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(54) LARGE-SIZE FLOATING STATE MANUFACTURING METHOD FOR MARINE ENGINEERING EQUIPMENT

(57) A large-size floating state manufacturing method for marine engineering equipment comprises: using a submersible long working platform (5) as a floating platform for constructing marine engineering equipment, each section of a bottom layer block (1) being carried and integrated on the working platform; submerging the submersible long working platform (5) after the bottom layer block (1) is constructed, so as to use the buoyancy of water to make the bottom layer block (1) be separated from the working platform (5) and go into the water; and then, using the bottom layer block (1) as the floating platform, and constructing a main hull (2, 3) and a deck (4) of the marine engineering platform and performing outfitting thereon. In the method, manufacturing is performed in sections in allowance-free sectional construction manner on the floating working platform, and then superposition is performed layer by layer; in the manufacturing process, dynamic measurement and anti-deformation control technologies are adopted, so as to ensure quality and precision of floating state manufacturing, and finally realize construction of large-scale marine engineering equipment.

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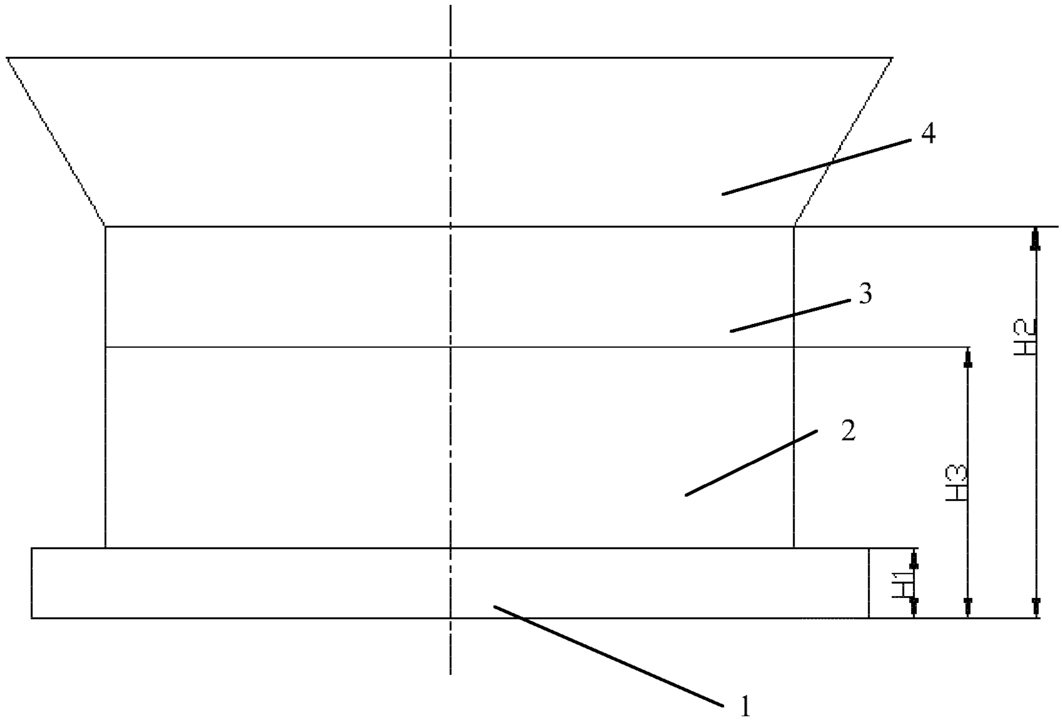

Figure 1

Description

Technical Field

[0001] The invention relates to the field of manufacturing marine engineering equipment, in particular to a floating state manufacturing method for huge overweight oil storage platform for drilling for the development of oil and gas resources in deep sea, and also for the construction and assembly of huge vessels or offshore structures.

Background of the Invention

[0002] With the shortage and large consumption of oil resources, the oil imports in China are increasing year by year. In 2010, China's degree of dependence upon foreign oil reached 55%, which was the second consecutive year of exceeding the international warning line by 50%. The development of offshore oil is of great urgency, and the development of offshore resource has been raised to a high degree of national security strategy. The manufacturing technology of marine engineering equipment is regarded as an important key technology in the development of offshore, deep sea and ultra-deep resources. Especially for the development of oil and gas resources in deep sea, constructing huge overweight oil storage platforms for drilling is pre-requisite. Huge docks and shipways and large-scale lifting equipment are required in the event of constructing in accordance with conventional methods for manufacturing marine equipment, which has high investment cost, long construction period, poor adaptability, large occupancy and low utilization rate. Meanwhile, difficulties in constructing large-scale marine engineering equipment, such as high system integration degree, complex process and uncontrollable construction schedule, are required to be overcome. In addition, safe launching of vessels is also one of the most important procedures during the construction; this is because any mechanical damage will cause inestimable impact to the service life of the vessels. An oil drilling platform in deep sea is high in construction cost, generally from 500 million to 800 million dollars, and is required not to be repaired in dock within 25 years of offshore operation; therefore, the structure safety, stability and fatigue life are particularly demanded for an oil drilling platform in deep sea.

[0003] In recent years, the development boom of offshore oil and gas stimulates the prosperity of the manufacturing industry of marine engineering equipment. However, there are only few patent technologies about assembly and construction of marine engineering equipment. It is known from retrieval that, American Patent US6135673, titled *Method/Apparatus for Assembling a Floating Offshore Structure,* proposed that the bottom and the decks to be mounted are assembled by means of butt-jointing to form a whole due to the buoyancy of a hollow cavity of the bottom means of an offshore engineering platform. Another American Patent US3528354, titled *Offshore engineering platform Structure and Construction Method,* described a method that the top platform comes into connection with the chamber on the bottom structure by means of butt-jointing at first, and then comes into contact and integration with the bottom structure under the action of the ballast. American Patent US4848967, titled *Load-Transfer System for Mating an Integrated Deck with an Offshore engineering platform Substructure,* proposed that a probe extending outside a deck and a vibration absorption system consisting of double springs are employed to reduce the vibration loads generated when the integral deck is assembled with the platform bottom structure by means of butt-joint. The above researches on the integration and construction of marine engineering equipment mainly direct at methods for realizing integration with buoyancy of the chamber or the ballast and at the reduction technology of dynamic loads during the integration, still depending on shipways and docks. Chinese patents ZL200410052950.5, ZL02295585.2 and ZL 200510045929.7 had reported various methods and devices for integrating the block of large-scale marine engineering equipment, mainly as follows: the integration of the block and the construction of the main body or the assembly of large or medium-scale equipment on vessel are realized by the sliding of shipways on the slipways, walking tracks or shipways.

