C228-E006A

Access to your success
SHIMADZU

CFT-500D/100D

Shimadzu
Flowtester Capillary Rheometers

Efficient evaluation of rheological and thermal properties

Stand-alone system

The operation is quite easily managed on the LCD screen of a touch panel type. Also, an excellent cost-performance ratio is ensured.

Personal computer control system

Sophisticated, highly efficient data processing capabilities are provided through the operation in the Windows™ environments.

CFT-500D/100D

Shimadzu Flowtester Capillary Rheometers

Efficient evaluation of rheological and thermal properties

The Shimadzu CFT-500D and CFT-100D will be your workhorse instruments for the R&D, production control, and quality control of plastics, adhesives, rubbers, paints, printing inks, toners for copying machines, foods, cosmetics, and many others.

APPLICATIONS

Thermoplastic resins

Measurement of melt viscosity of resins provides useful information for determination of molding temperature, pressure, and flow rate.
The CFT-500D and CFT-100D, operating with a shear stress like that used in actual injection molding in production process, provide highly practical data.
It is necessary to measure mean molecular weights and molecular weight distributions in order to evaluate the quality of blended polymers. The CFT-500D and CFT-100D provide useful data for determining the blending ratios of polymers.

Thermoplastic resins and adhesives

The measurement of hardening rates of thermoplastic resins is rather difficult with any other method. With the CFT-500D or CFT-100D, hardening time can be obtained from the plasticity curves.

Toners for copying machines

The melting temperature and viscosity are important factors for obtaining clean and clear print in copying machines.
The CFT-500D and CFT-100D permit easy and efficient measurement of such temperature and viscosity.

Rubbers and rubber materials

Injection molding machines are often used in rubber production. The CFT-500D and CFT-100D, which utilize a mechanism similar to that of ordinary injection molding machines, can provide highly useful data for setting the molding parameters. The data are also used for viscosity control of non-sulfurized rubbers.

Plasticity of ceramic materials

In molding of ceramics, some types of resins, called binders, are added to enhance the plasticity, before they are charged in a mold. The CFT-500D and CFT-100D are used to measure such plasticity to know the best mixing ratio of binders.

Foods

The CFT-500D and CFT-100D are used to select the best components and their best composition ratios, in production of chewing gum, butter, margarine, bread, candy, chocolate, etc.

Cosmetics and medicines

The CFT-500D and CFT-100D are used to evaluate physical properties of these materials.

Paints and inks

The CFT-500D and CFT-100D are used for measurement of their

Fibers

The CFT-500D and CFT-100D are used to select the best melt condition for production of synthetic fibers.

FEATURES

Wide range selection of extruding pressure (0.4903 - 49.03 MPa (5-500 kgf/cm²) in CFT-500D / 0.098 - 9.807 MPa (1-100 kgf/cm²) in CFT-100D)

Measurement can be conducted with an extruding pressure like that used in the actual injection molding.
The CFT-500D and CFT-100D, therefore, provide more practical data than the instruments that use conventional MFR (melt flow rate) method, in which the test pressure is lower than the actual injection molding pressures.

Test at constant heating rate is possible

The CFT-500D and CFT-100D permit tests at a constant heating rate, as well as at a constant sample temperature.
Tests at a constant heating rate make easy the measurement of softening temperatures and flow beginning temperatures of resins which is impossible with capillary rheometers of any other type. Also, the shear rate and viscosity at particular temperatures can be easily measured.

Accurate flow rate measurement, and reliable data

Weights are used for loading to ensure high accuracy in constant-loading tests.
Temperature is one of the most important factors for obtaining reliable data; The CFT-500D and CFT-100D use the Shimadzu's original temperature control system, specifically designed for this purpose, which ensures high accuracy and stability in temperature control and measurement.

Wide test temperature range

The test temperature is adjustable over the range from 40°C to 400°C. This ensures reliable tests of a wide variety of materials, ranging from foods to engineering plastics.
The test temperature range can be further widened through the use of the optional low temperature test attachment and/or higher temperature heating attachment.

Easy die replacement and cylinder cleaning

The cylinder unit can be swung 90° in both sides to ensure ease of die replacement and cylinder cleaning.

Touch panel type LCD screen (Stand-alone system)

The operation is easily done on the LCD screen of a touch panel system.

Operation in Windows™ environments (Computer control system)

Data processing is carried out quite easily in the Windows™ environments.

Contents

Principle Of Measurement

The CFT-500D and CFT-100D measure sample viscosities using the flow resistance of the sample melt to flow through the die orifice. The construction of the cylinder unit, core of the testing machine, is shown below.
The sample is charged in the heated cylinder to melt.

After a specified time, the sample melt is extruded with a constant force by the piston, through the die orifice. The flow rate is obtained from the speed of extrusion; and the plasticity (viscosity of the sample melt) is calculated from the formula below:

(1) Flow rate Q

$$Q = A \cdot \frac{S_2 - S_1}{10 \cdot \Delta t} \ (cm^3/s)$$

A : Piston cross sectional area (cm^2)
S1: Calculation start point (mm)
S2: Calculation end point (mm)
Δt : Piston travel time from S1 to S2 (second)

(2) Apparent shear rate γ

$$\gamma = \frac{32Q}{\pi D^3} \cdot 10^3 \ (s^{-1})$$

D: Die orifice diameter (mm)

