where $x = x_0 + A\sin\omega t$; $\Phi(A) = K \dfrac{(1 - aA)S_k}{(1 - aA)^2 + S_k^2}$.

The structural circuit of linearized twin-motor drive PTK is represented in relation 8. It is easy to notice that it differs from the structural circuit only in one respect: the hardness of speed-torque characteristics of drive motors β^1 and β^2 are replaced with $-q_1(A_1)$ and $-q_2(A_2)$ hence, the expression (7) remains unchanged, and the values of K_1 and are determined as follows:

$$K_1 = \frac{I^2 q_1(A_1)}{I^1 q_2(A_2) + I^2 q_1(A_1)}, \ K_1 = \frac{I^1 I^2}{I^1 q_2(A_2) + I^2 q_1(A_1)}.$$

The motor rigidity in this case is determined by positive definiteness and, therefore the inequation

$$I^1 q_2(A_2) + I^2 q_1(A_1) > 0$$

similar to (10), and represents the necessary and sufficient condition of stable operation of a motor in dual-motor drive PTK.

In the preceding analysis of multi-motor drive operation PTK it was assumed that the rotation frequency of nth motor can take any values from the given range of rotation frequency variation without dependence on other motors frequency rate. This hypothesis is equivalent to the statement about absolute stretchability of a conveying chain and correct only when taking-up of clearance, i. e. in the case when tension stations have no restrictors. In other borderline case, when a conveying chain is considered to be absolutely stiff, the transient equation is:

$$I_\Sigma \frac{d\omega}{dt} = M_{\text{пр}}(\omega, U^i) - M_s, \tag{12}$$

where $I_\Sigma = \sum_{i=1}^{n} I^i$, $M_{\text{пр}}(\omega, U^i) = \sum_{i=1}^{n} M^i_{mot}(\omega, U^i)$.

The extended analysis of dynamic characteristics of asynchronous drive is presented in the following papers [1, 3, 6].

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Electropulse technology of briquetting shavings and others scrap of ferrous metals

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One of actual problems is rational use of a lightweight metal scrap that is important for their recycling, preservation the fond of metal and uses as cheap charge [1—3]. Them concern a metal shavings, sheet crop, flash, splashing and others. These are an industrial waste which is important to use more full because their repeated recycling to provide the minimum accumulation of impurity. Other perspective source of a lightweight metal waste — the mixed scrap, including en from of a solid domestic wastes. The concept of separate gathering and recycling of the waste, accepted in the developed countries, already at the first stage assumes full recycling metal waste [4]. Russia the next years will join this program, in particular in Saint Petersburg is to utilize by 2014 50% of a waste (it will be in this time thrown out 500 thousand ton ferrous and 260 thousand ton nonferrous metals) [5]. Waste can become a source of the cheap metallurgical raw materials, bat it contain a complex mixed scrap. The offered way of its recycling includes crushing (crushing degree should be above, than on existing the installations intended for recycling of cars) and separation. Magnetic steels can be taken by means of an electromagnet, and stainless steel and nonferrous metals — with the magnetopals separator [6]. In the course of recycling the significant amount of the crushed scrap ferrous and the nonferrous metals which briquetting on existing a briquette–press is impossible is formed. Complexity of processing of a lightweight metal waste is connected with their low bulk density and absence of effective technology of loading at transport and in technological units. At a shavings meltdown in bulk time of loading of furnaces essentially increases, and the metal charcoal fumes can reach 30 % and more. Time of loading of furnaces briquettes almost same, as well as at loading of a lumpy scrap, and charcoal fumes is reduced to several percent. However existing ways of briquetting demand the big efforts of pressing (3–4 t/sm^2) and allow to briquettes effectively only rather soft materials, for example low-carburized steels [3].

