MASSIVE COMPOSITE MATERIAL ON THE BASIS OF IRON.

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The massive composite material on the basis of iron is created by broach bit of a metal matrix a flow of powder particles. Process of broach bit is executed in a condition of superdeep penetration (SDP) and ensures introduction of powder particles at speeds of ∼1000 m/s on depths in hundreds millimeters. Due to processes of interaction between particles and Fe matrix at pulsing pressure from above 8-12 GPa the volumetric strengthening skeleton is synthesized.

INTRODUCTION.

Massive steel composite materials are traditionally made by methods of casting or powder metallurgy. As a rule, heightening of a level of physicomechanical properties of these materials is achieved at substantial increase of concentration of doping elements and strengthening structures. This technical approach need’s greater material and power expenditures and, substantially, has exhausted the opportunities. By manufacture of composite materials on the basis of plastics and cloths materials the method of stitching is widely used. Iron and its alloys have durability which considerably exceeds durability of plastic and fabrics. Therefore it seemed impossible to use technique of the stitching of the iron matrix. However, in space dust bunches stitch protective screen with widths in tens millimeters. In a condition of superdeep penetration (SDP) the flow of powder particles with speeds of ∼1000 m/s stitches solid steel billet on depth in hundreds millimeters [1]. Particles of a powder material at driving in a solid body are needles and strengthening cords simultaneously. In conditions SDP the energy of interaction is localized in narrow (microns) and lengthy (tens and hundreds millimeters), so-called channel zones.

As a result of impulse operation there are boundaries of section between zones high (≥8GPa) and low pressure (≤0.8 GPa). Conditions in zones of high and low pressure differ so considerably, that properties of materials of these zones made of iron, sharply differ among themselves. The entered substance concentrates in channel zones (the zone of high pressure). As a result at stitching in the pulse regime on the basis of solid steel billets the typical composite material is created. On the basis of solid steel billets from HSS the composite tool material, with a level of properties on tens - hundreds percent differing from a level of properties of initial steel [2] has been created. In this case, apparently, there is no direct communication of mechanical behaviors and concentrations of doping elements.

The purpose of the given research is definition of the reasons of reinforcement of a steel composite material at SDP.

EXPERIMENTAL RESEARCHES.

Feature of the steel composite material received in condition SDP, is significant differences in chemical and electrochemical potential between the material of strengthening filaments and the iron matrix. Though basis of the composite material is iron it is possible to determine strengthening zones and to evaluate their volume part. Depending on condition SDP the portion of strengthening filaments can be ~ 1 volumetric %. Concentration of in addition entered substance in iron and its alloys at SDP has increased thus on 0.001-0.1 masses % only. At use of powders from borides in material of the zone of high pressure acquires the heightened chemical stability. Experiments on research of the fiber elements created in a barrier have been executed (carbon ≈0.45 %) at introduction in condition SDP of the flow of particles NbB. At preparation of exemplars the material of these zones appears above surface microsection and is visible as light filaments (Figure 1). As boron (B) by means of a microprobe was not determined. This analysis had semiquantitative character. Results of the analysis of elements of structure have displayed, that the fiber consists basically from Fe-
Mn-Nb. Concentration Mn from the center of the fiber to walls of the channel is diminished in 13.7 times, and concentration Nb is diminished in 23.5 times. Unexpected there was heightening of Mn concentration in strengthening skeleton of steel composite material up to 33 masses. %. In an initial matrix density Mn did not exceed 0.01 %, and Nb and Ti were absent.

Average concentration Mn in the composite material was augmented more than in 10 times. This element which almost was absent in host materials, has been localized in a material of the skeleton.

For inspection of this anomaly the mass spectrometer analysis has been executed. In fibers (channel zones) has been detected $^{55}$Mn or $^{55}$Fe. Uniquely to determine, what chemical element was the basis for creation of the skeleton in the composite material, at the given stage of researches it was not possible.

Anisotropy of mechanical properties of a massive composite material was defined by that density of strengthening structural elements in a longitudinal and cross-section direction differed among themselves in 2-3 times.

The tool composite material with matrix from steel HSS (6%W, 5 %Mo) after introduction in condition SDP of flow of particles TiB$_2$ of fraction 10-14 mkm and heat treatment had equal hardness with initial steel (64.5 HRC). Wearing capacity under the same conditions at this material was in 1.8 times above, than at matrix steel. If it is possible to explain this heightening of wearing capacity only influence of material of the skeleton the skeleton should have wearing capacity at level of a hard alloy. Research has displayed, that in volume of the matrix in addition there are zones of influence localized around of a skeleton. The material of these zones does not differ from initial matrix on a chemical compound, but has the physico-chemical properties essentially differing from initial matrix.

Changes have occurred due to decrease of elements from initial structure up to nano and micro level. These changes of structure, for example, activate interaction with solutions of acids. The part of activated material of the steel matrix was ~ 15 volumetric %.

THE CONCLUSIONS.
At broach bit of steel matrix the stream of powder particles in condition SDP forms Fe massive composite material. The strengthening skeleton (~ 1 volumetric %) consists of products of synthesis of the entered and matrix material. The important component of strengthening structural element is the isotope not defined definitely - $^{55}$Mn or $^{55}$Fe. Concentration of the isotope in strengthening fiber achieves 33 masses. %. The composite material is in addition strengthened by zones of influence (~ 15 volumetric %), representing crushed up to micro and nano levels the initial steel matrix.

THE LITERATURE