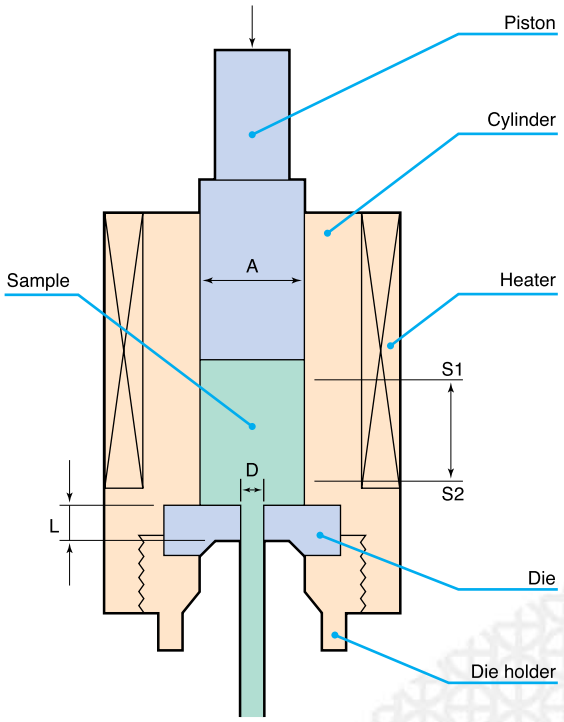
(3) Apparent shear stress τ

$$\tau = \frac{PD}{4L} \ (Pa)$$

P: Test pressure (Pa)
D: Die orifice diameter (mm)
L : Die length (mm)

(4) Apparent viscosity η

$$\eta = \frac{\tau}{\gamma} = \frac{\pi D^4 P}{128LQ} \times 10^{-3} \ (Pa \cdot s)$$



Construction of Cylinder Unit

Correlation with JIS K7210 (Reference), 1995

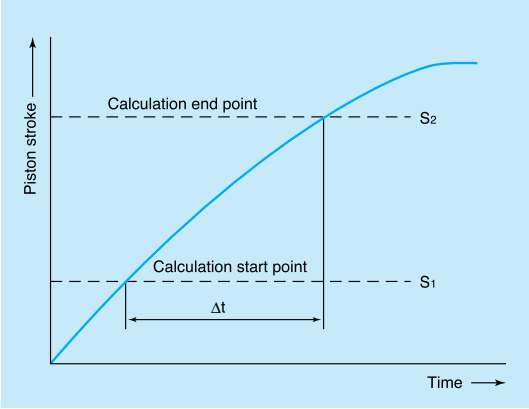
The CFT-500D and CFT-100D provide data that agree with data given by the JIS method when the calculation start point is set to 3 mm and the calculation end point to 7mm.
In the Japanese Industrial Standards, the flow rate is defined as follows:

$$Q = \frac{0.4}{t} \ (cm^3/s)$$

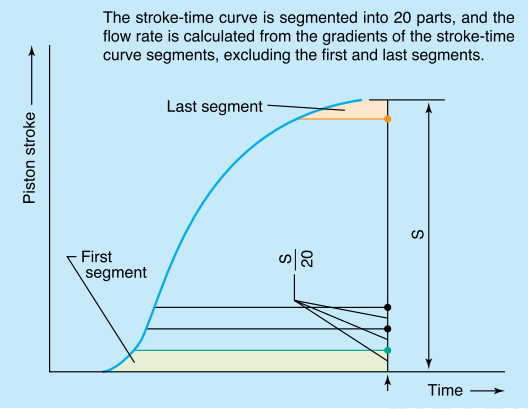
t : Time (second) for the piston to travel from the 3 mm point to the 7 mm point.

Constant Temperature Method

The sample is heated to a constant temperature and then extruded by the piston. The flow rate of the melt is calculated from the stroke-time curve of the piston between the preselected two points. The calculation is made in either the "limiting" method or the "automatic" method. In the limiting method, the calculation start and end points are specified, and the flow rate is calculated from the gradient of the stroke-time curve between these two points. In the automatic method, the stroke-time curve is segmented into 20 parts of the piston stroke, and the flow rate is calculated from the gradients of the curves in the thus segmented parts, excluding the first and last segments.



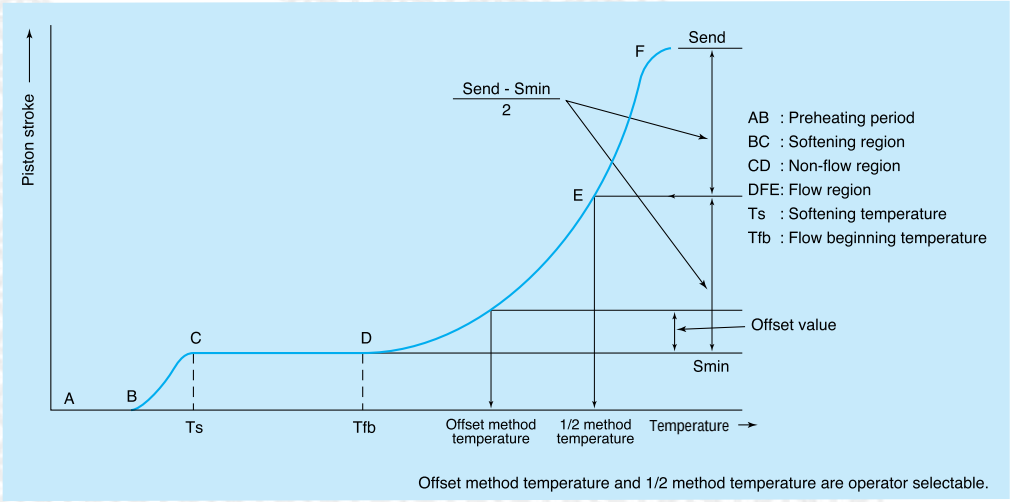
Limiting Method



Automatic Method

Constant Heating-rate Method

After preheating, the sample temperature is increased at a constant rate as the material is being extruded. This method is possible only with the Shimadzu capillary rheometers.
This method permits easy and accurate determination of the softening temperature and the flow beginning temperature of the sample. Also, this method permits rapid determination of the plasticities for the respective temperatures, in a single run of test.