In Russia such equipment is not made. Fuller and rational use of a lightweight metal waste probably by means of an electrophysical electropulse method of briquetting [7–13] in which as the technological tool the electric current of the big density [7] is used. The method consists in pressing crushed metal scrap at rather small pressure (to 0,5 t/sm^2 for high-strength alloys and porosity of briquettes on 50 %) and processing with use of short impulse of an electric current. Such processing allows to connect the pressed material in a firm briquette. All metal at briquetting heats up slightly, and local zones of contacts are exposed to heating for short time that allows to avoid metal oxidation even at briquetting on air of such chemically active metal, as the titanium. The model of process of briquetting [8, 11] is developed, allowing to estimate necessary parameters of process, i. e. a range of duration and amplitude of an electric current for a shavings and other waste of any metals and alloys. The first experiences have been executed with a shavings of titanium alloys [9–11]. On laboratory and pilot installations have made briquettes of the different form, the size and density of a shavings of various titanium alloys, including highly strong (VT1-0, 3M, VT20 and other). Mechanical tests of samples of briquettes of different density have shown that at small amplitude of a passed current briquettes are not formed, at amplitude increase briquettes of small durability are formed, and then durability of briquettes increases. It has been established that at rather small entering of energy (~5 kW·h/t) durability of briquettes on rupture has exceeded 200 kN/m^2 that it is quite enough for their transportation and processing. Research of influence of process of briquetting on quality of received metal was conducted. During research received mini-briquettes, malt it in the condition weighed in a magnetic field with reception mini-ingots, defined the chemical analysis of metal and its mechanical properties. Research has shown that at briquetting on air even such chemically active metal as the titanium, nitrogen connections are not formed, oxidation is insignificant also metal pollution as a whole slightly. Estimation of technological possibilities of use of briquettes in industrial conditions (for melt of ingots in weight about 100 kg, a share of use of briquettes spent electrodes are made of a shavings in charge has made 5 and 10 %) has shown that quality of metal corresponds to preliminary calculations. At increase in a share of briquettes in structure of charge on 1 % the oxygen maintenance in an alloy has increased by 0,008 %. Defined dependence of temperature of all briquette after processing from size of a passed electric current which was regulated by change of initial voltage of the condenser battery. For briquettes of the big density (25 % of metal) this temperature did not exceed 200 ^oC. At such heating there is no metal deterioration that is confirmed by results of the chemical analysis. Besides, it shows that the given technology is power saving up that also confirm calculations and other experimental data. During experiences on electropulse briquetting of other materials trial briquettes from a shavings of aluminium, copper and a brass have been received. Experiences and the calculations executed on the basis of developed theoretical model, have shown that the given technology allows to briquette a shavings of any metals and alloys and other kinds of the crushed scrap on one installation and without readjustment. Pilot installation for briquetting of a shavings of titanium alloys BT80 by productivity of briquettes of 80 kg at an hour is developed. The first works on electropulse briquetting have been directed on recycling of a titanium shavings. However discussion of these problems with potential consumers has shown that the given technology is actual for a shavings and a scrap of ferrous metals. High-alloyed steels at cost come nearer to titanium alloys, and amount of producing and uses of ferrous metals there are more then nonferrous. At the same time pig-iron and highly strong, including carbonaceous steels badly give in to briquetting by pressure on usual briquette–press, and briquetting with heating demands the big expenses of energy, leads to deterioration of metal and environmental contamination. In communication with it is expedient to investigate process of electropulse briquetting of a shavings and a waste of ferrous metals. Calculation of parameters of process of electropulse briquetting for magnetic and not magnetic (stein less steel) steels under the formulas resulted in works [8, 11] has been executed. As the important characteristics for calculation for stein less steels, such as specific electric resistance, the temperature and warmth of fusion, are close to corresponding characteristics of the titanium alloys investigated earlier settlement parameters of process of briquetting are accordingly close also. At calculation of parameters of briquetting of magnetic and not magnetic steels following difference has been revealed. At briquetting of not magnetic materials, actually at any really achievable parameters of process, the thickness of skin layer for a current in a material of a briquette is much more then the diameter of the sample, i.e. the average current is distributed evenly on all sample. In briquettes from ferromagnetic materials, according to calculation, a thickness of skin layer less than characteristic distance between contact points or channels of course of a current. In this case each channel is a separate independent conductor, and the average current is evenly distributed on all sample. Whether it will lead to differences in the course of briquetting, it is possible to establish experimentally. Parameters of the experimental installation developing a current by amplitude to 500 kA and duration 400 μc (average density of a current to 25 kA/cm^2 at diameter of a briquette of 50 mm), allow to study process of electropulse briquetting of steels.

