MASSIVE COMPOSITE MATERIAL ON THE BASIS OF IRON.

Oleg Figovsky [1] ,Sergey Usherenko[1],Sobolev Valery[2]
[1] Israel Research Center Polymate, [2]National Mining University of Ukraine.
[1]figovsky@netvision.net.il,[2] valeriysobolev@rambler.ru

KEYWORDS: **STITCHING, SUPERDEEP PENETRATION, ZONES OF INFLUENCE, SYNTHTSIS, CARCASE.**

The massive composite material on the basis of iron is created by stitching of a metal matrix by a flow of powder particles. Process of stitching is executed in a condition of superdeep penetration (SDP) and ensures insertion 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 higher than 8-12 GPa the volumetric reinforcing skeleton is synthesized. In an iron matrix the reinforcing carcass has the raised concentration of stable isotope (≤33 masses. %) - ^{55}Mn or ^{55}Fe.

1. INTRODUCTION. Composite materials allow to realize a complex of various properties which cannot be realized in monomaterial [1]. The perspective for reception a new material is determined by possibilities which create conditions of processing. If to consider narrower group of composite materials, for example fiber materials, process of manufacture can be divided on three basic stages. To the first stage it is necessary to refer sampling and preparation of massive matrix material. Sampling and manufacture of filaments for reinforcement a composite material is refer to the second stage. Process of assembly of composite material from elements that made at first two stages of process refers to the third stage. At each stage of manufacture process of a composite material there are specific problems. The basic problem in creation of composite material, as a rule, is essential conflicts between engineering solutions for various stages of process.

The solution of a problem of obtaining a fiber (reinforcing) material with properties essentially distinct from a matrix material was creation of micro - and nanomaterials [2]. In micro -and nano state the material has the properties which are essentially distinct from properties of this material into macrolevel. It is possible to produce composite material with macro zones at various structural levels.

Earlier materials on micro- and nanolevel were created on the basis of a regrouping of traditional production engineering. Now we observe occurrence of new methods of refinement - new physical tools. However, successfully solved a task of the second stage - having created materials with structure on micro- and nano level, we have unexpectedly received a serious problem at the third stage of process. As a rule, the third stage of process assumes thermal process. Such process provides strength of contact between elements into composite material. If all structural elements of a composite material have equal or nearly so identical chemical compound at heating strong connection between these elements is realized.

The basic conflict during manufacture of massive material from nano and micro powders is that raise of intensity of heat treatment leads to growth of strength of connection between elements of a composite material and, simultaneously, initiates increase in the sizes of elements of structure into reinforcing component. The increase in the sizes essentially changes physical and chemical properties. Therefore simple addition of engineering solutions, characteristic for each stage of process of reception of composite materials, appears not effective.

A raising level of properties it is possible to achieve by transformation of iron or steels into the massive composite material that modified in volume by micro and nano elements of structure. Manufacture of a composite material on the basis of a matrix with micro and nano structure, now, economically is not justified. If nano- and microstructure is shaped only in reinforcing zones or fibers then basic problem is the common strength of a composite material. At the traditional technological approach (sintering) in powder metallurgy heating of a material initiates fast growth of the sizes of structural elements and lowering of mechanical properties. It can be observed on an example of decrease of impact resistance. There are also problems with a production efficiency of new materials.

It is possible to receive a massive composite material due to action on a base material, for example steel, by intensive alternating-sign strains and greater gradients of pressure and temperatures. However, refinement of elements of structure (increase of defectiveness) a tool material, is restricted by initial strength of a matrix material, ability to eliminate strains without cracks. These ideas are reasonable for realizing in manufacture of composite materials from metals or metal alloys. Manufacture of massive preforms with nano and a microstructure is possible. Were used methods of an intensive plastic deformation (torsion under quasi-hydrostatic pressure and equally channel angular pressing) and reception in massive of metal nano- and micro structures using electric discharges in melts [3].

Impulse loading of metals it is characterized by external physical effect of various factors on a real body (volumetric and surface forces, temperature, an irradiation, etc.) which differs with short time of operation. Intensity at loading can be very high. Then the loaded solid body will be destroying. At impact and explosive effect in a material the areas of perturbation with the complex is intense-deformed condition, metastable structures are formed. Dynamic hardening promotes formation of redundant amount of defects in crystalline structure.

