• ХИМИКО-МЕТАЛЛУРГИЧЕСКИЕ НАУКИ

УДК 629.4.057: 621.785 https://doi.org/10.51301/vest.su.2021.i6.08

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OPTIMIZATION OF CRANE WHEELS OPERATION

Abstract. Based on the metallographic studies of the undercarriage wheels, which are operated within different periods of time and have different types and degrees of wear, it can be concluded that steel with the chemical composition close to the eutectoid one, with the equilibrium crystal lattice, should be used for manufacturing. The microstructure of the working surfaces of the wheels should be fine pearlite, ideally sorbitol (fine type of pearlite).

These requirements are met by steel billets made of structural alloy steel 65G. This steel is the preferred material for the manufacture of running wheels of overhead cranes. These materials have stable mechanical characteristics and wear resistance, allow getting a stable and predictable result during heat treatment. In other words, the carried out tests showed that the wheels made of steel forgings, stamping or hot-rolled wheels made of steel grade 65G in their performance, wear resistance and durability are many times superior to the wheels made of cast billets. Given that forged or stamped billets provide higher reliability of the wheel structure (less prone to cracking and sudden destruction during production and operation), and more than twice reduce the wear of the material of the crane runway (rail).

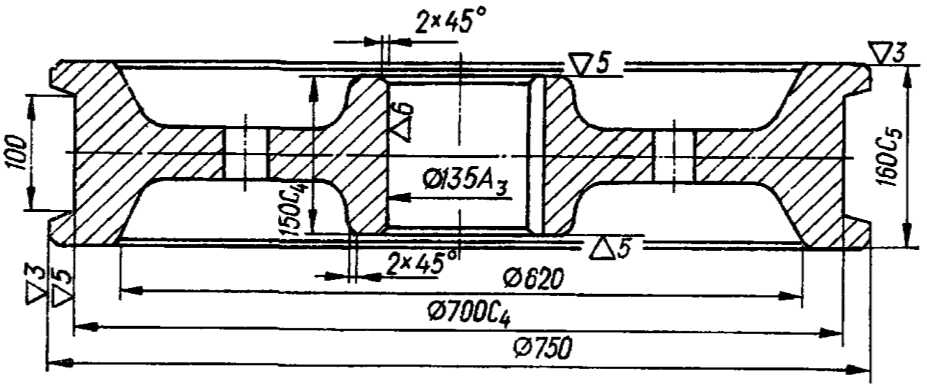
Keywords: steel, properties, microstructure, heat treatment, hardening, temperature

Introduction. Crane wheels of overhead traveling cranes are among the least durable elements. If the metal structures of cranes can be operated within 20-50 years, the service life of traveling crane wheels as a result of wear in some cases can be less than six months, and the average service life is several years. Due to the high loads during construction work, crane equipment, or rather, some of its parts often wear out and become unusable. These elements include crane wheels, which wear is caused by high mechanical stress. The costs associated with wheel replacement are in most cases decisive in the repair of crane wheels. A short average service life leads to a very significant consumption of high quality metal used for wheel replacement. In this regard, the problem of increasing the durability of crane wheels is urgent.

Typically, crane wheels of overhead cranes are made of 65G steel die blanks, 45, 50, 75 and 65G steel forgings, 75 and 65G rolled steel and 55 and 35GL steel castings.

The article presents the results of studying the microstructure and mechanical properties of 65G steel of which the crane wheel of an overhead crane is made in the conditions of the Maker Karaganda Foundry - Machine Building Plant LLP.

Methods. The main operation in the machining of crane wheels is vertical turning. In manufacturing a crane wheel (Figure 1), the following operations are performed: preliminary machining of the bores and ends of the hub, ends of the rim, flanges and rolling surfaces in two installations on a turning-boring lathe, heat treatment (sorbitization), finishing of wheels along the rolling circle and flanges , flange edge machining, final boring of the hub bore.



Pic. 1. Crane running wheel

Heat treatment technology. 65G steel is relatively cheap, which leads to its wide and effective use. The main components are: C (within 0.62...70 %), Mn (within 0.9...1.2 %), Cr and Ni (up to 0.25...0.30 %). All the other components: Cu, P, S, etc. refer to impurities and are allowed by their chemical composition in quantities limited by the state standard.

Normalization was used as the preliminary heat treatment, and quenching followed by tempering was used as the final heat treatment.

The heat treatment modes of steel were selected according to the operating conditions of the crane wheel and the initial steel structure.

