

A downhole-started self-locking casing centralizer

Field of the Invention

The invention relates to a centralizer capable of centrally fixing a casing in a borehole.

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Description of the Related Art

With the continuous development of the oil industry and the pursuit of productivity efficiency of high oil and gas reservoirs, the requirements for cementing quality are higher and higher, and the casing centrality in boreholes is one of the decisive factors for the quality of oil and gas well cementing. Therefore, how to accurately learn about the centralization of a casing string in a well, and how to improve the displacement efficiency in the cementing process are currently an urgent problem to be solved in oil fields. In the cementing process, the cementing quality is decided by the displacement efficiency of cementing, and the casing centrality in boreholes is an important factor affecting the displacement efficiency of cementing. Poor centrality easily results in wide edges and narrow edges. Therefore, during displacement of drilling fluid by cement slurry, cement slurry easily clings on wide edges and flows back, but drilling fluid of narrow edges cannot be displaced or fully displaced, affecting the cementing quality. Therefore, the use of centralizers plays a vital role in casing centralization in boreholes.

Existing conventional centralizers are basically divided into two categories: one is elastic centralizers, and the other is rigid centralizers, the elastic centralizers are designed according to the principle of springs, have advantages of large force, simple manufacturing process and low price, but have disadvantages of generating large running force during use, severely damaging borehole walls, and affecting normal casing running.

Rigid centralizers are further divided into semi-rigid centralizers, spiral rigid centralizers and roller type rigid centralizers. The rigid centralizers have advantages of large support force and small starting force or displacement force so that casings can run smoothly and keep at a high centrality. The rigid centralizers have disadvantages of high requirements for boreholes so that any undergaged interval cannot exist. In addition, the rigid centralizers will increase the string rigidity, resulting in difficulty in casing running, and the consumption of rigid centralizers is limited due to high manufacturing cost, complicated manufacturing process and unstable reliability.

Another downhole-started elastic centralizer is available. Although the centralizer has centralizing effect in borehole by sufficient restoring force generated by a bow spring leaf opened by differential pressure, the starting pressure thereof is difficult to control, and the maximum starting force is large, thus the centralizer is rarely used.

Summary of the Invention

The purpose of the invention is to provide a downhole-started casing centralizer with small starting force.

In order to achieve the purpose, the technical solution of the invention is to provide a downhole-

started self-locking casing centralizer, comprising a connecting part (1) and a connecting part (2) on both ends, a central supporting part being arranged between the connecting part (1) and the connecting part (2), and characterized in that the central supporting part comprises a hollow coupler, and at least three N-stage piston self-locking support devices extending by stages under pressure are evenly distributed along the circumference of the coupler, $N \geq 2$;

each N-stage piston self-locking support device comprises a support shell fixed to the coupler and a N-stage support consisting of a first stage support through an N^{th} stage support, the first stage support and the support shell are in a sliding fit, the first stage support through the N^{th} stage support are in a sliding fit successively by two adjacent stages so that the N-stage support can extend by stages under pressure from the N^{th} stage support, a supporting part for contacting with wall supports is arranged at the end where the N^{th} stage support goes against the support shell, fracture rings are formed at the bottoms of the first stage support through the N^{th} stage support, and the fracture rings allow starting pressure of the first stage support through the N^{th} stage support to drop by stages.

Preferably, the first stage support of each of the N-stage piston self-locking support device is nested in the support shell, and the N^{th} stage support through the first stage support are successively nested by two adjacent stages, wherein, a k^{th} stage support is nested in a $k-1^{\text{st}}$ stage support, $k=1, \dots, N$.

Preferably, the fracture ring of the current support and the inner wall of an adjacent support are in an interference fit, and the fracture ring of the first stage support and the inner wall of the support shell are in an interference fit.

Preferably, in each of the N-stage piston self-locking support device, at least one N^{th} stage ratchet-shaped locating slot is arranged on the outer circumferential surface of the N^{th} stage support, at least one ratchet-shaped locating slot is arranged respectively on the outer circumferential surface of the $N-1^{\text{st}}$ stage support through the first stage support, and a C-shaped locating self-locking ring is arranged respectively on the inner wall of the $N-1^{\text{st}}$ stage support through the first stage support, wherein, at least one j^{th} stage ratchet-shaped locating slot is arranged on the outer circumferential surface of the j^{th} stage support, and one $j+1^{\text{st}}$ stage C-shaped locating self-locking ring is arranged on the inner wall thereof, $j=1, \dots, N-1$, the N^{th} stage ratchet-shaped locating slot is fitted with the $N-1^{\text{st}}$ stage C-shaped locating self-locking ring, the j^{th} stage ratchet-shaped locating slot is fitted with the j^{th} stage C-shaped locating self-locking ring, and the first stage locating self-locking ring is arranged on the inner wall of the support shell.

