Digest of Translated Russian Literature

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INTERNATIONAL CHEMICAL ENGINEERING. Published by American Institute of Chemical Engineers, New York

Volume 2, Number 3, July 1962

Effect of Stream Velocity and Catalyst Bed Height on the Degree of Gas-Phase Mixing in a Fluidized Bed, K. V. Topchieva and I. P. Planovskaya, pp. 419–421.

An investigation of the degree of gas-phase mixing in a fluidized bed as a function of gas rate and catalyst bed height, using the model cumene cracking reaction, is made. An empirical equation is obtained relating these variables.

Effect of Oxygen Atoms on Combustion at Low Pressures, V. Ya. Basevich and S. M. Kogarko, pp. 450–452.

Certain common features in the mechanisms of the phenomena can be discerned between the acceleration of combustion processes which is observed due to the action of atoms and radicals at atmospheric pressure and the long-familiar rarefied atomic flames. In the first case, the addition of atoms and radicals accelerates the oxidation process, and in the second, occurring under low-temperature conditions, the reaction of atoms and radicals with the fuel is a fundamental feature of the process.

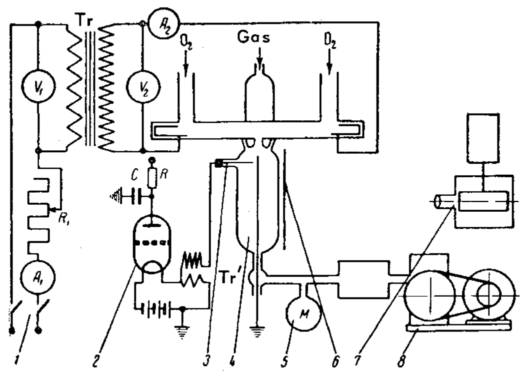

Fig. 1 Diagram of equipment: 1) electrical circuit for glow discharge; 2) generator for ignition spark; 3) discharge tube; 4) reservoir; 5) vacuum gage; 6) slit; 7) photorecorder; 8) vacuum pump.

In the paper the observation has been made that for acetylene and oxygen there is a region in which both types of flames can exist simultaneously—atomic flames, which are formed here at the relatively high pressure of several mm Hg, and ordinary flames, when combustion develops independently. Starting from the idea that the mechanisms of atomic and ordinary flames and the part played in them by the initial concentration of active reaction centers are the same, we chose as the problem to be investigated in the present work a study of the effect of atomic oxygen on the rate of flame propagation at low pressures and an investigation into the possibility of reducing the limits of combustion with respect to pressure as far as the region in which atomic flames exist.

Volume 2, Number 4, October 1962

Hydrodynamics and Heat Transfer in a Turbulent Incompressible Fluid Stream in the Gap between Rotating Coaxial Cylinders, Yu. A. Koshmarov, pp. 455–459.

Theoretical solutions of the hydrodynamic and thermal problems in the steady-state turbulent flow of an incompressible fluid in the annular channel formed by two smooth coaxial cylinders rotating relatively to one another are given.

Turbulent Heat Transfer during the Flow of a Heating Medium of Small Prandtl Number along a Tube, L. S. Kokorev and V. N. Ryaposov, pp. 514–519.

Experimental data on the flow of liquid mercury and calculation of the heat-transfer coefficient, with particular regard to its dependence on the Prandtl number, are given.

The Reynolds hypothesis of the analogy between the turbulent transfer of heat and momentum leads to satisfactory agreement with experimental results for the calculation of heat transfer in the turbulent boundary layer of a liquid with a Prandtl number of the order of unity. Liquid metals have Prandtl numbers much smaller than unity (from 0.05 to 0.005). In the calculations of heat transfer during the turbulent flow of liquid metals in tubes by Martinelli and Lyon, the Reynolds hypothesis has been extended, without sufficient grounds for doing so, to the case of liquids of small Prandtl number. The first estimation of the effects of the thermal conductivity of liquid metals on turbulent heat transfer was made approximately by K. D. Voskresenskii, and it was observed that the Reynolds hypothesis is not applicable to streams of liquid metals. The approximate calculations of the ratio of the turbulent transfer coefficients for heat and momentum in the papers by K. D. Voskresenskii and Daisler (Deissler) make use of empirical constants which have to be determined by comparing the results of the calculations with experimental values.

