Modular Compact Rheometer

Year of Purchase:

Cost:

The concept:

The new Physica MCR series is based on technical concepts at the cutting edge of technology. The revolutionary modular design features innovations such as the ToolmasterTM – the first automatic measuring and accessory detection system, TruGapTM - a patented measuring gap detection system (US-Patent 6,499,336), an extended torque range, a patented normal force sensor (US-Patent 6,167,752) with improved normal force capabilities, and unprecedented thermal stability of the normal force signal. The Physica MCR series incorporates modern design with a compact, low-compliance frame which houses both the mechanical and electronic control components. It provides a wide selection of measurement geometries, interchangeable environmental systems and special accessories. All the main components, such as the motor, air bearing, electronic control units, and frame have been optimized using state-of-the-art technologies.

Simple and sophisticated:

The housing and frame Ergonomics and functionality were the major design goals behind the compact, modern housing and frame. All the mechanical and electrical control components are incorporated into one single unit.

- Fast and simple exchange of environmental systems and accessories.
- Integrated instrument requiring minimum laboratory space; easy installation.
- Extremely rigid and stable frame for optimized mechanical and thermal stability.
- Machined to perfection for durability and longevity.
- Large working area provides optimal access for sample loading and trimming.
- Easy to clean.

Unrivaled precision:

The air bearing Together with the synchronous motor, the new, very rigid air bearing in the Physica MCR 101/301/501 series sets new standards in drift stability and low torque capabilities. A patented normal force sensor (US-Patent 6,167,752) located inside the air bearing performs a capacitive measurement and detects the natural movement of the bearing due to applied normal forces.

Calling on our many years of experience with air bearing technology, we were once again able to push back the boundaries and develop air bearings which have unmatched accuracy and stability.

- Position-sensitive torque mapping reduces residual torques to insignificant levels for measurements at the lowest torque values.
- Excellent normal force measurement with minimal signal drift and high thermal stability is available for all environmental systems and accessories.
- All bearings are machined and mounted in-house and undergo exhaustive quality control testing. this guarantees the highest quality and reliability of these components.

Maximum ease of use:
The quick-fitting coupling All Physica rheometers have a quick-fitting coupling for maximum ease of use. Geometries can be changed in seconds.

Tireless response: The motor drive
Principle The air bearing-supported synchronous motor is one of the unique key components of the Physica MCR rheometer series. High-energy permanent magnets mounted on a small rotor disc produce a constant magnetic field, providing fast, delay-free response. The rotor moves at the same speed, i.e. synchronous, with the stator field, which is produced by a series of coils.

It is possible to adjust the torque in such a way that it is linear to the total amount of stator current. A change in the stator current therefore causes a simultaneous change in the torque. In contrast to induction motors, the rotor field in a synchronous motor does not change. This means there are no eddy currents causing heating problems, which significantly alter the motor characteristics and lead to signal drifts. Rapid, linear response coupled with advanced control electronics results in unmatched speed and strain control.

Advantages:
- Highest efficiency.
- Absolute torque calibration due to the linear relationship between the electro-magnetic motor torque and the stator current.
- Suitable for all CSS and CSR tests over large stress, strain and frequency ranges.
- 4 The Direct Strain Oscillation (DSO) function enables straincontrolled oscillatory tests at the smallest torques and deflection angles.
- The constant rotor field means no heat production and no unwanted signal drifts.
- No overshoots in CSS and CSR tests.
- Over seven decades of torque.
- Speeds as low as 10-6 min-1 can be set easily. For example: a simple shear flow test for direct measurement of the zero shear viscosity of high molecular weight polymer melt.
- Excellent speed control over more than 9 decades.
- Precision air bearing allows accurate measurements at extremely low torques.
- Fast response for step tests.

Unique and error-free: The ToolmasterTM
The revolutionary ToolmasterTM represents the first completely automatic tool recognition and configuration system.

All Physica measurement geometries and environmental systems are recognized automatically as soon as they are connected to the rheometer.

With QuickConnect, the measuring geometries are easily connected to the instrument using the reliable Physica quick-fitting coupling. A transponder chip integrated in the geometry contains all relevant geometry data, which are automatically transferred to the software. The data from the connected environmental system or accessory is initialized in the software by SmartLink.

Advantages:
- No more errors resulting from a user inserting the wrong geometry or making the wrong selection in the software.
- Intelligent auto-configuration system for user-specific rheometer packages.
- Calculation of exact geometry factors using real geometry data, e.g. truncation, diameter and cone angle.
- Unique identification of individual measuring geometries by the transfer of geometry serial numbers.