Preferably, in each of the N-stage piston self-locking support device, two adjacent supports as well as the first stage support and the support shell are sealed respectively by a sealing ring.

Preferably, both the connecting part (1) and the connecting part (2) are of casing-connected thread structures.

Preferably, the contact part between the supporting part and the wall supports is a half-arc support contact cap.

The invention has the following advantages:

1. A threaded integral structure is adopted

Among all existing casing centralizers, all elastic centralizers are sheathed outside casings. In

practical use, the running force of centralizers is large with the running of casings, and then the centralizers will move along the casing surfaces or abut against couplings so that the tensile force of pipes will be increased when the couplings run, easily damaging threaded casings. However, coupling threads between some rigid centralizers and casings increase the quantity of couplings, increasing the production cost. The centralizer is designed into an integral structure using standard internal and external threads at both ends and connecting with the casing, which is equivalent to adding a coupling. The connecting structure facilitates on-site installation of the centralizer without increasing the production cost, and the length of the whole centralizer is short, thus the centralizer will not increase the string rigidity, and is effectively used in highly-deviated wells and horizontal wells. Connecting threads can use conventional LTC threads, or machined into special airtight threads so as to greatly improve the connection strength and sealing property between the centralizer and the casing. The integral centralizer researched and developed has a leakage resistance of 12000psi, and meets the technical requirements of special airtight fasteners.

2. A downhole-started self-locking support structure is adopted

(1) Downhole-started support form

The downhole-started rigid centralizer has the advantages that the running force of the casing is not increased, and casing running operation is very easy. But for an existing downhole-started centralizer, the spring leaf is flattened by a steel strip fastened to the spring leaf, and then the spring leaf and the steel strip are fixed together. The steel strip is controlled by a locking device, after going downhole with the casing, the locking device will be started under differential pressure to release the steel strip, thus releasing the bow spring leaf. As the flattened bow spring leaf has large elastic force, the steel strip under force cannot ensure steady starting, so that it is difficult to control the centralizing effect. But in the piston support form adopted in the design, all N-stage supports are held in the centralizer before starting, when the pressure in the casing increases, due to different surface areas at the bottoms of pistons, the N^{th} stage support will be first started, after the N^{th} stage support is moved in place, other stages will be successively started until the first stage is started. When the N^{th} stage support is started, the starting of supporting pistons is only related to the pressure in the casing but not other factors. When the pressure in the casing reaches 1500 to 2000psi, the N^{th} stage support will be started, and produce a supporting force ($>4000\text{N}$). The supporting force (the minimum reset force) is much higher than the standard value (2758N), thus the centralization performance is excellent.

In order to ensure that the centralizer is effectively started downhole, fracture rings are arranged at the bottoms of all N-stage supporting pistons of the centralizer in the design. Fracture pressures of the fracture rings are varied so as to ensure that the supporting pistons are started in sequence. When the pressure in the casing is constant, due to different areas at the bottom of pistons, the N^{th} stage supporting piston will be first started, followed by the $N-1^{\text{st}}$ stage supporting piston, and the first stage supporting piston is started finally to ensure the centralizing effect of the centralizer downhole.

(2) Supports can be locked in different boreholes to keep the casing reliably centralized

In horizontal wells and extended reach wells, the defects of existing centralizers are more and more obvious, mainly in that the reset force is unsecured, the starting force is large, the frictional coefficient with boreholes is large and the rotary requirements of pipe

strings cannot be met. But the centralizer of the invention is researched and developed to be started downhole, thus completely avoiding friction with boreholes, and meeting the rotary requirements of pipe strings before centralization. In addition, the centralizer of the invention can be conveniently used in irregular boreholes, and the starting pressure is low. The centralizer can be started when the pressure in a casing reaches 1500 to 2000psi. Once started, the C-shaped locating self-locking rings can lock supports at all stages, and the N-stage ratchet-shaped locating slot on the surface of the supports at each stage can fix the supporting pistons in certain positions, and produce large supporting force. In irregular boreholes, the centralizer of the invention can still be effectively centralized so as to ensure the casing centrality in boreholes. In addition, N-stage sealing rings can effectively seal the supporting pistons, so that the supporting pistons of the centralizer can bear pressures higher than 10000psi in casings without leakage. Practical use on site shows that the effect is fairly obvious.

