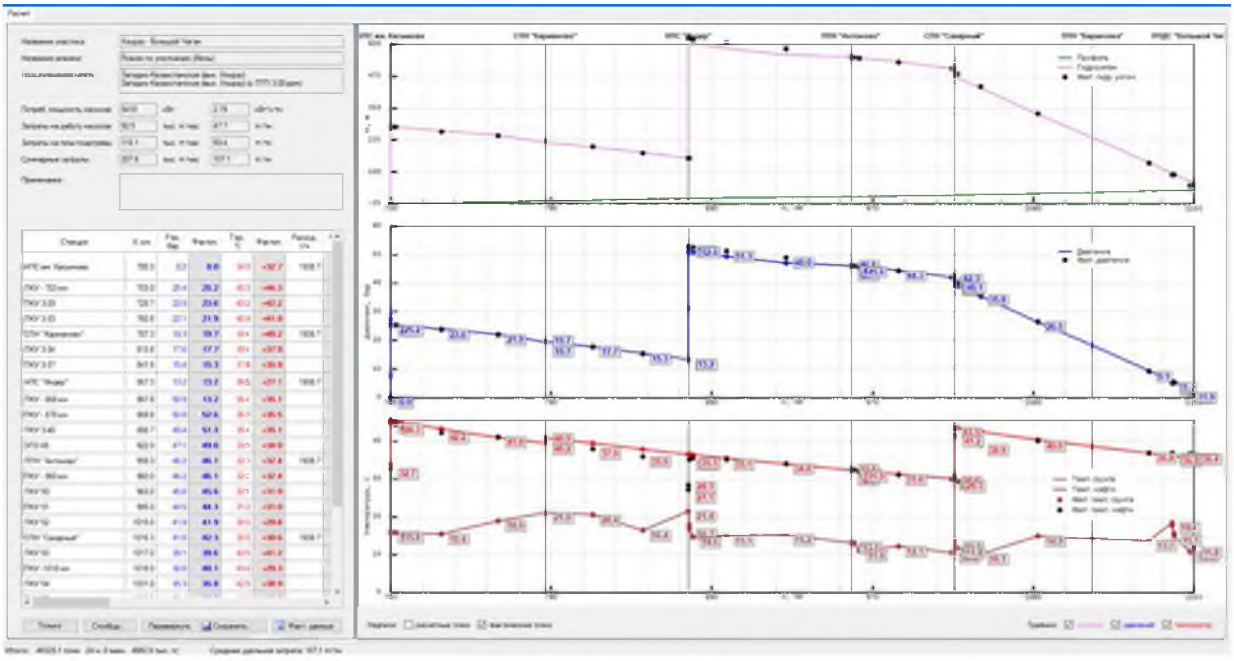


Figure 4 – Comparison of calculated (lines) data with experimental points of the Kasymov - Bolshoi Chagan section

At this pipeline section there is a “hot pumping” of high pour point oil mixtures with associated heating at the T. Kasymova and the Sakharny stations. In addition, an anti-turbulent additive is introduced at the Sakharny station to reduce the hydraulic resistance of the turbulent flow, since at this point the pipeline diameter changes from 1000 to 700 mm and the average flow velocity is almost doubled. Therefore, at high oil flow rates, for example, 1938.7 t / h (figure 4), the anti-turbulent additive is used to reduce the pipeline pressure and for the pumping safety.

The curves of hydraulic slope, pressure and temperature distribution show good agreement with the SCADA actual data (figure 4). Here are also presented the calculations of the energy consumed by pumps and preheaters for pumping and heating oil mixtures.

Figure 5 presents the calculated results of the technological modes of oil transportation along the following pipeline sections: Dzhumagaliyev – Atasu.

