Friction Wedge for Vibration Damper for Freight Car Boards from Synthetic Cast Iron

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FRICTION WEDGE FOR VIBRATION DAMPER FOR FREIGHT CAR BOARDS FROM SYNTHETIC CAST IRON

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Abstract. The article examines the prospect of using new materials, in particular synthetic cast iron, for the manufacture of a friction wedge for the vibration damper FWVD of freight car bogies, taking into account the design requirements placed on them. A new method for producing FWVD from synthetic cast iron in a one-time sand form is proposed with a description of the technological process.

Keywords.
friction wedge, vibration damper, freight car boards, synthetic cast iron, share of scrap steel, hardness, melting time, mechanical properties, mass fraction of elements.

1. Introduction

The efficiency of railway transport in modern conditions has a special role in increasing freight transportation in the republic. The main directions for increasing it are reducing the costs of servicing and repairing freight cars.

We have a scientific interest in studying the design and material of the friction wedge, which is a wear part. As a rule, the average mileage of gray cast iron friction wedges before replacement is just over 100 thousand kilometers, while the average wear (mass loss) along vertical and inclined walls averages 15-20% of the total material consumption. According to statistics, the annual need for this type of consumables, only for depot repairs, is more than 1.5 million pieces. At the same time, when the friction wedge wears out, about 4 thousand tons of cast iron are irretrievably lost.

We are faced with the task of developing new types of materials for friction wedges, including improving the design, optimizing the chemical composition, physical, mechanical and tribological properties, as well as predicting the performance of the vibration damper under various operating conditions.

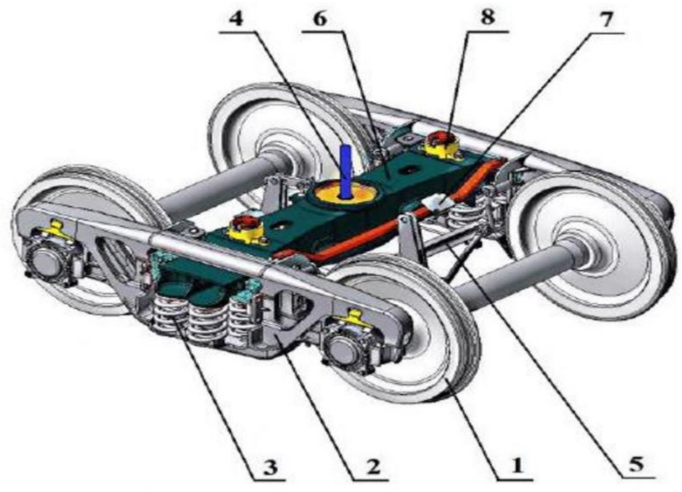


Fig. 1. General view of freight car bogie:
1 is wheel pair, 2 is side frame, 3 is spring suspension, 4 is pin, 5 is brake linkage, 6 is bolt, 7 is beam supporting auto mode, 8 is beam.

We know that as demands on the service life and reliability of friction wedges increase, there is a need to ensure a rational structure of cast iron. In this case, it is necessary to take into account the stable state of quantitative and qualitative indicators of the structural and phase composition of the cast metal in conditions of normalized fluctuations in the general parameters of the technological process for manufacturing the casting.

The goal of our research is the development and implementation of synthetic cast iron and its production method for the manufacture of friction wedges with improved performance properties.

An important role in ensuring traffic safety is played by cast parts of freight car bogies, in particular, the bolster, which is its most important part. Transferring the load from the car body through the spring sets to the wheelset performs the most important function. The general view of the car bogie is shown in Fig.1. The improvement of the operational performance of rolling stock parts depends on their technical condition [1].

Spring suspension with wedge friction vibration dampers is the main component of a three-element freight car bogie and is designed to reduce the amplitude of vibrations of the car body and the level of dynamic forces in the vertical and horizontal planes. When a car moves along periodic uneven tracks at a speed when the frequencies of forced natural vibrations are close in magnitude, large amplitudes of body vibrations on the springs (resonance) may occur if there are no or small resistance forces in the spring suspension system. Therefore, to dampen resonant vibrations, special dampers are introduced into the spring suspension system, which make it possible to reduce the amplitudes and accelerations of the oscillatory movement, and therefore reduce the impact of dynamic forces on the elements of the car and the transported cargo [2].