The high pressure in a solid body is not a primary factor of structure grinding. The more gradient of efforts in a solid body and the greater heterogeneity of the material forming this solid body, the higher probability, that in a material the local strains are created and the structure is crushed. The important factor influencing on impact grinding of structure, is the time of process. Occurrence of fluctuations in a solid body at impulse processes, and also gradients, energy, pressure, temperatures, strains, etc. is a rule, instead of exception. It dynamic processes differ from static processes [3].

The maximal changes in properties of materials can be received by using of physical tools which ensure simultaneously multiple-factor action on a material. In usual conditions high-energy ions, passing through substance, spend energy for braking and destruction along a trajectory of driving into a material. When experiment with an irradiation have combined in time with a loading the material by high pressure then the picture has appeared unusual. Reorganization of structure of a material (phase transition) [4] was observed and graphite became amorphous. Experiments with metallic zirconium have confirmed, that at combined action of an irradiation and a high pressure there are also structural transformations. The irradiation with heavy ions plays a role of the catalyst of structural transformation if the substance is under pressure. It is logical to assume, that due to this physical effect it is possible to create micro - and nano materials with new characteristics inside of a solid body.

The physical phenomenon at which are combined intensive electromagnetic radiation, a strain, pressure at a level of tens thousand atmospheres is known. This phenomenon has received popularity as superdeep penetration (SDP) or effect “Usherenko”. The clot of a dust in a range of conditions SDP gets into barrier on depths in tens and hundreds millimeters. Feature is that at usual impact the ratio of depth of penetration to caliber (the defining size) striker does not exceed 6-10. In SDP resistance of a material of a barrier to driving in it particles of a clot decreases in hundreds and thousand times [3]. SDP in an automodelling regime allows to realize stably the penetration of particles into a solid on depths in 100 -10 000 calibers. In conditions of superdeep penetration dust particles penetrate barrier, form in them length (tens millimeters) channel formations with a cross-section of channels in a range 10^{-4}-10^{-1} from striker caliber. Within the limits of SDP it is simultaneously possible to realize the big complex of physical effects: a high pressure, an intensive strain, electromagnetic fields, streams of ions, a dynamic doping and synthesis.

For 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 clots 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 [3]. Particles of a powder material at driving in a solid body are needles and strengthening cords simultaneously. In conditions of 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 action there are boundaries of section between zones of high (≥ 8GPa) and low pressure (≤0,8 ГПа). 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 [5] 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.

2. FEATURES OF DYNAMIC REARRANGEMENT AT SUPERDEEP PENETRATION.

Qualitative difference of process of creation of composite materials with use of effects of superdeep penetration from traditional powder metallurgy is that a high-speed clot of discrete particles (powder) is the basic physical tool. A matrix at SDP is the massive compact material with high initial strength. At a loading of solid metal body with small speed (static conditions) in a body there is a uniform field of pressure. In static conditions create pressure up to $\leq 10^5$ N/m^2. Assumed, that at extending of waves of perturbation and shock waves all volume of a barrier during impact has pressure up to level $\leq 10^9$ N/m^2 [3]. On figure 1 shock interacting between a striker and an obstruction at which there is a pressure in metal preparation is shown. When the scheme (fig.1) of distributions of area of high pressure is realized, then it is impossible to create a composite material on the basis of iron and a lean alloy steel.

Let's consider real experiment on shock interaction. We use a known method of registration of area of a high pressure due to change of structure and physical and chemical properties of a material of a barrier. For approximation to real geometry at impact the surface of steel preform was deformed preliminary a steel sphere with a diameter with 30 mm. As strikers

