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Analysis of the Use of the Polymer Concrete for the Production of Machine Tool Base Parts

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Abstract. *Since its inception, polymer concrete has become one of the main building materials. And in some cases has replaced expensive metal structures in critical engineering structures exposed to static and dynamic loads. Bridge arches, crane girders of large bridge cranes, industrial building frames, supporting columns and trusses, railway sleepers. A number of other structures are made of polymer concrete. The article analyzes the application of polymer concrete for the manufacture of basic parts of machine tools. It is revealed that the manufacture of the frame, stand or the whole machine tool, which allows to increase the vibration resistance of the machine in 2 times. The cost of material can be reduced by 70% due to reduced use of metal.*

Keywords: *tool, polymer concrete, syntegran, mechanical engineering, CAE engineering, polymer materials, machine tool, basing, CAD/CAM engineering, metal-cutting machine.*

Introduction

Great attention to polymer concretes is explained by the following advantages: there are no residual stresses in the parts, the stability in time increases, the ability of the material to absorb vibrations (cyclic loads), high corrosion resistance, the possibility of obtaining the part, not using further machining.

At present there is a high level of development of chemical industry. This allowed to create a completely new class of composite materials – polymer concretes, in which natural stones such as pebbles, granite and limestone are taken as the basis and synthetic resin is the binding link.

Since its inception polymer concrete has become one of the main construction materials and in some cases displaced expensive metal structures in critical engineering structures exposed to static and dynamic loads. Bridge arches, crane beams of large bridge cranes, industrial building frameworks, supporting columns and trusses, railway sleepers and a number of other structures are made of polymer concrete [1].

Modern scale production of polymer concrete allows using it instead of metal not only in construction but also in engineering. Polymer concrete is used to produce machine tool frames, power frames of presses. Recently created projects polymer concrete frames under the electric motors, polymer concrete frame for the conversion unit excavator and polymer concrete counterweight weighing 36t [11]. The counterweight is designed of five prefabricated blocks weighing up to 10 tons each. The blocks will be manufactured at the plant of polymer concrete structures, and installation of the counterweight of blocks will be held at the place of assembling the excavator. Especially great are the advantages of using polymer concrete in heavy engineering: from polymer concrete it is possible to create more powerful equipment than metal (heavy-duty presses weighing over 1000 tons).

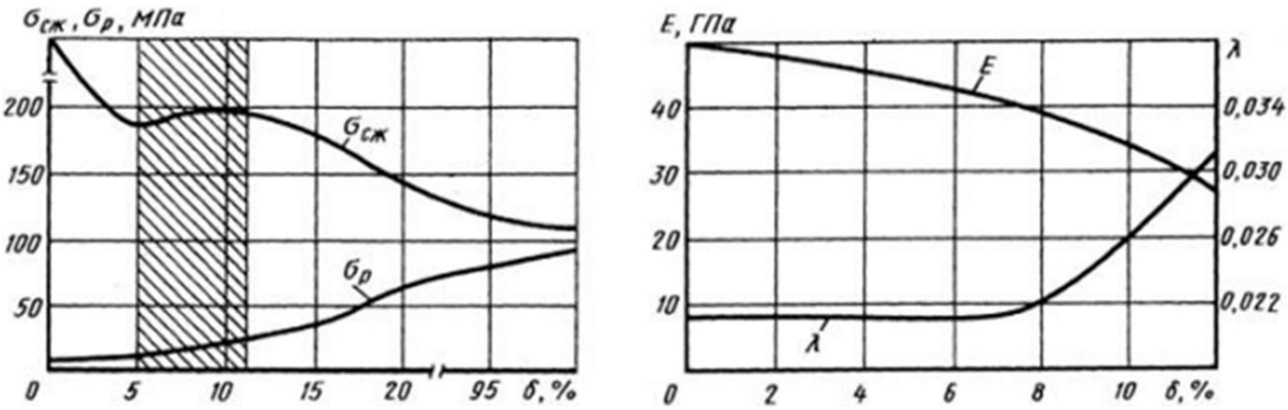
The advantages of polymer concrete structures include: 1) high resistance to mechanical forces, both compressive and tensile; 2) good resistance to dynamic loads (damping of vibrations in polymer concrete structures is 5 times faster than in steel); 3) high rigidity, characterized by small deflections under load; 4) fire resistance; 5) small consumption of metal; 6) cheapness, ease and rapidity of manufacturing; 7) ability to take any shape; 8) considerable durability [2].

The strength of concrete, protected from the action of the atmosphere increases over time, so the only threat to the polymer concrete is corrosion of the armature, the danger of which at a rational design and manufacturing technology is small. In this regard, polymer concrete surpasses all other materials in terms of durability, second only to the stone [13].

