MATERIAL SCIENCE AND TI-PRODUCTION PROBLEMS

IN VIEW OF NEW HORIZONS OF THE APPLICATION

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Abstract

The report analises the metallurgical material science and technological problems which are solving in the Russian Federation and is relating to the conversion of the titanium alloys application and expansion of its application in the national economy and domestic techniques. The special attention is paid to the problems relating to the reduction of prices of the metallurgical production and methods for the production of different structures.The examples of the effective application of the titanium alloys in the shipbuilding,pulp and paper industry and the shape castings in the municipal economy and medicine are given.

Introduction

It is possible to point out the several periods of titanium production with respect ot application areas. The first period - is titanium application for space, rocket and military equipment. The second period - is when titanium was partly applied (apart from space) for priority trends of modern equipment where it gives extremely high technical and economical effect (civil aviation, chemical industry, marine technique and shipbuilding power engineering and some other areas of shipbuilding). And at last titanium introduction in various industries up to domestic equipment, medicine devices and decoration things where titanium may be very useful and efficient. The diagram (Figure 1) shows approximate consumption of titanium in the USSR in various fields and according to periods given above.

Each period puts up specific tasks before titanium metallurgy. It requires material science investigations, special technological solutions. Thus, the first period had priority trends to work out perfect metallurgy of titanium, to develop series of refractory alloys and to produce their semifinished products in accordance with the areas of application. The second period was distingished mainly by the development of structural alloys and high corrosion-resistant alloys. It required to wide the scope of nomenclature in order to produce heavy-sized sheets and plates, heavy forgings, a wide range of pipes and welding wires. That period was characterized by the detailed investigations of Ti-alloys serviceability in various external media and loading conditions. The first two periods of titanium alloys application have been fully presented at the international seminars on titanium alloys. It seems that currently the third period is going on. It is the development

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of titanium application for general national economy, for people everyday needs. It became possible only after considerable relax of international tension in the world and sequently reduction in arnament expences. In essence, titanium conversion pwriod has come while until recently Ti had been

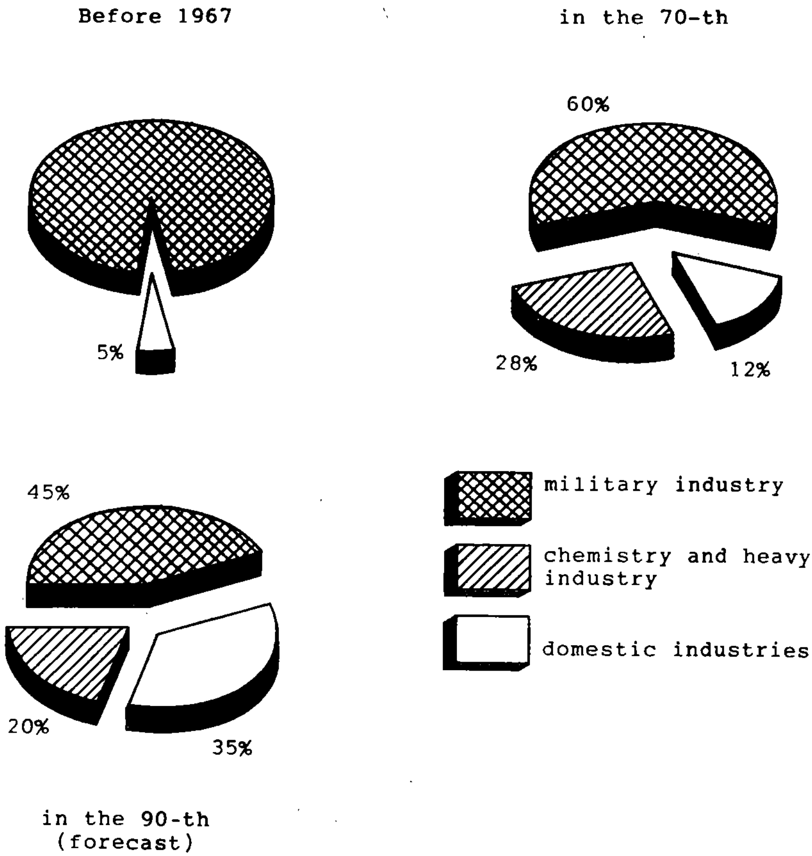


Fig. 1 Approximate shares of titanium consumption in our country in respect to different areas.

mostly applied for military equipment. The present paper is devoted to the third period and correspondently to the problems the titanium industry is facing with.

