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THE APPARATUS FOR CONTINUOUS NETWORK SAMPLING OF SOME GAS COMPONENTS OF WASTE GASES

APARATURA PRO KONTINUÁLNÍ SÍŤOVÝ ODBĚR VYBRANÝCH PLYNNÝCH SLOŽEK SPALIN

Abstract

A determination of average concentration of gas components of waste gases at exits from the combustion facility can be currently provided in several ways. However, single sampling is essential. The paper presents reasons why to use the apparatus for continuous network sampling and analysis of some gas components of waste gases, and presents its technical design.

Abstrakt

Stanovení průměrné koncentrace plynných složek spalin na výstupu ze spalovacích zařízení je možno v současnosti řešit několika způsoby. Podstatou jsou však jednorázové odběry.V článku jsou uvedeny důvody pro využívání aparatury pro kontinuální síťový odběr a analýzu vybraných plynných složek spalin a je představeno její technické řešení.

1 BACKGROUND

At the present, when the quantity of power sources and number of technologies needed to keep the current society living standard have been continuously increased, we have to be interested more intensively also in as much efficient heat and electric power generation, as possible. In our Republic, a way of electric power generation by its transformation from the heating power released in fossil fuels combustion, which, however, presents the main source of power in most advanced countries, resulting into harmful substances production and their discharge in the air, has been still prevailing.

This fact is inherently related also to large-scale measurement in order to monitor produced harmful substances, called emission measurements. This specific measurement field has its characteristic features.

An essential feature of emission measurements under conditions of industrial power facilities is almost always of no stationary character of the technological process. Only a small number of boilers, particularly in the heating connection, are operated in the stationary regime. The steam efficiency commonly varies in a quite wide interval, which means also variability in waste gases quantity. Changes in qualitative fuel features are quite frequent, too, particularly when several coal types are used. A consequence of such feature changes are also changes in waste gases composition and quantity. The measurement of waste gases and measurement of average waste gases in big size channels is, however, much complicated, and up to now no fully reliable determination method exists. Therefore, the subject regarding determination of waste gases quantity and concentration of gas components of waste gases is a separated chapter in diagnostic measurements when evaluating the efficiency.

With regard to the above mentioned facts, I deal herein with the subject of on-line real-time combustion information acquiring in a way of network measurement. Up to now, this field has been addressed only applying a discontinuous way, i.e. successive waste gases sampling from defined measurement points and their subsequent analysis.

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2 DETERMINATION OF AVERAGE CONCENTRATION OF GAS COMPONENTS OF WASTE GASES

At the present, several variants are available to determine average concentration of some gas components of waste gases. Their choice and use always depends on operation conditions of the facility and required accuracy depending on the measurement purpose. In principle, however, it is always point waste gases sampling in the waste gas ducting section, in combination with a consequent waste gases sample analysis applying a suitable analyzer.

2.1 Apparatus To Determine Average Concentration – Current Situation

The network measurement of average concentration has been still provided applying just a discontinuous way, in successive waste gases sampling from specified measurement points and their following analysis and resulting variables average calculation.

In this particular case, a probe is situated in the measurement point and, using an airtight fan and sampling pipe, necessary waste gases quantity is exhausted in a gas-collecting tube. The analysis of waste gases samples taken from particular gas-collecting tubes is carried out after sampling completion. The Figure 1 presents a simple chart of the current way of determination of average concentration of some harmful substances in waste gases in the course of diagnostic measurement.

