

DEVELOPMENT OF SPECIAL MEASURING TOOL FOR TRACE OF MICRO FORCE VALUE

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Abstract:

This paper introduces the development of the special traceability measuring tool for micro force value with the test force range of 0.009807 N ~ 9.807 N(1 gf~1 kgf) and the accuracy of better than $\pm 0.1\%$, including the selection of the electromagnetic balance module, the design of the hardware structure, and the compilation of the software program. Finally, the special traceability measuring tool integrating the test measurement, automatic data collection and automatic data processing is realized, and the test verification result is given. It provides a method to solve the problem of trace the small force value of existing micro Vickers hardness tester and Knoop hardness tester.

Keywords: micro force, measuring tool, traceability, micro Vickers hardness, Knoop hardness

1. INTRODUCTION

With the development of modern material surface engineering, such as Physical vapor deposition, magnetron sputtering, ion implantation, surface modification, thermal spraying, nitriding and carburizing, etc., the thickness of micro Vickers hardness and Knoop hardness test samples or the surface modified layer on the sample surface is getting thinner and thinner, and the hardness test force value is getting lower and lower, reaching 0.009807 N. However, the minimum measuring range of the existing force measuring instrument is 1 N. According to the principle of one tenth use, the minimum measurement can be 0.1 N, which can not meet the existing requirements. Therefore, it is very necessary and urgent to develop the special traceability measuring tool with the lower limit of 0.009807 N.

2. PROJECT DESIGN

In this paper, the special traceability measuring tool for micro force value is developed, which has

the force value range of 0.009807 N ~ 9.807 N(1 gf~1 kgf) and the accuracy of better than $\pm 0.1\%$. It selects the electromagnetic balance module as the core, and carries on the package design to it, has realized the test measurement, the data automatic collection, the data automatic processing as a whole special traceability measurement tool, specifically includes, the electromagnetic balance module selection design, the hardware structure design, and the software programming three parts.

The output value of the balance is the mass. The relationship between the force value and the mass is shown in formula (1).

$$F = mg \left(1 - \frac{\rho_1}{\rho_2} \right) \quad (1)$$

In the formula:

F - force value, N;

m - mass, kg;

g - the local acceleration of gravity in the laboratory, m/s^2 ;

ρ_1 -air density, kg/m^3 ;

ρ_2 -weight density, kg/m^3 .

Since the density of the weight is far greater than that of the air, $\frac{\rho_1}{\rho_2}$ is negligible.

2.1 Selection and design of electromagnetic balance module

According to the research, referring to the test requirements, working space of most hardness tester and other factors, by selecting the range, accuracy, geometric dimension and other indicators of electromagnetic balance module, the two electromagnetic balance modules of sartorius are finally selected, their models are WZA224-N and WZA1203-N, as shown in Figure 1, and their technical indicators are shown in Table 1.



a) WZA224-N



b) WZA1203-N

Figure 1 electromagnetic balance modules

Table 1 Technical indicators of lectromagnetic balance modules

Model	WZA224-N	WZA1203-N
Weighing Capacity(g)	220	1200
Readability(mg)	0.1	1
Maximum deviation(mg)	±1	±5
Standard deviation determined(mg)	0.1	1
Maximum Linearity(mg)	±0.2	±2
Physical dimension(mm)	181x67x73	200x67x78

Although the electromagnetic balance module with the smallest geometric size is selected on the premise of meeting the requirements of technical specifications, its length and width meet the requirements of micro Vickers hardness tester in our laboratory. Because the size of the micro Vickers hardness tester in our laboratory is 200 mm × 280 mm. But its height is still higher than the working space height of most hardness machines, including those in our laboratory. Therefore, it is necessary to reform the selected electromagnetic balance module, remove its own measuring head and replace it with a thinner force measuring base. Because the selected balance module is a mature commodity, it has a certain stiffness, and because the indenters used in micro Vickers hardness test and Knoop hardness test are diamond indenters, it is necessary to set a ceramic force measuring unit in the center of the force measuring seat to ensure its stiffness in use and reduce the impact on the test results. The designed balance module has good stiffness, which can reduce the influence of the deformation of the worktable on it in the use process. The accuracy of the design and operation is ± 0.01%, and the influence of the table deformation can be ignored. The design drawing of electromagnetic balance module transformation is shown in Figure 2.