Flow Test Curve with Constant Heating-rate Method

Stand-alone System

Standard type of easy operation and excellent cost-performance ratio

- The CFT-500D and CFT-100D of a stand-alone system are compact and ensure rapid and easy operation through the use of a touch-panel type LCD (liquid crystal display).
- Test pressure and temperature can be selected from wide ranges.
  Constant temperature tests, constant heating-rate tests, 1/2 method tests, offset method tests are selectable.
- Shear rate, viscosity, softening temperature, etc. of plastics can be measured.
- Stroke-time curve (constant temperature test) and stroke-temperature curve (constant heating-rate test) can be monitored in real time.
- Test results can be printed out on a printer.
- The stand-alone system can be easily upgraded to a personal computer control system through the use of software and a communication cable (both are optional).

The printer is not included in the standard setup.

Test Sequence

Initial Setting

Date
Test mode
Piston cross sectional area
Connection of printer
Connection of personal computer

Maintenance/adjustment programs

Constant Temperature Test Setting

Test condition saving/Loading

Input of sample name, sample number, density, and die

Input of test temperature, calculation mode, calculation start/end points, and number of repeats

Full-scale setting

Constant Heating-rate Test Setting

Test condition saving/Loading

Input of sample name, sample number, and die dimensions

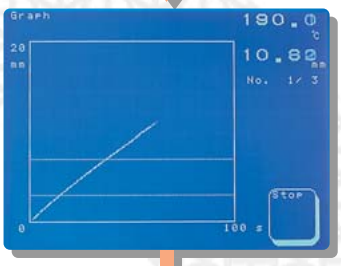
Input of start temperature, end temperature, heating rate, measuring interval, and selection of 1/2 method or offset method

Full-scale setting

Test start

Constant temperature test

Preheating

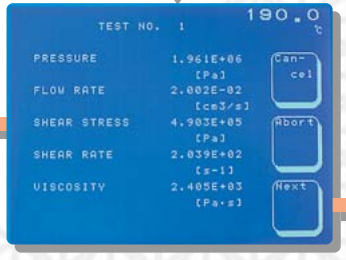


Measurement

Stroke-time curve
for constant temperature test
stroke-temperature curve
for constant heating-rate test

Constant temperature test
(Repeat Test)

End



Test results

Constant temperature test	Constant heating-rate test
Display of pressure, flow rate, shear stress, shear rate, and viscosity	Display of softening temperature, flow beginning temperature, flow end temperature, and 1/2 method or offset temperature

Data printout

Flow curve, test data, mean values of repeated tests

Personal Computer Control System

Higher performance type, ensuring easy operation and sophisticated data processing in Windows™ environments

- This system is an upgraded version of the stand-alone system.
  It has the same test items but provides higher data processing capabilities of a wide variety.
- All the operations, including test parameter setting, test start and end, data acquisition, data processing, data saving, and reanalysis of stored data, are carried out by the personal computer.
- Functions of this system include processing various types of curves, overlaid presentation of more than one curve, and zooming.
- This system permits viscosity correction by the Bagley plot method and calculation of shear sensitivity (Dshear stress/Dshear rate), which provides information on the molecular weight distribution.

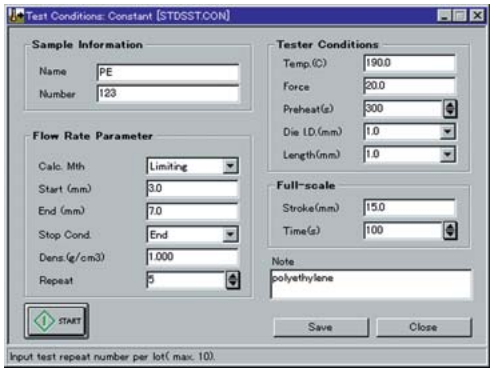
The personal computer and printer,
and the bench are not included in the standard setup.

On-line Software for acquisition of test data

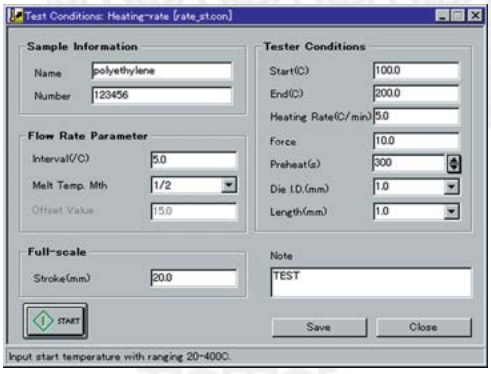
Input of testing parameters

All the testing parameters are entered and displayed in a window.

After parameter setting, just click the START key at the bottom left, to start the test.