Summary of the Invention

[0004] In view of common problems existing during the construction of large-scale marine engineering equipment, such as high cost, long construction period, large occupancy and difficulty in launching, the invention provides a new large-size floating state manufacturing method using the buoyancy of water for support directly by means of manufacturing in layers and superposition layer by layer without shipways and docks. The method may be applied in the construction of large-scale marine engineering equipment and vessels, especially in the integration and construction of offshore engineering platform without large-scale docks or shipways.

[0005] The technical solution employed in the invention comprises the following process steps: construction phase division for a main hull of an offshore engineering platform, construction and integration of a bottom layer block, manufacturing of the platform by superposition layer by layer, integration of a deck in sections, and carrying and lifting of the superstructure.

1) Construction phase division for main hull of an offshore engineering platform

[0006] A hull is divided into a bottom layer block, a lower main hull, an upper main hull and a platform deck from down to up in the molded depth-height direction. The layered manufacturing technology is adopted.

2) Methods for dividing the bottom layer block into sections

[0007] First, the appearance of the bottom layer of the offshore engineering platform is simplified by a largest circumscribed circle, that is, the constructed offshore engineering platform is always divided by the largest circumscribed circle as basis, of which the radius is R, no matter what appearance the offshore engineering platform looks like. Consequently, the bottom layer block of the platform may be divided into n circular rings from the circle center to the outside, where n is an integer. Then, all layers of circular rings are symmetrically and equally divided into m sectors on the circumference, as shown in Fig. 2. The innermost layer is a full circle and is not to be divided into sectors, regarded as a center section, and the center radius of the innermost layer is r_1. The total area of this section is $H_1 \cdot \pi r_1^2$ according to height H_1 of the bottom layer block. This section is a hollow cylinder when manufactured, where r_1 should be selected such that the weight of this section should be smaller than the buoyancy thereof, and the weight of all other divided sector sections should also be smaller than the buoyancy thereof. As the height of each section is equal to the height H_1 of the bottom layer block after the bottom layer block is divided, the area πr_1^2 of the full circle in the innermost layer is regarded as the division basis for other sector sections after the full circle radius of the innermost layer is determined as r_1, that is, the area of each sector section is about $\pi r_1 2$. Therefore, according to the area characteristic of the sectors, when the circular rings are divided from the circle center to the outside, the thickness of the circular rings (i.e., the difference between the inner radius and the outer radius) gradually decreases, the outer radiuses being $r_2, r_3, r_4 \ldots r_{n-1}$, R, respectively,

wherein, $\pi r_1^2 = \dfrac{\pi r_2^2 - \pi r_1^2}{m}, \Rightarrow r_2 = r_1\sqrt{(m+1)}$,

similarly, $r_3 = r_1\sqrt{(2m+1)}$, $r_4 = r_1\sqrt{(3m+1)}$, $r_5 = r_1\sqrt{(4m+1)}$, ...,

meanwhile, the radius R of the largest circumscribed circle, the radius r_1 of the innermost circle, the number n of layers of the divided circular rings and the number m of sectors symmetrically and equally divided on the circumference should satisfy the relationship as follows: $R = r_1\sqrt{(n-1)m+1}$.

2) Construction of the bottom layer block

[0008] After the bottom layer block is divided into sections, all the sections are constructed in allowance-free construction manner and all components are cut by high-precision numerical control. And then, the sector sections are numbered and sorted. The sector sections in the same sort are butt-jointed to form a sectional bottom layer structure in a specific manner. Sections of the bottom layer block are machined from inside to outside and then integrated together after machined.

3) Carrying and integration of the bottom layer block

[0009] The sections of the bottom layer block are butt-jointed and integrated on a submersible long working platform. Because the profile dimension R of the huge overweight offshore engineering platform is greater than the width W of the submersible long working platform, the integration of sections of the bottom layer should be completed in phases. First, the working platform is drawn into water with a desired depth by a tugboat, and the sections are butt-jointed according to the symmetry principle from inside to outside in the length direction of the working platform. Then, the working platform submerges to launch the butt-jointed part of the bottom layer into water so as to be separated from the deck of the working platform due to the buoyancy of water. The bottom layer or the working platform is drawn to rotate by a certain angle θ by the tugboat on the water, $\theta = 2 \cdot \arcsin\left(\dfrac{W}{2R}\right)$. Positioning and limiting devices are mounted on the working platform to guarantee that it rotates by angle θ precisely so as to make the non-constructed parts located in the length direction of the working platform. The working platform floats up and emerges from the water after carrying the bottom layer, and then the butt-jointing and integration for the non-constructed parts is performed in the length direction of the working platform. The manufacturing of the whole bottom layer block is accomplished by many times of submerging, rotating, carrying and floating of the bottom layer block. The number of times of submerging and rotating should be equal to an integer of $\left(\frac{\theta}{\pi}\right)$ circle. At last, the submersible working platform submerges to make the bottom layer block separated from the working platform due to the buoyancy of water so as to launch the bottom layer block into water stably, and then the submersible working platform is withdrawn.

4) Construction and integration of the main hull

[0010] First, the lower main hull of the platform is equally divided into two sections for separate manufacturing. Subsequently, the bottom layer block floating on the water is used as a floating platform for constructing the hull. The lifting and integration of the two sections of the lower main hull are performed on the bottom layer block, and the two sections are butt-butt-jointed into a whole after integrated. Structure survey must be performed for the lower main hull, and ultrasonic flaw detection must be performed for the welds on the hull. Then, the upper main hull is divided into dozens of small sections, each one of which is separately manufactured and respectively lifted onto the floating platform of the bottom layer block after completely manufactured to be butt-butt-jointed and integrated with the lower main hull, so as to complete the construction of the main hull of the offshore engineering platform.

