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FRIDAY 26 NOV 2021- CUMA 26 KASIM 2021	
10:00	**OPENING CEROMONY(ONLINE) / AÇILIŞ TÖRENİ (UZAKTAN)**
	İstiklal Marşı ve Saygı Duruşu/ National Anthem and Stance of Respect
	Sempozyum Başkanı Doç. Dr. Zahide Bayer ÖZTÜRK'nın Konuşması/ President of the Symposium Assoc.Prof. Dr. Speech by Zahide Bayer ÖZTÜRK
	Mühendislik /Mimarlık Fakültesi Dekanı Prof. Dr. Ersan KABALCI nin Konuşması/ Dean, Faculty of Engineering / Architecture Dr. Speech of Ersan KABALCI
Session Chairman/Oturum Başkanı:Assist. Prof. Dr. Fatma Zehra KOÇAK	**HALL OPENING CEROMINI/AÇILIŞ SALONU**
10:30-10:45	**Metalic Nanoparticles and De-oxy Sugar Containning Pro-angiogenic Synthenic Grafts to Accellerate Healing in Burns and Diabetic Foot Ulcer Wounds** **Assoc. Prof. Dr. Muhammad YAR**
10:45-11:00	**Novel Latex Based-Graphene Oxide Filled Nanocomposite Membrane For Oily Wastewater Treatment** **Prof. Dr. Mohamed KCHAOU**
11:00-11:15	**Thermo-viscoclastic Modeling of PVC Foam Based on DMA Test** **Prof. Dr. Jamal FAJOUI**
11:15-11:30	**Structural Changes at Metal of a Railway Wheel Along Rolling Surface** **Vakulenko I.Alex.**, Kurt B, Bolotova D, Colova
12:00-13:00	**ÖĞLE ARASI/ LUNCH BREAK**
Session Chairman /Oturum Başkanı: Prof. Dr. Yavuz SUN	**HALL URGUP/SALON URGUP**
13:30-13:45	**FRICTION STIR SPOT WELDING BETWEEN ALUMINIUM AND STEEL AUTOMOTIVE MATERIALS** Orkun Tekelioğlu, **Tanya A. Başer**
13:45-14:00	**STRUCTURAL AND ELECTRİCAL PROPERTİES OF (M= CO, MN AND Nİ; X=0.1) SUBSTITUED FORSTERITE CERAMİCS** **Saloua El Asri**, Mohammed El Hadri , Hamid Ahamdane, Lahoucine Hajji, Moulay Ahmed El Idrissi Raghni, and Mohamed Mansori
14:00-14:15	**INVESTIGATION OF THE MECHANICAL PROPERTIES OF BORON NANOPARTICLE DOPED ADHESIVE JOINTS EXPOSED TO SALT WATER ENVIRONMENTS** **Yasemin KORKMAZ**, Kürşat GÜLTEKİN
14:15-14:30	**EFFECT OF SILAN MODIFIED NANO H-B_4C DISPERSION ON THERMAL PROPERTIES OF STRUCTURAL EPOXY ADHESIVES** Yasemin KORKMAZ, **Kürşat GÜLTEKİN**, Yıldıray TOPCU
14:30-14:45	**EFFECT OF THE BORON NANOPARTICLES ON THE GLASS TRANSITION TEMPERATURE OF EPOXY POLYMER EXPOSED TO SULPHURIC ACID ENVIRONMENT** **Yasemin KORKMAZ** , Kürşat GÜLTEKİN
14:45-15:00	**THE EXTERİOR LİGHTİNG SYSTEMS FOR AUTOMATED VEHİCLE'S COMMUNİCATİON WİTH PEDESTRİAN AND VEHİCLE TO VEHİCLE** **Orhan Uras KURTULUŞ**
15:15-15:30	**INRUSH CURRENT MANAGEMENT OF AUTOMOTIVE SIDE TURN INDICATOR FUNCTION** **Ilayda TAYLAN**, Ahmet Gokhan GURBUZER
Session Chairman /Oturum Başkanı: Assoc. Prof. Dr. İsmail ESEN	**HALL KAPODOKYA/SALON KAPODOKYA**
13:30-13:45	**METHODS FOR PRODUCTION OF MGB_2 SUPERCONDUCTING IMD ROUND WİRES** **Doğan Avcı**, H. Yetiş, F. Karaboğa, F. M. Tanyıldız, M. Akdoğan, İ. Belenli
13:45-14:00	**CORE HOMOGENEITY OF MONO-FILAMENTARY FE/MGB2 WIRES PRODUCED BY TWO DIFFERENT EXCESS-MG ADDITION METHODS** **Doğan Avcı**, H. Yetiş, F. Karaboğa, F. M. Tanyıldız, M. Akdoğan, İ. Belenli
14:00-14:15	**POROSITY EFFECT ON THE FREE VIBRATION OF FGM NANO BEAMS BASED ON NSGT** **İsmail ESEN**
14:15-14:30	**BİR OTOMOTİV ACC BRAKETİ KORELASYON ÇALIŞMASI** **Furkan Sinan ERÇEL**, Dilara ERGİN, Metin ÇALLI
14:30-14:45	**EFFECT OF WELDING FORCE AND SPEED PAREMETERS ON FRICTION STIR WELDED AA6061-T6 ALLOY HARDNESS AND MICROSTRUCTURE PROPERTIES** **Mehtap HIDIROĞLU**, Orkun TEKELİOĞLU , Metin ÇALLI, Nizamettin KAHRAMAN

