POWER SHS COMPACTING AND HIGH-TEMPERATURE RHEODYNAMICS

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In this issue, three main methods of refractory SHS compacting are considered, namely, compaction, extrusion, and explosive pressure treatment, which are under development at the Institute for Structural Macrokinetics, Russian Academy of Sciences. Originally the term "self-propagating high-temperature synthesis" (SHS) was taken to mean the gasless autowave combustion of solid materials at their initial temperature producing the solid-phase materials at their combustion temperature. The notion of "solid flame" came into practice as a new variety of combustion. An attractive result of using "solid flame" as a production process was the combustion products themselves, which are refractory inorganic compounds of transition metals such as carbides nitrides, borides, and others. Special materials based on them are more and more extensively used in different fields of technology. The gasless combustion processes used to produce such materials have an advantage over the conventional furnace synthesis because they do not require electric power for heating (the process is sustained by the internal heat release), they have high productivity (combustion lasts a minute or even seconds), and give high-purity products (at a combustion temperature of 2000-4000 K all the impurities decompose and volatilize). The number of useful refractory combustion products increased gradually. Various kinds of powders, porous, poreless, compact, cast, and other materials were obtained. The term "SHS" was interpreted in a wider sense as a set of combustion processes of any chemical nature producing valuable condensed products.

In 1975 research was started to develop a number of new SHS-compacting processes which would produce articles of a preset shape and size from the combustion products. A combination of combustion and high-temperature deformation with application of high pressure to the combustion products is a characteristic feature of all these processes. The characteristic temperature range of forming the materials is rather wide, ranging from the combustion temperature to the recrystallization temperature; therefore, they belong to high-temperature metal treatment methods. However, the conditions of the production processes are unusual: short times (1-10 sec), high temperatures, and extremely high heating rates of the initial components (up to $2 \cdot 10^4$ deg/sec). All these factors give rise to fundamental differences in the structure-formation mechanisms and dynamics and pose new problems in the physical science of materials. The articles published here contain much experimental data on forming the structure and properties of materials and products, and possibilities of controlling the structural variations at the synthesis and shaping phases are investigated.

Aspects of the operation process of the SHS compacting are described in particular articles; others deal with the development of special equipment for the methods. Numerous studies were carried out to optimize the operation conditions and the experimental procedures. Though the experimental material presented is considered from the operation point of view, much attention is given to plastic deformability of brittle, hard deformable refractory compounds at high temperatures. This issue contains articles on the high-temperature rheology and rheodynamics of powder materials.

The rheological behavior of these materials transferred into a high-temperature state has been studied inadequately so far. The relevant research provides a phenomenological description of many compaction and extrusion mechanisms in porous materials. At present, the problems are being solved to develop the measurement methods for the main rheological characteristics and their dependence on the porosity, temperature, and deformation conditions. The development of the theory of main viscometry flows is under way, and the material deformation and compaction processes are being described.

The mathematical modeling of SHS-compacting methods is also considered. It is characterized by a complex interaction of numerous physicochemical and mechanical phenomena which cannot be described simultaneously in every detail. An approach in which emphasis is laid upon a single aspect of the process proves more efficient. The analysis of the heat and deformation process is the key to correct understanding of high-temperature compaction and moulding mechanisms in porous materials. In mathematical modeling, partition of the process into separate major phases appears useful. It is shown how the models developed facilitate solution of practical problems of producing the concrete items.

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The development of SHS-compacting methods is becoming very urgent because they provide great possibilities in the production of articles of different configuration and function from tungsten-free hard alloys. Unfortunately, many results of the theoretical and technological studies in the field have not been given due attention in the relevant literature. The reviews presented in this topical issue of the *Journal of Engineering Physics* will provide the reader with comprehensive information about all the scientific and technological developments in the field.