5) Integration of the sections of the deck

[0011] The deck of the main hull of the offshore engineering platform is divided into sector sections which are welded to be integrated together after manufactured. When the sector sections are welded on the deck, symmetric welding should be adopted for circular welds. During the integration of the whole main hull, a dedicated welding process is adopted for the circular welds.

6) Carrying and lifting of superstructure

[0012] The rest sections above the deck are manufactured, mounted and carried. The construction for the upper structure of the hull and the carrying and integral lifting of modules of the superstructure are continuously performed.

[0013] According to the large-size floating state manufacturing method provided by the invention, as the working platform is floating supported due to the effect of buoyancy, water flow and storm, the construction of the offshore engineering platform adopts the method of manufacturing in sections and superposition layer by layer. Therefore, the manufacturing precision of each section will directly affect the precision of size, form and position of the platform. The allowance-free sectional construction manner is used in order to control the manufacturing precision. Dynamic measurement and anti-deformation control are used during the butt-jointing and integration of the sections, thereby achieving the manufacturing of the floating state on the water. The technical solution is as follows:

1) Construction of a platform model

[0014] An amount of shrinkage is added to the data of the offshore engineering platform according to the design and manufacturing standards, and the data added with an amount of shrinkage is loaded to three-dimension design software for data modeling of the platform, so as to realize allowance-free blanking for components of all the sections.

2) Manufacturing of the sections of the main hull

[0015] The sections of the bottom layer block are all manufactured by an upright method. The outermost circle and the innermost circle of each section of the lower main hull are manufactured by a sideward method, respectively, using a designed curved surface for outer circles and a designed curved surface for inner circles as reference plane, while the rest sections of the lower main hull are manufactured by a sideward method using a wallboard as reference plane. The outermost circle and the innermost circle of each section of the upper main hull are manufactured by a sideward method, respectively, using a designed curved surface for outer circles and a designed curved surface for inner circles as reference plane, while the other sections of the upper main hull are manufactured by a sideward method using a wallboard as reference planer. The sections above the deck are manufactured by an upside-down method using the deck as reference plane.

3) Process division and precision control for the manufacturing of the sections

[0016] The construction procedure of the sections is divided into blanking, board-jointing, scribing, assembling, welding and survey on completion according to the construction schedule of the sections of the offshore engineering platform. Quality track and control are performed all the time during the implementation of each process.

4) Overall precision control of the offshore engineering platform

[0017] As the working platform floats on the water and will generate dynamic fluctuation due to the effect of water flow, buoyancy and storm, the dynamic measurement and anti-deformation control technologies are adopted for the butt-butt-jointing and integration of the sections of the offshore engineering platform, so as to guarantee the overall quality and precision of the floating state manufacturing of the platform.

[0018] The invention has the following beneficial effects.

1) The submersible working platform is used as the integration platform of the bottom layer. The pre-integration of the sections of the bottom layer block is realized by providing limiting and positioning components. Then, the bottom layer block is launched into water to be separated from the submersible platform, and then rotates, carries, floats up and integrates subsequently. Subsequently, the bottom layer is used as the manufacturing platform for manufacturing by superposition layer by layer so as to finally complete the construction of the whole offshore engineering platform. The invention has the prominent advantages of low cost, good operability and strong adaptability, and may be applied in the construction of large-scale marine engineering equipment and vessels. The invention solves the key technical problem of constructing large-scale offshore engineering equipment without ultra-large dedicated shipways.

2) During the construction of the bottom layer block, the bottom layer block is launched into water stably without any mechanical damage by using the mooring, positioning, submerging and withdrawing of the submersible working platform, with no need of any dedicated launchway or runway, so the process problem of difficulty in launching large-scale marine engineering equipment is solved.

3) The allowance-free sectional construction manner is adopted to construct the large-scale marine engineering platform on the floating platform, which cancels the butt-jointing allowance of head and tail sections in the conventional sectional construction. The dynamic measurement and the anti-deformation technology are adopted to control the construction precision for the overall butt-jointing and integration of the platform. It is unnecessary to perform allowance regulation during the integration of the shipway, which reduces the working strength of the operators, obviously improves the efficiency, shortens the construction period and meanwhile avoids structure deformation resulted from the flame machining carried out during the regulation.

Brief Descriptions of the Drawings

[0019]

Fig. 1 is a construction division diagram of a main hull of a large-scale marine engineering platform;
Fig. 2 is a diagram for a division method of sections of a double-layer bottom block;
Fig. 3 is a diagram of the bottom layer block which rotates and integrates by using a submersible working platform; and,
Fig. 4 is a layout drawing of an order of machining the sections of a lower main hull.

(1) Bottom layer block
(2) Lower main hull
(3) Upper main hull
(4) Deck
(5) Submersible long working platform
(6) 1# section of the lower main hull
(7) 2# section of the lower main hull

Detailed Description of the Invention

[0020] This embodiment will take the manufacturing process of an oil storage platform for drilling in deep sea on a semi-submersible long barge as example to in detail describe the details and process steps of a large-size floating state manufacturing method in combination with Fig. 1 to Fig. 4.

1. Phase division for construction of an oil storage platform for drilling in deep sea

[0021] As shown in Fig. 1, a hull is divided into a double-layer bottom block with a height of H1, a main hull (comprising a lower main hull with a height between H1 and H3 and an upper main hull with a height between H3 and H2) and a deck from down to up in the molded depth-height direction of the hull. The layered manufacturing technology is adopted.

2. Division and construction of the double-layer bottom block

[0022] At first, the circular arc is divided into parts and the steel plate is divided into sector sections, as shown in Fig. 2. All the sections are constructed in the allowance-free construction manner, and all the components are cut by high-precision numerical control. And then, the sector sections are numbered and sorted. The sector sections in the same sort are butt-jointed to form a sectional double-layer bottom structure in a specific manner. According to the symmetry principle, the sections of the double-layer bottom block are machined from the inner radius to the outer radius in a number sequence as shown in Fig. 2 (1A-2A-3A...1B-2B-3B...1C-2C-3C...), and are butt-jointed and integrated from inside to outside for another time of butt-jointing after machined.

