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(54) **Method of insulating water in the bottomhole zone of a production well**

(57) Abstract:

The invention relates to the oil industry, in particular to the method of carrying out water insulation works in a well during the development of an oil deposit underlain by water. EFFECT: increasing the efficiency of water insulation in the bottomhole zone of oil producing wells with a simultaneous reduction in the labor intensity and duration of water insulation works. The method of insulating water in the bottomhole zone of a producing well with hydraulic fracturing cracks includes pouring the insulating compound into the well with a preliminary determination of the volume of the insulating compound and selling it into the reservoir. In this case, they choose a well that is waterlogged solely due to the formation of a water cut cone. Determine the required volume of the insulating composition $V_{general.}$ according to the formula $V_{general.} = V_1 + V_{total.tr.}$, where V_1 - the volume of the well from the lower edge of the perforation to the bottom of the well, $V_{total.tr.}$ - the volume of the aquifer part of the crack space. Volume $V_{total.tr.}$ is calculated by formula $V_{total.tr.} = V_{pr.} \cdot h_3/h_1$, where $V_{pr.}$ is the volume of proppant pumped during hydraulic fracturing, m^3, h_1 is the capacity of the oil reservoir, m, h_3 is the capacity of the aquifer part of the reservoir, m. Pour the insulating composition of volume $V_{totally}$ into the selected well, pump into the well a sales fluid for pushing through the holes of perforation of the well of the insulating composition, creating an excessive hydrostatic pressure of the column of sales fluid, for the gravitational replacement of formation water in the hydraulic fracturing crack and the formation of a waterproof anti-filtration insulating screen at the base of the hydraulic fracturing crack in the bottomhole zone of the formation. A weighted polymer solution is used as an insulating compound, and water is used as a sales liquid. Moreover, an insulating composition and a sales fluid of such density are chosen at which the hydrostatic pressure of the column of the insulating composition and the hydrostatic pressure of the column of the sales fluid exceed the residual reservoir pressure. 1 z.p. f-ly, 4 il.

The invention relates to the oil industry, in particular to the method of carrying out water insulation works in a well during the development of an oil deposit underlain by water, namely to the isolation of the inflow of reservoir water in a well watered by being pulled up to the perforation zone of the water cut cone.

Various methods of carrying out water insulation work in a well are known from the prior art, but most of them are labor-intensive.

With a long stage of development of oil fields, as the reservoir pressure decreases, a water cut cone appears in the oil-saturated part of the deposit. Initially, plantar water begins to be pulled up to the wellbore in the form of a water cone, and through the perforation holes of the perforation interval, it will begin to rise along the shaft, overlapping the perforation interval, preventing oil from flowing from the well to the surface. The well is flooded and oil production from it stops.

This can be achieved by pumping through the perforation holes in the operational column to the upper part of the water-saturated zone of the reservoir (in contact with oil) a solution of a movable viscoelastic screen (Stukanogov Yu.A., Kogan E.S., Optimization of the mode of operation of water and oil deposits, Gas Industry, 1987, No. 5, pp. 58-61).

A method for isolating the inflow of reservoir water is known, including pumping a pressurized oil-well solution into the water-manifesting part of the reservoir and holding the well for the time of setting the oil-well solution (Reference book on current and overhaul of wells, A.D. Amirov et al., M.: Nedra, 1979, pp. 238-241).

The disadvantage of this method is the insufficient radius of the waterproofing screen, beyond which plantar water will bypass the waterproofing screen and the flooding of the well will continue.

A method for isolating the inflow of plantar water is known, including pumping a plug-in solution into the water-manifesting part of the reservoir under pressure and holding the well for the time of setting the oil-well solution (patent RU 2127807, MPC E21B 43/32; E21B 33/13, publ. 20.03.1999).

The disadvantage of this method is the insufficient radius of the waterproofing screen, beyond which plantar water will bypass the waterproofing screen and the flooding of the well will continue.

