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THE APPLICATION OF MOBILE DEVICES IN THE SYSTEM FOR CARBON MEASUREMENT IN VOLATILE ASHES FROM POWER INDUSTRY BOILERS

Key words

Measurement system, multi-user, smart phone, tablet, wireless communication.

Abstract

Commonly used mobile devices, like smart phones and tablets, are currently becoming an integral part of measurement systems. This paper describes the design principles for a measurement system using such devices and gives an example of a system for measuring the carbon content in the ashes from power industry boilers. The functions of the system are described with a division into the ones implemented on a mobile device and other user interfaces nodes. The methods of programming mobile devices are presented including their advantages and disadvantages. The presented multi-user solution can be used in other measurement systems, as well.

Introduction

Mobile devices – smart phones and tablets have made their presence felt in a variety of IT solutions. The forecasts predict that their share in IT market will expand surpassing stationary computers or laptops [1, 2]. It is due to a number

of features they possess such as: mobility, user-friendly interface, quick start and small size.

The requirement of the system for carbon measurement in volatile ashes from power industry boilers is that the results of the measurements have to be accessible in different points. The advantages and the widespread use of mobile devices were the reason why it has been decided to be used in order to meet the requirement. Monitoring of the results in remote access points was conducted with the use of these devices.

Although the number of smart phone applications is increasing, there is little information concerning their use in measurement systems. The research on mobile devices is mainly focused on applications concerning global solutions [3]. Theoretical studies on the architecture of distributed measurement systems were initiated when there were no such devices [4]. Therefore, the installation of a mobile device must be in line with the fundamental design principles of measurement systems [5]. The following part of this article describes the use of smart phones in the measuring system taking into account issues such as: integration of mobile devices in the structure of the system and the choice of their programming method.

1. The structure of the measuring system

The measurement of carbon content in the ash is performed photometrically – the measurement of diffuse reflectance using Ulbricht sphere [6]. The measuring head (sphere) comprising transmitting diode and a photodetector has a calibrated current output, which is the signal source for the other elements of the system. The head is devoted for use in power plants and coal-fired power plants. It is placed in the following structure: fuel-air-exhaust behind an electrostatic precipitator (ESP) (Fig. 1). Its design allows for collecting the ash from the electrostatic precipitator outlet channel. After the measurement the ash is put again into the outlet channel.

Due to the need for reading the measured value, the access was provided:

- locally, by the sensor,
- remotely, at the workstation of a process engineer,
- remotely, in in-company laboratory where the carbon content in the ash is determined by analytical methods.

On the one hand, the distribution of points, which gives access to measurement results, makes it necessary to expand the measurement system, on the other hand, it allows the user to control the process better.

The analysis of the environment in which the sensor operates allowed us to refine the requirements by the method of functions' decomposition [7]. Five basic functions were identified (Fig. 2): monitoring, calibration, measuring, malfunction service, data recording and data handling. Sub-functions, which

reflect the operations performed in the system, were specified in a further decomposition of the basic functions.