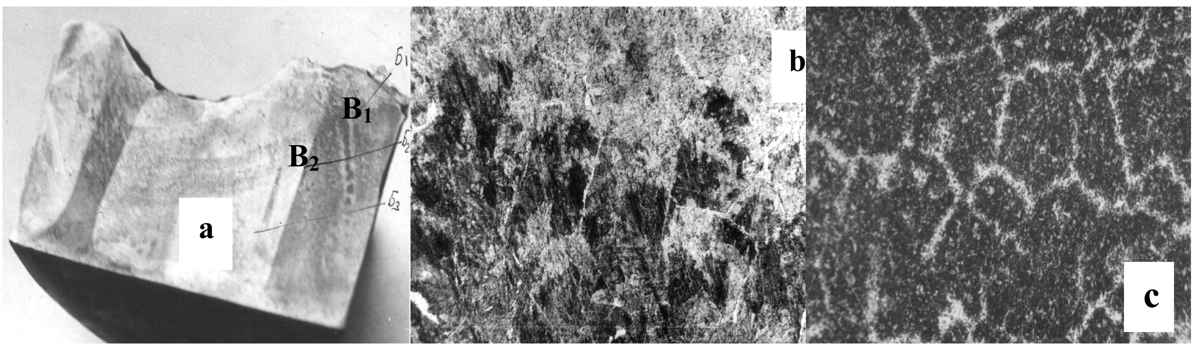


Fig.2. Distribution fields high pressures at impact: and a - × 1;b - boundary of section of areas of high and low pressure, ×200; c - subdivision of elements of structure of area of the high pressure of steel barrier at heat (1000^{o}C, 1 hour), ×200.

we use clots of powder particles. After impulse processing steel preform (density of carbon ≤0,45 mass %) cut it in longitudinal plane, polished a surface and processed an etching solution of nitric acid. Photographic registration (dark zones) for areas of a high pressure is shown at figure 2. The average level of pressure into massive steel barrier is 0,2 - 1 GPa. Thus in dark area of section the barrier of level of pressure more than 8-12 GPa is realized.

Between macro areas of high and low pressure the sharp boundary (fig. 2b) registers. It is possible to confirm, that in volume of a metal solid body at impact by clots of dust (powder) particles (in regime of superdeep penetration) simultaneously there are macro areas low and a high pressure. The area of a high pressure in volume of solid body is enclosed by area of low pressure. The length of area of a high pressure (oscillating soliton) corresponds to thickness of a barrier. Impulse act on a steel barrier is executed in a regime of superdeep penetration by a clot of particles of a powder. Therefore in the processed steel barrier registered the tracks organized by particles at penetration.

Tracks have been detected in areas with a different level of pressure. It, apparently, proves, that areas of a high pressure arise, as rather independent effects. It is possible to show, that the area of a high pressure is area of a material with the increased level of defects. For the proof of this assertion a metal solid body after SDP processing heated at temperature 1000^{o}C in current of 1 hour. After these operations compared structures for areas of high and low pressure. Qualitative difference in behavior of materials of these zones was revealed at heat treatment. Difference is that in structure of a zone of a high pressure after heating up the assemblage of dot defects was observed, crushing of grains, emersion of the numerous centers a recrystallization. Growth of grains (fig. 2c) took place after development of imperfections of structure (recrystallization). Therefore concretion of grains in time is decelerated. In the field of low pressure of grain of a material of a barrier at heat are integrated at earlier stage (in time). Therefore stability of steel at heat (red-hardness) in the field of a high pressure is more significant, than in the field of low pressure.

3.INVESTIGATION OF SUPERDEEP PENETRATION (SDP).

The first experimental *condition* of superdeep penetration process was formulated. The craters with a depth-to-striker size ratio of above 6÷10 are recorded at collision of the barrier with a stream of strikers having the sizes less than 500 microns [3].

Second experimental *condition* of SDP is the presence of a band of impact velocities. Impact velocity cannot be lower than the velocity of superficial perturbations at the barrier's surface. For the impact velocities higher than the velocity a shock wave passing in the barrier material, the strikers, at first, are broken according to the known mechanism and only then they are in SDP regime.

Third experimental *condition* of SDP is existence of a stage of preliminary formation of a compressing pressure in a barrier material.

Consideration of qualitative, semi-quantitative, and quantitative aspects of SDP allows us to know this unusual process. For SDP, the hardness of a striker material does not affect

