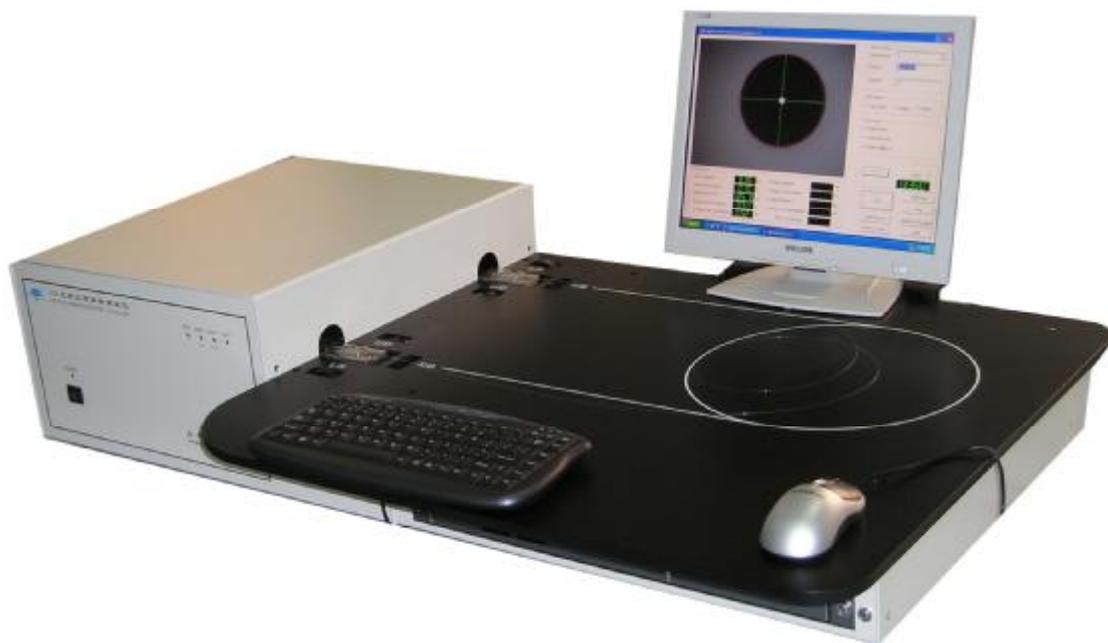# FGM5

## Optical Fiber Geometry Measuring Instrument

# Operation Manual

**Shanghai Electric Cable Research Institute**

# Contents

# Chapter I: General Remarks

The optical fiber geometric parameters such as core diameter, cladding diameter, core non-circularity, cladding non-circularity, core/cladding concentricity are important parameters of optical fibers. These parameters are necessary for R & D and production of optical fibers because they affect light coupling and transmission, fiber splicing etc. FGM Optical Fiber Geometry Measuring Instrument is an instrument with proprietary technology developed by Shanghai Electric Cable Research Institute (SECRI).

Advanced machine vision technology is employed in our FGM-5 Optical Fiber Geometry Measuring Instrument. The fiber geometric parameters are measured automatically by adopting EIA/TIA FOTP 176 grey scale technique. CCD camera, auto-control system and industrial PC made up of the measuring system for the purpose of bare fiber image and coating image automatic switching, automatic focusing and automatic centering. Combined with complete software and hardware technology, precise pixel boundaries of fiber core and cladding/coating are calculated from the grabbed fiber end image in near field. Therefore, the fiber geometric parameters, such as core diameter, core non-circularity, cladding diameter, cladding non-circularity, core-cladding concentricity, coating diameter, coating non-circularity, mean coating thickness and coating concentricity, are obtained. The fiber quality can be concluded from the test results according to the customized quality criterion. In this system, you will experience a visual, fast and accurate testing means.

The end face images of bare fiber and coating are respectively located by two individual high precise 3D adjusts driven by step motors. Additionally, the end face image is automatically adjusted by professional digital image process algorithm software to assure optimized imaging location of the enfaces of bare fiber and coating.

In terms of different fiber types  （single mode，multimode 50μm and 62.5μm），the instrument uses different light injection conditions and image processing software in order to achieve optimized test conditions, high measurement accuracy and high precise.

The system software supports Windows operation system. The software is human-centered designed and easily operated. Rationally arranged interface allows easily fiber image adjusting, testing, data processing, test results record reviewing and printing. The test results are saved automatically into database.

# Chapter II: Technology Description

This chapter presents the test methods of FGM-5 Optical Fiber Geometric Parameters Analyzer as well as the mathematical definition of test parameters. By reading this chapter, users are better informed by the capabilities of FGM-5 so that they can easily operate the instrument.

## Section 1: Test method

FGM-5 Optical Fiber Geometry Measuring Instrument adopts near field light distribution method(grey-scale).

## Section 2: Technical parameters

This section mainly presents the technical requirements and parameters of FGM. The instrument works under the conditions of ambient temperature between 0 and 40 ºC and atmospheric pressure. Following technical capabilities are obtained under ambient temperature 25±5 ºC and atmospheric pressure, and power on the system 30 minutes before test is required simultaneously.

Fiber types suitable for the measurement: A1, A2, A3, B

Test parameters：

**Bare fibers：**

| | |
|---|---|
| Core diameter | $2R_{co}(um)$ |
| Cladding diameter | $2R_{cl}(um)$ |
| Cladding non-circularity | $100(R_{\max cl} - R_{\min cl})/R_{cl}(\%)$ |
| Core/cladding concentricity error | $[(X_{cl} - X_{co})^2 + (Y_{cl} - Y_{co})^2]^{1/2}(um)$ |
| Core non-circularity | $100(R_{\max co} - R_{\min co})/R_{co}(\%)$ |

**Coating：**

| | |
|---|---|
| Coating diameter | （A + B）/2 |
| Coating thickness | （A+B）/4 － $R_{co}(um)$ |
| Coating non-circularity | 200（A-B）/（A+B） |
| Core/coating concentricity error | $[(X_{cl} - X_{co})^2 + (Y_{cl} - Y_{co})^2]^{1/2}(um)$ |

**Technical Capability:**

| Fiber type | Test parameter | | Repeatability error |
|---|---|---|---|
| Bare fibers | Core Diameter | ($\mu m$) | ≤0.05 |
| | Cladding diameter | ($\mu m$) | ≤0.05 |
| | Cladding non-circularity | ( % ) | ≤0.10 |
| | Core/cladding concentricity error | ($\mu m$) | ≤0.04 |
| Multimode fibers | Core diameter | ($\mu m$) | ≤0.08 |
| | Cladding diameter | ($\mu m$) | ≤0.05 |
| | Core non-circularity | (%) | ≤1.00 |
| | Cladding non-circularity | (%) | ≤0.10 |
| | Core/cladding concentricity error | ($\mu m$) | ≤0.08 |
| Coating | Coating diameter | ($\mu m$) | ≤0.20 |
| | Coating thickness | ($\mu m$) | ≤0.20 |
| | Coating non-circularity | ( % ) | ≤0.40 |
| | Core/coating concentricity error | ($\mu m$) | ≤1.00 |

**Test Time(includes automatically centering and focusing process)**

**Test time: ≤ 1 minute**

**Note: Above time doesn't include the end face dealing time.**

# Chapter III: Test Principle

The chapter presents optical fiber types and the test methods of geometric parameters regulated in standard as well as the test principle and method of FGM-5 Optical Fiber Geometry Measuring Instrument. By reading this chapter, users are better informed of the performance, fiber structure and test principle of FGM-5 in order to operate the instrument easily.

## Section 1: Optical fiber (for communication)Introduction

### 3.1.1    The structure and classification of the optical fiber

The basic structure of optical fiber is shown in Figure 3.1. it consists of core ,cladding and coating.
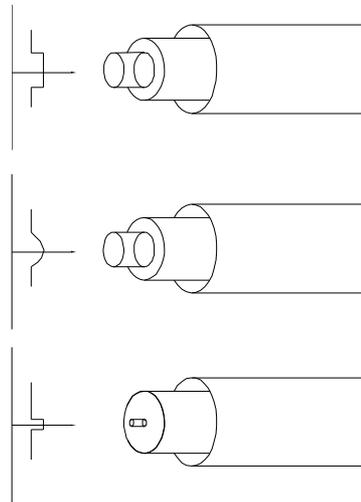


Figure 3.1 Optical fiber construction

In general, communication optical fiber is classified into two types, single mode(SM) and multi-mode(MM) according to the structure, material, refractive index distribution and transmission performance of optical fiber. The SM fiber only permits one mode transmission, the MM fiber permits two or more mode transmission. The permitted mode quantities can be estimated by the following formula:

$$M = \frac{g}{2(g+2)} V^2 \quad (1)$$

V is called the normalized frequency of optical fiber, it is an important parameter for the structure characteristic of optical fiber. It is defined as

$$V = k_0 a \sqrt{n_1{}^2 - n_2{}^2} = \frac{2pa}{1_0} n_1 \sqrt{2\Delta} \quad (2)$$

4

Where $k_0$ is wave number in vacuum, $\lambda_0$ is wavelength in vacuum

When$\lambda_0$ and refractive index are confirmed, the permitted transmission mode quantity relates only to the core diameter a. So the core diameter of MM fiber is much larger than that of SM fiber.

### 3.1.2    Definition of geometry parameters

### 3.1.2.1 cladding (coating)diameter

Cladding (coating) diameter is the diameter of fitted circle of cladding (coating) boundary.