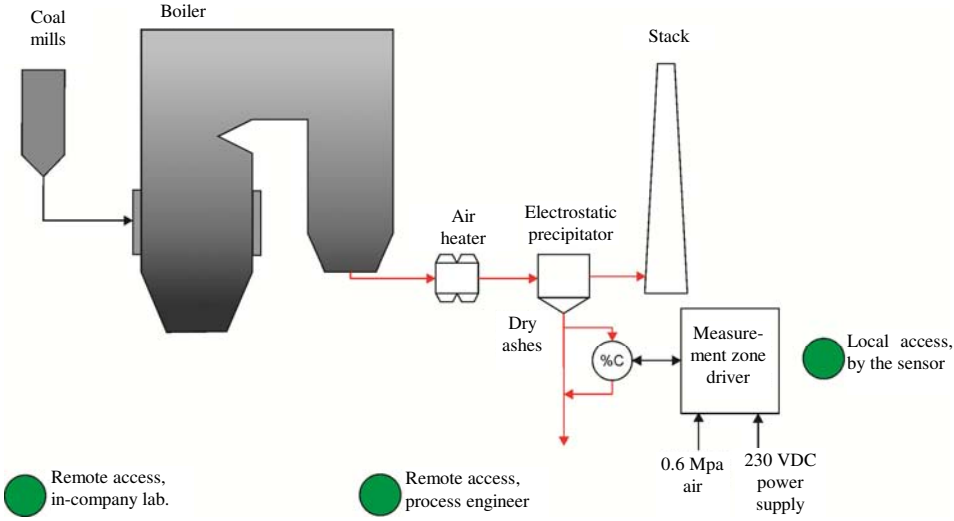

Fig. 1. The diagram of installation of a sensor for coal measurement in the ashes in a typical power unit

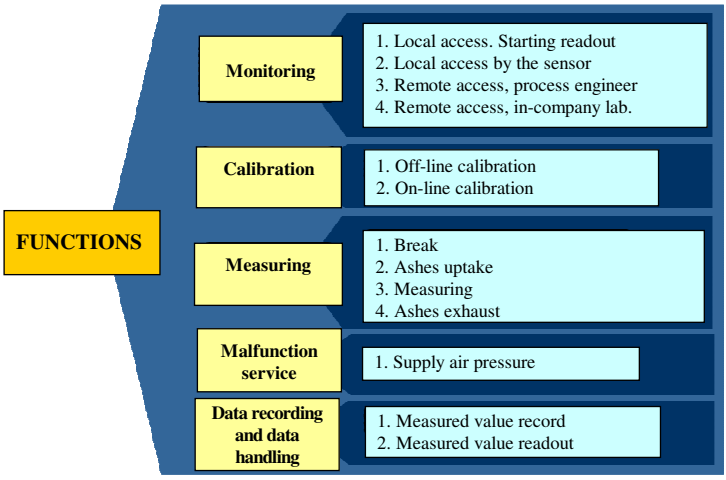

Fig. 2. Decomposition of the functions of the measuring system of carbon content in the ash

The allocation of the following functions in the hardware implementation of the system (Fig. 3) includes PLC software, operator's panel software (HMI), PC and smart phone mobile device software.

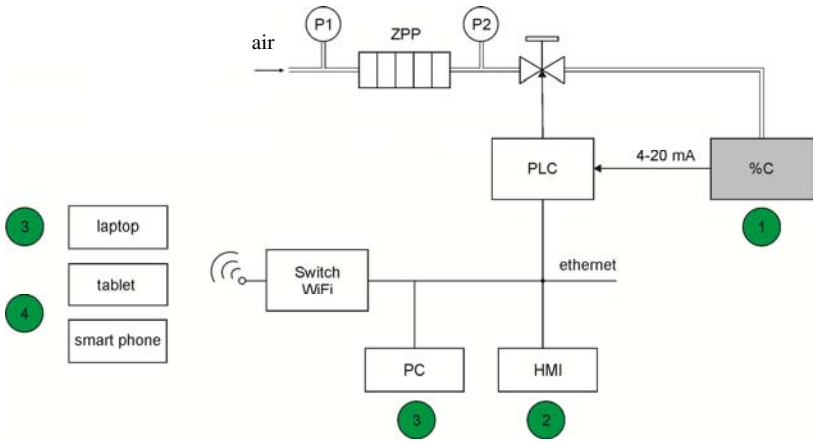

Fig. 3. The hardware structure of the measuring system

The data communication within the measuring system is possible due to the wired and radio Ethernet network. Wired connections are implemented by PLC server (Wago 750-881) with two Ethernet jacks. This allows the connection to be established with a PC HMI panel (sub-function 2 – local access by the sensor) and an external computer (sub-function 3 – away access, technologist). The wireless connection was implemented with the use of the Ethernet switch (type: AWK – 3121, Moxa) with a Wi-Fi standard communication standard. It is used for the implementation of the sub-function 4 – access away, the company's laboratory.

