Perspectives of utilization and usage of produced gas to increase recovery factor

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- **In the oil producing sector more than 90% of oil is produced in the fields, which are on the latest stage of development and are being developed with the application of water flooding. However more than a half of recoverable reserves of oil remain in the layer.**

- **The search for new methods is going primarily through the way of water flooding perfection.**

- **However, it is necessary to note that this approach becomes unacceptable during the production from deep-seated low-permeability layers (0,01 – 0,1 mkm^2). Under these conditions the usage of surface active agents and polymers is of low efficiency due to high layer temperature and substantial adsorption of chemical reagents in the reservoirs which have great specific surface.**

- **In the majority of oil-producing regions there is a great problem of utilization and usage of the resources of the produced hydrocarbon gas and broad fraction of light hydrocarbons (BFLH). The volumes of produced gas that contains 60 – 90% moles of methane the quantity of which amounts to billions of cubic meters are not used and are burnt on the flares. In these conditions perspective energy-saving methods to increase the recovery factor will be purely dry hydrocarbon gas injection or its combination with water-flooding.**

- **The methods of water-gas influence combine the advantages of gas such as a high quotient of oil displacement as well as advantages of water – achievement of a higher quotient of conformance. Water and gas can be injected simultaneously as well as sequentially (first water and then gas and vice versa).**

- **If water injection is effected in combination with gas injection, the increase of production rate with the usage of dry hydrocarbon gas will be from 5 – 10% to 15 – 20% with the usage of purified broad fraction of light hydrocarbon of gas.**

- **The main disadvantage of this method of formation influence is preservation of possibility of gas break through the fissures in heterogeneous layers.**

- **To overcome the said negative effect it is necessary to limit gas mobility.**

- **Pure gas influence is effective provided there is miscible or partially miscible displacement when surface tension forces on the border oil – gas are practically absent. Herewith the displacement quotient can amount to 95 – 98%, However it is not always that you can achieve the condition of miscible or partially miscible displacement for real layers.**

- **In case we do not have complete oil-gas miscibility, that is to say partial miscibility, similar results can be achieved with the application of foam formation effect with water-gas influence. For light oils this technology can be realized with the injection of rich gas with the application of foam formation agents in the process of water-gas influence, while for medium and heavy oils with the injection of gas enriched by the broad fraction of light hydrocarbons or CO_2 during the process of water-gas influence.**

- **The mechanism of water – gas influence with the application of foam formation effects can be based on the fact that gas can be present in the layer not only in the free form, but can also be dissolved in the form of micro bubbles occluded in the oil.**

- **Foam formation effect can also be created in the oil with water by adding various foam formation reagents which are soluble in oil and water. In order to produce light oils which are characterized by a rather low content of natural surface-active substances it is possible to inject into the layer water bank which contain foam formation substances which dissolve better in the oil than in water.**

- **On this basis there have been proposed various methods of oil pool development protected by the patents of the Russian Federation which can substantially increase the recovery factor. As the investigations have shown the majority of micro bubbles are adsorbed in the porous medium forming by this a layer which can be conventionally called “gas bearing”. Herewith the hydraulic resistances decrease, pressure difference decreases, and the oil with a part of occluded micro bubbles acquires a higher velocity (“channeling” effect). Herewith there is a substantial growth of fluid relative permeability and the oil productivity (fig. 1, 2).**

