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Intermetallic alloys with oxide particles and technological concept for high loaded materials

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Abstract: The article presents a material and technological concept of the fabrication of a composite of a laminated structure. The material of the composite's individual layers are intermetallic phases from the Fe-Al or Fe-Ti-Al–Al_2O_3 systems. The produced aluminium strips with a core in the form of metallic powders or priorly synthesized intermetallic phases are formed as packets. The packets of a predefined complex chemical composition are placed in moulds and subjected to pressing. The composite material is obtained in a self-propagating high temperature synthesis combined with sintering under pressure. By means of rolling, aluminium strips with iron dust were fabricated, after which they were subjected to heat treatment. The high temperature synthesis was carried out in order to obtain composite powders and sinters: Fe-Al, FeAl-TiAl – Al_2O_3 and FeAl-TiC – Al_2O_3. Structural and X-ray analyses have corroborated the phase composition and fine dispersed structure of the composite materials. The results obtained in the laboratory research allow the selection of equipment for the production of composite plates

Keywords: High loaded composite materials, Technological concept

1. INTRODUCTION

The protection of elements working in changed high load consist on the reduction the action of conditions or/and changes in the parts construction, through a proper selection of materials. First of all, extensive possibilities of forming the phase composition and structure of the protective elements are determined by obtained methods and application of materials used to the production. The good results are ensure through the take additionally technology and materials conceptions.

This paper presents the procedure of production the intermetallic composite intended to protect of the machine elements working in high loading. The presented method enables obtaining laminates in laboratory and extensive production. The laminates contain the intermetallic and carbides phases strengthened by oxides particles. The selected results of the investigations of the intermetallic composite allocate to the work in changed and high loaded environments are presented. Intermetallic matrix composite are such material candidates for applications such as armour and vehicle structure.

The selected papers presented state of art of armour materials with the good impact resistance for the protection [1-15].

2. MATERIALS AND TECHNOLOGICAL CONCEPT

The initial material were iron powders, technical grade aluminium of granulation to 100 μm, pulverized powder of titanium and ilmenite ores, and other components compliant with the conception of composite material, i.e. laminate, production.

