CONDITIONS OF MATERIALS CHOICE IN MANUFACTURING OF PRESSURE ORIGINATED DETAILS

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Abstract: Materials are evolving today faster than at any time in history. In nowadays developing a technique and technology considerably enlarge the exposure of the applicable materials, new materials are created still with much better mechanical and technological properties. Their development and prevalence quickly increase. Today wide use such materials that still recently call by future materials. In the several responsible engineering industry, as well as instrument engineering and other industries do better with "high – performance" composites, new engineering ceramics, high – strength polymers etc., what had previously been done with metals.

Choosing of materials is very important in several engineering industries, construction and instrument engineering industries, for example, crash of bench constructions is one of the reasons that the engineer who designed them used wrong materials or did not understand the properties of those used. Therefore for rational utilization materials, we need to know not only their properties, but also need understand factors, witch provides this properties. Therefore we should know how to select materials which best fit the demands of the design – economic and aesthetic demands, as well as demands of strength and durability. Choice of materials of pressure originated details, as also many manufacturing of other important details, which is one of the most actual problems in nowadays.

First of all this article shows advantages and disadvantages of the conditions of materials choice of pressure originated details in. The most rational conditions of materials choice, way how to eliminate possibility mistakes, witch can lead down to different difficulties are given for the manufacturing of the definite group of details.

There is an example witch describes conditions of materials choice for oil flooded screw compressors.

The denotations of different standards of the utilized materials are analyzed in this article. As well as the economic parameters of the various materials in the manufacturing of the oil flooded screw compressors are analyzed.

At the end of the article are given possibilities of the improving of materials. We can achieve improving of materials with different materials processing methods, which I had analyzed, for example, using mechanical, thermal, thermal-chemical processing or using different surfaces covering. In nowadays thermal processing method based on metal physic, dislocation theory and changes of metal structure regularity. These processing methods improve physical and mechanical properties of materials.

1. INTRODUCTION

Innovation in engineering often means skilfully to use, choose the new materials for the responsible constructions in various industries of engineering, which are evolving today faster than at any time in history, often consider materials that still recently call by future materials. In nowadays developing a technique and technology considerably enlarge the exposure of the applicable materials, new materials are created still with much better mechanical and technological properties. There are over 100 000 different materials available to design engineer. The duty of every engineer is to know the materials classifications so even well, as in the own book of remarks. Engineer and mechanic should be also as designer and technologist.

A designer needs to be able correctly to choose materials, which their properties would conform to these technical requirements of constructed detail. As often as not only in engineering we meet with various reasons which characterize with the use of incorrect materials. Choosing of materials is very important in several engineering industries, construction and instrument engineering industries; for example, crash of bench constructions is one of the reasons that the engineer who designed them used wrong materials. He was not able to choose materials with conformable properties and exploitation environments from this spacious offered expound of material. Therefore for rational utilization materials, we need to know not only their properties, but also should understand factors, witch provides this properties. So it is vital that the professional engineer should know how to select most suitable materials witch best fit the demands of the design – economic and aesthetic demands, economic requirements, criteria of safety as well as demands of strength and durability. The designer must understand the properties of materials, and their limitations.

2. MATERIALS IN NOWADAYS AND THEIR PROPERTIES

There are over 100 000 different materials available to design engineer. Main task is to reduce this very large number to a much smaller who let us to be competent more easily in these materials groups.

Mainly in the engineering industry use the alloys of metals, but far rarer technically spotless metals. Mechanical properties of alloys usually are better than mechanical properties of spotless metals. Chemical composition and structure are to affect the properties of alloy. Today we already use materials, which often are called as future materials.

Nowadays in the modern engineering materially divided on nine large groups:

- engineering alloys – metals and their alloys;
- engineering polymers – thermoplastics and thermosets;
- engineering ceramics – fine ceramics;
- engineering composites – glass, carbon or aramid fibere-reinforced plastics;
- porous ceramics – brick, cement, concrete, stone;
- glasses – silicate glasses;
- woods – structural timbers;
- elastomers – natural and artificial rubbers;
- foams – foamed polymers.

Every material is characterized by its mechanical, physical, thermal, chemical, and also technological and other properties. From spacious expound of the offered material we should choose most suitable material accordingly to our requirements. Choosing materials for the elements of machines, a designer must analyse all properties of these material.