Methods for the development of a waterlogged oil field are known (patent RU 2509885, IPC E21B 43/32, publ. 20.03.2014), the method includes drilling the field with production wells crossing the reservoir, consisting of a water-saturated zone separated by an impermeable natural layer with an oil-saturated zone, lowering the casing with subsequent perforation of the reservoir, studying its oil and water saturation and intervals of their occurrence, the size of the impermeable natural stratum, creation of a screen from an insulating compound separating the water-saturated zone of the reservoir from the oil-saturated zone, cutting out part of the casing column, expanding the wellbore in this interval, pouring the extended interval of the wellbore with an insulating compound, drilling the insulating compound after curing the insulating compound.

A method is known (patent RU 2586120, IPC E21B 43/32; E21B 33/138, publ. 10.06.2016), containing steps at which: prepare the insulating composition in a volume exceeding the internal volume of the well from the face to the upper limit of the perforation interval. A column of filling pipes is lowered into the well. The insulating compound is poured into the well at least to the upper limit of the perforation interval with the sale into the reservoir. Remove the column of pouring pipes from the well. Leave the insulating compound for curing. After curing the insulating compound, the insulating composition is drilled and the reservoir is opened by gentle perforation of the well in the roofing part of the reservoir. Moreover, the volume of the insulating composition is determined by the given mathematical expression.

The disadvantage of the method is that it requires an opening of the reservoir, which complicates it, in addition, they require the use of complex additional equipment, while the effective flow section of the well is reduced.

The closest technical solution to the claimed invention is a method for insulating water in the bottomhole zone of a producing well (patent RU 2326229, MPC E21B 33/13, publ. 10.06.2008), including the injection of water insulation material into the well with a preliminary determination of the volume of water-insulating material and its sale into the reservoir (aquifer part of the crack space), the waterproofing material is placed in the ring space of the bottomhole zone of the well, limited by equipotentials.

The disadvantage of this method is the complexity of determining the volume of waterproofing material.

The efficiency of oil well operation, with the presence of water-oil contact, in the cracks of hydraulic fracturing (hydraulic fracturing) is significantly influenced by the cone of water formation, as a result of which the well is significantly waterlogged. Existing technical solutions do not fully allow to solve this problem. Currently, there is a need to improve the efficiency of oil wells with plantar water.

The object of the invention is to increase the efficiency of the method of isolating water in the bottomhole zone of oil producing wells, reducing the labor intensity and duration of its implementation.

The task is solved by means of insulating water in the bottomhole zone of a production well with hydraulic fracturing cracks (hydraulic fracturing), including pouring the insulating compound into the well with a preliminary determination of the volume of the insulating compound and selling it into the reservoir, while choosing a well that is waterlogged solely due to the formation of a water contention cone, determining the required volume of the insulating composition $V_{generally}$ according to the formula.

$V_{total.}=V_1+V_{total\ tr.}$,

where V_1 is the volume of the well from the lower edge of the perforation to the bottom hole of the well,

$V_{total.tr.}$ - the volume of the aquiferous part of the fissure space,

$V_{total.tr.}$ - calculated by the formula

$V_{obshch.tr.}=V_{pr}\cdot h_3/h_1$,

where $V_{pr\ is\ the}$ volume of proppant pumped in hydraulic fracturing, m^3,

h_1 is the capacity of the oil reservoir, m,

h_3 is the thickness of the aquifer, m,

then prepare a solution of the insulating compound with a volume of $V_{total.}$ and pour the insulating compound into the selected well, pump a sales fluid into the well to push through the holes of the well perforation of the insulating compound, creating an excessive hydrostatic pressure of the column of the sales liquid, for gravitational replacement of the reservoir water in the hydraulic fracturing crack and the formation of a waterproof anti-filtration insulating screen at the base of the hydraulic fracturing crack in the bottomhole zone Of the reservoir, a weighted polymer solution is used as an insulating composition, and water is used as a sales liquid, and an insulating composition and a sales fluid of such density are chosen at which the hydrostatic pressure of the column of the insulating composition and the hydrostatic pressure of the column of the sales liquid exceed the residual reservoir pressure.