In the first series of experiments possibility of briquetting of a wide class of materials on an iron basis has been investigated. Briquettes from a pig-iron, stainless steel and magnetic steels shavings; from the crushed steel sheet scrap and metal-cord automobile tyres are received. Used materials of a different kind and quality: curly and powdery shavings; the crushed steel breakage with the sizes of pieces ~1×20×30 mm;

metal-cord; materials cleared from impurity and insignificant oxidized, and also strongly polluted by the oil, strongly oxidized (rusty), the painted steel scrap were used. It is established that all of them give in to briquetting, and presence of sheet of oxide, some greasing and even a paint does not prevent to process of briquetting. On Fig. 1–3 photos of some briquettes are presented.

Other series of experiences has been directed on research of process of electropulse briquetting. Received and investigated series of briquettes from a shavings of a carbonaceous steel of marks the Stal 3, Stal 45 and stainless steel 12X18H10T. Samples in diameter have made of 53 mm and height 100–140 mm. Volume of a current passed through the sample regulated bay change of the charge voltage of condenser battery Ub. Experiments spent at charge voltage of the battery 500, 1000, 1500..., 2500 V, it is also received briquettes of various density. In each experience registered oscillograms of the current and the voltage on the sample, the electric resistance of the sample before and after passed an electric current, temperature of the sample after passed a current, then samples tested for rupture and measured the maximum loading at rupture. Studying of the oscillograms of a current and voltage on the sample showed that at briquetting of steels the same processes, as at briquetting of titanium alloys are observed. The basic difference consists that electric resistance of the compressed steel shavings is less than a titanium shavings. It is connected with smaller specific electric resistance of steels and, probably, with differences in properties of the oxide layer on a surface of these metals. Thus, steel samples are similar titanium compressed to the big density. Magnetic properties of steels according to calculation and experiment do not render essential influence on briquetting process.

Fig. 1. A briquette from a pig-iron shavings; diameter of 53 mm, height of 90 mm, density of 2,8 g/sm^3 (porosity of 60%), weight 500 g

Fig. 2. A briquette from a shavings stein less steel 12X18H10T; diameter of 53 mm, height of 100 mm, density of 1,5 g/sm^3 (porosity of 80%), weight 340 g

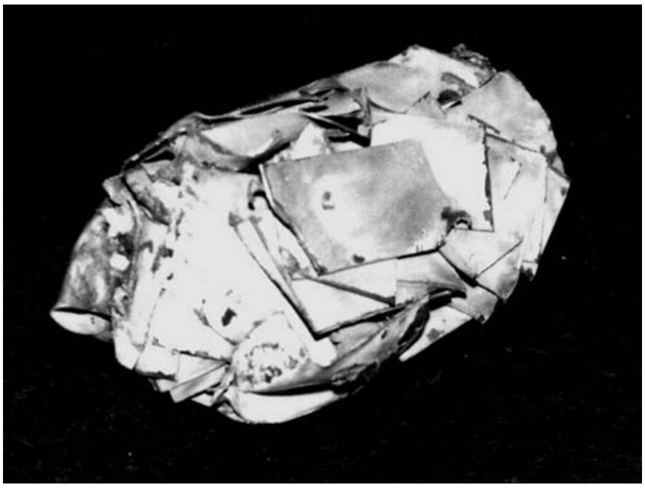

Fig. 3. A briquette from the steel crushed scrap (a piece 1×20×30 mm) of electric lighting fittings; diameter of 53 mm, height of 100 mm, density of 2,1 g/sm^3 (porosity of 70%), weight 465 g

Produced briquettes were tested with help of the breaking machine RD-05. Rate of loading made 5 mm/minutes. Collars, which protected briquettes from crushing at their installation in breaking machine have been made. Collars provide to break samples with effort to 200 kN, allowed to no destroy zone of captures, stronger samples slipped out collars. Destruction occurred not in a zone of captures though concentrators were not used. At charge voltage of the battery to 1 kV briquettes are not formed or formed briquettes with low durability (loading 5–15 N). At increase of voltage more than 1,5–2 kV (results are allocated by a bold type) durability of briquettes increases (loading at rupture to 100–200 N and more).