2. Methods

In freight car bogies, a friction wedge is used to dampen vibration. The authors of work [3] considered the possibilities of improving the parameters with an adjustable friction wedge, since bogies with adjustable friction and damping are currently widely used in freight rail transportation. They investigated a new variable friction wedge damper. Its structure is simple and provides good base rigidity. The trolley with improved damping device has the characteristics of a trolley with variable and constant friction damping. The relative friction coefficient of vibration damping is analyzed and tested. In addition, the influence of the wedge width on the dynamic characteristics of the vehicle, including rigidity, critical speed, trajectory and cornering characteristics of the improved bogie, is analyzed.

Wedge hangers are an important component in the operation of the trolley. The authors propose a methodology for optimizing the wedge design using various suspension models; a dynamic model is considered. Comparative experiments were carried out on two types of original wedge suspensions with three different toe-in angle configurations. the optimization issue was considered using the Pareto front method. The results of comparative experiments show that wedge suspensions with toe-in provide better dynamic characteristics of freight cars, and this also makes it possible to significantly reduce the maximum contact forces between the wheel and the rail [4].

Currently, synthetic cast iron is used to make a variety of parts for critical and especially critical purposes, for example, locomotive and carriage blocks, friction wedges, crankshafts, cylinder blocks, heads of internal combustion engines, wear-resistant castings, machine tool castings, etc. operating under high loads and elevated temperatures [5].

Cast iron, the oldest type of ferrous material for injection molding is also currently the most widely used material in foundries. In particular, this good technological properties (excellent fluidity, low tendency to shrinkage and their formation, low propensity for stress) as well as acceptable mechanical properties and good workability. Similarly, its physical properties and prefer it allows to produce castings with excellent specific characteristics, particularly heat and heat resistant, wear resistant and castings with special physical properties. Disadvantage of grey iron is its high fragility. This feature is designed production of spheroidal graphite cast iron. Another drawback is the relatively high variance properties, in particular mechanical, even in the stable composition [6,7].

It should be noted that the main reason for long-term downtime of cars is malfunction of the running gear. The service life of a freight car bogie depends on the performance of the parts included in the freight car bogie assembly, in particular the spring suspension with wedge friction vibration dampers, which is designed to reduce vibrations of the car body and the level of dynamic forces. The stable operation of the friction wedge vibration damper (FWVD) affects the operating time, since the friction force it creates to dampen vertical and horizontal vibrations of the car body decreases over time due to wear of the working surfaces of the friction wedge, which leads to an increase in the dynamic forces acting on carriage and track. The friction wedge is a quickly wearing part, that is, the average mileage of friction wedges made of gray cast iron before replacement is about 100 thousand kilometers. The annual need for FWVD, only for depot repairs, is more than one hundred thousand units. At the same time, approximately 0.3 thousand tons of cast iron will be consumed irrevocably when the friction wedge wears out. In turn, this sets the task of developing new materials for FWVD, including improving the design, optimizing the chemical composition, physical, mechanical and tribological properties, as well as predicting the operation of FWVD under various operating conditions [8,9].

The use of new types of materials, in particular synthetic cast iron, for the manufacture of FKGK in the conditions of the Republic of Uzbekistan is one of the priority areas, taking into account economic efficiency. We were interested in the issue of manufacturing FWVD from synthetic cast iron. To do this, we will consider the characteristic indicators and methods for producing synthetic cast iron, as well as the design requirements for the FWVD of freight car bogies in accordance with GOST 9246 [10].

Our goal is to study the performance properties of wedges made from synthetic cast iron, and to develop and implement a new method for producing synthetic cast iron with specified properties. Manufacturing a pilot batch of friction wedges made of synthetic cast iron, conducting laboratory and bench comparative tests with mass-produced wedges made of gray cast iron. To do this, consider the following questions:

- design requirements for FWVD;
- technological process for producing FWVD from synthetic cast iron in a one-time sand form.

The smelting of synthetic cast irons is the main means of raising iron foundries to a qualitatively new stage, since they can be classified as structural materials that differ significantly from the cupola cast irons used not only in strength properties, but in the nature and technology of production.

Design requirements for FWVD for two-axle three-element bogies of freight cars in accordance with GOST 9246 [10].

On the vertical surface of the wedges, visual indicators of the limiting state of wear and overestimation of the friction wedge are used, the locations of which are given in the design documentation. FWVD can be obtained by casting or another method. Today, FWVD is made from:

- steel grades 20L K20, 25L K20, 20GL K25, 20FL K30, 30GSL K35 according to GOST 977;
- cast iron grades SCh30, SCh35 according to GOST 1412 and from VCh60, VCh70 GOST 7293.

