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(54) **PUMP TRUCK AND CONTROL METHOD AND DEVICE THEREOF**

(57) A pump truck and a control method and a control device thereof are provided. The control method for the pump truck comprises the following steps: acquiring the degrees of opening of four outriggers (1, 2) of the pump truck; determining the end points of the four outriggers (1, 2) of the pump truck according to the degrees of opening and connecting the end points of the four outriggers (1, 2) to determine the boundary (7) of the safe operating area of the pump truck; calculating the metacenter (6) of the whole pump truck according to the gravity of the base of the pump truck, the coordinates of the center of gravity of the base and the gravity of the whole pump truck; calculating the center of gravity (5) of the whole pump truck according to the gravity of the base of the pump truck, the gravity of the boom of the pump truck, the gravity of the whole pump truck, the coordinates of the center of gravity of the boom of the pump truck and the coordinates of the center of gravity of the base of the pump truck; calculating the safety coefficient of the pump truck according to the boundary (7) of the safe operating area, the metacenter (6) of the whole pump truck and the center of gravity (5) of the whole pump truck; and controlling the

pump truck according to the safety coefficient. By the control method for the pump truck, the safety of the pump truck can be ensured when the outriggers of the pump truck cannot be opened completely. Fig. 1

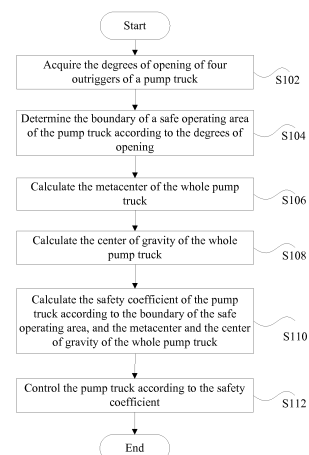


Fig.2

Description

Technical field of the invention

[0001] The invention relates to the field of pump trucks, in particular to a pump truck and a control method and a control device thereof.

Background of the invention

[0002] The safety of a concrete pump truck in the construction process is a key technical problem. At present, a pump truck opens its outriggers completely to ensure the maximum safe operating area, and as shown in Fig. 1, the concrete conveying radius of the pump truck can be maximized to ensure that the pump truck can pump concrete safely in the horizontal state of a boom. However, due to the limit of an operating space, the outriggers always fail to be opened completely, and consequently limiting the safe conveying radius of the pump truck and failing to ensure the pumping safety at any state of the boom; and moreover, the whole pump truck is likely to overturn in some cases. The first issue for preventing the pump truck from overturning is to dynamically determine the safe operating range of the pump truck so as to limit the action of the boom in the safe range when the outriggers are not opened completely.

[0003] There is still no effective solution to solve the problem that the safety of the pump truck cannot be ensured when the outriggers of the pump truck cannot be opened completely in the related arts.

Summary of the invention

[0004] The main objective of the invention is to provide a pump truck and a control method and a control device thereof, in order to solve the problem that the safety of the pump truck cannot be ensured when the outriggers of the pump truck cannot be opened completely.

[0005] To achieve the objective, in one aspect, the invention provides a control method for the pump truck.

[0006] The control method for the pump truck includes the following steps: acquiring the degrees of opening of four outriggers of the pump truck; determining the end points of the four outriggers of the pump truck according to the degrees of opening and connecting the end points of the four outriggers to determine the boundary of the safe operating area of the pump truck; calculating the metacenter of the whole pump truck according to the gravity of the base of the pump truck, the coordinates of the center of gravity of the base and the gravity of the whole pump truck; calculating the center of gravity of the whole pump truck according to the gravity of the base of the pump truck, the gravity of the boom of the pump truck, the gravity of the whole pump truck, the coordinates of the center of gravity of the boom of the pump truck and the coordinates of the center of gravity of the base of the pump truck; calculating the safety coefficient of the pump

truck according to the boundary of the safe operating area, the metacenter of the whole pump truck and the center of gravity of the whole pump truck; and controlling the pump truck according to the safety coefficient.

[0007] To achieve the objective, in another aspect, the invention provides a control device for the pump truck.

[0008] The control device for the pump truck includes: a first acquisition module for acquiring the degrees of opening of four outriggers of the pump truck; a first determining module for determining the end points of the four outriggers of the pump truck according to the degrees of opening and connecting the end points of the four outriggers to determine the boundary of the safe operating area of the pump truck; a first calculation module for calculating the metacenter of the whole pump truck according to the gravity of the base of the pump truck, the coordinates of the center of gravity of the base and the gravity of the whole pump truck; a second calculation module for calculating the center of gravity of the whole pump truck according to the gravity of the base of the pump truck, the gravity of the boom of the pump truck, the gravity of the whole pump truck, the coordinates of the center of gravity of the boom of the pump truck and the coordinates of the center of gravity of the base of the pump truck; a third calculation module for calculating the safety coefficient of the pump truck according to the boundary of the safe operating area, the metacenter of the whole pump truck and the center of gravity of the whole pump truck; and a control module for controlling the pump truck according to the safety coefficient.

[0009] To achieve the objective, in another aspect, the invention provides a pump truck.

[0010] The pump truck includes: any control device for the pump truck provided by the invention, and a display interface which is connected with the control device and used for displaying the state of the whole pump truck.

[0011] According to the invention, by the control method for the pump truck, including the following steps: acquiring the degrees of opening of four outriggers of the pump truck; determining the end points of the four outriggers of the pump truck according to the degrees of opening and connecting the end points of the four outriggers to determine the boundary of the safe operating area of the pump truck; calculating the metacenter of the whole pump truck according to the gravity of the base of the pump truck, the coordinates of the center of gravity of the base and the gravity of the whole pump truck; calculating the center of gravity of the whole pump truck according to the gravity of the base of the pump truck, the gravity of the boom of the pump truck, the gravity of the whole pump truck, the coordinates of the center of gravity of the boom of the pump truck and the coordinates of the center of gravity of the base of the pump truck; calculating the safety coefficient of the pump truck according to the boundary of the safe operating area, the metacenter of the whole pump truck and the center of gravity of the whole pump truck; and controlling the pump truck according to the safety coefficient, the problem that

the safety of the pump truck cannot be ensured when the outriggers of the pump truck cannot be opened completely is solved, so that the safety of the pump truck can be ensured when the outriggers of the pump truck cannot be opened completely.

