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MIXTURE FLOW PATTERN RECOGNITION BASED UPON ON-LINE ANALYSIS OF PHYSICAL PARAMETERS

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ABSTRACT

Full-scale technological, bench or laboratory scale, and in-vitro processes rely on mathematical models to allow adequate control of one-phase turbulent flow for homogeneous fluids. However, most processes utilize more complex fluids such as gas, liquid, and solid; gas and liquid; gas and solid; and liquid and solid which generate heterogeneous mixtures. In such instances, significant difficulty is encountered with the description, interpretation and uncertainty of the process due to the flow pattern phenomenon associated with dynamics for each of these mixtures. Generally, experimental data and correlations described in the literature consider a limited range of direct physical parameters, such as spatial and temporal distribution of the component concentration and fluid velocities. These direct physical parameters can then be utilized in flow pattern recognition in two- and three-phase single and multi-component heterogeneous mixture flow if approached as random, dynamic deterministic, and a combination of dynamic random and deterministic processes.

One area of progress in this field has been the detection, recognition, and integration of flow patterns into the description, design, or control of various technological, research, and control processes which would extend the current boundaries of empirical knowledge of flow dynamics in multi-phase flow. For example, a thorough understanding and detection of flow patterns has application and will bring significant progress in bioengineering for biofluids flow analysis in vitro, including blood dynamics with solid-like substance deposition and decomposition in the vessels; oxygen transfer in lungs; in situ bioremediation processes (mixture flow through porous media); in electronics for compact heat exchangers with phase transition; in systems to control flow induced vibrations; and in micro-electro-mechanical devices, including nanotechnology applications such as micro-heat exchangers, micro-actuators, and self-contained micro-submarine devices.

This paper reports the results of research that examines the potential of using on-line monitored physical parameters for flow pattern recognition that, in turn, will determine the dynamic or static structure of the mixture flow, or "frozen" patterns, by analyzing the dynamicity of the physical parameters. The signals detected in the process depict independent or dependent physical parameters that influence the process, such as in-situ spatial concentration phenomena, velocities, and pressure with their interphasecial spatial and temporal distribution. Both the internal relation and character of these parameters are examined on the micro and macro level as well as for different time scales. These parameters as a function of time and space can be used to define and identify, in objective ways, the various flow patterns.

Also, this paper contains descriptions of: The high frequency response system used to conduct this research; the on-line physical parameters such as velocity, concentration, and pressure measured and analyzed in time, amplitude, and frequency domains; and the computer-aided, on-line data analysis system based on specific parameters used for flow pattern recognition. The paper will also review the current literature, report the research results and findings regarding the results of the analysis on the applicability of the parameters, and analytical methodologies for flow pattern recognition and the identification process.