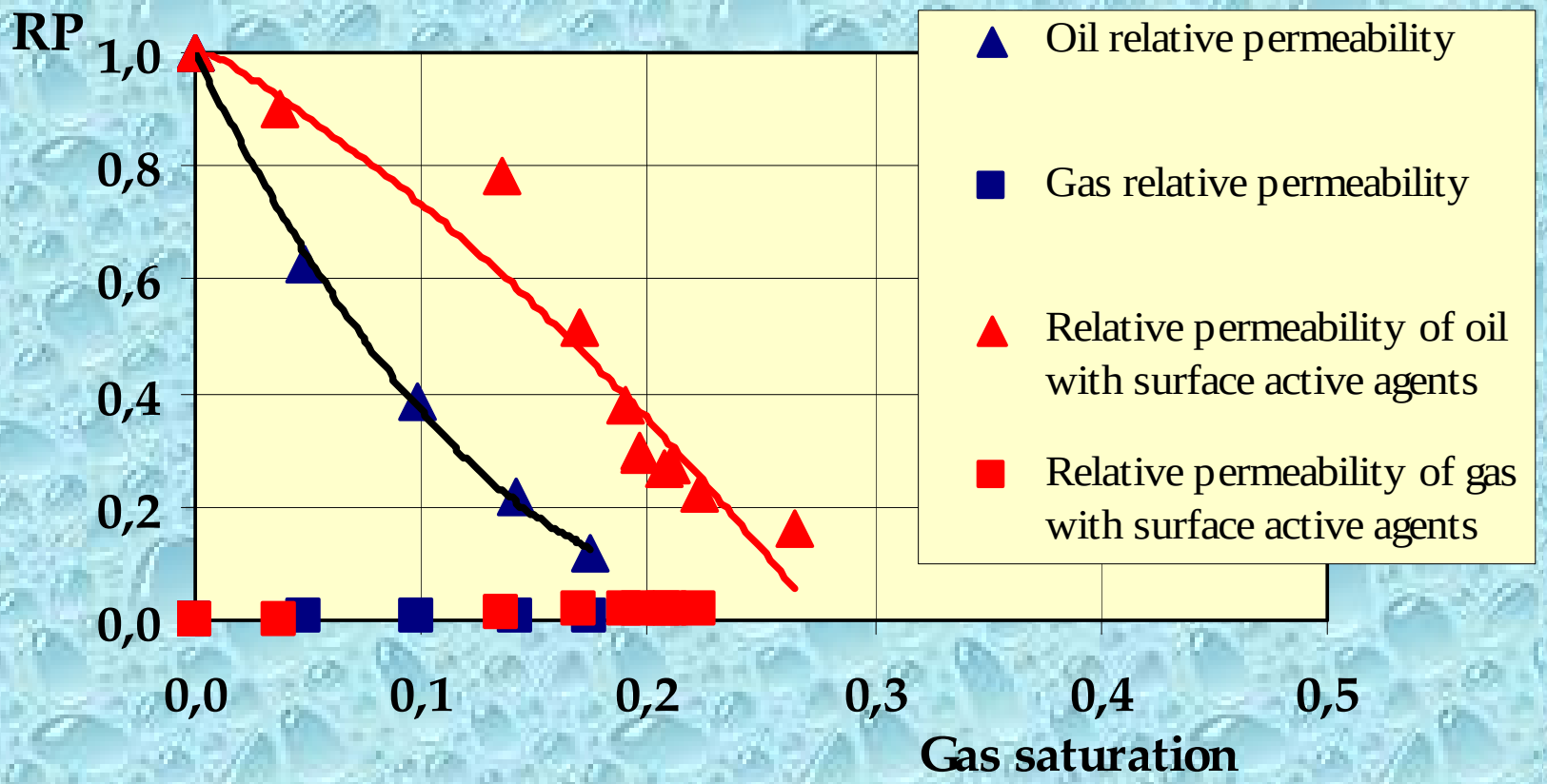

Fig. 1. Oil and gas relative permeability

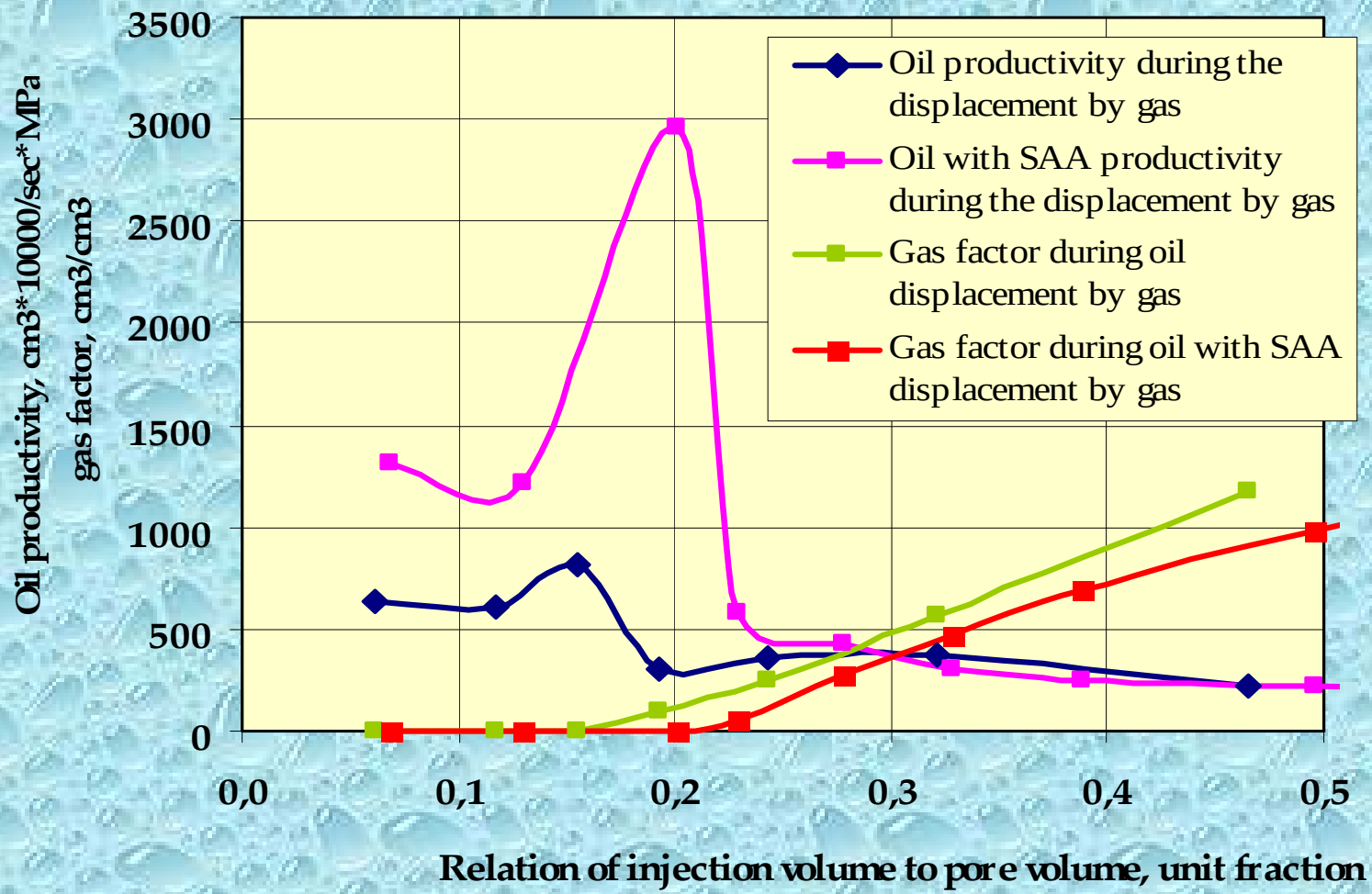

Fig. 2. Changes in productivity and gas factor during light oil displacement and displacement of oil with foam formation surface active agent by gas

- **With water-gas methods with the application of foam formation effect one can do with the resources of produced gas received in the fields. The utilization of this gas can substantially increase the recovery factor of the layers which pertain to hard to recover reserves.**

- **Calculations effected for the sections of oil and oil-gas layers of some oil fields have shown that the growth of oil displacement efficiency may reach 10 – 15%.**

- **The series of experiments effected by OJSC "VNIIneft" on the displacement of real oils under formation conditions on the installation of high pressure by water, water – gas influence and water-gas influence with the application of foam formation reagents have shown substantial advantages of the latter method in the conditions when miscibility of gas and oil are almost absent in comparison with water flooding and water – gas influence (fig. 3).**

- **As an example we can present the results received for low viscous oils of the layer AB-1 of the oil field Samotlorskiy. During the water-flooding oil displacement efficiency is equal to 0,54, the application of water-gas influence with methane increases oil displacement efficiency up to 0,66, while the application of water-gas influence with surface active agent of foam formation increases oil displacement efficiency up to 0,76, that is to say by 15% in comparison with water-gas influence.**
- **For highly viscous oils (μ = 90 mPa*s) for the layer PK-1 of the oil field Severo-Komsomolskiy, the foam formation of which is equal to 1,14 under 60 ^{0}C, flooding by hot water produces the possibility to acquire the displacement efficiency on the level of 0,41, while the application of water-gas influence method with foam formation surface active agents under the formation temperature of 34 ^{0}C increases the displacement efficiency up to 0,6, that is to say by 46%.**
- **For highly paraffinic oils of the layer P-5 of the oil field Kharyaginskiy with the conditions of average foam formation (1,37) and formation temperature on the level of 36 ^{0}C oil displacement efficiency increases with the application of water-gas influence by 14% in comparison with water flooding.**