3. Results and Discussions

The problem of efficient use of metal waste of low volumetric weight is most rationally solved by organizing the smelting of synthetic pig iron. The advantage of such smelting is the possibility of remelting waste directly at the place of their formation - in foundries of machine-building plants without long-term transportation and irretrievable loss of metal. Pig irons are generally excluded from the composition of the charge, which frees up the corresponding capacities of metallurgical production. The use of cheap metal waste for the smelting of synthetic pig iron provides a reduction in its cost by 25 30% compared to conventional remelted cast irons. It is advisable to use synthetic cast iron for the production of high-quality cast irons, especially with nodular graphite, given the low content of demodifying impurities in them [11].

Cast iron is an alloy of iron and carbon, the amount of the latter must be at least 2.14% and can be cementite or graphite. In addition, cast iron also contains impurities, Si, Mn, S, P and alloying substances. The mass fraction of elements in the composition of cast iron, depending on the grade of cast iron, is summarized in Table 1, and Table 2 provides approximate hardness data in the walls of castings of various sections [12].

Table 1

Mass fraction of elements in the composition of cast iron depending on the grade of cast iron

Cast iron grade	Mass fraction of elements, %				
	Carbon	Silicon	Manganese	Phosphorus	Sulfur
				No more	
gray cast iron - 10	3,5-3,7	2,2-2,6	0,5-0,8	0,3	0,15
gray cast iron - 15	3,5-3,7	2,0-2,4	0,5-0,8	0,2	0,15
gray cast iron - 20	3,3-3,5	1,4-2,4	0,7-1,0	0,2	0,15
gray cast iron - 25	3,2-3,4	1,4-2,2	0,7-1,0	0,2	0,15
gray cast iron - 30	3,0-3,2	1,3-1,9	0,7-1,0	0,2	0,12
gray cast iron - 35	2,9-3,0	1,2-1,5	0,7-1,1	0,2	0,12

Table 2

Approximate hardness data in casting walls of various sections.

Cast iron grade	Casting wall thickness, mm						
	4	5	15	30	50	80	150
Hardness NB, no more							
gray cast iron 10	205	200	190	185	156	149	120
gray cast iron 15	241	224	210	201	163	156	130
gray cast iron 20	255	240	230	215	170	163	143
gray cast iron 25	260	255	245	238	187	170	156
gray cast iron 30	-	270	260	250	197	187	163
gray cast iron 35	-	290	275	270	229	201	179

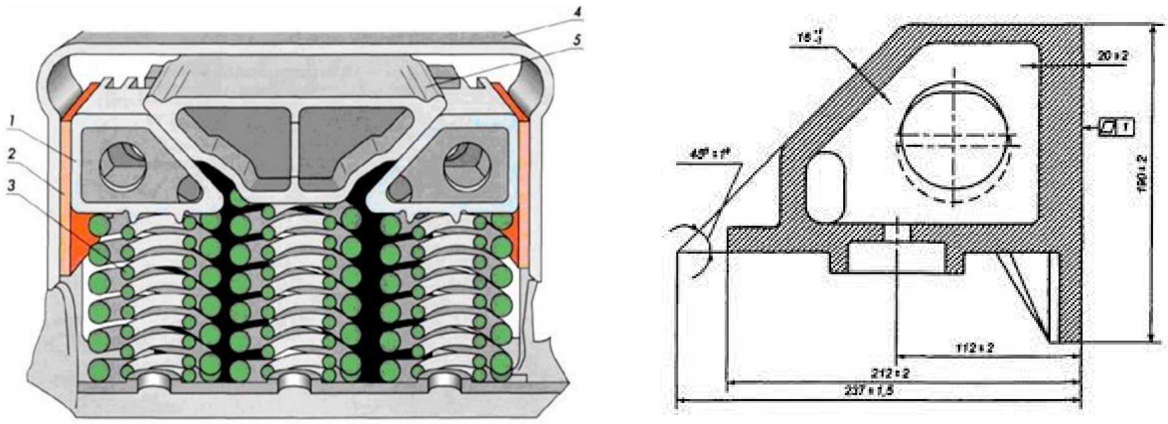
Provided that the design and functional requirements are met, the FWVD may use other materials, where, with the help of design documentation, the following are established: requirements for the material; requirements for the microstructure of materials for cast iron castings; requirements for mass and shape tolerances; molding slopes; removal of profits and feeders. If they do not interfere with control operations on the wedges and do not affect the quality of assembly, then the presence of burnt marks and scale can be allowed in places that are difficult to access for cleaning [13,14]. FWVD are not allowed on all surfaces and cannot be corrected: through casting defects; hot, cold cracks; refrigerators and drawers not welded to the base metal.