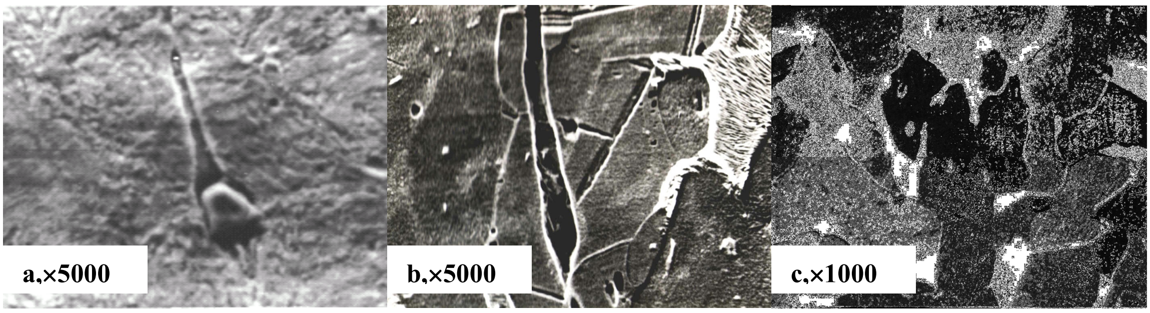


Figure 3. Zones of interaction of particles and a steel matrix (≤ 0,45 %C): a - the rest lead (Pb) striker; b - a channel zone from VC; c - a trajectory of driving of lead particles in iron.

essentially a penetration depth. In Fig. 3a, the zone of a retardation of a striker, made of highly plastic material (Pb), is shown.

At comparison with usual and abnormal craters it becomes obvious that for SDP the visible diameter of the channel is always smaller than an initial size of a striker (Figs. 3 a,c).

The shown diameter of the channel is called the transverse dimension of a penetration trajectory (penetration zone) which can be seen after polishing and etching processes of a metallographic specimen. By using, as a striker, very hard ceramics (VC) particles, the same symptoms of superdeep channel formation were observed (Fig. 3b).

Similar character of channels formation (zones) at macroimpact is observed for a shot into elastic material, for example, into rubber. In this case, the zone of a puncture (channel) completely collapses under action of pressure forces. The fragment we can see as the longitudinal cavity (Fig. 4) has appeared as a result of etching solution influence on the activated iron zone. Using the solutions of acids and alkalies of different concentrations, it is possible to gain various diameters of a puncture zone (channel).

Traces of a bullet (copper or iron) in rubber after its penetration are displayed only on the axis of its movement. On the basis of this similarity, it is possible to explain experimental results of micro-alloying of the barriers at SDP.

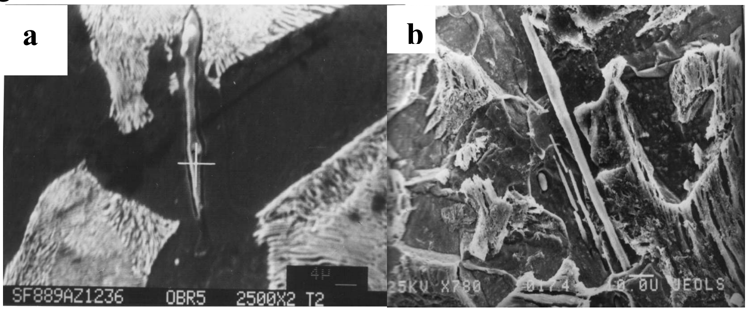


Figure 4. Fiber structure in steel after processing in SDP regime: a - filament from Al=13,99 %; Mn = 39,17 %; Pb = 17,68 %, Fe- the rest; b - filament on the basis of Al_2O_3

At SDP, the channel collapses (closes). It is possible to confirm this assertion in the experiments with lead dust. Lead (Pb), injected into the channel zones, at SDP, during preparation of a specimen for investigation, reacts with an etching solution. However, the products of a chemical reaction do not leave a surface.

The trajectory of motion of lead particles in a barrier in the form of white strings can be seen at a metal surface of a barrier (Fig.3c). Only those sections of a trajectory which are at a plane of a longitudinal cross-section of a barrier are visible.

We treat similarly the process of punching a rubber barrier by bullets. On this basis, we try to answer a question what causes a collapse of a channel at SDP? Strong compressing stresses appear in a volume of barrier’s material at SDP. What is the reason of these stresses? At usual impact, compression forces (pressure) are not significant and a crater diameter exceeds a striker calibre more than in four times. An individual striker cannot give such results.

It is obvious, that when a clot of dust particles affects a barrier, the pressure fields appear. The pressure fields in a barrier originate due to a kinetic energy of the impact. Emergence of a variable pressure field explains the presence of velocity gradients and density in a volume of a clot of separate strikers. After the striker starts to create a channel element, just in this zone the relief of a pressure field occurs. The channel element closes. Therefore the presence of a pressure field in a volume of a barrier is an obligatory condition of superdeep penetration [3,5].

Studying these questions has led to a formulation of the second condition of SDP implementation. Superdeep penetration of strikers into a barrier can occur only at the impact of a clot of microstrikers. Individual strikers do not penetrate in SDP regime.

