STRUCTURAL STRENGTH CHARACTERISTICS OF POROUS COMPOSITE POWDER-FIBROUS MATERIALS

Anatoly G. Kostornov, Anatoly L. Moroz, Andrew A. Shapoval
Frantsevich Institute for Problems of Materials Science of NASU,
3, Krzhizhanovsky St., Kiev, 03142, Ukraine E-mail: shap@rst.kiev.ua

Abstract

Results of development of the leaf composite materials consisting of metal fibers and powders are submitted. A number of structural and strength characteristics of the developed materials is investigated. It is shown, that structural characteristics of layered fibrous-powder compositions are higher that that of fibrous and powder materials themselves. For manufacturing the tubular filter-elements it is preferable to use frame compositions which elasticity is higher than that of fibrous materials.

KEYWORDS

Powder and fibrous materials, composite materials, structural and strength characteristics, experimental research, modulus of elasticity

INTRODUCTION

The ways of increase of physical properties of porous powder and fibrous materials [1-3] are known. Increase of structural and hydrodynamic characteristics is reached due to creation of non-uniform porous structure, for example, by mixing of powders and fibers, sedimentation of fine particles in sintered large-porous preparations, serial backfilling of fibres and powders into the form with their subsequent pressing or vibroforming. However the listed ways have a number of essential lacks. In the present work results of research of structural and strength characteristics of sheet porous compositions from fibers and powders of stainless steel are submitted.

RESEARCH OF STRUCTURAL STRENGTH CHARACTERISTICS OF POROUS COMPOSITE POWDER-FIBROUS MATERIALS

As object of research the cylindrical (∅30 × 1... 5 mm) and prismatic samples (1...5 × 5 × 80 mm) with porosity of 20-90 % were used. The samples were produced by joint and separate vibroforming and sintering of fibres and powders followed by their free sedimentation at pressure 1,25 … 40 MPa and cutting of the sintered single-layered and two-layer sheet preparations. Formation of high-porous fibrous-powder compositions was carried out on special vibroequipment, allowing to obtain a number of effective structures: 1) as besieged according to the given sequence of separate high-porous fibrous and powder layers; 2) as high-porous fibrous skeleton holding thin working fibrous-powder layers.

Results of researches of permeability and medium-sized pores in one and two-layer samples of composite materials are submitted in fig. 1. If the complex of properties "permeability – pore size" is concerned, the layered samples are considerably better than the fibrous and powder materials themselves. Such materials consist from linear (fibre) and dot (powder) structural elements simultaneously. Depending on a ratio of the sizes of fibrous and powder particles, and the thickness of fibrous and powder layers, as well, their characteristic can shift towards both porous fibrous and porous powder materials.