### 3.1.2.2 Core diameter(MM fiber)

Accoding to refractive index distribution, the refractive index of core boundary of the MM fiber has a regulation value more than the refractive on most inner cladding, the regulation value is k(n1-n2). The core diameter of MM fiber is the diameter of best fitted circle of core( the refractive on its boundary is n3)

$$n_3 = n_2 + k(n_1 + n_2) \qquad (3)$$

Where, n2 -the refractive of most inner cladding, n1 - the biggest refractive of core, k - the constant, called "k factor"

### 3.1.2.3 Core(cladding, coating) non-circularity(synonym ovality)

The attribute of an optical fiber, the cross section of the core or cladding of which deviates from a perfect circle. In an optical fiber, the degree of deviation, from perfect circularity, of the cross section of the core or cladding/coating. The cross sections of the core and cladding are assumed to first approximation to be elliptical. Quantitatively, the ovality of either the core or cladding is expressed as 2(*a-b*)/(*a* +*b*), where *a* is the length of the major axis and *b* is the length of the minor axis. The dimensionless quantity so obtained may be multiplied by 100 to express ovality as a percentage. Alternatively, ovality of the core or cladding may be expressed or specified by a tolerance field consisting of two concentric circles, within which the cross section boundaries must lie.

### 3.1.2.4 Concentricity error

In an optical fiber, the distance between the center of the two concentric circles that specify the cladding diameter and the center of the two concentric circles that specify the core diameter. *Note:* The concentricity error is used in conjunction with tolerance fields to specify or characterize optical fiber core and cladding geometry.

# Section 2: Working principle of FGM-5

The instrument uses high performance LEDs as injection and illumination light source, which improve brightness stability and service life of the light source. The bare fiber and coating can be SIMULTANEOUSLY tested, while the end faces of bare fiber and coating being putted into the test ports respectively after dealt cleanly. The end faces of bare fiber and coating are imaged in best positions by adopting precise electric 3D adjuster, advanced imaging tech., precisely control tech., appropriate software criterion and specially developed control program.

### 3.2.1 Working framework of FGM-5 Optical Fiber Geometric Parameters Analyzer

The instrument consists of fiber position adjustment framework, fiber end face imaging system, automatic control system, image acquisition system, automatic identification system and data processing module. The detail framework is shown in figure 3.2.
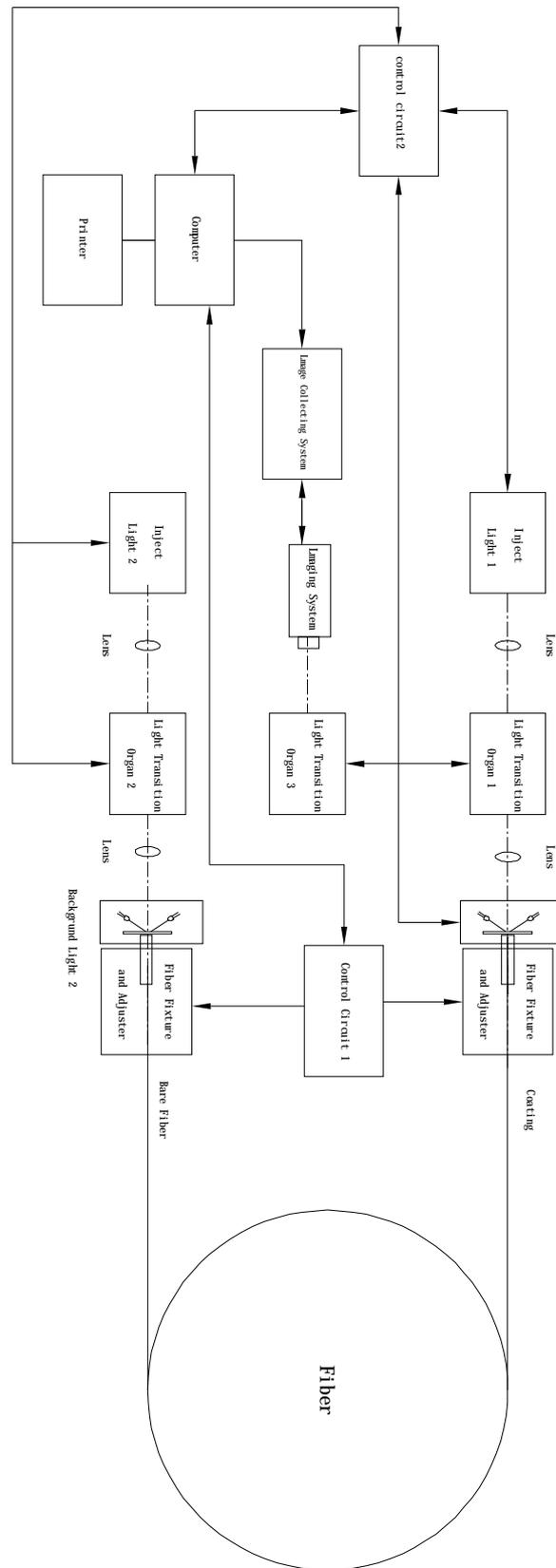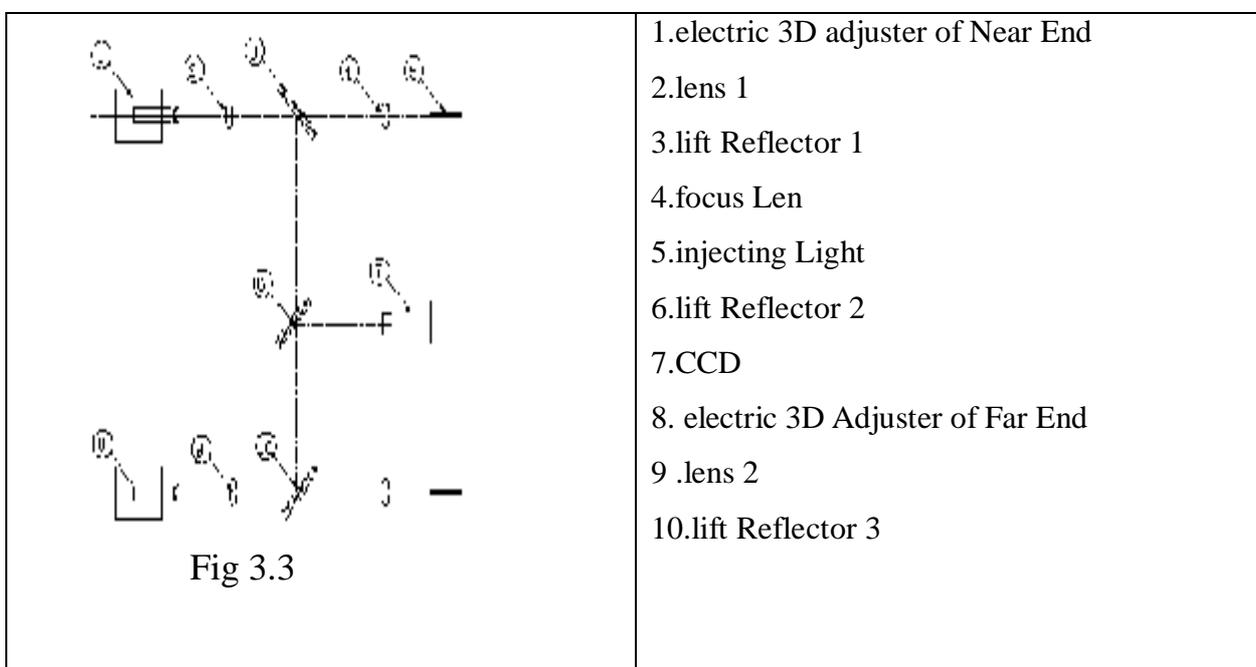
**Fig 3.2 Working framework**

### 3.2.2 Working principle

Two test ports are made in the instrument. One is for bare fiber, the other is for coating fiber. The same port can be used not only as test port but also as injecting port. When the bare fiber is under tested, the coating port serves as injection port, and the bare fiber port serves as testing port. When the coating is under tested, the bare fiber port serves as injection port, and the coating port serves as testing port. Considering of the diameter of bare fiber is 125μm and the diameter of coating is 250μm, the instrument adopts different magnifying multiple lens for the two ports in order to achieve good imaging quality and high test accuracy. Just one CCD is employed in our instrument. The detailed light rout is shown in Figure 3.3.

| <br>Fig 3.3 | 1.electric 3D adjuster of Near End<br>2.lens 1<br>3.lift Reflector 1<br>4.focus Len<br>5.injecting Light<br>6.lift Reflector 2<br>7.CCD<br>8. electric 3D Adjuster of Far End<br>9 .lens 2<br>10.lift Reflector 3 |
|---|---|

### 3.2.3 Test method----near field light distribution method (cross section geometry parameter measurement)

The method is basic test way (RTM) for the SM fiber geometric parameters and substitute test method (ATM) for the MM fiber. The cross section geometry parameters are obtained through analyzing the near field light distribution of the end face of tested fiber.

grey scale analysis method may be adopted in testing fiber geometric parameters, as well as near field scan method. The grey scale way can realize the two dimension (x-y) near field scan by one video system, and the near field scan way only can realize the one dimension near field scan.

Grey scale way can obtain the following geometry parameters, the details refer to    table I.

