TECHNICAL SOLUTIONS FOR ECOLOGICALLY SAFE AND SUSTAINABLE DEVELOPMENT OF SHELF DEPOSITS

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ABSTRACT
Complicated environmental and climate conditions (ice conditions, temperature, wind direction) which is typical for the most Arctic shelf deposits, limit access to reservoir during the whole year. This reason determines necessity of searching alternative technical facilities for shelf deposits. Subsea turbo compressor units (STU) provide ability for whole-year reservoir production, and it sustainable development. The paper analyzes STU operation experience and shows advantages of it utilization, the main of which is ecological safety, low capital and operating costs, energy efficiency and other. Operating subsea compressor units, it components and types are described. Besides, the paper highlights the main problems of traditional electromechanical systems with compressor units for shelf deposits. For providing successful and effective Arctic projects it need to take into account not only exploitation experience of top-leader country and companies, but law and organizational systems for it providing. Paper shows the example of successful system on the base of effective Norwegian experience.

Key words: Shelf deposit, subsea technologies, subsea turbo compressor


1. INTRODUCTION
The main features of Arctic shelf are complicated environmental, climate and ice conditions, fragile ecosystem in hydrocarbons regions. Nowadays for the shelf deposits recovery the various types of oil rigs, tankers, gas carrier (gas tankers) and other floating vessels are exploited.

Because of the special conditions typical for Arctic deposits it is required to use the special ice class of operating facilitates. The development of new solutions for this region involves both high scientific level and technical experience.
The alternative for traditional Arctic shelf facilities is subsea production systems [1-3]. Such systems provide the whole-year hydrocarbon deposit operation and has no limitation linked with external climate and environmental factors. The main requirements for subsea techniques are high level of reliability, safety, operational, energy and ecological characteristics [4-7]. Consequently, the problem of technical solutions development for perspective subsea facilities design has a great potential.

After drilling operation and production well completion the issues of safe and effective hydrocarbon gathering and transporting has a great importance and can be solved with subsea turbocompressor units (STU) utilizations. STU has a potential not only for new deposits but also for old reservoirs with low formation pressure and high water-cut. For old deposits STU implementation helps to increase the recovery factor. But often the producing companies face with problem of low formation pressure in new deposits and it expand STU field of operation.

2. EXPERIMENTAL SETUP
The following positions prove subsea turbocompressor units effectiveness as alternative for traditional technologies of hydrocarbon transporting:

1. Ecological safety
   STU decrease artificially-produced impact on Arctic sea and ocean environment. For instance, STU with electric drive based multiphase pump exclude green house gas emissions.
2. Safety
   STU helps to provide high level higher level technological processes, equipment and technologies safety is provided. Hydrocarbon emissions are prevented with protection equipment, technology does not require gas tankers, platforms, pipeline protection is provided with cutaway valves.
3. Whole-year exploitation
   STU provides deposit operation without seasonal breaks.
4. Simple control
   State-of-art control systems provide adaptive high precise control for multiphase pumps and submersible pipeworks.
5. Low capital and operating costs.
   Subsea unit utilization decreases upstream costs to 30-40% in comparison with traditional facilities, for production period it reaches 35-70%.
6. Low resource and metal consumption.
   STU weight is 5 000-ton, weight of compressor unit on floating platform is 30 000 ton;
7. Energy efficiency
   For transporting the equal volume of hydrocarbon STU consumes 25 MVt, traditional technology – 41 MVt.

Prerequisites for developing reliable STU with controllable electric drive for multiphase pumps, providing effective and safe subsea transporting systems are following:

1. Wide experience of electric drive gas pumping units operation for land gas and oil pipelines
2. High reliability of STU main equipment – drives, frequency converters, control systems etc.
3. Successful experience of subsea technologies for North and Norwegian Sea shelf in Europe and Mexican sea in USA.
3. THEORETICAL ANALYSIS
Global oil and gas companies including Russian, has great experience in construction and exploitation of mainline and field subsea pipelines. One of the biggest subsea mainline projects - Nord Stream is based on idea of direct gas transporting from Vyborg (Russia) to Greifswald (Germany) without transit countries. Subsea field pipelines in Russian Federation are exploited in Sakhalin shelf deposits, besides field pipeworks are used in North Sea between Norway and United Kingdom.

For Arctic shelf the great interest has technical units for production well drilling, units for hydrocarbons gathering, treating and transportation without floating installations. World leadership in design and producing of shelf technical equipment belongs to FMC Technologies and Aker Solutions (Norway), besides Siemens and MAN has big volume decisions. But world top-company in subsea technology is Statoil (Norway).

