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REQUIREMENTS FOR PREPARATION OF ACCOMPANYING OIL GAS FOR SMALL POWER ENGINEERING

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The possibility of using accompanying oil gas directly at the place of production and conditions meeting the corresponding requirements on fuel quality are grounded.

Introduction

The modern period in development of Russian economics is characterized by increasing role of power engineering in reliable and safe functioning of industrial enterprises and the economics in general [1]. Excessive wear of main equipment of the most part of electric stations and electrical networks and electric energy high deficiency in many industrial regions of Russia result in considerable increase of quantity and duration of irregularities in electric supply from central energy systems. At the same time, in many regions of Russia (to 40 % of country territory) there is no central energy supply. The systems of independent heat and electric supply using associated-dissolved gas (ADG) as fuel have been widely developed in such regions.

The support of the most complete ADG resources conservation is very important for efficiency increase of oil industry and national economy on the whole. Associated gas of petroleum deposits is still the least needed hydrocarbon raw material produced in Tomsk region territory. It is connected, to a large extent, with petroleum deposits remoteness from gas main pipelines and experience of deposits development emerged in recent times. In connection with deterioration of oil and gas mineral-raw material base and rise in prices for heat and electric energy the tendency of more careful treatment to this kind of resources as well appears at many enterprises. At present, about $3\cdot10^9$ m^3 of ADG per year is extracted at hydrocarbons production and about $1\cdot10^9$ m^3 is burned down at field torches because of absence of other variants of its use [2]. Such situation makes consider additional ways of efficient gas utilization straight at the place of its production.

Objectives of the paper

The choice of ADG way of preparation for its industrial application depends on raw material composition and demands for the end product. Two ways of ADG using are possible (except useless burning at torches): energy and petrochemical.

Petrochemical. ADG may be recycled for obtaining tank gas, meeting the requirements of BS 51.40-93 «Gases fuel, natural, delivered and transmitted by gas-main pipelines», natural gasoline, wide spread of light hydrocarbons. Associated gas is, for instance, a raw material for producing methanol, formaldehyde, acetic acid, acetone and many other chemical compounds. Synthetic gas, widely used for further synthesis of valued oxygen-containing compounds – alcohols, aldehydes, ketones, acids – is also produced from associated gases. The production of synthetic ammonia and chlorine derived hydrocarbons on the basis of ADG achieved the considerable degree. Petroleum gas serves as a raw material for obtaining olefinic hydrocarbons, and first of all ethylene and propylene.

Energy. Certain perspectives in the field of energy use of ADG are connected with new directions in engineering and technology as a result of creation and introduction of movable and stationary power plants consuming gas. The main problem of investigations solved in this paper is generalization of gas composition requirements for its industrial application as a fuel. At the same time, the main requirements to ADG follow from plants performance data.

In the conditions of deposits use underfunding, using ADG for local power consumption is the most perspective, i. e. applying petroleum gas as a fuel for minor power engineering. The example of justification for economic appropriateness of ADG burning as a fuel is the stationary gas-piston power station in an easily constructed building at Yraynerskiy oil deposit in YNAO built and let in September 2003. The possibility to make a choice of preparation technique, corresponding technologies and agents, space planning of objects of preparation and gas consumption subject to consumers' specific character and other factors for achieving the highest energy data appears only at sufficient information completeness on physical chemical peculiarities of the given fuel.

Study of ADG properties of Tomsk region deposits has already carried out in the laboratories of research and design institute of «TomskNIPIneft» corporation. However, it is known that petroleum gas composition changes constantly in connection with a change of its production volumes at deposits in one or another area, therefore, it is necessary to specify qualitative indexes from time to time (not rarely than once in five years).

Methodological support

Unlike natural gas, produced from gas and gas-condensate fields, petroleum gas is characterized by high content of ethane, propane-butane and pentanoic fractions; hexanes, heptanes and heavier hydrocarbons, including aromatic and naphthenic compounds (benzene, toluene, xylenes, cyclopentane, cyclohexane and others) are presented. Heavy hydrocarbons (ethane and higher) content reaches 20...40 %, sometimes 60...80 % in associated gases. Nonhydrocarbon components of ADG are mainly presented by nitrogen and carbon dioxide with the admixture of hydrogen sulfide and inert gases (generally helium), sometimes hydrogen is occurred [3].

The detailed study of oil and gas single fractions and direct determination of individual hydrocarbons in them became possible only owing to multipurpose use of up-to-date methods of gas-liquid chromatography in aggregate with mass-spectrometry, infrared spectroscopy and other physicochemical methods of investigations.