The experimental values in the literature for the ratio of the coefficients of turbulent transfer of heat and momentum $\epsilon = \epsilon_q/\epsilon^\tau$ for the flow of liquid metals along tubes differ widely among themselves. In these experiments the temperature distributions in the stream were measured by movable thermocouples which were traversed along a radius of the tube at a given cross section. It was necessary to insure that: the experimental conditions fulfilled the requirements assumed in evaluating the experimental results; there was no disturbance of the boundary conditions; the temperature distribution was axially symmetrical; there was a stable excess temperature profile along the pipe; and there were no effects due to natural convection. The introduction of a temperature probe through the walls of the tube in other papers could lead to an infringement of the first condition and make it difficult to check whether the other requirements were fulfilled. In the present work the measurements of the temperature distributions in a turbulent stream of mercury in a pipe were carried out using an elongated temperature probe which made it possible to satisfy the conditions listed above. The experimental equipment operated on a closed recycling system; a centrifugal pump was used for circulating the mercury.

Experimental Study of Heat Transfer during Melting of a Metal and in the Case When a Molten Metal is Injected through a Porous Wall in a Supersonic Stream, I. A. Zotikov and L. N. Bronskii, pp. 528–530.

Quantitative relationships are derived which are explained by the effects of flowing liquid films on heat transfer.

The flow of liquid films is accompanied by the formation of large and small waves on their surfaces. The "liquid roughness" caused by these waves can be the source of additional turbulence in the boundary layer and the increased heat transfer rates associated with this.

The present paper deals with an experimental study of heat transfer on the surface of the flat front end of a cylinder placed axially in a supersonic stream when the metal on this surface is being melted and when a liquid metal is forced through pores in the wall. We have investigated the effects on heat transfer of the thin liquid films of metal formed on the surface by melting or artificially produced by injecting metal through pores.

The experiments were carried out in a gasdynamic apparatus with an open working section. The experiments on melting were carried out at a stagnation temperature of 580°C in the jet. The Mach numbers M were 1.8, 2.3, 2.7. The nozzle diameter at the outlet section was 30 mm. Tin was used as the metal which was melted and forced through the pores.

In the melting experiments, the model investigated consisted of a hollow cylinder with a diameter of 16 mm with a flat end. This was constructed of "Steklotekstolit" (a glass-resin-impregnated laminated material). Rods of tin were inserted into an opening on the axis of this cylinder and were arranged such that their flat ends projected 1–2 mm relative to the flat end of the glass-resin cylinder. The model was attached to an arrangement which made it possible to introduce it rapidly into the hot supersonic stream. The protruding flat end of the tin rod then began to melt. A special device made it possible to feed the rod forward axially as it melted so that the projection of its end relative to the end of the glass-resin cylinder remained constant during the experiment. The rate of melting (that is, of feeding the rod forward) and the size of the projection were recorded by means of cinéphotographs of the process, which were taken by a KS-50B camera at 8–24 frames per sec.

The side walls of the melting rod were thermally insulated by the glass-resin cylinder. The effectiveness of this insulation is estimated. A separate piece of equipment made it possible to thermostat the model before its installation in the stream at any temperature up to the temperature of melting. By bringing the model to various preliminary temperatures in this way, we were able to obtain various rates of melting for the same parameters of the approaching stream.

The experiments on heat transfer with injection of a liquid metal through a porous surface were carried out in the same main equipment as the experiments with melting. The configuration and dimensions of the model were the same as in the melting experiments, which made it possible to compare the results obtained for this case with those for the melting of rods.

Heat Exchange in Three-Component Flow, Yu. N. Piottukh and S. I. Shabanov, pp. 520–524.

Development of a system of differential equations describing heat exchange in a three-component stream and solution of this system of equations in terms of terminal differences are presented.