3. Carrying and integration of the double-layer bottom block

[0023] The integration of the sections of the double-layer bottom block is completed on the submersible working platform 5. Due to the restriction of the width of the working platform, the rotation and integration process of the double-layer bottom block is shown as Fig. 3, comprising three phases and two rotations. Phase I: at first, the sections are butt-jointed according to the symmetry principle from inside to outside in the length direction of the working platform, to achieve the construction of 1/3 bottom layer block. Phase II: the working platform submerges to launch the butt-jointed part of the bottom layer into water so as to be separated from the deck of the working platform due to the buoyancy of water. The bottom layer block is drawn by the cable on the tugboat to rotate anticlockwise by 60 degrees (the bottom layer block may also be kept unmoved, and the working platform rotates clockwise by 60 degrees). And then, the working platform floats up to be repositioned. Sectional integration is continuously performed to achieve the construction of 2/3 bottom layer block. Phase III: the working platform submerges again. After the bottom layer block rotates anticlockwise by 60 degrees for the second time, the working platform floats up again to be repositioned, so as to complete the integration of the rest sections, and finally to achieve the construction of the bottom layer block.

4. Manufacturing and integration of the main hull

[0024] As shown in Fig. 4, at first, the lower main hull is divided into 1# section 6 and 2# section 7 for separate manufacturing. The two sections of the lower main hull are lifted and integrated on a semi-submersible barge, and are butt-jointed to form a cylinder after integrated. Then, structural survey is performed for the hull, and ultrasonic flaw detection must be performed for the welds on the hull. Afterwards, the lower block (the double-layer bottom block and the lower main hull) is separated from the semi-submersible barge to launch the lower block into water. The steps for launching the lower block into water include: movement of the semi-submersible barge outward, mooring and positioning, submerging, tightness checking, separation of the platform main hull from the semi-submersible barge and launching of the hull. At last, the upper main hull 4 is divided into 52 small sections, and then each one of which is manufactured separately. After manufactured, the small sections are lifted onto the lower block for integration.

5. Integration of the sections of the deck

[0025] The deck of the main hull of the drilling platform is manufactured in sections. After manufactured, the sections are welded to be integrated. When the sector sections of the deck are welded, symmetric welding should be adopted for the circular welds. During the integration of the whole main hull, dedicated welding technology is adopted for the circular welds.

6. Carrying and lifting of superstructure

[0026] The sections above the deck are manufactured, mounted and carried. The construction for the upper structure of the hull and the carrying and integral lifting of modules of the superstructure are continuously performed.

[0027] In order to meet the quality and precision requirements on the manufacturing of the large-size floating state, the following technical solutions are adopted for the construction precision control for the oil storage platform for drilling in deep sea.

1. Construction of a platform model

[0028] An amount of shrinkage of 0.1‰0-0.35‰ is added to the data according to the design and manufacturing standards and in combination with the actual conditions of the drilling platform in deep sea, and then the data added with an amount of shrinkage is loaded to three-dimension design software TRIBON for data modeling of the platform by using the three-dimensional Green's function method, so as to realize allowance-free blanking for all components. Slab joints of the outer board, profiles of the outer board and grillages of the curved surface (generally referring to the outer board) are manufactured. The manual full-scale lofting on the lofting platform with a proportion of 1:1 is completely canceled.

2. Manufacturing of the sections of the main hull

[0029] Sections of the double-layer bottom block are all manufactured by an upright method. The outermost circle and the innermost circle of each section of the lower cylinder are manufactured by a sideward method, respectively, using a designed curved surface for outer circles and a designed curved surface for inner circles as reference plane, while the rest sections of the lower main hull are manufactured by a sideward method using a wallboard as reference plane. The outermost circle and the innermost circle of each section of the upper cylinder are manufactured by a sideward method, respectively, using a designed curved surface for outer circles and a designed curved surface for inner circles as reference plane, while the other sections of the upper main hull are manufactured by a sideward method using a wallboard as reference planer. The sections above the deck are manufactured by an upside-down method using the deck as reference plane.

3. Process division and precision control for the manufacturing of the sections

[0030] The construction procedure of the sections is divided into blanking, butt-jointing, scribing, assembling, welding and survey on completion according to the construction schedule of the sections of the offshore engineering platform. Quality track and control are performed all the time during the implementation of each process.

1) Numerical control programming is performed at first during blanking of the sections, and then the sections are cut by a plasma numerical control cutting machine. The blanking of all the sections should satisfy the conditions as follows: the straightness of the profiles should be less than or equal to 3mm/m and the dimensional deviation of the full length should be less than or equal to 10mm.
2) The platform should be guaranteed to be flat before jointing of the boards, and then all the sections are butt-jointed and the boards are jointed and positioned according to the parts drawings. Arcing and arc quenching craft boards are welded on two ends of the slab joints, and then jointing and welding of boards are performed.
3) The outline dimension and the diagonal dimension, including assembly lines, assembled molded lines, survey lines and center lines of all sections, have to be guaranteed during scribing, wherein the precision of the assembly lines, the assembled molded lines, the survey lines and the centre lines is controlled to be less than or equal to 5mm. The dimensional deviation of all sections in the length direction is controlled to be less than or equal to 5mm, and the dimensional deviation of all sections in the width direction is controlled to be less than or equal to 4mm;
4) V-shaped or U-shaped grooves are provided for the butt-joints of all sections before assembly, and meanwhile the surface quality, angle, direction and straightness of each groove are guaranteed, The assembling clearances should have leveled end faces for the assembly of the sections.
5) The shrinkage and deformation of each welded section should be strictly controlled when in welding, and meanwhile the welding order should be strictly controlled during the welding: vertical welding first and then flat fillet welding, welding from the middle of each section to around.
6) The smallest dimension of the craft boards for the board-jointing and welding processes is 130 × 130mm, and the thickness thereof should be the same as that of the welding plates. During welding, the sections of all the straight boards are machined by submerged arc welding. CO_2 shielded arc welding is adopted for the fillet welding of the sections, and the difference between the largest width and the smallest width of the welds should be not more than 10mm. During the welding of the sections, it is better to arrange an even number of welders to perform symmetric welding. It is necessary to arrange an even number of welders to perform symmetric and radial welding from the middle to around, so as to reduce the welding deformation of the sections.
7) During the assembly of the sections, the precision of the assembling clearances should be less than or equal to 5mm. The dimensional deviation in the length direction and the width direction should be less than or equal to 2.5mm. The diagonal deviation in plane assembly should be less than or equal to 8mm. The diagonal deviation of the curved surface assembly and the three-dimensional assembly should be less than or equal to 15mm.
8) Survey on completion is performed for the sections to guarantee the integrality of all sections, and meanwhile

the main dimension, horizontality and verticality thereof should satisfy relevant requirements. During the survey of completion for the sections, the flatness of each section should be less than or equal to 15mm, and the horizontality and verticality should be less than or equal to 18mm.