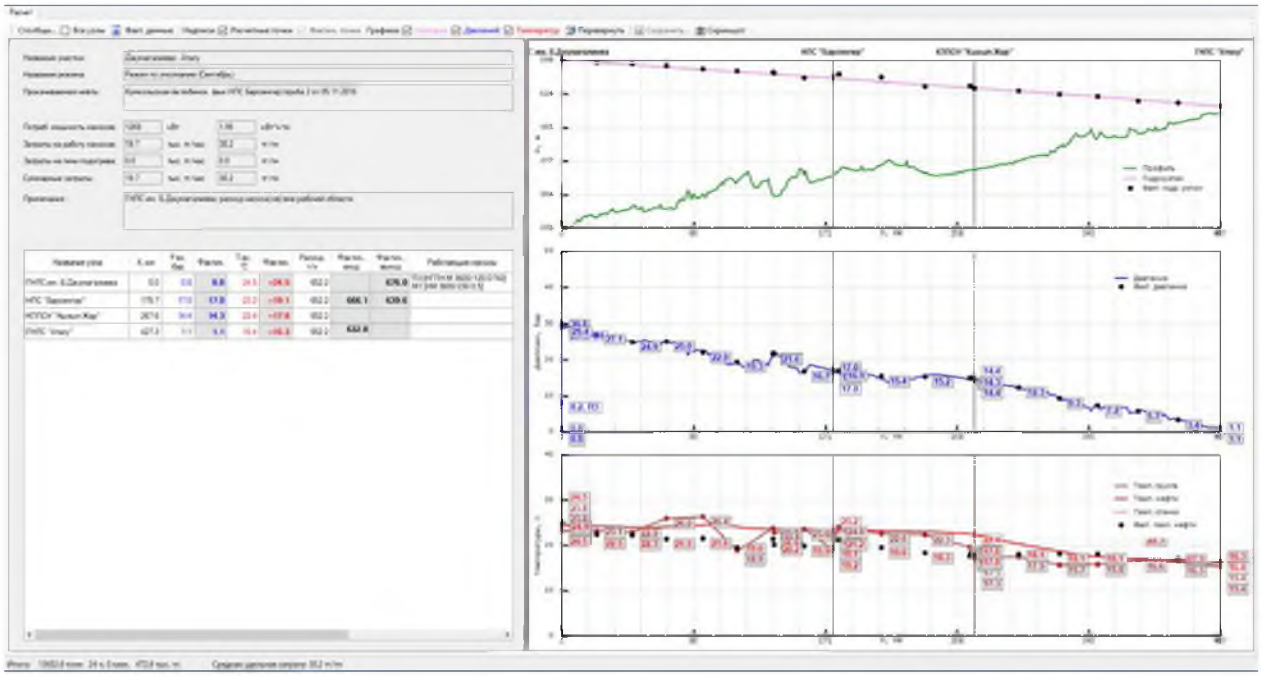


Figure 5 – Comparison of calculated (lines) data with experimental points of the Dzhumagaliyev – Atasu section

In all case, the comparison of the calculated curves obtained by the SmartTran software with the actual SCADA values (figure 5) shows good agreement.

In this way, the comparison of the calculated curves with the actual data confirm the functional capabilities of the SmartTran software for modeling, planning and optimizing the oil transportation of through the oil pipeline routes of JSC "KazTransOil".

Conclusion. 1. The intelligent system for automating calculations, planning and optimizing the technological practices of oil and oil mixtures transportation though the oil pipeline routes of JSC "KazTransOil" has been created by the authors through the integration of SmartTran software with the SCADA and AMS systems of JSC "KazTransOil".

2. The calculation results are in good agreement with the actual data of the SCADA system. SmartTran software together with SCADA and AMS systems is an effective tool for safe operation of pipelines and calculation of economic factors for oil and oil mixtures pumping through the JCS "KazTransOil" main oil pipelines.

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«ҚАЗТРАНСОЙЛ» АҚ МҰНАЙЫН ТАСЫМАЛДАУ БОЙЫНША SMARTTRAN БАҒДАРЛАМАЛЫҚ ЖАСАҚТАМАСЫ

Аннотация. SmartTran бағдарламалық жасақтамасын «ҚазТрансОйл» АҚ-ның SCADA және АСКУЭ ақпараттық жүйелерімен интеграциялау нәтижесінде магистральды құбырлармен мұнай және мұнай қоспаларын айдаудың технологиялық режимдерін бақылау, басқару және оңтайландыруға арналған сандық технологиясы жасалды.

SmartTran бағдарламалық жасақтамасында «ҚазТрансОйл» АҚ-ның мұнай құбырларының, соргы қондыргыларының, жылыту пештерінің, топырақ параметрлері мен мұнай қоспаларының сипаттамалары бойынша дерекқоры бар.

Багдарлама әр түрлі конфигурациядағы мұнай құбырларының жаңа учаскелерін жобалауга, модельдеуге, соргы жабдыгы және пештердің параметрлері мен мұнай қоспаларының реологиялық қасиеттерін дерекқорга енгізуге немесе оны мәліметтермен жаңартуга мүмкіндік береді.

SmartTran бағдарламалық жасақтамасы тұтқырлыгы жогары және жогары температурада қататын мұнай қоспаларын айдаудың стаңионарлық және стаңионарлық емес режимдерін жылу-гидравликалық есептеуге мүмкіндік береді. Есептеу барысында құбырга жол бойы қосымша мұнай айдау мен шыгаруды, қосымша құбырлар мен тармақтарды, құбырлардың ақауларын, қысым реттегіштерін, депрессорлық және антитурбуленттік қоспаларды енгізуді ескеруге болады.

Багдарламада келесі функңионалдық мүмкіндіктер бар: соргының қосылуының оңтайлы вариантарын іріктеу арқылы, сонымен қатар ауыспалы жиілікті жетектерді қолданумен энергия үнемдеу режимдерін анықтау; «ыстық» айдау кезінде мұнай қоспаларының оңтайлы қыздыру температураны анықтау; қауіпсіз айдау жагдайларын ескере отырып, құбырдың максималды өнімділігін болжау; энергияны ең аз тұтынатын ауыспалы режимді қолдана отырып ай сайынгы айдау көлеміне арналган оңтайлы режимді анықтау; SCADA жүйесінің тарихи мәліметтеріне сәйкес соргы жабдықтарының нақты параметрлерін бейімдеу; мұнай құбырларының учаскелеріндегі топырақтың жылу өткізгіштік қабілетіне байланысты құбырлардың гидравликалық сипаттамаларын және жылу беру коэффиңиентін бейімдеу.