Brief description of the drawings

[0012] The drawings constituting one part of the application are to provide further understanding of the invention, and the exemplary embodiments of the invention and the explanations thereof are intended to explain the invention, instead of improperly limiting the invention. In the drawings:

Fig. 1 is a diagram showing control for a pump truck according to the prior art;

Fig. 2 is a diagram showing the flow of a control method for a pump truck according to one embodiment of the invention;

Fig. 3 is a diagram showing control for a pump truck according to one embodiment of the invention;

Fig. 4 is a diagram showing calculation for arm of force of a cylinder of a pump truck according to one embodiment of the invention;

Fig. 5 is a diagram of a control method for a pump truck according to one embodiment of the invention; and

Fig. 6 is a block diagram of a control device for a pump truck according to one embodiment of the invention.

Detailed Description of the Embodiments

[0013] It should be noted that, in the case of no conflict, the embodiments of the application and features therein can be combined with each other. The invention will be described below in detail with reference to the drawings and in conjunction with the embodiments.

[0014] Fig. 2 is a diagram showing the flow of a control method for a pump truck according to one embodiment of the invention, as shown in Fig. 2, the method includes Step 102 to Step 112.

[0015] Step 102: Acquire degrees of opening of four outriggers of a pump truck.

[0016] In the step, the degrees of opening of the outriggers are measured by an outrigger sensor, including a bracing wire sensor and an angle sensor, in real time. Fig. 3 is a diagram showing control for a pump truck according to one embodiment of the invention, and as shown in Fig. 3, measuring the degrees of opening of two front X outriggers 1 and two rear swinging legs 2 are included.

[0017] Step 104: Determine the boundary of a safe operating area of the pump truck according to the degrees of opening and then the end points of the outriggers are connected to form a quadrangle to form the boundary of the safe operating area of the whole pump truck, and as

shown in Fig. 3, the boundary 7 of the safe operating area of the pump truck is determined according to the degrees of opening of the two front X outriggers 1 and two rear swinging legs 2.

[0018] Step 106: Calculate the metacenter of the whole pump truck.

[0019] As shown in Fig. 3, the metacenter 6 of the whole pump truck is calculated by the following formulas:

$$X_{stab}=G_{truck}*x_{truck}/G_{total}$$

$$Y_{stab}=G_{truck}*y_{truck}/G_{total}$$

wherein X_{stab} is the x-coordinate of the metacenter of the whole pump truck, Y_{stab} is the y-coordinate of the metacenter of the whole pump truck, G_{truck} is the gravity of the base, G_{total} is the gravity of the whole pump truck, (x_{truck}, y_{truck}) are the coordinates of the center of gravity of the base, and the gravity of the base, the gravity of the whole pump truck and the coordinates of the center of gravity of the base are inherent parameters of the pump truck.

[0020] Step 108: Calculate the center of gravity of the whole pump truck.

[0021] As shown in Fig. 3, a revolving circle 4 for the center of gravity is obtained by taking the center of gravity 5 of the whole pump truck as the center of the circle, and a right-angle coordinate system is formed by taking the center of a revolving table 3 as the origin of coordinates, the head and tail direction of the truck as the transverse axis and the vertical direction of the revolving table 3 as the longitudinal axis. The center of gravity of the whole pump truck is calculated according to the gravity of the base of the pump truck, the gravity of the boom of the pump truck, the gravity of the whole pump truck, the coordinates of the center of gravity of the boom of the pump truck and the coordinates of the center of gravity of the base of the pump truck by the following formulas:

$$X_{center}=(G_{boom}*x_{boom}+G_{truck}*x_{truck})/G_{total}$$

$$Y_{center}=(G_{boom}*y_{boom}+G_{truck}*y_{truck})/G_{total}$$

wherein x_{center} is the x-coordinate of the center of gravity of the whole pump truck, y_{center} is the y-coordinate of the center of gravity of the whole pump truck, G_{boom} is the gravity of the boom, G_{truck} is the gravity of the base, G_{total} is the gravity of the whole pump truck, (x_{boom}, y_{boom}) are the coordinates of the center of gravity of the boom, (x_{truck}, y_{truck}) are the coordinates of the center of gravity

of the base, the gravity of the boom, the gravity of the base, the gravity of the whole pump truck and the coordinates of the center of gravity of the base are inherent parameters of the pump truck, and the coordinates of the center of gravity of the boom are calculated by the following formulas:

$$x_{boom} = FL_{cylinder} * \cos\theta$$

$$y_{boom} = FL_{cylinder} * \sin\theta$$

wherein x_{boom} is the x-coordinate of the center of gravity of the boom, y_{boom} is the y-coordinate of the center of gravity of the boom, θ is the revolving angle of the boom, and $FL_{cylinder}$ is the arm of force of the cylinder.

[0022] The revolving angle of the boom can be obtained by an angle sensor. The arm of force of the cylinder is related to the angle of inclination and structure size of the main arm of the pump truck. Fig. 4 is a diagram showing calculation for arm of force of the cylinder of the pump truck according to one embodiment of the invention, and as shown in Fig. 4, the upper hinge point of the cylinder is A, the lower hinge point of the cylinder is B, the revolving point of the boom is O and the pedal of the revolving point of the boom on the connection line of the upper and lower hinge points of the cylinder is C, and the distance of OC is the arm of force of the cylinder, the arm of force is obtained by calculation according to the geometrical relationship of the horizontal distance LD between the lower hinge point B of the cylinder and the revolving point O of the boom, the vertical distance LC between the lower hinge point B of the cylinder and the revolving point O of the boom, the distance LE between the upper hinge point A of the cylinder and the revolving point O of the boom along the direction of the main arm of the pump truck, the distance LF between the upper hinge point A of the cylinder and the revolving point O of the boom along the vertical direction of the main arm of the pump truck and the angle of inclination of the main arm of the pump truck; and the calculation process is purely geometric calculation, thereby needing no further description.