Mechanical properties of material are one of the most important properties of them. These properties characterize material can resist to influence of external force. Taking apart mechanical properties of material, we analyse their plasticity, modulus of elasticity, yield strength and tensile strength, hardness, fracture toughness, fatigue strength, creep strength and damping. Yield strength and tensile strength are one of main parameters with which characterrized most of all materials. Tensile strength of material is described after the indexes of mechanical properties, which obtain in mechanical verifications. Tensile strength of material depends on such characteristic properties as endurance, kind of hot processing, and from density of material.

The constructed devices always work in more unfriendly circumstances, which influencing from various dynamic loadings, temperatures, and also those constructions are inferior to the always greater loadings. Fracture toughness is inculcated for characterizing of materials. Fracture toughness is the index of material, what characterizes ability of material resist to the various impact loadings in various temperatures.

Analysing physical properties of material, we adjoin with such sizes as specific gravity of material, density, and also for the coefficients of the linear and dimensional expansion.

Also thermal properties of material keep us in interest, when we analysing the external environments of construction. Knowing thermal properties of material – thermal conductivity, specific heat, thermal expansion coefficient, and also temperature of melting, we can define efficiency of action of construction in the various intervals of temperatures. Thermal properties of material allow to us correct choosing of the thermal processing modes, if necessary to improve the materials by the thermal process.

Electric and magnetic properties – resistivity, dielectric constant, magnetic permeability are used also for characterrizing of materials.

Properties of surface are important in many engineering constructions. Knowing properties of surface, we can reason about oxidization ability of material, ability to resist corrosion, and also we are able to predict endurance of wear. Corrosion of metals causes of enormous losses for industry. To prevent the severe losses, in the engineer and in the other industries of production, details should be covered with varnishes, paints, chemical hardy metals or thin layer of oxides. In a few cases use the special alloys with good chemical stability.

There is a copula type of operations, which helps to us improve wearproofness of surface, such as mechanical, thermal, chemical-thermal, and also coverages of surface.

A technological property of metal and other materials characterizes workability with various hot and cold processing methods, i.e. workability pours, hammering, welding, cutting etc.

Constructing of any device makes to us more or less interest to properties of making of material are ease of manufacture and joining, finishing and also aesthetic properties as colour, texture, feelings.

During designing of machine, we also should analyse ecological properties of materials toxicity, possibilities of contamination of environment, and also recyclability.

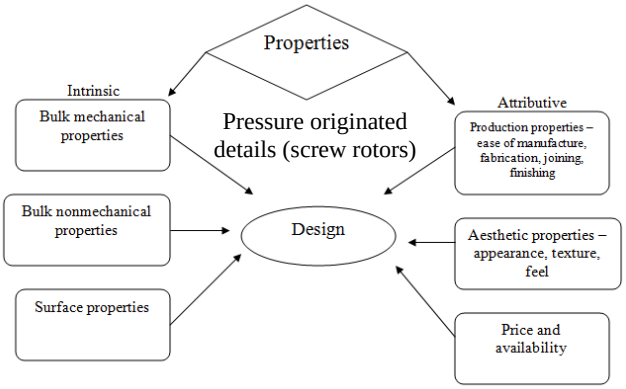

Fig. 1. Stages of materials choice

In the first figure is demonstrative shown the stages of material choice, with which we adjoin designing the devices.

Now majority producers and users pay very large attention to price of material. Users primary in the choice of materials assume an error, which is why that they choose material depending on a price. More faithful there would be that a designer projected the device and chooses necessary material and then, if the cost of materials dissatisfies, then arranges competition for the cost of material.

In our days the main task of every designer - to make not a mistake in the calculations and in the choice. In the type of example we will examine the terms of choice of materials of pressure originated details. So that correctly and faultlessly to choose of materials for manufacture of rotors of screw type compressor, we need to stipulate all possible information of output for rotors, for example, this

mechanical, technological, and also properties of surface, circumstances of exploitation etc.

The rotors of screw spaciously use for production of compressed air and in the devices of cooling systems. The rotor is inferior to influencing of variable forces, which create the compressed gases, forces of inertia, moments of rotation, processes of various resonance and friction. In case of resonance external and internal tensions appears additionally. The processes of wear can be described with a few hypotheses as abrasive, diffuse, process of wear of oxidizing and reduction etc. Choosing materials for rotors of screw compressors it is needed to notice, that they would provide excellent in statistical and dynamic mechanical pointers of resistance, wearproofness, longevity, and also they must be technological, temperature resistance etc.

