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The Composites materials Type Carbon –Aluminum Alloy

GULEVSKIY Victor Alexandrovich[a] , SHTREMMEL Svetlana Andreevna [b] , KIDALOV Nikolay Alekseevich[c] , KORSHUNOV Sergey Sergeevich [d], YUDIN Alexander Alexandrovich [e], ERIZHIPOV Aydabek Migrimbaevich [f], GUNDROV Oleg Yurievich [g]

Department of Machines and Technology of Foundry, Volgograd State Technical University, 400005, Volgograd, ave. Lenin, 28, Russia

[a]gulevskiy.v@mail.ru, [b] lana_shtremmel@mail.ru , [c] nich@vstu.ru , [d]melkii95@bk.ru , [e] sashok-08@mail.ru, [f] erizhipov@mail.ru , [g] gundrov96@mail.ru

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Abstract.

The article contains technology of producing of carbon-aluminum alloy type composite with using non-autoclave (gasless)way of impregnation carbographite skeleton by matrix aluminum alloy. The article shown the results of the tests, the scope and the evaluation of the properties of the obtained composites.

Introduction

An extremely promising area of creating a high-performance composite of functional purpose is the development of composite materials (CM) based on the porous carbon graphiteskeleton, impregnated with metal alloys with high chemical resistance and good anti-friction properties. In this CM the properties of carbon graphite skeleton (elevated antifriction characteristics, resistance to high temperatures, chemical resistance, etc.) combined with the properties of metal (high strength, good electrical and thermal conductivity) [1].

While carbon graphiteframe provides the increased antifriction properties, matrix alloy significantly improves physical and mechanical characteristics of the material. Among other matrix alloys very attractive from the point of view of technical and technological capacities are aluminum alloys.

Leading manufacturers of composite materials "Ringsdorf" (Germany), "Schunk" (Germany), "Morgan" (United Kingdom) "Mersenne" (France), do not include the range of its products materials impregnated with aluminum-based alloys, as evidenced by the tables and avenues of firms. However, the prospect of the use of these composites is obvious.

