Chemical and Petroleum Engineering, Vol. 37, Nos. 5–6, 2001

CHARACTERISTIC FEATURES OF PROCESS SEQUENCE DIAGRAMS FOR THE CONTINUOUS PREPARATION OF MULTICOMPONENT POWDER MIXTURES

A. V. Chuvpilo

UDC 621.762.2:66.011

At the present time, continuous-mixing processes, which make it possible to react to deviations from the normal course of an operation, and to regulate these deviations, are used to produce multicomponent powder mixtures.

That mixture, when the components for the minimum heterogenous reaction microcell in which they are in the required (assigned) proportion and required (assigned) mutual arrangement dictated by the purpose of the constituent components, can be considered ideal. Nonobservance of these two conditions will result in incomplete utilization of the properties of the components. In chemical sources of electric current of a manganese-zinc system, for example, a total of 60–70% of the manganese-zinc powder mixture is utilized with respect to computed capacity efficiency, the energy potential of a solid rocket fuel is reduced due to a disturbance in the proportion of the combustible material and oxidizing agent in the minimum reaction cell, and so forth.

In ideal heterogeneous cells having the required ratio of concentrations and mutual arrangement of components, it is possible to note a regularity of structure, and, consequently, if the components are delivered in the required proportion as particles (single-layer flow), the requirement is precluded in the mixer for the production of the required cell structure.

From this position, the mixer should be treated as a device that compensates for the impossibility of supplying initial particle components at the required output; this reduces the degree of segregation to zero for a single-layer flow.

Inconsistencies between the quality of the mixture, the required mixing time, and the output are virtually eliminated, if it is assumed that the overall process of controlled continuous mixture preparation consists of the following stages: continuous metered feed of components with a minimum flow section and required output; continuous restructuring of the flow of components to a single layer flow; and continuous mixing with eventual zero segregation of the mixture [1].

Preparation of the mixture in accordance with the proposed procedure significantly lowers the power consumption of the equipment (kWh/ton of mixture), since the paths of the particles of the components are short for the required quality of the mixture as a result of connection between single-layer flows, whereas in traditional schemes used for mixture preparation, each particle of the components should advance between other particles for an extended time to form a homogeneous mixture; this requires large energy outlays.

A process diagram with a thin-wall stacking of flows of powder components will make it possible to diminish the effect of the physical, chemical, and mechanical properties of the material, which frequently impede attainment of the required quality of mixture (when traditional flow diagrams are used). The proposed process flow diagram will make it possible to prepare the powder mixture easily with respect to the differential-variable ratio of proportions between components, and also periodically add a component feed to, or remove it from the preparation process; this may be of special interest to production engineers working in the chemical and foodstuff industries, powder metallurgy, etc.

Figure 1 shows a process sequence diagram of the method under consideration for the preparation of multicomponent powder mixtures. All components pass through a preparation process for a metered feed to average-out the

---

MGUIÉ. Translated from Khimicheskoe i Neftegazovoe Mashinostroenie, No. 6, pp. 9–10, June, 2001.

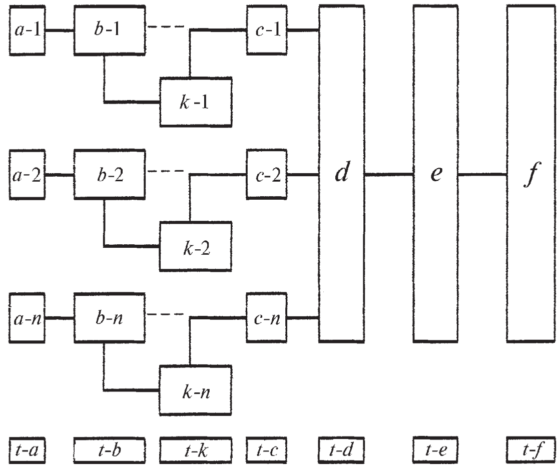

Fig. 1. Process sequence diagram of continuous preparation of multicomponent powder mixtures: *a*) preparation of component for metered feed; *b*) continuous bulk metered feed of component; *c*) restructuring of flow of component to possible minimum section; *d*) encounter and stacking of component flows at beginning of mixer; *e*) continuous delivery of mixture into production flow; *f*) continuous delivery of mixture into production flow; *k*) weight check of bulk metered component feed; *t*) process time of corresponding operation; 1, 2, ..., *n*) number of components in mixture; – – –) possible alternate scheme of technology.

physico-mechanical properties of the initial powder. A continuous bulk metered feed is accomplished by a feeder with a velocity and minimum section satisfying the requirements of fail-safe operation and the required output. After the weight of the components has been checked, the flow section is restructured to a single-layer flow with use of either a gravitational field (trough device), or special throwers-accelerators (mechanical, pneumatic, etc.). The single-layer flows of components are easily implanted one in the other in the mixer.