Materials from as we can make the pressure originated detail of screw type compressors stand more, then we will appeal only for one of the group of materials - for metals and their alloys.

As already I mentioned beforehand, more frequent in all characterize materials with mechanical properties. At one time in Latvia usually characterized materials with one of the more characteristic properties, fatigue strength – could resist to deformations or crash down, which to cause the static or dynamic loading. Fatigue strength characterizes the maximal put external loading which material can survive. For fatigue strength of material reason after the indexes of mechanical properties, which obtain in mechanical verifications. Now adjusting for the European norms, materials are always more frequently characterized with the fracture toughness. Majority aggregate and construction the scopes of elastic deformation operate to us.

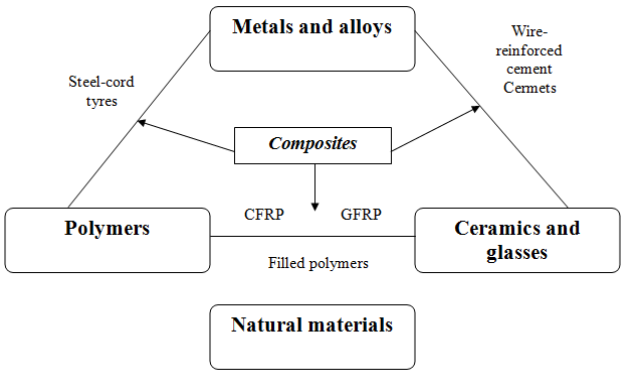

Fig. 2. The classes of engineering materials

We need to choose such material, what is able to work us in certain office hours, to survive influencing of external forces, to be comparing easily accessible and cheap.

In the second figure we can examine the main groups of materials, which offer to us in engineering.

3. MATERIALS CHOICE OF PRESSURE ORIGINATED DETAILS

There are a few ways how to choose materials for manufacturing of pressure originated rotors of screw type compressor. One of them, knowing the mechanical, physical, technological properties values of detail and also external environments, we can take all materials in succession and to execute the experiments, till we find anymore befits. This principle of choice is comparing expensive and labour-consuming.

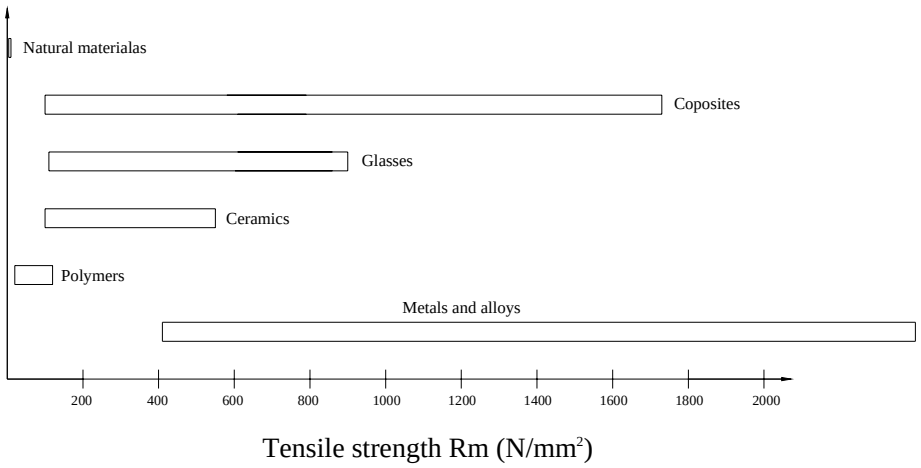

Fig. 3. Tensile strength of materials groups

The second from variants is a little bit stranger. The experiments do not need to be executed, but already from information of experiments we choose for us the most suitable material. To characterize material it is possible with much and for more various properties, therefore we need to estimate the most important properties from those, for example, fracture strength, fatigue strength, tensile ductility, creep strength, hardness etc. Estimating all the properties of materials, I will choose materials for manufacture of pressure originated details after the fatigue strength. In the next figure we can see the group of main materials which I described with one of their characterizing parameters - fatigue strength. From this figure we can define groups of materials for manufacture of pressure originated details. So even well we could choose a material group after plasticity or fracture strength. So, that many

groups of materials more or less than to correspond noticeable for the requirements, then I chose one of widespread groups of materials - metals and their alloys.