Friction vibration dampers are introduced into the spring suspension to create resistance forces to the oscillatory process of the sprung masses of the cars and reduce the amplitude during resonances. The operation of the parts included in the main assembly of the friction vibration damper is decisive in determining the period between overhauls of freight car bogies [15,16].

In friction dampers, friction forces create the necessary resistance to vibrations and oscillations of the sprung parts of the car, which occur with the relative displacement of the rubbing surfaces of the parts (friction wedge and friction strip). These forces can be constant or variable per cycle. Depending on the design characteristics of the dampers [17,18].

The advantage of friction vibration dampers is operational reliability and simplicity of design. Due to this, they are widely used in spring suspension of freight car bogies, as well as in axle-box suspension of freight and passenger car bogies. The disadvantages of such absorbers include: insufficient stability of operation, i.e. change in damper characteristics. As a result, the states of the surfaces rubbing against each other change; the inability to regulate friction forces depending on the oscillation mode of freight cars; large static friction forces, which prevent deflections of the spring suspension at low speeds.

The general installation diagram of the FWVD assembly under conditions of spring suspension of the trolley is shown in Fig. 2.



a *b*

1-friction wedge, 2-friction bar, 3-spring set, 4-tank frame, 5-support beam.

Fig.2. Central stage of spring suspension of the trolley (a) and design diagram of FWVD (b)

Wedge friction dampers are most widely used in spring suspension of freight car bogies [18,19]. The typical design of the friction wedge for the vibration damping unit of a three-element freight car bogie is a box-shaped steel or cast iron casting [20]. Three walls form the working contour of the surfaces that ensure the operation of the wedge.

4. Analysis of the obtained results.

The main factor that determines the content of the development strategies of a modern foundry is the use of modern technological processes, especially melting technology. First of all, this applies to the production of iron castings, which make up 65% of the mass of all alloys. Since 2000, in Russia, there has been a sharp decrease in the amount of pig iron scrap, the cost of foundry and pig iron and the cost of their transportation have increased significantly. This led to an increase in material costs in the production of castings from synthetic iron, which was mainly obtained in crucible induction furnaces of industrial frequency (ICT). In addition, problems began to arise with the use of acidic lining as the cheapest and most durable, since an increased amount of steel scrap began to be used in the metal charge, and for this reason the melting temperature was raised above 1450 ° C. The durability of the lining has sharply decreased, and downtime associated with its replacement has increased. All this had a negative impact on the efficiency of the production of synthetic iron castings [21].

Our scientific team received in the production conditions of the DP "Foundry-Mechanical Plant" in the city of Tashkent, from synthetic cast iron, FWVD sand form, which is shown in Fig.3.

Fig.3. FWVD from synthetic cast iron in a one-time sand form

With the transition to modern high-intensity processes, technological approaches to obtaining a given carbon content in cast iron have radically changed. If previously they sought to obtain a carbon concentration at the outlet of a smelting unit within the target range for a given grade of cast iron, then the concept of a modern high-intensity process in most cases involves the production of cast iron from a unified low-carbon intermediate product by carburizing the metal in a ladle [22,23].

Technological process for producing FWVD from synthetic cast iron in a one-time sand form. FKGK from synthetic cast iron is obtained by casting methods in a one-time sand mold, in which molten metal is poured into a mold made of tightly compacted sand. Casting from synthetic cast iron is carried out in several stages; the technological process for obtaining FWVD from synthetic cast iron in a one-time sand form is shown in Fig. 4.