[0023] Step 110: cording to the boundary of the safe operating area, and the metacenter and the center of gravity of the whole pump truck.

[0024] The safety coefficient is obtained by calculating the safe distance between the center of gravity and the metacenter of the whole pump truck at first, then calculating the relative position minimum distance between the center of gravity of the whole pump truck and the boundary of the safe operating area, and finally dividing the minimum distance by the safe distance.

[0025] Step 112: Control the pump truck according to the safety coefficient.

[0026] Controlling the pump truck according to the

safety coefficient includes: controlling the pump truck to lock action of the pump truck according to the safety coefficient, controlling the pump truck to implement the opposite action of the locked action and controlling the pump truck to unlock the locked action. The action of the pump truck is correspondingly locked according to the danger level at first, and then, the pump truck is controlled to actuate the boom in a safe revolving direction or the unlocked action direction of a boom section by implementing the opposite action of the locked action, so that the safety coefficient is increased, the pump truck enters the safe area, the action limited by the anti-overturning function of the whole pump truck is restored and the whole pump truck can be timely prevented from overturning.

[0027] When the safety coefficient of the whole pump truck is equal to 1, the overturning moment and the moment of the whole pump truck keep balance, and at the moment, the whole pump truck is in a critical state of overturning; when the safety coefficient of the whole pump truck is less than 1, the whole pump truck may overturn as an accident; in order to prevent the whole pump truck from overturning, the safety coefficient should be greater than 1; and the overturn danger level of the whole pump truck, corresponding to three safety coefficients, a, b, c, where $a > b > c$, is divided into a, b and c levels, the less the safety coefficient is, the greater the overturn danger level is, and different safety coefficients represent different overturn danger levels of the whole pump truck. If the safety coefficient is less than a and greater than or equal to b, the whole pump truck is at a danger level of a and may be controlled by a controller program to lock the high gear of the boom, enter a low gear mode, lock the downward action of a first boom section, and lock the rotation on one side in the dangerous direction; if the safety coefficient is less than b and greater than or equal to c, the whole pump truck is at a danger level of b and is controlled to lock the action of the boom to continue for several seconds, optionally 5 seconds, lock the high gear of the boom, enter a low gear mode, lock the downward action of the first and second boom sections, and lock the rotation on one side in the dangerous direction; and if the safety coefficient is less than c and greater than or equal to 1, the whole pump truck is at a danger level of c and controlled to lock the action of the boom in a safe rotation direction and lock pumping. The safety of the whole pump truck is ensured by hierarchical control; when the pump truck tends to be dangerous, the action of the boom in the dangerous direction is limited to ensure that the boom is operated in the safe direction to restore the safety of the whole pump truck; and when the pump truck is at the highest danger level, all the possible dangerous actions of the whole pump truck are limited to ensure the safety state of the whole pump truck. After the whole pump truck is beyond danger, the anti-overturning function of the whole pump truck can be shielded by a function shielding switch so as to remove all the limits of the anti-overturning function on the whole

pump truck.

[0028] It should be noted that the pump truck can be controlled hierarchically according to the safety coefficient of the whole pump truck, and the control way is not limited to controlling the boom, rotation and pumping, such as controlling the function of a remote control.

[0029] Fig. 5 is a diagram of a control method for a pump truck according to one embodiment of the invention, and as shown in Fig. 5, in the calculation process, the measurement for a parameter is neither limited to the measurement way of one or more sensors nor limited to the type of the sensor, for example, the measurement for the degrees of opening of the outriggers can be measured by a bracing wire sensor, an angle sensor, a laser sensor and the like in one or more ways.

[0030] By the control method for the pump truck in the embodiment, the anti-overturning of the pump truck can be intelligentized, and the safety coefficient of the whole pump truck can be dynamically calculated to judge the overturn danger level of the whole pump truck and perform corresponding control to limit the action of the boom in the overturn dangerous direction; and meanwhile, the boom is directly operated to return the center of gravity of the whole pump truck to a safer operating range; therefore, the using flexibility of the pump truck is improved, pumping can be still implemented automatically in a safe range when the opening space of the outriggers is limited, and the safety, stability and continuity of the construction of the pump truck are ensured.

[0031] According to one embodiment of the invention, a control device for a pump truck is provided.

[0032] Fig. 6 is a block diagram of the control device for the pump truck according to one embodiment of the invention, and as shown in Fig. 6, the control device includes: a first acquisition module 10, configured for acquiring the degrees of opening of four outriggers of the pump truck, wherein the degrees of opening can be measured by an outrigger sensor, including a bracing wire sensor and an angle sensor, in real time; a first determining module 20, configured for determining the boundary of the safe operating area of the pump truck according to the degrees of opening, wherein the end points of the outriggers are connected to form a quadrangle to form the boundary of the safe operating area of the whole pump truck; a first calculation module 30, configured for calculating the metacenter of the whole pump truck according to the gravity of the base of the pump truck, the coordinates of the center of gravity of the base and the gravity of the whole pump truck; a second calculation module 40, configured for calculating the center of gravity of the whole pump truck according to the gravity of the base of the pump truck, the gravity of the boom of the pump truck, the gravity of the whole pump truck, the coordinates of the center of gravity of the boom of the pump truck and the coordinates of the center of gravity of the base of the pump truck; a third calculation module 50, configured for calculating the safety coefficient of the pump truck according to the boundary of the

safe operating area, the metacenter of the whole pump truck and the center of gravity of the whole pump truck; and a control module 60, configured for controlling the pump truck according to the safety coefficient.

