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DEVELOPMENT AND FEACN CLASSIFICATION OF A DRY LUBRICANT COMPOSITE FOR STEEL WIRE DRAWING BASED ON LOCALLY AVAILABLE RAW MATERIALS

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Abstract:*The article presents the development of a dry lubricant composite based on locally available raw materials for cold drawing of steel wire and the results of laboratory and industrial testing. The composite contains kaolin, borax, talc, sodium stearate, sodium acetate, and calcium acetates. Its stability during wire drawing, adhesion to the metal surface, thermal resistance, influence on die wear, and effect on the surface quality of drawn wire were investigated. The developed composite demonstrated stability in the temperature range of 250–300 °C, while its adhesion to the metal surface was 12% higher than that of imported analogues. Its production cost was 2–3 times lower than that of imported compositions. The main technological parameters and material balance were established under industrial conditions, and an experimental batch of 3000 kg was produced. Based on its composition, functional purpose, physical form, and application, FEACN/TIF TN code 3403 10 10 01 was recommended for the product.*

Keywords: *steel wire, cold drawing, dry lubricant composite, kaolin, talc, borax, adhesion, drawing die, local raw materials, FEACN, TIF TN, 3403 10 10 01.*

MAHALLIY MAVJUD BO‘ LGAN XOM ASBOBLAR ASOSINDA PO‘ LAT SIMLARNI CHIZISH UCHUN QURUQ MOYLASH COMPOZITINI ISHLAB CHIQISH VA FEACN TASNIFI

Annotatsiya: *Maqolada mahalliy xom ashyolar asosida po‘ lat simlarni sovuq holda cho‘ zish jarayonida foydalanish uchun ishlab chiqilgan quruq surkov kompozitining texnologik va ekspluatatsion xususiyatlari hamda laboratoriya va ishlab chiqarish sharoitidagi sinov natijalari keltirilgan. Kompozit tarkibiga kaolin, boraks, talk, natriy stearati, natriy atsetati va kalsiy atsetatlari kiritilgan. Kompozitning filera orqali sim o‘ tish jarayonidagi barqarorligi, metall sirtiga adgeziyasi, harorat ta’siriga chidamliligi, filera yeyilishiga ta’siri va sim sirtining sifati o‘ rganilgan. Tajriba natijalariga ko‘ ra, kompozit 250–300 °C harorat oralig‘ ida barqarorlikni namoyon qilgan, metall sirtiga adgeziyasi import analoglariga nisbatan 12 % yuqori bo‘ lgan. Mahsulot tannarxi import kompozitsiyalariga nisbatan 2–3 marta past bo‘ lgan. Ishlab chiqarish sharoitida asosiy texnologik parametrlar va moddiy balans ishlab chiqilib, 3000 kg miqdorida tajriba partiyasi tayyorlangan. Mahsulotning tarkibi, funksional vazifasi va qo‘ llanish sohasidan kelib chiqib, TIF TN bo‘ yicha 3403 10 10 01 kodi tavsiya etilgan.*

Kalit so‘ zlar: *po‘ lat sim, sovuq cho‘ zish, quruq surkov kompoziti, kaolin, talk, boraks, adgeziya, filera, mahalliy xom ashyo, TIF TN, 3403 10 10 01.*

РАЗРАБОТКА И КЛАССИФИКАЦИЯ СУХОГО СМАЗОЧНОГО КОМПОЗИТА ДЛЯ ВОЛОЧЕНИЯ СТАЛЬНОЙ ПРОВОЛОКИ НА ОСНОВЕ МЕСТНЫХ СЫРЬЕВЫХ МАТЕРИАЛОВ

Аннотация*: В статье представлены результаты разработки сухой смазочной композиции на основе местного сырья для холодного волочения стальной проволоки и ее лабораторных и производственных испытаний. В состав композиции входят каолин, бура, тальк, стеарат натрия, ацетат натрия и ацетаты кальция. Исследованы стабильность композиции при волочении проволоки, адгезия к металлической поверхности, термостойкость, влияние на износ волоки и качество поверхности проволоки. Установлено, что композиция сохраняет стабильность в диапазоне 250–300 °C, а ее адгезия к поверхности металла на 12 % выше по сравнению с импортными аналогами. Себестоимость композиции в 2–3 раза ниже импортных аналогов. В производственных условиях разработаны основные технологические параметры и материальный баланс, изготовлена опытная партия объемом 3000 кг. На основании состава, функционального назначения и области применения предложен код ТН ВЭД 3403 10 10 01.*