Testing parameter Window for constant temperature tests

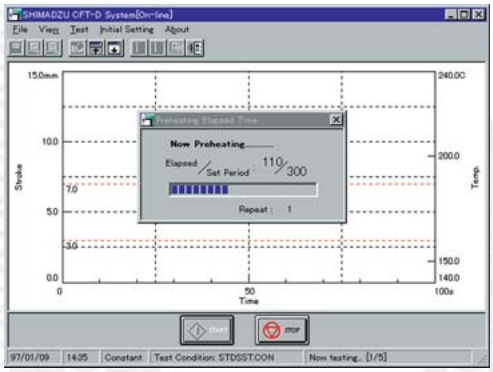


Testing parameter Window for constant heating-rate tests

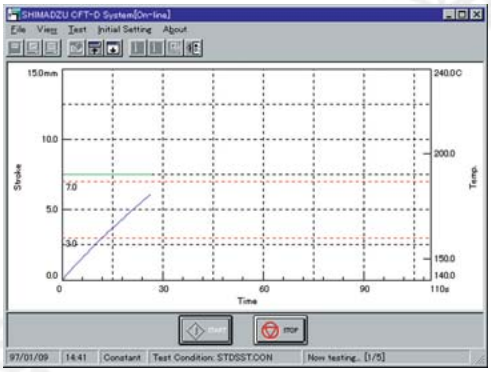
Input of testing parameters

As sample preheating starts, the elapsed time is indicated as a bar. When preheating is finished, the loading unit works to start measurement.

The piston stroke and the cylinder temperature are shown in an extra monitor Window.



Preheating

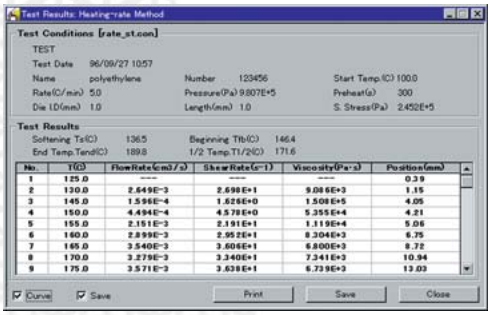


Test underway

Display of test results

After a run of test is over, the test results and the testing parameters are displayed together.

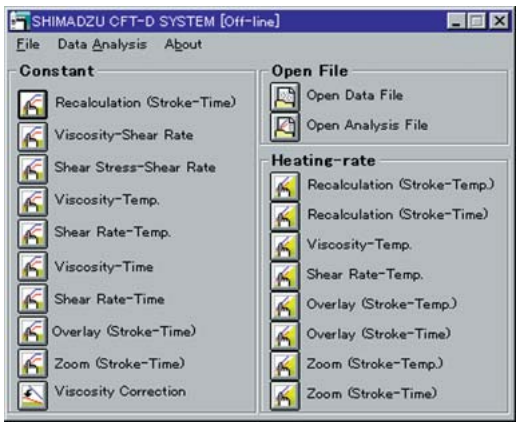
The test data is automatically saved, and recalled at any time for reprocessing with off-line software.



Personal Computer Control System

Off-line Software for reprocessing of test data

Test data saved in the hard disk can be recalled at any time for processing with different parameters and for generating a variety of curves.
The reprocessing items are selectable from a menu as shown to the right.

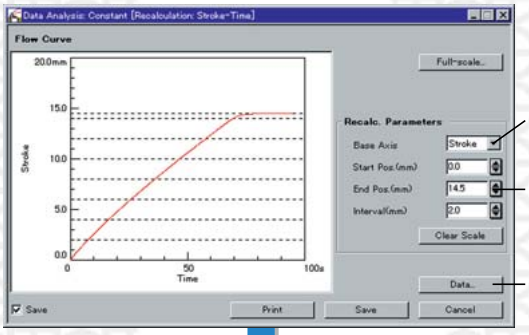


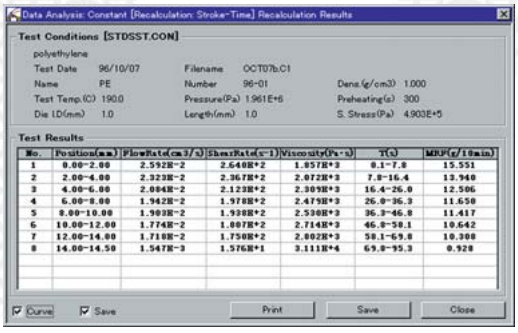
Off-Line Software Menu

1. Recalculation

The calculation interval can be changed with respect to stroke or time (temperature) to obtain the viscosity and/or the shear rate of the desired regions.

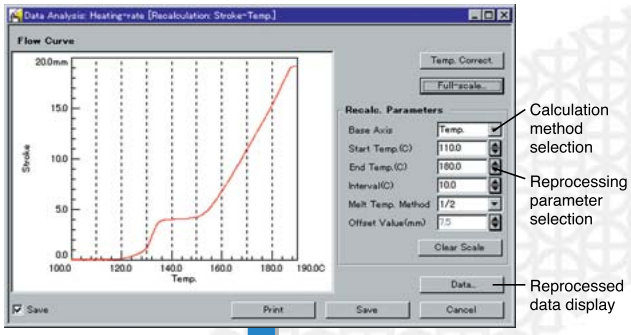
Constant Temperature Test

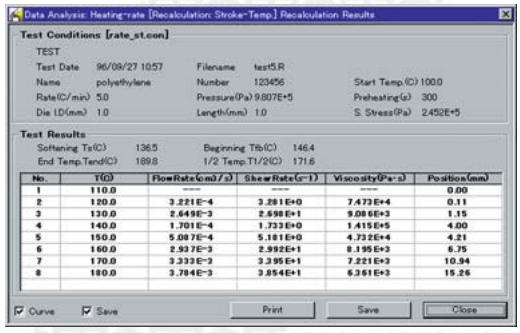




Reprocessed Data

Constant Heating-rate Test





Reprocessed Data

2. Curve generation

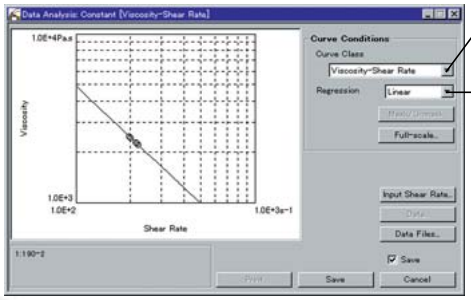
Saved data can be recalled at any time, and the following types of curve can be drawn and displayed in an automated sequence.

