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Technical Information

to the

Constant Torque Gieseler Plastometer

PF-22

for determining plastic properties of coal
according to the **ASTM D 2639** Standard

August 2017

Introduction

The PF-22 Constant-Torque Gieseler plastometer has been designed for measuring plastic properties of coal according to the ASTM D2639 Standard. The current version of the Standard is called ASTM D 2639-08. Plastic properties of tested coal are determined by applying constant torque on a stirrer which is surrounded by tested coal or coal mixture in a heated retort. Testing with Gieseler plastometer gives a semi-quantitative measurement of the plastic properties (of apparent melting) of coal when heated under prescribed conditions in the absence of air. The measuring method used attempts to simulate real conditions in a coking oven during the coking process.

The PF-22 Plastometer is a fully automated, compact, single-furnace equipment. It is controlled by an industrial PC. The course of testing is given by the ASTM D2639 Standard. A constant torque is applied on a stirrer placed in a crucible into which the coal was charged. The crucible with tested coal sample is a part of retort that is immerged into a molten $NaNO_3/KNO_3$ salt bath – or solder bath, consisting of approx. 50 % tin (Sn) & 50 % lead (Pb). The solder bath is not recommended in EU countries with regard to hygiene standards.

During the test, the plasticity curves can be viewed on system's color display. In addition, all important values being measured can be displayed and plotted in different screens (current temperature of the bath, temperature gradient, current plasticity value, etc.).

The PF-22 plastometer is equipped with a remote control and service system that is accessible via Internet and comprises special diagnostic and service programs.

Principles of the test procedure according to ASTM D2639 Standard

The apparatus for doing tests according to the ASTM D2639 Standard is depicted below in **Fig. 1**. Individual parts of the assembly are specified in the Standard itself.

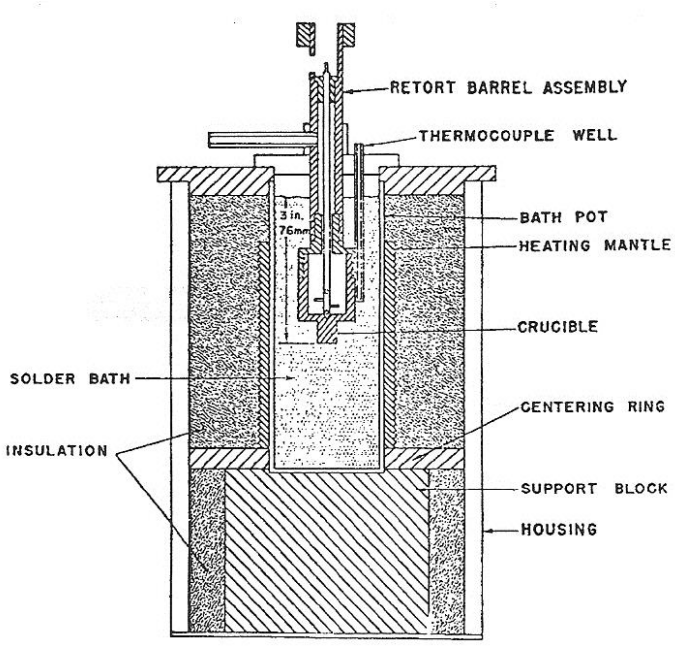

Fig. 1 Furnace Assembly according to the ASTM D 2639 Standard

The values normally determined with the Gieseler type plastometer are:

a) ***Initial softening temperature***: temperature at which the dial movement reaches 1.0 dial division per minute (100 dial divisions = one complete revolution of the stirrer); may be characterized by other rates, but if so, the rate must be reported.

b) ***Maximum fluidity temperature***: temperature at which the stirrer rotation rate reaches a maximum value.

c) ***Solidification temperature***: temperature at which the first zero DDPM is reached after the last stirrer rotation.

d) ***Maximum fluidity***: maximum measured stirrer rotation rate, in dial divisions per minute (DDPM).

e) ***Plastic range***: difference between the solidification (**c**) and initial softening (**a**) temperatures.