Application and analysis of syntegran

One and the most common of the varieties of polymerconcretes is sintagran, its name comes from

Figure 1 – Manufacturing process of reinforced concrete frame



а б

Figure 2 – Dependence of synthran properties on polymer binder δ content

the words «synthetic» and «granite». Sintgran is a composite material, which consists of a high-strength mineral aggregate of gabbro-diabase type (fraction size of rubble 0,6-20 mm), based on epoxy resin polymer binder, fine-dispersed filler with particle size not exceeding 60 microns. Also, sintagran is similar to natural granite in its performance and physical-mechanical properties. Depending on the configuration and wall thickness of the parts, their application and special requirements, it is possible to modify the physical and mechanical properties of sintagran [12].

The properties of synthran depend significantly on its parts. Figure 5 shows the dependence of mechanical properties on the content «δ» of polymer binders. The figure shows σcr, compressive strength; σp, tensile strength; E, dynamic modulus of elasticity; λ, vibration damping decrement [14].

The shaded area corresponds to the recommended binder content for the synthesizer. Thus, in the manufacture of the main mass of machine-building parts, it is recommended to use sintagran containing up to 11% of the binder. A comparison of the vibration damping properties of machine tools made of sintagran and cast iron at frequencies corresponding to the cutting process at low spindle speeds showed that the sintagran bed had no advantage over the cast iron bed, since the dynamic compliance depends mainly on the tools and jigs used, and they are generally the same for both versions of the bed [15]. However, in terms of the degree of influence exerted on the amplitude of oscillation of the workpiece by perturbations on the head, which are transmitted through the bed, the bed made of syngran showed better results by 25-50% than the cast-iron one. Studies of forced vibrations in the boring head bearing area and on workpieces at different spindle speeds revealed that the sintagran bed has advantages in

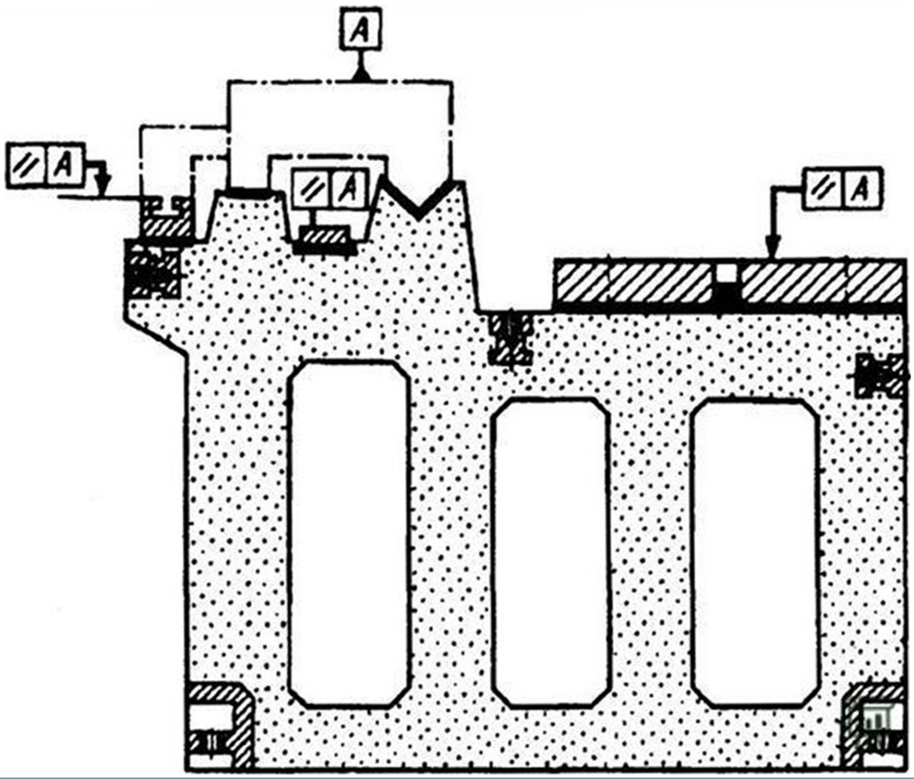


Figure 3 – Diagram of the bed made of polymer concrete

vibration damping with increasing spindle speed. The average values of vibration velocity are 15-27% lower at 3000 rpm [3,4]. The high-frequency components of vibrations in a syntegranium bed are much lower than in a cast iron bed. This applies in particular to the vibration spectrum of the workpieces, to which the disturbances due to the rotation of the spindles reach through the bed.

