ОБРАБОТКА МЕТАЛЛОВ ДАВЛЕНИЕМ

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STUDY OF THE TECHNIQUE TO PRODUCE BIMETALLIC DEFORMED SEMI-FINISHED PRODUCTS FOR JEWELRY CHAINS MADE FROM RED GOLD ALLOYS

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Abstract. The authors of this paper propose and provide scientific substantiation for a new technique of producing bimetallic wire from precious metals for jewelry chains. The method is protected with a patent of the Russian Federation. The authors did calculations to define the processing regimes of cold rolling and drawing that would ensure a uniform distribution of the drawing force between the passes thus minimizing the required drawing force parameters. The PROVOL software was used for calculations that accounted for the actual production environment of the Gulidov Krasnoyarsk Non-Ferrous Metals Plant (aka JSC «Krastsvetmet»). The software has a certificate of state registration. Using the developed regimes, experimental studies were conducted to obtain a bimetallic wire with the core made of 925 silver alloy and the shell made of 585 gold alloy. A trial run of the technique, which was conducted by JSC «Krastsvetmet» to produce bimetallic wire for Singapore style chains, resulted in quality products. A study of the structure and properties of long-length deformed semi-finished products showed that the use of the new technique lead to enhanced strength and performance of the bimetallic wire for jewelry chains preventing defects during the chain bending process. Thus, the authors propose a new technique for producing bimetallic semi-finished products from precious metals alloys that helps improve the quality and expand the assortment of finished jewelry products.

Keywords: bimetallic semi-finished product, jewelry chains, gold, silver, core, shirt, modes of deformation, rolling of sections, drawing.

Introduction

Currently, the major share of the jewelry market falls on the production of jewelry chains and bracelets, the deformed semi-finished products for which are manufactured using metal processing operations [1–4], and only 10% are exclusive jewelry with precious and semiprecious stones [5]. Jewelry market is shrinking assortment of manufactured jewelry products, while Russia's share in world jewelry exports is only 0.12% ($ 120 million). Most consumers prefer more affordable products, for example hollow chains, but at the same time in no way inferior in terms of external characteristics of full-weight products. At the same time, hollow chains are characterized by low strength and performance characteristics, and, as a rule, cannot be repaired. The main trends in the development of the jewelry market are an increase in competition for the import of jewelry a reduction in demand for the existing range of products. This entailed a reduction in the production of jewelry chains and bracelets as they become unclaimed which stimulates jewelry companies to work on cheaper production and facilitating products [6, 7].

At the result with these trends in the development of the jewelry market the first main thing is the search for new methods and technologies for the production of jewelry chains from new alloys based on precious metals characterized by manufacturability in deformation processing and an increased level of strength and consumer properties. The authors suggest a method for preparing a bimetallic wire made from precious metals [8] which allows achieving the above advantages and at the same time is characterized by a relatively low production cost. In this case, a silver alloy of 925 samples was proposed as the core, and a new alloy of 585, which has a high level of mechanical properties due to a change in the percentage content of the alloy components and the use of modifying additives [8].

JSC «Krastsvetmet» produces about 160 jewelry braids which are based on various technologies for obtaining a deformed semi-finished product. [4]. The **fig.1** one of such typical technologies for the production of type «Korda» chains:

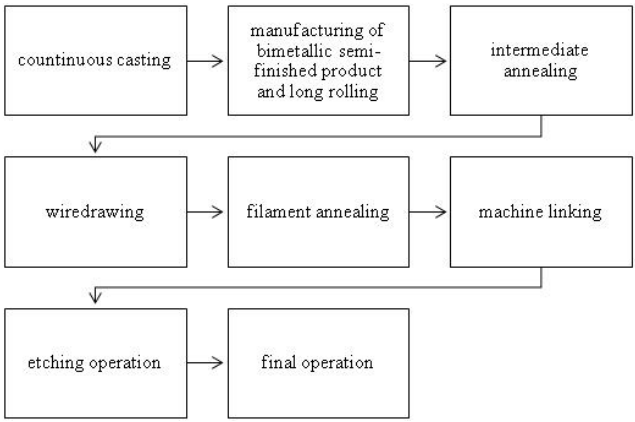


Fig.1. Typical technology for manufacturing jewelry chains

This technology is characterized by high process complexity and the use of etching to make a hollow chain. The basis of the bimetallic billet with the iron core and the shoe is made of a band of gold alloy of 585 tests. The main operations for the manufacture of lengthy deformed semi-finished products are the following: obtaining the cast billet from a gold alloy and rolling it to a strip of specified sizes: obtaining an iron core with a diameter of 8,0–8.3 mm; folding a gold strip around the iron core with a strip of gold; multi-transitional processes of cold profiled rolling and drawing of a bimetallic semi-finished product to produce a wire of the required diameter.