- No more errors when documenting a configuration – perfect for traceable documentation (e.g. 21CFR Part11).

True innovation: The TruGapTM function

For the first time it is possible to monitor and control the real gap in cone-and-plate or parallel-plate measurements. The new, patented (US Patent 6,499,336) technology is based on an induction method which determines the exact gap size, therefore eliminating errors from thermal expansion and normal force.

The TruGapTM function is available for Peltier elements, electrically heated, and convection-based environmental systems. It uses special measuring geometries and lower plates for each environmental system.

Advantages

- Allows truly accurate temperature sweeps with cone-and-plate geometries.
- Works over wide temperature ranges and heating rates.
- Determination of the measuring gap at all times, independent of the rheological test.

Environmental Systems, Accessories and Geometries

Temperature control technologies:

Temperature greatly influences the rheological behaviour of almost all substances. For this reason, AntonPaar engineers have invested a lot of time and effort in the development of new temperature control systems. The result is a complete range of environmental systems using a number of temperature control technologies. All the temperature control systems are highly accurate, with minimal thermal gradients. In addition, traceable automatic temperature calibration sensors are available to ensure the system is always operating within specification. The product line covers a temperature range from –150 °C to +1000 °C.

Cone-and-plate/parallel-plate thermal chambers -

- Liquid temperature control (-30 to +180 °C).
- Peltier temperature control (-40 to +200 °C).
- Electrical resistance heating with low temperature option (-130 to +400 °C).
- Convection oven (-150 to +1000 °C).

Concentric cylinder thermal chambers

- Liquid temperature control (-30 to +180 °C).
- Peltier temperature control (-20 to +200 °C).
- Electrical resistance heating (RT to +300 °C).

Geometries

Anton Paar offers a wide selection of different geometries for concentric cylinder, cone-and-plate and parallel-plate systems for the Physica MCR rheometer series. Almost any diameter, cone angle, truncation, surface treatment, coating and material can be supplied to cover all application needs. Special geometries include stirrers, disposable systems, and customer-specific designs for unique samples and applications. Like our rheometers, the Physica RheoPlus user software is a modular system which can be configured to meet individual requirements, from quality assurance to R&D. RheoPlus is multilingual, speaking to users in the language of their choice

RheoManager

The RheoManager helps users who are new to the software or rheology in general. It condenses our application knowhow and suggests suitable measuring methods for a large number of applications. Standardized methods for numerous industrial branches are easy to find. Over 70 methods and 200 templates are provided.

Of course, users can also create and manage their own test profiles. The file structure helps keep files under control even when managing a large amount of data.

Convenient analysis routines are an integral part of the predefined RheoManager templates. All analysis routines run in RheoManager can be adapted to suit individual needs and organized in an analysis script. Reports can be configured automatically, and “pass/fail” tests are easily developed using the automation feature.

Auto-configuration
The ToolmasterTM is an intelligent configuration system, which automatically transfers geometry data and control parameters for the measuring and temperature control systems to the RheoPlus. This eliminates user errors, which can occur when manually entering data for accessories.

Compatibility
Users of Microsoft® Office will recognize many of the features in the RheoPlus software and use them intuitively. Drag & drop is just one of the many features which make working with RheoPlus easy and efficient. Data from earlier Physica software versions can be imported and data and graphs from RheoPlus are easily exported into MS Excel®, MS Word® or as ASCII data.

Reliability
Physica RheoPlus was developed according to ISO 9001 guidelines and runs as C/C++ software for the latest WindowsTM operating systems. The electronic signature, audit trail, archiving and retrieval of data comply with the regulations in 21 CFR Part 11 from the US Food and Drug Administration (FDA).

PC connection
The LIMS-SAP module means results can be automatically saved in an external data base. Measuring profiles can also be activated by other programs via the interface, allowing users to work through the script. RheoPlus is the first rheometer software to provide both a serial interface (RS 232) and an Ethernet interface for communicating with the instrument.

Flexibility
There are no limits for programming and linking test sequences. Test types can be combined in real time in whichever order required. Additional instruments or signals such as power supplies, relays and magnetic valves are supported by RheoPlus in real time and can be synchronized with the rheological measuring profile. This makes RheoPlus the perfect platform for setting up measuring procedures which simulate processes and applications.

Applications
FLOW AND VISCOSITY CURVE…or: how to get information about the flowability of a polymer-
Flow and viscosity curves reveal information about the flowability of polymers under different shear and simulated process conditions. The zero shear viscosity η0 at low shear rates is an important material property and is directly proportional to the average molar mass Mw. To determine a viscosity curve over a broad range of shear rates, a master curve can be calculated using the time-temperature superposition (TTS) in combination with the conversion method according to the Cox-Merz rule.