Let's consider shaping structure of steel on mezolevel as a result of affecting in SDP regime. As working substance f discrete stream it is used powder materials which in usual conditions do not interact with iron, and at chemical interaction badly interact with acid solutions. For example, powders Pb and Al_2O_3. At interaction of these materials with iron in SDP condition the wide spectrum of metastable materials is created. In volume of solid metal body as a result SDP processing's fiber structures with a diameter 0,1 - 3 microns and length in tens millimeters arise (fig. 3a,c;4).

Thus density of elements from skeleton in longitudinal direction is in 3 times above, than in a transversal direction. Strikers move on a barrier on a way of the least resistance and in a transversal direction concerning an axis of driving oscillate. The filaments generated as a result of this driving and as track formations on cross section are selected (fig. 3c;4).

The structural elements arising into a metal basis at mezolevel directly influence to physicomechanical properties of a composite material. Depending on modes of superdeep penetration the density of channel formations in a cross-section varies from 60 up to 200 mm^{-2}. It is accepted to evaluate elements of structure of such composite materials through parameters: D - mm^{-2}, D aver - micrometers. In channel zones at complex interaction there is a synthesis of a metastable material on the basis of matrix and entered materials.

4. REGULATION OF STRENGTH FOR NEW MASSIVE COMPOSITE MATERIAL.

Let's consider shaping a composite tool material on the basis of HSS matrixes. HSS are rapid tool steel which have a wide circulation in the metal cutting instrument. For a basis have taken the tool steel containing about 6 mass % W, 5 mass % Mo, 1 mass % V, 1,1 mass % C, and other iron. As entered substance it is used ceramic dusts (TiCN) and mixtures of ceramics with metals. The structure of steel after processing in condition SDP is shown in figures 1a; 2a, b, c; 3a, b. As the basic criteria of an estimation of a composite material we use characteristics: wear resistance and bending strength.

As at cutting metals by the basic criterion for a tool material its wear resistance is, we use characteristic of relative wear resistance for a primary estimation of the reinforced material. For the beginning we will consider change of relative wear resistance (in relation to base steel) the steel matrix that reinforced by a stream of different particles (table 1,2).

Table 1. Change of relative wear resistance (%) depending from regimes of heat treatment. HSS ← TiCN.

Tempering temperature ^{0}C	Quenching temperature, ^{0}C				
	1200	**1205**	**1210**	**1215**	**1220**
600	+131,7	+140,1	+151,3	+128,4	+161,5
590	+21,7	+23,7	-39,9	-34,9	+71,4
580	-27,9	-15,8	-20	-16,6	-16,6
570	-38,1	-35,5	-35,3	-27,6	-25
560	-22,6	-28,6	-22,4	-20	+11,1
550	+17,2	+20	+24,4	+65,7	+71,4
540	+31,4	+49,9	+102,8	+63,6	+80
530	+20,8	+8,3	+10,1	+13	+21,7
520	+30,9	+30,3	+19,7	+27,7	+35,7

Table 2. Change of relative wear resistance (%) depending from regimes of heat treatment HSS← mixture of particles.

Tempering temperature , ^{0}C	Quenching temperature , ^{0}C				
	1200	**1205**	**1210**	**1215**	**1220**
600	+111,2	+125,2	+1,333	+126,7	+183,3
590	+100	+116,6	-1,7	+3,8	+135,2
580	+125	+142,9	+128,5	+127,3	+127,3
570	+160	+132	+175	+205,5	+170,1
560	+132	+150	+125	+122,2	+177,7
550	+172,1	+140	+124	+132	+130,8
540	+130,2	+136,7	+209,5	+125	+104,5
530	+141,7	+116,6	+108,2	+100	+100
520	+123,5	+131,4	+126,7	+140,1	+137,6

It is obvious, that at the set matrix the entered structure essentially influences to change of relative wear resistance in all range of conditions of heat treatment. An optimum mode for heat treatment the matrix material assume heat under quenching 1220^0C and triple tempering at temperature 560^0C. Raise of wear resistance is also function of a condition of heat treatment. The area of the raised wear resistance corresponds, as a rule, to the raised temperatures at quenching and tempering. Process of volumetric reinforcement was made to steel exemplars with a constant chemical compound. It is logical to assume, that change of wear resistance is connected with increase in a volume part of a reinforcing phase. It is obvious, that the share of a reinforcing phase varies as a result of diffusive growth of this phase at heating.