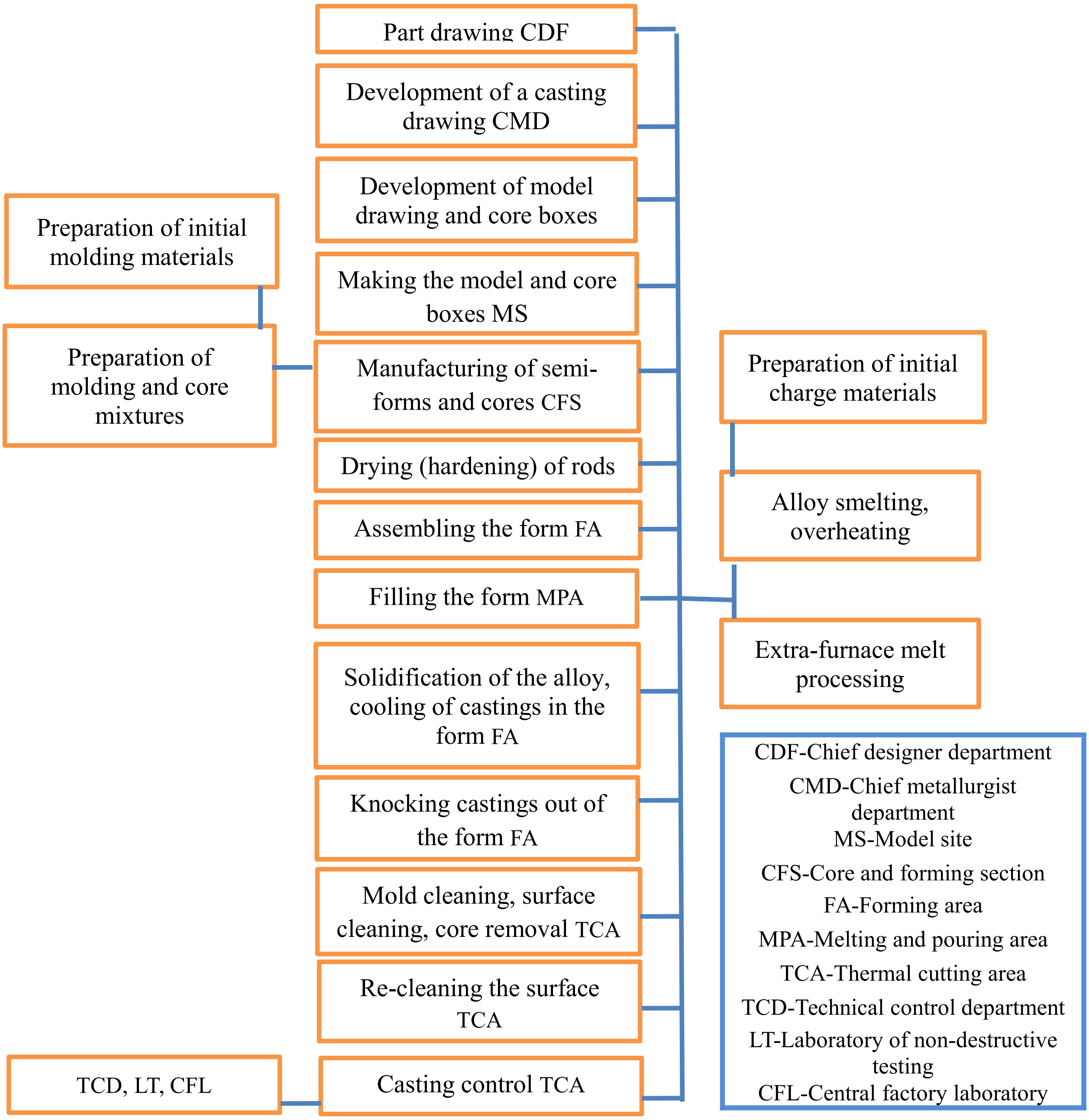


Fig.4. Technological process for producing FWVD from synthetic cast iron in a single sand form.

The technological parameters of the synthetic cast iron obtained using the proposed method, in particular the hardness of the HB, meets the requirements of GOST 1412-85 "Cast iron with flake graphite for castings." The dependences of the technological parameters of synthetic cast iron on the share of steel scrap are given in Table-3.

Table 3

Dependence of hardness HB of synthetic cast iron on the share of steel scrap

Share of steel scrap, %	Hardness, HB	finished products at the exit, %
0	210	97,5
10	234	97,33
20	247	97,24
30	279	97,15
40	296	97,05

*Scientific research is being conducted to identify and systematize the dependence of the influence of mechanical properties, chemical composition and structure of synthetic cast iron friction wedges on their tribological and strength characteristics and service qualities.

5. Conclusions.

Under the production conditions of the subsidiary "Foundry and Mechanical Plant" in the city of Tashkent, FWVD was obtained from synthetic cast iron in a one-time sand form. Technological parameters of the obtained synthetic cast iron using the proposed method, in particular the hardness of NV, complies with the requirements of GOST 1412-85 "Cast iron with flake graphite for castings", and FWVD are not inferior in terms of performance and technical characteristics to analogues mass-produced in the production of friction wedges

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