So as metal and their alloys are very spacious, then analysing after the equivalent figure I choose the group (steels) of metals, which the rotor of screw will be made from. The rotors of little oil flooded compressors operate in the comparing easy circumstances, and then I choose steels of ordinary quality. The leading producers of screw compressors are recommending constructions of quality steels (C22, C45), for larger compressors advise the alloyed materials of constructions (15Cr3). Substantially mechanical properties of materials are influenced by alloying elements as chrome, nickel, molybdenum, vanadium etc. Alloying elements improve mechanical properties of material. The dry type screw compressors operate to the comparing greater temperatures, therefore I choose alloy steels with more resistance of temperature (30CrMoV, 35CrNi5). Increasing for the temperatures of materials, mechanical stability of steels diminishes. Compressors which work in aggressive environments use by resist corrosion alloy steels (X10Cr13, X7Cr13). To protect rotors from influencing of unfriendly external environment, applies coverages of various thermo - diffusive surface kinds.

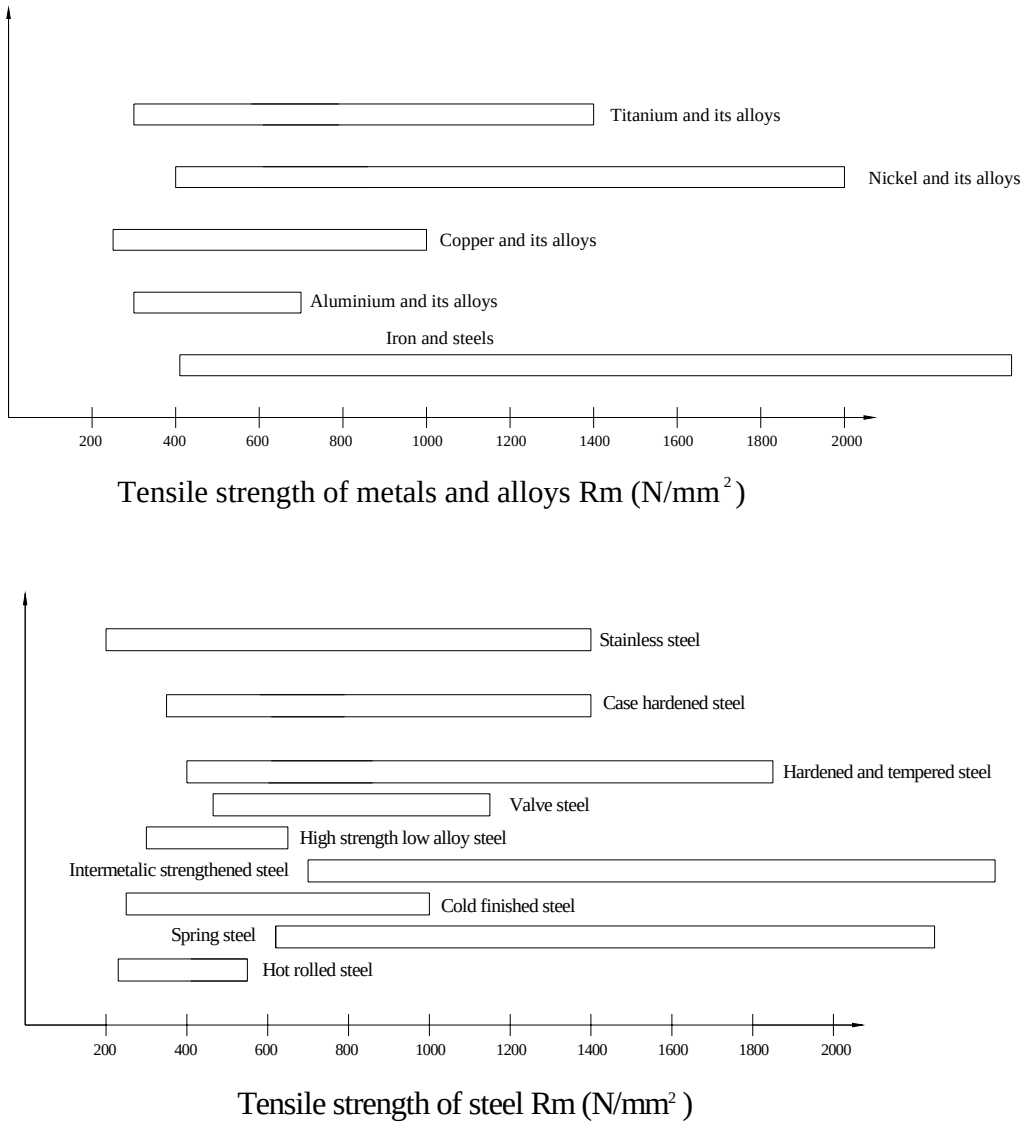

Fig. 4. Tensile strength of metals and steel

4. IMPROVING WAYS OF METALS MECHANICAL PROPERTIES

Not looking on a spacious metal and their alloys, we can improve mechanical properties for almost any material. We can purchase materials with lower mechanical and physical properties, but processing those, obtain properties of material for our necessities. Approach of choice of such material is comparing cheaper than to purchase already suitable material. To decrease payments of screw rotors and weight, rotors can be made from chopped carbon fibre epoxy composite materials by the RTM (resin transfer