The bed of any machine tool is the main base part on which almost all assemblies and parts are located and fastened. All moving mechanisms and parts move in relation to the bed. Its properties will determine the accuracy and vibration parameters of the machine tool [16].

The analysis of Syntegranum application possibilities for manufacturing basic machine parts revealed that the manufacturing of a bed, a rack or a whole machine tool from Syntegranum allows increasing the vibration resistance of a machine tool by 2 times, while the material costs can be reduced by 70% at the expense of reducing the use of metal. Great attention to polymer concretes is explained by the following advantages: absence of residual stresses in parts, increased stability in time, ability of the material to absorb vibrations (cyclic loads), high corrosion resistance, the possibility of obtaining a part without the use of further machining [5,6].

Synegran is very popular in the manufacture of basic parts for machine tools, as it does not require high requirements, synegran can provide sufficient statistical and dynamic stiffness with sufficient strength.

Figure 4 – Metal-cutting machine made of polymer concrete

Thus, in the machine tool industry polymer concrete can be used for the manufacture of the heaviest parts of machine tools – frames. By its design, the cast-iron bed is a set of the same elements as the building structure (uprights, crossbars, beams). Its static calculation scheme is similar to that of polymer concrete structures. Therefore, the replacement of cast iron castings by polymer concrete is a matter of quite realistic [7,8,17].

Thus, in the machine tool industry polymer concrete can be used for the manufacture of the heaviest parts of machines – frames. By its design the cast-iron bed is a set of the same elements as the building structure (stands, crossbars, beams). Its static calculation scheme is similar to that of polymer concrete structures. Therefore, the replacement of cast iron castings by polymer concrete is a matter of quite realistic [9,18,19].

Conclusion

The reality of using polymer concrete for the manufacture of machine tool beds is confirmed by the experience of a number of domestic and foreign plants. Also proposed ways for further improvement of metal-cutting equipment designs on the basis of new approaches in development:

- The frames of metal-cutting machine tools can be made of both conventional and pre-stressed polymer concrete.
- Modern methods of manufacturing polymer concrete structures by using concrete of high grades and economical reinforcement make it possible to use lightweight box-section frames instead of solid ones. However, the up-to-date technique for calculating the frames according to the design limit states requires clarification and improvement [10]. This primarily concerns the establishment of differentiated coefficients of overloads and working conditions of beds for different types of metal-cutting machines, as well as solving the issue of the joint work of polymer-concrete beds and foundations [20,21].

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Станоктардың базалық бөлшектерін жасау үшін полимербетонды қолдануды талдау

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Аңдатпа. *Құрылғаннан бері полимербетон негізгі құрылыс материалдарының біріне айналды. Ал кейбір жағдайларда статикалық және динамикалық жүктемелерге ұшыраған аса маңызды инженерлік құрылыстардағы қымбат металл конструкцияларын алмастырды. Көпір аркалары, үлкен көпір крандарының кран арқалықтары, өндірістік ғимараттардың рамалары, тірек бағаналары мен фермалар, теміржол шпалдары. Бірқатар басқа құрылымдар полимербетоннан жасалған. Мақалада машинаның негізгі бөлшектерін жасау үшін полимербетонның қолданылуы талданады. Білдектің дірілге тұрақтылығын 2 есеге арттыруға мүмкіндік беретін раманы, тіректі немесе тұтас станокты дайындауға болатындығы анықталды. Металды пайдалануды азайту арқылы материалдың құнын 70% төмендетуге болады.*

Кілт сөздер: *құрал, полимербетон, синтегран, машина жасау, CAE-инжиниринг, полимерлік материалдар, станок жасау, базалау, CAD/CAM-инжиниринг, металл кесетін станок.*

Анализ применения полимербетона для изготовления базовых деталей станков

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Аннотация. *С момента своего создания полимербетон стал одним из основных строительных материалов. А в некоторых случаях заменил дорогостоящие металлоконструкции в критически важных инженерных сооружениях, подверженных статическим и динамическим нагрузкам. Мостовые арки, подкрановые балки больших мостовых кранов, каркасы промышленных зданий, опорные колонны и фермы, железнодорожные шпалы. Ряд других конструкций выполнен из полимербетона. В статье анализируется применение полимербетона для изготовления основных деталей станков. Выявлено, что возможно изготовления рамы, стойки или всего станка в целом, что позволяет повысить виброустойчивость станка в 2 раза. Стоимость материала может быть снижена на 70% за счет сокращения использования металла.*

Ключевые слова: *инструмент, полимербетон, синтегран, машиностроение, CAE-инжиниринг, полимерные материалы, станкостроение, базирование, CAD/CAM-инжиниринг, металлорежущий станок.*

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