The following areas of titanium alloys application can be regarded as the new ones: oil-production offshore drilling rigs /1/, members of hyll equipment and propellers for civil and fishing vessels /2/ (foil devices for sea-swift passenger ships, propellers and shaft lines etc), for bleaching and boiling towers for cellulose-paper industry (Figure 2), pumps, tanks and other equipment for chemical /3/, food and wine industries, everyday equipment (plates and dishes, accessories, decorations), power and finishing units in civil engineering /4/, sport equipment, public services (sanitary technique), inpantants and surgical instruments for medicine, gas-cleaning

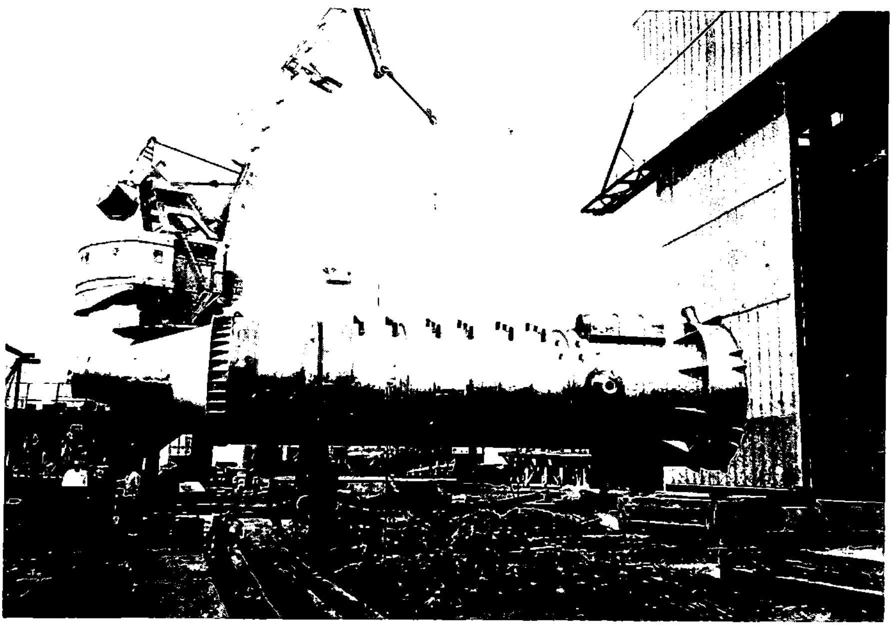


Figure 2 Cellulose bleaching tower in the process of manufacture.

(on the request of Ahlstrom company /Finland/)

devices for smoke desulphyrization in steam power plants /5/ etc.
The main problem of above mentioned areas of titanium application is the competitiveness of titanium with materials traditionally applied in these areas and primarily the price of applied alloys and efficiency of products fabrication. The latter needs special investigations and requires to solve the problems in metallurgy and titanium material science as well as the problems of titanium treatment.

Metallurgical tasks

Manufacturing cost of production may be governed by the composition of charge for titanium alloys melt, different technologies of ingots melt and semi-finished products. For this reason in the conditions of military orders conversion and in the course of transfer to national industry production one should reconsider the quality requirements and melting methods. One of the ways to reduce the titanium semifinished products manufacturing cost is to make good use of the Iow grades of sponge and metal wastes like scrap and chip in ingots melting. Introduction of a large quantity of various wastes requires to use special melting methods and corresponding melting equipment. In the USSR in the majority of cases the first remelt at serial ingots melt from sponge is accomplished by vacuum-arc melting of consumable electrode (with the exception of shape castings manufacture). In the USSR the garnisage consumble electrode melting (GCE method) is under development at wastes remelt. This promising method allows to introduce a large quantity of wastes at melting, but is not widely applied in serial production though it gives a good quality of metal. It is necessary to consider the economical efficiency of other melting methods application (plasma-arc, electron-beam, induction melting etc.) in order to find optimum varients with the aim at considerable reduction of titanium alloys ingots cost due to wastes application.