Preferably, the hydrostatic pressure of the column of the insulating composition and the hydrostatic pressure of the sales fluid exceeds the reservoir pressure of not more than 5-10 kgf/^{cm2}.

Disclosure of the invention.

Preliminary stages of work for the implementation of the proposed invention.

1. According to the working affairs of wells at the field, the most suitable wells for water insulation work are selected, those that have cracks.

A proppant (proppant) is pumped into the fracture during hydraulic fracturing to prevent the crack from closing and thus ensure improved recovery of the extracted fluids, such as oil, gas or water.

The proppant maintains the distance between the walls of the crack, creating permeable channels in the formation.

The choice of wells is made according to the following parameters:

- well stratigraphy;

- well design;

- history of well operation.

2. Well stratigraphy.

At this stage, the composition of the oil-bearing reservoir is evaluated. According to the data of geophysical materials, the depth of the deposited reservoir is studied (the depth of the sole and roof of the reservoir), then the thickness of the reservoir is determined. According to the data of inclinometry, we determine the curvature of the shaft and then the reservoir power along the wellbore. We also determine the degree of homogeneity of the oil reservoir and the presence of impermeable prostrates in it. Next, the level of reservoir pressure is determined.

In FIG. 1 shows schematically the location of the well in the oil reservoir,

Where is:

h_1 is the capacity of the oil reservoir;

h_2 is the capacity of the oil-saturated interval;

h_3 is the capacity of the aquifer part of the formation;

h_4 is the perforation interval;

3. Well design.

The depth of the well face, the diameter of the casing columns and the perforation interval are determined. These indicators are necessary in the future for calculations, when determining the volumes of the insulating composition and the sales fluid.

The hole hole depth is used to determine the volume of the V1 well from the bottom edge of the perforation to the bottom hole.

4. History of operation.

In the history of operation of wells, we determine the amount of oil extracted to determine the percentage of oil extracted from the drained reserves. Next, the graph of waterlogging of wells is studied. According to the graph of waterlogging, the method of watering is determined.

In the process of operating wells at maximum levels in the bottomhole zone of the reservoir, at the level of the water-oil contact (VNK), a zone of increased vacuum appears, which contributes to pulling up to the perforation zone of reservoir water.

Due to the significantly lower viscosity, the water covers the entire perforation zone and the well further supplies exclusively reservoir water to the mouth.

The largest discharge zone is in the immediate vicinity of the wellbore. As you move away from the barrel, the level of discharge weakens.

The magnitude of the discharge is directly proportional to the magnitude of the depression and inversely proportional to the distance from the bottomhole zone.

In FIG. 2 shows the change in the magnitude of the discharge at a distance from the bottomhole zone, where:

1 - level of VNK;

2 - perforation interval;

3 - zone of greatest discharge;

4 - zone of moderate discharge;

5 - low discharge zone;

6 - area not subjected to discharge;

7 - the roof of the oil reservoir.

8 During the operation of the well, the zone of greatest discharge increases, which leads to an increase in the cone of waterlogging, and as a result, an increase in the zone of overlapping of the perforation interval with water.

In the intercrushed space of the reservoir, the level of VNK remains almost at the initial level.

In FIG. 3 shows a top view of the wellbore, conditional cracks and the direction of movement of the liquid, where:

8 - wellbore;

9 - conditional crack;

10 - the direction of movement of the liquid;

11 - edge of the crack.

The essence of the proposed method is as follows: the volume of cracks from the sole 17 and up to the level of BNK 1 is filled with an insulating compound - for example, a weighted polymer solution. As an insulating composition, any compositions known in the art are used, it is possible to use in the composition of additional additives that improve the pushing of the insulating compound through the perforation holes of the perforation interval 2 in the well. Under reservoir conditions, the polymer solution in a static position, under the influence of elevated temperature, acquires pronounced viscoscous-viscous properties and creates an obstacle in the way of produced water.

Oil, since it is above the level of BNC 1, has the possibility of unhindered access to the perforation zone of the well.