Let's consider change of bending strength of this material after processing by mixture of dusts. We will consider the reinforced steel, as a composite material. Filaments and a matrix are deformed in a composition the same as at their separate test. All filaments have identical values of tensile strength and fail at equal deformation.

In view of the specified assumptions the tensile strength of composite materials is defined by a rule of additivity: $\sigma_\Sigma = \sigma_f V_f + \sigma_m (1-V_f)$,
where σ_Σ - bending strength of composite material, σ_f - bending strength of filaments, σm - bending strength of a matrix, V_f - inclusion volume fraction of filaments.

Experimentally certain structural parameters after SDP processing are resulted in table 3.

Table 3. Parameters of structure of HSS steel after impulse processing in condition SDP.

Distance from a surface, mm	0 -30,5
d_{aver}, mkm	0,862
D, mm^{-2}	173,98
Part, %	0,0101%

Remarks. Average diameter of the activated microzone - d_{aver}; density of the activated zones in a unit platform - D; a share of the activated zones - Part.

The main problem for an estimation of strength of fiber σ_f is definition of a share of fiber structure in volume of a composite material. The average share of influence of fiber structure in a metal composite material is accepted ≈ 10 volumetric %. Such volume fraction (10 %) eliminates an opportunity overestimate of magnitude s_f. Bending strength and parameters of structure after quenching from different temperatures we will consider in tables 4, 5.

Table 4. Characteristics of composite material that been quenched at 1200^0C.

Tempering temperature,	σ_Σ	σ_m	σ_f	$\Delta\sigma$	V_f	d_{aver}
^{0}C	GPa	GPa	GPa	GPa		mkm
600	4,6	3,8	11,8	0,8	0,1	27
590	4,5	3,7	11,7	0,8	0,1	27
580	4,2	3,4	11,4	0,8	0,1	27
570	4,0	3,5	8,5	0,5	0,1	27
560	3,8	3,8	3,8	0	0,1	27
550	3,6	3,9	0,9	-0,3	0,1	27
540	3,3	3,9	0,9	-0,6	0,2	38,2
530	2,9	3,7	0,9	-0,8	0,444	57,0
520	2,7	3,1	0,9	-0,4	0,1818	36,4

Table 5. Characteristics of composite material that been quenched at 1220^0C.

Tempering temperature,	σ_Σ	σ_m	σ_f	$\Delta\sigma$	V_f	d_{aver}

^{0}C	GPa	GPa	GPa	GPa		mkm
600	4,0	3,8	5,8	0,2	0,1	27
590	3,8	3,4	7,4	0,4	0,1	27
580	3,8	3,1	10,1	0,7	0,1	27
570	3,6	3,2	7,2	0,4	0,1	27
560	3,6	3,4	5,4	0,2	0,1	27
550	3,6	3,6	2,7	0	0,1	27
540	3,4	3,6	0,9	-0,2	0,074	23,2
530	3,0	3,3	0,9	-0,3	0,125	30,2
520	2,7	3,0	0,9	-0,3	0,142	32,2

At temperatures of heat at tempering ≈ 550^{0}C and below the variance in strength of flexure of fiber and matrix material is negative. The strength, activated SDP fiber zones, at the same conditions of heat treatment is below, than matrix strength. It is obvious, that process of growth of reinforcing phases at these temperatures of tempering is not end. In the activated zone process of growth of grains is preceded with a stage of development of new points of growth that demands additional energy at heat, as shown in work [5]. Accordingly diameter of a filament at temperatures of tempering below, than 550^{0}C appears above, than at higher temperatures. The material of a filament with not completed reorganization of structure is more friable, possesses the lowered density. At this stage of heat treatment the activated zones lower strength characteristics of an workpiece. This error in heat treatment composite tool steel explains failures at use of a new material. Comparison of results reduced in tables 4-5 shows, that at use SDP process of growth of reinforce fiber zones is displaced in area more heats, leading to raise of bending strength of a material of these zones in 13 times. Strength of the grown filaments is made comparable with strength of ceramic and metal whiskers. Raise of bending strength of a tool material (macrobody) in the given variant in 1,2 times is ensured. Simultaneously, raise of wear resistance in 1,7-1,8 times is ensured.