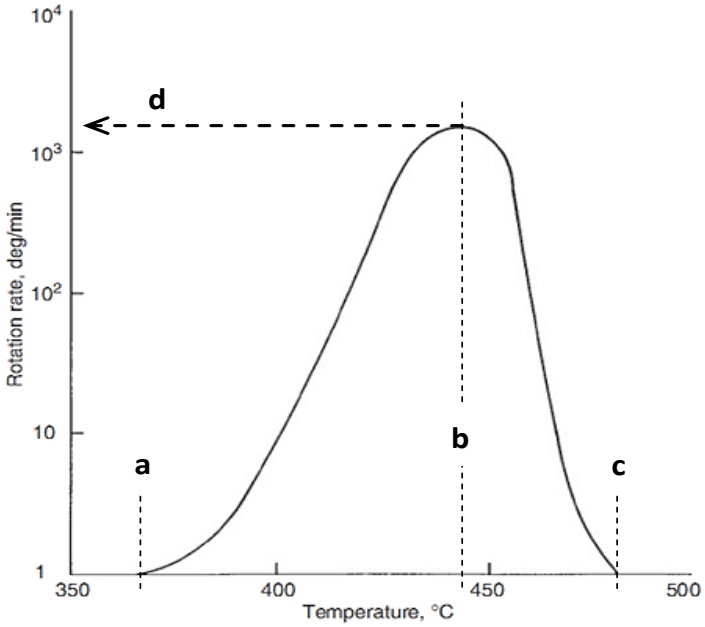

Fig. 2. Typical view of coal plasticity in dependence on temperature

Brief description of the measuring process with PF-22 Plastometer

Once switched on, the plastometer works in a fully automatic mode. It automatically checks whether the system is ready, preheats the furnace, inserts the retort with crucible into the bath, brings temperature to the starting value, raises the temperature at constant rate of 3 °C/min, and then performs the measurement of plasticity itself.

If the temperature has reached 330 °C (i.e. the starting value), a torque of 101.6 g*cm is applied on the measuring stirrer. Then, keeping the temperature gradient on +3 °C /min, stirrer's rotational speed is continuously monitored as indicator of current plasticity of the coal sample, together with the sample temperature course. Termination of the measurement can be made in more ways:

- By reaching the limit for the testing temperature
- By reaching the status of zero plasticity (rotation of measuring stirrer's has stopped)
- In case of exceeding the maximum allowable surface level before inserting test crucible into the furnace
- In case of an error detected (temperature measurement error, for instance)
- By the operator at any time.

After measurement has been terminated, the test crucible is taken out of the furnace automatically.

For quick cooling down after each measurement, the equipment has a built-in fan allowing another measurement to be started shortly afterwards.

The implemented software, in addition to the control of the process testing, also enables doing calibration of the equipment as well as automatic evaluation of test results and printing the test protocol.

Automatic test control is provided by a powerful PC system with a color graphics TFT display, wireless mouse, wireless keyboard, and other electronic parts. A color graphics printer is attached to the system, too, and the computer can be connected to an ETHERNET 10 /100 M network.

The PC computer with Windows 8 operational system is equipped with powerful control software for preparation and execution of tests, which in the form of queries of the respective "MENU" instructs the operator to select the test mode and the correct sequence of activities in the preparation of the test. This ensures perfect adjustment and inspection of the equipment before the test, completing the accompanying form for the test, automatic testing with set parameters and the furnace cooling after the test, archiving the form and all measured data and printing the resulting protocol.

View of operator's screen with Technological Scheme of the PF-22 Plastometer is depicted in Fig. 3. An example of the course of measured parameters during is given in Fig. 4.