[0031] The floating state manufacturing method for a large-scale oil storage platform for drilling provided by the invention realizes rotary integration and subsequent integration and construction of the bottom layer block by a submersible floating platform, with advantages of low cost, good operability and strong adaptability, and solves the key technical problem of constructing large-scale offshore engineering equipment without any ultra-large dedicated shipway.

Claims

1. A large-size floating state manufacturing method for marine engineering equipment, comprising construction phase division for a main hull of an offshore engineering platform, construction and integration of a bottom layer block, manufacturing of the platform by superposition layer by layer, integration of a deck in sections, and carrying and lifting of the superstructure, specifically:

A) construction phase division for main hull of an offshore engineering platform: a hull is divided into a bottom layer block, a lower main hull, an upper main hull and a platform deck from down to up in the molded depth-height direction, and the layered manufacturing technology is adopted;
B) construction of the bottom layer block: the bottom layer block is divided into sections, all of which are constructed in allowance-free construction manner, and all components are cut by high-precision numerical control; and then, the sector sections are numbered and sorted, and the sector sections in the same sort are butt-jointed to form a sectional bottom layer structure in a specific manner; and sections of the bottom layer block are machined from inside to outside and then integrated together after machined;
C) carrying and integration of the bottom layer block: the sections of the bottom layer block are butt-jointed and integrated on a submersible long working platform; because the profile dimension R of the huge overweight offshore engineering platform is greater than the width W of the submersible long working platform, the integration of sections of the bottom layer should be completed in phases: first, the working platform is drawn into water with a desired depth by a tugboat, and the sections are butt-jointed according to the symmetry principle from inside to outside in the length direction of the working platform; then, the working platform submerges to launch the butt-jointed part of the bottom layer into water so as to be separated from the deck of the working platform due to the buoyancy of water; the bottom layer or the working platform is drawn to rotate by a certain angle θ by the tugboat on the water, $\theta = 2 \cdot \arcsin\left(\frac{W}{2R}\right)$, positioning and limiting devices are mounted on the working platform to guarantee that the bottom layer or the working platform rotates by angle θ precisely so as to make the non-constructed parts located in the length direction of the working platform, wherein the width of the submergible long working platform is W and the radius of the largest circumscribed circle of the outline dimension of the huge overweight oil storage platform is R; the working platform floats up and emerges from the water after carrying the bottom layer, and then the butt-jointing and integration for the non-constructed parts are performed in the length direction of the working platform; the manufacturing of the whole bottom layer block is accomplished by many times of submerging, rotating, carrying and floating of the bottom layer block, and the number of times of submerging and rotating should be equal to an integer of $\left(\frac{\theta}{\pi}\right)$ circle; at last, the submersible working platform submerges to make the bottom layer block separated from the working platform due to the buoyancy of water so as to launch the bottom layer block into water stably, and then the submersible working platform is withdrawn;
D) construction and integration of the main hull: first, the lower main hull of the platform is equally divided into two sections for separate manufacturing; subsequently, the bottom layer block floating on the water is used as a floating platform for constructing the hull, the lifting and integration of the two sections of the lower main hull are performed on the bottom layer block, and the two sections are butt-butt-jointed into a whole after integrated; structure survey must be performed for the lower main hull, and ultrasonic flaw detection must be performed for the welds on the hull; then, the upper main hull is divided into dozens of small sections, each one of which is separately manufactured and respectively lifted onto the floating platform of the bottom layer block after completely manufactured to be butt-butt-jointed and integrated with the lower main hull, so as to complete the

construction of the main hull of the offshore engineering platform;
E) integration of the sections of the deck: the deck of the main hull of the offshore engineering platform is divided into sector sections which are welded to be integrated together after manufactured; when the sector sections are welded on the deck, symmetric welding should be adopted for circular welds; and during the integration of the whole main hull, a dedicated welding process is adopted for the circular welds;
F) carrying and lifting of the superstructure: the rest sections above the deck are manufactured, mounted and carried, and the construction for the upper structure of the hull and the carrying and integral lifting of modules of the superstructure are continuously performed.

2. The large-size floating state manufacturing method for marine engineering equipment according to claim 1, **characterized in that** the following methods are employed during the division of the bottom layer block into sections:

first, the appearance of the bottom layer of the offshore engineering platform is simplified by a largest circumscribed circle, that is, the constructed offshore engineering platform is always divided by the largest circumscribed circle as basis, of which the radius is R, no matter what appearance the offshore engineering platform looks like; consequently, the bottom layer block of the platform can be divided into n circular rings from the circle center to the outside, where n is an integer; then, all layers of circular rings are symmetrically and equally divided into m sectors on the circumference; the innermost layer is a full circle and is not to be divided into sectors, regarded as a center section, and the center radius of the innermost layer is r_1; the total area of this section is $H_1 \cdot \pi r_1^2$ according to height H_1 of the bottom layer block; this section is a hollow cylinder when manufactured, where r_1 should be selected such that the weight of this section should be smaller than the buoyancy thereof, and the weight of all other divided sector sections should also be smaller than the buoyancy thereof; as the height of each section is equal to the height H_1 of the bottom layer block after the bottom layer block is divided, the area πr_1^2 of the full circle in the innermost layer is regarded as the division basis for other sector sections after the full circle radius of the innermost layer is determined as r_1, that is, the area of each sector section is about πr_1^2; therefore, according to the area characteristic of the sectors, when the circular rings are divided from the circle center to the outside, the thickness of the circular rings (i.e., the difference between the inner radius and the outer radius) gradually decreases, the outer radiuses being $r_2, r_3, r_4 \ldots r_{n-1}$, R, respectively, wherein,

$$\pi r_1^2 = \frac{\pi r_2^2 - \pi r_1^2}{m}, \Rightarrow r_2 = r_1\sqrt{(m+1)},$$

similarly, $r_3 = r_1\sqrt{(2m+1)}$, $r_4 = r_1\sqrt{(3m+1)}$, $r_5 = r_1\sqrt{(4m+1)}$, ...,

meanwhile, the radius R of the largest circumscribed circle, the radius r_1 of the innermost circle, the number n of layers of the divided circular rings and the number m of sectors symmetrically and equally divided on the circumference should satisfy the relationship as follows: $R = r_1\sqrt{(n-1)m+1}$.

