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«КӨЛІК ЖӘНЕ ЭНЕРГЕТИКАНЫҢ ӨЗЕКТІ МӘСЕЛЕЛЕРІ: ИННОВАЦИЯЛЫҚ ШЕШУ ТӘСІЛДЕРІ» Х ХАЛЫҚАРАЛЫҚ ҒЫЛЫМИ-ТӘЖІРИБЕЛІК КОНФЕРЕНЦИЯСЫНЫҢ БАЯНДАМАЛАР ЖИНАҒЫ

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Материалы конференции дают отражение научной деятельности ведущих ученых дальнего, ближнего зарубежья, Республики Казахстан и могут быть полезными для докторантов, магистрантов и студентов.

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HEAT-STRENGTHENED REINFORCING BAR AND ITS ECONOMIC EFFICIENCY

Jaxymbetova Makpal Adlikanovna
dzhaksymbetov@list.ru
senior lecturer of the «Standartization, certification and metrology» department of the Eurasian national university after L.N. Gumilyov, Nur-Sultan, Kazakhstan
Kanayev Amangeldy Tokeshovich
d.t.s., professor of the «Standartization, metrology and certification» department of the KazATU after S.Seifullin, Nur-Sultan, Kazakhstan
Akhmedyanov Abdulla Ugubayevich
c.t.s., associate professor of the «Standartization, certification and metrology» department of the Eurasian national university after L.N. Gumilyov, Nur-Sultan, Kazakhstan
Kirgizbayeva Kamilya Zhuzbayevna
c.t.s., associate professor of the «Standartization, certification and metrology» department of the Eurasian national university after L.N. Gumilyov, Nur-Sultan, Kazakhstan
Smagulov Askhat Kanatovich
third year student of the «Transport, transport equipment and technologies» department of the Eurasian national university after L.N. Gumilyov, Nur-Sultan, Kazakhstan
Suyessinova Zhaukhaz Alibekovna
third year student of the «Transport, transport equipment and technologies» department of the Eurasian national university after L.N. Gumilyov, Nur-Sultan, Kazakhstan

In connection with the rapid development of scientific and technological progress in various sectors of the economy, ever higher requirements are imposed on the quality of metallurgical products. An important place among measures to improve the quality of finished metallurgical products belongs to hardening heat treatment. By increasing the strength characteristics of the metal, hardening heat treatment can reduce the specific consumption of steel, increase the service life of products, reliability and durability of parts and assemblies, which is equivalent to an increase in the volume of finished metal products. The most promising method of hardening is quenching from rolling heating, when the metal is quenched immediately after leaving the finishing stand of the rolling mill. In this case, the residual heat of heating the metal after hot rolling is used, i.e. heat treatment is combined with the process of hot plastic deformation. This provides thermal hardening from rolling heating with great technical and economic advantages in comparison with other methods of hardening heat treatment.

Reinforcement steel of periodic profile - reinforcement bars with transverse protrusions (corrugated) evenly located on their surface at an angle to the longitudinal axis of the rod to improve adhesion to concrete.

The starting material for the production of thermally hardened bar reinforcing steel with a periodic profile with a diameter of 20, 22 and 25 mm is blanks of ordinary quality steel grades St5sp and St5ps according to GOST 380-2004, which come from the open-hearth shop in accordance with the specifications.

The purpose of the work is to analyze the technological process of thermal hardening and evaluate the economic efficiency of using heat-strengthened reinforcing bars in construction.

Preparation of the pilot industrial plant for start-up begins with filling the reservoir with water, for which a gate valve regulating the supply of water from the shop water supply network to the tank is fully opened.

Measuring instruments (FEP-4M, pressure gauges, flow metres) are installed in the appropriate areas of the measurement and connected to the connecting cable going to the cabinet of control and measuring devices.

Devices are turned on for recording control parameters on paper (temperature of the end of rolling, temperature of interrupted hardening and self-tempering, pressure and water flow).