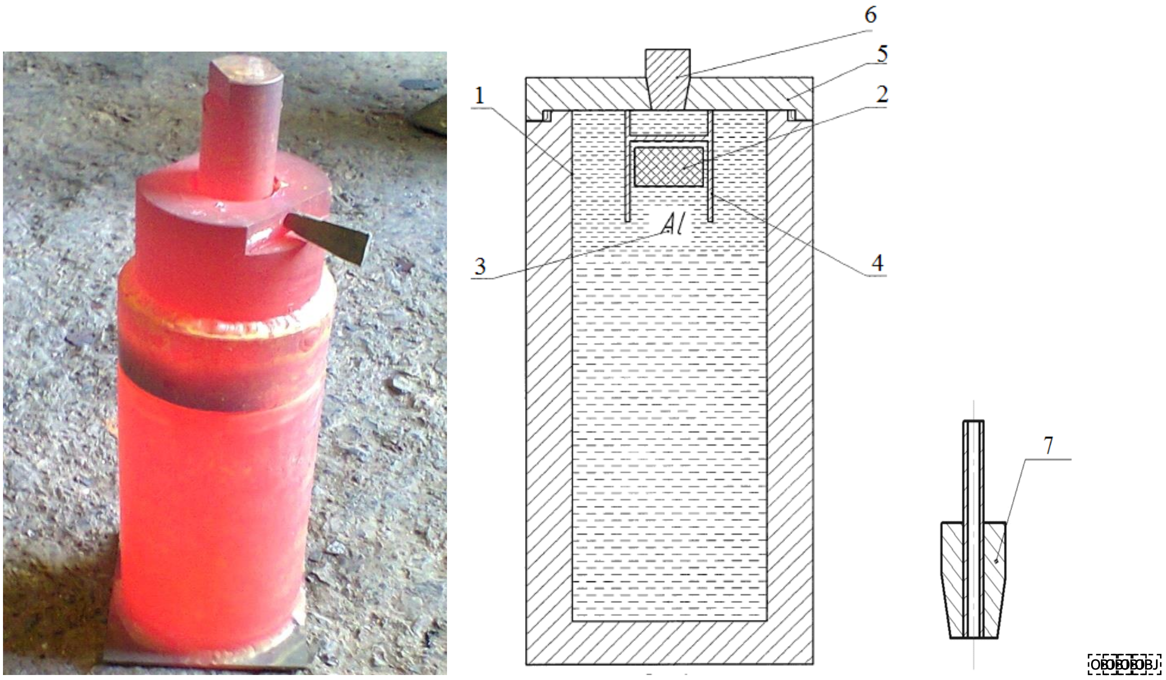
Experiment

This study focuses on the impregnation of carbon skeletons by alloys based on aluminum. The impregnation tank (Figure 1) was implemented in the form of a thick-walled cups made of The titanium alloy VT1-0. For impregnation process a porous carbon billetsinstalled, covered this antiflotation device and heated up to 600 °C.At this time the matrix aluminum-based alloy heated to a temperature of 950°Cin melting pot. Then matrix aluminum-based alloy poured in camera of impregnation, capped and vacuumed up to a pressure vacuum of 0.01 MPa with simultaneous exposure to vibration (flow table) during 15-20 min at 800 °C. Then matrix alloy with temperature 950 °C filled up to the top edge of thedownsprue with the advent of this part convex meniscus of matrix aluminum-based alloy, and sealed by cork preheated up to 950 °C. Filling of the camera with aluminum melt lets to create optimal pressure for impregnation due to the difference of thermal expansion coefficients of the camera to create pressure and melt of aluminum [2].

Under the proposed method, the CM carbon graphite AG-1500-aluminium alloy was obtained. Sample of carbon graphite was executed in the form of a cube with a side of 30 mm, has an open porosity of 15%. Volume of carbon graphite skeleton is 900 mm^3, pore volume in the frame is 135 mm^3.

Thus, impregnation has two stages. On the first stage, there is the partially filling of open pores of the carbon billets. Aluminum-based alloy steps into the pores of the carbon skeleton due to pressure of vacuum and vibration. At the second stage of impregnation the pressure is increased and the alloy penetrate deeply and fills an open porosity due positive difference coefficients of thermal expansion of aluminum alloy relative to steel - device material (Figure 2, 3).

Advantage of impregnating by alloys based on aluminum are the best opportunity to increase strength, hardness, improve wear resistance material. Aluminum has high corrosion resistance in many aggressive environments, good anti-friction properties.



a) b)

a- after impregnation; *б*– diagramofagas-freeimpregnationdevice*1* – impregnation chamber, *2* – porouscarbonfiberblank,*3* – aluminum matrix alloy, *4* - device, *5* – cap, *6* – stopper,*7* – gas stopper.

Fig. 1.Tank for production composite material with a stopper for sealing containers

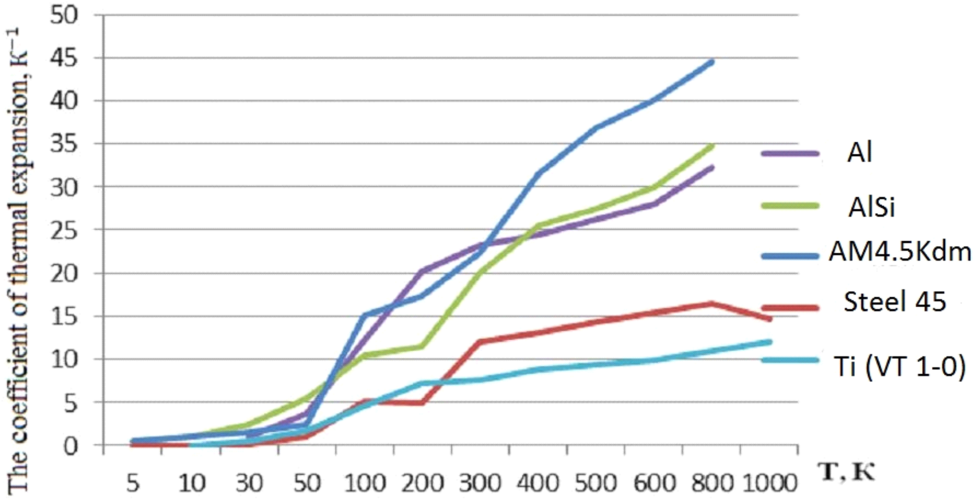


Fig. 2.Dependence of the coefficient of thermal expansion of metal from temperature

Results of Research

Obtained CM was tested for compressive strength, the degree of filling of open pores, the structure of the CM was evaluated based on the results of metallographic studies (Table 1).