Table I geometry parameters measured by grey method

| Parameters | Suitable optical fiber type |
|---|---|
| Core diameter | A1,A2,A3 |
| Core non-circularity | A1,A2,A3 |
| Core/cladding concentricity error | A1,A2,A3,B |
| Cladding diameter | A1,A2,A3,B |
| Cladding non-circularity | A1,A2,A3,B |
| Coating | A1,A2,A3,B |
| Coating non-circularity | A1,A2,A3,B |
| Core/coating concentricity error | |

### 3.2.3.1 Equipment

The test equipment of near field light distribution see figure 3.4
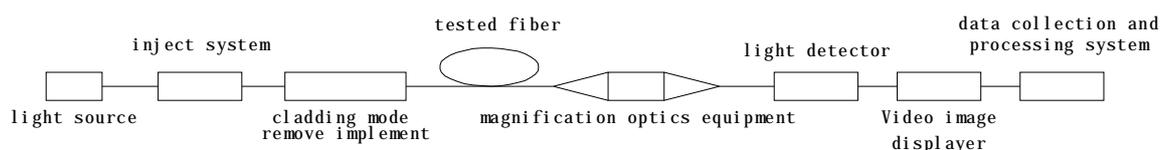


fig 3.4

### 3.2.3.2 Light Source

To select suitable light source to illuminate the core and the cladding. During the test period, the light intensity should be adjustable and stable. The spectrum width of light source for cladding should not be more than 100nm.

Injection illumination requirements

Fully uniform light injection in different angle must be satisfied for the illumination equipment. The uniform illumination for the cladding background must be also satisfied on the output port of the fiber end face.

### 3.2.3.3 Positioning mechanisms and stationary device for tested fiber

Stable stationary devices are adopted to fix the input end and output end of tested fiber. The stationary devices are assembled together with positioning mechanisms to realize the precise alignment of the input and the output light beam respectively at the input port and the output port of tested fiber.

### 3.2.3.4 Cladding mode remover

The cladding mode remover is adopted to remove the light power transmitting in the cladding. When the refractive index of fiber coating is larger than that of cladding or only the geometric parameters of cladding under test, the cladding remover isn't a must.

### 3.2.3.5 Optical amplification equipments

Suitable optical amplification equipments are adopted to magnify output near field image of tested fiber so that the magnified images can be scanned. The magnification factor need to be calibrated, the magnification factor of equipment should be matched with the space resolution.

### 3.2.3.6 Light detector

When grey scale method adopted, the analog image signal on the photosensitive surface of the CCD is grabbed by the image acquisition system into digital signal, which is sent to the PC system for calculation and analysis.

The pixel size of CCD or the base element size of video array detector must be much smaller than the magnified near field image.

$$d \leq \frac{1.22 Ml}{4NA} \ldots\ldots\ldots\ldots.4$$

Where, d--the pixel size of CCD or the base element size of video array detector(μm), M--approximate magnification factor of optics system, $l$ —smallest measure wavelength (μm), NA--numerical value aperture of tested fiber when core diameter of A type fiber under test, or numerical value aperture of object lens when cladding diameter under test.

### 3.2.3.7 Data collection and image processing system

In grey scale method, PC is used to calculate geometric parameters from the digital video data.

### 3.2.3.8 Parameters calculation (grey scale method)

The best core and cladding/coating boundaries are calculated from the raw fiber cross section image. By the digital image process algorithms, the following geometric parameters are obtained.

Core diameter $\hspace{6cm} 2R_{co}(um)$

nearest distance from core boundary to core center $\hspace{2cm} R_{\min co}(um)$

farthest distance from core boundary to core center $\hspace{2cm} R_{\max co}(um)$

core non-circularity $\hspace{4cm} 100(R_{\max co} - R_{\min co})/R_{co}(\%)$

cladding diameter $\qquad\qquad\qquad\qquad\qquad$ $2R_{cl}(um)$

cladding non-circularity $\qquad\qquad\qquad$ $100(R_{\max cl} - R_{\min cl})/R_{cl}(\%)$

core/cladding concentricity error $\qquad$ $[(X_{cl} - X_{co})^2 + (Y_{cl} - Y_{co})^2]^{1/2}(um)$

The light intensity amplitude of the output near field image is normalized. The function curve is obtained for the normalized light intensity amplitude and the valid scanning position of the output end face. Then the following two methods are used for parameters calculation.

Core diameter:

a)    the core diameter is obtained directly from the tested light tension curve without curve fit method;

b)   Curve fit

At normalized light intensity curve, least square method is adopted to fit the 10% to 80% points into the following expression:

$$I(r)/I(0) = 1 - \left(r/a\right)^g \qquad (5)$$

Where, a-core radius, g-shape factor.

The fit variables include a, I(0) and g. A robust curve fit algorithm is necessary for the fit result not be affected by the uninterested raw data. At the fitted curve, $I(r) = 0$, the distance between two roots is the core diameter.

# Chapter IV:Hardware illustration

The chapter mainly introduces the hardware components, structure feature and wiring connection of FGM-5.

By reading this chapter, users can rightly operate the instrument and reduce the wrong operation.

## Section 1:Instrument appearance

As shown in figure4.1，FGM－5 optical fiber geometric analyzer consists of main machine, industrial computer, control panel, display, keyboard, mouse and other auxiliary tools.
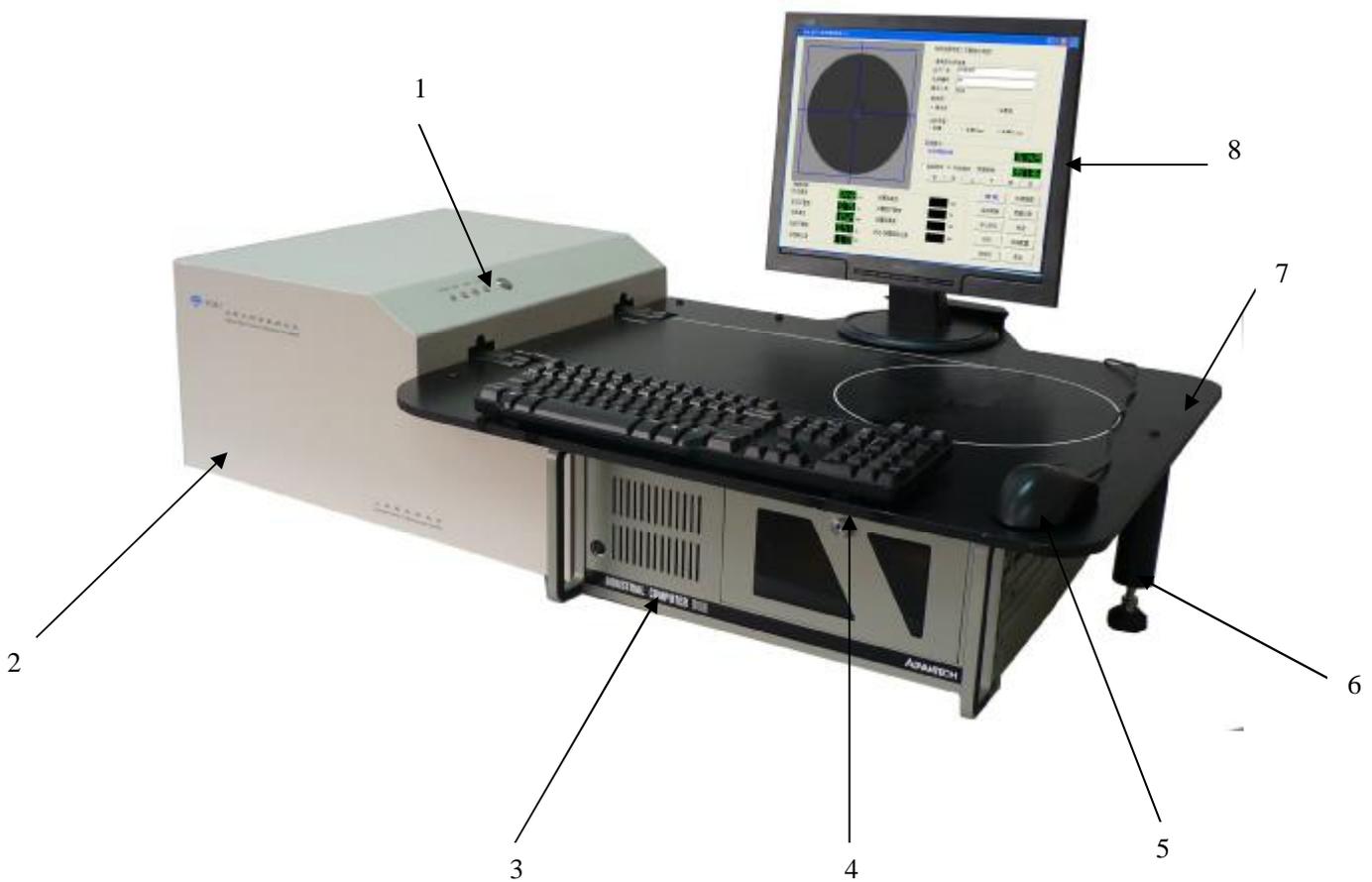


1、chief switch and indicator light　　2、main machine　　3、industry computer　　4、keyboard
5、mouse　　6、support　　7、working panel　　8、displayer