3. A circular arc support cap helps ensure large support force and reduce damage to borehole walls

The contact between supporting points and borehole walls of both flexible and rigid centralizers is of line contact or point contact. In order to ensure a certain supporting force, unit pressure of the supporting points is large, thus the borehole walls will be damaged. But the arc support cap adopted in the design can be effectively fitted with boreholes so as to change the line contact or point contact into arc surface contact, thus effectively reducing pressure per unit area of the supporting points while ensuring large supporting force and minimum damage to boreholes, and completely avoiding defects of existing centralizers, thus the centralizer of the invention is high reliable and practical.

Brief Description of the Drawings

Figure 1 is an external structural diagram of a downhole-started self-locking casing centralizer provided by the invention;

Figure 2 is a structural diagram of the central supporting part (before starting) of the invention;

Figure 3 is a structural diagram of the central supporting part (after starting) of the invention; and

Figure 4 is a local enlarged view of position A in Figure 3.

Description of the Preferred Embodiment

The invention is described in detail in combination with the following drawings and preferred embodiments for clear understanding.

As shown in Figure 1, a downhole-started self-locking casing centralizer provided by the invention comprises a connecting part (1) and a connecting part (2) on both ends, a central supporting part (3) is arranged between the connecting part (1) and the connecting part (2), the connecting part (1) and the connecting part (2) are of casing-connected thread structures, the connecting part (1) uses LTC PIN thread, and the connecting part (2) uses LTC BOX thread.

The downhole-started self-locking casing centralizer of the invention is in threaded connection with a casing, replacing couplings and exerting connection function, thus avoiding the problem

that an elastic centralizer cannot control the downhole location as the elastic centralizer is sheathed outside a pipe string, and also avoiding the problem of difficulty in casing running as a rigid centralizer increases the string rigidity. In addition, replacement of couplings helps save the production cost, and the centralization position is relatively fixed, thus casing running operation is convenient and reliable. The dimensions of connected casings are 4 1/2" to 5 1/2".

According to Figure 2 to Figure 4, a central supporting part (3) comprises a hollow coupler (5), and at least three N-stage piston self-locking support devices extending by stages under pressure are evenly distributed along the circumference of the coupler (5), $N \geq 2$. The invention will be further described by taking $N=3$ for example.

Each 3-stage piston self-locking support device comprises a support shell (4-1) fixed to the coupler (5) and a 3-stage support consisting of a first stage support (4-2) through a third stage support (4-4), a starting orifice (4-10) communicated with the support shell (4-1) and the 3-stage support is arranged on the coupler (5). Fluid pressure enters from the starting orifice (4-10) to the support shell (4-1) and the 3-stage support, and then the 3-stage support extends by stages under the pressure. After three 3-stage supports are extended in place, the casing is centrally fixed and supported in the borehole. The first stage support (4-2) is nested in the support shell (4-1) and in sliding fit with the support shell (4-1), the second stage support (4-3) is nested in the first stage support (4-2) and in sliding fit with the first stage support (4-2), and the third stage support (4-4) is nested in the second stage support (4-3) and in sliding fit with the second stage support (4-3). A first stage sealing ring (4-9-1), a second stage sealing ring (4-9-2) and a third stage sealing ring (4-9-3) are respectively arranged between the first stage support (4-2) and the support shell (4-1), between the second stage support (4-3) and the first stage support (4-2) as well as between the third stage support (4-4) and the second stage support (4-3). A first stage fracture ring (4-6-1), a second stage fracture ring (4-6-2) and a third stage fracture ring (4-6-3) are respectively arranged at the bottoms of the first stage support (4-2), the second stage support (4-3) and the third stage support (4-4), the first stage fracture ring (4-6-1) and the inner wall of the support shell (4-1) are in interference fit, the second stage fracture ring (4-6-2) and the inner wall of the first stage fracture ring (4-6-1) are in interference fit, and the third stage fracture ring (4-6-3) and the inner wall of the second stage fracture ring (4-6-2) are in interference fit.