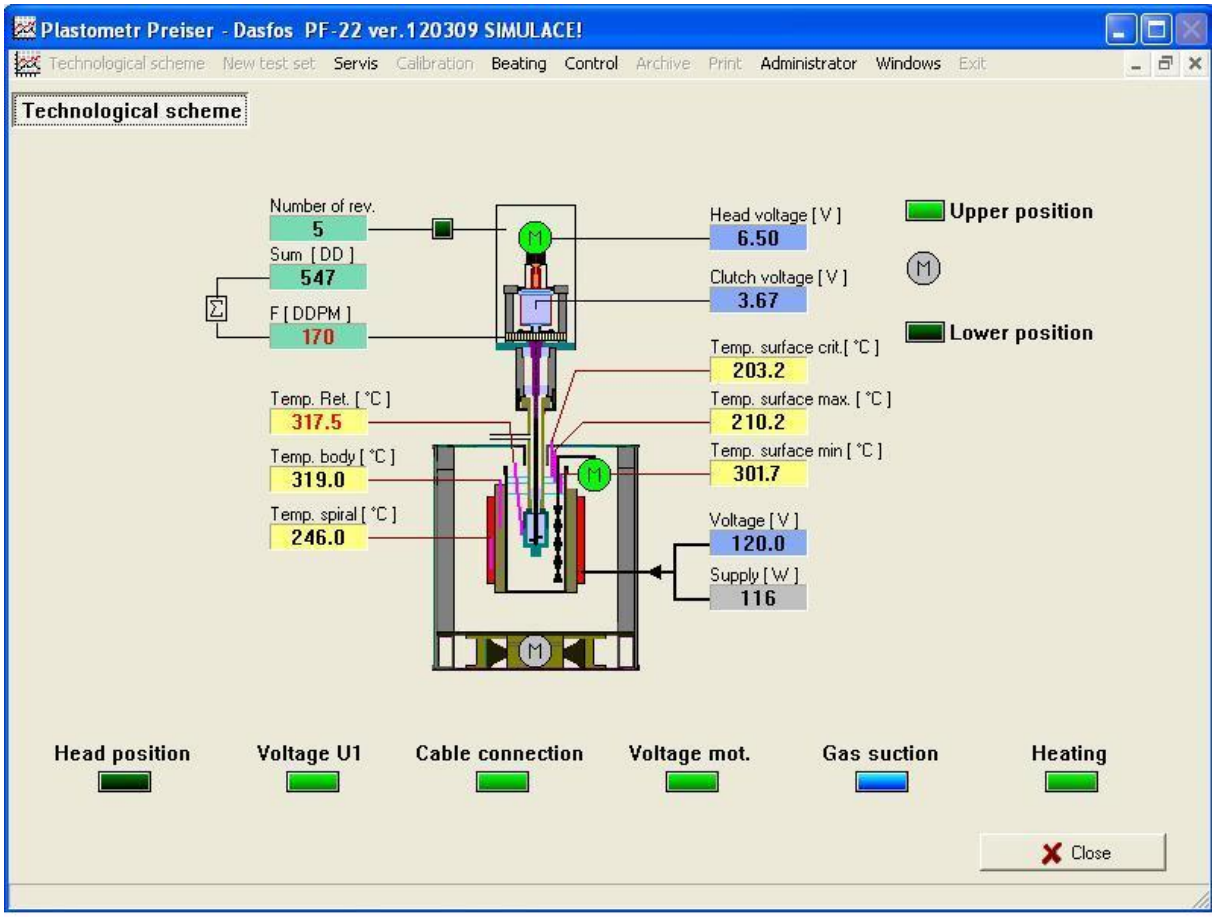

Fig. 1 Technological scheme of PF-22 Plastometer

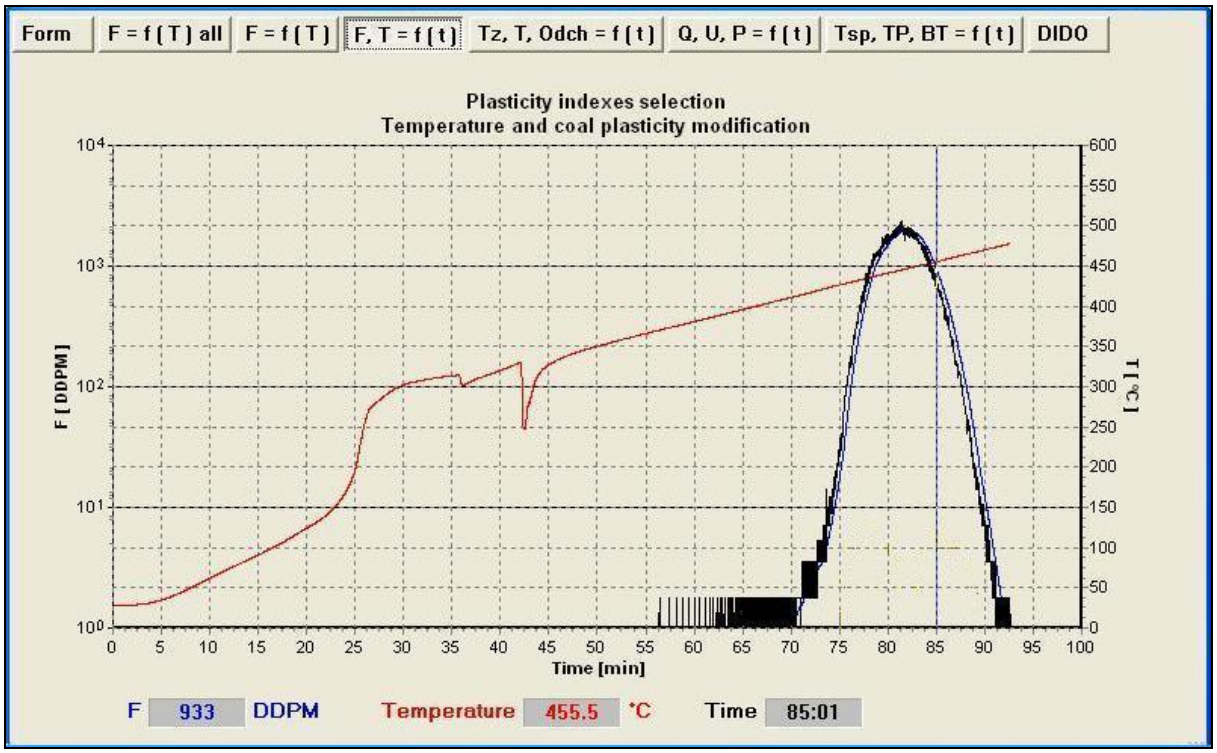

Fig. 2 The temperature and coal plasticity as functions of time

Main advantages of the PF-22 system

- automatic sample tamping - according to ASTM D 2639-04 Standard
- torque calibration - according to ASTM D 2639-04 Standard
- automatic Torque Calibration and Inspection before each measurement (EU patent pending)
- built-in exhaust device
- detection of temperature measurement failure
- detection of measuring stirrer's rotation
- detection of measuring head's rotation
- checking of bath level before inserting the retort
- cooling down the furnace with a fan
- automatic evaluation of final results from 2 or 3 subsequent measurements, as required by ASTM D 2639-04 Standard
- unique measuring head with electronic torque control, which is kept constant regardless the actual rotational speed of measuring stirrer
- fully automated operation – permanent operators 'attendance is not required
- automatic creation of *. csv files for statistical analysis.

Technical parameters of the PF-22 plastometer

according to ASTM D2639 – 08 Standard

Furnace bath medium	$NaNO_3$/ KNO_3 salt mixture, optionally a mixture of approx. 50 % tin (Sn) & 50 % lead (Pb)
Torque on the measuring stirrer	101.6 ± 5.1 g*cm (40.0 ± 2.2 g*inch)
Plasticity measurement – resolution	0.1 D.D.P.M [1]