Figure 4.1    Instrument appearance

# Section2:System wire connection

**Each output port of main machine is shown in figure 4.2:**

COM1--------------circuit board control port

COM2--------------adjuster control port

SIGNAL------------Video signal output port

240V/5A/50HZ------power supply input port
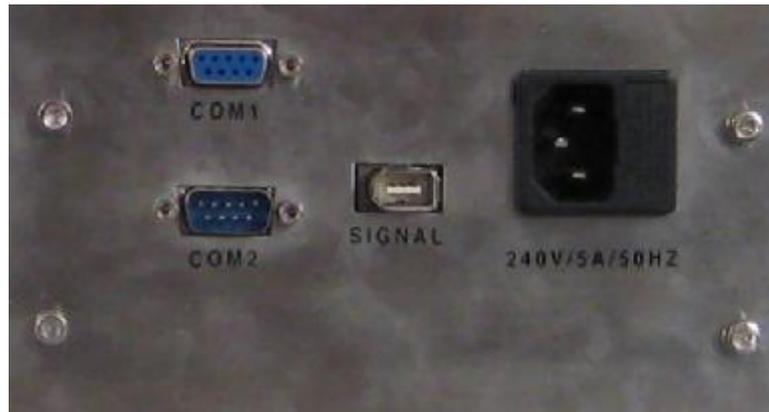


Figure 4.2 System wire connection

The output ports of industry computer is shown in figure 4.3:
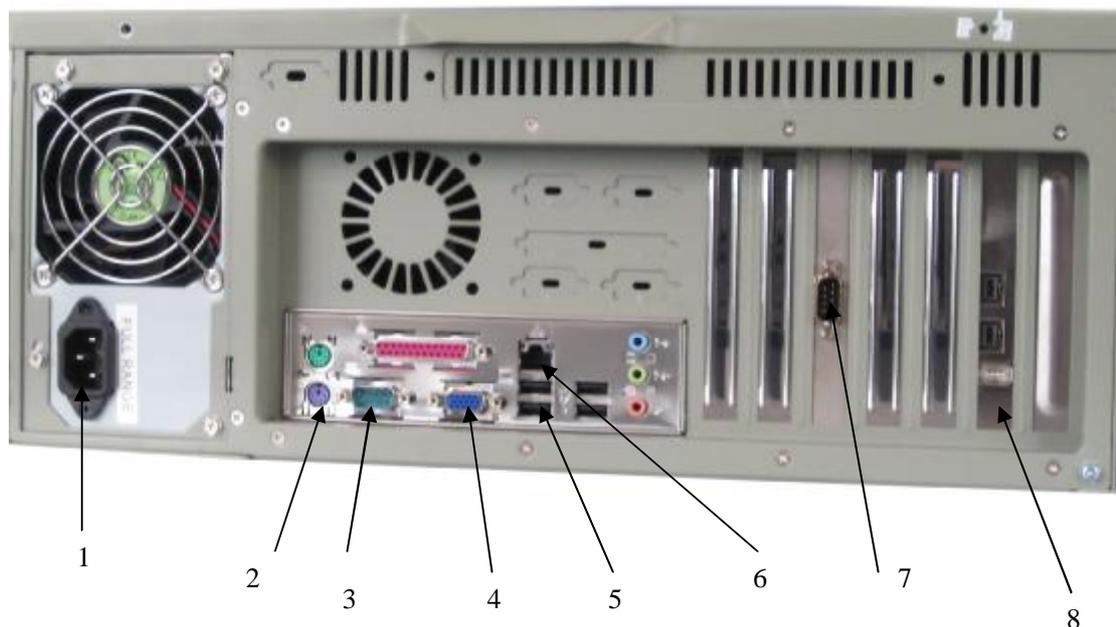


1、 Power supply input port    2、keyboard and mouse port 3、COM1    4、video port   5、USB port
6、network port    7、COM2    8、image clip input port

figure4.3 Output ports of industry computer

Wiring connection graph is shown in Fig 4.4
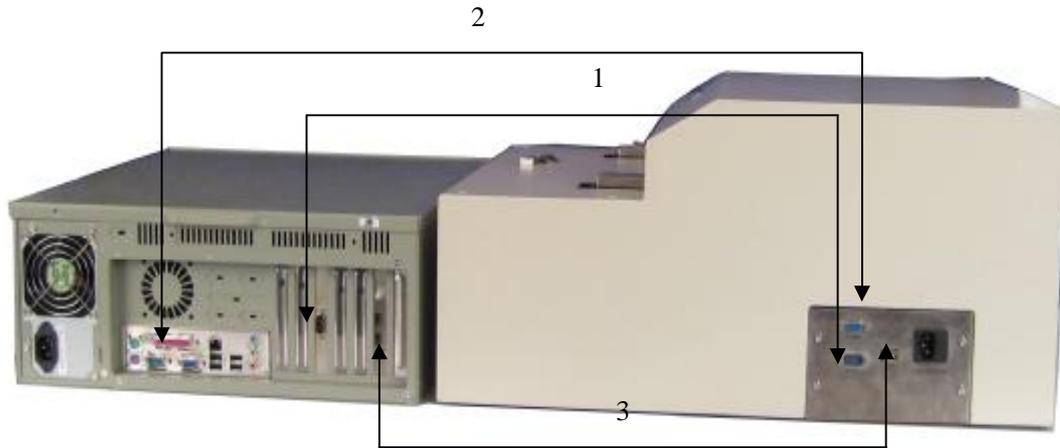


1：adjuster control cable      2：circuit board control serial cable      3：video input wire

figure4.4    Wiring connection

# Chapter V:software application

## Section 1:system software frame figure

### 5.1. user login and registration

After open the computer, enter Windows XP interface，double-click software shortcut small icon on desktop，then enter language selection interface as shown in fig5.1。



Figure 5.1 Language selection

Select the language，enter the system login interface，as shown in fig5.2
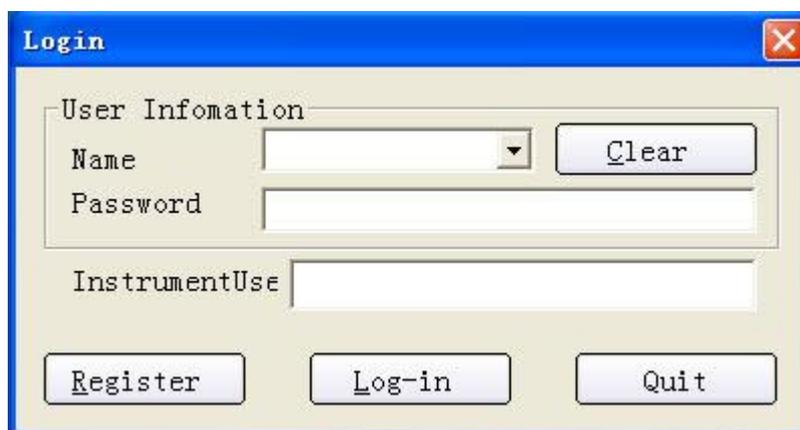


Figure 5.2 System login interface

The user database is empty after the software installed. When you login the system at the first time, please register a new user，click "register" button, then you will see a user registration interface as shown fig5.3.

**5.1.1 New common user registration**



Figure 5.3 New user registration

The FGM-5 system supports two user types, one is common user, the other is administrator. Common user can not change any system configuration data, such as fiber quality criterion and system calibration, but administrator can.

Input user name and password, select the user type, that is power limit, and click "Ok" button ,then enter next step，if user has existed, system will popup the following dialog box, as shown in Fig5.4.



Figure 5.4 New user name exists in database

Otherwise, a registration success message will prompt，as shown in fig5.5:



Figure 5.5 Registration success

**5.1.2 Administrator registration**

If you want to register an administrator, power limit authorization is needed, as shown in Figure 5.6. The super user name is "instrument", initial password is "86-21-55620082".



Figure 5.6 Power limit authorization

Return login interface，you can enter software system after input user name and password，as shown in fig5.7:
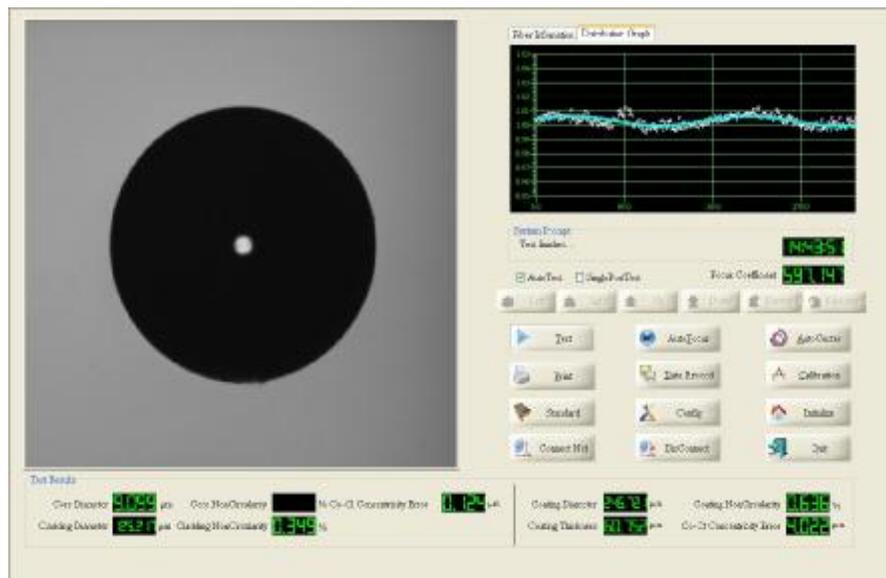