(1) Viscosity-Shear rate curve (Constant)
(2) Shear stress-Shear rate curve (Constant)
(3) Viscosity-Temperature curve (Constant)
(4) Shear rate-Temperature curve (Constant)
(5) Viscosity-Time curve (Constant)
(6) Shear rate-Time curve (Constant)
(7) Viscosity-Temperature curve (Heating-rate)
(8) Shear rate-Temperature curve (Heating-rate)
(9) Stroke-Temperature curve (Heating-rate)

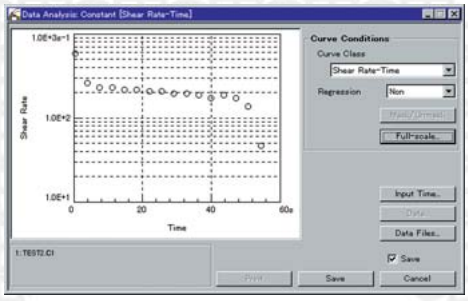
In the curves (1)~(4), up to five different types of data, each of which consists of data obtained with different shear stresses, can be processed at a time in one window. This is convenient for comparing data given at different temperatures, for example. Tests may be performed with different shear stresses and test temperatures.

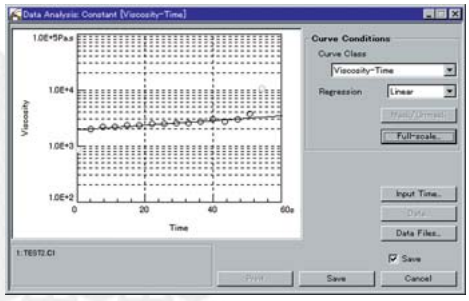
Up to five files are selectable for the curves (5)~(8) and the curves can be overlaid on the screen or in printout.

The ordinate values for up to five abscissa values of the curves (1)~(8) can be displayed. The sear sensitivity N can be displayed for the shear stress-

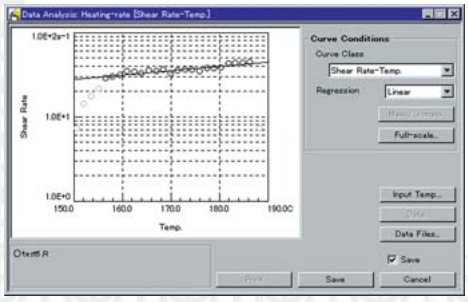


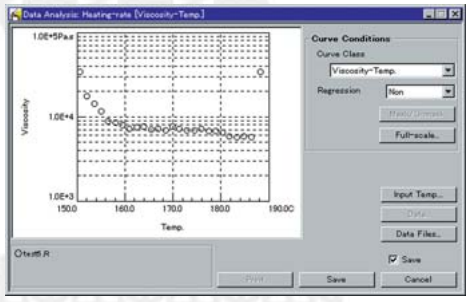
Graphic Curve Display in Constant Temperature Test





Graphic Curve Display in Constant Heating-rate Test

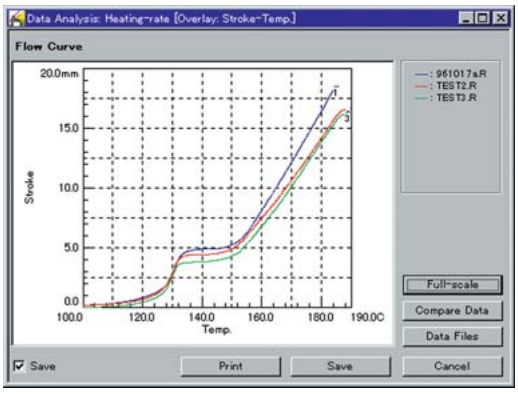




Personal Computer Control System

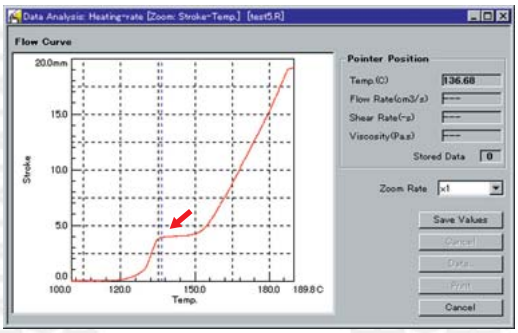
3. Overlay plotting

Shown to the right is an overlay plotting of stroke-time curves obtained in a constant heating-rate test.
Up to 10 curves can be overlaid at a time.

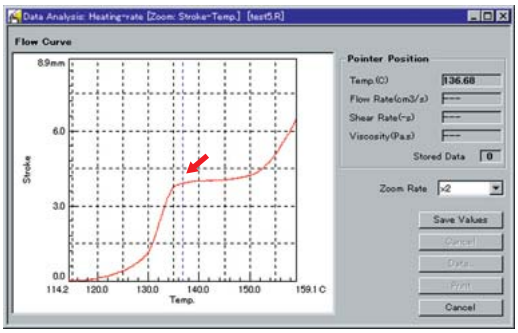


Up to 10 graphs may be overlaid.