Ключевые слова: *стальная проволока, холодное волочение, сухая смазочная композиция, каолин, тальк, бура, адгезия, волока, местное сырье, ТН ВЭД, 3403 10 10 01.*

INTRODUCTION

Cold drawing of steel wire is a widely used technological process for obtaining products with specified geometric dimensions, surface quality, and mechanical properties. During drawing, the wire is pulled through a die under considerable contact pressure and frictional interaction between the metal and the die. Therefore, the properties of the processed material and the technological conditions of deformation directly influence the quality and stability of the process [1,2]. The efficiency of mechanical-processing operations depends on process stability, dimensional accuracy, surface quality, productivity, and rational use of materials [3,4]. In cold wire drawing, inadequate lubrication may increase frictional resistance, drawing force, thermal effects, and die wear and may cause deterioration of the wire surface. An effective dry lubricant should form a stable protective layer between the wire and the die and retain its functional properties during deformation. From a tribological standpoint, the composition and structure of a lubricant determine its ability to reduce direct contact between interacting surfaces and maintain stable lubrication conditions.

Previous research by Parpiyeva and Doliyev demonstrated the possibility of obtaining lubricant composites from locally available raw materials with favorable physicochemical and tribological properties [5]. These results provide a basis for developing specialized dry lubricants for metal-forming processes.

The use of local raw materials is also economically important. Localization can reduce dependence on imported technological materials, decrease production costs, and promote the efficient use of domestic mineral and chemical resources. At the same time, classification of a newly developed material within the Foreign Economic Activity Commodity Nomenclature (FEACN/TIF TN) is important for its future commercialization and foreign economic circulation [6,8].

The aim of this study was to develop a dry lubricant composite based on locally available raw materials for cold drawing of steel wire, evaluate its technological and operational characteristics under laboratory and industrial conditions, determine its economic efficiency, and substantiate its FEACN/TIF TN classification.

MATERIALS AND METHODS

The investigated dry lubricant composite was prepared from kaolin, borax, talc, sodium stearate, sodium acetate, and calcium acetates. The components were selected with the aim of obtaining a homogeneous dry material capable of forming and retaining a lubricating layer in the metal–die contact zone.

The technological preparation included raw-material preparation, preliminary mechanical treatment, dosing, dry mixing, homogenization, and quality control. The technological sequence was selected taking into account the general principles of technological-process organization, material utilization, product quality, and production efficiency [7,8].

The functional properties of the composite were evaluated during steel-wire drawing through the die. The main evaluation criteria were:

- continuity and stability of wire passage through the die;
- occurrence of wire breakage and deformation;
- adhesion and retention of the composite on the metal surface;
- thermal stability;
- condition and wear of the drawing die;
- surface quality of the drawn wire;
- economic efficiency.

The behavior of the steel wire was considered in relation to the general principles of materials science and deformation processing [5,6]. Previous research on local-raw-material-based lubricant composites was also used as a scientific basis for assessing their physicochemical and tribological behavior .

Following laboratory preparation, the composition was tested under industrial conditions at “IFODA Agro Kimyo Himoya” JV LLC and the “MEXMASH” metalworking plant. During industrial testing, raw-material consumption, technological losses, homogeneity of the mixture, stability of wire drawing, lubricant retention, and the condition of the die and wire surface were monitored.

RESULTS AND DISCUSSION

The experimental results showed that the developed composite performed effectively during steel-wire drawing. Continuous passage of the wire through the drawing die was maintained, and no wire breakage was observed under the investigated conditions. No significant visible surface defects were detected on the drawn wire.

The obtained results correspond to general technological requirements for metal deformation processes, in which process stability and product quality are important indicators of technological efficiency [5,7,8].

3.1. Thermal stability and adhesion

One of the important characteristics of the developed composite was its behavior under elevated temperatures generated by friction. The experimental results showed that the composite retained its technological properties within the temperature range of **250–300 °C**.

Thermal stability is important for dry lubricants because the lubricant layer is simultaneously subjected to mechanical loading and thermal effects in the working zone. The preservation of functional properties within the investigated temperature interval indicates the suitability of the composite for the studied drawing conditions.

The adhesion of the composite to the metal surface was also evaluated. The obtained results demonstrated that the adhesion of the developed composite was **12% higher than that of the imported reference analogues**.

Higher adhesion is technologically significant because stable retention of the lubricant on the wire surface facilitates preservation of the lubricating layer within the friction zone. This can reduce direct metal–die interaction and contribute to stable drawing conditions. The importance of physicochemical and tribological characteristics of local-raw-material-based lubricant composites was also demonstrated in previous research.

During laboratory and industrial tests, the developed composite demonstrated stable behavior in the drawing zone. No wire breakage was recorded, and continuous wire passage through the die was maintained.

