APPLICATION OF BINDERS BASED ON TECHNICAL LIGNIN IN THE PRODUCTION OF CASTINGS

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ABSTRACT

In this paper are studied the possibilities of using technical lignin as a promising raw material for the development of various types of binder for foundry. In order to overcome the resource deficit problem, new technical solutions are required for the use of new materials, the advantages of which are to rationalize the use of the available resource potential of the plant processing industry, using technical lignins as an example. Experimental studies have been conducted to find effective modifiers of technical lignin. A class of substances has been established that makes it possible to increase the binding ability of technical lignosulfonates in a technologically acceptable level. The results of the development of foundry binder material based on technical lignin (TLS) allow us to talk about the technological feasibility of creating binder materials based on lignin materials that can successfully compete with phenol-based synthetic resins widely used now. Lignosulfonate materials can be considered as a typical example of technology for resource conservation and rational use of secondary raw materials produced from renewable natural resources.

Keywords: resource-saving technologies, technical lignin, lignosulfonate materials, binders, plant materials, binding ability, methods for increasing the binding ability.

INTRODUCTION

The practice of casting foundries shows that technical solutions based on the concept of resource - saving will make it possible to obtain cheaper, environmentally friendly, and therefore competitive end products [1, 7]. We take into account the use of binders. In casting foundries, where they are used as a technology component, and this: foundry, metallurgy, production of chipboard and fiberboard, plywood, in the construction industry and the automotive industry, it is advisable to switch to binders made from plant materials [2, 13]. The absence of real steps in this direction leads to a whole range of negative problems: the rise in the price of the final product, due to an increase in its cost (a steady increase in the price of binders) [2, 14, 15]; decrease, for this reason, its competitiveness; environmental degradation at the locations of such industries [3, 5, 11]; decrease in industrial safety [3, 8, 9, 10]; an increase in all kinds of occupational diseases associated with the use of expensive and environmentally hazardous binders based on a variety of synthetic resins and oil binders [1, 4, 5]. Technical lignin is a product of the delignification of plant materials, which can be any plant tissue, from wood to seaweed. In a plant cell, this material is invariably present in different states, fulfilling the function of binding, which ensures the overall strength of the structure. For this reason, during processing, it is generated as a by-product, usually in the form of waste. Because of the importance of the problem in 1992 in Lausanne (Switzerland), the International Lignin Institute was created.

According to it, annually from 40 to 50 million tons of technical lignin are formed in the world, the utilization of which presents significant difficulties and does not currently have a rational solution.

Russia, possessing the largest forest resources and is one of the main countries generating technical lignin. The leader in this process is the pulp and paper industry. According to experts, the controlled volumes of the annual formation of this product, in various forms of its presentation (sulphite liquor, technical lignosulfonates, hydrolysis lignin, etc.) range from 4-5 million tons.

In Russia, over the past periods of economic activity, about 95 million tons of technical lignin have been accumulated. According to experts, the volume of processing plant materials will increase, it is expected that by 2050. this indicator will increase by 50-60%, in this regard, the issue of the rational disposal of lignin waste will be acute both in the short term and in the future.

One of the promising fields of rational use of lignin is the use of its modifications as binders in foundry.

METHOD

It is a comprehensive study of the possibilities of creating, based on products by the processing of vegetable raw materials - technical lignins and lignin-containing materials (technical lignosulfonates), new binders. Such an approach, if implemented, will make it possible to achieve a rational use of the resource potential of plant raw materials, as well as effectively solve the environmental problems of production and ensure occupational safety and health at work.

RESULTS

To determine ways to overcome this problem, it is necessary to consider the resource potential of the products of processing plant materials and its real, technical, and technological ability to replace traditionally used binders, providing that the required level of quality of the products is maintained.

We considered the potential of a possible resource provision for the implementation of the concept

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of creating new effective binding materials based on products of processing plant raw materials.

In Canada, the USA, the CIS countries and northern Europe, the largest production problem for the processing of plant raw materials is the woodworking, pulp and paper industries.

Analysis of wood processing technology, as the most significant, in terms of production scale, representative of large-scale processing of plant raw materials, which has established production traditions of a large-scale nature, shows that approximately 90 - 95% is accounted for by the technology of processing wood for cellulose by the sulfite method of cooking. The product of this technology is cellulose, which is then processed into paper; waste - sulphite liquor. Approximately 30% of the processed wood is accounted for by this waste, in turn, is dumped into the river. The consequence of this condition is the total pollution of the water basin, rivers and lakes in the areas where such production is located (pulp and paper mills). An example is the sensational “Baikal problem” in the USSR [1, 3].