The linear velocity of the components in the mixer is lowered to reduce segregation in the radial direction during continuous axial displacement of the mixture. The design of the mixers may differ (drum, paddle, etc. [2, 3]). A primary condition of mixer selection is the provision for a piston-operating regime, which eliminates fluctuations (lag and lead) in the dwell time of particles of mixture components in the vessel. Additional production operations (grinding, heat treatment, wetting, etc.) are possible during the mixture's transport. The final mixture is delivered either into a production flow, or is supplied as a final packaged product.

This structure of the process flow used to prepare a mixture corresponds to a sequence diagram. Only certain characteristics of the component parts of the sequence diagram can be examined from the overall procedure employed to analyze the cycle of continuous mixture preparation.

The process time *t–a* required to average-out the density of the powder fluctuates within a broad range depending on the initial physico-mechanical properties, but is a deciding factor for the production of a quality mixture, and is determined experimentally.

During the metered feed *t–b*, premises for degradation of the averaged powder density are, as a rule, created in the flow, because at the moment of formation of the measured flow, the density of the powder may become nonuniform under the influence of vibration and boundary effects; the time *t–b* should therefore be shortened to a minimum, and metering devices with appreciable sluggishness should not be used; moreover, it is desirable to use mechanisms with simple and reliable forms of measured tapping of the powder flow: screw, plate, and other metering mechanisms. The time *t–k* required to check the powder flow, and the time *t–c* required to restructure the section of the flow of components should, for the same reason, also be reduced to a minimum.

The time *t–d* from the start of the encounter between the thin-layer components to their stacking across the section of the mixer is the basic period of active mixture formation with minimum segregation. Calculation of the time *t–d* (computed in tens of seconds), and the building of equipment that would take this time into account have basically preceded the production of high-quality powder mixtures for autonomous chemical sources of current [4] in continuous-action plants.

The time *t–e* must be provided for in those cases when it is required to overcome specific physico-chemical properties not of the individual components, but of the entire moving mass of components, and also to carry out additional operations: wetting, plasticizing, heat treatment, etc. Calculation of this time must be done for the piston regime of the mixing process with minimum deviation (lag and lead) of the dwell time of component particles in the system.

In existing productions of multicomponent powder materials (especially dry materials), little attention has been focused on the time of delivery to the production flows, or the storage time *t–f* of the mixture. With time, however, the majority of prepared mixtures tend to irreversible segregation (due to a difference in the densities and gradation of the components) during vibration from equipment operating in the room, frequent overfilling of the mixture from one container to another, and similar phenomena.

The process sequence diagram presented for the machinery and circuit breakers employed for multicomponent powder mixtures will make it possible to create conditions for the design of equipment ensuring reliable formation of the structure of a heterogeneous powder cell.

REFERENCES

1. A. V. Chuvpilo, *Innovation in the Theory and Equipment of Powder-Mixture Preparation* [in Russian], Vsesoyuznyi Nauchno-issledovatel'skii Institut Élektromekhaniki, Moscow (1964).
2. Yu. I. Makarov, B. M. Lomakin, and V. V. Kharakov, *Domestic and Foreign Equipment for Mixing of Free-flowing Materials* (Review) [in Russian], Tsentral'nyi Institut Nauchno-Tekhnicheskoi Informatsii, Moscow (1964).
3. D. A. Dolzhkov, "Type sizes of dual-shaft all-purpose continuous-action mixers," *Khim. Neft. Mashinostr.*, No. 2, 38–40 (1964).
4. A. V. Chuvpilo, "Investigation of plaints for the continuous preparation of multicomponent mixtures," in: *Collection of Works of the Academy of Sciences of the USSR "Analysis, Design, and Investigation of Equipment for the Production of Current Sources"* [in Russian], Énergiya, Moscow (1968).