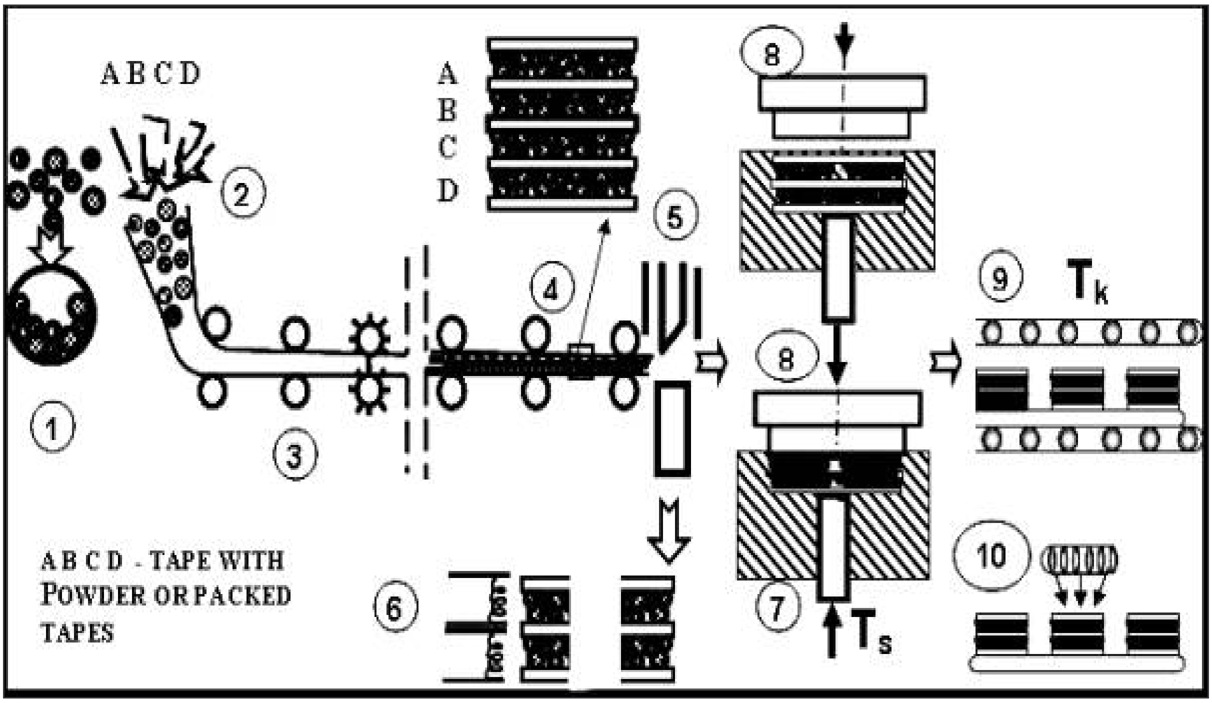


Figure 1. Technological concept of composite plates fabrication.

The fabrication of composite plates of a laminated structure with the possibility of changing their chemical and phase compositions requires the following procedures (Fig. 1):

1.a) Preparation of charge material:
- check of materials for the processes
- powders of initial materials of a required chemical composition
- metallic strips of a predefined thickness and width

1.b) Grinding and mechanical alloying of powder mixtures
- mixtures of powder and composite powders will be obtained in the process of mechanical-chemical activation and mechanical alloying; they will also contain powders of hard reinforcing phases.

2. Fabrication of strips with a powder core between two metallic strips.
3. The procedure of fabrication of strips with a powder core will be repeated for each predefined and required chemical composition of consecutive layers in the gradient composite material.
4. In the technological variant, it is possible to put together a few powder strips and subject them jointly to plastic deformation at thickness required for a high-temperature synthesis of the composite material.
5. The compiled and preliminarily strained packets of strips with powder cores will be cut to the required dimensions.
6. Next, the packets will be synthesized in a self-propagating high temperature synthesis.
7. The process of self-propagating synthesis of a composite material consisting of a packet of strips with a powder core
   - The synthesis time and temperature will be defined.
   - Any additional instrumentation will include systems of no contact temperature and process time measurement and will offer the possibility of observing the relocation of the combustion zone in model investigations.

8. Deformation – compaction of the synthesis products of a complex, in terms of its chemical and phase composition, composite material will be carried out after cooling the material to a predefined temperature in the process of hot compaction at specified pressure.
9. Heat treatment of the products at specified time and temperature will be conducted to homogenize the chemical composition of products' stress relaxation after compaction synthesis.

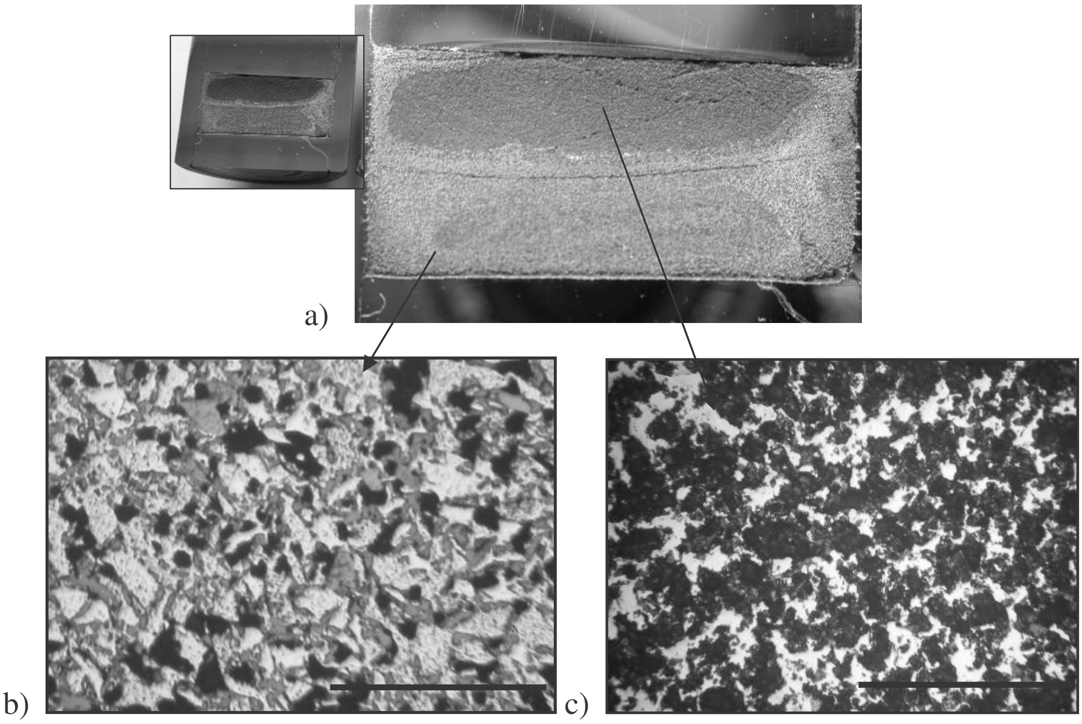
Quality control of the products obtained and handing them over for further treatment and assembly.