The attempt to intensify heat and mass transfer in the processes of drying, calcination, thermal decomposition, etc., leads more and more to the use of fluidized bed techniques in these processes.

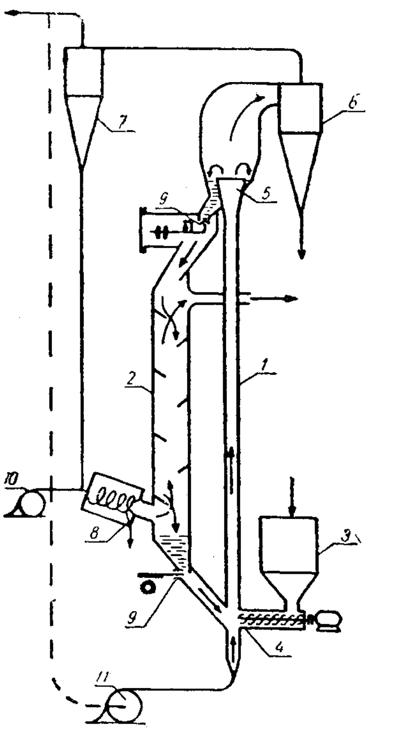

Fig. 1 High thermal-rate treating of solid fuel using three-component heat exchange: 1) pipe-reactor; 2) furnace; 3) fuel feed hopper; 4) screw conveyor; 5) separator of the "fluidized" type; 6) cyclone for separation of semicoke; 7) fine particle cyclone; 8) burner; 9) slide valves; 10) air blower; 11) recirculating blower.

The high turbulence thus obtained favors intensive heat exchange. However, due to the low specific heat of the gas carrier, undesirably large quantities of gas are required for a given heat exchange. Since the specific heats of solids are approximately a thousand times greater than those of gases, the use of solids for heat transfer appreciably reduces the masses involved. On this basis, a new solid fuel thermal treatment (Fig. 1) has been developed by the Transport-Energy Institute, Academy of Sciences, USSR, in which heat exchange is accomplished in a rising three-component stream consisting of sand heat-carrier particles heated to incandescence, solid fuel particles being heated, and gaseous thermal decomposition products functioning both as carrier and heat transfer agent.

Effect of Diffusion of a Radiating Additive on Convective Heat Transfer, A. N. Rumynskii, pp. 554–559.

Equations are developed for calculating the convective transfer of heat to the stream in the neighborhood of the critical point of a blunt body on which a radiating gas is liberated.

Calculation of Optimal Processes in Chemical Reactors by the Method of Dynamic Programming, L. M. Pis'men and I. I. Ioffe, pp. 567–575.

Equation for an arbitrary process in a reactor with ideal mixing, based on the work of Aris in using dynamic programming to solve the problem of optimal temperature sequence, is given.

The development of computer technique and the appearance of modern high-speed computers have created the prerequisites for a new approach in principle to calculation of processes in chemical reactors. Until a relatively recent time, finding a calculating method for the concentration, hydrodynamic, and thermal parameters which assure the flow of a reaction in a preassigned process was considered an achievement in the area of design. The process was selected on the basis of experimental investigations on a laboratory or experimental reactor.

A number of shortcomings are inherent in such a solution of the problem. To begin with, the laboratory and experimental reactors are not a complete model of a production reactor. Moreover, when the scale of a chemical reactor is changed, the same systems are not preserved as regards chemical, hydrodynamic, and thermal parameters. This is very definitely manifested in heterogeneous catalytic processes. Furthermore, the experimental selection of a technological process is very laborious, and therefore the optimal solution possibly will not be found. In the overwhelming majority of chemical reactions that are of practical interest, to obtain the maximum end product, the reaction process must vary in time (for periodic processes) or in space (for continuous). Finding such processes by an experimental method is practically impossible because of the excessive complexity of the problem. Finally, it is no trivial matter that no success has been attained in obtaining, in a single process, maximum utilization of raw material, maximum yield of the reaction space, and minimum expenditure of energy, and it is necessary to sacrifice one for another. As a result of this, the selection of the most suitable process becomes not only a chemical but an economic problem.