AMPLITUDE SWEEP...or: how to determine the deformation stability and yield stress of a suspension or emulsion-
Rotational tests, often used in the past, can deliver very different results when calculating the yield stress. Using G’ and G’’ of an amplitude sweep with preset strain (Direct Strain Oscillation, DSO) plotted over the shear stress permits more reliable and practically relevant results for the yield stress value. Significant parameters for evaluating the mechanical stability of a material can be calculated using automated analysis routines in the software.

INTERVAL THIXOTROPY TEST...or: how to measure the structural regeneration of a material after a short period of high shear Almost every coating process consists of 3 phases (1 – at rest, 2 – structural

decomposition, 3 – structural regeneration). the material's behavior is described by G' and G'' over time. Time-dependent effects such as leveling and sagging, dot sharpness, layer thickness and separation stability of emulsions and dispersions can be correlated directly to the curve progression.

TEMPERATURE TEST…or: how important is a closed temperature control system for reproducible results?

The same ice cream sample was measured in a Peltier system with an actively heated hood (closed system) and in a Peltier system without a hood (open system). As can be seen in Fig. 4, the values of G' and G'' are much lower when measured by the open system compared to the measurements from the closed system. Samples in the closed system have a higher average sample temperature. Due to the large temperature gradients, samples measured in the open system have shallower curves. In short: the open system cannot describe the melting process of the ice cream accurately enough.

TRANSIENT TEST TYPES(creep, stress relaxation tests)…or: what can we learn from the first normal stress difference?

Step stress (creep & recovery), step strain (stress relaxation) and step rate (stress growth / start-up flow) experiments are typically performed to measure the transient response of a material to a given constant shear stress, strain or rate. Besides the shear viscosity, the measurement of the first normal stress difference N1 and coefficient ψ1 also gives valuable information about the sample. Physica MCR rheometers include a patented normal force sensor (US-Patent 6,167,752) which allows the evaluation of the first normal stress difference N1 and the coefficient ψ1 over a large range with virtually no thermal drift.

COMBINATION OF SMALL ANGLE LIGHT SCATTERING AND RHEOLOGY…or: how to get information about both the micro and macrostructure

The combination of a Physica MCR rheometer and the small angle light scattering (SALS) system enables the simultaneous determination of microstructural properties (using the optical method) and macroscopic, or bulk, material properties (using rheology). The flow behavior of a polymer blend (1% Polyisobutylene (PIB) in Polydimethylsyloxane (PDMS)) can be explained by looking at the scattering images. At rest and in the zero viscosity range the scattering patterns have a symmetrical shape. This is due to the circular PIB droplets in the PDMS matrix. At higher shear rates, the viscosity decreases and the sample starts to flow. The scattering patterns become elliptical, indicating an orientation and deformation of the PIB domains in the direction of flow.

Specifications

	Unit	Physica MCR 51	Physica MCR 101	Physica MCR 301	Physica MCR 501
Bearing		mechanical	air	air	air
Min. torque	µNm	250	0.5	0.1	0.1
Min. torque DSO	µNm	-	-	0.02	0.02
Max. torque	mNm	125	125	200	230
Torque resolution	µNm	<0.1	0.002	0.001	0.001
Deflection angle (preset)	µrad	1 to ∞	1 to ∞	0.1 to ∞	0.1 to ∞
Internal angular resolution	µrad	0.012	0.012	0.012	0.012
Min. speed (CSS)	1/min	10^{-5}	10^{-6}	10^{-7}	10^{-7}
Min. speed (CSR)	1/min	10^{-3}	10^{-4}	10^{-6}	10^{-6}
Max. speed	1/min	3000	3000	3000	3000
Min. frequency	Hz	10^{-4}	10^{-4}	10^{-5}	10^{-5}
Max. frequency	Hz	100	100	100	100
Normal force range	N	-	0.1 to 30	0.01 to 50	0.01 to 50
Normal force resolution	N	-	0.02	0.002	0.002
Direct Strain Oscillation		no	no	optional	yes
Toolmaster™		yes	yes	yes	yes
TruGap™		no	no	optional	yes
Temperature range Depending on the environmental system used	°C	-150 to +1000	-150 to +1000	-150 to +1000	-150 to +1000
Accessories and environmental systems		all	all	all	all
Dimensions (W x D x H)	mm	440 x 600 x 620	440 x 600 x 620	440 x 600 x 620	440 x 600 x 720
Weight	kg	43	43	43	50