3. RESULTS OF THE INVESTIGATION

Selected investigation results are related to the important stages of composite material manufacture, which include: the process of strip fabrication, high temperature synthesis of intermetallic phase composite powders with ceramic ones and high temperature sintering of intermetallic phase powders or packets with intermetallic phases. The composite powders for the manufactures the sinters were obtained by SHS method (sellf high temperature propagation synthesis) [7-15]. The phase composition of the powders for the manufacture are designated by the reactions:

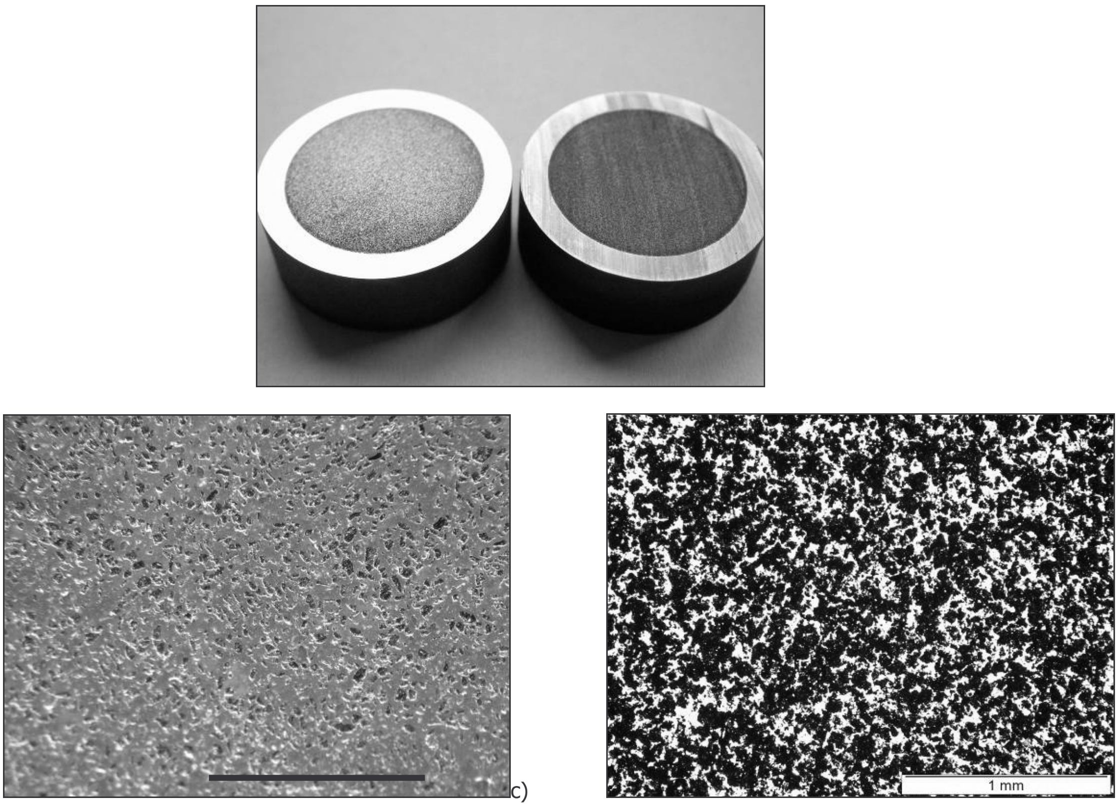
- $FeTiO_3+4Al \rightarrow FeAl+TiAl+Al_2O_3$
- $FeTiO_3+3Al+C \rightarrow FeAl+TiC+Al_2O_3$

The views of the structure of composite sinters are presented in fig.2-4.