Figure 5.7 Main software interface

# Section 2:software frame chart

Following chart(fig 5.8) is software frame chart of system:

```
FGM System
    ├── Video of fiber end face
    ├── Fiber registration information
    ├── Non-circularity Distribution
    ├── Fiber test items
    ├── Fiber type
    ├── System prompt
    ├── Testing means
    │       ├── Auto focusing
    │       ├── Auto centering
    │       ├── Auto testing
    │       └── Manual testing
    ├── Test results
    ├── System initialization
    ├── Database operation
    ├── System calibration
    ├── Criterion management
    └── Test results printing
```
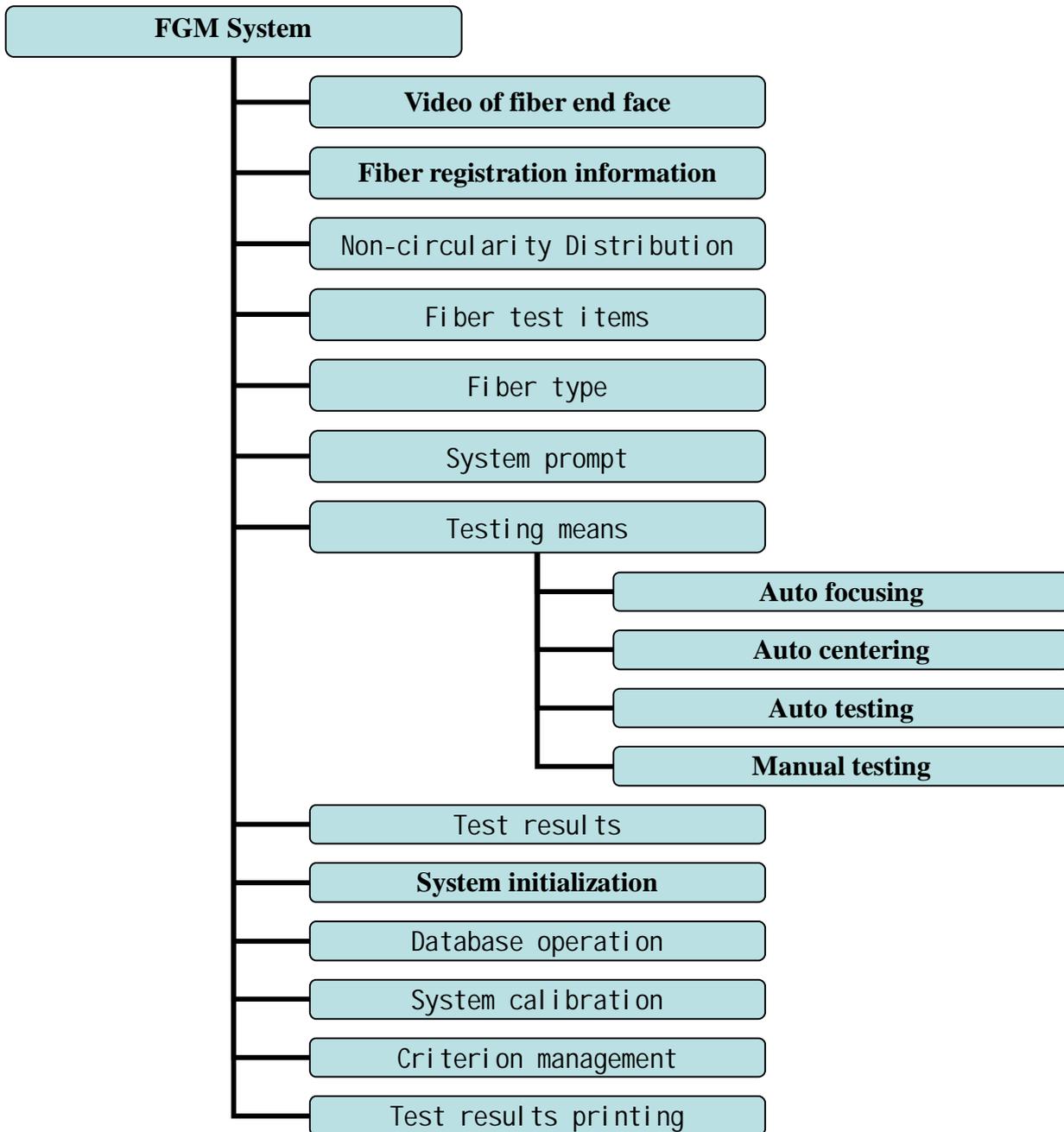
Figure 5.8 software frame chart

As shown in Figure 5.8, system software frame chart consists of fiber sight field area, fiber registration information, distance distribution graph, fiber test items, fiber types, system hint, fiber position adjust, test result information, initialization, data record administration, fiber calibration, standard management and test results printing.

# Section 3:Software test interface

### 5.3.1　Fiber end face image

The area in red frame is the fiber end face image from CCD.
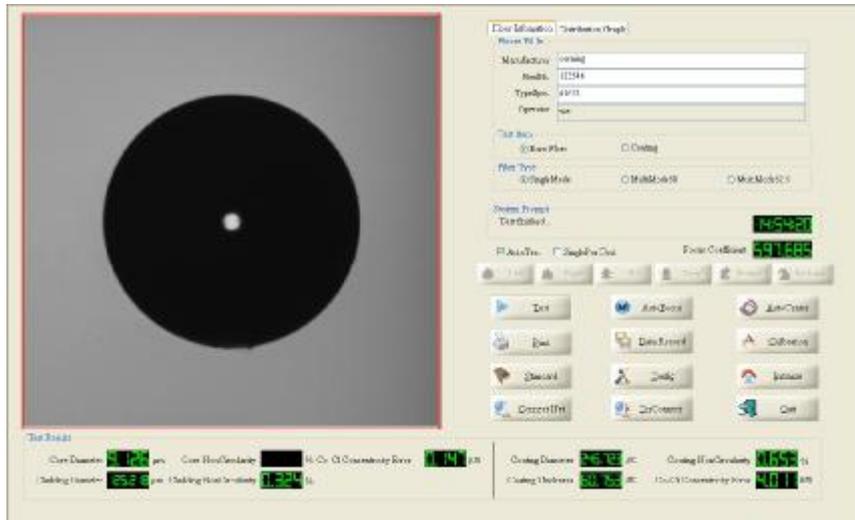


（fig5.9）

The fiber imaging location can be watched in the field of view, as shown in figure 5.9. If you don't watch an image shown in figure 5.9, please click centering and Auto focus button. Otherwise, Click Initialize button to initialize the system.

### 5.3.2 fiber registration information

The area of fiber registration information is shown in figure 5.10. It is in the red frame.
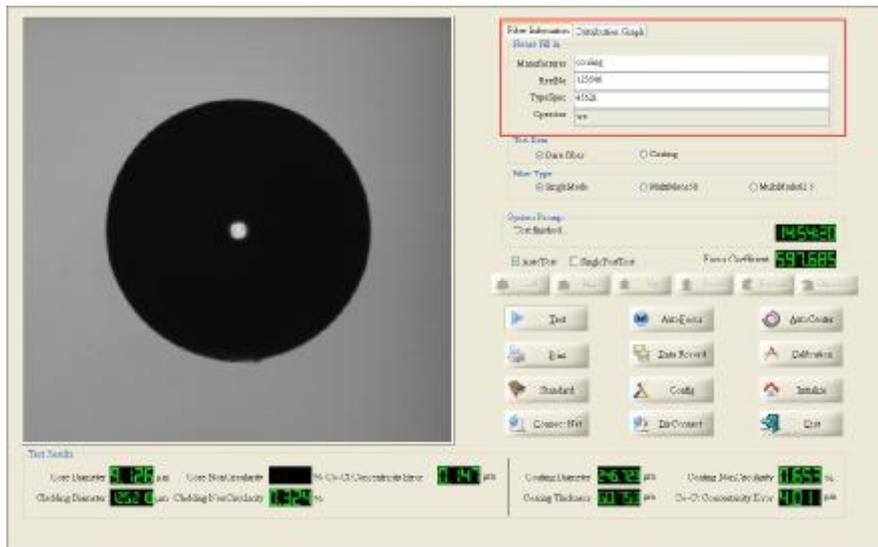


Figure 5.10

Fiber registration information includes：manufacturer and fiber lot number. Please fill in the two basic information before test. The default operator is user's registration name, you cannot change it manually.

### 5.3.3 Distribution chart for non-circularity

The red area, shown in Figure 5.11, is distribution chart for cladding non-circularity.
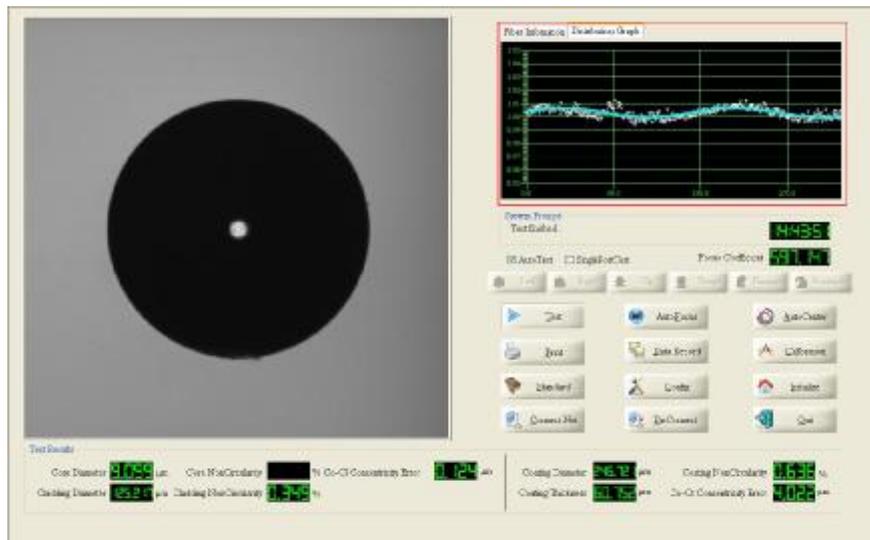


Figure 5.11

We can know the non-circularity information from above chart when we test bare fiber. If the coating is being tested, the area is invalid.