A more detailed analysis shows that waste discharged into rivers and polluting them by - sulphite liquor - can be a valuable product for the development and creation on its basis of fundamentally new binder materials with predetermined properties instead of expensive and potentially environmentally hazardous synthetic resins and oil binders which Now traditionally used as foundry binders [2, 16, 17].

The volumes of sulphite liquor generation in the UIS countries in absolute terms are approximately 3 million tons per year. The volume of rational use, as a binder, is only 250 - 300 thousand tons, i.e. about 8 - 10% of the volume, which clearly illustrates the contradiction between the huge potential resource and the low practical demand for this material as anthropogenic raw materials for the development of effective binders, as an alternative to phenolic-based synthetic resins [1].

The aforementioned indicates a high resource potential of the indicated lignosulfonate material as a raw material for the production of highly effective binder materials to create competitive foundry products [18, 21].

In this regard, it is advisable to consider the technical and technological components capable of transferring this class of lignin-containing substances to such conditional states, in various combinations with other promising materials [19, 20], which could ensure the production of high-quality binders and thus gradually displace expensive and environmentally friendly hazardous synthetic resins and oily materials.

Let us analyze, in more detail, a set of possible technological tools and methods for creating effective binding compositions based on TLS. Considering them as a material with an unlimited resource, and their use as a way to solve environmental problems, by excluding binders from the production cycle leading to the formation of harmful emissions at the stages of the technological process.

This involves clarifying and resolving the following issues related to:

- an assessment of the environmental performance of such actions;
- analysis of the real reasons hindering the use of lignosulfonate binders;
- the search for affordable, but effective tools to overcome the identified shortcomings and the reasons for containing their wider spread;
- optimization of technological processing modes for creating new binding compositions based on TLS;
- The development of formulations of effective binder materials based on TLS;
- Verification of their environmental characteristics;
- The adaptation of the developed compositions of binders based on TLS to the conditions of specific technological processes.

The aforementioned constitutes a problem field that requires a solution to realize the potential of the class of materials under consideration.

Considering the environmental and economic aspects. In the conditions that are taking shape at this stage of product development, it is advisable to use such binders that, providing the technically necessary level of requirements, possessed not only, but maybe not so much, relatively low cost and manufacturability as they would be environmentally friendly materials [4, 5].

To a certain extent, lignosulfonate materials may become such a promising material for development, of which technical lignosulfonates (TLS) are a typical representative on the binder market.

A comprehensive analysis of the state of the quality indicators of this material shows that the TLS are:
environmentally friendly natural materials for humans and the environment; one of the cheapest binder materials (current price level, respectively, in US dollars per ton of binder: lignin-containing materials (TLS) - $ 80 -120 [16], synthetic resins 1000 - $ 2500 [12], oil binders - $ 500-1000 [16]);

Not scarce, resource-rich, produced in Canada, USA, UIS countries and northern Europe, although this factor does not play a dominant role, since the availability of technology, i.e. tools and development methods based on TLS of qualitatively new effective binder materials, will allow to buy TLS as a raw material and to sell to consumers, regardless of the geography of their location, manufacturers of initial TLS. Similar technologies are supranational.

All this predetermines their attractiveness when searching for alternatives to solve the problems of greening production processes associated with the use of binders.

It should be emphasized that TLS is obtained from wood, whose resources, unlike oil, are renewable. At the same time, wastewater disposal issues are comprehensively addressed, since TLS are a product of processing sulphite liquor - large-tonnage, liquid waste in the production of sulphite pulp, on the one hand, and environmental problems of the enterprise where binders based on TLS will be used instead of synthetic resins and oil binders, with other.

Consider the technological aspect of the problem. The main limiting factor of the class of materials under consideration is that TLS have a low binding capacity and possess unstable properties. Recently, ways to solve these problems have been outlined, primarily by modifying the TLS, that is, introducing special additives into their composition that eliminate these drawbacks to one degree or another [2, 3, 6].

To overcome these drawbacks, especially the low binding ability of lignosulfonate binders, a hypothesis was proposed about the possibility of introducing into their composition special substances with a complex effect: structuring, ordering the binder composition in a liquid state and ensuring the formation of a three-dimensional network polymer in the process of structure formation. Moreover, to create centers of initiation, intensification of the processes of structure formation, it was proposed to process the binder composition on a disintegrator [1, 2].

From the material science point of view, such processing provides processes leading to the formation of a structure with a three-dimensional polymer matrix and cross-linking, namely, such polymer structures correspond to maximum strength characteristics.