The development and introduction of special equipment is required as well as new standards and requirements to metal quality.

The second important problem in metallurgy is the production of secondary titanium alloys (alloys produced from production scrap). There is a task to select the composition of secondary alloys and correspondently the development of several technically pure titanium grades. One must identify the limits of alloying elements and impurities content for one or several alloys in order to use the whole range of secondary alloys to be put into production taking into account the quantity aspect for each alloy. It is necessary to adopt the acceptable limits of technological impurities content (mainly, oxygen) for every grade of secondary technically pure titanium. At production of secondary titanium alloys the problem of possible requirements on mechanical properties is to be solved. Some grades of secondary titanium may be produced according to "customers request", for example, currently titanium is widely used for bells production (Figure 3), where shaped castings with a wide range of chemical composition are applied. The same situation is with domestic things of decoration and art purposes (statuettes, decorative patterns etc.).Shaped castings melting is very important due to universal method to obtain parts of various configuration.

In our country the centrifugal casting in metal and ceramic moulds with protective coatings is of wide use as well as investment casting where cheap castings may be used for different purposes, in particular for tanks and members of pumps (Figure 4).

There is no doubt that much attention is to be given to powder metallurgy which allows to produce pseudoalloys with unique properties efficiently used in instrument making industry, friction joints etc. Besides, there are wide possibilities for titanium application for long-term filters of various purposes./5/.

Material science problems

The most developed Ti-alloy produced on an industrial scale are the heat-resistant (more accurately, thermal-resistant) alloys applied for the aerospace equipment. In general these alloys are alloyed by expensive in short supply materials such as vanadium, molybdenum, sometimes by zirconium, niobium and tantalum. These alloying elements not only make the alloy noble, but make them more expensive. Because of this the commercially pure titannium is more technological for wide and various application. Some grades of the commercially pure titanium of a different strength level as a function of a procedure impurity contents (oxygen, nitrogen, carbon, iron) are required to provide its wider application for the domestic equipment. It is necessary to expand activities aiminig the development of economically alloyed titanium alloy of the widest application meeting the high requirements of the safety and the procedure in metallurgical and job production. The best properties can be provided by the multicomponent alloying, not by high content of alloying elements. To provide good procedure the strentth requi-