Steel belongs to the hypo-eutectoid type therefore, its composition at temperatures above the lowest point of austenitic transformation, - 723 °C - at 30-50 °C contains austenite in the form of a solid mechanical mixture with a small amount of ferrite. Since austenite is a harder structural component than ferrite, the quenching temperature range for 65G steel is significantly lower than for structural steels with a lower percentage of carbon. Thus, the temperature range of hardening of this grade steel should be within no more than 800 - 830 °C.

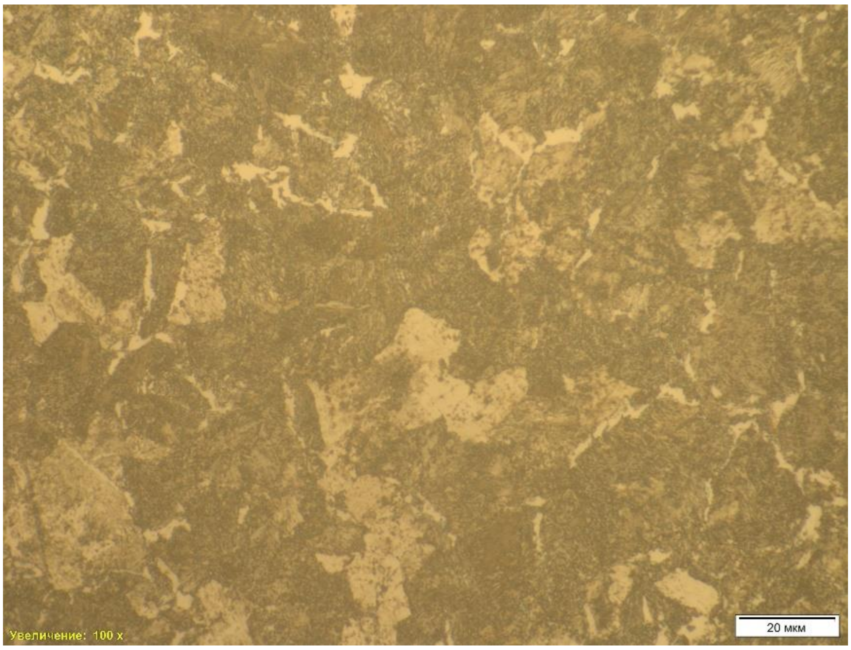
Pretreated wheels made of 65G steel were heated in the furnace to the temperature of 700 - 820 °C and kept within 2 hours. After rolling out the car from the furnace, two wheels were mounted with the help of tongs grips on a special device for intermittent hardening.

Table 1. **Heat treatment modes (hardening in an electric furnace)**

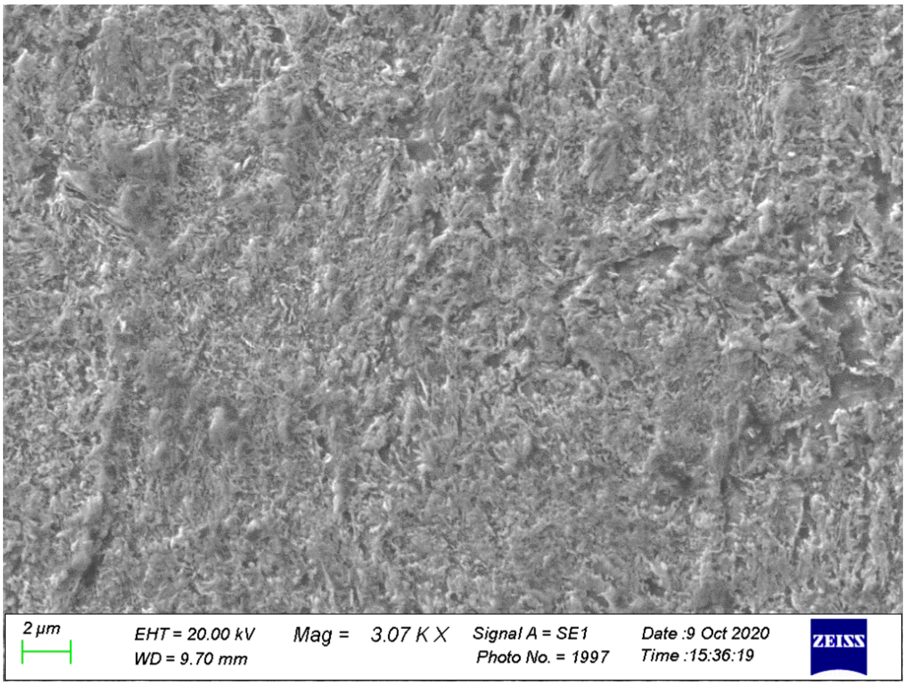
Sample size, mm	Heating time, min	Holding time, min
Before 100	50	120
Before 200	88	240

When the quenched wheel rotated, the rim sections were submerged periodically in water, and the intermittent quenching process proceeded. The structure of the metal and the depth of the hardened layer depend on the hardening mode, i.e., on the number of wheel revolutions, the total duration of hardening and the tempering mode. For wheels with the diameter of 500…700 mm, the best hardening results were obtained when the wheel was rotated with the speed of 23…25 rpm, the quenching duration of 2.5-5 minutes and tempering at the temperature of 490…500 °C.