The set of experiments confirmed this hypothesis [2]. The most effective were modifiers from the class of nonionic surfactants (nonionic surfactants). It has been experimentally established that the use of certain types of nonionic surfactants as TLS modifiers dramatically (by an order of magnitude, from 0.05 MPa /% to 0.5-0.7 MPa /%, in terms of specific binding ability) increases their strength characteristics and stabilizes the properties (see Figure-1.). Technologically, the modification process consists in adding modifiers (special chemical additives) to the TLS in certain proportions and under the established modes. The effectiveness of the modifier was evaluated by the degree of increase in the binding ability of the TLS, while the change in the curing rate and the effect of the modifier on the stability of their properties were controlled.

The change in these parameters was evaluated according to the properties of the technological sample. The composition of the technological sample includes: dry quartz sand 1K02B or 1 K016A - 94 wt. h., Verkhnedneprovsky quarry; lignosulfonate Sokolsky PPM - 5.2 - 5.7 wt. hours, the modifier is 0.3-0.8 wt. hours

In turn, mechanical treatment (mechanical activation) leads to an intensification of the processes of structure formation, and the curing rate increases.

As a result of processing, binders with high strength (up to 3.0 MPa, in absolute terms) indicators and stable properties were obtained.

Evaluating and summarizing the available scientific results [2, 3, 4, 6], we can say that the technological basis has developed the theoretical foundations of a methodology for finding the optimal compositions of multicomponent core mixtures with TLS, considered as binder systems using the general principles of a comprehensive physico-chemical analysis.

Possible methods and technological methods for the development of new complex binders with a controlled rate of thermal curing, which reduce the drying temperature of the rods and the specified strength characteristics, are determined.

Scientific criteria are established for the search for effective TLS modifiers. These can be both individual inorganic substances and organic materials, as well as still bottoms of organic synthesis. They are used purposefully for the development of specialized commercial products - modified lignosulfonates.

The technological dependences of the physicomechanical and technological properties of mixtures and core systems with TLS on the ratio of the components of the binder complex, temperature and curing time, as well as on the type of filler were revealed. Methods are proposed for modifying TLS and hardening foundry cores based on.

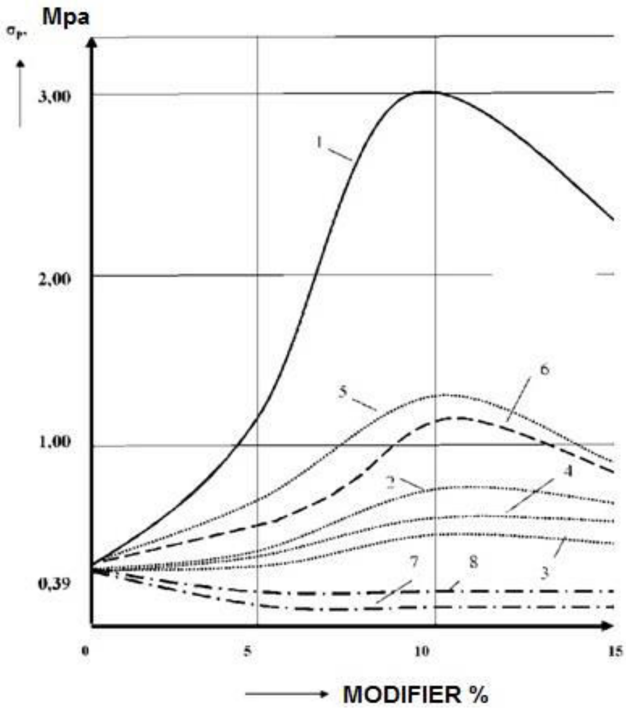

Figure-1. Indicators of the action of substances of various classes (acids, salts, alkalis) on the binding ability of TLS, curves: 1. - nonionic surface-active substances (nonionic surfactants); 2. - hydrochloric acid; 3.- sulfuric acid; 4.- nitric acid; 5.- sulfonic acid; 6- ammonium sulfate (12% aqueous solution); 7- potassium hydroxide solution; 8 - sodium hydroxide solution [1, 2].

In the works of Evstefeev E.N. [3, 6], the technology of hydrophobization of modified TLS is shown and developed, which made it possible to create a new

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type of thermal curing binders that provide rod mixtures with unlimited formability; fundamentally new foundry binders in the form of acidic modified lignosulfonates and formulations of mixtures based on them have been developed, which significantly improve the environmental situation in the manufacture of cores in heated equipment. The possibility of creating formulations of low-toxic hot cure mixtures based on binder TLS with the properties of resin mixtures that meet the environmental requirements of modern foundry has been investigated, pilot-industrial tests have been successfully conducted with these types of binder compositions [1, 2, 3, 6].