500 µm 500 µm

Figure 2. a) Macrostructure and microstructure of the two intermetallic layers of composite sinters: b) FeAl-TiAl-Al_2O_3; c) FeAl-TiC-Al_2O_3



b)

1mm

Figure 3. a) View on structure of composite sinters b - c) Microstructure of intermetallic-ceramic sinters

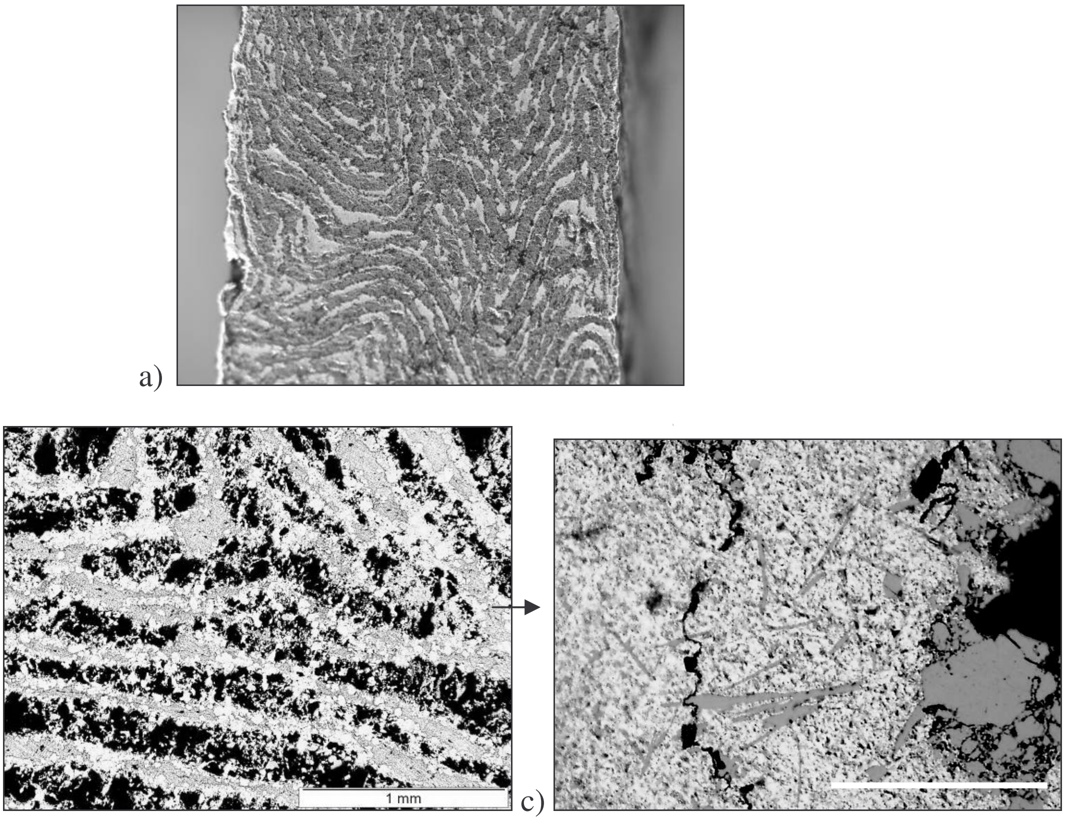


Figure 4. Microstructure Fe-Al composite compaction at 800^{o}C, 6 hours b-c) lamellar structure.

4. CONCLUSION

The material and technological concept presented in the article describes the fabrication of a composite material, i.e. a laminate containing in its individual layers fine dispersion metallic and ceramic phases form the Fe-Al, TiAl and Al_2O_3, TiC systems. The presented cycle of technological procedures including the preparation of strips with a powder core and strip packets, afterwards subjected to initial compaction, high temperature synthesis and final compaction, allows obtaining a composite material of an assumed predefined structure. The fine dispersion structure of sinters obtained in the SHS and force compaction processes in the laboratory investigations should be characterized by high hardness and strength, including high impact strength. The on-going research takes into account a correction of the technological parameters at particular stages of the composite material production as well as important, selected mechanical tests.

The investigations must be continuing in order that the parameters of laboratory process precisely defined and then transported the results to the parameters of production process. It can be calculated that the intermetallic composite : FeAl –TiAl- Al_2O_3 and FeAl-TiC-Al_2O_3 strengthened with oxide or carbide particles are the better materials for the work in high loading compared to the materials without the particles. The obtained intermetallic laminates are the perspective materials to application for the high loaded element of machines.

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