Low-density ceramic proppant and its production method

The invention relates to the area of oil and gas industry and can be used for enhancement of the oil and gas production, in particular, when using the hydraulic fracturing technique. Low-density ceramic proppant consisting of a light aggregate and a ceramic binding material, wherein a natural mineral which is able, when burnt, to expand its volume in a proppant granule and to change its true and apparent densities, is used as the light aggregate.
Low-Density Ceramic Proppant and Its Production Method.

The invention relates to the area of oil and gas industry and can be used for enhancement of the oil and gas production, in particular, when using the hydraulic fracturing technique.

The invention describes ceramic granules which constitute proppant particles having a low density below 2.65 g/cm³, their composition and preparation method.

In the oil production technology based on the use of the hydraulic fracturing method, the well production is enhanced by injecting proppant granules into fractures made in an oil-bearing formation, in order to fix the position of the fracture walls, thus preventing them from closing. The proppant is injected into fractures by pumping a proppant-containing fracturing fluid under high pressure. It has been experimentally established that a lower apparent density allows a more uniform distribution of the proppant and increases the oil and gas production levels.

There is a prior-art technical solution (WO, application 2006/034298) which describes proppant granules as coated particles made of an inorganic material which is a mixture of quartz and alumina taken at a ratio of approximately 2.2 : 5 and having a bulk density less than or approximately equal to 1 g/cm³. Besides, this technical solution describes an underground formation treatment method, according to which a fracturing fluid is injected into an underground formation, and the said fracturing liquid contains inorganic particles consisting of quartz and alumina at a ratio of approximately 2.2 : 5, and the said inorganic material has an apparent density less than or approximately equal to 1 g/cm³.
Also, there are prior-art low-density composite particles (US, Patent 6,582,819) which are based on a binder and a filler and are suitable for use in the hydraulic fracturing technique. The filler may contain two or more different materials. The binder usually consists of a polymeric material, possibly, with cement added. The resulting composite particles have a bulk density varying from 0.5 to 1.30 g/cm³ and can be used as a proppant in the oil and gas production industry, as well as for filtration of water and for production of synthetic grass for sports grounds. The prior-art technical solution also describes methods of production of the said composite particles.

There also prior-art composite particles (US, Patent 6,632,527) which are based on a binder and a filler and are suitable for use in the hydraulic fracturing technique. The filler is usually a fine mineral substance to which fibrous materials can be added. Apart from the hydraulic fracturing technique, the said particles can be used for filtration of water and for production of synthetic grass for sports grounds. Methods of production of the said composite particles are also described.

According to experimental checks, the prior-art proppants show lack of efficiency in the hydraulic fracturing technique.

The technical problem to be solved by the technical solution developed consists in the development of a ceramic proppant having a density below 2.6 g/cm³.

The technical result obtained through the implementation of the technical solution developed consists in the enhancement of the production of a well which is worked by using the hydraulic fracturing technique.

In order to achieve the said technical result, it is proposed to use a proppant in the form of spherical and/or angular particles having a low
apparent density below 2.6 g/cm³ and consisting of a light aggregate which is also referred to as a filler, and of a binding material which is also referred to as a binder.

The said light aggregate is a natural mineral which is able, when burnt, to form a new phase in a proppant granule and to change the specific volume of the light aggregate (vermiculite, pearlite, hydromicas and natural zeolites) or which already has a porous structure (pumice).

It is possible to pre-coat the said light aggregate with an organic or inorganic (including metal) coat (e.g. silicon, dextrin, silicate glass, epoxy resins or their compositions), in order to improve the molding properties and the end-use properties of the material.

It is possible to use combinations of different types of light aggregates (in particular, at least one of the following series: vermiculite, agglporite, expanded clay, pearlite, synthetic and natural zeolites) at different weight ratios and each of the light fillers can be pre-coated. The light filler content in the finished product is below 80 wt% (usually 10-40 wt %) and depends on the physical properties of the fillers themselves, as well as on the requirements imposed on the resulting proppant granules.

The binding materials are organic, inorganic or metal powders, such as bauxites, kaolins, clays, alumina, metallurgical-grade slags, phenol-formaldehyde resins, aluminum, bronze or their combinations.

The developed proppant granule production method includes pre-crushing and pre-mixing of raw components, followed by their granulation, drying and screening to size. In this method, at least a ceramic binder and a filler are used as the raw components, and at least one natural mineral which is able, when burnt, to form a new phase in a proppant granule and
to change its apparent density due to volume changes caused to the filler by heat treatment, is used as the light aggregate.