The choice of Ethernet protocols was driven by economic reasons and the fact that the measuring system is not limited by time constraints of data communication [8]. The measuring process is relatively long – putting the ash into the sphere and removing it with compressed air – can take up to several seconds. The delay caused by the network does not affect the overall the performance of the system.

The proposed communication enables to collate complex structures from the one which is used in this system – line topology (bus) through hierarchical topologies to network topology (mesh). The measuring system can be connected to the Internet and a local intranet network. The system can be easily supplemented with additional functional nodes, such as a webcam.

The software for the sub-function 4 was developed with the use of a mobile smart phone and tablet.

2. Mobile devices programming

Managing measuring system with the use of portable devices can be performed in three ways: through a web server, through software in native languages devoted for a particular model of a device and through screen sharing software.

Fig. 4. Windows of the web server in a web browser: a) *Monitoring* function, b) M*easurement service* function, c) *Calibration* function, d) *Malfunction service* function

The use of a web server (Figure 4) enables access to the system resources on any mobile device having a web browser. The website software (HTML and JavaScript) comes from the server (PLC) thanks to which the user is not engaged in any programming. The disadvantage of this method is that the target

device's functions cannot be used. The application in the browser does not have access to resources and functions of the device. You cannot use for example, a camera, a calendar, contacts, etc. An important advantage of this method is its applicability to many platforms. The measuring system can be available for devices with Android, iOS (Apple), Windows 8, and others in the smart phone market. Another technical disadvantage of this method is incompatibility of simple browsers installed in smart phones with the web server that uses complex graphical objects. There is usually a need to install more powerful browsers on a smart phone device.

The use of the native language makes the application on the smart phone work as a stand-alone program. It is possible to use the device's operating system and to have access to the resources of the device [9]. The software is developed in languages and environments dependent on an operating system. For the purpose of measurement of carbon content in volatile ashes from power industry boiler the following tablet type was used: Galaxy Tab 2 10.1 with Android 3.2 operating system and software written in Java with the use of Eclipse with ADT and SDK Plug-ins (Fig. 5). The data connectivity layer uses Modbus TCP protocol with direct addressing PLC registers of the measurement system.

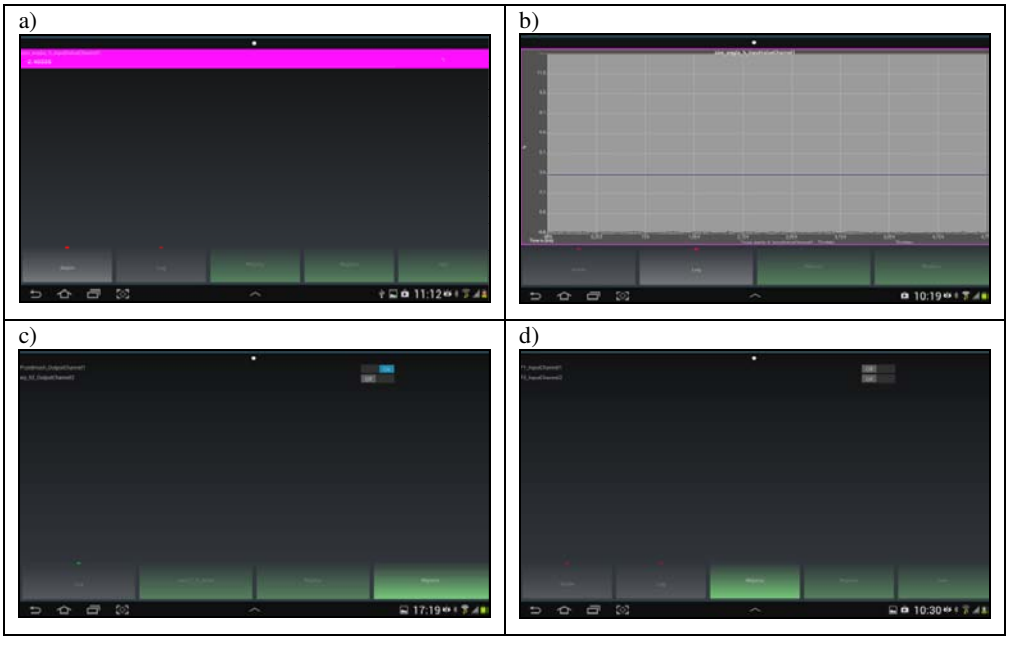

Fig. 5. The mobile tablet screens: a) a numerical readout of a measured value with an error message about exceeding a preset value; b) a variation plot of the measured unit; c) the output of the measuring system; d) the input of the measuring system