The proposed method is carried out as follows:

1. From the entire well stock, choose the most suitable well. The well must have a water cut solely due to the formation of a water cut cone.

2. We study the lithology of the well, determine the composition of the reservoir, the presence of uniformity of the reservoir or the presence of layers in it, determine the residual reservoir pressure. We also determine the viscosity of oil and its composition. We determine the composition of the produced water, the density.

3. We calculate the volume of water-polymer solution $V_{total.}$, necessary for injection into the well, which includes the volume V_1 of the well from the lower edge of the perforation 15 to the bottom of the well 12 and the volume of the aquifer part of the fracture space $V_{tr.}$, which is equal to the volume of the proppant solution $V_{pr.}$, pumped into the aquifer part of the crack space during hydraulic fracturing.

In FIG. 4 shows the preparation of the well for the implementation of the method of water insulation.

1 - level of VNK;

2 - perforation interval;

8 - wellbore;

11 - edge of the crack;

12 - well bottoming;

13 - produced water;

14 - funnel;

15 is the lower edge of the perforation interval;

16 - funnel shoe;

17 - the sole of the aquifer part of the formation (the base of the hydraulic fracturing crack).

The ratio of the thickness of the oil reservoir h_1 and the power of the aquifer of the formation h_3 shown in FIG. 1 is used to determine the volume of the insulating composition for displacing the formation water, since in the intercrushed space of the reservoir the level of VNK remains at the initial level.

We determine the total volume of the cracked space ($V_{total\ tr.}$) by the volume of pumped proppant $V_{p.}$ with hydraulic fracturing. At 100% of the crack height, V_{is} also equal to 100%. The percentage h_3 of h_1 is equal to the ratio of $V_{total\ tr.}$ to $V_{pp.}$. Therefore, the percentage of the aquifer part of the crack space is equal to the percentage of the volume of the pumped proppant.

Using this simple calculation, made from the well data, we find the volume $V_{total.tr.}$ of the insulating compound that needs to be pumped into the base of the hydraulic fracturing crack in the bottomhole zone of the formation. There are known calculations of the size of hydraulic fracturing cracks, but all of them are quite complicated.

4. As we calculate the required volume, for example, a water-polymer solution, we determine the chemical composition of the reservoir water and, taking into account the data, as well as the reservoir conditions, we select the necessary insulating composition, for example, a polymer, which will meet the necessary characteristics. The density of the solution is calculated according to the Darcy-Weisbach formula.

5. Next, we calculate the density of the water-polymer solution. We take residual reservoir pressure as a basis. For successful injection of the solution to the bottom of the well, it is necessary to create a hydrostatic pressure of the liquid column that exceeds the residual reservoir by no more than 5-10 kgf $/^{cm3}$.

Well preparation.

Immediately before pumping the water-polymer solution, we lift all the suspension equipment from the wellbore. Funnel 14 then descends into the well. The shoe of the funnel 16 shall be located at the level of the lower part of the perforation zone 15.

To calculate the volume of the water-polymer solution (insulating composition), it is necessary to take into account the volume of well V_1 from the lower edge of the perforation 15 to the bottom of the well 12 and the total volume of the solution V_{total}. = $V_{total.}$ +V_1.

The insulating compound with a volume of V_1 remains in the bottom of the well or is pumped out at the final stage of pumping after the sales fluid.

After preparing the required volume of the solution of the insulating composition and the sales liquid, we pump in series the solution - the sales liquid. Water with an appropriate density can be used as a sales liquid.

If necessary, the density of the sales fluid is increased in known ways.

The mode of injection of the solution into the well is calculated for each well individually. It shall ensure a gradual, without pressure surges, supply of an insulating compound - a water-polymer solution to the bottom of the well 12, followed by a flow into the crack space $V_{total\ tr.}$.

Reservoir water is gradually displaced into the wellbore, mixed with the sales fluid.