Analysis of the presented industrial technology for the production of hollow chains and features made it possible to propose the replacement of the iron core with silver from a 925 silver alloy. The shirt to be made from a new alloy based on 585 red gold with additives of modifiers in order to obtain a product with high strength and performance characteristics.

In the proposed technology, a deformable alloy based on precious metals has a high plasticity when processing a bimetallic semi-finished product with respect to an iron core that during deformation, can lead to cracks in the workpiece and wire breaks. In this connection problems of the correct choice of the deformation modes were taken into account, taking into account the limitations on energy-force parameters. The appointment of intermediate annealing between the processing cycles, in order to restore the ductility of the metal and to determine the mechanical properties of the deformed semi-finished products for studying their structure at each of the processing stages.

Computation of deformation modes of processing

Using the technical characteristics of the equipment used for standard technology and data on the geometric dimensions of the billet and wire, the deformation modes and energy-force parameters of cold-rolled and multiple-drawing processes were calculated. For their calculation, the PROVOL program [9], developed at the Department of Metal Pressure Processing of the Institute of Non-Ferrous Metals of the Siberian Federal University was used. This program was adapted to the industrial production conditions of OJSC Krastsvetmet, taking into account the existing scheme for the production of bimetallic semi-finished products for chains of the “Korda” type when rolling a billet 8 mm in diameter to a square rod with dimensions of 1.12x1.12 and drawing it further to a final wire diameter of 0.25 mm.

As a result, technological parameters for long rolling and drawing were obtained then used to carry out experimental studies in laboratory and industrial conditions. An example of calculating the drawing parameters is shown in **Fig. 2**.

Analysis of the base data showed that in contrast to the existing technology for the production of chains type of the “Korda” a uniform distribution of individual extracts and values of the stock coefficients is ensured, ensuring the production of semi-finished products without breakages during deformation (**Table 1**).

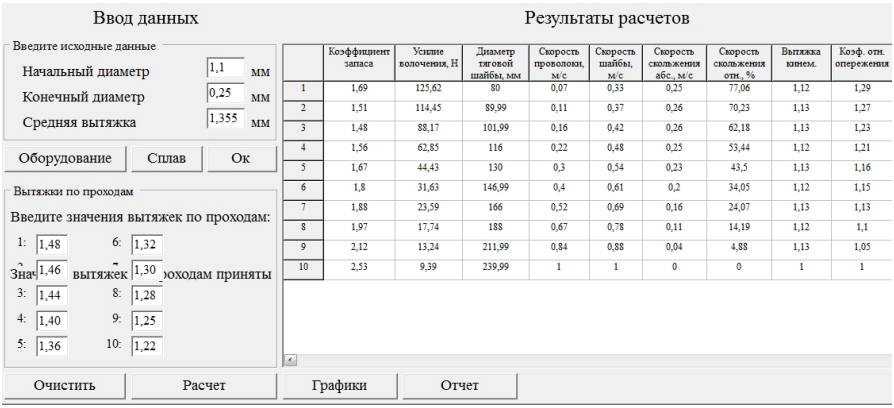


Fig. 2. The window to PROVOL program for calculating multiple drawing parameters

Table 1

Route of wire drawing

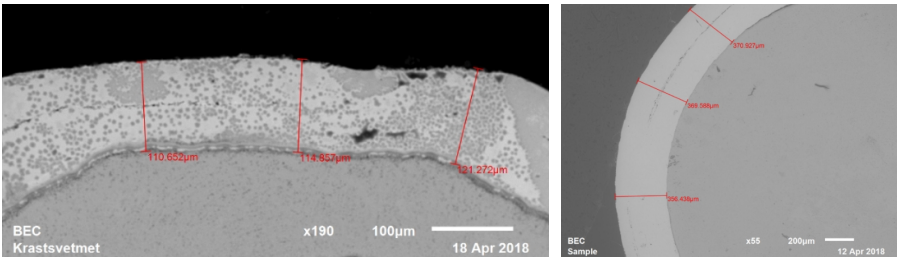
Travel number	Diameters, mm	Cross- section area, mm^2	Single rolling out	Total rolling out	Deformation degree, %	Draw stress, MPa	Reserve coefficient
1	0.90	0.64	1.48	1.48	32.4	379.3	1.83
2	0.75	0.44	1.46	2.16	31.5	551.4	1.54
3	0.60	0.31	1.44	3.11	30.6	622.6	1.49
4	0.53	0.22	1.40	4.36	28.6	623.1	1.56
5	0.45	0.16	1.36	5.92	26.5	598.2	1.67
6	0.39	0.12	1.32	7.82	24.2	561.1	1.81
7	0.34	0.09	1.30	10.17	23.1	543.0	1.88
8	0.30	0.07	1.28	13.01	21.9	522.1	1.97
9	0.27	0.06	1.25	16.27	20.0	486.4	2.13
10	0.25	0.05	1.22	19.84	18.0	449.2	2.31