3. The large-size floating state manufacturing method for marine engineering equipment according to claim 1, **characterized in that** the allowance-free sectional construction manner and the superposition layer by layer are used, and dynamic measurement and anti-deformation control are used during the butt-jointing and integration of the sections, comprising the following steps:

A) construction of a platform model: an amount of shrinkage is added to the data of the offshore engineering platform according to the design and manufacturing standards, and the data added with an amount of shrinkage is loaded to three-dimension design software for data modeling of the platform, so as to realize allowance-free blanking for components of all the sections;
B) manufacturing of the sections of the main hull: the sections of the bottom layer block are all manufactured by an upright method, the outermost circle and the innermost circle of each section of the lower main hull are manufactured by a sideward method, respectively, using a designed curved surface for outer circles and a

designed curved surface for inner circles as reference plane, while the rest sections of the lower main hull are manufactured by a sideward method using a wallboard as reference plane; the outermost circle and the innermost circle of each section of the upper main hull are manufactured by a sideward method, respectively, using a designed curved surface for outer circles and a designed curved surface for inner circles as reference plane, while the other sections of the upper main hull are manufactured by a sideward method using a wallboard as reference planer; and the sections above the deck are manufactured by an upside-down method using the deck as reference plane;

C) process division and precision control for the manufacturing of the sections: the construction procedure of the sections is divided into blanking, board-jointing, scribing, assembling, welding and survey on completion according to the construction schedule of the sections of the offshore engineering platform; and quality track and control are performed all the time during the implementation of each process;

D) overall precision control of the offshore engineering platform: as the working platform floats on the water and will generate dynamic fluctuation due to the effect of water flow, buoyancy and storm, the dynamic measurement and anti-deformation control technologies are adopted for the butt-butt-jointing and integration of the sections of the offshore engineering platform, so as to guarantee the overall quality and precision of the floating state manufacturing of the platform.

4. The large-size floating state manufacturing method for marine engineering equipment according to claim 3, **characterized in that** the procedure division of sectional construction and precision control are performed during the implementation of each process; numerical control programming is performed at first during blanking of the sections, and then the sections are cut by a plasma numerical control cutting machine; and the blanking of all the sections should satisfy the conditions as follows: the straightness of the profiles should be less than or equal to 3mm/m and the dimensional deviation of the full length should be less than or equal to 10mm.

5. The large-size floating state manufacturing method for marine engineering equipment according to claim 3, **characterized in that** the procedure division of sectional construction and precision control are performed during the implementation of each process; the outline dimension and the diagonal dimension, including assembly lines, assembled molded lines, survey lines and center lines of all sections, have to be guaranteed during scribing, wherein the precision of the assembly lines, the assembled molded lines, the survey lines and the centre lines is controlled to be less than or equal to 5mm; and the dimensional deviation of all sections in the length direction is controlled to be less than or equal to 5mm, and the dimensional deviation of all sections in the width direction is controlled to be less than or equal to 4mm.

6. The large-size floating state manufacturing method for marine engineering equipment according to claim 3, **characterized in that** the procedure division of sectional construction and precision control are performed during the implementation of each process; V-shaped or U-shaped grooves are provided for the butt-joints of all sections before assembly, and meanwhile the surface quality, angle, direction and straightness of each groove are guaranteed; and the assembling clearances should have leveled end faces for the assembly of the sections.

7. The large-size floating state manufacturing method for marine engineering equipment according to claim 3, **characterized in that** the procedure division of sectional construction and precision control are performed during the implementation of each process; the smallest dimension of the craft boards for the board-jointing and welding processes is 130 × 130mm, and the thickness thereof should be the same as that of the welding plates; during welding, the sections of all the straight boards are machined by submerged arc welding, CO_2 shielded arc welding is adopted for the fillet welding of the sections, and the difference between the largest width and the smallest width of the welds should be not more than 10mm; during the welding of the sections, it is better to arrange an even number of welders to perform symmetric welding, and it is necessary to arrange an even number of welders to perform symmetric and radial welding from the middle to around, so as to reduce the welding deformation of the sections.

8. The large-size floating state manufacturing method for marine engineering equipment according to claim 3, **characterized in that** the procedure division of sectional construction and precision control are performed during the implementation of each process; during the assembly of the sections, the precision of the assembling clearances should be less than or equal to 5mm, the dimensional deviation in the length direction and the width direction should be less than or equal to 2.5mm, the diagonal deviation in plane assembly should be less than or equal to 8mm, and the diagonal deviation of the curved surface assembly and the three-dimensional assembly should be less than or equal to 15mm.

9. The large-size floating state manufacturing method for marine engineering equipment according to claim 3, **characterized in that** the procedure division of sectional construction and precision control are performed during the implementation of each process; survey on completion is performed for the sections to guarantee the integrality of all sections, and meanwhile the main dimension, horizontality and verticality thereof should satisfy relevant requirements; and during the survey of completion for the sections, the flatness of each section should be less than or equal to 15mm, and the horizontality and verticality should be less than or equal to 18mm.