4. Zooming



The center to be zoomed is selected by means of the mouse-operated pointer.

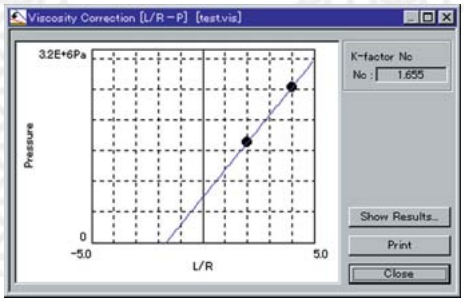


The area selected is zoomed at x 2, x 5, or x 10.

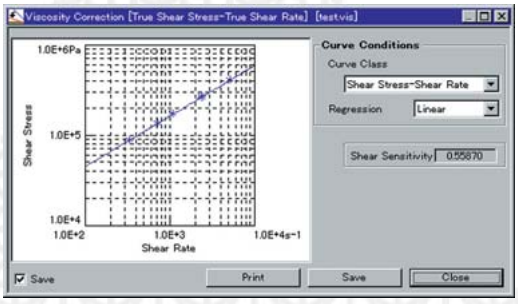
5. Viscosity correction

In calculation of shear stress, shear rate, and viscosity by conventional capillary rheometers, the pressure losses at the outlet of the die are neglected. These values, therefore, are called "apparent" shear rate, viscosity, etc.
Correction of these values into "true" values is generally accomplished by the "Bagley" plot method (longer die length correction method), in which tests are repeated with different die lengths and extruding pressures, and apparent values are corrected into true values, using the data thus obtained.
The program of the CFT-500D and CFT-100D is so made that apparent flow rates are corrected into true viscosities, and then true viscosity · shear stress-shear rate curves are easily generated.
Repeated tests with different extruding pressures and die lengths (hence different L/R values) are required to establish the extruding pressure-L/R curves. Die length correction factors are obtained from the abscissa intercepts of the curves and used to assume the true shear rates and true viscosities.
The shear sensitivity (N) is also calculated from the true shear rate-true shear stress curves.

$$N = (\log SS_2 - \log SS_1) / (\log SR_2 - \log SR_1)$$



Calculation of Die Length Correction Factors



True Shear Stress-True Shear Rate Curves

Specifications

Testing Unit

1 Test method: Constant-pressure extrusion system using weights.

2 Type of tests: Constant temperature test and constant heating-rate test

3 Extruding pressure range:
CFT-500D 0.4903 - 49.03 MPa,
0.4903 MPa step selection
CFT-100D 0.098 - 9.807 MPa
0.098 MPa step selection
Pressure precision
Better than ±1% of the set value

4 Measuring range:
CFT-500D 8×10^{-1} (*1) - 1×10^{6} (*2) Pa · s
CFT-100D 1.6×10^{-1} (*1) - 2×10^{5} (*2) Pa · s
(*1) for 0.5 ID x 1.0 mm length die
(*2) for 1.0 ID x 1.0 mm length die

5 Heating method: Electric, 500 W

6 Test temperature:
Range (Ambient + 20°C) - 400°C
Heat sensor 100Ω platinum resistor
Measuring precision error of heat sensor + (±0.3°C)
Control precision ±0.2°C in stable state
Heating rate 0.5 - 6.0°C/min (0.1°C step).
(For constant heating-rate tests)

7 Piston stroke: Effective stroke 15 mm
Stroke detector Linear potentiometer
Measuring precision ±0.5% (for 15 mm stroke)
Resolution 0.01 mm

8 Maximum sample size: 1.5 cm^3

9 Piston diameter: 11.282 mm (1 cm^2 in cross sectional area)

10 Cylinder diameter: 11.329 mm

11 Standard dies (interchangeable):
0.5 ID x 1.0 mm length
1.0 ID x 1.0 mm length
1.0 ID x 2.0 mm length
1.0 ID x 10.0 mm length

12 Operational requirements:
Power source 100 VAC, 50/60 Hz, 7 A max.
Pneumatic source About 0.5 MPa,
15 NL/run
Temperature 10 - 35°C
(below 29°C in wet bulb reading)
Humidity 30 - 80% (No condensation)

13 Approximate dimensions and weight:
Rheometer main body 840^{W} x 650^{D} x
$1{,}530^{H}$ mm, 150 kg
Attachments 60 kg

Control Unit

1 CPU: Single chip microcomputer, 16 bit

2 Memory size:
512 Kbyte ROM and 320 Kbyte RAM

3 Display:
5.7" monochromatic LCD,
touch panel type

4 Personal computer interface:
RS-232C

5 Clock incorporated

	Stand-alone System Specifications	Personal Computer System Specifications
1 Parameters	Selection of constant temperature method (hereafter called constant) or constant heating-rate method (hereafter called heating-rate), piston cross sectional area, piston drive condition, testing load, preheating period, sample name, sample number, test temperature (Constant), number of test repeats (Constant), density, calculation start/end positions (constant), test start temperature (Heating-rate), test final temperature (Heating-rate), heating rate (Heating-rate), interval of flow rate measurement (Heating-rate), die dimensions (orifice diameter and length), selection of flow rate calculation methods (limiting method or automatic method), full scale time, full scale stroke	
2 Data processing items	Shear stress τ (Pa), flow rate Q (cm^3/s), shear rate γ (s^{-1}), viscosity η (Pa · s), melt flow rate (MFR)(*), softening temperature (Constant), flow beginning temperature (Heating-rate), 1/2 method, offset temperature method (Heating-rate)	
3 Graph generation	Stroke-time curve (Constant), stroke-temperature curve (Heating-rate)	
		Viscosity-shear rate curve (Constant) Shear stress-shear rate curve (Constant) Viscosity-temperature curve (Constant) Shear rate-temperature curve (Constant) Viscosity-time curve (Constant) Shear rate-time curve (Constant) Viscosity-temperature curve (Heating-rate) Shear rate-temperature curve (Heating-rate) Overlay of up to 10 curves Zooming display (Constant and Heating-rate) Viscosity correction by the Bagley plot method Shear sensitivity N

(*) The cylinder dimensions of CFT-500D/100D system is different from that of the melt indexer based on ASTM/JIS standards, therefore, this measurment results are not always equal to thoes of the melt indexer.