[0033] Through the control device for the pump truck in the embodiment, the safety coefficient of the whole pump truck can be dynamically calculated, and according to the safety coefficient of the whole pump truck, the overturn danger level of the whole pump truck is judged, and the action of the boom in the dangerous overturning direction is correspondingly limited, therefore, the anti-overturning function of the pump truck is more intelligent, the using flexibility of the pump truck is improved, pumping can be still implemented automatically in a safe range when the opening space of the outriggers is limited, and the safety, stability and continuity of the construction of the pump truck are ensured.

[0034] The first calculation module 30 calculates the metacenter of the pump truck by the following formulas:

$$X_{stab}=G_{truck} * x_{truck}/G_{total}$$

$$Y_{stab}=G_{truck} * y_{truck}/G_{total}$$

wherein X_{stab} is the x-coordinate of the metacenter of the whole pump truck, Y_{stab} is the y-coordinate of the metacenter of the whole pump truck, G_{truck} is the gravity of the base, G_{total} is the gravity of the whole pump truck, (x_{truck}, y_{truck}) are the coordinates of the center of gravity of the base, and the gravity of the base, the gravity of the whole pump truck and the coordinates of the center of gravity of the base are inherent parameters of the pump truck.

[0035] The second calculation module 40 calculates the center of gravity of the whole pump truck by the following formulas:

$$x_{center}=(G_{boom} * x_{boom}+G_{truck} * x_{truck})/G_{total}$$

$$y_{center}=(G_{boom} * y_{boom}+G_{truck} * y_{truck})/G_{total}$$

wherein x_{center} is the x-coordinate of the center of gravity of the whole pump truck, y_{center} is the y-coordinate of the center of gravity of the whole pump truck, G_{boom} is the gravity of the boom, G_{truck} is the gravity of the base, G_{total} is the gravity of the whole pump truck, (x_{boom}, y_{boom}) are the coordinates of the center of gravity of the boom, (x_{truck}, y_{truck}) are the coordinates of the center of gravity of the base, the gravity of the boom, the gravity of the base, the gravity of the whole pump truck and the coordinates of the center of gravity of the base are inherent parameters of the pump truck.

ordinates of the center of gravity of the base are inherent parameters of the pump truck, and the coordinates of the center of gravity of the boom are calculated by the following formulas:

$$x_{\text{boom}} = FL_{\text{cylinder}} * \cos\theta$$

$$y_{\text{boom}} = FL_{\text{cylinder}} * \sin\theta$$

wherein x_{boom} is the x-coordinate of the center of gravity of the boom, y_{boom} is the y-coordinate of the center of gravity of the boom, θ is the revolving angle of the boom, and FL_{cylinder} is the arm of force of the cylinder.

[0036] The revolving angle of the boom can be obtained by an angle sensor. The arm of force of the cylinder is related to the angle of inclination and structure size of the main arm of the pump truck, and Fig. 4 is a diagram showing calculation of the arm of force of the cylinder of the pump truck according to one embodiment of the invention, thereby needing no further description.

[0037] Preferably, the third calculation module 50 includes: a first calculation sub-module, configured for calculating a first distance, and the first distance is the distance between the center of gravity and the metacenter of the whole pump truck; a second calculation sub-module, configured for calculating a second distance, and the second distance is the minimum distance between the center of gravity of the whole pump truck and the boundary of the safe operating area, and a third calculation sub-module, configured for calculating the safety coefficient according to the first and second distances.

[0038] In the embodiment, the distance between the center of gravity and the metacenter of the whole pump truck is a safe distance, i.e., the first distance; the minimum distance between the center of gravity of the whole pump truck and the relative position of the boundary of the safe operating area is the second distance; and the safe coefficient is obtained by dividing the minimum distance by the safe distance.

[0039] The control module 60 includes: a first control sub-module, configured for controlling the pump truck to lock action of the pump truck according to the safety coefficient, a second control sub-module, configured for controlling the pump truck to implement an opposite action of the locked action, and a third control sub-module, configured for controlling the pump truck to unlock the locked action.

[0040] In the embodiment, the action of the pump truck is correspondingly locked according to the danger level at first, and then, the pump truck is controlled to actuate the boom in a safe revolving direction or the unlocked action direction of a boom section by implementing the opposite action of the locked action, so that the safety coefficient is increased, the pump truck enters the safe

area and the action limited by the anti-overturning function of the whole pump truck is restored.

[0041] With reference to the magnitude of the safety coefficient, the first control sub-module controls the pump truck to lock action of the pump truck: specifically, lock the high gear of the boom, enter a low gear mode, lock the downward action of a first boom section, and lock the rotation on one side in the dangerous direction when the safety coefficient is less than a first safety coefficient and greater than or equal to a second safety coefficient; lock the action of the boom to continue for predetermined time, lock the high gear of the boom, enter a low gear mode, lock the downward action of the first and second boom sections, and lock the rotation on one side in the dangerous direction when the safety coefficient is less than the second safety coefficient and greater than or equal to a third safety coefficient, and lock the action of the boom in a safe rotation direction and lock pumping when the safety coefficient is less than the third safety coefficient and greater than or equal to 1.

[0042] In the embodiment, the danger is divided into three levels to be correspondingly controlled according to the condition of the pump truck, in order that the pump truck can be prevented from overturning by least measures under different conditions.

[0043] According to one embodiment of the invention, a pump truck is provided. The pump truck includes: any control device for the pump truck provided by the invention, and a display interface, which is connected with the control device and used for displaying the state of the whole pump truck. The coordinates of the outriggers, the coordinates of the center of gravity, the coordinates of the metacenter and the like are sent to the display interface to form a top view showing the safety of the pump truck. As shown in Fig. 3, a safety man-machine interface is formed in combination with the parameters of a sensor, so that a driver can know the state of the whole pump truck in time to perform corresponding adjustment. Therefore, the safety of the driver is ensured, equipment is saved and the service life of the pump truck is prolonged.