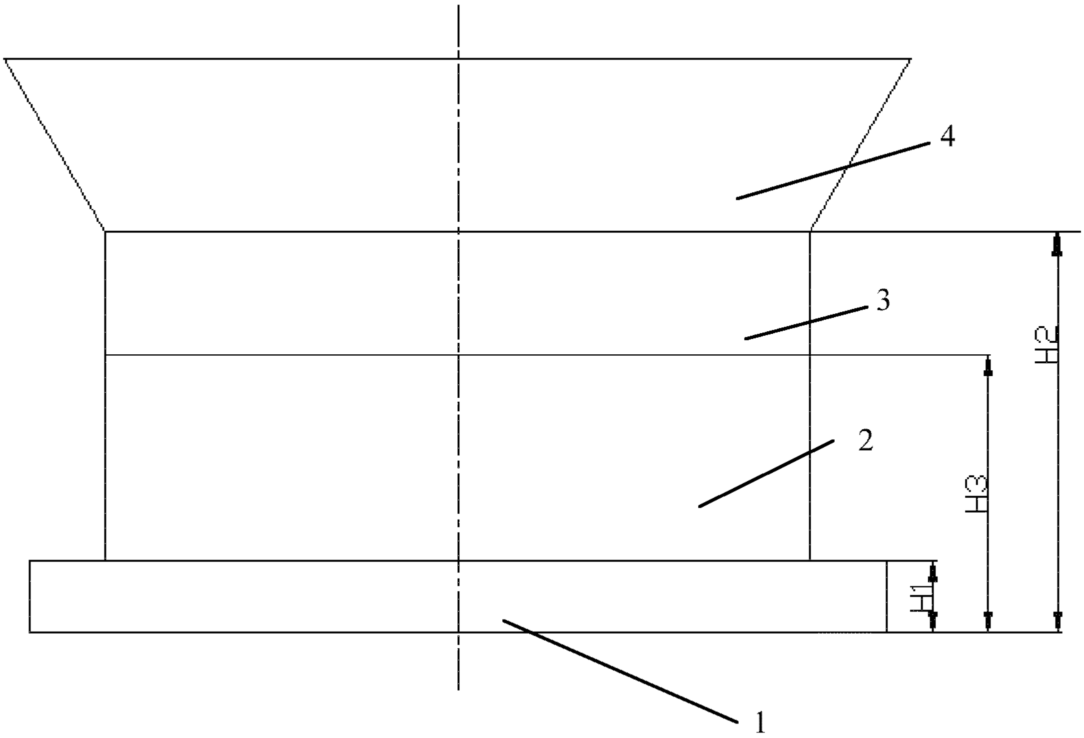

Figure 1

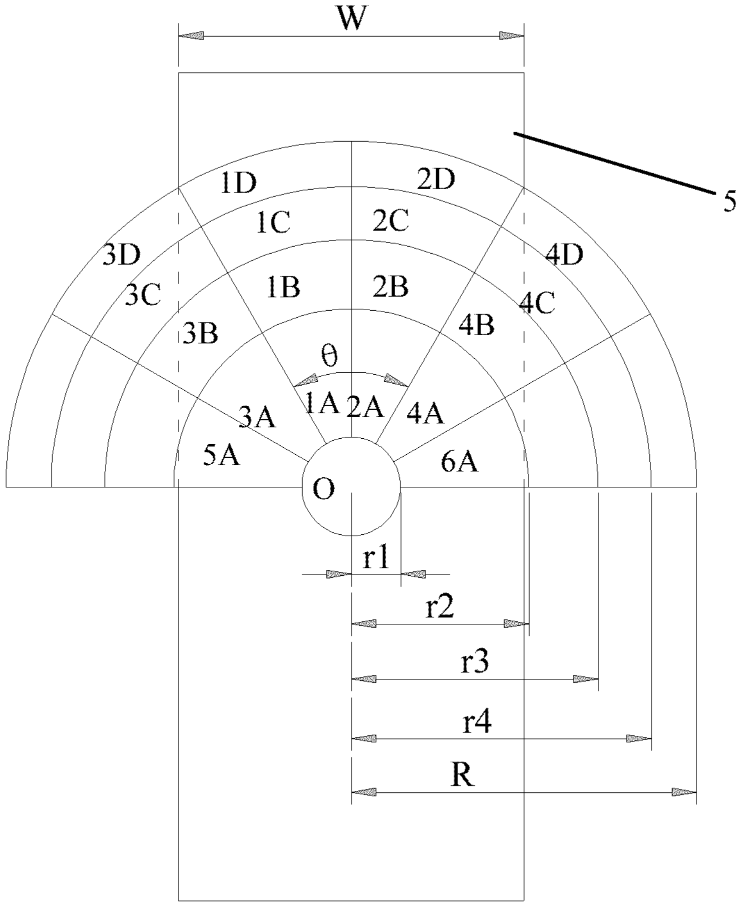

Figure 2

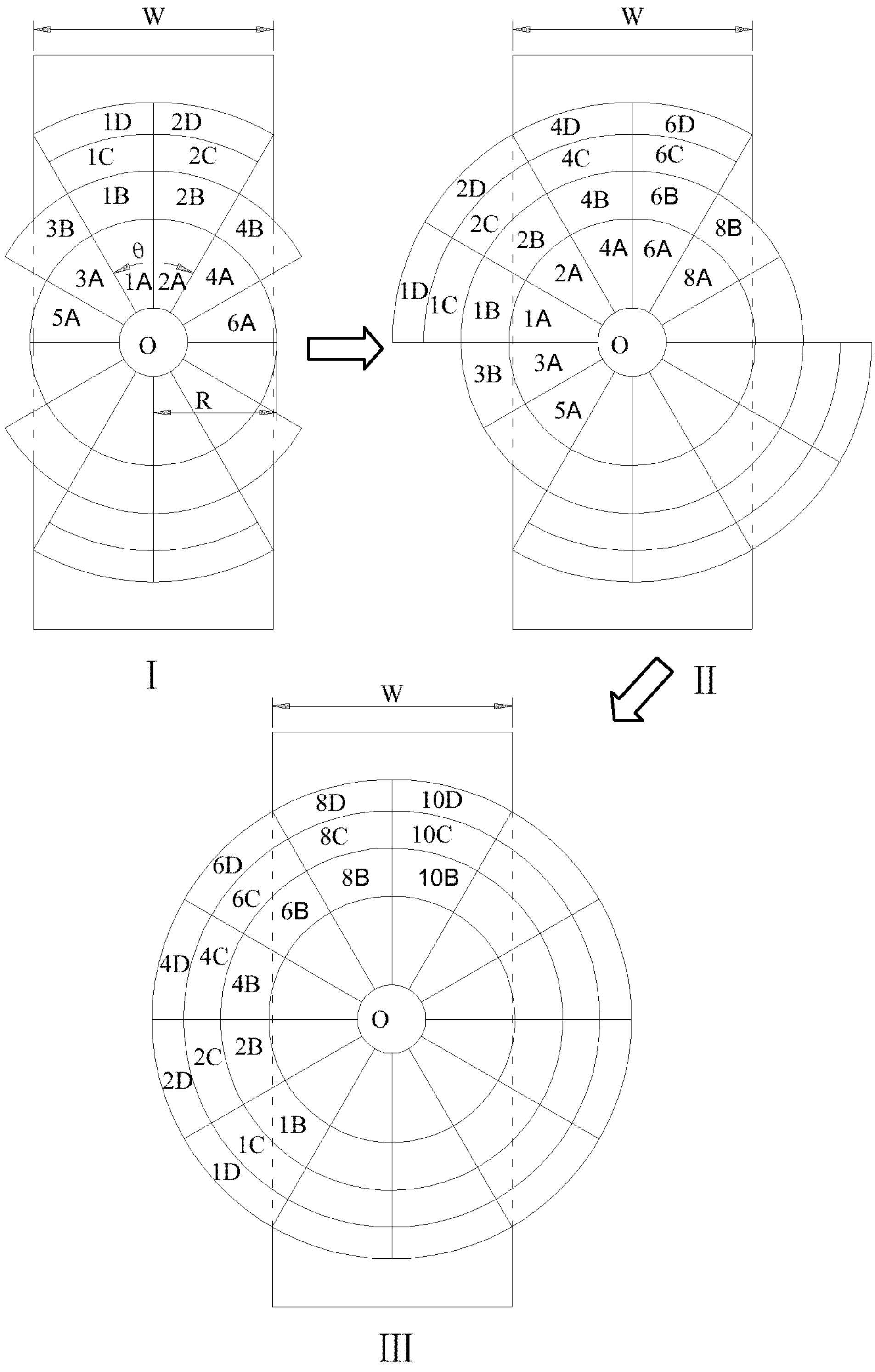
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Figure 3

