

THE IMPROVEMENT TO SOLVE THE PROBLEM OF THE INDEPENDENT OVERWEIGHT FORCE STANDARD MACHINE'S PROCEED AND RETURN PHENOMENON

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Abstract: Through the analysis of the working principle of the original control system in deadweight force standard machine with independent weight application structure and the stress state of the center boom, we find out the inherent problem in proceeding test, which contains returning process, or in the returning test, which contains proceeding process, due to the weight rearrangement in loading and unloading process. To solve this problem, we propose an innovative technical improvement solution based on classical structured deadweight force standard machine. The standard measurement instrument of force value dissemination is employed to measure the force value volatility caused by weight rearrangement in classical structured deadweight force standard machine.

Keywords: Force standard machine; Applying weight ; Proceeding and returning ; A combination of flexibility and rigidity ; Structural transformation; Servo control

INTRODUCTION

The deadweight force standard machine adopts independent weight application structure, since it has the advantages of high accuracy, measurement repeatability, good long-term stability, saving space and shortening the loading time, which is often as a classic structure used by measuring department from all countries. But due to the laboratory height and hanging structural strength, the weight series of this force standard machine is limited. And to make the limited weight of the hang recur more force value measurement points within measurement scope, the classic structured force standard machine in the process of testing have to rearrange weight according to the strength change to form different force levels. Because the weight is a rigid body, the general structure is unable to solve the problem in proceeding test, which contains returning process, or in the returning test, which contains proceeding process due to weight rearrangement. Based on the problem of proceeding and returning of the classic structured force standard machine generally existed in the process of the weight rearrangement, the article puts forward innovative technical improvement solution specially researched and developed to solve the problem.

This scheme finds out a new way to solve the problem to reduce the influence of the performance characteristics of the standard measurement instrument of force value dissemination in the process of test/calibration of the deadweight force standard machine, (such as standard dynamometer or force sensor). In this paper, the technical improvement scheme increases strength measurement points compared with classic force standard machine with independent weight application structure; The force sensor or weighing sensor in testing the lag or creep performance can be fully realized the way of the pure proceeding or returning to apply detection force to meet the requirement R60 2000 of international legal metrological organization' weighing sensor measurement regulation. This paper has important guiding significance to the deadweight force standard machine's structure design, to the structural transformation of the classic structured deadweight force standard machine in service, to the improvement of the deadweight force standard machine's work efficiency, and to the decrease of the measurement uncertainty.

1. FORCE STANDARD MACHINE'S ORIGINAL CONTROL MECHANISM OF THE PROCEED AND RETURN

Deadweight force standard machine's mean to load and unload has two kinds: one is to make weight connected in series in top-down order to apply weight and to apply force to the tested standard measurement instrument of force value dissemination; The other is to realize independent control of each weight set, so as to apply weight and to apply force to the tested standard measurement instrument of force value dissemination. Although the independent weight application structure of force standard machine can through the way to increase the weight's quantity to increase testing point, in some specific test/calibration measurement range of the standard dynamometer (or force sensor) still need weight rearrangement, there is a proceeding and returning phenomenon unwanted produced in the process of measuring. Therefore, currently most deadweight force standard machine with independent weight application structure cannot achieve that force sensor or weighing sensor in testing the lag or creep performance is fully realized the way of the pure proceeding or returning to apply detection force in

many cases, which cannot meet the requirements of the relevant international advice R60.

In the original structural design of force standard machine, in order to avoid unwanted proceeding and returning in the process of exchanging weights, adopting the structure of hydraulic organizations to hold the center boom tightly in its arms , the structure schematic is shown in figure 1. This kind of holding mechanism relies on the friction, whose application effect or safety performance cannot meet the requirements that mainly be embodied in the following two aspects.

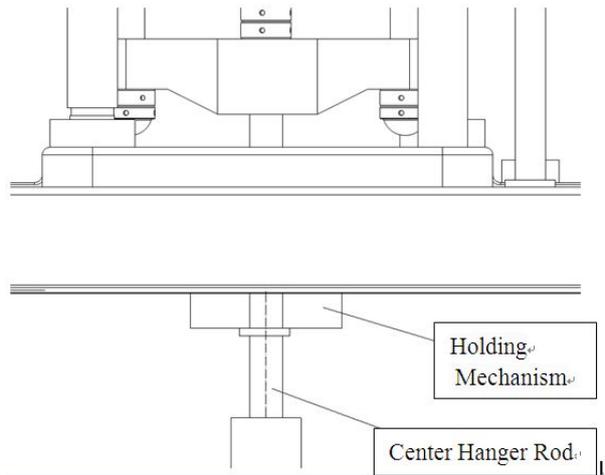


Figure 1 Original structure schematic drawing of hydraulic holding mechanism

1) when the center boom itself is in a state of freedom it will have slight swing, in the process of hydraulic holding mechanism the state of the center will change from freedom to constraint, state change of the center boom will inevitably affect the derrick relationship with the relative position between the measured force sensor, which affects the repeatability of the measurement result.