[0044] It can be seen from what described above that the invention achieves the following technical effects: the safety coefficient of the whole pump truck can be dynamically calculated, and according to the safety coefficient of the whole pump truck, the overturn danger level of the whole pump truck is judged and the action of the boom in the overturn dangerous direction is correspondingly limited, therefore, the control flexibility of the pump truck is improved, particularly, pumping can be still implemented automatically in a safe range when the opening space of the outriggers is limited, and the safety, stability and continuity of the construction of the pump truck are ensured.

[0045] It should be noted that the steps shown in the flowchart of the drawings can be executed, for example, in the computer system of a group of computer executable instructions; moreover, the flowchart illustrates the

logic sequence, but the steps shown or described can be executed in different sequences in some cases.

[0046] Obviously, those skilled in the art shall understand that the models or steps of the invention may be implemented by general computing devices and centralized in a single computing device or allocated in a network consisting of multiple computing devices. Optionally, the models or steps may be implemented by program codes executable by the computing devices, so that they may be stored in a storage device and executed by the computing device, or respectively made into integrated circuit modules or a single integrated circuit module. By doing so, the invention is not limited to any specific combination of hardware and software.

[0047] The above are only preferred embodiments of the invention and not used for limiting the invention. For those skilled in the art, the invention may have various modifications and changes. Any modifications, equivalent replacements, improvements and the like within the spirit and principle of the invention shall fall within the scope of protection of the invention.

Claims

1. A control method for a pump truck, **characterized** by comprising:

acquiring degrees of opening of four outriggers of the pump truck;

determining end points of the four outriggers of the pump truck according to the degrees of opening and connecting the end points of the four outriggers to determine boundary of safe operating area of the pump truck;

calculating metacenter of the whole pump truck according to the gravity of the base of the pump truck, the coordinates of the center of gravity of the base and the gravity of the whole pump truck; calculating the center of gravity of the whole pump truck according to the gravity of the base of the pump truck, the gravity of the boom of the pump truck, the gravity of the whole pump truck, the coordinates of the center of gravity of the boom of the pump truck and the coordinates of the center of gravity of the base of the pump truck;

calculating a safety coefficient of the pump truck according to the boundary of the safe operating area, the metacenter of the whole pump truck and the center of gravity of the whole pump truck; and

controlling the pump truck according to the safety coefficient.

2. The control method for the pump truck according to claim 1, **characterized in that** the metacenter of the whole pump truck is calculated by the following for-

mulas:

$$X_{stab}=G_{truck}*x_{truck}/G_{total}$$

$$Y_{stab}=G_{truck}*y_{truck}/G_{total}$$

wherein X_{stab} is x-coordinate of the metacenter of the whole pump truck, Y_{stab} is y-coordinate of the metacenter of the whole pump truck, G_{truck} is the gravity of the base, G_{total} is the gravity of the whole pump truck and (x_{truck}, y_{truck}) are the coordinates of the center of gravity of the base.

3. The control method for the pump truck according to claim 1, **characterized in that** the center of gravity of the whole pump truck is calculated by the following formulas:

$$X_{center}=(G_{boom}*x_{boom}+G_{truck}*x_{truck})/G_{total}$$

$$Y_{center}=(G_{boom}*y_{boom}+G_{truck}*y_{truck})/G_{total}$$

wherein x_{center} is x-coordinate of the center of gravity of the whole pump truck, y_{center} is y-coordinate of the center of gravity of the whole pump truck, G_{boom} is the gravity of the boom, G_{truck} is the gravity of the base, G_{total} is the gravity of the whole pump truck, (x_{boom}, y_{boom}) are the coordinates of the center of gravity of the boom and (x_{truck}, y_{truck}) are the coordinates of the center of gravity of the base.

4. The control method for the pump truck according to claim 3, **characterized in that** the coordinates of the center of gravity of the boom is calculated by the following formulas:

$$x_{boom}=FL_{cylinder}*\cos\theta$$

$$y_{boom}=FL_{cylinder}*\sin\theta$$

wherein x_{boom} is x-coordinate of the center of gravity of the boom, y_{boom} is y-coordinate of the center of gravity of the boom, θ is the revolving angle of the boom, and $FL_{cylinder}$ is the arm of force of the cylinder.

5. The control method for the pump truck according to

claim 1, **characterized in that** calculating the safety coefficient comprises:

calculating a first distance, wherein the first distance is the distance between the center of gravity of the whole pump truck and the metacenter of the whole pump truck; 5
calculating a second distance, wherein the second distance is the minimum distance between the center of gravity of the whole pump truck and the boundary of the safe operating area; and 10
dividing the second distance by the first distance to obtain the safety coefficient.

6. The control method for the pump truck according to claim 1, **characterized in that** controlling the pump truck according to the safety coefficient comprises: 15

controlling the pump truck to lock an action of the pump truck according to the safety coefficient; 20
controlling the pump truck to implement an opposite action of a locked action; and
controlling the pump truck to unlock the locked action. 25

7. The control method for the pump truck according to claim 6, **characterized in that** controlling the pump truck to lock an action of the pump truck according to the safety coefficient comprises: 30

locking high gear of the boom, entering a low gear mode, locking a downward action of a first boom section, and locking the rotation on one side in a dangerous direction when the safety coefficient is less than a first safety coefficient and greater than or equal to a second safety coefficient; 35
locking an action of the boom to continue for a predetermined time, locking high gear of the boom, entering a low gear mode, locking a downward action of the first and the second boom sections, and locking rotation on one side in a dangerous direction when the safety coefficient is less than the second safety coefficient and greater than or equal to a third safety coefficient; and 40
locking an action of boom slewing in a safe direction and locking pumping when the safety coefficient is less than the third safety coefficient and greater than or equal to 1, 45
wherein the first safety coefficient is greater than the second safety coefficient, and the second safety coefficient is greater than the third safety coefficient. 50