The results of the research and analysis

Experimental research on pilot-industrial testing of the developed technology was carried out in the conditions of JSC «Krastsvetmet». The alloy for making the strip was obtained by direct fusing of the main components in a continuous casting furnace in a protective atmosphere. Modifying additives were introduced into the melt in accordance with known methods for modifying gold-based alloys. Rhodium pre-precipitated from the electrolyte by galvanic means to silver, was introduced into the melt in the form of an Ag-Rh ligature with a rhodium content of 0.001 to 0.01 wt. % immediately before crystallization. Iridium was introduced as a melt of Cu-Ir components. The composition of the alloy was controlled by quantitative chemical analysis.

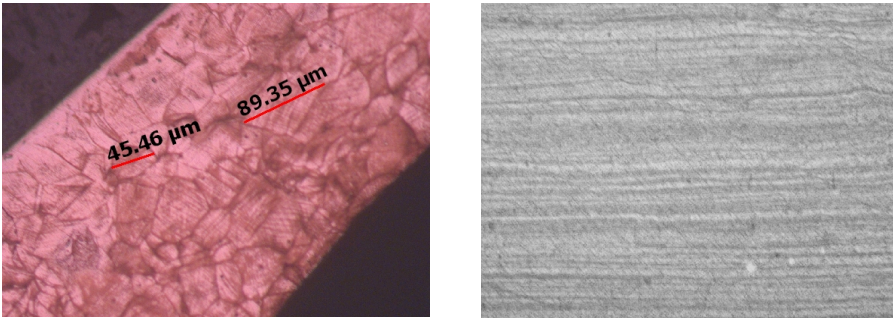
The bimetallic wire consisted of a silver core (alloy 925 – Sterling silver) and a shell of the proposed alloy based on 585 gold. The tape of a gold alloy 0.33–0.50 mm thick obtained by the cold rolling method was wrapped around a silver core - a bar with a diameter of 2.5–8.2 mm. This ensured the production of bimetallic billets and reduced the risk of shell detachment from the core of the wire during processing. Thus the ratio of the cross-sectional are-

as of the core and the body of the semi-finished product was 0.27–2.6. The bimetallic billet was subjected to cold long rolling and subsequent drawing to a final wire diameter of 0.25 mm. In the process of carrying out the pilot-industrial test during deformation, it was possible to ensure a tight fit of the gold shirt against the silver core (**Fig. 3**), to achieve a homogeneous fine-grained structure (**Fig. 4**) and to reach a high level of mechanical properties (**Table 2**).



a b

Fig. 3. Adjoining the golden shirt to the silver core after cold-rolled (a) and drawing (b)



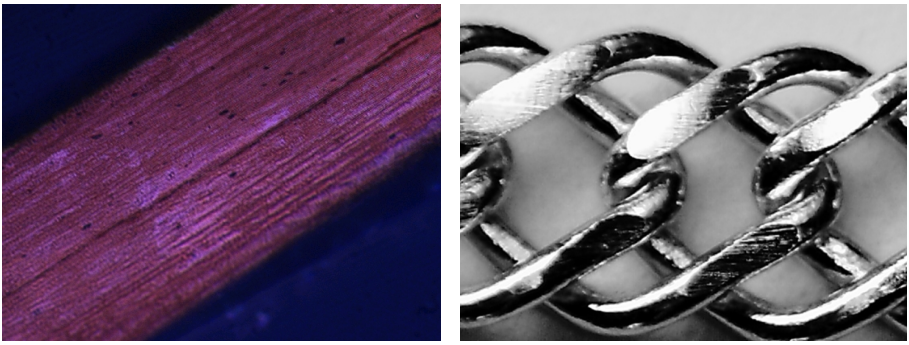
a b

Fig.4. Microstructure of the bimetallic wire with a diameter of 0.6 mm: a – shell of a gold alloy of 585 samples; b – core made of 925 silver alloy, x500