moulding) process using separable four-piece moulds for easy demoulding of helical shape screw rotors. So as materials of composites it is difficult to process after, therefore at the beginning is necessary to make pretty exact form in which we will form rotors with specific profile.

One of varieties of improvement of mechanical properties of materials is the mechanical processing. With processing methods, we can improve mainly only properties of overhead layer of material (we strengthen an overhead layer) – increasing hardness of overhead layer, wearproofness, higher tensile strength. Mechanical processing we can carry with, for example, processing the overhead layer of material with pellets, for the special billows etc. Mechanically strengthening the overhead layer of material, we plastic deforms it. The depth of the fixed overhead layer is identical with the deformed stratified density.

Often for the only made details it is necessary to decrease or to take off detail forge. To rest of steel there is diminishing of deformation of crystalline grate and partial renewal of physical chemical properties.

In our days heat treatment of material are spaciously used, which consists of that good warms and cooling which task - to change the structure of material and properties, noticing the certain modes. Thus obtain considerable changes of properties, and do not change chemical composition. In nowadays thermal processing method based on metal physic, dislocation theory and changes of metal structure regularity. Kind of thermal processing stipulate instead character of temperature changes, but phases of metal and changes of structure. Heat treatment can be executed for moulding, forging, rolled metal, details of drawing machine, welding connections, for more responsible details of machine and tools. Main thermal processing kinds are shown in the Fig. 5.

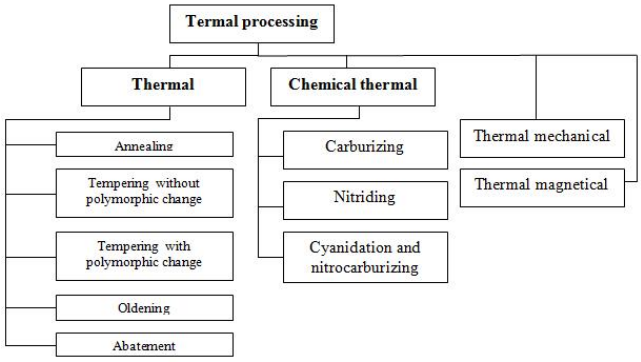

Fig. 5. Types of main thermal processing

In the result of technological processes of detail manufacturing, plastic deforming and processing, tensions, to develop untransient by the first order tensions in material which are counterbalanced in all volume of detail, which is unfriendly exploitation of detail in time. By using one of thermal processing kinds – annealing, we can liquidate internal tensions. Annealing is thermal processing kind in which result metal or alloy obtains the almost balanced structure without untransient tensions, and also high plasticity, but in correlation low force.

Untransient internal tensions can cause in further treatment of deformations of wares or in exploitation and added up with the tensions created by the external loadings, prematurely to cause crashing down of material or impermissible deformation by a construction, and also promote possibilities of fragile break.

Purpose of tempering is considerable to promote force of material and hardness. We can execute tempering mainly for more part steels, in which C>0.25...0.30%. Tempering leans on steel crystallization means heating above critical temperatures, sufficiently maintaining in this temperature and quickly cooling. In such kind prevent austenite transformations in perlite. Tempering steels haven't balanced martensite, beinit, trostite or structure of sorbite. Tempering can be executed also only for the overhead layer of detail. Tempering of surface of detail above a critical temperature, heat a thin overhead layer only, but internal layers are not heated. After tempering detail has hard overhead layer and sinewy core.

There are also failings of material tempered from which it was needed to shy away. The defects of tempering are cracks, warping and decarbonisation. Cracks appear because in separate places a volume changes is irregular and appears tensions which in these places exceed tensile strength of metal. Crack and warping main reason is the uneven change of volume of detail warming, and also exceptionally quickly cooling. Surface of steel decarbonisation appears in the result of burning down of carbon, if long warm a detail in an environment oxidizing in a high temperature.