SCADA және АСКУЭ жүйесінің тарихи мәліметтерін өңдеу нәтижесінде мұнай айдаудың технологиялық режимдері бойынша өндірістік деректерге талдау жасалды; соргы агрегаттарының сипаттамалары олардың жұмыс ресурстарына қарай бейімделді; құбыр учаскелерінің гидравликалық сипаттамалары бейімделді, магистральды мұнай құбырларының учаскелеріндегі мұнай мен топырақ арасындағы жылу беру коэффиңиенті және жылыту пештерінің сипаттамалары бейімделді.

SmartTran багдарламасының модульдерін пайдалана отырып «ҚазТрансОйл» АҚ «Қаражамбас - Ақтау», «Ақтау - Жетібай», «Қасымов – Үлкен Шаган» и «Жұмағалиев - Атасу» атты мұнай құбырларының учаскелеріне жылу гидравликалық есептеулер жүргізілді. Есептеу нәтижелері SCADA және АСКУЭ жүйелерінің мұнайдың гидравликалық ауытқуы, қысымы, температурасы, топырақ температурасы, соргы қондыргыларының энергияны тұтынуы бойынша нақты мәліметтерімен салыстырылды.

Есептеу нәтижелері мен нақты деректердің бір-бірімен сәйкестігі SmartTran бағдарламалық жасақтамасының «ҚазТрансОйл» АҚ магистральдық мұнай құбырларымен мұнай және мұнай қоспаларын тасымалдаудың технологиялық режимдерін есептеуді автоматтандыру, жоспарлау және оңтайландыру мақсатында қолдануга жарамды екенін көрсетеді.

Түйін сөздер: багдарламалық жасақтама, интеграция, магистральды мұнай құбыры, мұнай тасымалдау, модельдеу, оңтайландыру.

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ПРОГРАММНОЕ ОБЕСПЕЧЕНИЕ SMARTTRAN ПО ТРАНСПОРТИРОВКЕ НЕФТИ АО «КАЗТРАНСОЙЛ»

Аннотация. В результате интеграции программного обеспечения SmartTran с информационными системами SCADA и АСКУЭ АО «КазТрансОйл» разработана цифровая технология для мониторинга, управления и оптимизации технологических режимов перекачки нефти и нефтяных смесей на участках магистральных нефтепроводов.

Программное обеспечение «SmartTran» имеет базу данных по характеристикам участков нефтепроводов, насосным агрегатам, печам подогрева, параметрам грунтов и нефтяным смесям АО «КазТрансОйл».

Программа позволяет проектировать и моделировать новые участки нефтепроводов различной конфигурации, дополнять и обновлять базу данных параметрами насосного оборудования, печей подогрева и реологическими свойствами нефти и нефтяных смесей.

Программное обеспечение SmartTran позволяет проводить тепло-гидравлические расчеты стационарных и нестационарных режимов перекачки высоковязких и высокозастывающих нефтесмесей с учетом попутных подкачек и откачек, лупингов и ответвлений, дефектов трубы, регулятора давления и ввода депрессорных и противотурбулентных присадок.

Программа имеет следующие функциональные возможности: определение энергосберегающих режимы с подбором оптимальных вариантов соединения насосов, а также с использованием частотно-регулируемых приводов; определение оптимальной температуры подогрева нефтесмесей при «горячей» перекачке; прогнозирование максимальной производительности нефтепровода с учетом условий безопасной перекачки; определение оптимальных режимов перекачки при заданном месячном объеме перекачки с использованием переменного режима с наименьшим удельным энергопотреблением; адаптация фактических параметров насосного оборудования по историческим данным системы SCADA; адаптация гидравлических характеристик труб и коэффициента теплопередачи в зависимости от теплопроводности грунта на участках нефтепроводов.

В результате обработки исторических данных SCADA и АСКУЭ проведены анализ производственных данных по технологическим режимам перекачки; адаптация характеристик насосных агрегатов в зависимости от ресурса их работы; адаптация гидравлических характеристик участков трубопроводов, адаптация коэффициента теплопередачи между нефтью и грунтом на участках магистральных нефтепроводов, адаптация характеристик печей подогрева.

С использованием модулей программного обеспечения SmartTran были проведены тепло-гидравлические расчеты на некоторых участках нефтепроводов АО «КазТрансОйл»: «Каражанбас - Актау», «Актау - Жетыбай», «Касымова – Большой Чаган» и «Джумагалиева - Атасу». Результаты расчетов для каждого участка нефтепроводов были сопоставлены с фактическими данными SCADA и АСКУЭ по распределению гидравлического уклона, давления, температуры нефти и грунта, потребляемой мощности насосного оборудования.

Согласие расчетных и фактических данных показывает применимость разработанной цифровой технологии для автоматизации тепло-гидравлических расчетов, планирования и оптимизации технологических режимов транспортировки нефти и нефтесмесей по магистральным нефтепроводам АО «КазТрансОйл».

Ключевые слова: программное обеспечение, интеграция, магистральный нефтепровод, транспортировка нефти, моделирование, оптимизация.

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