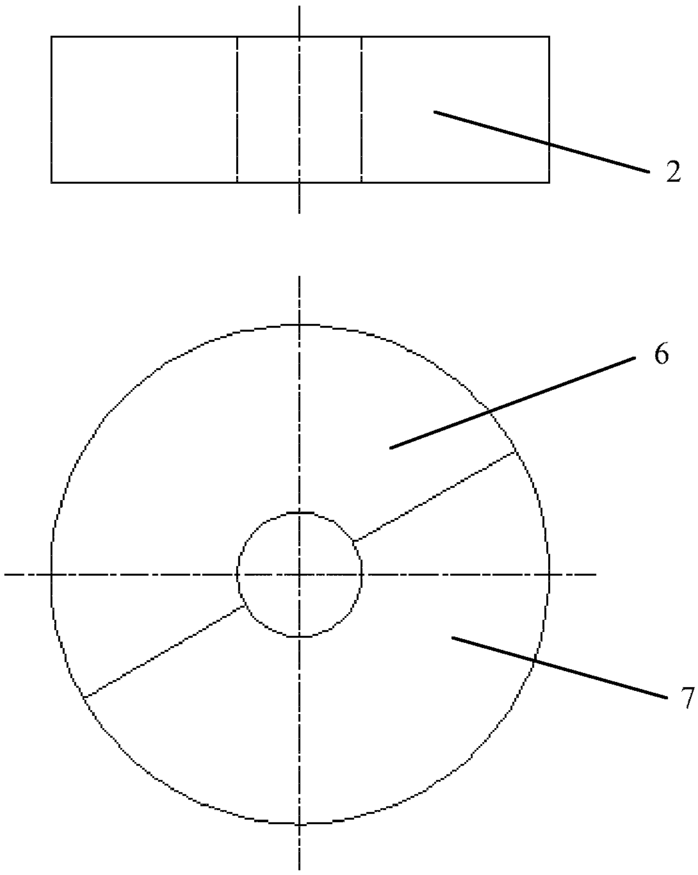

Figure 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2011/084097

A. CLASSIFICATION OF SUBJECT MATTER

B63B 9/06 (2006.01) i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: B63B 9/-

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI; EPODOC; CNPAT; CNKI: JIANGSU UNIVERSITY; ZHANG, Yongkang; ZHANG, Chaoyang; WANG, Fei; WANG, Yun; GU, Yongyu; CUI, Chengyun; TONG, Yanqun; floating status, flotage, petroleum, drilling, oil storage, oil vapor, ocean, offshore, layering, overlay, platform, offshore W unit, offshore W platform, offshore W structure, drilling W platform, production W platform, boring W platform, well W platform, drilling W unit, ship, shipping, boat, vessel, watercraft, float, floating, floated, construct+, assembling, produc+, make, making, made, manufactur+, build, building, create, creating, shut, shuting, shutted, fold, folding, subsection, sectionalize? segmentation, sublevel

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	CN 101844605 A (COSCO (NANTONG) SHIPYARD CO., LTD. et al.), 29 September 2010 (29.09.2010), claims 1-6, description, paragraphs 36-38, and figures 1-4	1-9
Y	CN 101870335 A (COSCO (NANTONG) SHIPYARD CO., LTD. et al.), 27 October 2010 (27.10.2010), claims 1-6, and figures 1-3	3-9
A	CN 101481001 A (COSCO (NANTONG) SHIPYARD CO., LTD.), 15 July 2009 (15.07.2009), the whole document	1-9
A	JP 2010179757 A (SASEHO JUKOGYO KK), 19 August 2010 (19.08.2010), the whole document	1-9
A	WO 0040806 A2 (EXXONMOBIL UPSTREAM RES CO), 13 July 2000 (13.07.2000), the whole document	1-9

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
10 July 2012 (10.07.2012)	**23 August 2012 (23.08.2012)**

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2011/084097

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
CN 101844605 A	29.09.2010	CN 101844605 B	13.07.2011
CN 101870335 A	27.10.2010	CN 101870335 B	07.09.2011
CN 101481001 A	15.07.2009	CN 101481001 B	03.11.2010
JP 2010179757 A	19.08.2010	None	
WO 0040806 A2	13.07.2000	US 6340272 B1	22.01.2002
		WO 0040806 A3	10.05.2007

Form PCT/ISA/210 (patent family annex) (July 2009)

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- US 4848967 A **[0003]**
- CN ZL200410052950 **[0003]**
- CN ZL02295585 **[0003]**
- CN ZL200510045929 **[0003]**