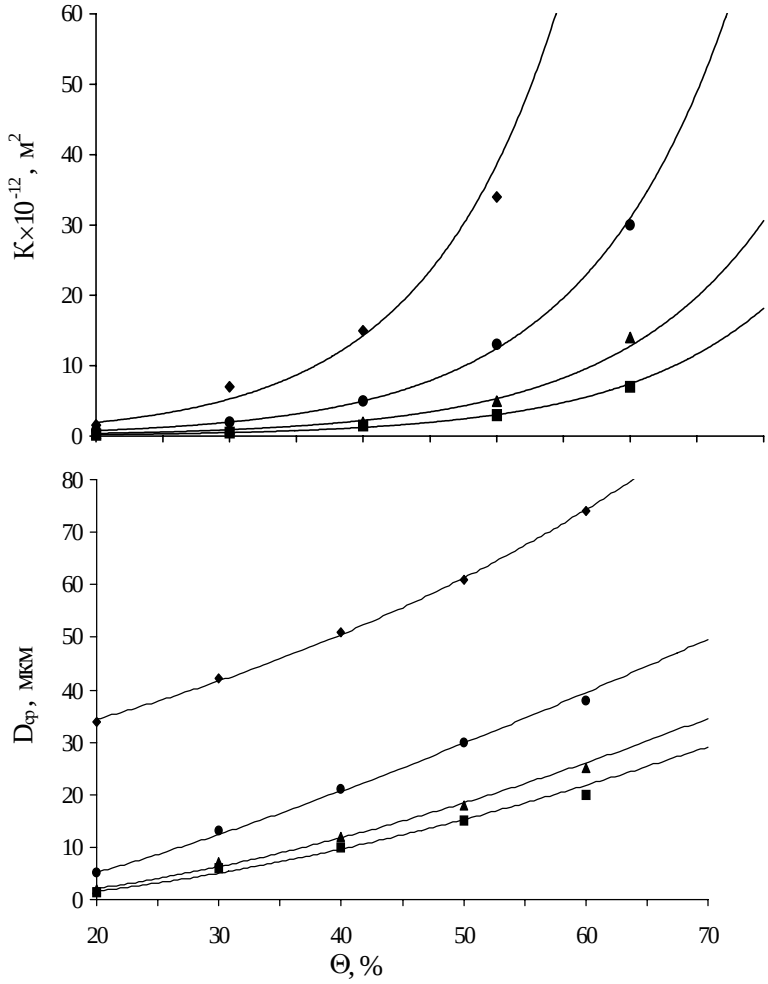

Fig. 1. Dependence of factor of permeability and medium-sized of pores from porosity of one and two-layer materials from metal fibres and powders ◊ - Layer from fibres ∅50 microns; • - Layer from fibres ∅ 50 microns and a layer from a powder dispersiveness 60 … 80 microns; ∇ - Layer from fibres ∅30 microns and a layer from a powder dispersiveness 60 … 80 microns; □ - Layer from a powder dispersiveness 60 … 80 microns

For example, the material containing a fibrous layer of 50 microns in diameter and a layer from a powder with dispersity 60 … 80 micron and porosity of 60 %, in comparison with a single-layered material from the same fibers possesses the pores of 2 times smaller size, and in comparison with a single-layered material from the same powder - 5 times larger permeability. The developed compositions can contain a layer from fibers of 30 microns in diameter with the maximal and average pores size 100 and 45 microns and a layer from a powder with dispersity 40 microns, with the maximal and average pores size 9 and 2 microns, accordingly, the sizes providing a high gradient of the pores size along the thickness of a material (fig. 2).

In fig. 3 dependences of the module of elasticity of actually fibrous, layered and frame fibrous-powder compositions from stainless steel against their porosity are submitted.

Microdeformation of the materials was studied basing on the results of tests of samples for a bend under the four-dot circuit by test machine " CERAM " [4]. With increase of porosity (fig. 3) conductivity and elasticity of researched materials is reduced. Thus, actually fibrous materials surpass on electrical conductivity and elasticity the layered fibrous-powder compositions in all range of change of porosity, the frame materials - only in the field of high porosity (more than 60 %).

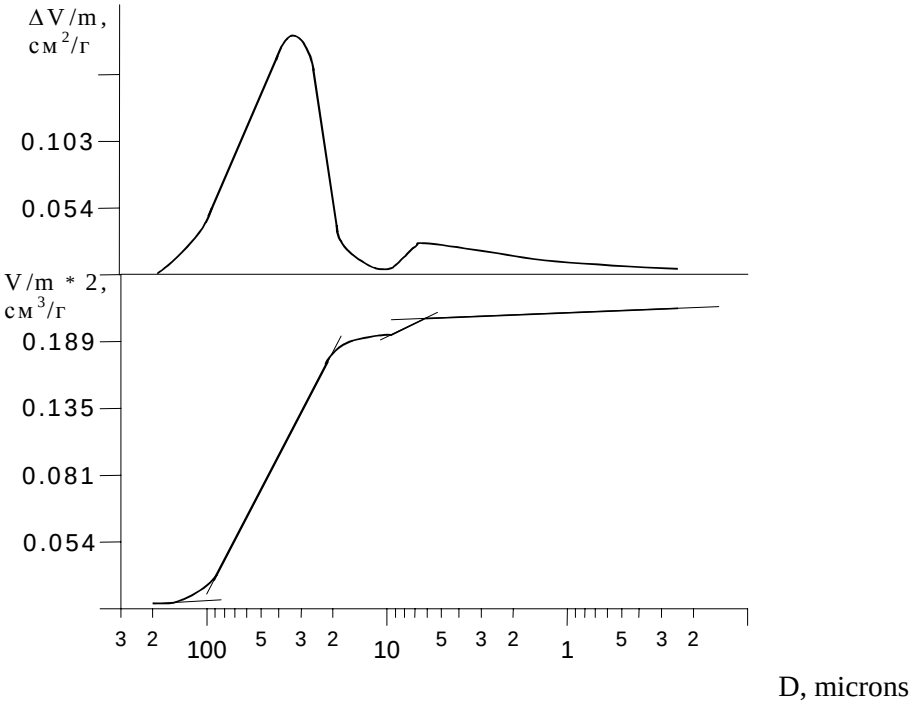

Fig. 2. Differential and integrated curve distributions of pores in a material porosity of 64 %, containing a layer from fibres ∅ 30 microns, thickness of 1,5 mm and a layer from a powder dispersiveness 40 microns, thickness of 0,5 mm.