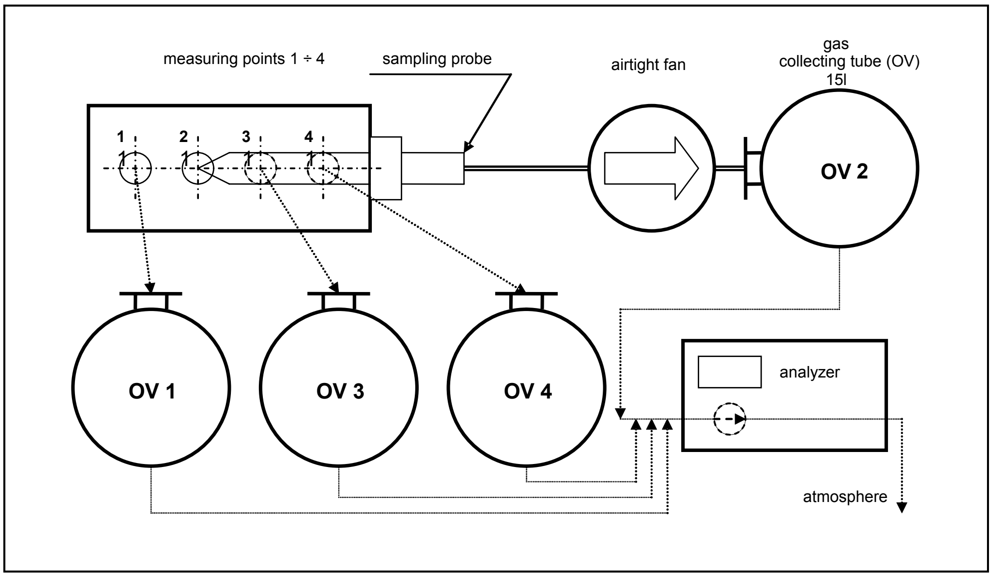

Fig.1 A chart of apparatus for single determination of gas harmful substances concentration

2.2 Apparatus To Determine Average Concentration – Continuous Network Sampling

The continuous waste gases sampling from several points (network sampling) along the waste gas ducting cross-section and its real-time analysis presents a more precise solution to determine average concentration of some gas components.

When designing the apparatus for continuous waste gases sampling from several measurement points, the following circumstances had to be taken into account:

- The whole apparatus should be designed as portable, mobile;
- The sampling probe should be universally adjustable for a various number of points in one measuring line;
- The probe dimensions are limited in terms of design by measuring hole sizes and screwing type use (M36x3);

- Due to constructional reasons in production of probes and material cost for heated sampling pipes, it is currently suggested to use the apparatus to the waste gases temperature of 200oC;
- A choice of particular measurement apparatus components should allow their easy maintenance, connections should be perfectly airtight;
- A choice of the movable pump is based on a hydraulic calculation and arrangement of resistance characteristics of the whole sampling route;
- The sampling modulus is limited by the weight and dimensions allowing its transport.

The Figure 2 presents a simple chart of a designed sampling apparatus meeting the specified conditions, including a description of particular measuring points.

The Figure 3 presents a probe type enabling to set and situate the sampling pipe in various measuring points on one measurement line. Potential exhaustion was taken into account at each probe from four measurement points in chosen intervals (according to ČSN ISO 9096), under setting using a movable holder (bridge) and various length of the Teflon sampling pipe.