8. A device for controlling a pump truck, **characterized by** comprising:

a first acquisition module, configured for acquiring degrees of opening of four outriggers of the pump truck;

a first determining module, configured for determining end points of the four outriggers of the pump truck according to the degrees of opening and connecting the end points of the four outriggers to determine boundary of safe operating area of the pump truck;

a first calculation module, configured for calculating metacenter of the whole pump truck according to the gravity of the base of the pump truck, the coordinates of the center of gravity of the base and the gravity of the whole pump truck; a second calculation module, configured for calculating the center of gravity of the whole pump truck according to the gravity of the base of the pump truck, the gravity of the boom of the pump truck, the gravity of the whole pump truck, the coordinates of the center of gravity of the boom of the pump truck and the coordinates of the center of gravity of the base of the pump truck; a third calculation module, configured for calculating a safety coefficient of the pump truck according to the boundary of the safe operating area, the metacenter of the whole pump truck and the center of gravity of the whole pump truck; and

a control module, configured for controlling the pump truck according to the safety coefficient.

9. The device for controlling the pump truck according to claim 8, **characterized in that** the third calculation module comprises:

a first calculation sub-module, configured for calculating a first distance, wherein the first distance is the distance between the center of gravity and the metacenter of the whole pump truck; a second calculation sub-module, configured for calculating a second distance, wherein the second distance is the minimum distance between the center of gravity of the whole pump truck and the boundary of the safe operating area; and a third calculation sub-module, configured for calculating the safety coefficient according to the first and the second distances.

10. The device for controlling the pump truck according to claim 8, **characterized in that** the control module comprises:

a first control sub-module, configured for controlling the pump truck to lock an action according to the safety coefficient; a second control sub-module, configured for controlling the pump truck to implement an opposite action of a locked action; and

a third control sub-module, configured for controlling the pump truck to unlock the locked action.

11. A pump truck, **characterized by** comprising: 5

a device for controlling the pump truck according to any one of claims 8 to 10; and
a display interface, connected with the device for controlling the pump truck, configured for displaying the state of the whole pump truck. 10

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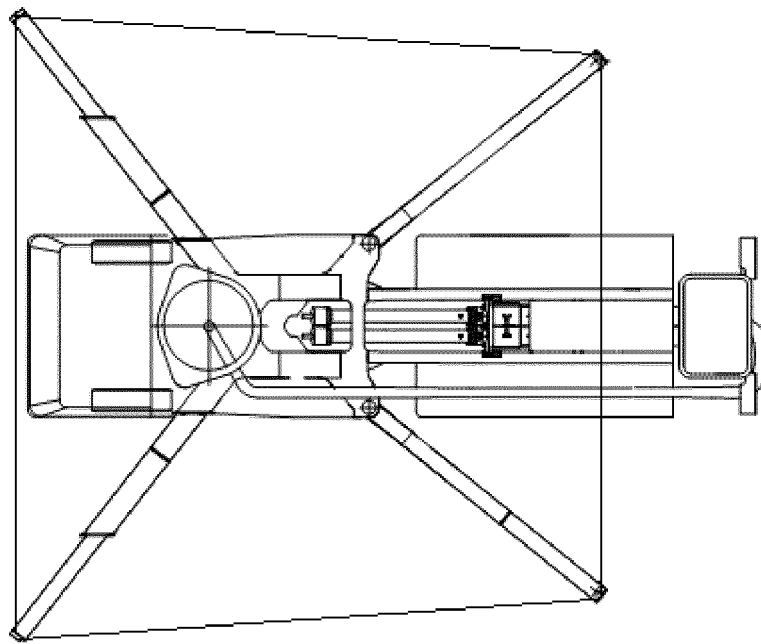
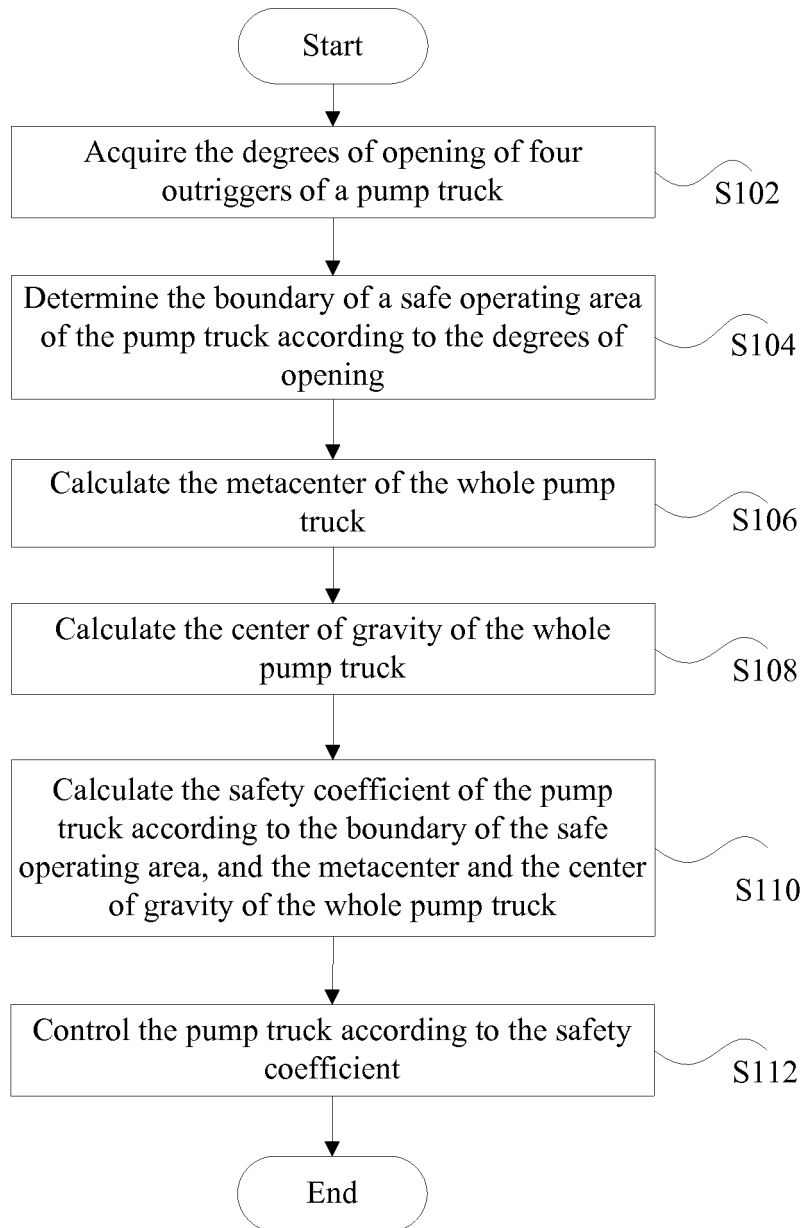