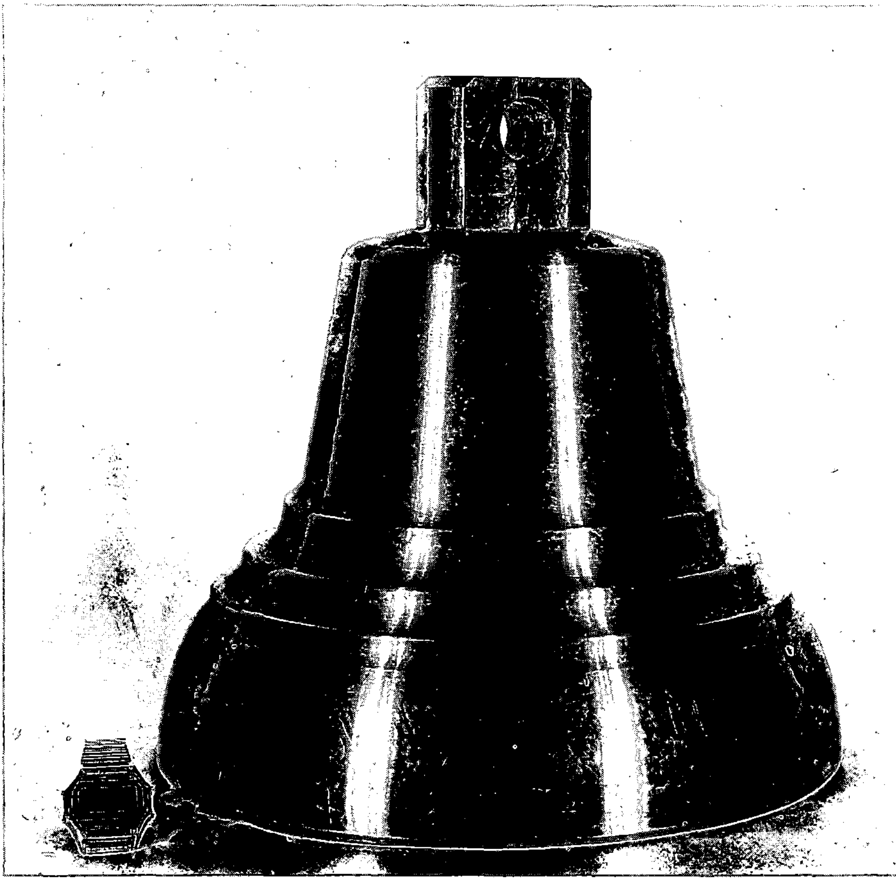
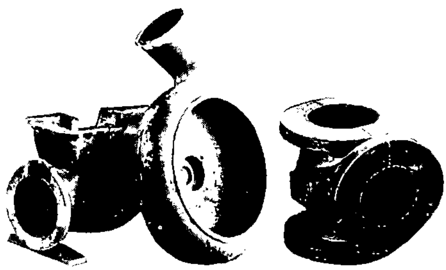
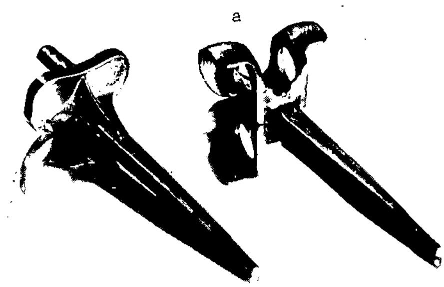


Figure 3 Ship's bell.



a) Pump bodies 620 kg in mass.



b) Endodentures elements for surgery.

Applied alloy TL5 (Ti 4Al 2V)

Technical characteristics:

$\sigma_{0,2} \geqslant 588$ MPa ; $\sigma_{B} \geqslant 637$ MPa

$\delta \geqslant 8$ % ; KCV $\geqslant 392$ kj/m^2

Figure 4 Titanium shaped castings.

rement can't exceed 550-600 MPa. In view of the fact that the application of the titanium in consumation fields is based on the high corrosion resistance and the satisfactory biological compatibility the corrosion resistance and the corrosion cracking resistance of a new unified alloy is to be studied. The performance and the safety of the secondary alloys for the critical products (turbines, inner combustion engines) is to be thoroughly investigated as the increased contents of impurities can result in appreciable reduction of structural strength parameters of metals (fatigue resistance, crack resistance, corrosion cracking resistance etc)/6/. During further Ti investigations the surface properties of the titanium decorative coating or chemical heat treatment, especially, to obtain the desired surface properties is also to be paid an immense attention. Among the new methods of the decorative coating application the microarc oxidation resulting in the uniform stable colour of the surface: from white to black is of note. The methods of the stable colouring and its natural wear resistance is to be studied. The possibility of the titanium decorative colouring by defferent types of the gas thermal coating has been studied in a limited extent (only the decorative plasma spraying by the titanium nitrides and blackening have been investigated). Some obscure phenomena can be observed when the titnaium is applied for the utensiles and the table covers (blackening by spoons and knives on china, tarneshing of dishes and plates etc.). The investigation of these phenomena must result in precision of efficiency of the titanium application in this field.