Table 1- Researchresults

Measuredparameter	"АГ – 1500", Russia [4,6,7]		SIGRI, Germany [4,6,7]		*CG365"ElectrocarbonTopolcany"*, Slovakia	
	graphite	graphite+Al	graphite	graphite+Al	graphite	graphite+Al
Density[kg/m^3]	$1{,}78 \cdot 10^3$	$2{,}15 \cdot 10^3$	$1{,}63 \cdot 10^3$	$2{,}03 \cdot 10^3$	$1{,}68 \cdot 10^3$	$2{,}10 \cdot 10^3$
Strength [MPa] compressing	80-100	170	80…90	150	70…80	145
bending	35-37	65-75	18…20	38	28…30	50
Hardness[HB]	104	213	20…25	40…45	50…55	84
Totalporosity[%]	18	4	25	6	20	4

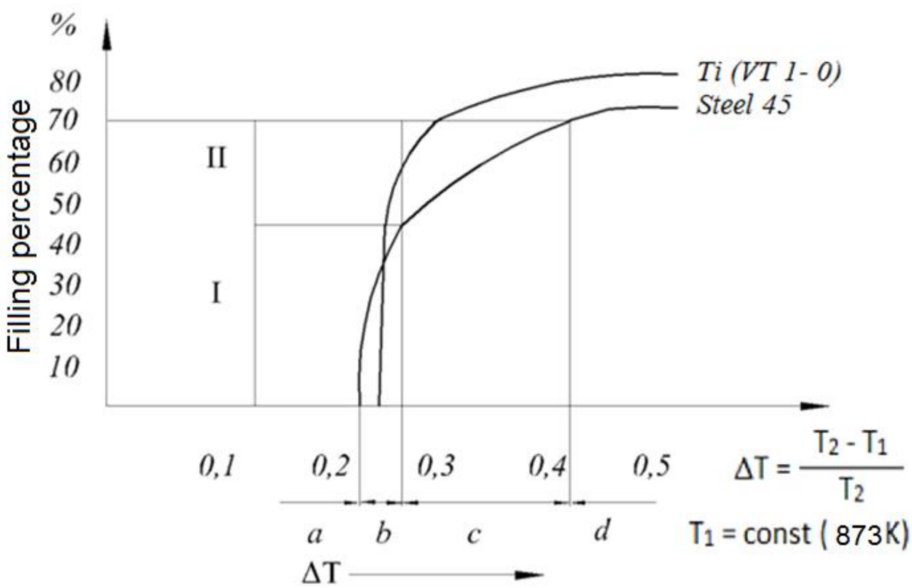


Fig.3.Dependence degree of filling carbon by aluminum alloy from the magnitude of its overheating

At the station (a) laid the range of temperatures at which overheating of the alloy corresponds to a pressure not exceeding backpressure in the pores of carbon graphite frame, so there is no impregnation(Figure 3).. On the area b-I take place effective filling of pores carbon graphite by impregnating alloy, due to the creation of the necessary conditions for the impregnation, i.e. it corresponds to a pressure exceeding ΔPy - capillary pressure. However, the difference of pressure values let fill thepores larger than 30 microns, the pores in the range of 30-60 microns are of about 48% of a total volume of open porosity, this can explain the sharp increase in the degree of filling (Pz) carbon graphite by alloy at area (b-I), although the quantities pressure is still insufficient. For complete filling of carbon graphite, the pressure was increased. As a result, on area c-II is done filling the pore sizes 0-30 microns, 60-150 microns, which are of about 15-20% and 25-30% respectively of a total volume of open porosity. which alloys to 60-80% of the optimum filling open porosity of skeletal CM with the required physical and mechanical properties, and does not concede on this indicator, the main foreign analogues. On the area (d) noted a marked decrease in intensity of filling from the increase of impregnation pressure, which depends, moreover, on sizes remaining unfilled pore and their distribution, branching, surface roughness, etc.