The disadvantage of this method is that the software can operate only on a single platform. Difficulties may occur in transferring the application even within a single platform. Currently, there are eight major versions of Android [10], and each requires testing of the software and implementing appropriate changes. Developing the software for other operating systems requires the use of other tools. For example, the environment Xcode and Objective C language are designed for devices with iOS and Visual Studio environment and C# language for Windows 8.

The characteristic feature of method using screen sharing software (Fig. 6) is its simplicity of use. The user must only run the appropriate application on the main computer (technological node computer) and on the used smart phone. Examples of such applications are the following: TeamViewer, VNC, RDP, LogMeln, Jump Desktop, Screens, Splashtop, and others.

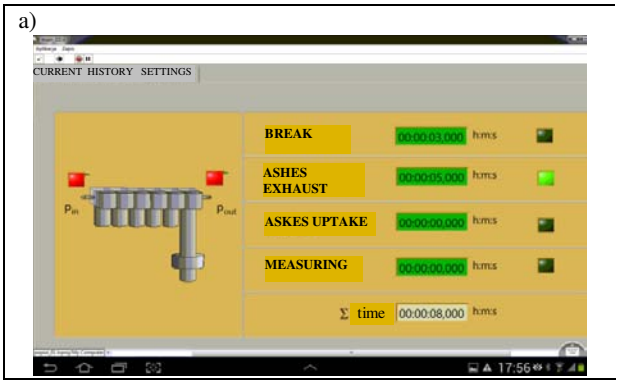

Fig. 6. The screens of computer software run on the technological node computer available in the tablet with TeamViewer software

The disadvantage of this method is the Internet access requirement, the lack of control over the data send via the Internet and worse usability of screen sharing option resulting from different ways of handling applications in Windows (a mouse and a keyboard) and a smart phone (touch screen). At the same time, a smart phone with multi-touch technology makes it possible to comfortably change the size of the screen, which is impossible in a classic PC.

It is also possible to develop screen sharing software using the mechanisms of the TCP/IP engine working as a server within software from the technological node computer and built-in Java classes working as a client in the mobile device [8].

The combination of the developed software and methods for handling spatially distributed measuring system (Fig. 7) shows that the integration of mobile devices has been achieved through the separation of the functions of the system. For each of the access implementations a subset of the functions of the measuring system was specified. These functions perform the tasks provided for each access node. In particular, mobile devices are deprived of the possibility of system calibration and interference in the measurement process.