Procedure problems

The wide application of the titanium in many new fields is related to the various methods of welding and brazing. First of all it relates to the large structures: celulose bleaching columns, the foil devices for the ships (Figure 5) ship machinebuilding etc. where automatization of the welding, multilayer welding, precision welding of small thickness of fine parts (if apparatus, utensiles, adornment are in mind) are required. The titanium can be welded by different methods. The selection of a welding method can be argued by economical reasons and technical feasability of the particular structure and features of the welded joints itself. The most applicable process is an argon arc welding and its modifications. The application of the high concentrated heat sources allows to weld the titnaium alloys of a large thickness range and to obtain the relatively low residual stresses and small buckling of the structures. Sometimes it allows to give up the following heat treatment as undesired. Among the welding methods,in spite of the expensive equipment, the most reasonable are electron beam welding and laser welding. The former is widely used for the military equipment and the laser welding is applied for the precision welding of domestic structures and jewelry when the powerful energy sources are not required.
The simple welding methods: contact welding (point and seam welding including), the diffusion welding and the friction welding were hardly used. The ample application of the titanium for a domestic use can undoubtely evaluate the efficiency of these welding methods.
Along with welding the brazing can provide either similar joints where welding is not reasonable or dissimilar joints of the titanium and other metals (steels, copper, aluminium alloys). The available solders for brazing the titanium are characterized by high procedure parameters as compared to generally used silver solders and are less expensive (the cost of the solders amounts about 70-80% of the titanium cost). The surface chemico-thermal treatment of the titanium alloys, the gas thermal coating of the surface and different local deposits allow to manufacture friction units and seals of the required working capacity (tube fittings and systems, for example).

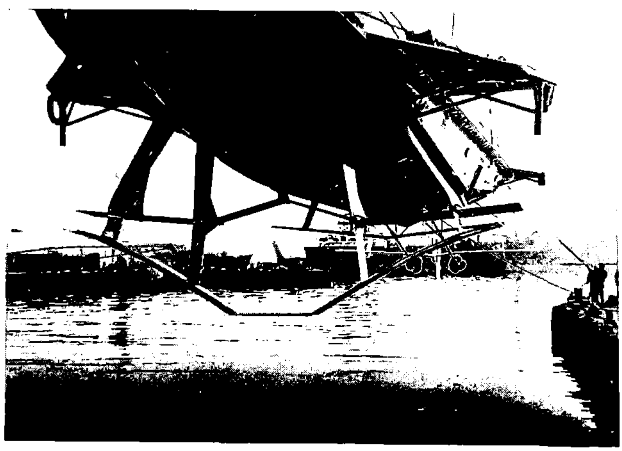
THE FOIL DEVICES OF SEA - SWIFT WALKING SHIP "COMETA" PRODUCED OF PT3V THE TITANIUM ALLOY

THE TECHNICAL DATA OF PT3V ALLOY:

The yield strength, MPa...................585 not less

The tensile strength,MPa..................880 not more

The endurance limit in sea water ....0,4 - 0,5σ_B



The ships with foil devices of the titanium alloys are navigating on all latituds of the World Ocean.

The foil devices of the PT3V titanium alloy are characterized by unlimited actual service life, can withstand the load twice as high as the foils of the austenitic steels.

Figure 5 Titanium foil devices for the sea swift pleasure ship "Cometa".
(made by "Prometey")

Issue of the standard guide documentation

When the titanium alloys were used for the aerospace and other type of military equipment some procedure developments and standards were made. However, in many cases the documentation is of special nature and is not always available for a wide range of the scientists, technologists and designers. It is necessary to extend the documentation relating to the delivery of the titanium semiproducts, all the feasability of the material production including, in accordance with the simplified requirements concerning with dimensions of the product up to pieces and standard scrap, which must result in the reduction of their cost. It implies a considerable increase of finished product yield and of efficiency of the titanium application.
The appropriate technical documentation of non-confedential type must represent the newest achievements in the procedure of production of different semi-products expanding their range (for tubes, bands and foils, especially).
The retreatment and conversion of the technical documentation is very important as it makes easier to develop scillful production of the titanium goods of people consumption for a wide range of the manufactures, small enterprizes including. Of note is the specificity of the procedure properties of the titanium alloys relating to the heating and welding, especially.
It is undenyable that the expansion of the scientific and popular publications and the technical literature edition are required and not only in the aerospace field. The leading research and development institutes and organizations of the USSR are ready to resolve the discussed problems with a large scale cooperation with foreign countries.

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