While studying ADG the technique of investigations was used. It is intended for defining component analysis of natural and associated gases, containing hydrocarbons C_1–C_6 as well as nonhydrocarbon components (hydrogen, helium, oxygen, nitrogen, carbon oxide and dioxide). ADG component analysis is defined by the method of gas-solid chromatography in conformity with SS 23781-87 «Burning natural gases. Chromatographic method for determination of component composition». The given standard extends to natural hydrocarbon gases and ascertains two methods of chromatographic quantitative determination of the components: the method of determination of nitrogen, oxygen, helium, hydrogen, dioxide of carbon and hydrocarbons C_1–C_6 at volume fraction of hydrocarbons C_5 and higher not more than 1 % and nitrogen not more than 20 %; the method of determination of hydrocarbons from C_4 and higher (to C_8) at volume fraction from 0,001to 0,5 %.

ADG samples were selected into sample tanks of 500 ml capacity by chemical analytical laboratory of oil and gas preparation control by the geological survey of oil-production enterprises at well head, in the amount necessary for analyses reproducibility. Mechanical impurities content (tars and dust) in gas by 223874-77 SS were measured at sampling. The selected gas sample should not change its composition over a period of storage. For this purpose the samples were stored in the same reservoirs, where they were selected, at the temperature of 30...35 °C over the layer of sealing liquid.

Hydrocarbon part of ADG was analyzed at two meter column filled with polymeric sorbent «Parapak-Q». Nonhydrocarbon part was analyzed at three meter column filled with zeolites of CaA type. Hydrocarbons C_1–C_6 and CO_2 were analyzed at chromatographer supplied with temperature programmed block. Heavier hydrocarbons C_7–C_8 were determined by means of capillary column of 50m length filled with a stagnant liquid phase OV-101 with the use of flame-ionization detector in the mode of column temperatures programming.

Samples of formation liquids and gases were investigated in special laboratories of «TomskNIPIneft VNK» corporation according to the branch standard BS 153-39.2-048-2003 «Oil. Standard investigations of reservoir fluids and separator oils».

Moisture dew point, the index, which defines the conditions of hydrate-free gas transfer, provides the increase in reliability of automation means operation and decreasing corrosive wear of gas pipelines and processing facilities. In SS 5542-87 moisture dew point is not normalized, however, it is observed that this index should be lower than the temperature of incoming gas at the delivery place.

Heat of combustion is the main characteristic at estimation of ADG energy capacity. According to the SS 22667-82 heat of combustion is determined by additivity with the use of the data on composition and corresponding heats of combustion of natural gas components.

The results of compositional analysis

The reliable data on gas composition of gas-condensate fields may be obtained only after the investigation of samples from a great number of wells, with which all places of deposits and the whole reserve of pay section were dissected. Such results of recent gas investigations of three petroleum deposits in Tomsk region (Sobolinoe, Luginetskoe and Pervomayskoe) are presented in the Table.

The correct accounting of caloricity and caloric equivalent of ADG at its consumption as a fuel for minor power engineering has a significant value. Understating of these indices may result in unreasonable gas losses and their overstating may cause troubles in provision of gas for consumers. The gas of Lugenetskoe petroleum deposit possesses rather high caloricity – about 41000 kJ/m^3 , for Pervomayskoe one it is 54305 kJ/m^3, for Sobolinoe it is 54702 kJ/m^3, that is rather substantial consumer index in comparison with natural gas, which heat of combustion for the most part of deposits is 35500...37560 kJ/m^3 [2].

Hydrogen sulfide content in associated dissolved gas equals 0,7, 0,8 and 0,7 mg/m^3 water content is equal to 1,4, 1,8 and 1,7 g/m^3 respectively for Luginetskoe, Pervomayskoe and Sobolinoe deposits.