The briquettes received on new electropulse technologies, can be used as charge for remelting, half-finished products, including master alloy, materials and finished articles. Most simply to use briquettes as charge. Thus the main advantage of technology — universality, i. e. possibility of briquetting without readjustment and at the guaranteed constancy of a chemical compound and high durability of briquettes of any materials: the shavings, the crushed scrap and a breakage of any metals and alloys, including high-strength, reactionary, fragile (for example, the carbonaceous and alloyed steels, pig-iron, titanium alloys, bronze интерметаллидов, ferroalloys and etc.). Use of such briquettes as charge is much more effective, than a shavings meltdown in bulk: losses of metal and pollution of environment decrease, time of loading decreases and the filling of furnaces increases. The briquettes received on electropulse technology, except high durability, have sufficient porosity to make clearing of metal of a greasing and a moisture in briquettes. Besides, it is possible to delete a covering from the briquetted metal, to restore the oxidized metal, etc. Such briquettes can be used in any metallurgical units, including electric furnaces, converters, vacuum-arc furnaces.

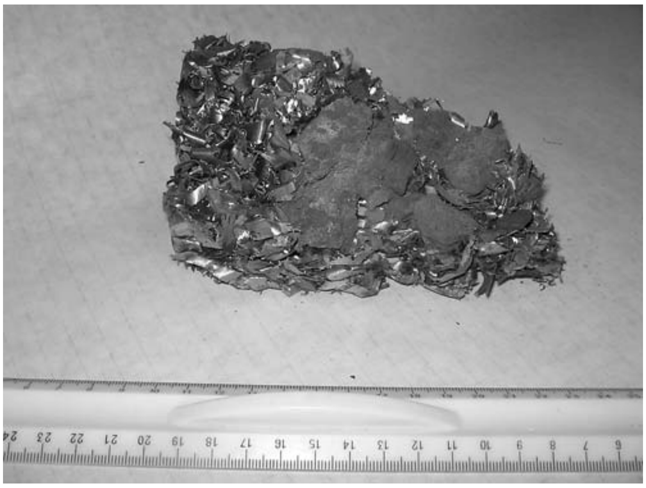

Fig. 4. A fragment of a composite briquette from a shavings became the Stal 3 with the additive of pieces of a material with low conductance (the size 200×60×60 mm; density of 1,4 g/sm^3, weight of 1 kg (400 g shavings + 600 g metal-containing rock)

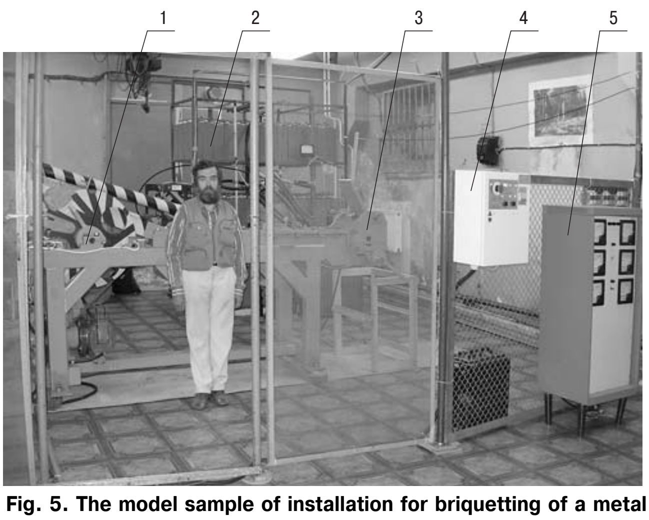

Fig. 5. The model sample of installation for briquetting of a metal shavings: 1 — the press; 2 — the capacitor battery; 3 — the press chamber; 4 — the control panel a press; 5 — the panel of management of the capacitor battery

It is favourable to use briquettes as half-finished products, for example preparations for punching, and also master alloy. As alloying materials it is offered to use the briquettes made of a shavings and other crushed metal or a mix of a shavings of different metals, and also composite briquettes from a shavings and a lumpy material both spending, and dielectric, in particular elimination of small fraction master alloy usual type. The briquettes made on electropals technology, possess the big porosity which can be regulated practically from bulk density of an initial shavings (10—15 % from metal density) and to 50 % from metal density. Briquettes can be entered into the set zone of melt, by regulating their weight, density and drop height. At the expense of the big porosity of briquettes master alloy it is acquired much faster, than at use of pieces. Possibility microalloying and refinements of aluminium alloys by briquettes from a shavings of a titanium, alloying of steels by briquettes from a mix of 30 % of steel and 70 % of a titanium shavings (analogue of 70 % ferrotitanium), alloying titanium alloys composite briquettes from the titanium shavings, containing pieces of aluminium and aluminium-vanadium is experimentally investigated. It is possible to receive composite briquettes with inclusions of pieces of a material with high and low conductance. As such material pieces of metal-containing rock, and as a briquette basis — a shavings from a steel Stal 3 have been used (Fig. 4.) [13].