Structural changes at metal of a railway wheel along rolling surface

Vakulenko I.Alex[a]., Kurt B.[b], Bolotova D.[c], Colova O[d].

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Abstract

As a result rolling of the hardened carbon steel without slipping, only due to normal loading, a decrease in hardness is observed. The observed decrease in hardness is due to the development of softening processes during plastic deformation. Additional slippage at the contact points of the samples accelerates development of softening effects in the hardened metal. It has been found that softening during rolling of a quenched metal is accompanied by a refinement of the coherent scattering regions, increase in internal stresses, and increase at number of crystal structure defects.

Keywords: Steel, hardness, deformation, softening

1. Introduction

During operation of railway wheels, a level of contact stresses is reached along the rolling surface that exceeds the yield point of carbon steel [1]. Moreover, the local nature of plastic deformation is actually accompanied by the development of strain hardening and softening processes from cyclically changing contact stresses. In addition, when breaking the rolling stock, the metal of the wheel rim close to the rolling surface can be heated to temperatures exceeding onset of phase transformations [1,2]. The combined effect of these phenomena is actually accompanied by an unpredictable ration between development processes of increasing density of crystal structure defects, their redistribution and annihilation in the metal [3,4]. In addition, the gradual nature of the accumulation defects in the metal can be disrupted by the occurrence of random influences, such as local slippage wheel on the rail, when breaking the rolling stock, etc. Based on this, expect sufficiently rapid achievement critical conditions at the formation damage of the rolling surface to the wheel rim.

2. Material and research methods

The material for the study was carbon steel of a fragment of a railway wheel with a chemical composition of 0.62% C, 0.78% Mn, 0.3% Si, 0.027% P, 0.026% S, 0.09% Ni, 0.14%.Cr and 0.15% Cu. After the samples for wear testing with a diameter of 50 and a thickness of 12 mm were made, they were quenched from normal heating temperatures (above Ac_3). Rockwell hardness (HRC) was used as a characteristic at strength of the metal. Wear tests were carried out on an СМЦ-2 machine under dry friction conditions. A measure adhesion between two contact surfaces was emerging moment of the forces. The studies were carried out at different levels of specimen pressing to contra specimens and different degrees of slippage between them. The dislocation density, size of the coherent scattering regions and distortions of type II was estimated using X-ray structural analysis techniques by measuring width a line of the X-ray interference (211) (B_{211}) [5].

3. Results

The formation of surface damage to the wheel rim (Fig. 1) is determined by several factors of influence. The main ones are: the structural state of the metal [27,30], its ability to work hardening, resistance to the development of friction processes at high contact stresses [1,2].

Fig.1. The typical view a chipping metal on the rolling surface of the railway wheel.