Plasticity measurement – guaranteed accuracy	0.5 D.D.P.M
Measured plasticity range	30 000 D.D.P.M
Cumulative plasticity range	999 999 D.D [2]
Time interval of evaluating the plasticity	1, 5, 10 or 60 s
Heating temperature range	200 to 600 °C
Temperature gradient range	1.0 to 9.9 °C /min
Temperature setting – resolution	±0.1 °C
Temperature control - accuracy	± 1 °C
Setting of final temperature of testing	up to 600 °C
Thermocouples	K-type (OMEGA)
Loading /unloading of the test retort into furnace	fully automated
Supply voltage	230 V ± 15 %, 50 Hz
Power consumption – test furnace	800 VA
Power consumption – control computer	250 VA
Dimensions – test furnace	
Dimensions – control computer	
Weight – test furnace	ca. 40 kg
Weight – control computer	ca. 20 kg
Automatic system diagnostics	during the whole test
Delivered software includes programs for: *Note: The programs run under Windows 8 operation system*	control of the measurement course, visualization of results, archiving incl. back-up, printing of test protocols, system supervising and checking
Archiving of results	automatic, in form of files
Computer connecting interface	ETHERNET 10 /100 M

[1] **D**ial **D**ivisions **P**er **M**inute. One D.D.P.M = 1/1440 rev. of the PF-22 measuring stirrer per minute.

[2] **D**ial **D**ivisions. Means the total number of Dial Divisions read per one measurement.