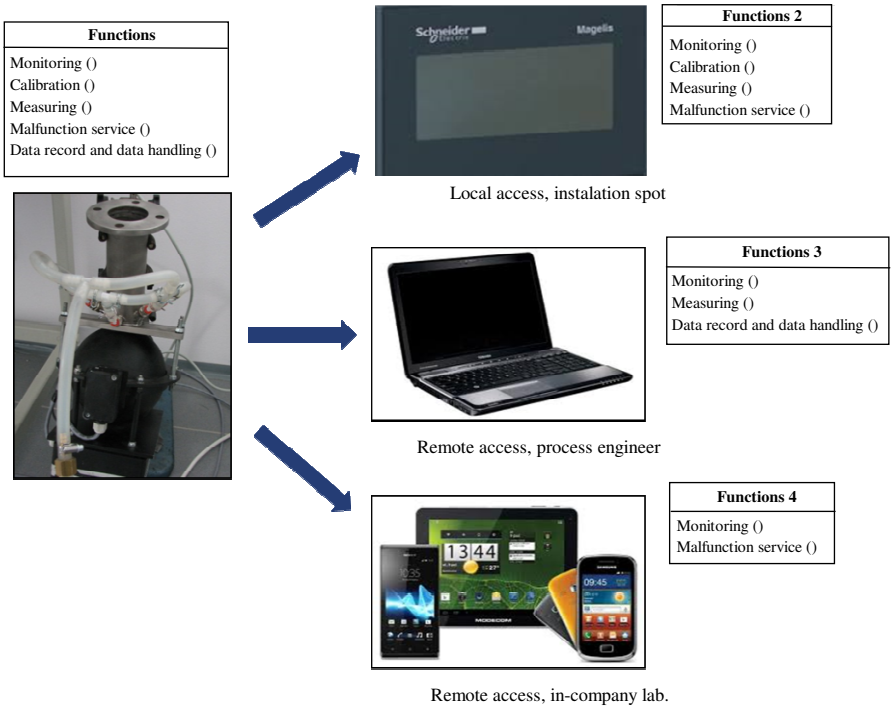

Fig. 7. The structure of developed methods of distributed measurement system of the carbon content in volatile ashes from power industry boilers

Such separation is natural from the user's point of view, who only needs information about the current readout from the measuring head. In addition, the separation of functions increases the security of the system [11]. Lack of access to parameters' settings eliminates the consequences of possible attacks that could disrupt the functioning of the system. Other simple means to ensure safety are the usage of: passwords, "remote wipe" software – to delete the contents in case of loss of a device and antivirus software.

Summary

The paper presents the structure of the measuring system described as a multi-user solution which means that there is a possibility to access the system resources in multiple locations simultaneously without any problems arising from the other users' actions. Remote access is performed with the use of mobile devices – smart phones and tablets. Developing software for these devices in line with the majority of described methods is not difficult, if there is "basic" software such as web server or SCADA. This opinion can be supported by a noticeable trend in the use of personal smart phones to monitor industrial installations [12]. A lot of companies provide software compatible with their packages of SCADA type, which is used by the system's operators except the "official" tools. The only problem can be a variety of types and versions of operating systems and compatibility of individual applications. Users of measurement systems will more often expect the possibility to use the mobile device as standard equipment.

Among the latest capabilities within the scope of the use of mobile applications in measuring systems a few key trends can be distinguished:

- new monitoring methods using hardware solutions like Google Glass and aiming at 3D imaging and speech synthesis;
- specialized sensors, e.g., for medical applications, dedicated to mobile devices;
- access to large measurement databases and knowledge bases such as the use of "app stores" technology, in which plenty of users on a global scale use and complete the database at the same time. This is also related to the IMC technologies (In-Memory Computing) – changes in the databases' structure and the increase of their search speed;
- technologies of augmented reality for mobile devices that can be used for example in the areas of modeling, service, measurement systems teaching.

The unusual dynamics of the development of mobile devices can result in the appearance of some other, surprising solutions enriching measurement systems.

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Zastosowanie urządzeń przenośnych w systemie pomiaru węgla w lotnych popiołach z kotłów energetyki zawodowej

Słowa kluczowe

System pomiarowy, wielodostępność, smartfon, tablet, dostęp bezprzewodowy.

Streszczenie

Powszechnie używane urządzenia przenośne typu smartfony i tablety stają się obecnie także nieodzowną częścią systemów pomiarowych. W artykule opisano zasady projektowania systemu pomiarowego wykorzystującego takie urządzenia na przykładzie systemu do pomiaru zawartości węgla w popiele z kotłów energetyki zawodowej. Opisano funkcje systemu z rozdzieleniem na realizowane w urządzeniu mobilnym i innych węzłach interfejsów użytkownika. Przedstawiono metody programowania urządzeń przenośnych z uwzględnieniem ich zalet i wad. Zaprezentowane rozwiązanie wielodostępności może znaleźć zastosowane również w innych systemach pomiarowych.