After the completion of the introduction of the water-polymer solution and the sales liquid, the well must stand to acquire the required state by the solution. The waiting time is determined depending on the polymer selected. During the wait, attachments are lowered into the well. After starting the submersible electric centrifugal pump (PETSN), pumping out the liquid begins, at the initial stage the sales fluid will be pumped out, then the reservoir water along with the sales fluid and the oil begins to pull up to the well.

An example of calculating the volume of a polymer solution for displacing produced water.

We use a vertical well with hydraulic fracturing, which has the following initial data:

1) roof of 7 oil-bearing formation 2990 m;

2) the sole of the aquifer part 17 of the oil-bearing formation 3000 m;

3) the volume of pumped proppant at hydraulic fracturing 150 m^3;

4) water-oil contact 1 at the level of 2997 m;

5) the diameter of the operational column is 140 mm;

6) reservoir pressure 350 atm.

1. Determine the volume of the solution for displacing the produced water - $V_{total.tr.}$.

The thickness of the oil reservoir h_1 is 10 m, the aquifer section is 3 m. Determine the percentage of the aquifer from the total reservoir capacity:

10 m - 100%

3 m - x

Therefore, × = 30%. It is necessary to prepare 30% of the volume of pumped proppant.

$(150\ m^3 \times 30\%)/\ 100 = 45\ m^3$

Thus, $V_{total\ tr.}$ is 45^{m3}, such a volume of insulating solution is pushed through the holes of perforation of the well into the base of the crack.

2. Determination of the density of the insulating solution and the sales liquid, taking into account the excess hydrostatic column of the liquid.

$P=\rho \cdot g \cdot h$, where:

ρ - density ($kg/^{m3}$);

g - acceleration of gravity (9.8 m/s^2);

h is the height of the column of liquid (m).

From the formula for determining the pressure of the hydrostatic column of the liquid, we derive the formula for determining the density of the solution:

$\rho=P/(g \cdot h)$

If the reservoir pressure is 350 atm., we take for calculation a pressure exceeding the reservoir pressure by 10 atm., i.e. 360 atm.

To calculate, we translate the pressure into Pascali (360 atm. = 35303940 Pa):

ρ=35303940/(9,8·3000) m=1,2 kg/^{m3} - insulating solution and sales liquid.

Using known methods of preparing solutions of insulating composition, they are prepared with a density of at least 1.2 kg.

There are formulas for determining the size of cracks in hydraulic fracturing, but they all differ in complexity.

The technical result of the proposed invention is to increase the efficiency of the method of isolating water in the bottomhole zone of oil producing wells, reducing the labor intensity and duration of its implementation.

Claims

1. A method of isolating water in the bottomhole zone of a production well with hydraulic fracturing cracks, including pouring the insulating compound into the well with a preliminary determination of the volume of the insulating compound and selling it into the reservoir, differing in that they choose a well that is waterlogged solely due to the formation of a water content cone, determine the required volume of the insulating composition $V_{generally}$ according to the formula

$V_{common} = V_1 + V_{total\ tr.}$,

where V_1 is the volume of the well from the lower edge of the perforation to the bottom hole of the well,