Personal Computer Hardware Requirements

Personal computer

Pentium™, 120 MHz or faster, DOS/V , supporting Windows™ XP/2000

Operating system

Windows™ XP/2000

Display

1,024 x 768 or higher in resolution

Serial port

RS-232C (COM 1 port)

Standard Setup

Component \ System		Stand-alone System		Personal Computer System	
		CFT-500D	CFT-100D	CFT-500D	CFT-100D
		344-04106-05	344-04106-15	344-04106-25	344-04106-35
1. Testing unit		1 set	1 set	1 set	1 set
2. Piston, 1 cm^2	347-25000-01	1 pc.	1 pc.	1 pc.	1 pc.
3. Die (ID x length in mm)					
0.5 x 1.0	341-69057-04	1 pc.	1 pc.	1 pc.	1 pc.
1.0 x 1.0	341-69057-12	1 pc.	1 pc.	1 pc.	1 pc.
1.0 x 2.0	341-69057-13	1 pc.	1 pc.	1 pc.	1 pc.
1.0 x 10.0	341-69057-35	1 pc.	1 pc.	1 pc.	1 pc.
4. Weight					
10 kg	341-00016-01	4 pcs.	—	4 pcs.	
5 kg	341-00015-01	1 pc.	3 pcs.	1 pc.	3 pcs.
2 kg	341-00014-01	1 pc.	1 pc.	1 pc.	1 pc.
1 kg	341-00013-01	2 pcs.	2 pcs.	2 pcs.	2 pcs.
0.5 kg	341-00012-01	1 pc.	—	1 pc.	—
0.2 kg	341-00134-01	—	4 pcs.	—	4 pcs.
5. Die holder	341-69878	1 pc.	1 pc.	1 pc.	1 pc.
6. Die hole stopper	341-69883	1 pc.	1 pc.	1 pc.	1 pc.
7. Grounding wire	341-69217	1 pc.	1 pc.	1 pc.	1 pc.
8. Grounding adapter	071-60813	1 pc.	1 pc.	1 pc.	1 pc.
9. Air hose, 9.5 mmID., 3 meters long	016-02210	1 pc.	1 pc.	1 pc.	1 pc.
10. Hose band	340-01007-02	2 pcs.	2 pcs.	2 pcs.	2 pcs.
11. Hose nipple	035-61511	1 pc.	1 pc.	1 pc.	1 pc.
12. Fuse, 3 A	072-01660-20	1 pc.	1 pc.	1 pc.	1 pc.
13. Wire brush	086-71028-21	1 pc.	1 pc.	1 pc.	1 pc.
14. Tool kit		1 set.	1 set.	1 set.	1 set.
15. Instruction manual	347-05413	1 pc.	1 pc.	1 pc.	1 pc.
16. Instruction manual	347-05415	—	—	1 pc.	1 pc.
17. Software	344-89713	—	—	1 pc.	1 pc.

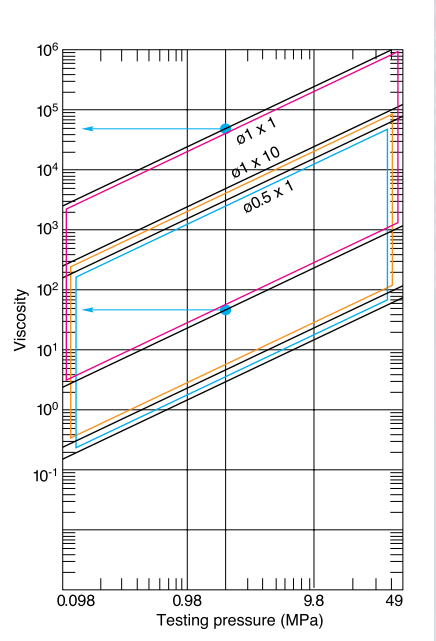
The standard setup does not include a printer, printer cable, personal computer, or communication cable (RS-232C, D-SUB9 pin, female-female type).

Optional Accessories

Die (Nozzle)

Dimensions ID Length (mm)	Type and material	P/N
0.3 x 1.0	Flat, sintered alloy	341-69057-02
0.5 x 0.5		341-69057-03
*0.5 x 1.0		341-69057-04
0.5 x 2.0		341-69057-06
0.5 x 2.5		341-69057-07
*1.0 x 1.0		341-69057-12
*1.0 x 2.0		341-69057-13
0.2 x 1.0	Flat, stainless steel	341-69057-21
0.3 x 1.0		341-69057-22
0.5 x 0.5		341-69057-23
0.5 x 1.0		341-69057-24
0.5 x 1.5		341-69057-25
0.5 x 2.0		341-69057-26
0.5 x 2.5		341-69057-27
0.5 x 5.0		341-69057-28
0.5 x 10.0		341-69057-29
1.0 x 5.0		341-69057-34
*1.0 x 10.0		341-69057-35
2.0 x 2.0		341-69057-15
2.0 x 5.0		341-69057-17
2.0 x 10.0		341-69057-18
3.0 x 3.0		341-69057-43
3.0 x 6.0		341-69057-45
2.095 x 8.0		341-69057-51
Non-Orifice		341-69057-52
0.5 x 10.0	Split type nozzle, sintered alloy	341-68997-07
1.0 x 10.0		341-68997
0.5 x 10.0	Split type nozzle, stainless steel	341-68997-02
1.0 x 10.0		341-68997-01
	Split nozzle resolver	341-69024

*Asterisked items are included in the standard accessory set.