Nowadays Statoil are used submersible equipment in several deposits, for instance Ormen Lange deposit (Barents Sea), which production starts at 2007.

Since it beginning, during the producing wells drilling, each wellbore was provide with seabed template with drilling openings; after well completion the subsea producing unit is placed on installed template.

Subsea compression station (fig.3) includes manifold and all required complex of well-head equipment for safe hydrocarbon recovery.

![Figure 1 Subsea compression station, OrmenLange deposit (Barents Sea)](image)

Multiphase hydrocarbon flow, which consists of hydrocarbons (oil, gas, condensate), sand and water, is transporting through 160 km subsea pipelines to processing plant, located on island near Hammerfest. After treating, liquefaction, preparation processes gas is loaded to tankers, separated gas is pumped back to well.

For gas, oil and sand separation on Tordis deposit in North Sea, the submersible separators (fig.4) are used.
Besides subsea drilling, completion and separation technologies, the other one important process is gas transporting to onshore storage or plant. In most cases the tankers are used for such purposes. But several deposits (Asgard since 2013, Ormen Lange in near future) utilize subsea compressor units and in result it provide the whole year reservoir production, indifferent to ice conditions.

Nowadays subsea hydrocarbon recovery technologies involved deposits number is almost 130. Leading global electrotechnical companies launch the technologies for that, for instance MAN Hofim-type (Fig.5), Siemens ECO-II (Fig.6) compressors.

Manufacturing and growth rate of perspective technical solutions for shelf development and consequently safety and effectiveness of shelf projects in arctic regions determines financial and organizational politics, provided by government of countries with shelf access. The leader-countries experience in this field should be researched and taken into account.
One of the country, which experience is considerable is Norway, because in 1970th and 1980th it had almost zero technological level of shelf projects, but by means of foreign investment and wise politics technologies development for several years country transform to leader in effective and safe development of shelf hydrocarbon deposits. After that Norway established producing and service-providing companies, which nowadays has top positions. The country performs the expansion to the global market of surface production equipment and become leader in the field of design, testing and utilization of subsea shelf techniques. Nowadays, Norway shelf of North sea and Norwegian sea can be classified as global “laboratory” for designing and developing of state-of-art technical solutions for shelf deposits.

Research Council of Norway is the main institute of Norwegian oil and gas industry, and it coordinates the all hydrocarbon industry companies.

Council is financially funded by Norwegian government. The organization support such national level oil and gas projects as: PETROMAKS – funding for oil sector projects; GASSMAKS – funding for gas industry projects; DEMO2000 – funding for pioneer oil and gas projects and it future commercialization; RENERGI – ecological projects for energy industry; CLIMIT – funding for ecologic safe gas projects.

In Russian Federation there was Federal Target program “Global Ocean”, with the main purpose of developing complex decision of research, development and effective using of global ocean resources for country economic growth and safety providing. But after in completion no new similar program was launched.

The other important issue of success in shelf projects is legal system. During investment period for shelf projects the following typical in Norway were arranged: The 50 % Agreement; Financial Agreement; Goodwill Agreement.

The first agreement allows to foreign companies to develop country deposits, but during this it has to provide no less than 50% of whole researches, which is necessary for this particular reservoir. Such type of agreements now is obliging for all shelf agreements, and it performance is controlled by Norwegian Ministry of Petroleum and Energy. Shell company, when it was an operator for first Troll deposit development phase, spent 73% of all research budget for Norwegian companies and institutes services, for «Draugen» deposit – 80%.
The second type of agreement is financial, and it obliges foreign companies to provide all necessary researches in Norway during established period and with specified budget (as usual it is a share of profit from deposit recovery).

The third type of agreement is Goodwill, and it allows foreign companies to provide unlimited amounts of scientific researches, without strict law obligation, but it requires annual reports to Research Council.

Collaboration within the frames of aforementioned agreements provides a wide range of researches in the fields of sea, energy, machine building and other for shelf oil and gas industry. And it needs to mention that all agreements are controlled by Norwegian Petroleum and Energy Ministry.

4. CONCLUSIONS
For Arctic shelf whole-year producing, ecologically safe and energy effectiveness proving it need to develop subsea technologies in a whole and subsea turbo compressors particularly. Designing state-of-art subsea techniques is an effective alternative for traditional technologies with floating vessels, because of it ecological safety, low capital and operating costs, lower energy consumption. That is why the development of such technologies it is the question of national importance for countries with shelf deposits and it require special law and organizational support, scientific projects and programs for its future sustainable growth.

REFERENCES