$V_{total.tr.}$ - the volume of the aquiferous part of the fissure space,

$V_{total.tr.}$ is calculated by the formula

$V_{obshch.tr.} = V_{pr.} \cdot h_3/h_1$,

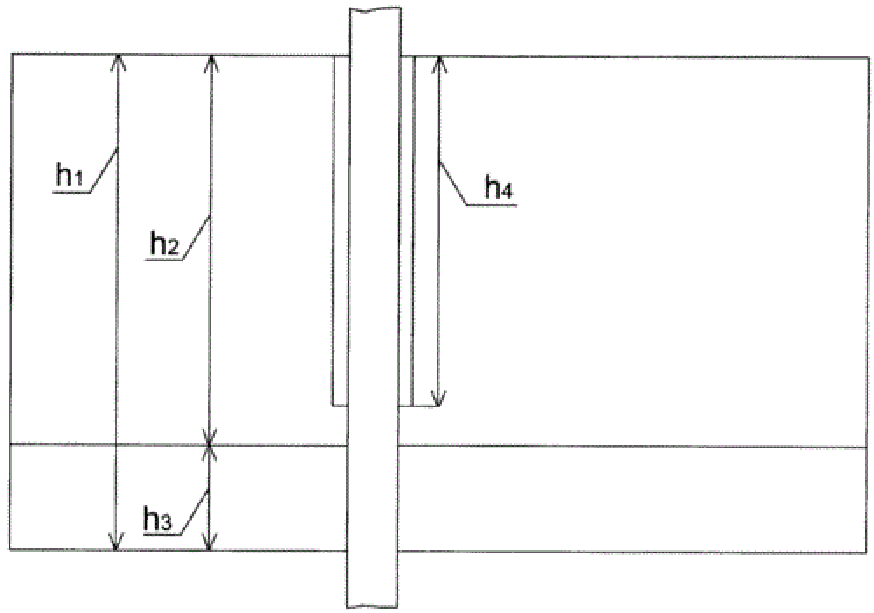
where $V_{pr.}$ is the volume of proppant pumped during hydraulic fracturing, m^3,

h_1 is the capacity of the oil reservoir, m,

h_3 is the thickness of the aquifer, m,

then prepare a solution of the insulating compound with a volume of $V_{total.}$ and pour the insulating compound into the selected well, pump a sales fluid into the well to push through the holes of the well perforation of the insulating compound, creating an excessive hydrostatic pressure of the column of the sales liquid, for gravitational replacement of the reservoir water in the hydraulic fracturing crack and the formation of a waterproof anti-filtration insulating screen at the base of the hydraulic fracturing crack in the bottomhole zone Of the reservoir, a weighted polymer solution is used as an insulating composition, and water is used as a sales liquid, and an insulating composition and a sales fluid of such density are chosen at which the hydrostatic pressure of the column of the insulating composition and the hydrostatic pressure of the column of the sales liquid exceed the residual reservoir pressure.

2. The method according to claim 1, characterized by the fact that the hydrostatic pressure of the column of the insulating composition and the hydrostatic pressure of the sales liquid exceed the reservoir pressure of not more than 5-10 kgf/ cm^2.



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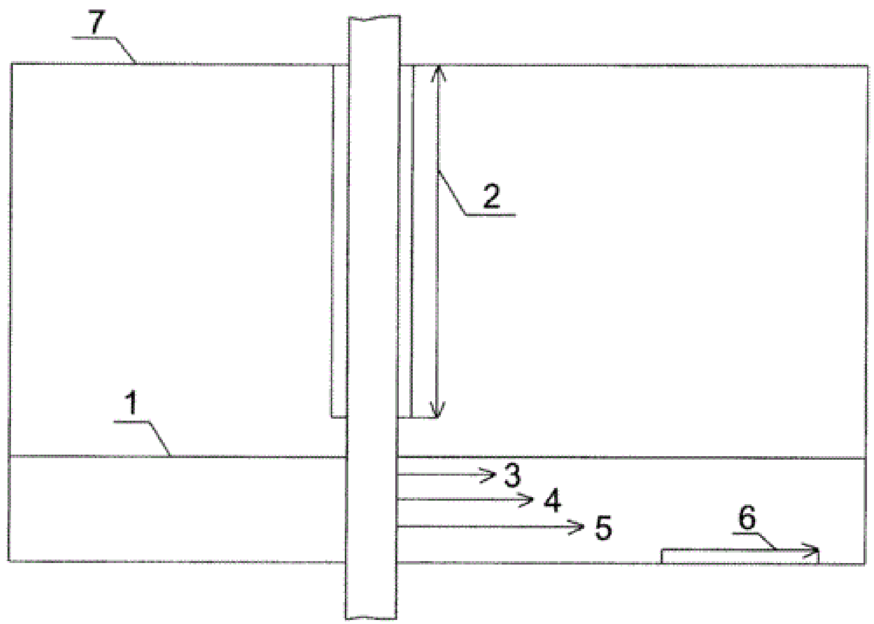