The mode of thermal hardening of reinforcing bars is established and control valves are opened to the nozzles of the corresponding section of the cooling device depending on the diameter of the hardened bar according to Table 1 [1].

Table 1– Modes of thermal hardening of reinforcing rods at the mill according to GOST 10884-2004 for strength class AT-111S(At 500)

Type of product	Rod diameter, mm	Weight 1 kg	Temperature, °C		Number of cooling sections
			End of flattening	Self-tempering	
Reinforcing rod made of St6sp	20	2,47	950-1000	450-600	2
Reinforcing rod made of St6sp	22	2,98	970-1020	450-650	3
Reinforcing rod made of St6sp	25	3,85	990-1050	450-650	4
Note: Self-tempering temperature control ranges are determined according to fluctuations in carbon content and flattening speed					

The air supply valve to the air nozzles is opened, which serves to cut off excess waste water entering the guide pipes for schemes and calibrations used for the production of hot-rolled bar reinforcement with a diameter of 20.22 and 25 mm from low-alloy steel 35GS in accordance with the requirements of the technological instruction TI-309-PST -3-95. at the same time, reinforcing bars receive a pattern and profiles corresponding to the strength class At-11C (At500) in accordance with GOST 5781.

Thermal hardening of two rolls from the first workpiece is carried out, passing them sequentially through the cooling sections of the pilot industrial installation of thermal hardening.

The self-release temperature of heat-strengthened rod valves at the outlet of the pilot plant should be within 450-600°C depending on the carbon content in the steel and rolling speed.

The required heat hardening mode, depending on the diameter of the reinforcement and the carbon content in the steel, is assigned by the foreman of the mill according to Table 3. In this case, additional regulation of the heat hardening mode is carried out by redistributing the coolant between the nozzles.

After reaching the required parameters of thermal hardening, at the signal of the foreman of the mill, it is necessary to start hardening a given amount of rolled products. Responsible for compliance with the specified mode of thermal hardening is the shift foreman of the mill [2].

Technical advantages are the possibility of heat treatment in the production technological flow of hot rolling, use of residual heat for rolling for thermal hardening of products, in a shorter duration of the process and in obtaining a cleaner surface of rolled products. Heat-strengthening from rolling heating allows you to use an important reserve of additional increase in the strength and plastic properties of the metal by carrying out high-temperature thermomechanical processing, which summarises the effect of phase riveting from phase transformations in the process of accelerated cooling with the effect of hot riveting in the process of hot plastic deformation.

Economic advantages include no additional costs of electricity or fuel, no costs for the construction of heating furnaces and other equipment, a sharp decrease in the need for labor, a reduction in intra-shop and intra-factory transport operations. However, despite the indicated advantages of heat strengthening with rolling heating compared to heat strengthening with furnace heating, the organization of this technological process is associated with certain difficulties. A significant disadvantage of heat treatment with rolling heating is the inclusion of additional operations in the rolling process flow, which can disrupt the rhythm of the rolling mill.

To fully exploit the benefits of heat hardening from rolling, it is essential that the accelerated cooling process be as continuous and efficient as the hot rolling process. The implementation of such a single technological process required the development and creation of efficient cooling devices, with the help of which the pilot implementation of the innovative technology of heat hardening from rolling heating was successfully implemented.

The following should be noted on the effectiveness of thermal and thermomechanical hardening in relation to long product reinforcement profiles [3].

First of all, it should be emphasized that the reinforcement (metal weight) used in reinforced concrete structures is consumed irreversibly, i.e. is not returned as scrap metal to smelters, but remains in concrete. Therefore, reducing the metal consumption of reinforced concrete structures by increasing their strength characteristics is an important scientific and technical task and shows the effectiveness of their thermal and thermomechanical hardening.

Being the main structural material in the construction industry, reinforced concrete consumes a large number of reinforcing profiles, their annual consumption by reinforced concrete reaches millions of tons, and the specific consumption of metal per 1 m3 of reinforced concrete is on average 70 kg.