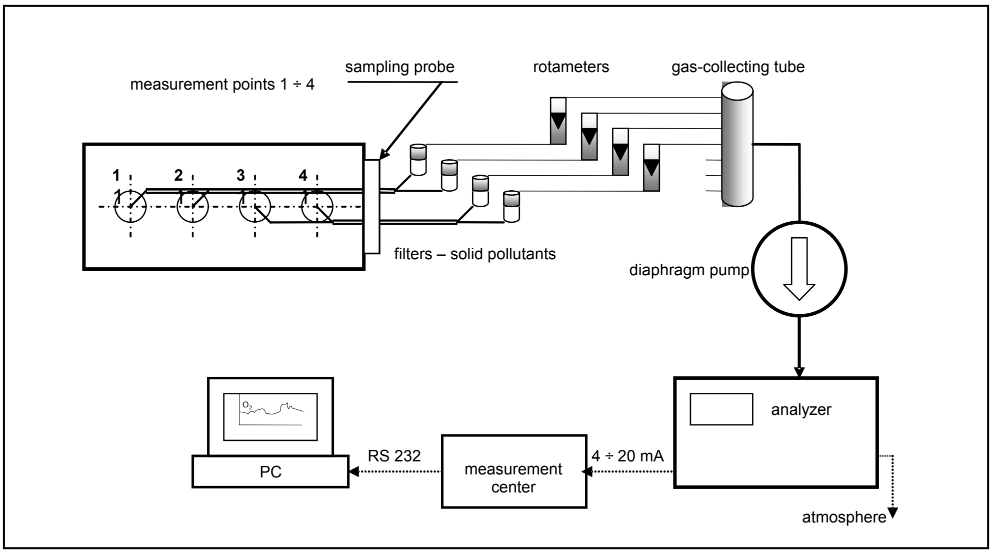

Fig. 2 A chart of a sampling apparatus design for continuous network sampling

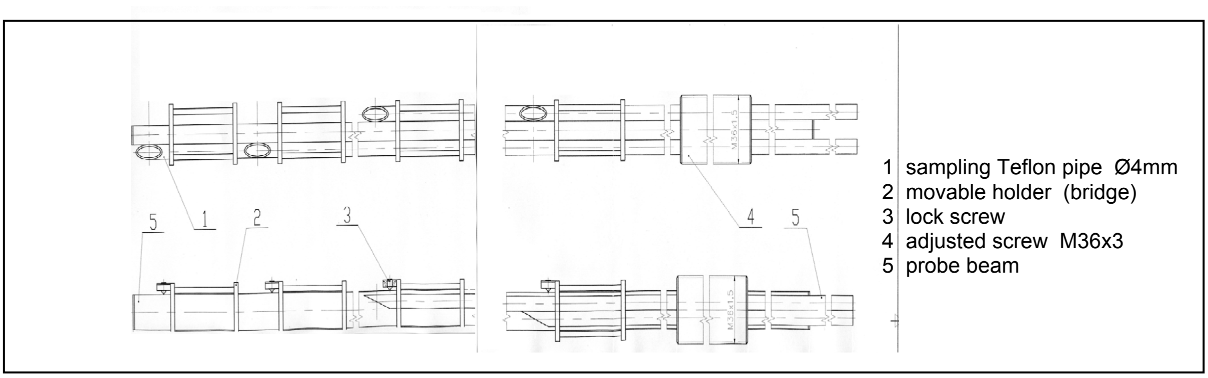

Fig. 3 Sampling probe chart

3 THE ARRANGEMENT OF THE APPARATUS FOR CONTINUOUS NETWORK SAMPLING AND ANALYSIS OF GAS COMPONENTS

For purposes of single operation measurements, which the sampling apparatus is intended for, a set of measurement devices was designed based on practical experience and availability of particular materials, which allows to take waste gases samples in the same speed simultaneously from 16 measurement points distributed along the cross-section of the waste gas ducting according to ČSN ISO 9096, deliver it to the analyzer, and continuously record a value of average gas component concentration in waste gases. The apparatus consists of :

- 4 x probe (I ÷ IV) = 16 x sampling pipe ø 4mm (1 ÷ 16);
- 16 x solid pollutants filter with condensate exhaust FWA ¼ C (serving as a cooler);
- 16 x not heated sample ducting (silicon connecting pipe ø 5mm);
- 16 x float flow meter (rotameter 1 ÷ 16);
- Bus bar;
- Diaphragm pump;
- 2 x control rotameter;
  - Float flow meter of the total gas sample flow in the analyzer;
  - Float flow meter of released gas quantity in the surrounding (bypass) ;
- Continuous gas analyzer.

The Figure 4 presents a simple chart of the whole sampling apparatus for which necessary calculations were carried out to determine resistance characteristics of the apparatus, choice of a respective pump type and constructional design of particular measurement points.