***Table**.* *Component analyses of ADG of Luginetskoe, Pervomayskoe, Sobolinoe petroleum deposits, mole, %*

Component	Deposits					
	Luginetskoe		Pervomayskoe		Sobolinoe	
	$P_и$=5,9 atm $T_г$=26 °C	$P_и$=6,2 atm $T_г$=0 °C	$P_и$=5,9 atm $T_г$=26 °C	$P_и$=6,2 atm $T_г$=0 °C	$P_и$=5,9 atm $T_г$=26 °C	$P_и$=6,2 atm $T_г$=0 °C
Oxygen	0,12	0,14	0,10	0,11	0,10	0,12
Nitrogen	1,68	1,88	2,28	2,60	2,75	2,40
Carbon dioxide	0,94	1,21	0,98	1,12	0,13	0,14
Methane	87,34	87,72	56,41	65,56	54,41	58,84
Ethane	4,16	3,79	6,72	7,44	5,01	4,56
Propane	2,94	2,67	15,45	13,16	19,75	18,03
Isobutene	0,72	0,64	3,93	2,52	4,73	3,94
N-butane	1,11	0,96	8,21	4,74	9,40	9,73
Isopentane	0,32	0,26	2,25	1,07	1,69	1,77
N-pentane	0,32	0,24	2,18	1,00	1,83	1,55
N-hexane	0,07	0,06	–	–	0,30	0,84
Heptane + higher	0,08	0,07	1,59	0,79	2,89	2,14

$P_и$ is the pressure of associated dissolved gas at separation; $T_г$ is the temperature of ADG

Physicochemical properties of ADG of the given deposits have considerable peculiarities, particularly in content of methane homologues (C_2 and higher) and nitrogen. As it is seen from the given Table, gas preparation for its use in power plants for Lugenetskoe deposit requires minimal costs and for Sobolinoe deposit the costs are maximal.

Preparation phases for combustion

Gas preparation of various degree of complexity is necessary for power engineering needs depending on quality of produced ADG [4]. One of the most serious problems in the use of petroleum gas is its purification from gas distillate, condensed, fine-dispersed, aerosol moisture and mechanical sludge impurity. According to the data on gas composition, presented in the Table, the following requirements for procedures of ADG preparation for minor power engineering are validated.

1. ADG should be maximum separated from impurities and dehumidified before entry into a gas feed system into power plant for preventing formation of crystalline hydrates at gas feeding. The accepted value of moisture presence should be not more than 9 mg/nm^3 [3].
2. Gas purification from hydrogen sulfide and carbon dioxide should be applied for preventing their corrosion influence on equipment and distribution pipeline and adjusting their content in gas with the requirements of sanitary code. Content of sulfur compounds (in terms of sulfur) in ADG, supplied to a gas engine (in the case of gas stationary electro assemblies), should not be more than 0, 2 % (by mass).
3. Gas topping (complete or partial) should be applied for removing propane-butane and heavier hydrocarbon components from gas for preventing the formation of liquid obstructions.
4. Every gas fraction has its fire point, therefore, an unstable mode of gas combustion (knocking combustion) occurs, which is defined by the permissible minimum methanic number; different ways of gas preparation may be applied, including the above mentioned removal of single heavy hydrocarbon gas constituents.

Thus, in comparison with a standard technique of gas preparation for combustion, developed in centralized conditions of gas preparatory stations – plants, the procedure of hydrocarbon heavy fractions removal is added in order to avoid these fractions adhering on installations surfaces with formation of obstructions and maintaining optimal conditions of fuel combustion. In this case, the specific character consists in the fact that in spite of capital-intensive and multistep techniques of petroleum gas preparation existing in large-tonnage manufactures, the question of preparation should be solved for benefit of medium-priced but efficient installations to be used in minor power engineering.

To achieve the assigned aims, the author of this paper suggests the following patented engineering and production solutions in the part of deleting or significant decreasing entry of heavy hydrocarbons into gas combustion system, which supports the possibility of petroleum associated gas combustion by the installation of so-called zeolite filter.

1. Gas combustion system, according to the first variant (Fig. 1) contains coaxially situated inner air feeding and outer fuel channels. The fuel channel is connected with annular vortex chamber formed by a spiral ring and a tangential fuel-supplying branch pipe. Before this branch pipe and between two diffusers, one of which is fixed at the mentioned branch pipe, and another one is at a gas pipeline, a changeable zeolitic filter is arranged. In the air feeding channel of gas combustion system there is an adapter with a hollow head at the end, the outlet cuts of which are in the same plane with the fuel channel.
2. Gas combustion system (Fig. 2) according to the second variant contains closely situated air pipes, arranged between porous and nonporous cylindrical surfaces, where distributing gas collector is attached. The gas collector is attached to the gas pipeline. Before it the changeable zeolitic filter is installed. The diffuser, which is connected to the air pipe, is attached to the nonporous cylindrical surface. The suggested gas combustion system allows for compact combustion zone with a short-flame fire. The gas pipeline is connected tangentially to the distributing collector for equal fuel distribution over the whole gas combustion system.