Regardless of the structural state of the metal of the wheel, in a thin layer of the rim near the rolling surface, the successively developed processes of strain hardening and tempering during deceleration of the railway stock lead to the formation of cementite particles different dispersion and morphology (Fig. 2a,b). Taking into account tendency to obtain high strength wheels as a result of using hardening heat treatments, when the metal internal structure on the wheel surface approaches quenching and tempering at middle temperature range, development of wear processes must be different for the different structural state of the metal Moreover, at process of intensive wheel slip on the rail, certain sections of the rolling surface are capable of rapidly heating up to the temperatures onset of the phase transformation.

a

b

Fig.2.Structure of the steel in rim of railway wheel after fabrication: near the rolling surface (a) and at distance of 25 mm (b). Magnification is 800 - (a), 1000 - (b).

As a result of subsequent cooling at rates close to the critical value, structures in indicated volumes of the metal by intermediate or even shear mechanisms are formed. In terms by surface appearance, structure and hardness, these areas differ significantly from the cold-deformed metal of the rolling surface. Carbon steel of a railway wheel after operation had a rolling surface hardness of 35 HRC. After quenching, the samples (for wear tests) had a hardness of 65 HRC. At a pressure level between the specimen and contra specimen, 180 N, for a spindle speed of 300 $\min^{-1}$ without slipping, it was obtained that after 1200 cycles decrease at hardness on 5 to 7%. In order to explain the observed softening, parameters of the crystalline structure of the steel were estimated. Thus, at state after quenching, the steel under study had a certain degree tetragonality crystal lattice of the ferrite, which is proportional degree a super saturation of the solid solution with carbon atoms. To assess the specified characteristics, should use the relation [6]:

$$(c/a)=1+0{,}045p, \qquad (1)$$

where p - is the weight % of carbon atoms in steel, a - is the crystal lattice parameter of ferrite, and c - crystal lattice cube edge size of the ferrite in a martensite crystal [6]. The hardness values of the steel corresponded to the degree of tetragonality the crystal lattice. Consequently, the higher carbon content in steel, and its concentration at martensite crystal, higher the level of strength properties should be. For the steel under study, after substitution in (1) p and independently determined ratio c/a=1.027, coincidence was obtained with data for a similar steel [7]. After 1200 cycles rolling without slipping, degree tetragonality crystal lattice of the ferrite decreased and amounted to 1.0255. The result obtained indicates development processes softening of the martensite crystals from contact phenomena during of the rolling. Results similar in nature were obtained after insignificant plastic deformations of the hardened medium-carbon steels [8]. To analyze the nature observed phenomenon, use relation (1). After substitution c/a = 1.0255 in (1), it was found that p value corresponds to a carbon content of 0.56%. Thus, release of carbon atoms from martensite crystals during rolling process begins already after minor plastic deformations. At same time, the nature of changes characteristics crystal structure of the metal deserves some attention. As a result of heating to the average temperature range of cold-deformed carbon steel, observed softening is accompanied b increase at size of the coherent scattering regions (L), decrease by accumulated dislocation density (ρ) and distortions of type II (μ) [3]. After 1200 cycles of rolling the samples, a decrease degree tetragonality crystal lattice of the ferrite was accompanied by a decrease in L from 618 to 445 Å, increase in ρ from $9.7 \cdot 10^{11}$ to $1.2 \cdot 10^{12}$ cm^{-2} and μ from $1.98 \cdot 10^{-4}$ to $1.66 \cdot 10^{-3}$. The nature of change in these values is actually similar to the hardening of metal as from cold plastic deformation [4]. It can be assumed that change characteristics crystal structure of the metal is the result of the joint development of hardening and softening processes from contact phenomena. To confirm this, during rolling, a slippage of 10% between the samples was additionally used. During slippage, increase at intensity development of strain hardening processes should to a greater extent suppress effect of the metal softening. However, already after 600 loading cycles with a slipping of 10%, the hardness value was the same 62 HRC (before testing 65 HRC), at L= 504Å, $\mu= 2{,}6\cdot10^{-3}$ and $\rho=14{,}7\cdot10^{11}$ cm^{-2} . Comparative analysis shows that decrease at hardness of the hardened metal after rolling with slipping remained at about the same level (5% of the hardened state). The result obtained, in terms parameters of the crystalline structure, is similar to that of rolling without slipping. The same dispersion of the coherent scattering regions, an increase in and, is observed. A decrease in the value remained at about the same level, although in absolute values one can speak of insignificant differences. An analysis of the results obtained indicates existence qualitative dependence development softening processes on plastic deformation of the hardened steel. In order to explain mechanism influence of the slipping process during the rolling of a railway wheel on hardness of the metal, influence effect should be decomposed into stages. The first stage should include the processes that are associated with initiation and propagation of plastic deformation at volume of the rim close to the rolling surface. The second stage is the appearance separation metal particle from rolling surface of the wheel by interaction with the rail. So a metal that has undergone large plastic deformations, due to the inhomogeneous development of the process strain hardening, by have a certain number of the sub- and micro cracks. On this basis, the growth indicated micro cracks in the direction action of the maximum tangential stresses during slipping should contribute to the achievement conditions for separation of the metal micro volumes. Consequently, can assume that is a connection between processes slip of wheel on the rail and destruction metal along the rolling surface. The slipping process can be estimated by adhesion between metals of the wheel and rail. For constant load level of the wheel, rolling speed and temperature of the surface, existence of the inversely proportional communication between the slippage and adhesion of the metal is quite justified. Based on this, to evaluate the adhesion, it is proposed to use the moment of forces in the contact surface area. On fig. 3 show dependence moment of the forces at the point of contact between the samples. Under conditions of constant slippage, an increase at clamping force between the samples and spindle speed leads to increase in M. The sum effect of the simultaneous influence of P and v is manifested in an almost equidistant arrangement of the curves M~f(v, P).