Practical application

From the technological point of view, choosing aluminum alloy as impregnation alloy, we prefer a modified silcumin (alloy of aluminum and silicium doped by nickel and chromium (2555737 Patent of Russian Federation, MPK C22C21/02, C22C49/06, C22C101/10. Casting aluminum-based alloy for obtain composite materials by impregnating of carbon graphite frame). This group of alloys have excellent casting properties such as high yield, good capacity, and minimum linear shrinkage. Wherein technology of alloy modification by dope it by various element is available and has been received precisely in the process of impregnation, and moreover, it can be improved to get the best combination of properties of the alloy.

According to expert estimates the composite materials of type "porous carbon graphite -aluminum alloys" is very promising when it uses as inserts radial and thrust bearings, guide bushings, plates, piston rings, brushes, current collector elements, elements of mechanical seals in machine-building, instrument-making, as well as technological equipment for chemical and petrochemical industry [8].

Using as a matrix alloy - aluminum alloy and as a porous billet - carbon graphite or ceramic allows to obtain composite materials, which are widely used in machinery to produce current collectors, pantographs inserts, electric toothbrushes, sealants, liners, bearings use which is very diverse and includes not only the above listed articles, but also details of aerospace grade [9].

Carbon brush which slide on electrical contact, carries current from or to the moving surface. Brush performs this function within limited mechanical system. Unlike most of other electrical contacts, brushes require more frequent replacement, resulting in longer wear of the brushes, the crucial question. Brush wear out under the influence of a combination of mechanical wear and tear as a result of friction and electrical wear due to excessive contact resistance at the surface (arcing).For a quantitative assessment leads to the tear as a result of friction and cause of mechanical wear of the brushes and the voltage drop is the primary indicator of electrical wear. At any time during operation, carbon brushes wear out as mechanically so electrically simultaneously. Therefore, the overall wear is the sum of the mechanical and electrical wear. It is also important to note that there is often a slower pace of wear with the highest permissible pressure on the brush. The general recommendation is to reduce pressure until the arcing becomes visible, and then increase of the pressure should be adjusted to the next degree. Many of the previously published literature indicates that this ideal pressure range is from two to three pounds per square inch square brushes (90-135 g/cm^2) [10].

The main foreign producer of electric brushes is company "Elektrokarbon". They produce brushes for different international companies such as BOSCH, Makita, Hitachi, Hilti, etc. [6]. Most of these brushes are standardized and only marginally differ by geometrical dimensions, which can be attributed to higher quality products. Brushes produce for different household appliances and industrial machinery.

There are several types of brushes such as: metal-graphite, electro graphite, graphite, associated with resin, carbon-graphite. Metal-graphite (impregnated) brushes are used in more responsible sites and different mechanisms. From this it follows that appropriate and feasible will use brushes made from composite carbon-aluminum alloy, in view of the above positive features CM.

In the current trolleybus collector used contact insert different designs: profile form flange, cross-sectional configuration on the length and shape of the plan, as well as material: carbon-graphite, metal and ceramic-metal. Applicability (demand) of one kind or another type of pin inserts is defined as their technical characteristics: abrasion resistance, mechanical strength, electrical conductivity, sparking intensity while ensuring the durability of the contact wires trolleybus lines, and their cost, which is often decisive for the consumer. However, despite these constructive differences, and differences in the use of materials (compositions) in the producing of contact inserts, can be isolated the general constructive sign of inserts: single-layer [11].

It's known the method of improving the contact insert (patent for utility model No 160301 (RF) Contact insert of current trolleybus collector (Gulevskiy

V.A., Chernichkin E.E., Gimbatov P.D., Mosin N.A., Vatanskii V.A., Kidalov N.A. ; published 10/03/16-BI № 25) (Figure 4)..