### 5.3.4    Fiber test items

The red area, shown in Figure 5.11, is the area is fiber test items
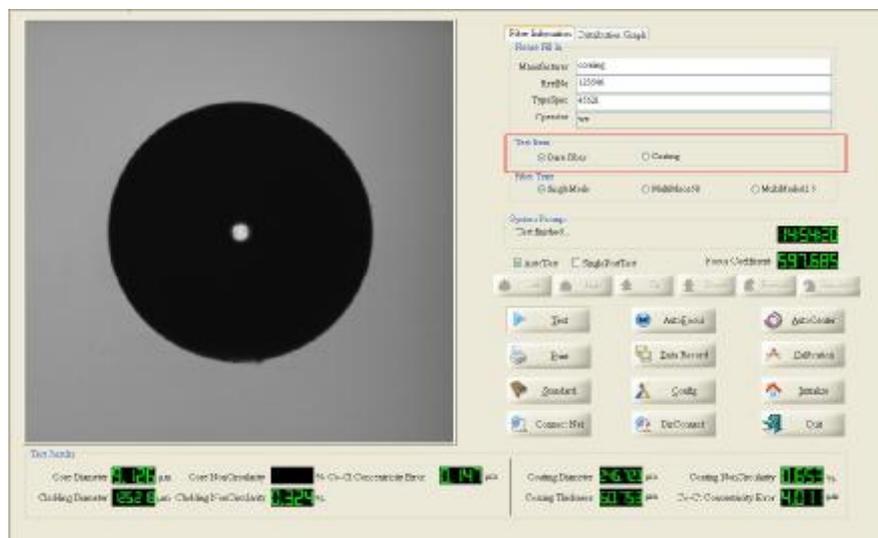


Figure 5.12

Fiber test items include:  bare fiber and coating,. Please select corresponding test item before test.

### 5.3.5    Fiber type

Three basic fiber types can be tested by the instrument, that is, SM fiber, MM 50um, MM 62.5um. You should select fiber type in the red frame shown in Figure 5.13 before you execute

you test process.
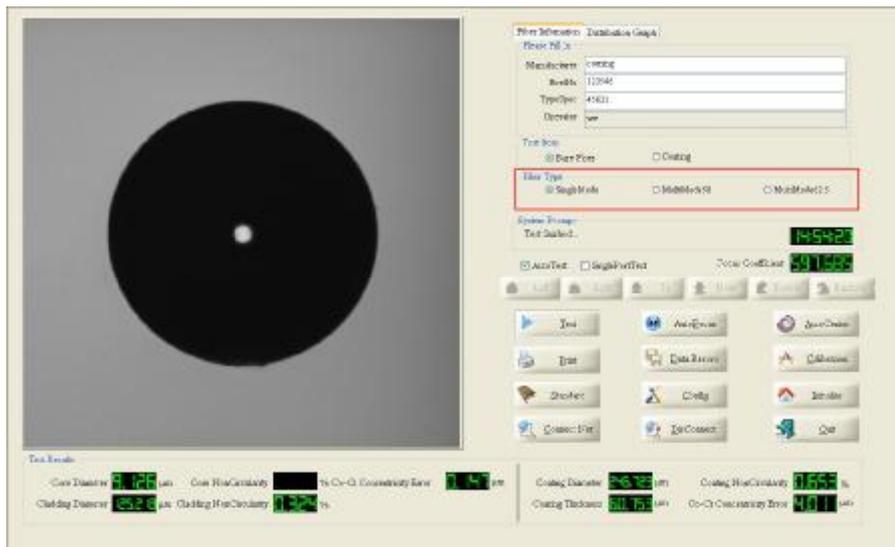


Figure 5.13

### 5.3.6   System prompt

The instrument work status is displayed in the red frame, shown in Figure 5.14. The current time is displayed on the right side.
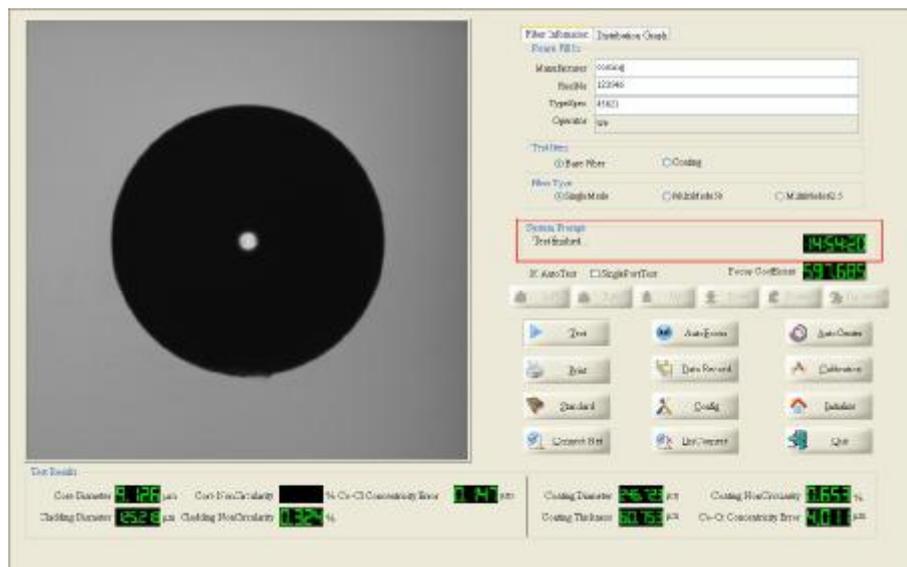


Figure 5.14

### 5.3.7 Control buttons and test steps

### 5.3.7.1 Control buttons introduction

As shown in Figure5.15, click one of the six buttons(left, right, up, down, front, back) on the panel, the fiber will be moved to the corresponding direction. These buttons are valid when selecting manual test. Up, down, left, right four buttons adjust the image location. Forward and backward button adjust the definition of fiber image. The fiber location also can be adjusted by the corresponding shortcut key on the keyboard, that is: left: left arrow (←)，right—right

arrow(→), up—up arrow(↑), down—down arrow(↓), front — Page up key, back— page down key.

Auto-focus and auto-center can locate the fiber image to a best position automatically without any manual intervene as long as you see the fiber image in the view of field.

### 5.3.7.2 Test mode:  manual test and automatic test

- ⊐  Manual test. Designed for testing single item. Under this mode, you can test bare fiber and coating individually if necessary. Use the control key of 5.3.7.1 to adjust the image location.

- ⊐  Automatic test. Designed for the completely automatic test bare fiber and coating. One thing you should do is to click the TEST button and wait for the test results.

**Note:    in despite of the selection of the manual test mode or automatic test mode, you should manually move the fiber image into the view of field using the control keys of 5.3.7.1. At the same time adjust the definition. When choose manual test mode, you should confirm the fiber end face image of the injection port has been focused and centered. Then you click the test button, the fiber end face image will be auto-centered and auto-focused. When choose automatic test, just need to click choose fiber type, and test button directly, test system will finished both bare fiber and coating test, the test results will be shown in the red area in Figure 5.15.**
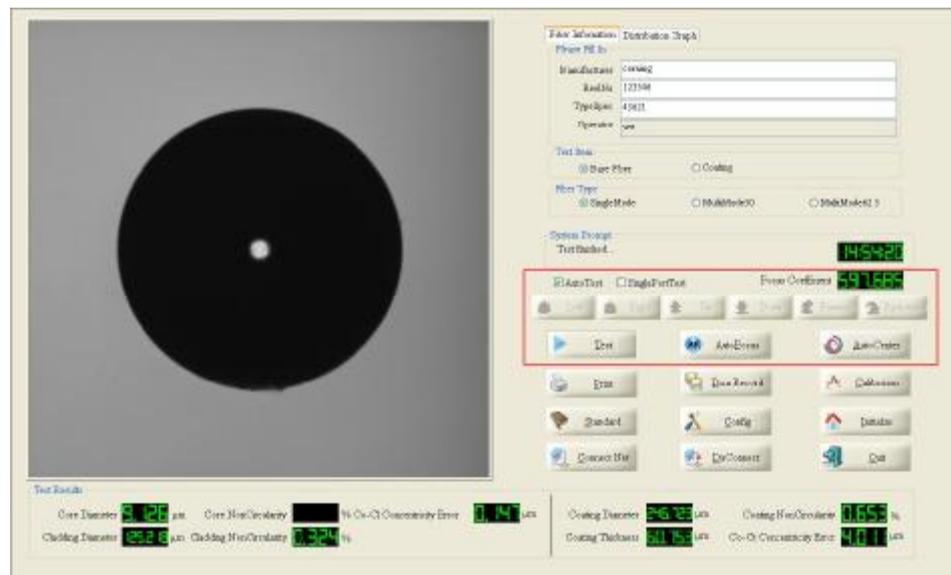