We also note that the reinforcing profiles used in reinforced concrete structures are the main element that perceives tensile loads, thereby ensuring the strength and reliability of the structure. An important factor ensuring the joint operation of reinforcement with concrete is their adhesion, the increase of which is achieved by using reinforcing profiles of a periodic profile. All this shows the relevance of increasing the strength characteristics of reinforcing profiles by thermal and thermomechanical hardening. Particularly important is the use of high-strength reinforcing profiles in structures and structures based on prestressed reinforced concrete, which are increasingly being used. Thus, according to economists, the use of heat-strengthened reinforcement with a strength of 600–1300 MPa, due to an increase in the design resistance, makes it possible to reduce metal consumption by 20–45%, which gives a significant economic effect [4].

The specificity of calculating the efficiency of production and use of thermally and thermomechanically hardened rolled products is that the economic effect is revealed mainly in the sphere of consumption, and therefore the actual economic efficiency can only be determined by comparing all the costs of living and embodied labor for the production of thermal hardening of rolled products on metallurgical plant and costs in industries that consume metal for the manufacture and production of machines, mechanisms, various metal structures, reinforced concrete, etc.

Thus, the criterion for the economic efficiency of thermal hardening of rolled products is the saving of total costs required to meet certain needs of the country's economy.

As noted above, the organisation of production of thermally hardened rolled products increases operating costs for energy costs, wages, depreciation, current repairs, etc. At the same time, the use of hardened rolled products in the economic sectors leads to a decrease in operating and capital costs in industries that consume this hardened rolled products.

The general principle underlying the methodology for determining metal savings is the condition of equal-strength of thermally hardened and unstrengthened rolled products. In accordance with this principle, metal savings are determined by comparing the specific costs of hardened and unstrengthened rolled products with the same purpose.

In each specific case, the principle of compliance with the condition of equal strength should be implemented in different ways: in some cases, by comparing the consumption of metal for products of equal use value, produced using hardened and non-reinforced rolled products (reinforcing profiles), in other cases - per unit length of rolled products, if we are talking about shaped profiles (corners, channels) or per unit of usable area of rolled products, if we are talking about sheet metal.

The amount of metal savings is influenced by the change in waste and scrap of metal during the production and thermal hardening of rolled products. So, in the production of heat-strengthened reinforcing and corner profiles, no increase in the metal consumption coefficient is observed, since thermal hardening is carried out immediately after the finishing stand of the rolling mill.

Facilitating the mass of heat-strengthened rolled products requires less steel for its production and, accordingly, cast iron, ore, coking coals, which leads to a decrease in total capital investments as a result of the use of thermally hardened rolled products. There is also a reduction in transportation costs due to the transportation of less metal to meet consumer requests and facilitate the weight of structures and machines made of rolled products with high mechanical properties.

An important link in the choice of the technological process of thermal hardening of rolled products was the study of the possibility of replacing furnace tempering, which requires large capital investments, with self-tempering, which does not entail additional energy costs. Research in this direction made it possible to propose a technological process of hardening heat treatment of long products according to the scheme of interrupted hardening followed by self-tempering, which is the most economical option for heat treatment [5].

The cooling device used in the works of this direction easily fits into the current technological process for the production of long products, it is designed for intensive cooling of moving rolled products from a temperature of 1000-1050°C to 450-500°C, which will improve working conditions in the sections of the rack cooler and adjustment of the rolling mill due to a sharp decrease in heat release from hot rolled products. This is important for a significant improvement in working conditions and will lead (along with economic) to a significant social effect.

The cooling medium during the deformation-heat treatment of metal products is process water, which is used from the workshop circulating water supply and sewerage with filtration from suspended particles (the size of suspended particles in water should be no more than 1.0-1.5 mm). Therefore, the production of deformation-thermally hardened rolled products at existing or under construction rolling mills does not affect the environmental situation in this area, which is also of no small importance.

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