Table 2

Mechanical properties of the metal bimetallic wire

Diame-ters, mm	Tensile strength, MPa	Flow limit, MPa	Percentage extension,%	Tensile strength, MPa	Flow limit, MPa	Percentage extension,%
	Cover from alloy of gold 585 of JSC «Krastsvetmet»			Cover of a gold alloy 585 samples with the addition of modifiers		
0,9	657	338	43.2	694	553	48.5
0,75	803	413	36.7	848	675	41.2
0,6	906	465	28.6	956	761	32.1
0,45	945	486	24.3	998	795	27.3
0,25	983	505	19.5	1038	827	21.9



a b

Fig. 5. Type of wire (a) with increasing x200 and jewelry chain «Double diamond» (b)

A comparative analysis of the data on the mechanical properties of a metal shell made of a 585-alloy gold alloy used by JSC «Krastsvetmet» and a shell of a new alloy [8] shows that the strength and plastic properties of the latter are higher. This makes it possible to assume that the chaining process will take place without the formation of defects and the performance properties of jewelry chains manufactured by the new method will correspond to the existing requirements for this type of product.

From the obtained wire, experimental many high-quality jewelry chains were made (**Fig. 5**), with no breaks or detachments of the shirt from the core during chain linking.

Conclusion

At the result, the conducted studies showed that the proposed method of manufacturing bimetallic wire provides an increased level of mechanical properties and their uniform distribution along the length of the product. The process of manufacturing of bimetallic wire realized in industrial conditions on the basis of this method, makes it possible to obtain a tight fit of the shell to the core, is characterized by greater manufacturability of bimetallic semi-finished products increased strength and plastic properties of the metal. Decrease in the probability of breaks in the drawing process and stratification of the gold sheath during binding chain webs due to greater uniformity of mechanical properties along the length of the product. At the same time, the quality of jewelry, the mechanical and operational characteristics of the finished product is increased and its cost is reduced which gives grounds to recommend the proposed method for producing bimetallic wire in production.

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ИНФОРМАЦИЯ О СТАТЬЕ НА РУССКОМ ЯЗЫКЕ

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ИССЛЕДОВАНИЕ ТЕХНОЛОГИИ ПОЛУЧЕНИЯ БИМЕТАЛЛИЧЕСКИХ ДЕФОРМИРОВАННЫХ ПОЛУФАБРИКАТОВ ПРИ ПРОИЗВОДСТВЕ ЮВЕЛИРНЫХ ЦЕПЕЙ ИЗ СПЛАВОВ КРАСНОГО ЗОЛОТА

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Аннотация. Предложен и научно обоснован новый способ получения биметаллической проволоки из драгоценных металлов для ювелирных цепей, защищенный патентом РФ. Проведены расчеты деформационных режимов холодной сортовой прокатки и волочения, которые обеспечивают равномерное распределение вытяжек по проходам и дают возможность минимизировать энергосиловые параметры обработки. Для расчетов применительно к промышленным условиям производства ОАО «Красноярский завод цветных металлов имени В.Н. Гулидова» (ОАО «Красцветмет») применена программа «PROVOL», на которую получено свидетельство о государственной регистрации программы для ЭВМ. С использованием разработанных режимов проведены экспериментальные исследования по получению биметаллической проволоки, у которой в качестве сердечника использовался сплав серебра 925 пробы, а в качестве оболочки – сплав золота 585 пробы. Опытно-промышленная апробация технологии получения биметаллической проволоки в ОАО «Красцветмет» для изготовления ювелирной цепи типа «Ромб двойной» позволила получить качественную продукцию. Исследования структуры и свойств длинномерных деформированных полуфабрикатов показали, что при использовании нового способа повышаются прочностные и эксплуатационные характеристики биметаллической проволоки для производства ювелирных цепей, и процесс цепевязания проходит без образования дефектов. Таким образом, предложен новый способ и технология получения биметаллических полуфабрикатов на основе сплавов из драгоценных металлов, которые позволяют повысить качество готовой продукции и расширить ассортимент ювелирных изделий.

Ключевые слова: биметаллический полуфабрикат, ювелирные цепи, золото, серебро, сердечник, рубашка, режимы деформации, сортовая прокатка, волочение.

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