Figure 5.15

### 5.3.8 Test results

The test results are shown in red frame of Figure 5.16.
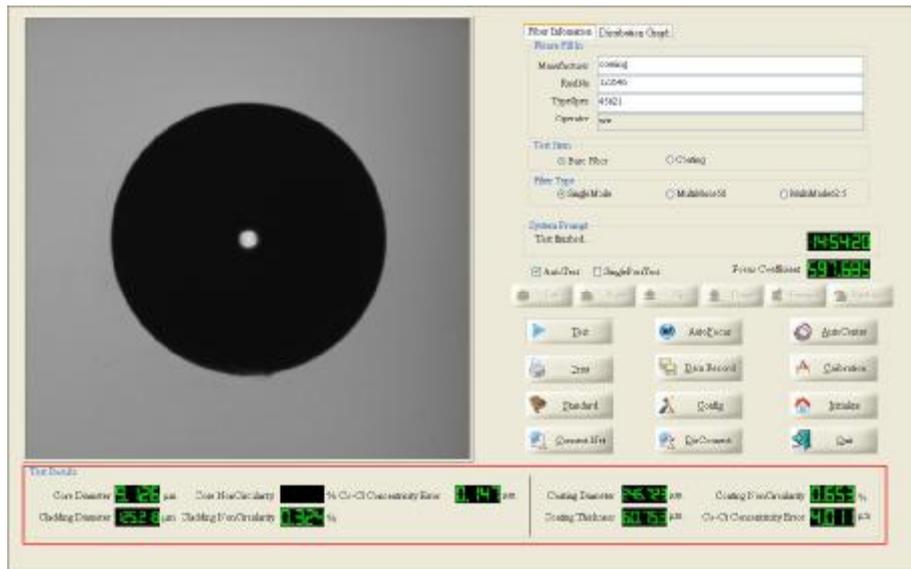
Figure 5.16

In the test results area, bare fiber test results are displayed in the left column, and the coating test results are displayed in the right column.

### 5.3.9  System initialization

Click "initialize" button，system will be initialized. The electric 3D adjuster will run to the position according to the configuration data. The motor steps have been set up after instrument manufactured. When the fiber image can not be adjusted into the view of field, just click this button.

### 5.3.10  Fiber calibration

The two test port must be calibrated independently by a BARE standard optical fiber. You can use the same standard fiber to calibrate the bare fiber test port and the coating test port. The standard optical fiber must be cleaned and cut roundly. Select test port, click the Calibrate button(shown in fiber 5.17) and input the standard cladding diameter(shown in figure 5.18) correctly. After you confirm you input, click OK button, the test port calibration will be processed automatically.
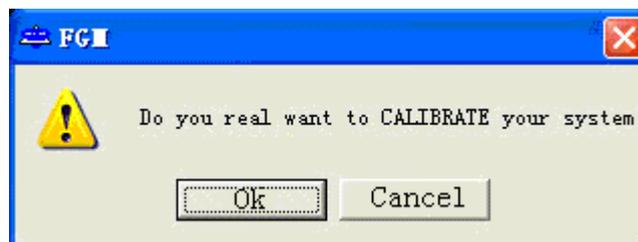


Figure 5.17 Calibration confirmation

Figure 5.18 Input cladding diameter of the standard fiber

## 5.3.11 Standard management

The FGM-5 software system can estimate the tested fiber quality by the customized criterions. If you want to change the criterion, please click Standard button, and the standard management dialog will popup, shown in Figure 5.19.
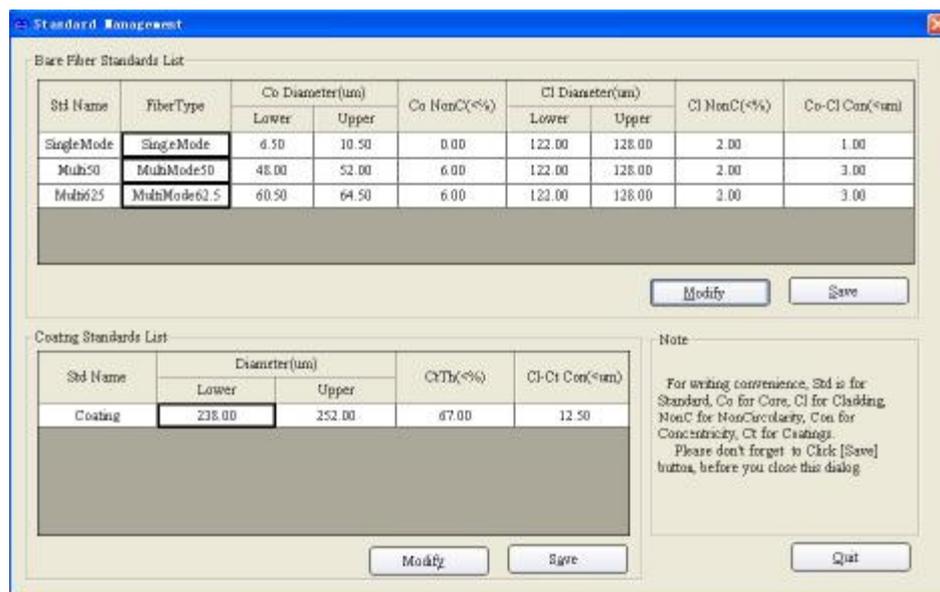


Figure 5.19

According to the test item, two kinds of standards are designed, bare fiber standard and coating standard. If you want to modify the quality criterion, a user with administrator power limit login in the system is necessary. Click "Modify" button，then double-click the data in the form, change the values and don't forget to click save button before close the dialog.

## 5.3.12  Data record management

The FGM-5 testing system saves the tested data automatically. All the tested data are stored

in database. Click Data button, and you will browse all the tested data from the dialog, shown in figure 5.20. You can query the tested data by test items, fiber lot number, manufacturer, test time and tester. Select query conditions and click Query button, the tested data met with the query conditions will be filled into the data list.
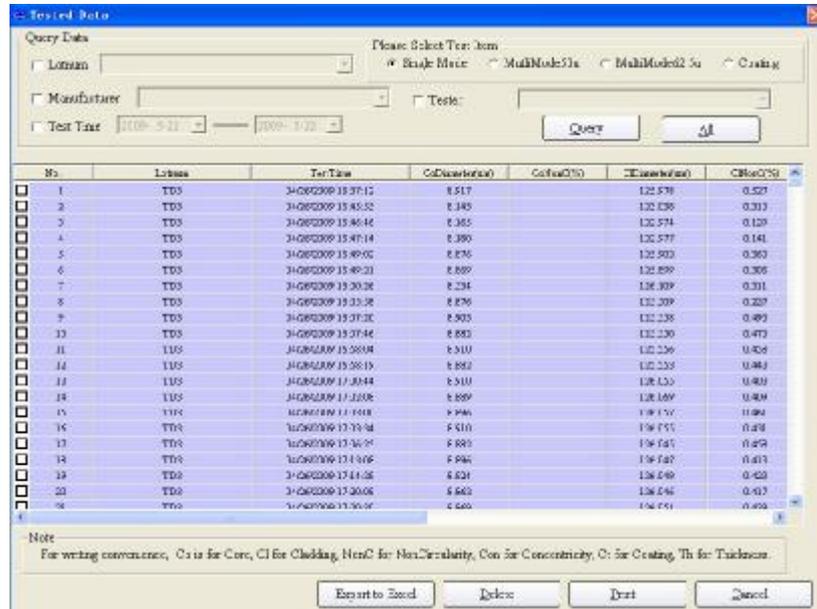


Figure 5.20 Review of tested data

Data calculation, delete and print functions are available for the selected test data from the data list. Press the right button of mouse, a menu will pop up in the data list. You can select one single data item or select all the data item. If you click Clear All item, All selected data item will be cleared. Furthermore, you can calculate the selected more than three test data(shown in Figure 5.23) to get the mean values and the standard deviation of the test data, shown in Figure 5.22.
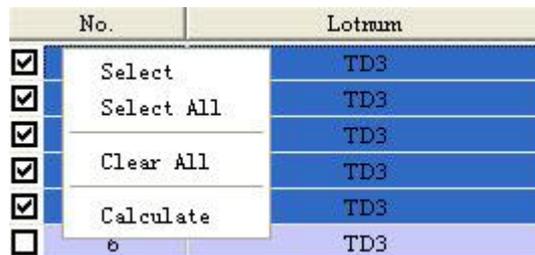


Figure 5.21 Right button menu popped up from the data list
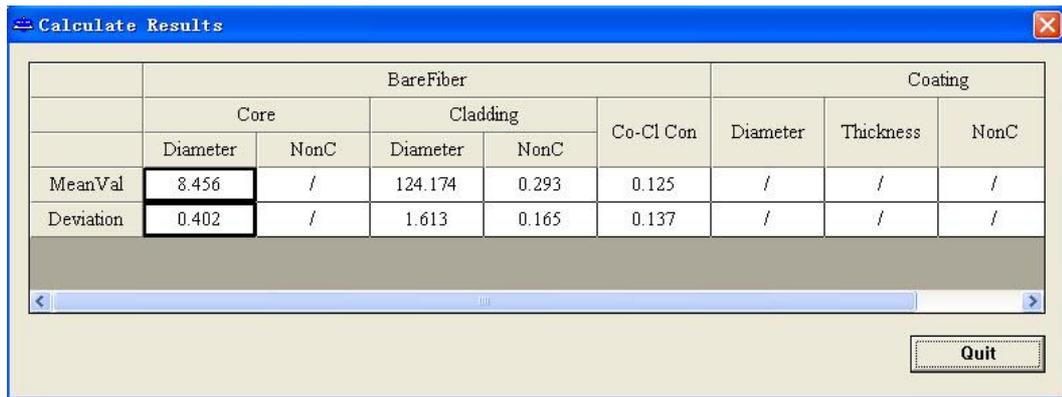
Figure 5.22 Calculation results



Figure 5.23 Selected data message

Select test data of the same lot number, click Print button the print the report in our default format, shown in Figure 5.24. If you want to Edit the data in your own report format, select the interested data, and click "Export to Excel" button.