After testing, no excessive wear of the working surface of the drawing die was observed under the investigated conditions. The wire surface also remained free from significant visible defects.

The condition of the drawing die and the quality of the wire surface are important indicators of technological efficiency. Material properties and deformation conditions influence the behavior of steel during processing [5,6], while rational organization of the technological process is necessary to maintain quality and productivity.

The combined results of adhesion, thermal stability, continuous drawing, and absence of significant surface defects indicate that the developed composite possesses the functional characteristics required for the investigated dry-lubrication process.

The use of locally available raw materials provided a significant economic advantage. The production cost of the developed composite was approximately **2–3 times lower than that of the imported Chinese and Russian analogues** considered in the study.

Compared with certain imported lubricant composites, the locally developed material was found to be **up to 45% less expensive**.

The economic effect is associated with the availability of local raw materials and the possibility of localized production. Reduction of material costs and technological losses is consistent with the general principles of production efficiency and technological-process optimization.

After laboratory optimization, the composition was tested under industrial conditions. The production technology included preparation of raw materials, mechanical treatment, dosing, dry mixing, homogenization, and quality control.

During industrial production, uniform distribution of the components and homogeneity of the finished composite were monitored. The technological losses and material consumption were also considered in establishing the material balance.

The industrial tests confirmed stable application of the composite to the wire surface and its retention in the friction zone. Continuous wire passage through the die was maintained, no wire breakage was recorded, and no significant surface deterioration was observed.

An experimental batch of **3000 kg** was successfully produced. This result confirms the technological feasibility of transferring the developed composition from laboratory preparation to industrial-scale production.

The results also extend the authors' previous investigations of lubricant composites based on local raw materials. While the previous research focused on physicochemical and tribological characteristics, the present study demonstrates the practical applicability of the developed material to steel-wire drawing.

FEACN/TIF TN CLASSIFICATION

An important practical aspect of the study was the classification of the developed dry lubricant composite according to the Foreign Economic Activity Commodity Nomenclature (FEACN/TIF TN).

The classification of goods should take into account their composition, physical form, functional purpose, and field of application. The TIF TN system provides the basis for systematic identification and coding of goods involved in foreign economic activity.

The developed composite is a dry lubricant intended for technological lubrication during cold drawing of steel wire. Therefore, its functional purpose is associated with providing lubrication in the metal–die contact zone.

According to **Information Letter No. 29/05-25-2972 dated December 16, 2025**, issued by the Central Customs Laboratory of the Customs Committee under the Ministry of Economy and Finance of the Republic of Uzbekistan, the

composition and functional characteristics of the lubricant composite developed by D.A. Parpiyeva were examined, and **commodity code 3403 10 10 01** was recommended for the product.

The classification result is important for the further commercialization of the developed material because a defined commodity code facilitates product identification in foreign economic activity, customs procedures, statistical accounting, and market circulation.

The proposed classification should be considered within the applicable edition of the TIF TN and the relevant decisions of the competent customs authorities. Thus, the classification result represents an important organizational step in transferring the developed composite from a research product to a commercially identifiable technological material.

CONCLUSION

A dry lubricant composite based on locally available raw materials was developed for cold drawing of steel wire. The composition contains kaolin, borax, talc, sodium stearate, sodium acetate, and calcium acetates.

Laboratory and industrial testing demonstrated the technological suitability of the composite. It retained its functional properties within the temperature range of **250–300 °C**, while its adhesion to the metal surface was **12% higher than that of imported reference analogues**. During the drawing tests, continuous wire passage through the die was maintained, no wire breakage was observed, and no significant surface defects were detected. No excessive wear of the drawing die was observed under the investigated conditions.The use of local raw materials provided a considerable economic advantage. The production cost of the developed composite was approximately **2–3 times lower than that of the imported analogues**, and in comparison with certain imported compositions it was up to **45% lower**.

The principal technological parameters and material balance were established under industrial conditions, and an experimental batch of **3000 kg** was produced. This confirms the possibility of industrial-scale preparation of the developed composite. The study continues the authors' previous research on lubricant composites based on local raw materials and extends it toward practical application in steel-wire drawing.

According to Information Letter No. 29/05-25-2972 of the Central Customs Laboratory, **FEACN/TIF TN code 3403 10 10 01** was recommended for the developed lubricant composite [4]. This result creates an important basis for its identification, commercialization, and future introduction into foreign economic activity within the relevant TIF TN regulatory framework.

The developed composite therefore has technological and economic potential as an import-substituting dry lubricant for steel-wire drawing based on locally available raw materials.

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