According to one embodiment of this method, a previously heat-treated filler or a mixture of different fillers is added, along with other components, to the base material, and the mixture is then granulated and burnt. For example, 25% of the mixture consisting of kaolin and bauxite are added to pre-expanded clay having a porosity of 75% and an average particle size of about 40 microns. The ratio of kaolin to bauxite in the mixture is 80 to 20 wt%, respectively. The resulting mixture is granulated in an Eirich-type mixer, with a 5% solution of polyvinyl alcohol added thereto in the amount of 10 vol% of the volume of the material to be granulated. The total granulation time is equal to 4 minutes, out of which 1 minute constitutes the nucleation time and 3 minutes constitute the granule growth time. The resulting granulated material is dried in a desiccator at a temperature of 100°C and is then burnt at a temperature of 1,350°C at a rate of 3°C per minute and held at the final temperature for 2 hours. The resulting proppant 20/40 in size has shown a density of 1.75 g/cm³ and a crushing strength of 5 wt% at 5,000 psi.

According to another embodiment of this method, a filler which has not been previously heat-treated is added, along with other components, to the base material, and the mixture is then granulated and burnt. It is possible to pre-treat this filler with different substances (in particular, with hydrogen peroxide or with a number of phosphate binders, such as H₃PO₄, an aluminum-chromium-phosphate binder, an aluminum-boron-phosphate binder, an aluminum-boron-phosphate concentrate, potassium-ion-containing salts, as well as with a number of ammonium salts and nitrate
salts) in order to intensify the phase formation process and to reduce its temperature.

For example, raw vermiculite powder is pre-coated with an aluminum-chromium-phosphate binder at a ratio of 9 to 1. The resulting mixture is mixed in a mixer for 2 minutes. 90% of kaolin clay is added thereafter to the resulting pulp in addition to 100% and granules are rolled. The resulting granulated material is dried, burnt at a temperature of 1,350 °C and then screened to size. The resulting proppant 20/40 in size has shown a density of 2.3 g/cm³ and a crushing strength of 5 wt% at 7,500 psi.

According to the third embodiment of this method, when using two or more additives, one or more previously heat-treated fillers are mixed with the ceramic binding material and with other components, while the remaining fillers are added to the binding material without being heat-treated, and the mixture is then granulated and burnt.

For example, raw vermiculite powder is pre-coated with an aluminum-chromium-phosphate binder at a ratio of 9 to 1. The resulting mixture is mixed in a mixer for 2 minutes. 70% of kaolin clay is added thereafter to the resulting pulp in addition to 100% and granules are rolled and 30% of expanded clay is added. The resulting granulated material is dried, burnt at a temperature of 1,350 °C and then screened to size. The resulting proppant 20/40 in size has shown a density of 2.0 g/cm³ and a crushing strength of 6 wt% at 5,000 psi.
Claims.

1. Low-density ceramic proppant consisting of a light aggregate and a ceramic binding material, wherein a natural mineral which is able, when burnt, to expand its volume in a proppant granule and to change its true and apparent densities, is used as the light aggregate.

2. Proppant according to claim 1, wherein vermiculite, pearlite, hydromicas, natural zeolites, aggloporite, expanded clay are used as the natural mineral which is able, when burnt, to expand its volume in a proppant granule and to change the specific volume of the additive.

3. Proppant according to claim 1, wherein the light aggregate content in a proppant granule does not exceed 80 wt%.

4. Proppant according to claim 1, wherein the light aggregate is pre-coated with an organic or inorganic coat before it is added to the raw mixture.

5. Proppant according to claim 1, wherein clays, kaolins, bauxites or their compositions are used as the binding material.

6. Proppant according to claim 5, wherein alumina, metallurgical-grade slags, phenol-formaldehyde resins, aluminum, bronze or their combinations are additionally added to the binding material.

7. Proppant production method which includes pre-crushing and pre-mixing of raw components, followed by their granulation, drying and screening to size, wherein at least a ceramic binding material and a light aggregate are used as the raw components, and at least one natural mineral which is able, when burnt, to expand its volume in a proppant granule and to change its specific volume, is used as the light aggregate.

8. Method according to claim 7, wherein the light aggregate is burnt prior to the mixing stage, which results in a volume change.