Figure 5.24 Data report

Additionally, you can print the current test data on the main interface, as shown in Figure 5.25
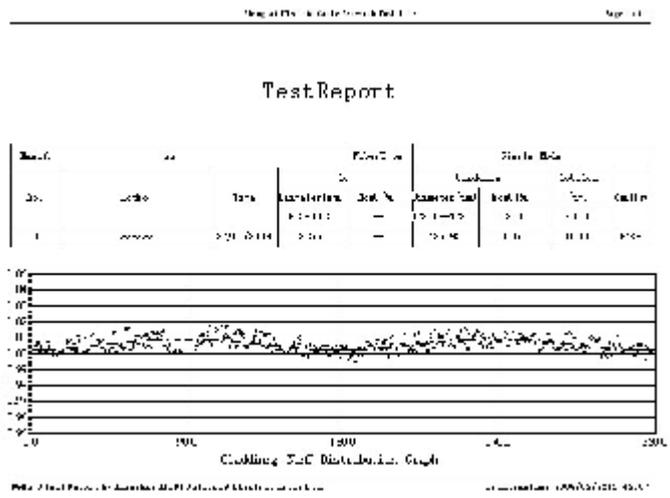
Test Report

Figure 5.25 Current test data report

# Chapter VI:Operation manual

The chapter mainly introduces the operation illumination of FGM-5 optical fiber geometric analyzer. From above chapters，you may have a general understanding of FGM-5 instrument. The test process is introduced in the following part.

## 6.1  Preparation

    6.1.1 Power on:  power on the FGM_5 main machine firstly, power on the industry computer and displayer，preheat 30 minutes;

    6.1.2 Login:  select a registered user name login the software system, detail operation refers to 5.1.

## 6.2   Test process

    6.2.1 Information input. Enter main interface of software，firstly input the information of tested fiber according to requirement, select the test items and fiber type.

    6.2.2 End surface processing. Cut one piece of fiber of 2-meter in length, remove the coating layer of one end with special tool, clean it，then clamp it with fixture of bare fiber, the V-type groove must be filled with are fiber. Cut the end face correctly by a fiber cutter. Clamp the other end of fiber with the coating fixture，then cut the coating end surface with the special coating cutter，then insert the two fixtures into the corresponding test ports. Pushing the fixtures along the side of the guide channel close to operator is necessary for keeping fiber from warping.

    6.2.3 Test process. Select test mode according to item 5.3.7, test data will be saved into database automatically;

    6.2.4 When deal with the end surface of coating again, firstly initial the instrument so that fiber coating end surface can be found in sight field. If fiber image can't be watched after initialization，fiber end surface should be processed again.。

## 6.3   Current test data print.

Click the print button on the main interface, the current tested fiber data will be print. Note: printing report must be executed before you switch to another test item or fiber type. Meanwhile, the current test results and relative information are saved into database automatically. Click "Data Record"，you can to operate the tested data according to the item 5.3.12.

**6.4  Calibration.**

All geometry parameters are tested based on the optics imaging system combined with digital image processing technology. Before calculate the tested fiber geometry parameters, it is necessary to calibrate the system to get the correct coefficient of imaging system. The coefficient is the scale coefficient between image pixel and real fiber size. Three steps are needed for the system calibration.

6.4.1  Raster calibration. A standard raster is to calibrate the X and Y axis of optics system before instrument produced. The X and Y axis are calibrated respectively. This step is not open for instrument users.

6.4.2  Standard fiber calibration. Generally, only nominal values of bare fiber are provided by a standard fiber. Standard bare fiber is adopted to calibrate the near port and far port independently (you can do the calibration with your own standard fiber），the detail calibration method refers to 5.3.10.

Different digital image processing algorithms are adopted for calculating the fiber core and cladding. The value of core diameter relates with the customized threshold，as shown in red frame in Figure 6.1. A calculation tool is designed for changing these coefficients more easily. Click "Calculator" button，you can see the calculator dialog, as shown in Figure 6.2.


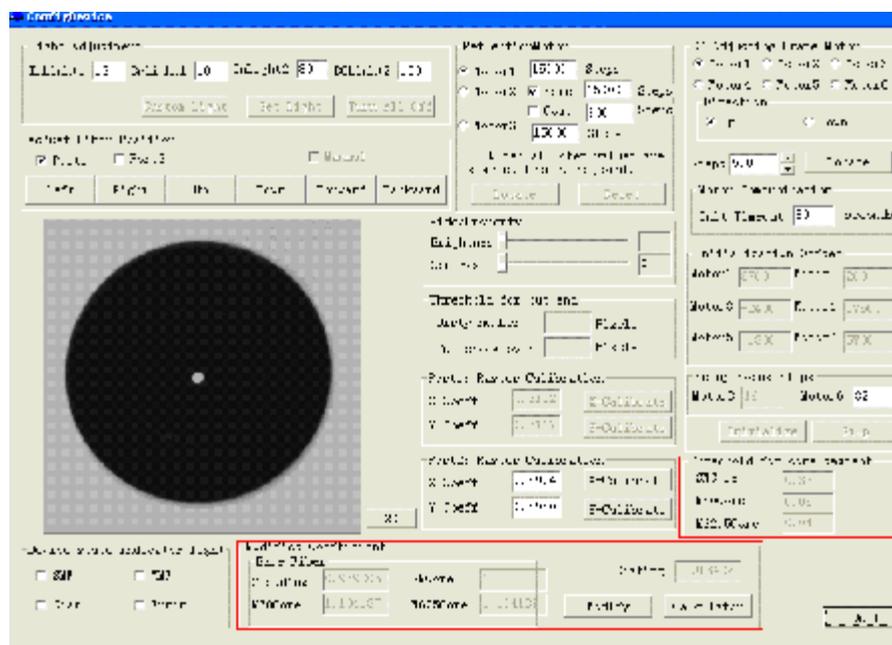
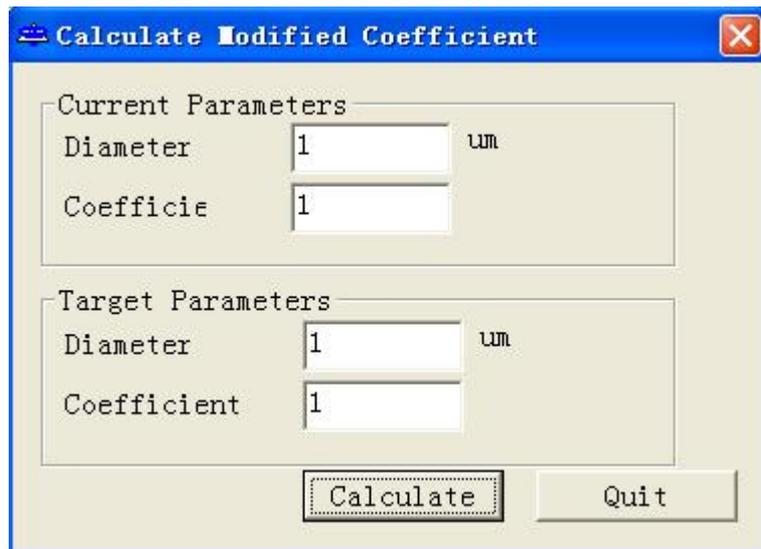Figure 6.1 Core calculation threshold and system calibration coefficients

Figure 6.2 Coefficient calculator

Notes:

1．Please ensure the correct wire connection of hardware, especially, two COM ports linked correctly.

2．Ensure the fiber end surface clean，do your best to avoid the coating warp;

3．Coarsely location of the fiber image is needed before auto-focusing to shorten focus time elapsed as possible.

4．Keep FGM-5 main machine stationary during the test process. No instantaneous force on the test system is a must.

# Chapter VII:Additional Notices

**7.1 Electric power requirements:**

200~240VAC，50Hz with good earthed;

**7.2Environment requirements:**

Ambient temperature:  20℃±5℃

Relative humidity:  ≤70%;

**7.3 Quakeproof, dustproof and keeping away from sunlight and electromagnetic radiation (Dark color curtain should be put on in the testing room).**

**7.4 Size of work table:  200×120cm$^2$。**

# Chapter VIII:Technique supports

Telephone： (86)021-65491166

Fax： (86)021-55620082

Contact： After-sale Service Group of Instrument and Meter Department

Address: No.1000, Jungong Rd., Shanghai, P.R.China

Repair telephone for Epson printer: 800-810-9977

 Repair telephone for Philips Display: 800-820-5128