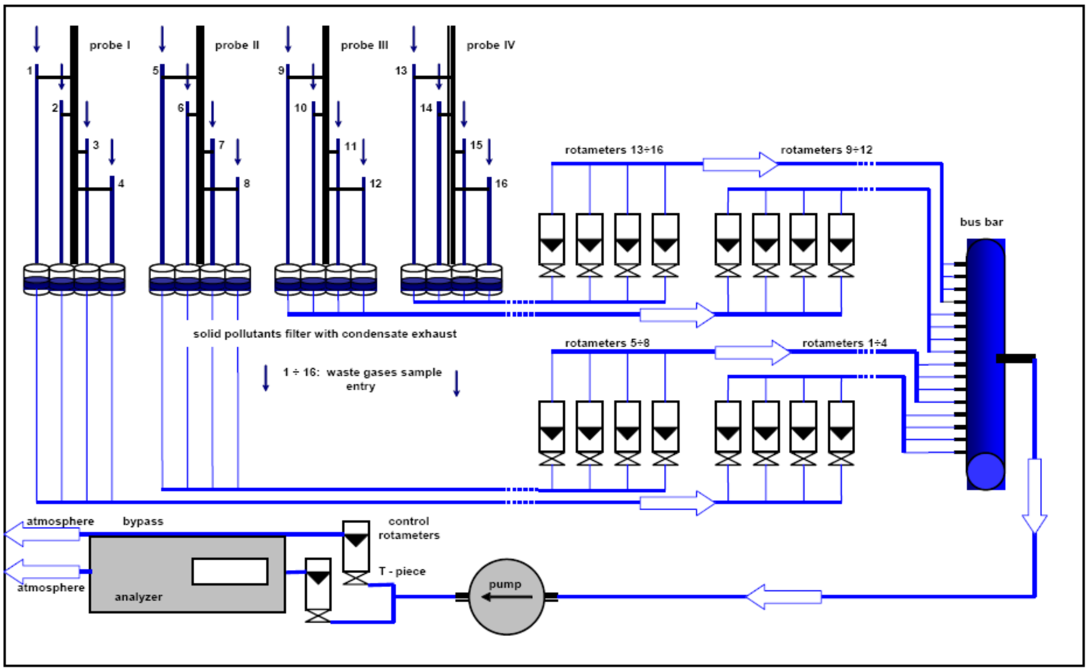

Fig. 4 A chart of the apparatus for waste gases continuous network sampling and analysis

3.1 Production and Operation Test of the Apparatus

Based on the proposed design, particular apparatus components were produced in the cooperating engineering firm, or they were bought from supplier firms. Following the apparatus completion, a verification test was carried out under operation conditions. The installation of the produced apparatus under operation conditions is presented on Figure 5.

Fig. 5 The operation installation of the apparatus

The apparatus benefit is evaluated based on measurement findings compared to operation measurement of concentrations of some gas components of waste gases. Based on this comparison, it can be stated that the average concentrations measured by the means of the designed apparatus fully correspond to the operation status of the facility, and they are in compliance with concentration values measured by operation apparatuses.

In addition, a possibility to determine concentrations in particular measurement section points was verified at time of operation tests numbers 2 and 3, which did not affect a resulting value of the average concentration at all. This is evident from Figure 6, where always average particular gas component concentrations are calculated in particular time sections corresponding to averages for the whole test duration.

Reviewing graphic dependencies of gas component concentrations of waste gases on time in more details, it is also possible to determine concentrations of these components in particular points of the measurement cross-section.