holding mechanism can produce horizontal friction force, the force must be considerable to keep no change of the plumb direction's force values because of the weight rearrangement , so frequently used holding mechanism will inevitably produce damage to the center boom. Moreover due to the interaction between friction and gravity, the weight in the vertical direction must have traces of sliding phenomenon. Because most center boom are of rigidity, even the tiny displacement will bring obvious force change, so the institution to overcome the effect of the problem of the proceeding and returning is very limited. Practice proved that the device can not realize that in proceeding test, which doesn't contain returning process, or in the returning test, which doesn't contain proceeding process.

2. THE TECHNICAL TRANSFORMATION OF THE ORIGINAL FORCE STANDARD MACHINE

To overcome the original force standard machine's faults and to restrict effectively the phenomena of the proceeding and returning, there are some mechanical structure and the corresponding control method transformations to the original force standard machine.

1) Modification of the weights' supporting institution, making the weight bearing parts of the rigid body into a combination of flexibility and rigidity , and its mechanical structure is shown in figure 2.

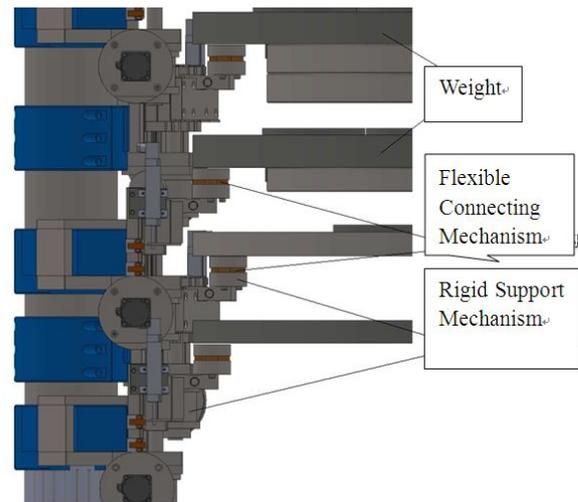


Figure 2 Weight bearing structure diagram

When weight is in added or in uninstall process, not completely separating from the supporting institution or center of the boom, the flexible mechanism is being part of the compression state and is of the trend and space of the deformation .When the weight is placed on the supporting institution in full, the position is fixed and stable. This organization has the advantage of increasing the displacement of the space during the weight is in added or in uninstall process, so during which there is a linear relationship between force

and displacement . In the classic design, because weight and bearing body are both rigid bodies, it is both instantaneous to separate the weight from the bearing body or to place the weight on it. Its essence is a stage-type loading process, often less than 0.05 seconds, and the time of loading and unloading is so short and it's usually can't be controlled, therefore when rearranging weights it is inevitable to appear the problem of the proceeding and returning. The improved weight bearing parts is of a combination of flexibility and rigidity that will extend the adding and unloading time to 10 seconds, which can easily adopt closed-loop servo control to solve the problem of proceeding and returning.

2) Equipped with the above displacement amplification mechanism, it can through increasing the force sensor on bearing parts to sense every moment's force value in the process of weight's loading and unloading and through increasing the displacement sensor to sense deformation of the flexible body at different time . The application method of force sensor and displacement sensor are shown in figure 3. Having these sensors can measure the force value rate in the process of the weight rearrangement and the rate of displacement change. Through the computer software to realize double closed loop servo control, thus the problem of the checked sensors' proceeding and returning (load inversion phenomenon) caused by weight rearrangement can be controlled in a certain range. After such technical renovation ,weight charging and discharging system can better achieve the required function and can control the load volatility caused by the proceeding and returning within 1% in the process of weight rearrangement .

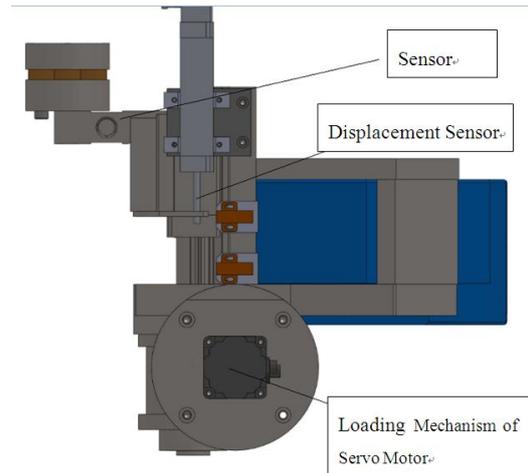


Figure 3 Force sensor and displacement sensor application methods

Deadweight force standard machine with independent weight application structure whose per level's weight is placed by three bearing points, which according to the principle of three points decides to a plane, the supporting way is shown in figure 4. But if one point of the three supporting points is not in a same plane with other two points, the weight will be loaded to the center of the boom aslant, which will cause that the gravity produce component force and cause the whole loaded weight produce significantly oscillation phenomenon and ultimately affect the accuracy of the force value. To avoid this kind of phenomenon, this project increases synchronization controller to control that three points is in the same plane. Each weight's each loading and unloading action is strictly synchronous to always ensure that weight is in a state level and smooth loading and unloading without impact and the phenomenon of shaking. It will be mentioned in clause 2 to through a displacement sensor to achieve auxiliary monitor in real time.