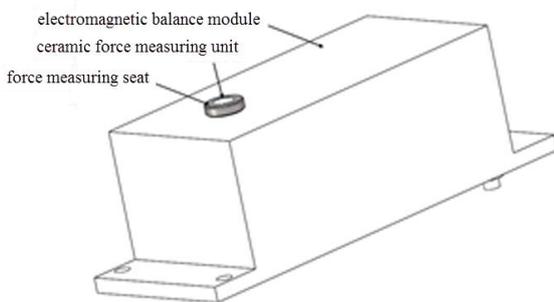


Figure 2 Design drawing of electromagnetic balance module transformation

2.2 Hardware structure design

The special measuring tool for trace of micro force value is often carried out, so it needs to be easy to carry, simple to make mistakes, and anti-collision and other functions. Therefore, hardware structure design should be carried out on the basis of electromagnetic force balance module. The hardware structure design diagram is shown in Figure 3.

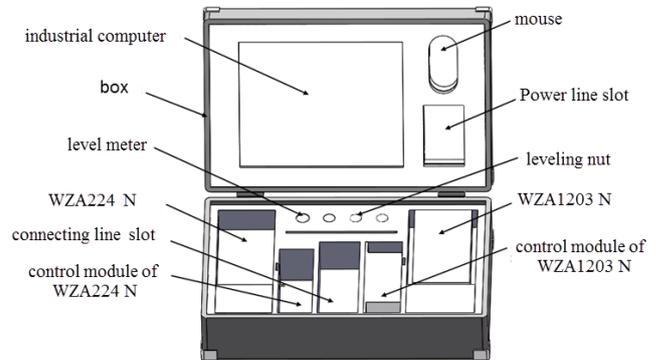


Figure 3 Hardware structure design drawing

After completion, the special measuring tools for trace the micro force value include the box with pull rod, industrial computer, mouse, power supply, two modified electromagnetic balance modules and their corresponding control board, level meter, leveling nut, etc.

The box with pull rod is made of aluminum alloy with light weight, high strength and easy to carry and move. The box is filled with thick sponge to protect internal parts. The industrial computer is used for operation test, collection and processing of test data. The level meter and leveling nut are used to ensure the level of the device during the test. The WZA224-N module and WZA1203-N module are used for test force. The control module is used to control the electromagnetic balance module, and the trunking and mouse are used to link and operate.

2.3 Programming and design of software

In order to reduce the error of manual calculation, the special traceability measurement tool for micro force value is designed and compiled with supporting automatic processing software, which adopts automatic reading, automatic calculation and other functions.



Figure 4 Automatic processing software interface

Table 3 Test Results

Standard value (g)	Test value (g)	Error (%)	Repeatability (%)
1.0000	1.0000	0.000%	0.001%
2.0000	2.0001	0.005%	0.000%
5.0000	5.0002	0.004%	0.001%
10.0000	10.0000	0.000%	0.001%
20.0000	20.0002	0.001%	0.002%
50.0000	50.0000	0.000%	0.000%
100.0000	100.0009	0.001%	0.001%
200.0000	200.0012	0.001%	0.000%
300.000	300.001	0.000%	0.002%
500.000	500.000	0.000%	0.000%
1000.000	1000.001	0.000%	0.003%

3. SUMMARY

This paper introduces the development of a special measuring tool for micro force traceability, which has a measuring force range of 0.009807 N ~ 9.807 N (1 gf ~ 1 kgf), and the accuracy is better than $\pm 0.1\%$. It includes the selection of electromagnetic balance module, the design of hardware structure, the determination of measurement accuracy, and the compilation of software program. Finally, a special traceability measuring tool which integrates measurement,

automatic data acquisition and data processing is realized, and the experimental verification results are given. At the same time, it has been well applied in our laboratory. The special inspection tool for trace of micro force provides a new method to solve the problem of micro force traceability of micro Vickers hardness tester and Knoop hardness tester. The next step is to develop a small force traceability tool with smaller geometry for most micro Vickers and Knoop hardness machines.

4. REFERENCES

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