If we speak about creation of a composite material in such material specific feature - anisotropy of mechanical properties is realized. Therefore the composite steel material in a direction, perpendicular axes of introduction of a flow of powder particles has mechanical properties essentially lower.

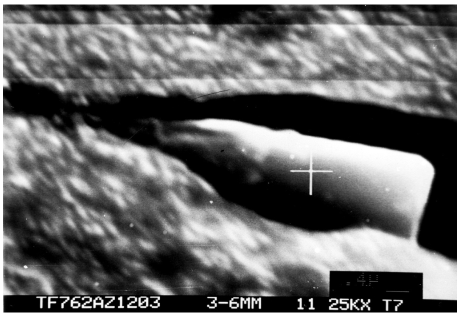
5. FEATURES OF THE REINFORCING CARCASS.

Feature of the iron composite material received in SDP regime, is significant differences in chemical and electrochemical potential of a material of a reinforcing carcass and iron matrix. A basis of a composite material is iron, but because of a variance of properties it is possible to reveal reinforcing zones and to estimate their volume fraction. Depending on condition SDP the volume fraction of a reinforcing material is ≥ 1 volumetric percents. Concentration of addition entered substance in iron and its alloys at SDP has risen only on 0.001-0.1 mass percents [5].

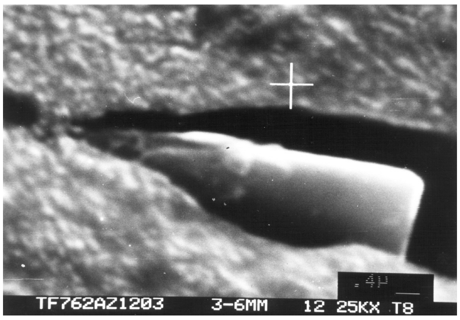
Zones of high and superhigh pressure are realized in solid body. These zones are volumetric oscillating solitons (fig. 2a). Microstrikers move in these zones because the material of these zones has low static strength [3,5]. In these zones the entered substance and a matrix material of a barrier interact among themselves and realize full complex of SDP effects [3,5,6]. The entered substance to be broke into trajectory of their driving in radius, as a rule, 1-2 microns from an axis of a track. Results of tens thousand experiments that ensures good statistical level of reliability of results are observed. Time of effect in SDP condition averaged 400 micro seconds.

At examination of the iron targets, subjected to processing in SDP mode by various powders, it was revealed, that on a plane of a metallographic specimen there are numerous structural elements of the extended shape. As a rule, such elements of structure have high concentration of manganese and sulphur [6].

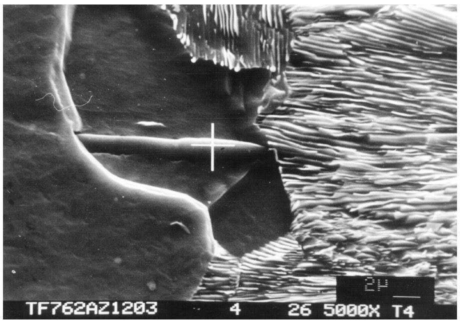
By using powders from borides of metal the material of a zone of high pressure gains the raised chemical durability. Experiments of research of the fiber elements created into barrier (a steel with concentration of carbon ≤0,45 %) have been executed at penetration of flow from NbB particles in SDP mode (fig. 7). By preparation of samples the material of these zones appears above a surface of a micr osection and visible as light filaments. This analysis had semiquantitative character as boron (B) using a microprobe did not determine. Presence of entered substance was determined by presence of niobium which in host material of a target was absent.



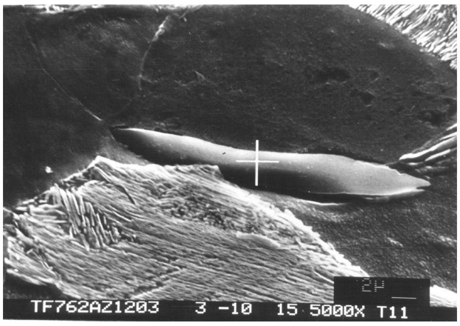
a



b



c



d

Figure 7. Elements of fiber structure in a steel barrier (≤0,45%C), after processing by flow - NbB+Al: a - the microanalysis in the center of a fiber (depth ≈ 6 mm); b - the microanalysis of a wall of channel element (depth ≈ 6 mm); c - the microanalysis of a fiber on depth ≈17 mm; d - the microanalysis of a fiber t on depth ≈ 36 mm.