Fig.1

**Fig.2**

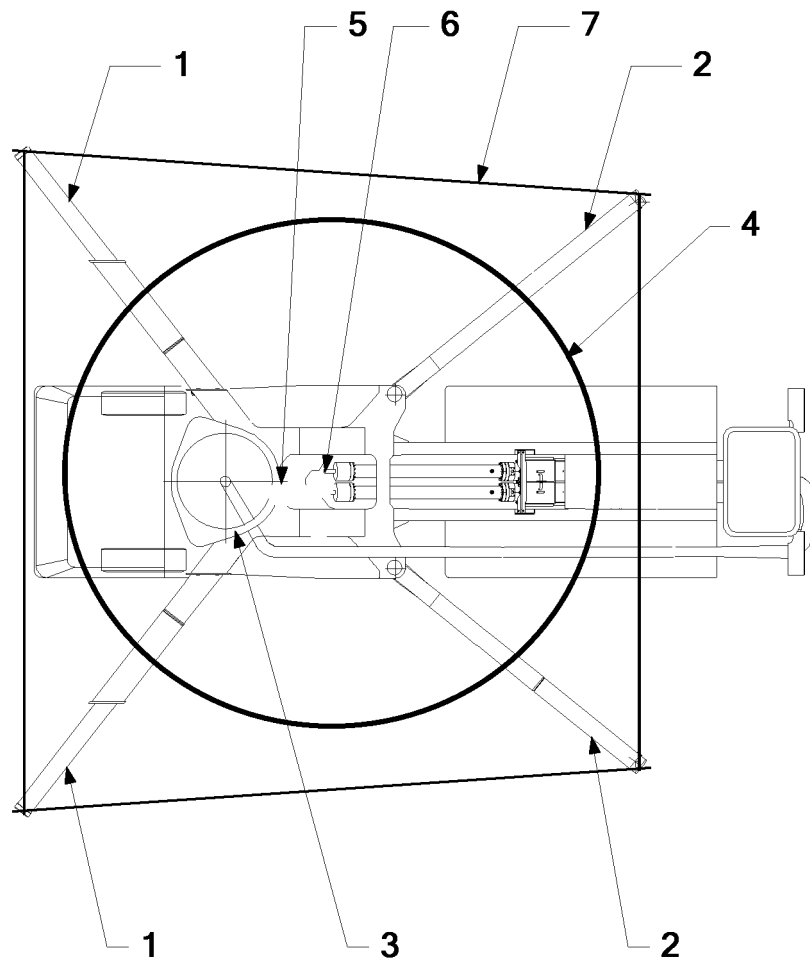


Fig.3

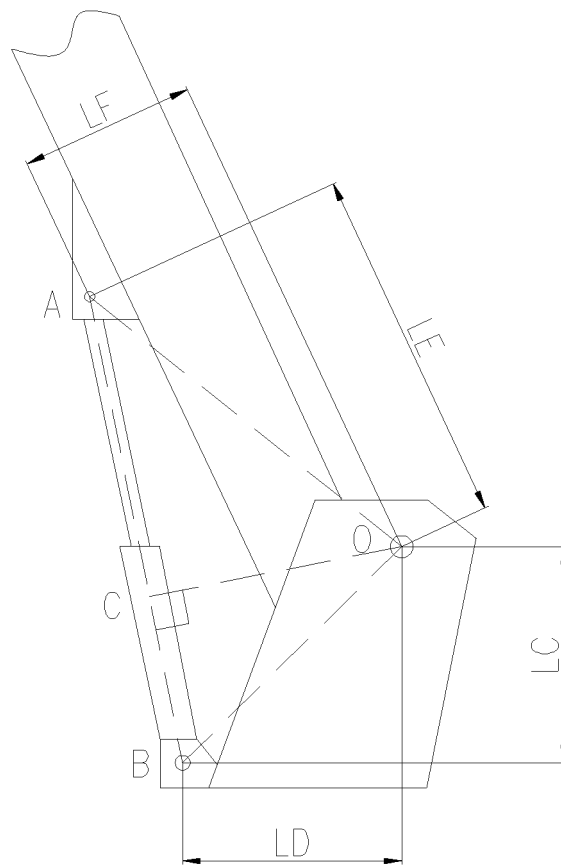


Fig.4

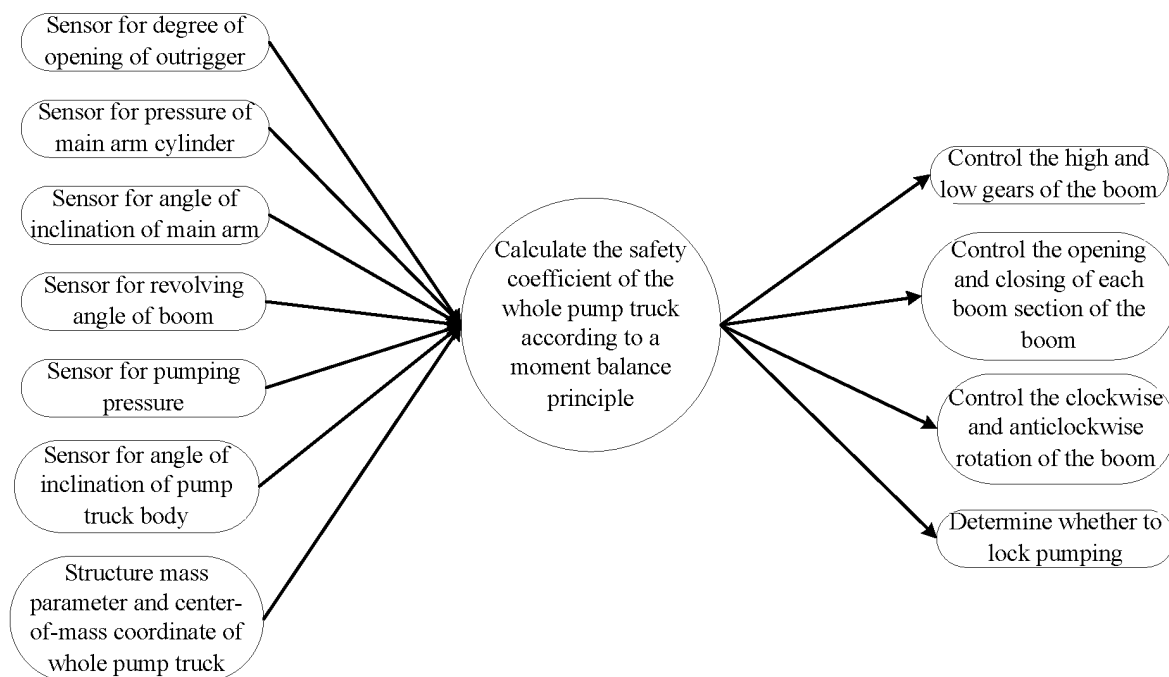


Fig.5

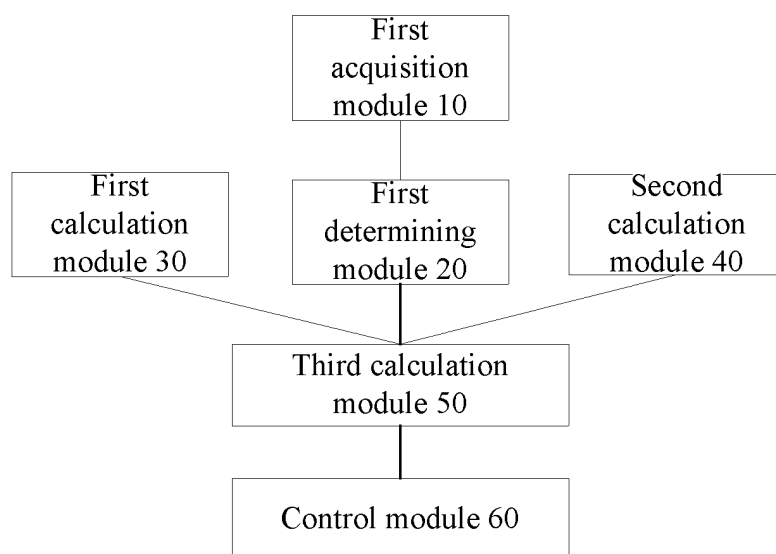


Fig.6

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2011/080899

A. CLASSIFICATION OF SUBJECT MATTER

E04G 21/02 (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: E04G 21/-, B66C 23/-

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)

EPODOC, WPI, CNPAT, CNKI: pump truck, supporting leg, barycenter, roll-over, pump, vehicle, truck, concrete, cement, leg?, support+, gravity, metacentre, safe+, secure, roll+

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CN 101833287 A (SANY HEAVY INDUSTRY CO., LTD.), 15 September 2010 (15.09.2010), see description, paragraphs 46-52, and figures 1-4	1-11
A	CN 101457589 A (SANY HEAVY INDUSTRY CO., LTD.), 17 June 2009 (17.06.2009), see the whole document	1-11
A	CN 101845892 A (XCMG CONSTRUCTION MACHINERY CO., LTD. BUILDING MACHINERY CO.), 29 September 2010 (29.09.2010), see the whole document	1-11
A	CN 201329855 Y (SHANDONG HONGDA CONSTRUCTION MACHINERY GROUP CO., LTD.), 21 October 2009 (21.10.2009), see the whole document	1-11
A	CN 201647861 U (XUZHOU INSTITUTE OF TECHNOLOGY et al.), 24 November 2010 (24.11.2010), see the whole document	1-11

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

* Special categories of cited documents:	"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
"A" document defining the general state of the art which is not considered to be of particular relevance	"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
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"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)	"&" document member of the same patent family
"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	

Date of the actual completion of the international search 28 March 2012 (28.03.2012)	Date of mailing of the international search report 19 April 2012 (19.04.2012)
Name and mailing address of the ISA/CN: State Intellectual Property Office of the P. R. China No. 6, Xitucheng Road, Jimenqiao Haidian District, Beijing 100088, China Facsimile No.: (86-10) 62019451	Authorized officer YANG, Guiquan Telephone No.: (86-10) 62085242

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2011/080899

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CN 101487343 A (SANY HEAVY INDUSTRY CO., LTD.), 22 July 2009 (22.07.2009), see the whole document	1-11
A	US 6785597 B1 (WIGGINS LIFT CO INC.), 31 August 2004 (31.08.2004), see the whole document	1-11
A	JP 5248094 A (ASAHI CHEMICAL IND.), 24 September 1993 (24.09.1993), see the whole document	1-11

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/CN2011/080899

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CN 201329855 Y	21.10.2009	None	
CN 201647861 U	24.11.2010	None	
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JP 5248094 A	24.09.1993	JP 2956918 B2	04.10.1999

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