As often as not, that would temper steel, it needs to be prepared, executing his normalization. In the result of normalization steel obtains a fine-grained and homogeneous structure.

As often after tempering of steel we would necessary to increase fatigue strength and to decrease fragility, and abatement it. Abatement softens influence of tempering, diminishes or takes off untransient tensions, promotes fatigue strength, diminishes hardness of steel and fragility.

Not so popular kind of thermal processing is chemical-thermal treatment. That treatment to consolidate thermal and chemical influence, what changing chemical composition of overhead layer and structure, together with improving of good mechanical, physical and chemical properties. By using of tempering we do not incompletely use part of material core. Chemical-thermal treatment allows us to manufacture the detail from the cheapest and the simplest material, his overhead layer proper strengthening. In nowadays chemical heat treatment is often only unite with ordinary heat treatment. About the steel chemical heat treatment call the satiations of overhead layer in diffusive type in high temperatures with various elements, for example, carbon, nitrogen, aluminium, silicon, chromes etc.

In a process of cementations we executed satiation of surface of steel with a carbon. Carburizing is used for multiplying wearproofness elements of the machines. For providing large dynamic loading resistances, part of detail core desirable to save plastery. Therefore for making of the carburizing details choose steel with maintenances of carbon 0,1...0,18%. Diffusion of carbon in steel is possible only then, if a carbon is in the specific state.

Satiation of overhead layer of material with nitrogen often is called as nitriding. This process is used for increasing wearproofness, longevities, hardness of surface and for

multiplying endurance of corrosion of machines details. Hardness of nitriding overhead layer considerably exceeds hardness of the cemented and tempered overhead layer. Nitridind is doing for the responsible details of machines and mechanisms, which are inferior to the friction and which the variable loading of size and direction operates on.

As often as not, to improve properties of overhead layer of detail, poured cyanidation and nitrocarburizing processes in which takes place simultaneous satiation of steel surface with a carbon and nitrogen. Thus is the treated surface both carburizing and nitriding properties of surface: large hardness, wearproofness and resistance of corrosion in the atmospheric circumstances and longevity is promoted in case of the variable loading.

These are one of processing kinds, with the help of which we can multiply hardness and wearproofness of surface of screw rotor of screw type compressor.

The thermomechanical treatment is comparatively new processing type of steels, heat treatment and plastic deformation is incorporated in. In a result of thermomechanical processing obtain much mechanical dignities nothing in ordinary heat treatment - higher fracture and fatigue strength and force, more longevity, but plasticity and viscosity is saved or is even increased.

To decrease remaining austenite amounts and promote hardness in tempered steel, then we converts untransient austenite – martensite, using treatment of steel with a cold which described with cooling of tempered steel below than a zero. Martensite is the hardest and fragilest structure.

I offer to use various coverages for improving properties of overhead layer of rotors material of screw type compressors. That will multiply hardness of overhead layer of screw rotors, and also wearproofnes and diminishes a friction. The overhead layer of material can be covered with various coverages, for example, TiN, Ti(CN), SiC, Mo2N, TiAlN, teflon, and also other coverages. Coverages on the working surfaces of rotors are possible to cover with various methods. One of the methods - CVD, the second method of covering is PVD. For coverages of material surface we can also use methods of sputtering or to use the method of electronforming. With the help of coverages we obtain an overhead layer with the diminished porosity, balanced structure, promoted connection with a basic layer. Covereges we can also create in much coverage.

5. SUMMARY

From all beforehand examined flow out, that the choice of materials nowadays is very spacious and it importance is very important in most of all industries. Faultlessly to choose correct material it is needed to know main output information of constructions, for example, this mechanical, technological, and also properties of surface, circumstances of exploitation etc. Mechanical properties of materials are pretty important in exploitation of detail in time. Properties we can easily to change with heat treatment.

In our days the methods of production and facilities are so varied, that one and the same result it is possible to extract with various technological processes. Heat treatment in a large measures stipulate a various detail, instrument and other quality of wares. With heat treatment we can assign for wares necessary mechanical properties and provides for them normal term of service, knowing development conditions of materials. Analyzing these special methods of details for force increasing drew a conclusion, that with it thermal processing methods for material helps we can extract the much better mechanical, physical and technological dignities nothing using simple methods. We can extract these dignities, using the special methods of increase of force of material. From plastic material far more hardy material which can not be achieved with ordinary methods.

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