ANALYSIS OF THE EFFECTIVENESS OF MODERN PROPPANTS USING HYDRODYNAMIC MODELING FOR THE OIL FIELD IN WESTERN SIBERIA

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Oil reserves of most fields at both Western Siberia and Russia as a whole, are hard-to-recover, which means that they are located in deposits confined to low-permeable and poorly drained reservoirs. Hydraulic fracturing (fracking) is one of the most commonly used methods of stimulating production, used to make the extraction of oil from such deposits profitable.

Russian oil and gas companies, along with the leading global giants of the industry, strive for the use of the most advanced technologies and materials so as to maximize profits and reduce environmental risks. At request of Gazpromneft Science & Technology Centre, together with the Heriot-Watt center, for the purpose of increasing oil production at the specific field, an analysis of more than 30 scholarly works on the study of proppants for the past year has been carried out. This paper provides a brief critical review of the two types of proppant, approved by Gazpromneft Science & Technology Centre for the follow-up examination, as well as the results of mathematical modeling. [2]

According to the totality of technical, technological and economic parameters, two types of propping agents have been recognized as the most appropriate: SD3 and FCFP.

The first one, SD3, is a novel type of ceramic proppants with high physical and mechanical properties based on serpentinite rocks. The uniqueness of the proppant is based on the transformation of hard-to-sinter forsterite into enstatite after the sintering process. This effect is achieved by adding diatomite raw materials to the pre-calcined serpentinite, which leads to the reduction of the firing temperature from 1300–1350 °C to 1280–1250 °C. This made it possible to develop compositions and technological parameters for obtaining magnesia-silicate proppants with a bulk density of 1.58–1.62 g/cm3 at a firing temperature of 1250–1300 °C, capable of withstanding breaking pressure up to 52 MPa. These characteristics allow less energy to be spent on manufacturing the SP3 proppant, while at the same time producing a very qualitative proppant. [1]

The second one is the fully coupled fiber–proppant (FCFP), which is developed from the resin-coated proppant with the application of fiber. There were some conclusions made after the experiment: 1) the FCFP had a high channel rate and pavement efficiency in both fresh water and hydraulic fluid with different viscosities. 2) The FCFP formed a cellular pattern in the fracture and self-grafted to support the groups, establishing high-porosity channels. 3) The FCFP was not temperature sensitive and could easily float into the secondary fracture. 4) The application of FCFP was eco-friendly by adding some polymer (with few modified fibers) and could be used without the polymer of fracture fluid. [3]

A further step was to carry out mathematical modeling of the hydraulic fracturing process in the tNavigator software. The model of the field under study was provided by Gazpromneft, the main initial data were presented by the following characteristics: rock closure pressures in the range: 3000-6000 psi (or 210-414 atm); range of cyclic loads: 20 - 100 atm; range of formation pressure values: 220-270 atm; range of formation permeability values: 0.08 - 9.2 mD; oil viscosity range: 0.4-3 cPs; water viscosity range: 0.1-1 cPs. The key properties of the proppant were specified in the model according to the manufacturer of this type of proppant or replaced by properties of similar types of propping agent. Quartz sand was used to compare with the effect of new proppant types. The data on proppant required for further calculation of the fracking process is shown in Table 1.

Table

The Initial data on proppants for further calculations

Closure pressure, atm	FCFP permeability, mD	SD3 permeability, mD	Quartz sand permeability, mD
138	420	432	395
276	385	392	358
405	340	342	312
542	260	277	234
681	205	215	195
819	155	170	132
957	110	125	98

Next, oil and water flow rates were calculated for each proppant with a linear and exponential flow function. The results of mathematical modeling of fluid inflow to the well after performing hydraulic fracturing are shown in Figures 2 and 3 for linear and exponential dependence, respectively:

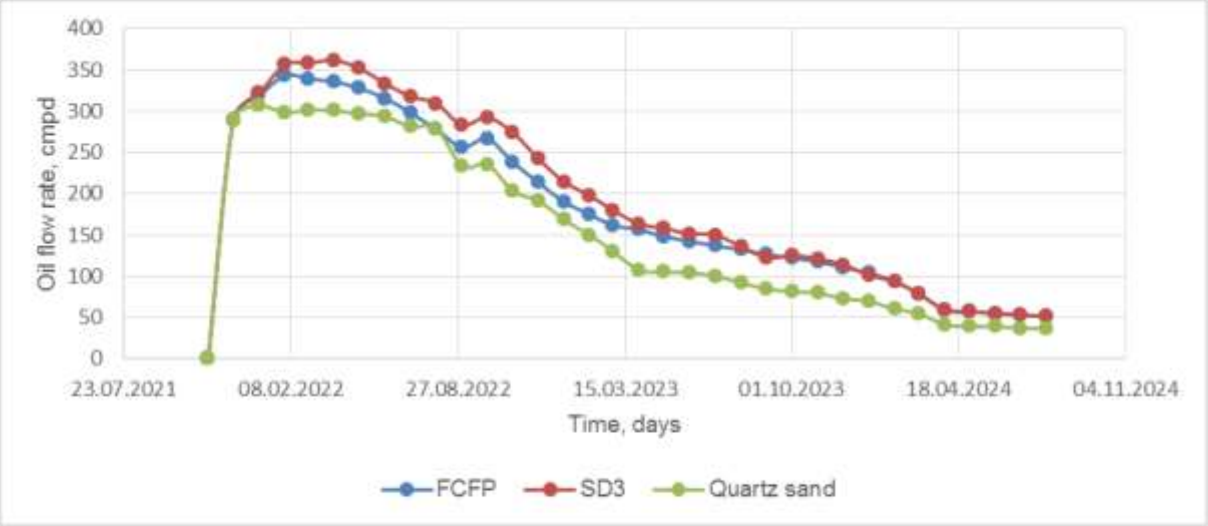

Fig. 2. Oil flow rate dynamics chart with a linear flow function

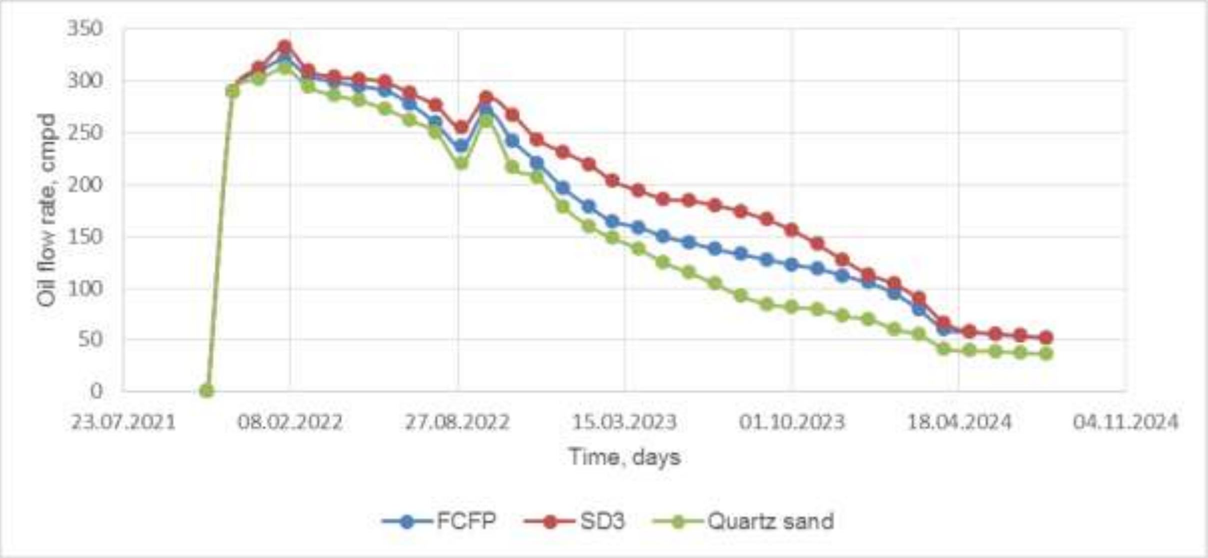

Fig. 3. Oil flow rate dynamics chart with an exponential flow function

As can be seen from the simulation results, among the three types of proppant considered, magnesia-silicate ceramic proppant with enstatite phase, SD3, is the most effective and suitable for use in the field. The findings might guide the new operation technology, optimize operation parameters, improve proppant transportation and distribution efficiency, and, finally, reduce operating expenses and increase company revenue.

References

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