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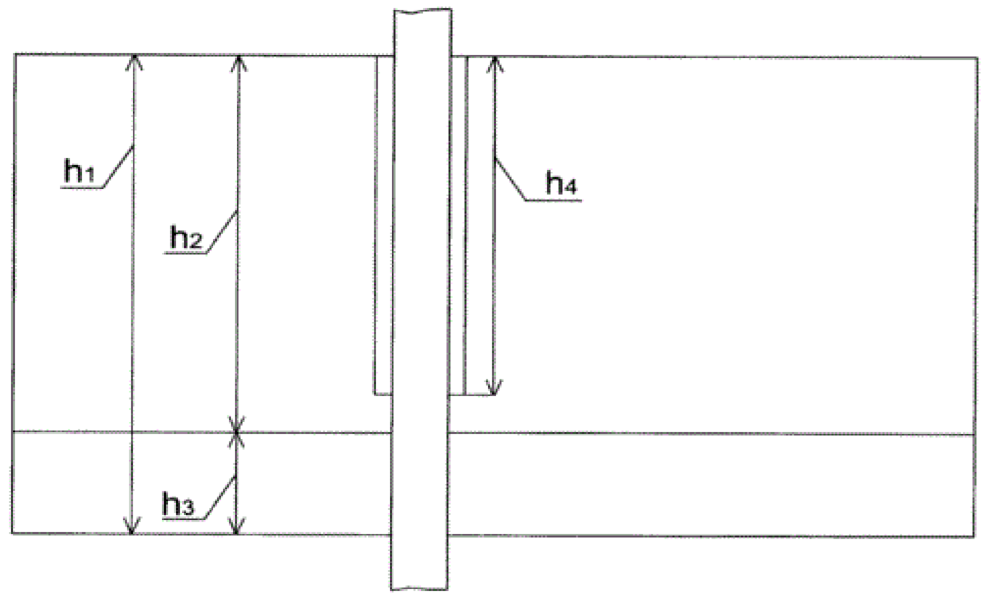

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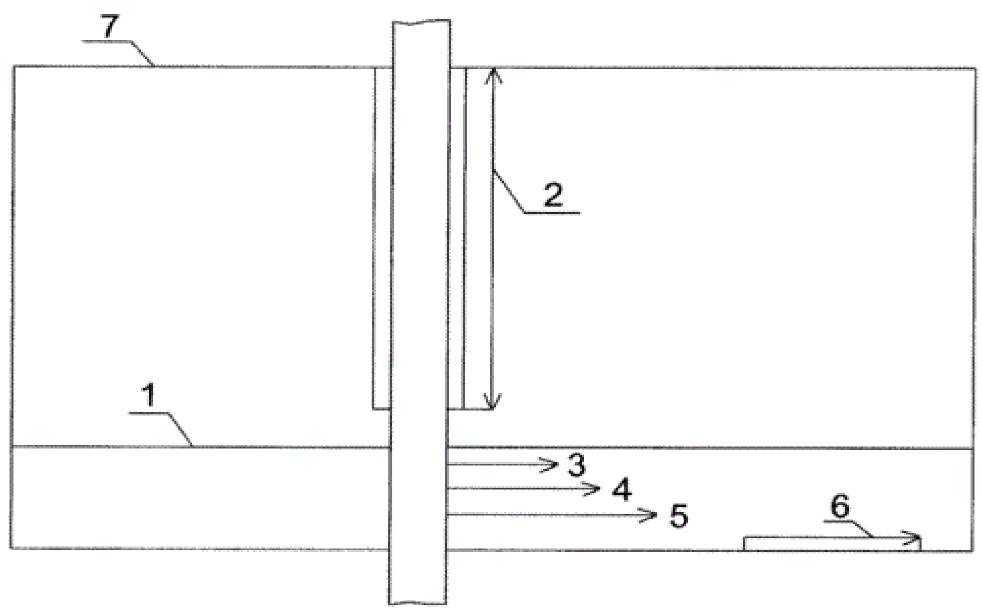

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