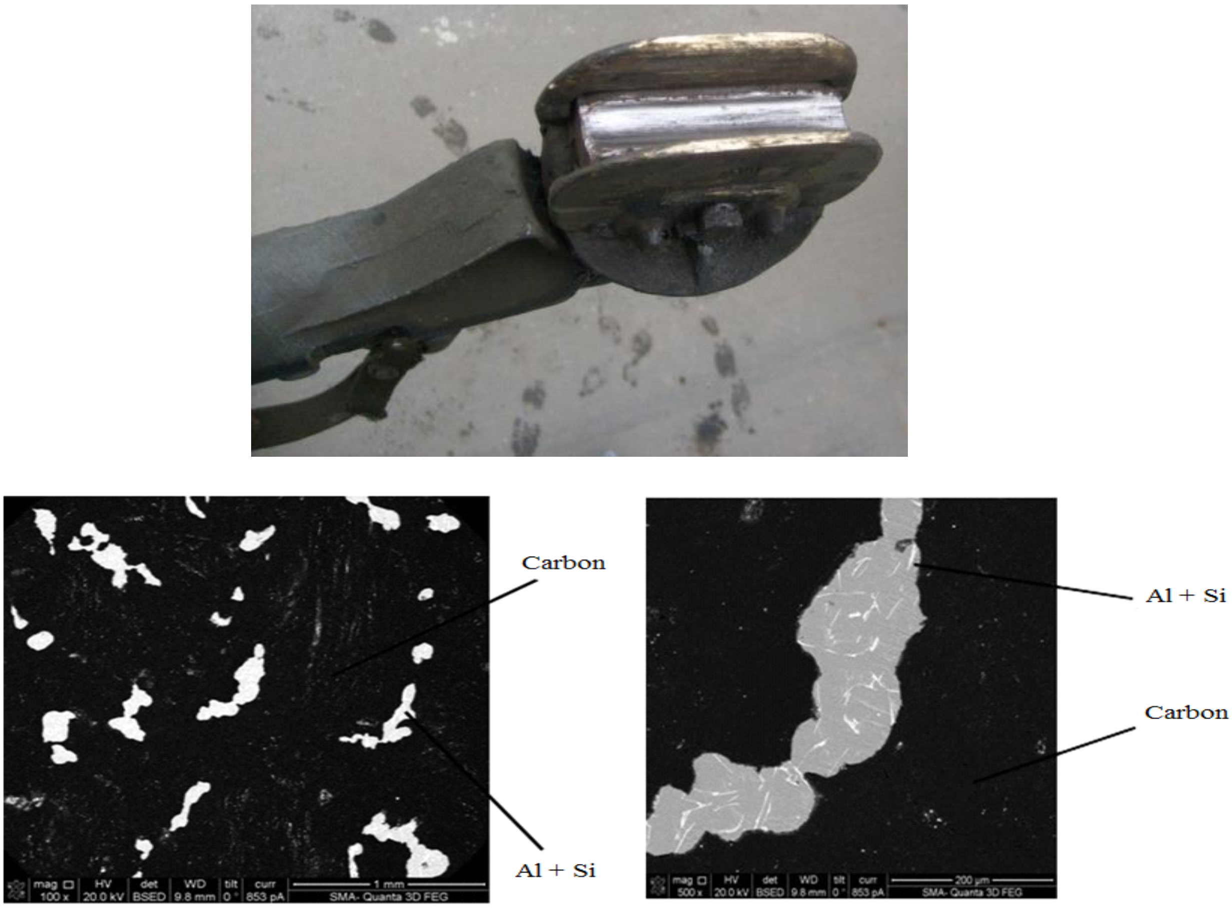


Fig.4 - Testing of a carbon-graphite insert of a trolleybus pantograph impregnated with aluminum alloy

Method consists of the following: electrically conductive copper element placed in the working part of the insert. This design ensures reduced electrical resistance of contact layer in 2-3 times while maintaining durability and high lubricating properties, as well as the durability of the wire contact lines.

It would be appropriate to improve the construction of contact brushes by impregnating of the working layer by aluminum alloy for increasing strength, electrically conductive and antifriction properties. Aluminum is not significantly inferior to copper in electrical properties, as its share in the composition of CM is only 15%, and thus it has better casting properties. In this direction, we conductre search work.

In addition, the application of the method of gasless impregnation can significantly reduce the cost of composite materials due to the use of equipment of conventional construction materials. Because of low cost snap-ins, can make a large number of tanks for impregnation to organize serial or mass production of composites

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