For reception of composite briquettes it is possible to use in a significant amount any materials both spending, and dielectric that is especially important at manufacturing master alloy. The method can be used and for returning in metallurgical process of any kinds of a disperse waste. So, iron scale, which on a number of the enterprises is formed in considerable quantities, it is possible to briquette together with a small pig-iron or steel shavings and again to enter into malt.

Briquettes can be used as materials and products. It is a new perspective porous material, which in a number of areas can to substitute porous ceramics, metal and nonmetallic fibres and others. Briquettes can be welded with sheet metal and a foil that will allow to receive a material of higher durability. It is possible to cover a surface of briquettes frothmetal, and unessentially with the same name. It is possible to make plates from which on the same technique then to weld panels of any size, to make cylindrical and conic details, pipes.

Other possibility of recycling lightweight scrap is their processing in powders. Metal powders can be used directly, and also being based on the first successful experiences of the new concept; it is possible to receive from them porous products. Rather cheap metal powders product from a lightweight metal scrap by to mechanical crushing, and then briquetting on electropulse technology. Thus, wide prospects of use of offered technology open.

Now for reception of experimental batches of briquette model installation is developed and it made briquettes of any metals and alloys, including from a mix of a shavings of different metals, and also composite briquettes (Fig. 5). This installation is a prototype of the future automatic plant for briquetting of a waste of any metals and alloys annual production rate on a steel at one-shift work — from 500 ton to 2,5 thousand ton briquettes and at round-the-clock work — from 2 to 10 thousand ton. Equipment cost approximately corresponds to cost import briquette-press at essentially big technological possibilities. Plants, by calculations of the author, pay off within one two years.

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The pioneer of applied sciences

Paying the tribute to the talent, and width of views of the outstanding French natural scientist — Rene Anthony Farchault de Reaumur, his coevals called him the Pliny[1] of the XVIII century, and compared him with the great philosopher — Francis Bacon. However, the scientific knowledge at that time was a lot more uniform than it is today, and most of the scientists were carrying out investigations on a broader scale, and not in single scientific field, most of which just appeared. Yet, Reaumur's scientific achievements are astonishing. His fields of study included: mathematics for which he was awarded a membership at the Paris Academy of Science, development of the manufacturing process for French porcelain production, discoveries in the field of zoology, creation of a thermometric scale, and of course the amazing fundamental works in the field of ferrous metallurgy, that are not mentioned in any article at the Great Soviet Encyclopedia.

Rene Anthony Farchault de Reaumur was born at Rouchelle on the French Atlantic coast, on the 28th of February, 1683 at the noble family. The father of the future scientist, Rene Farchault held a rank of amicus curiae[2] at La Rouchelle court house. He died in 1684, when Rene Anthony was one year old. Rene was then educated by his maternal uncle. Rene Anthony graduated from the Jesuits college at Poitiers and then studied civil law at Bourges.

In 1702, Reaumur moved to Paris, and applied himself wholly to the mathematics under the guidance of Gine, who later introduces him to Pierre Varignon — mathematician and engineer, member of the Royal Academy of Sciences. That acquaintance played an important role in Reaumur's life. Varignon became Reaumur's close friend and a teacher. Besides, in 1708, Varignon helped Reaumur to enter the

[1] Pliny Senior, Guy Pliny Secund (23, or 24 Comum, modern Como - 79), Roman writer, scientist and statesman. The author of the "Natural History" 37 books (the antique encyclopedia of the natural knowledge). Contains information on: astronomy, physical geography, meteorology, ethnography, anthropology, zoology, botany, agriculture and forestry, medicine, mineralogy, metallurgy etc. Until the end of the 17th century was widely used as a knowledge base about nature.

[2] Court house adviser (Lat.)