The variants of using zeolitic filter showed in Fig. 1, 2 allow excluding or decreasing heavy hydrocarbons entry that reduces considerably the quantity of oil-paraffin

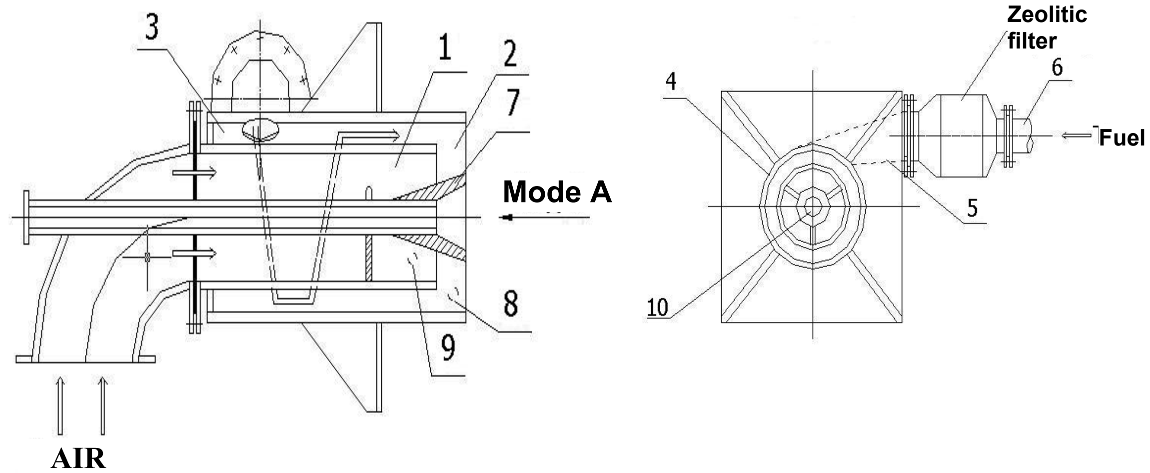

Fig. 1. *Gas combustion system: 1) the inner air feeding channel, 2) the outer fuel channel, 3) the annular vortex chamber, 4) the spiral ring, 5) the tangential fuel-supplying branch pipe, 6) the gas pipeline, 7) the hollow head, 8, 9) the annular chambers, 10) the adapter*

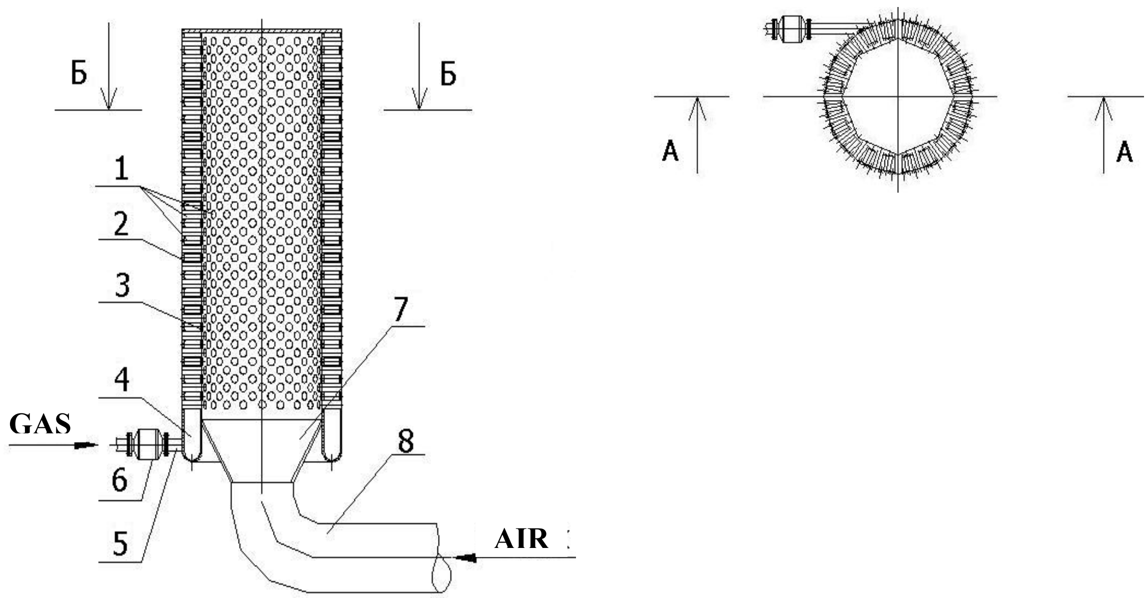

Fig. 2. *Gas combustion system: 1) the air pipes, 2) the porous cylindrical surface, 3) the nonporous cylindrical surface, 4) the distributing gas collector, 5) the gas pipeline, 6) the changeable zeolitic filter, 7) the diffuser, 8) the air pipe*

deposits on the details of gas combustion systems and supports normal conditions of their operation; decreases the number of precipitations of incomplete combustion products on heating elements of power plants and supports normal heat transmission processes in heat-exchangers; reduces harmful substances concentration in passing gases, and, therefore, improves ecological situation of the environment.