A hypothesis on the chemical mechanism of curing of modified lignosulfonates by modifiers of the type of nonionic surfactants is proposed and tested.

The experimental dependences characterizing the intensity of the release of toxic substances from binder materials developed on the basis of TLS were studied at various stages of their application: during the mixture preparation process, during the curing process and when pouring metal into molds in the foundry industry. A comparative assessment of the conditional toxicity of the developed binders based on LST with existing analogues confirmed their positive advantages.

The thesis about the low heat resistance of these materials, and therefore not the possibility of their widespread use in modern foundry, is refuted by the practice of using these materials (SS, SSB, LKBZH and other brands) in the foundry of the Soviet period. This class of materials can be easily used for the production of iron and aluminum castings. By the way, according to RAL, as of 2015, about 75% of all castings produced in Russia accounted for cast iron castings. An example is the production of small and medium-sized iron castings (see Figure-2).

Figure-2. An example of implementation in the production of iron castings.

The synergy of interaction between developers, chemists - technologists working with TLS, and machine builders with experience of "dressing in iron" - the creation of foundry equipment that takes into account all the specifics of this material, allows us to optimistically assess the prospects of this area, creating a "lignin process", as a potential alternative to the use of phenolic-based synthetic resins [22].

Implementation examples. Studies have been conducted aimed at increasing their binding ability. It was found that the most effective additives were from the class of nonionic surfactants (nonionic surfactants). It was experimentally established that the use of certain types of nonionic surfactants as TLS modifiers dramatically (by an order of magnitude, from 0.05 MPa /% to 0.5-0.7 MPa /%, in terms of specific binding ability) increases their strength characteristics and stabilizes properties.

The results achieved show the possibility of a significant increase in the binding ability of TLS due to their modification. This eliminates the reason restraining their practical application, since it provides a modern level of strength characteristics.

The issue of curing speed can be solved by blowing the mixture with hot air (see Figure-3).

The results obtained made it possible to conduct pilot tests of the developed binder compositions based on TLS. The compositions of the core mixtures for the production of cast iron shaped castings were prepared [23].

According to environmental indicators, in comparison with other organic binding materials, TLS have the best indicators.

Implementation experience shows that the replacement of oil binders such as USK and KO, or phenolic-based resins, with a TLS binder leads to a significant improvement in the sanitary and hygienic working conditions in the workplace.

Such and data are confirmed by the results of experiments to determine the quality and quantity of gas evolution of mixtures with TLS in comparison with the mentioned binders.

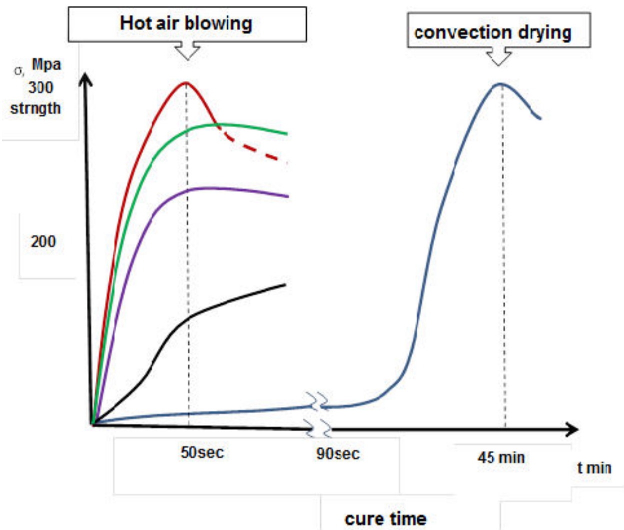

Figure-3. The ability to ensure the strength of the binder compositions on theTLS, with different methods of curing.

CONCLUSIONS

The results of the development of foundry binder material based on technical lignin (TLS) allow us to talk about the technological feasibility of creating binder materials based on lignin materials that can successfully compete with phenol-based synthetic resins that are widely used now. Lignosulfonate materials can be considered as a typical example of technology for resource conservation and rational use of secondary raw materials produced from renewable natural resources.

The above allows us to talk about the technological feasibility of developing binder materials based on TLS that can replace and really successfully compete with synthetic resins and oil binders that are widely used now. The above argument allows us to state that lignosulfonate materials can be considered as a typical example of resource-saving technology and rational use of secondary raw materials produced from a renewable source.

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