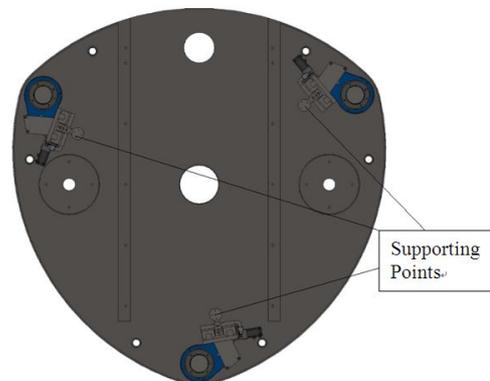


Figure 4 Schematic weight's three-point supporting way

4) in order to guarantee the smoothness of the loading process, in the technical transformation, the hydraulic loading mechanism originally and

generally used is further replaced by electric draw stem load (or electric cylinder), there are three such advantages:

- ◆ continuous smooth loading process, no jittering or intermittent process phenomenon caused by hydraulic pressure sealing mechanism ;

- ◆ make full use of the screw in the process of loading features automatically eliminate clearance, which can ensure that the weight is loaded without wave loading;

- ◆ make full use of the characteristics of the screw locking, which can ensure that in the process of adding and unloading it will not happen the slant to cause accident because of power outages which will results in the complex adjustment.

5) When some weights' centroids and the center booms' axes are not coincident, it will inevitably cause a strength's partial load phenomenon at the same time it will lead to the phenomenon of out of plumb of center boom after weight loaded into the center of the boom, which leads to substantial swing and affects the value uncertainty level. Therefore in the process of installation and debugging must according to adjusting the weights of counter weight to ensure that all weights' centroids and the center booms' axes are coincident.

Adding a double cross cutter structure at the center of the reverser force standard machine on the derrick in the transformation plan, shown in figure 5, Which is used to replace the original tee connection mode. This institution not only improves the flexibility of the center boom and the backward frame, but also improves the stability of weight's loading and unloading process. So, it reduces the weight's oscillation amplitude.

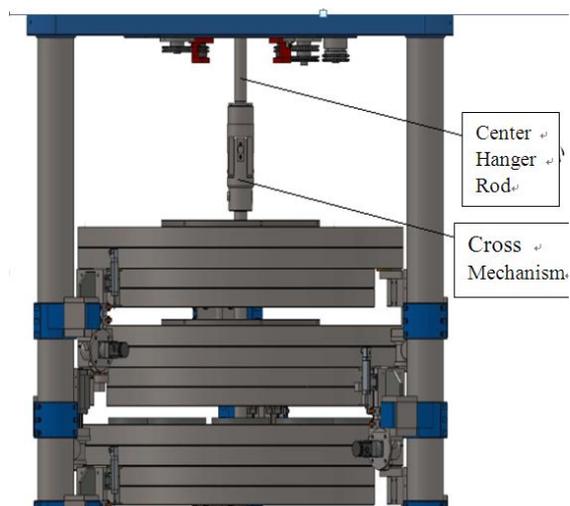


Figure 5 Center boom's double cross cutter structure

3. AFTER TRANSFORMATION THE RELEVANT MEASUREMENT PERFORMANCE TEST

After structure transforming many experiments have been done, about the load inversion problem caused by weight rearrangement, the improvement effect of test results and related technology described as below now.

1) Force value volatility of the weight rearrangement

The force value of any two level changes, it usually can be achieved by one loading or unloading process, when rearranging weights, the process of weight loading and unloading is fulfilled synchronously .After device modification, using standard dynamometer to test the force value volatility in the process of weight rearrangement and at the same time the force value maximum allowable values of volatility is set to no more than 1% .Part of the experimental results are shown in figure 6 and figure 7. The horizontal axis represents the recording duration since load command starts (unit is s) flat, vertical axis (unit is μV) represents sensor output. Figure 6 is the force value volatility curve loaded from 20 kN to 30 kN , which shows its strength curve is a perfect ladder load curve and in the process of weight loading force value volatility does not exceed 1%.Compared with the classic structured deadweight force standard machine, the process to complete the above process of applying weight is necessarily done by weight rearrangement ,which requires to load a level 20 kN weight at the same time uninstal level 10 kN weight, if uncontrolled, the exchange process is 20 kN - 10 kN - 30 kN and the returning amount is- 10 kn. Figure 7 is the force value volatility curve loaded from 30 kN to 50 kN, if uncontrolled, the exchange process is 30 kN - 10 kN - 50 kN and the produced returning amount is - 20 kN. See from figure 7, returning amount increases and does not have obvious control error and the load curve is also very perfect.