Results of analysis these structural elements that executed by a microprobe are resulted in table 3.

Table 3. Concentration of chemical elements in a reinforcing carcass

№ specimen	Chemical elements , %						
	O	Si	Nb	Ti	V	Mn	Fe
Initial composition of a target	0,0	0,0	0,0	0,00	0,00	0,0	99,5
Initial composition of particles			NbB+Al 100				
a dot analysis	0,35	0,0	14,14	0,07	0,00	29,91	55,54
b dot analysis	0,0	0,0	0,60			2,18	97,14
c dot analysis	0,38		13,10			24,28	62,07
d dot analysis	0,32	0,0	17,95			32,95	48,79
e dot analysis	0,27	0,11	0,20	1,84	0,15	13,37	76,06

Results of the analysis of structure elements have shown, that the filament consists basically from Fe-Mn-Nb. Concentration of Mn from the center of a filament to walls of the channel decreases in 13,7 times and concentration Nb decreases in 23,5 times. Unexpected feature of massive composite has appeared increasing in concentration of Mn in the reinforcing carcass of iron composite up to 33 mass percents. In an initial matrix the concentration of Mn did not exceed 0,01 %, and Nb and Ti were absent. Average concentration of Mn in a composite material has increased more than in 10 times. This element which was absent in basic materials, has been localized in a material of carcass. For inspection of this anomaly the masses spectrometry analysis has been executed. In filaments (channel zones) has been detected ^{55}Mn or ^{55}Fe [7].

At the given stage of researches it was not possible unequivocally determine chemical element what is a basis for reinforcing carcass. Anisotropy of mechanical properties of massive composite was defined by that the density of reinforcing structural elements in longitudinal and a transverse direction differed in 2-3 times.

CONSEQUENCE. On the basis of the presented results of the given complex research it is possible to draw following outputs:

1. At operation of powder clots on steel preforms in SDP condition steadily there is a reorganization of structure and a doping on depths in tens and hundreds millimeters that allows to make a massive composite material.

2. Depending from entered powder composition and conditions of the subsequent heat treatment the level of mechanical properties of a tool composite material essentially varies.

3. Growth of reinforcing zones depending from a temperature regime of subsequent heat treatment is shown. It is established, that activation in SDP condition demands displacement of a temperature regime in area of higher temperatures.

4. Due to regulation of a temperature regime of heat treatment the bending strength of tool material in 13 times and wear resistance in 1,7-1,8 times is increased.

5. The reinforcing carcase consists of products of a synthesis of an entered and matrix material. The important component of a reinforcing structural element is the isotope not certain unequivocally - ^{55}Mn or ^{55}Fe. Concentration of an isotope in a reinforcing filament reaches 33 masses. %. The composite material is reinforced by zones of influence ($\leq$ 15 volumetric %). These zones represent interlaced among themselves the doped filaments and zones crushed up to micro and nano levels of an initial iron matrix.

REFERENCES

1.M. L. KERBER Composite materials. Soros's educational log-book, №5,1999, p.p.33-41.[in Russian]

2.Yu.D.TRETYAKOV, N.N.OLEYNIKOV, O.A.SHLYAKTIN, Cryochemical technology of advanced materials, Chapman & Hall, London,1997, 319 p.

3. S. USHERENKO, The phenomenon of superdeep penetration, Scientific Israel-technological advantages, vol.8, issues 1.2 (special), 2006, p.p.83-94.

4. U. A. GLASMACHER et al., Physical Review Letters, 96, 195701 (17 May 2006)

5. FIGOVSKY O., USHERENKO S., USHERENKO YU. The creation of metal composite materials. The Physics and technics of high-energy processing of materials .-Dnepropetrovsk: The Art-Press, 2007, p.p.218-235. [in Russian]

6.SOBOLEV V.V., USHERENKO S.M. Shock-wave initiation of nuclear transmutation of chemical elements. J.Phys, IY France,134, 2006, p.p. 977-982.

7. FIGOVSKY O., SOBOLEV V., USHERENKO S. Anomalies of energetic of the superdeep penetration of clots of particles in iron barrier. Idea, №6, 2007. Israel, Ashdod,p.p.29-38. [in Russian]