These solutions are not the panacea for the technological problems at ADG combustion; however their application allows increasing reliable operating age of power plants on ADG and improving environmental situation at a field.

Conclusion

Collection, preparation, transportation and recycling of ADG have their technological and economical peculiarities and problems, which differ substantially from the technology and economic parameters of production, preparation and transportation of natural gas. The situation with energy supply in the fields prompts to consider the possibility of ADG use for auxiliaries as a fuel for low power energy installations. Aas a rule, ADG use in this capacity is accompanied with complications: hydrate and liquid blocks formation in supplying gas pipelines, repeating floodings of gas combustion systems, which may initiate explosions of the equipment. In most cases, the condensate precipitating in field gas pipelines and collected in condensate tanks is released to the barns for evaporation and combustion. Petroleum gas combustion, containing considerable amount of target hydrocarbon components, as a fuel in field conditions at the simplest gas combustion systems occurs in detonating mode at low efficiency accompanied with incomplete gas combustion and significant atmospheric ejection of contaminants. The problem of petroleum gas use in minor power engineering should be solved by means of new, economically sound developments, which find wide application both in prolific and minor deposits of Tomsk region. Depending on ADG composition of these deposits before power plants the following procedures should be carried out: separation from impurities and dehydration, purification from hydrogen sulfide and carbon dioxide, topping, removal of single heavy hydrocarbon gas constituents.

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NUMERICAL INVESTIGATION OF CYLINDRICAL PRESS-MOULD FILLING PROCESS WITH POLYMER MASS BY THE MOLDING METHOD UNDER PRESSURE

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On the basis of numerical solution of the problem on flow of nonlinear visco-plastic liquid with free surface the process of cylindrical press-mould filling has been studied. Mathematical statement of the problem is presented and the factors influencing the formation process are analysed. Numerical experiments carried out in the wide range of problem input parameters reveal the characteristics of hydrodynamic behaviour of free surface form of flowing polymer mass and demonstrate the influence of the main problem parameters on the basic characteristics of the process.

Introduction

Qualitative and defectless manufacture of articles from polymeric materials (PM) by the molding method under pressure is mainly stipulated by structural-mechanical (rheological) properties of PM, operating mode of its recycling and constructive peculiarities of applied processing equipment. Therefore, both rheological characteristics of polymeric composition and the most important sides of the process itself should be deeply studied for formulating scientific requirements for manufacturing process.

Cylindrical press-moulds filling with polymeric mass by the molding method under pressure as well as by the method of free molding is characterized by one very important hydrodynamic feature – the presence of moving mass free surface contacting with solid stationary walls of a press-accessory. From this point of view, the whole process of press-moulds filling with polymeric mass is the process of formation and development of moving mass free surface up to its disappearance by the moment of cycle ending.

The experimental research [1, 2] shows that PM flow behavior in the elements of press-accessory is determined by a number of factors, which may be divided into three groups with a certain convention.

1. Hydrodynamic and rheological factors. Mass consumption in press-mould determined by processing equipment capacity, press-mould geometry; physical-mechanical mass properties (density, viscosity, rheological characteristics etc.); mass forces are referred to this group.
2. Thermalphysic factors. First of all, it is molding temperature conditions (temperature of inflowing polymeric mass, temperature and insulation properties of press-mould frame walls, temperature of environmental air) and thermalphysic properties of PM itself.
3. Physicochemical factors. The factors connected with hardening processes and finally determining time and manner of two previous groups of factors are usually referred to the third one.

The investigation of various factors influence on molding process of articles of PM is economically unprofitable directly in operation conditions. Therefore, it is necessary to use the methods of physical and mathematical simulation with further control and introduction of the obtained results into manufacturing. In mathematical simulation the simultaneous consideration of the whole complex of factors is rather difficult. In this connection, it is appropriate to simplify the problem relying on experimental data and considering the influence of the separate, most important factors from this point of view. The carried out investigations [3-9] show that the free surface form of moving mass in the elements of press-accessory is mainly defined by hydrodynamic and rheological parameters of processing mode of molding articles of PM.