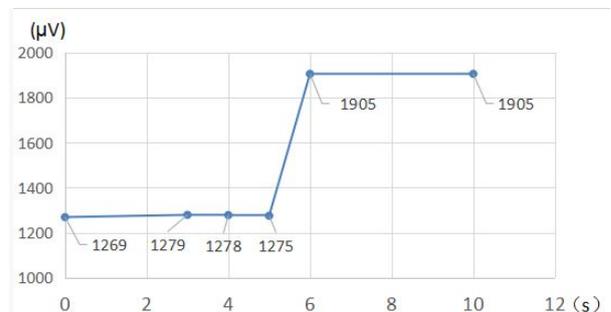


Figure 6 20kN→30kN force value volatility curve during the process of the weight rearrangement

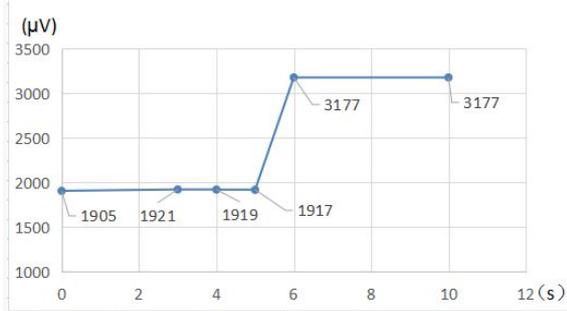


Figure 7 30kN→50kN force value volatility curve during the process of the weight rearrangement

2) Using the standard force sensor to detect weight rearrangement 'test results

Chose a C3 level of weighing sensor produced by METTLER TOLEDO equipped with a complete set of 8530D digital measuring instrument, according to provisions of R60 to carry out performance testing at room temperature. Load point selection for 10 kN, 20 kN, 30 kN, kN 40 and 50 kN, which uses the arithmetic mean value tested by three times to calculate sensor's linearity, showed by chart. During the trial of 20kN↔30 kN and 40 kN - 50 kN all exist in the exchange of different weights, and its exchange capacity of plus or minus is ±10 kN and ± 20 kN respectively. Figure 8 is the calibration curve without weight rearrangement and the sensor calibration curve has obvious abnormal inflection point. By visible in figure 9 with the controlling of the exchange process, the sensor test curve is smooth and is of no obvious abnormal fluctuations caused by weight rearrangement during the process of the weight's loading and unloading.

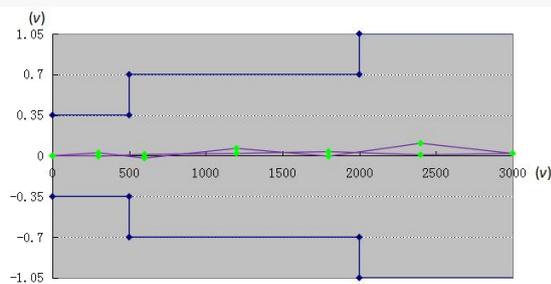


Figure 8 Sensor error curve without weight rearrangement control

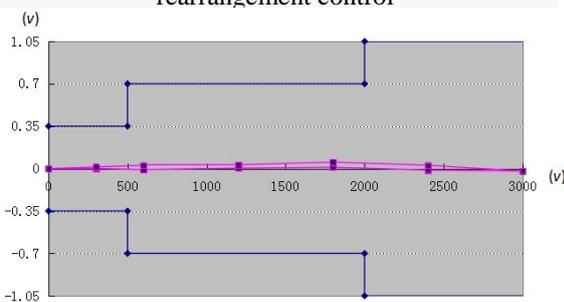


Figure9 Sensor error curve with weight rearrangement control

CONCLUSION

By above performance test results of the deadweight force standard machine with improved mechanical structure, it is fully proved that the proposed technical improvement solution can completely solve the proceeding and returning problem of deadweight force standard machine with independent weight application structure in weight rearranging process.

This technology can be widely promoted and applied in the design and manufacturing of deadweight force standard machine, as well as the reform of classical structure in service. It ensures that the deadweight force standard machine has not only good technical performance but also wider strength testing scope. Moreover it improves the force measurement repeatability, reproducibility and work efficiency of this type deadweight force standard machine.

REFERENCES

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