In the invention, three 3-stage piston self-locking support devices are evenly distributed along the circumference. Each device holds a 3-stage support capable of being extended by three stages. The first stage support (4-2), the second stage support (4-3) and the third stage support (4-4) of the 3-stage support have different starting forces due to different sectional areas. When the casing is kept at a constant pressure (psi), the third stage support (4-4) is first started, then the second stage support (4-3) is started after the third stage support (4-4) is moved in place, and the first stage support (4-2) is started after the second stage support (4-3) is moved in place. In order to ensure the starting sequence of the 3-stage support, the first stage fracture ring (4-6-1), the second stage fracture ring (4-6-2) and the third stage fracture ring (4-6-3) are respectively arranged at the bottoms of the first stage support (4-2), the second stage support (4-3) and the third stage support (4-4), the fracture rings have different fracture starting pressures in a fracture sequence from the third stage fracture ring (4-6-3), through the second stage fracture ring (4-6-2) to the first stage fracture ring (4-6-1). The starting pressure at each stage is a multiple of the previous stage, $P_2=2P_3$, $P_1=2P_2$ (P_3 , P_2 and P_1 represent the starting pressure of the third stage fracture ring (4-6-3), the second stage fracture ring (4-6-2) and the first stage fracture ring (4-6-1) respectively). When the differential pressure in the casing reaches 1000 to 2000psi, the 3-stage

support can be started. The 3-stage support device has the advantage of low starting pressure. The minimum reset force is larger than 3000N during starting, and after each stage is started, each stage will generate a corresponding reset force, and after the three stages are started, the maximum reset force will go far beyond the weight of the pipe string, thus the centralization performance is highly reliable.

Three ratchet-shaped locating slots, i.e., a first stage ratchet-shaped locating slot (4-7-1), a second stage ratchet-shaped locating slot (4-7-2) and a third stage ratchet-shaped locating slot (4-7-3), successively from top to bottom are respectively arranged on the outer circumferential surfaces of the first stage support (4-2), the second stage support (4-3) and the third stage support (4-4). A first stage C-shaped locating self-locking ring (4-8-1), a second stage C-shaped locating self-locking ring (4-8-2) and a third stage C-shaped locating self-locking ring (4-8-3) are respectively arranged on the inner walls of the support shell (4-1), the first stage support (4-2) and the second stage support (4-3). The first stage C-shaped locating self-locking ring (4-8-1), the second stage C-shaped locating self-locking ring (4-8-2) and the third stage C-shaped locating self-locking ring (4-8-3) are respectively fitted with the first stage ratchet-shaped locating slot (4-7-1), the second stage ratchet-shaped locating slot (4-7-2) and the third stage ratchet-shaped locating slot (4-7-3).

When the first stage support (4-2), the second stage support (4-3) and the third stage support (4-4) are started, the first stage ratchet-shaped locating slot (4-7-1), the second stage ratchet-shaped locating slot (4-7-2) and the third stage ratchet-shaped locating slot (4-7-3) on the first stage support (4-2), the second stage support (4-3) and the third stage support (4-4) will be locked with the first stage C-shaped locating self-locking ring (4-8-1), the second stage C-shaped locating self-locking ring (4-8-2) and the third stage C-shaped locating self-locking ring (4-8-3). Three ratchet-shaped locating slots, i.e., a first stage ratchet-shaped locating slot (4-7-1), a second stage ratchet-shaped locating slot (4-7-2) and a third stage ratchet-shaped locating slot (4-7-3), are respectively arranged on the surfaces of the first stage support (4-2), the second stage support (4-3) and the third stage support (4-4) so that the first stage support (4-2), the second stage support (4-3) and the third stage support (4-4) can be fixed at any extended position and applied to different boreholes. Due to locating self-locking, after the first stage support (4-2), the second stage support (4-3) and the third stage support (4-4) are extended and self-locked, the resultant reset force is constant, and will not change under external forces. The maximum reset force depends on shear strength of the first stage C-shaped locating self-locking ring (4-8-1), the second stage C-shaped locating self-locking ring (4-8-2) and the third stage C-shaped locating self-locking ring (4-8-3), thus the maximum reset force is much higher than the weight of the pipe string. The structural form is not currently present in existing centralizers.

A supporting part (4-5) for contacting with wall supports is arranged at an end of each third stage support (4-4), the contact part between the supporting part (4-5) and the wall supports is a half-arc support contact cap (4-5-1).

