Specific features of gas field development on Yamal and Gydan using offshore technologies

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With a view to ensuring index of reliability and economic efficiency of field development on Yamal and Gydan Peninsulas it is necessary to use non-traditional engineering solutions such as offshore technologies.

There are the following main reasons of the low economic efficiency and reliability of traditional oil and gas technologies for Yamal and Gydan Peninsula’s Fields development:

• all-round presence of perennially frozen rocks (permafrost);
• high presence of water in the ground in this area;
• high level and duration of spring flood;
• lack of sufficient resources of inert matters (sand and gravel) to construct supporting structures and foundations of the field.

The proposed technical solutions for the construction of cluster site for drilling and exploration of wells are relayed on offshore experience by reference to onshore specific features.
In our opinion the main task of field facilities construction is a maximum reduction of facility area and its efficient use.

This can be achieved by following decisions:

• Cluster drilling of production wells using extended reach drilling methods.
• Multi-row spacing of wells with minimum distance between them, due to criteria of wellhead equipment arrangement and service.
• Double-deck arrangement of Drilling Rig Substructure with wellhead spacing on a lower level, which doesn't preclude for rig skidding.
• Multy-row well spacing is achieved by coordinated rig skidding.
• Pitless drilling due to use of specific equipment and waste management technologies.
• Reduce distance from wellhead to accommodations and flues - lubricant storage by using safe rig fixation to avoid its fall towards to these objects.
• Use technologies and equipment that provides strict requirements for fire, industrial and environmental safety.

The cluster sites regarding to design features and construction methods is related to bridge-type constructions, but regarding to technological features - to offshore platforms. Therefore it should meet normative requirements as well as for bridge constructions and offshore platforms.
It is considered two alternative constructions of cluster sites such as the pier type and a modular type. For both types the following technology solution are common:

- Drilling rig «Uralmash-3000 ЭУК» fully meets requirements of equipment close-together arrangement.
- Also it is possible to use drilling rigs «Uralmash 3200/200 ЭУК-2МЯ» and «Uralmash-3900/225 ЭК-БМ». In this case the size of drilling site should be increased, that can by partly compensated by advantages of echelon drilling with moving rig from well to well.
- Such types of a site construction allow to put stage build-up of construction due to dynamic of putting of wells on production.
- A cluster site superstructure is continuous structure for arctic conditions. All metal constructions are made from profiled rods from low-alloyed still grade 09Г2С-15 which satisfies arctic conditions.
Cluster site for drilling of 5 wells. Pier type construction.
Cluster site for drilling of 5 wells. Modular type construction
Support structure of derrick substructure
Layout of drilling facility for 5 and 9 wells

- Derrick unit
- Circulation unit
- Compressor unit
- Power unit
- Pump unit
- Accommodation

Centre line of road (pier)
Methods and sequence of construction of pier type cluster site

1. Boring of pile-holes with depth up to 8 m
2. Pitching of pile S-11 with weight up to 1 t. Sand-cement grouting of pile-holes with grout volume up to 2 m³
3. Installation of coupled cross beam with weight up to 1 t. Welding of support brackets (OC) (2 pcs to 1 pile)
4. Installation of substructure coupled beam SB-6 with weight up to 1.5 t
5. Installation of floor precast concrete slabs P-1 with weight up to 2.5 t each

Layout of the cluster site at different construction stages
Methods and sequence of construction of modular type cluster site

1. Transportation of erection block (MB-1) by skidding through winter road. Dimensions and weight: 36.5*18.5*3.0 m, 100 t

2. Aligning of MB-1 on the construction site

3. Boring of pile-holes with depth up to 8 m. Pitching of pile S-11 with weight up to 1 t. Sand-cement grouting of pile-holes with grout volume up to 2 m³

4. Connection of piles with MB-1 by means of support brackets OS-1

5. Layout of the cluster site at different construction stages

   Installation of floor precast concrete slabs P-1 with weight up to 2.5 t each

   Fragment of connection of foundation pile with erection block MB-1
### Summary figures of general material consumption depending on types of cluster sites

<table>
<thead>
<tr>
<th>Site type with</th>
<th>Type of material</th>
<th>Pier</th>
<th>Modular</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Weight of metal structure, t</td>
<td>Volume of precast concert slabs, m³</td>
</tr>
<tr>
<td></td>
<td></td>
<td>for 1 well</td>
<td>overall</td>
</tr>
<tr>
<td>Site with 5 wells</td>
<td></td>
<td>89,0</td>
<td>445,0</td>
</tr>
<tr>
<td>Site with 9 wells</td>
<td></td>
<td>76,1</td>
<td>684,8</td>
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<tr>
<td>Site with 13 wells</td>
<td></td>
<td>67,2</td>
<td>873,9</td>
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<tr>
<td>Site with 20 wells</td>
<td></td>
<td>57,1</td>
<td>1142,0</td>
</tr>
</tbody>
</table>
Prevention of permafrost thawing

• Change of permafrost conditions of object foundation soils during construction and exploration makes an essential impact on stability of system soil - foundation and consequently on a stability of the structures.

• Progression of negative geocryological processes starts even with minor changes of heat balance in the system “air-construction-permafrost”. That is why the very important issue is the development of temperature control means of foundation soils and other infrastructure facilities.

• Without regulation and stabilization of heat conditions of permafrost with the aid of different types cooling facilities the construction and exploration of field facilities in areas with cryolithozone are practically impossible.
Gazprom VNII GAZ carried out scientific and technological work of design and implementation of efficient double-phase cooling facilities of different types and modifications. This heat-exchange equipment is now popular in industrial and civil construction. That is why to eliminate a negative technological impact nearby pile foundations it is required to install season cooling facilities, which reduce the soil temperature and raise a pile load capacity during its work.
Prevention of permafrost thawing at wellhead area

To prevent the degradation of permafrost at wellhead area during exploration period together with known passive methods (cement heat insulating screens, special cement Termafrost, insulated lift pipe, etc.) we introduce new technology and techniques of active protection using self-sufficient season cooling facilities - vertical type long-length cooling facilities DOU-03V.

Studies and process modeling of thermal interface in the system “wells – permafrost – double-phase thermosyphon - air” were carried out justify and estimate wells pattern step and optimal installation layout of double-phase thermosyphon at wellhead area.

The modeling fits to the climatic conditions of Gydan. Calculations were done for the gas temperature in wells as 8, 16 and 30oC at depth 10m underground with and without heat insulation and with and without long-length cooling facilities DOU-03V.

Based on the results of modeling and design features of cluster sites an interval between wells at site can be no more than 6m
Results of modeling

On top: ground temperature profile around well with the gas temperatures 8°C and 30°C at the start of exploration moment;
Left: ground temperature profile around well and DOU-03V with the gas temperatures 8°C after 10 years of exploration;
Right: ground temperature profile around well and DOU-03V with the gas temperatures 30°C after 10 years of exploration.
Based on the results of modeling it is possible to make following conclusions:

- Without use of heat insulation and long-length cooling facilities DOU-03V permafrost thawing areolas would close after 10 years if the gas temperature will 8 °C, or after 2 years if the gas temperature will 30 °C.
- Using only heat insulation without long-length cooling facilities DOU-03V with high gas temperatures (16-30 °C) allows only to slow down permafrost thawing. In this case closing of thawing areolas would accrue after 12-15 years.
- Using double-phase thermosyphons provides safe exploration of well whatever gas reservoir temperature (8, 16, 30 °C) at a field, because stationary permafrost heat conditions will accrue after five years of its exploration. Even if the gas temperature is 30 °C the permafrost thawing areolas around well would not go over 1 m.
Thanks for your attention