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DESIGN OF A NEW TYPE OF BUCHHOLZ HARDNESS TESTER

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Abstract:
This paper describes a new type of Buchholz Indentation Hardness Tester used in Buchholz Indentation test for paint and varnishes. This new type tester uses a bridge structure to connect two cantilever sensors together, so we can instantly know the magnitude of the acting load on paint and varnishes. The design overcomes the defects of the previous load changes that could not be accurately predicted. At the same time we can use the adjustment hole to accurately adjust the level of the hardness tester, to ensure the standardization of the measurement process. By evaluating the uncertainty of the measurement results, the newly designed hardness tester ensures the accuracy and reliability of measurement results.

Keywords: design; bridge structure; adjust hole; hardness tester

1. INTRODUCTION

Buchholz indentation test is a kind of hardness test used to measure and evaluate the spraying quality of paints and varnishes. The performance index of the instrument itself plays a decisive role in the test result.

At present, the known buchholz indentation test is achieved by a specific shape and size of the indentation machine according to the standard of ISO 2815. Buchholz indentation hardness tester is composed of a rectangular metal block with two pointed feet, with a specific shape and size of the indentation machine. The metal block has a certain quality, the whole indentation instrument flat on the test sample above, the indentation machine with a fixed load downward pressure to the paint film surface, with a certain amount of time in the paint film formed on the indentation length characterization of the paint film performance.

Current equipment has two defects, the first is that level of the upper surface usually was broken, then the adjustment of the level is difficult. The second is that the whole mass change of the equipment provided by rectangular metal blocks can not be found easily. Due to the real-time display itself has no load, the naked eye cannot observe the slight change, therefore, users do not know whether the load changes, resulting in errors in the daily indentation test, then its improvement and innovation is imperative.

Buchholz indentation hardness tester [1] in use is shown below as the following Figure 1.

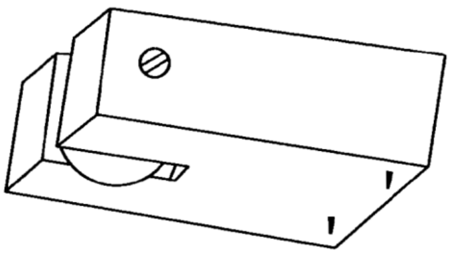

Figure 1: Buchholz indentation hardness tester

2. DESIGN OF NEW HARDNESS TESTER

In the use of Buchholz hardness tester from its structure, is a three-point load structure, two legs for the support platform, indentation for the load point, and the load remains constant. One reason the load is prone to deviation during use is that the tester is physical and does not display in real time, and its levels may have been damaged. The change of the centre of mass makes the load no longer meet the standard requirements, so the measurement results will have a large deviation.

In order to solve this problem, we can use the shaft of the indentor to connect two parallel cantilever beam load cell together at one end, and it is processed into a whole at the other end with the measuring circuit built in. through the upper rectangular metal piece to the other end of the cantilever beam load cell are linked together, to adjust the length of the two pins stretched out under the surface, form with the discretion of the indentation device must have difference, and then get moving centre of mass, indentation on the load change [2]. At the same time, there is a cavity in the middle of the metal block, and the mass can be adjusted by adding or subtracting objects in the cavity.

Secondly, in order to solve the problem that the upper surface level is easy to be damaged but difficult to adjust, it is necessary to design structural components that are easy to adjust.

We use high hardness alloy material as the screw through the tester as the pin, the top of which is two threaded pins, two pins through the body of the tester. In this way, the tail of the two fulcrums in the upper plane can be adjusted so that the length of its bottom protrudes varies, thus adjusting the level of the entire durometer to obtain the required quality, see Figure 2. From a vertical angle, it can be found that the position of the adjusted cavity is in the center of the upper rectangular metal sheet. The ends of the two pins have a word-adjusted pit and use a screwdriver to adjust the upper surface of the indentation gauge to keep it level.

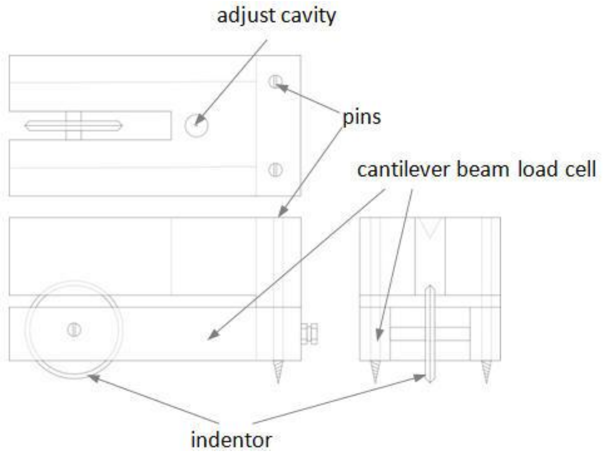

Figure 2: three view drawing of the new designed buchholz indentation hardness tester

Through two parallel cantilever beam load cells can be smaller sensor is used to implement the design of the large load, to monitor the quality of load connection secondary instrument at the same time, convenient to realize real-time monitoring of indentation load, the indentation load numerical value, avoid the common indentation hardness tester load change is big and can't find shortcoming; By adjusting the extension length of the threaded dowel, the level of the upper surface of the durometer is adjusted to realize the load regulation of the indentation wheel; The splicing material is made of high strength steel, and after strict heat treatment, it has high hardness and is not easy to bend.