When the reset force is larger, the contact area between supporting points of the centralizer and borehole walls is the key to accurate centralization of the pipe string. When the contact area is too small, pressure per unit area of the supporting points is large, thus the borehole walls will be damaged and the pipe string cannot be well centralized. When the area of the supporting points is large, supporting force on unit area is small, thus the pipe string can be effectively supported for centralization, and damage to the borehole walls will be reduced. In the invention, the half-arc support and cap support contact form is adopted, so that the support form changes from point

contact to surface contact, thus effectively reducing pressure per unit area of the borehole walls while keeping centralization supporting strength for the pipe string unchanged, effectively reducing supporting damage to the borehole, and ensuring casing centralization in the borehole.

- 5 In order to facilitate smooth running of the casing string, the centralizer provided by the invention is started by downhole pressure. After the casing arrives at the designated downhole position, pressure in the casing will control the supports to be started to centralize the casing. This starting and support approach will not result in damage to the borehole, and is applied to different boreholes, thus reducing requirements for boreholes, and greatly expanding the scope of application.
- 10 Application of the centralizer of the invention to horizontal test wells shows obvious effect, the casing centrality in boreholes is tested to be quite accurate, the displacement efficiency of cementing is high, and the cementing quality is stable. The downhole-started self-locking casing centralizer has been unanimously praised by users, and is ~~now~~ widely under popularization for the time being.

Claims

1. A downhole-started self-locking casing centralizer, comprising a connecting part (1) and a connecting part (2) on both ends, a central supporting part (3) being arranged between the connecting part (1) and the connecting part (2), and characterized in that the central supporting part (3) comprises a hollow coupler (5), and at least three N-stage piston self-locking support devices extending by stages under pressure are evenly distributed along the circumference of the coupler (5), $N \geq 2$;

each N-stage piston self-locking support device comprises a support shell (4-1) fixed to the coupler (5) and a N-stage support consisting of a first stage support through an N^{th} stage support, the first stage support and the support shell (4-1) are in a sliding fit, the first stage support through the N^{th} stage support are in a sliding fit successively by two adjacent stages so that the N-stage support can extend by stages under pressure from the N^{th} stage support, a supporting part (4-5) for contacting with wall supports is arranged at the end where the N^{th} stage support goes against the support shell (4-1), fracture rings are formed at the bottoms of the first stage support through the N^{th} stage support, and the fracture rings allow starting pressure of the first stage support through the N^{th} stage support to drop by stages.

2. The downhole-started self-locking casing centralizer of claim 1, characterized in that the first stage support of each of the N-stage piston self-locking support device is nested in the support shell (4-1), and the N^{th} stage support through the first stage support are successively nested by two adjacent stages, wherein, a k^{th} stage support is nested in a $k-1^{\text{st}}$ stage support, $k=1, \dots, N$.

3. A downhole-started self-locking casing centralizer of Claim 2, characterized in that the fracture ring of the current support and the inner wall of an adjacent support are in an interference fit, and the fracture ring of the first stage support and the inner wall of the support shell (4-1) are in an interference fit.

4. A downhole-started self-locking casing centralizer of Claim 2, characterized in that in each of the N-stage piston self-locking support device, at least one N^{th} stage ratchet-shaped locating slot is arranged on the outer circumferential surface of the N^{th} stage support, at least one ratchet-shaped locating slot is arranged respectively on the outer circumferential surface of the $N-1^{\text{st}}$ stage support through the first stage support, and a C-shaped locating self-locking ring is arranged respectively on the inner wall of the $N-1^{\text{st}}$ stage support through the first stage support, wherein, at least one j^{th} stage ratchet-shaped locating slot is arranged on the outer circumferential surface of the j^{th} stage support, and one $j+1^{\text{st}}$ stage C-shaped locating self-locking ring is arranged on the inner wall thereof, $j=1, \dots, N-1$, the N^{th} stage ratchet-shaped locating slot is fitted with the $N-1^{\text{st}}$ stage C-shaped locating self-locking ring, the j^{th} stage ratchet-shaped locating slot is fitted with the j^{th} stage C-shaped locating self-locking ring, and the first stage locating self-locking ring is arranged on the inner wall of the support shell (4-1).

5. A downhole-started self-locking casing centralizer of Claim 2, characterized in that in each of the N-stage piston self-locking support device, two adjacent supports as well as the first stage support and the support shell (4-1) are sealed respectively by a sealing ring.

6. A downhole-started self-locking casing centralizer of Claim 1, characterized in that both the connecting part (1) and the connecting part (2) are of casing-connected thread structures.

7. A downhole-started self-locking casing centralizer of Claim 1, characterized in that the contact part between the supporting part (4-5) and the wall supports is a half-arc support contact cap (4-5-1).