Difference in elasticity of the materials studied is caused by both different mechanisms of condensation, and their design features.

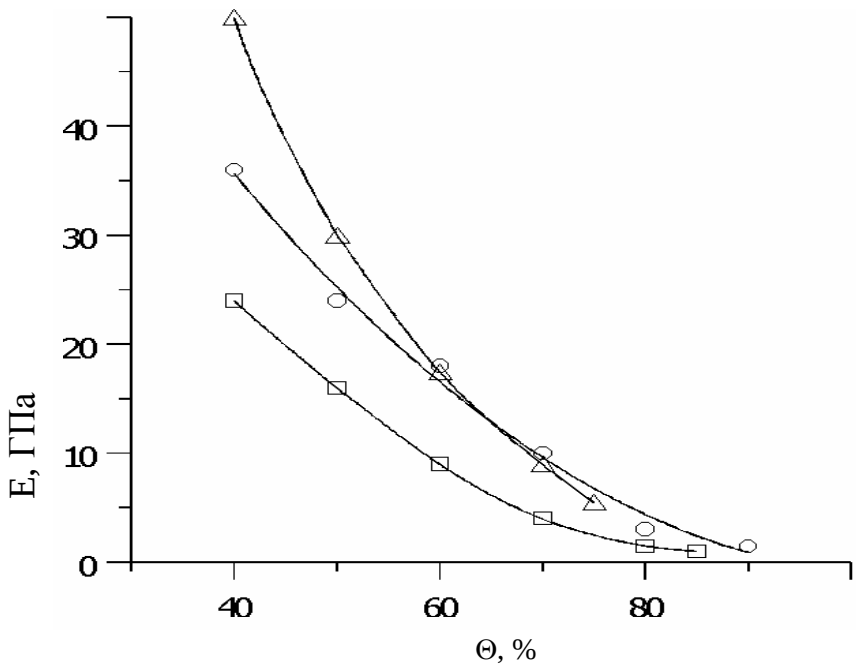

Fig. 3. Dependence of the module of elasticity fibroporous, layered and frame fiber-powder compositions from porosity
∇ - Layer from fibres ∅ 40 мicrons, filled with a powder dispersiveness 40 microns; O - Layer of a fibre
∅ 40 microns; □ - Layer from fibres ∅ 40 microns and a layer from a powder dispersiveness 200 microns

Compositions as high-porous fibrous skeleton, partly or completely filled with a powder, porosity more than 60 % insignificantly concede in elasticity to actually fibrous materials. The basic loading in such materials perceives a fibrous skeleton. With decrease of porosity of materials good contacts form not only between fibers, but also between fibers and powders. Frame compositions have a higher elasticity than fibrous materials. Effective tubular filter-elements of already all sizes can be produced from such materials by bending and welding.

CONCLUSION

As a result of research the sheet composite materials consisting of metal fibers and powders, with effective porous structure and elevated strength characteristics are developed. Materials of such type can successfully be used for a thin filtration and capillary transport of various liquid and gas environments..

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References

1. Тумилович М.В., Косторнов А.Г., Леонов А.Н. и др. Пористые волокново-порошковые материалы на основе меди. Порошковая металлургия, 1992, № 3, с. 56-60.
2. Витязь П.А., Шелег В.К. , Капцевич В.М. и др. А.с. № 1014657 СССР. Бюл. изобр., 1983, № 16.
3. Леонов А.Н. ,Тумилович М.В. , Косторнов А.Г., Шелег В.К. Пористые порошково-волокновые материалы на основе меди. Порошковая металлургия , 1997, № 9-10, с. 23-28.
4. Фирстов С.А., Шлесар М. Структура и прочность порошковых материалов. Киев: Наукова думка, 1993, 170 с.
5. Косторнов А. Г. Проницаемые металлические волокновые материалы. Киев: Техника, 1983, 128 с.