The analysis using an electron microscope shows that on the rolling surface the structure is characterized by the predominance of uniformly distributed globular (round-shaped) carbides and a smaller number of plate-shaped carbides. Round-shaped carbides have higher hardness compared to plate-shaped carbides. As the distance from the rolling surface of the wheel increases, the content of plate-shaped carbides in the metal structure increases, which causes smooth decreasing the metal hardness.



Pic.2. Microstructure of the sample after heat treatment



Pic. 3. Surface topography

65G steel hardening modes. To achieve the maximum degree of heating uniformity, steel was first heated in the preliminary chambers of thermal furnaces to temperatures slightly lower than that of quenching furnaces: from 550 to 700 °C, and only then the part was sent directly to the quenching furnace.

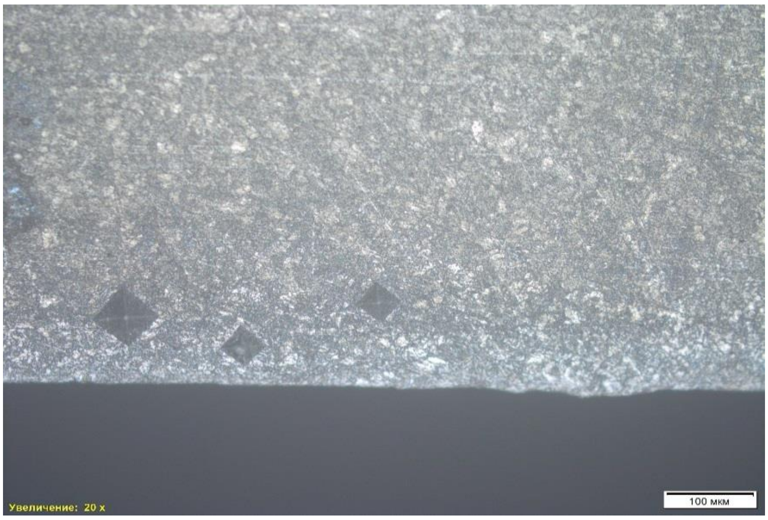
Based on the hardening temperature, for 65G steel at 800...820 °C the limiting value of the decarburized layer should not exceed 50...60 microns.

The microhardness of the metal was determined using an ISOSCAN OD microhardness tester according to the Vickers method in accordance with ISO 6507. The load was 0.5 N

Table 2. **Measurement of microhardness from the edge of the sample to the center**

№	1 sample	2 sample
1	298,2	332,3
2	229,1	332,3
3	215,4	306,2
4	304,2	300,1
5	310,2	303,5

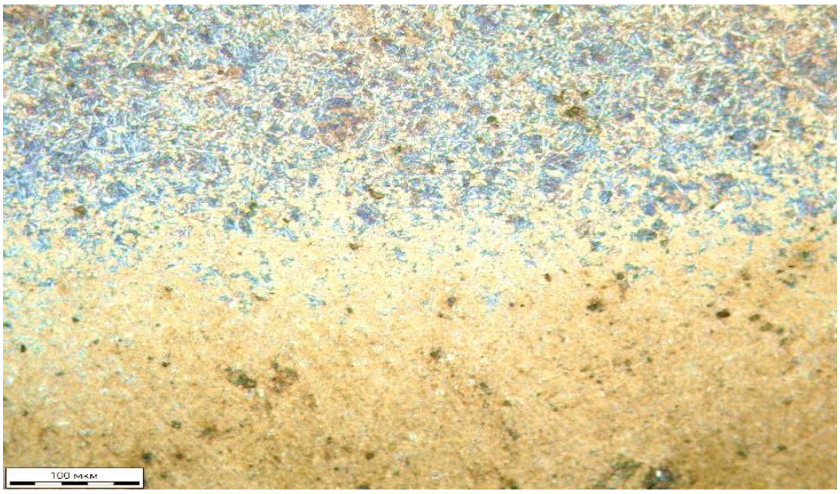
65G steel is not afraid of overheating, however, upon quenching at the upper value of the temperature range the impact toughness of the material begins to decrease, which is accompanied by the growth of grains in the microstructure.