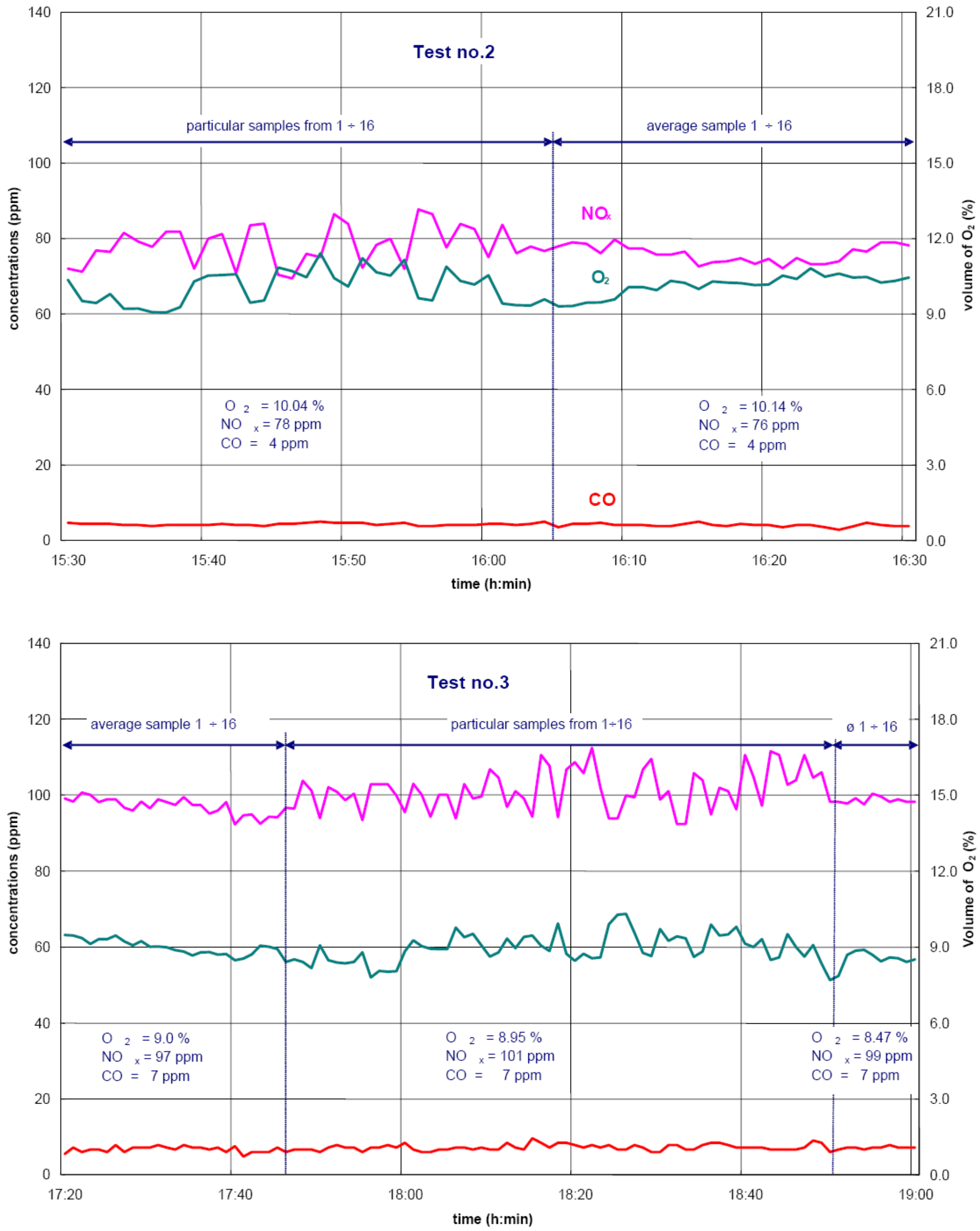

Fig. 6 Measured concentrations of CO, NO_x and O_2 in the course of operation tests

In the course of measurement, the produced condensate from waste gases collected in water separators with a filter was periodically discharged by a discharge valve, always after closing of a sampling route by the appropriate rotameter. The Figure 7 displays attachment of these water separators with a discharge valve at the end of each probe.

Also the workmanship of probes from stainless steel and Teflon duct attached with movable holders (bridges) proved by measurement to be optimal. Particular sampling pipes were not clogged, and location of the sampling route in a required point was made applying easy handling at the measurement place. The fly ash deposited on probe beams after measurement was easily removed after measurement completion due to properties of chosen materials, and, therefore, probes are ready to be reused. The probe clogging with fly ash after measurement completion is presented on Figure 8.

Fig. 7 Attachment of separators at the probe end

Fig. 8 Probes after measurement completion

4 CONCLUSION

The paper deals with development, production and operation testing of a portable apparatus for continuous network sampling and analysis of some gas components of waste gases which will be mostly used in diagnostic measurement of combustion sources, in big size waste gas ducting.

Operation tests with the apparatus proved the appropriateness of preconditions correctness of the selected measurement equipment and results of calculations aimed to dimensioning of sampling routes and exhaustion pump parameters.

The tests proved that the easy serviced apparatus is able to provide on-line results of average gas component concentration in waste gases in the waste gas ducting, and store and process them applying a service software in arbitrarily chosen intervals.

Further, a concentration determination possibility was verified in particular measurement points following easy control rotameters handling. This information is interesting in a point of view of diagnostics of potential leakages in the air combustion tract, and the results acquired by the means of the designed apparatus serve to identification of leakage points.

The condensate discharge from separators installed at the end of particular probes was made manually in the course of measurement not impacting resulting average concentration values, always when individual sampling routes were short-term closed.

The chosen probe and sampling pipe materials proved to be suitable, requiring minimum maintenance both in the course of particular measurement preparation and after its completion.

Another field of application is measurement of boiler efficiency, where it will be possible to compare efficiency calculation results considering the O_2 and CO concentration determined by the operation analyzer (in one cross-section point), and determined by the means of continuous network analysis apparatus .

In the course of compiling, financial means from the NPV II – Interviron – 2B06068 Project were used. Due to these means, a completely new measurement apparatus was produced which makes the up to now known and applied methods for determination of average gas harmful sub-

stances concentrations more precise, quicker and optimized. Another benefit is also on-line real time results acquiring. Following a long-term operation testing of the apparatus, its continuous use in power generation operation plants can be considered to gain backgrounds for combustion optimization.

At the present, the apparatus technical design – utility model - is registered in form of the application. On 12 October 2009, the evaluation commission of VŠB TU Ostrava decided to exercise a right for the subject of industrial ownership and file an application to the Patent Office.

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