There are two principal prerequisites for accomplishing the optimal calculation.

1) *A mathematical description of the process:* that is, a combination of the dependences which enable one to calculate the result of the process (the state of the reacting stream at discharge from the reactor) at known initial state and values of all the parameters governing the process. The mathematical description is worked out on the basis of the results of experimental investigations of the chemical kinetics, macrokinetics, and hydrodynamics of the process.

2) *The dimensionless function used for optimization.* This generally is worked out by starting from the economic considerations; the optimal selection of the process must bring the dimensionless function to a maximum.

Volume 3, Number 1, January 1963

Flame Propagation along the Contact Surface between a Metal and a Solid Oxidizing Agent, D. P. Polikarpov and N. N. Bakhman, pp. 1–5.

Results of an experimental investigation of the dependence of the flame propagation on the characteristic dimensions, the structure of the metallic layer, and the pressure is given.

In earlier papers we studied the previously unknown phenomenon of the propagation of flames along plane and cylindrical contact surfaces between layers of solid organic combustible materials of any thickness and solid oxidizing agents. In the present paper we will investigate the analogous phenomenon for the case in which a powdered metal is used as the combustible material.

Combustion in a system consisting of plane or cylindrical layers of the components in contact (a "stratified system") is of interest as a limiting case of the combustion of the more usual random mixture of particles of the same components with large particle dimensions.

Calculation of the Optimal Process in Chemical Reactors by the Method of Dynamic Programming, L. M. Pis'men and I. I. Ioffe, pp. 24–32.

Application of a theoretical solution developed in a previous article on the same subject (Intern. Chem. Eng. **2**, October 1962) is given.

Hydrodynamically, a condition of ideal mixing can be attained, as is known, in liquid-phase reactors with mixers and, under certain conditions, in reactors with a fluidized catalyst bed. The kinetic characteristics of such systems are for the most part unfavorable, due to the hydrodynamic irregularity of the stream and the limited possibilities of purposefully directed action on the process (the small number of degrees of freedom in design and control). In the transition from a single reactor to a chain of reactors with ideal mixing combined in a series, all the technological conveniences of this method of carrying out the process are preserved, and the shortcomings mentioned are to a considerable degree removed. By virtue of this, reactors with ideal mixing combined in series constitute an effective reactor arrangement for many chemical processes. In the following, an analytical method for calculating the optimal process in such reactors is described, based on the theory of dynamic programming.

Application of Burman-Lagrange Series in the Analysis of Transition Processes in Chemical Engineering Equipment, B. N. Devyatov and Yu. N. Kornev, pp. 36–44.

The practical value of the use of these series for the approximation of transcendental transfer functions and the corresponding transition functions is demonstrated by examples.

The determination of transition conditions for a broad range of chemical engineering equipment, in view of its typical presence in countercurrent or direct-flow processes, is related to the analysis of systems of general fundamental equations with partial derivatives.

For such systems, which have distributed parameters, in the majority of cases it is inexpedient to express precise solutions of the equations, since their expressions are either unwieldy or in general do not lend themselves to determination. The corresponding transfer functions are more readily determined, but are transcendental, and their direct analysis is very difficult.

Therefore, indirect methods of constructing the corresponding solutions of the equations for a transfer function in the form of a convergent series, without direct solution of the equations with partial derivatives, acquire a special importance. Burman-Lagrange series can be used very effectively for this purpose. In this case, the selection of one or another concrete form of Burman-Lagrange series is conditioned, on the one hand, by the requirement of very great precision in describing the given part of the transition process, and on the other, by the nature of the transition process itself, and by its nearness to some simple functional dependence.

It is evident from physical considerations and from experimental data that processes which correspond to the general equations for the reaction of moving media in industrial equipment are, in the presence of a gradual disturbance, steady and limited in a majority of cases. The character of the flow in these processes is close to an exponential function.

These peculiarities of a transition function have been taken into consideration in the specific selection of a Burman-Lagrange series, for the purpose of assuring its sufficiently rapid convergence in practice.