When, for example, a die of 1 mm orifice diameter and 1 mm length is used and the extruding pressure is set at 1.96 MPa , the viscosity measuring range will be about 50 to 50,000 Pa·s. When a die of 5 mm in orifice length is used, multiply the above values by 1/5.

Option

Low Temperature Test Attachment, complete with a transformer

P/N 344-04024-01 (50 Hz line, 100VAC)
P/N 344-04024-02 (60 Hz line, 115VAC)

This attachment is used for tests at a temperature lower than that provided by the standard instruments.

Temperature range: 0 - +90°C
Heater Model CHW-1

RTE-7

Large Sample Heating Attachment

P/N 344-69983

Having a cylinder with a large cross sectional area, this attachment is used for the test of parallel plate samples.

Model: CH-4P
Cylinder cross sectional area: 4 cm^2
Standard setup: A large sample heating attachment and a piston, 4 cm^2 in cross sectional area.

Preforming Die / Hand Press

P/N 341-68212 / P/N 341-69973

Powder samples cannot easily charged in the cylinder. It is recommendable to preform them into tablets so that the test is easily and simply carried out.

Standard contents:
Preforming die: Forms tablets, about 11 mm in diameter and 13 mm in length.
Hand press: About 1,200 N in the maximum pressure

High Temperature Test Attachment, with ceramic piston (1 cm^2)

P/N 344-81960-01

This attachment is used for tests up to 500°C in extruding temperature.

Air Compressor

P/N 042-70131 for 50 Hz line, 100VAC
P/N 042-70131-01 for 60 Hz line, 100VAC

This is necessary when a compressed air line is not available in your lab.

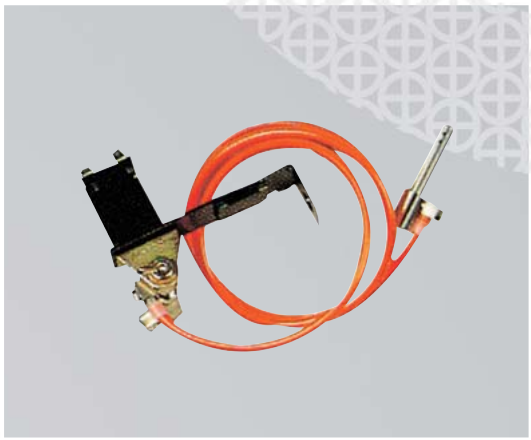
1. Rated pressure 0.5 MPa
2. Delivery 22 NL/min.
3. Tank capacity 21 L

Cylinder Cooling Piston

P/N 341-69997-01

In a constant heating-rate test in the repeat mode, it is necessary to cool the cylinder rapidly so that the next run of test can be initiated without long delay. This piston cools the cylinder rapidly with a stream of cool air.
This attachment is not applicable to the Large Sample Heating Attachment.

Standard setup: A cylinder cooling piston and an air hose.

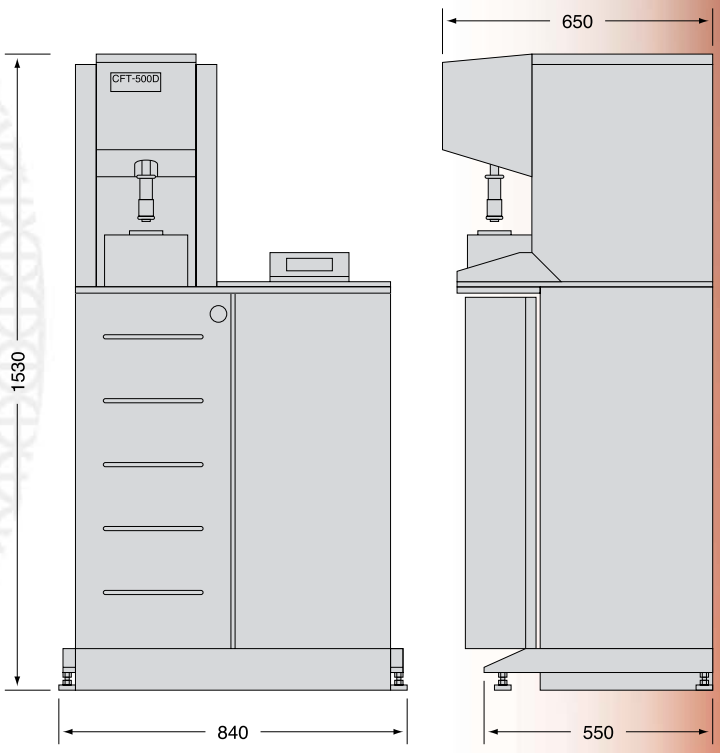


Electronic Balance

Use of a high precision balance is recommended for accurate weighing of samples.

External Dimensions

Shimadzu CFT-100D Capillary Rheometer (Stand-alone system)



Unit: mm

JQA-0376

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