Pic. 4. Sample microhardness

The exposure within the period of the product quenching in the given temperature range lasts until the complete transformation of pearlite occurs.

The following tempering technology. To obtain the structure of sorbitol, the products were subjected only to high-temperature tempering at the temperature of 550…600 °C, with cooling in the still air.



Pic. 5. Smooth transition of the structure from the center to the surface after sorbitization

Conclusions. The results of observing the wear of the wheels of the undercarriage in the operating conditions, comparing plaster prints taken from the working parts of the rims in different periods of the wheels operation, as well as the results of laboratory studying the worn wheels and their wear resistance allow concluding that the main cause of wear for the vast majority of the undercarriage wheels is abrasion accompanied by plastic deformations of the surface layers of the working parts of the wheel rims.

Based on the metallographic studies of the undercarriage wheels, which are operated within different periods of time and have different types and degrees of wear, it can be concluded that steel with the chemical composition close to the eutectoid one, with the equilibrium crystal lattice, should be used for manufacturing. The microstructure of the working surfaces of the wheels should be fine pearlite, ideally sorbitol (fine type of pearlite).

It is advisable to increase the working part hardness of the rim by heat treatment (hardening) up to 300...360 HB for the rolling surface of the running wheels and up to 350...400 HB for the flanges. Further increasing hardness is permissible only if the crane rail heads hardness is increased.

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КРАН ДӨҢГЕЛЕКТЕРІНІҢ ЖҰМЫСЫН ОҢТАЙЛАНДЫРУ

Андатпа. Әр түрлі уақыт кезеңінде жұмыс істейтін және әр түрлі тозу дәрежесі бар жүгіру дөңгелектерінің металлографиялық зерттеулерінің негізінде химиялық құрамы эвтектоидке жақын және тепе - тең кристалды торы бар болат деп қорытынды жасауға болады. Дөңгелектердің жұмыс беттерінің микроқұрылымы жұқа дисперсті перлит, ең дұрысы сорбитол (жұқа перлит түрі) болуы керек. Осы талаптарға болат дайындамалар бірі конструкциялық легирленген болат 65Г қанағаттандырады. Бұл болат аспалы крандар доңғалақтарын дайындау үшін қолайлы материал болып табылады. Бұл материалдар тұрақты механикалық сипаттамаларға және тозуға төзімділікке ие, термиялық өңдеу кезінде тұрақты және болжамды нәтиже алуға мүмкіндік береді. Басқаша айтқанда, жүргізілген сынақтар 65Г маркалы болаттан жасалған, штампталған немесе ыстықтай илектелген доңғалақтардың сипаттамалары, тозуға төзімділігі және беріктігі бойынша құйылған дайындамалардың дөңгелектерінен бірнеше есе асып түсетінін көрсетті. Сонымен қатар, жалған немесе штампталған дайындамалар доңғалақ құрылысының жоғары сенімділігін қамтамасыз етеді (өндіріс пен пайдалану кезінде крекингке және кенеттен бұзылуға аз сезімтал) және кран жолының (рельс) материалының тозуын екі есе азайтады.

Негізгі сөздер: болат, қасиеттері, микроқұрылымы, термиялық өңдеу, каттылығы, температурасы.

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ОПТИМИЗАЦИЯ РАБОТЫ КРАНОВЫХ КОЛЕС

Аннотация. На основании металлографических исследований колес ходовой части, эксплуатируемых в разные периоды времени и имеющих разный тип и степень износа, можно сделать вывод об использовании стали с химическим составом, близким к эвтектоидному и с равновесной кристаллической решеткой. Микроструктура рабочих поверхностей колес должна быть мелкодисперсным перлитом, в идеале сорбитом (мелкий вид перлита).

Этим требованиям удовлетворяют стальные заготовки из конструкционной легированной стали 65Г. Эта сталь является предпочтительным материалом для изготовления ходовых колес мостовых кранов. Эти материалы обладают стабильными механическими характеристиками и износостойкостью, позволяют получать стабильный и предсказуемый результат при термообработке. Иными словами, проведенные испытания показали, что колеса из стальных поковок, штамповочные или горячекатаные из стали марки 65Г по своим характеристикам, износостойкости и долговечности многократно превосходят колеса из литых заготовок. При этом кованые или штампованные заготовки обеспечивают более высокую надежность конструкции колеса (меньше подвержены растрескиванию и внезапному разрушению при производстве и эксплуатации) и более чем вдвое снижают износ материала подкранового пути (рельса).

Ключевые слова: сталь, свойства, микроструктура, термическая обработка, твердость, температура.