3. EVALUATION OF UNCERTAINTY

3.1 Calibration Method

Buchholz tester is a special instrument for measuring the compression performance of paint film. The load on the wheel indentation tester is one of its main technical indicators. According to the requirements of the specification, the wheel indentation device is placed on the stress end of the micro-load measuring device, adjust the whole indentation instrument to make the surface level, then the load measured is the measurement result. In order to verify the reliability of the new Buchholz hardness tester, it is necessary to evaluate the overall load after adjustment。 The overall load of the hardness tester is measured for 10 times and the average value is taken as the measurement result.

3.2 Mathematical Model

According to the specification, the error of load indication is expressed as a formula in the form of absolute error (1)

$$f_b = f_B + \delta \, . \tag{1}$$

In the formula:

f_b is the load of the Buchholtz Hardness tester under test in g;

f_B is the load measurement value of micro-load measuring device in g;

δ is the load indication error of the Buchholz Hardness tester under test in g.

3.3 Synthetic standard uncertainty of error of indication value

$$u_c^2(y) = \sum_{i=1}^{n} (\frac{\partial f}{\partial x})^2 \, u^2(x_i) \tag{2}$$

$$u_c^2 = c_1^2 u_1^2 + c_{12}^2 u_2^2 \tag{3}$$

In the formula:

u_1 and u_2 are uncertainties brought by microload measuring device and repeatability respectively.

4. SOURCES OF UNCERTAINTY

Uncertainty component introduced by error of microload measuring device

The tolerances of the dynamometer are ± 0.1%, subject to uniform distribution, class B uncertainty, calculated with 500g calibration point, so

$$u_1 = \frac{0.1\% \times 500}{\sqrt{3}} = 0.289 \text{ g} \, . \tag{4}$$

The uncertainty component of the load of buchholtz indentation instrument u_2

The load 500g calibration point was selected for analysis, and the point was measured repeatedly for 10 times, and the value obtained was shown in Table 1 (g) :

Table 1: The results of measurement (g)

Times	Load	Times	Load
1	500.20	6	499.95
2	499.98	7	500.15
3	500.10	8	499.96
4	499.94	9	499.94
5	499.98	10	499.94
Average	500.14		

Standard deviation of single measurement:

$$s(x_i) = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \overline{x})^2}{n-1}} = 0.0998\ \text{g}\,. \quad (5)$$

Standard uncertainty:

$$u_1 = \frac{s}{\sqrt{10}} = \frac{0.0998}{\sqrt{10}} = 0.032\ \text{g} \quad (6)$$

A list of Standard Uncertainty Components is given in Table 2.

Table 2: List of standard uncertainty components

Serial number	**Source of uncertainty**	**Symbol**	**Distribution**	**Absolute value of sensitivity c_1**	**Standard uncertainty component u_i / g**
1	standard device error	u_1	type B, uniformly distribution	1	0.289
2	indicates repeatability of values	u_2	type A	1	0.032

The Error of The Composite Standard Uncertainty

$$u_c = \sqrt{c_1^2\, u_1^2 + c_{12}^2\, u_2^2} = \sqrt{0.289^2 + 0.032^2} = 0.29\ \text{g} \quad (7)$$

Expanded Uncertainty

According to the requirements of JJF1059, the confidence probability of the measurement uncertainty is 95%. Taking the inclusion factor $k = 2$, taking two significant digits, the extended uncertainty of load indication error can be obtained as follows:

$$U = k \times u_c = 0.58\ \text{g}\,. \quad (8)$$

Expressed in relative terms, then:

$$U_{\text{rel}} = \frac{0.58 \times 100}{500.14}\% = 0.12\%\,. \quad (9)$$

5. CONCLUSIONS

According to the evaluation results, we can see that the new designed buchholz hardness tester meets the measurement requirements. Once the load is determined, the accuracy can be maintained at about 0.1%. Buchholtz indentation hardness tester with secondary instrument, can display the numerical of its load in real time.

The new designed buchholz hardness tester has obvious advantages. The load can be adjusted easily throgh the adjust cavity and the level adjustment; The two pins can adjust the height and level, then the load can be adjusted easily. So it can real-time display the numerical of the steel applied load, and can be adjusted according to the deviation in time and again at the same time meet the requirements of the equipment used for a long time, With good innovation and applicability, it can be widely used in paint and varnish Buchholz indentation test.

Of course, the design of the hardness tester itself remains to be improved and will be further improved in the subsequent measurement process.

6. REFERENCES

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