It should be noted that the particular form of series adopted by us approximates better the transition functions of systems with nonoscillating limited transitional characteristics, and even better with monotonic. On the other hand, in principle it is possible to construct a Burman-Lagrange series of another type which better approximates oscillating-damping processes, that is, processes typical for automatic control systems. In this sense, the universality of this method of describing transition processes is valuable.

MEASUREMENT TECHNIQUES (Izmeritel'naia Teknika). Published by Instrument Society of America, Pittsburgh, Pa.

Number 3, March 1962

Problems in Measuring Pulsating Flows, N. F. Gonek, L. A. Kirmalov, and B. I. Pilipchuk, pp. 244–246.

Number 4, April 1962

Instrument for Remote Measurement of Temperature of Moving Media, B. L. Gunbin, pp. 288–291.

An instrument for remote temperature measurements of a flow moving with infrasonic velocities is described in this article. The schematic of the instrument (Fig. 1) consists of an unbalanced

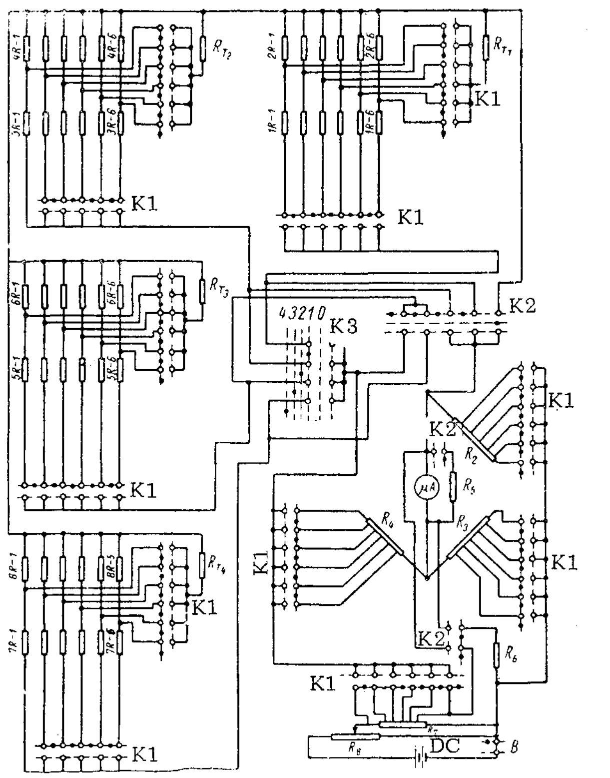

Fig. 1 R_{T1}–R_{T4} are microthermistors type MT-54; K1 are roller switches type KTROI 15-31/5-15; K2 is a roller switch type KTROI 7-17/7-17; K3 is a switch type PMT-4; R_2–R_8 are manganin resistors; 1R-1 to 1R-6, 3R-1 to 3R-6, 5R-1 to 5R-6, 7R-1 to 7R-6 are manganin resistors; 2R-1 to 2R-6, 4R-1 to 4R-6, 6R-1 to 6R-6, 8R-1 to 8R-6 are resistors type VS or MPT; B is a switch type TP1-2; μ A is a microammeter type M91 with a range of 10 μ a; DC are dry cells type ZsL-30.

bridge with a thermistor connected to one of its arms. The instrument has four transducers which are switched-in consecutively. Its temperature range is 0° to 100°C.

Number 5, May 1962

Calorimetric Equipment for Determining the Enthalpy and Thermal Capacity of Substances, E. N. Fomichev, V. V. Kandyba, and P. B. Kantor, pp. 376–380.

The calorimetric equipment of the KhGIMIP (Khar'kov State Institute of Measures and Measuring Instruments), which is described in this article, is intended for measuring the enthalpy of substances in a condensed phase over a wide temperature range of 500° to 3000°K with an accuracy of 0.3 to 1%.

Selection of Optimum Parameters for a Filter at the Output of a Transducer, V. F. Dmitriev and Ya. A. Kupershmidt, pp. 404–408.

The majority of transducers used in industry operate on currents of a standard frequency (50 or 400 cps). Transducers are