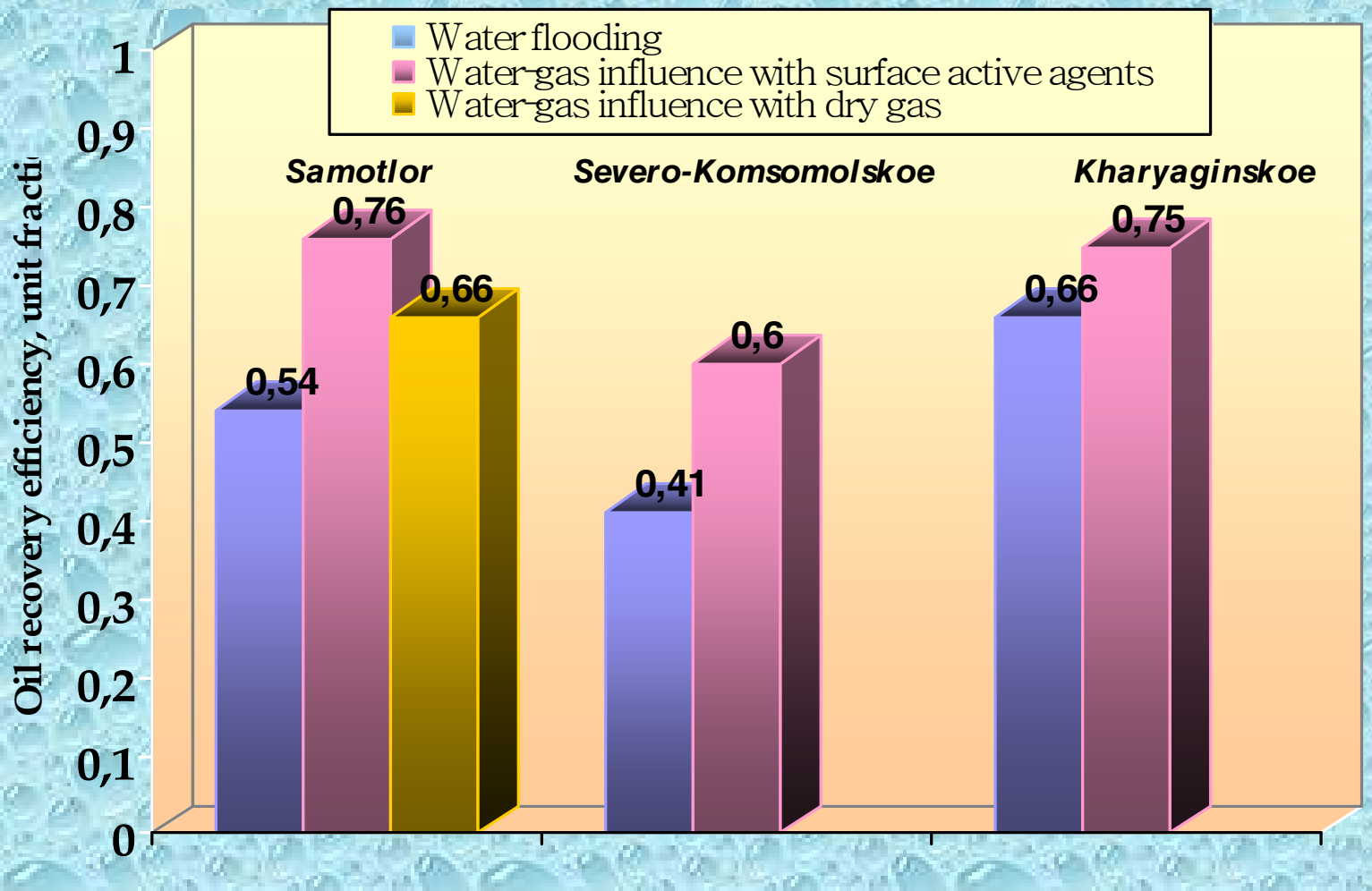

Fig. 3. Changes of oil recovery efficiency depending on technologies