Automated Research System for Studying Fluidized Bed Hydrodynamics

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Abstract—The paper examines a computer appliance for carrying out automated fluidized-bed hydrodynamics researches. The researches are conducted in order to obtain empirical data for real-time diagnosis of bed state by the fluctuations of differential pressure of the reactor and fluidized-bed modeling.

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1. INTRODUCTION

Combination of physical and mathematical modeling of objects, effects, and processes appears to be a priority direction for research efficiency enhancement.

Employment of information telecommunication technologies in manufacturing creates favorable environment for improvement in quality and effectiveness of applied scientific research.

The paper analyzes an automated system for fluidized bed hydrodynamics research. Fluidized-bed reactors are widely used in catalytic cracking of petroleum fractions, gasification of coal, production of phthalic anhydride, acrylonitrile, sulfur trioxide, polypropylene, and, etc. In addition to performing chemical processes, they are utilized for adsorption of substances from gases and burning and drying of solid metals. Results of the research on the considered lab may be applied to real-time diagnosis of catalyst state, determination of the mass of particles in the bed, and catalytic process optimization.

Hydrodynamics is studied using a laboratory unit that permits to measure phase contacting surface, distribution of gas bubbles with bed height, pressure fluctuations, and, etc.

2. SOFTWARE AND HARDWARE IMPLEMENTATION

The automation object is a laboratory unit for fluidized bed hydrodynamic research. The flow diagram is shown in Fig. 1. A two-dimensional fluidized bed R-1 and a three-dimensional reactor R-2 having 20 cm in diameter are the primary elements of the stand. Air which is supplied to the vessels through the fan with a variable-frequency drive is used as a fluidizing agent.

The research process is controlled by communicating software services. The appliance architecture is demonstrated in Fig. 2. Data management and exchange services of the appliance are implemented on the laboratory server. The main interaction with the equipment is carried out by using a Toshiba V-series 100 PLC to which the lab equipments are connected in this case. Functions of the automated research system are distributed among three servers:

— a control Internet server which is a node that coordinates all the services of the system. Communication between remote clients and distributional services of the appliance, authorization and authentication of clients, research launching operation, and research result storing and presentation are performed here;
— a server of the research unit, which is meant for interaction with experimental facilities and collection, preprocessing, and storing of research data. The main part of the facilities is connected to the PLC. Data exchange between the program and the PLC is carried out via the OPC DA Protocol. A Webcam is used for remote monitoring of the experiment procedure. Some experimental data (data of the high-resolution video records) is introduced into the system by a lab assistant. The server can perform functions of an automated workstation of the assistant;

— secondary servers, which are intended for solving the tasks that require heavy computational efforts, for instance, processing of the initial data of video records or integration of a mathematical model for a reactor of the fluidized bed.