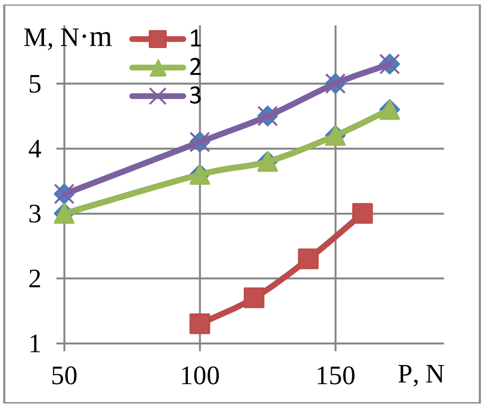

Fig.3. Influence of the clamping force between samples (P) and the machine spindle rotation speed (1 - 300, 2 - 500, 3 - 1000 min^{-1}) on the moment of forces, when slipping 20% between the samples.

Like most processes that are associated with deformation, the process of slipping must be thermally activated. To estimate the activation energy, the well-known equation [9] was used:

ε = A·exp (-Q / RT) • M^{m}, (2)

where - ε is the deformation rate, A is a constant, Q is the activation energy, R is the universal gas constant, T is the absolute temperature, M is the moment of forces that occurs between surfaces during slipping, m is the exponent. The evaluation of Q was carried out at force between specimens 200N, a slipping value of 20%. The number revolution of the machine spindle (v) was taken as a characteristic of the deformation rate. After transformation of relation (2), obtained the dependences for dry slip conditions:

(Q / m) = [(R·lnM)/(1/T)] - (lnv/m) (3)

or:

Q = RT (m·lnM - lnv) (3a)

The samples were tested at v = 300 and 500 min^{-1} and temperatures of +20 and +120˚C. At a constant temperature, an increase in v from 300 to 500 min^{-1} practically does not change the value (a decrease from 15.3 to 15.1 KJ/mol for 293˚K and from 20,6 to 20.2 KJ/mol for 393˚K). It follows from the results obtained that at a constant temperature, slipping 20% and force of the clamping 200N, increase at rotation speed does not lead to a change at activation energy. On other hand, at v = const, increase at test temperature is accompanied by an increase in Q by about 1.3 times. Taking into account that samples had a structure similar to that after formation of slipping on the rolling surface of a railway wheel during operation (the structure after quenching for martensite), the results obtained were in agreement with the data [1,2].

Compared with structures after quenching, it is of some interest to evaluate behavior steel with a structure after thermal treatment of the wheel rim. For this purpose, the samples of the steel under study were heated to temperatures of 870°C, followed by cooling in air. The tests carried out have established that at a temperature of 293°C and a slipping of 10%, increase in v from 300 to 500 min^{-1} is accompanied by a decrease in Q by about 30%. Similar results were obtained for a slipping of 20%. On other hand, for a speed of 300 min^{-1}, increase slipping from 10 to 20% leads to a decrease in Q by about 6-7%, and for at 500 min^{-1} this characteristic is already 1.5-2 times less.

The given character change in the value is due to the peculiarities behavior of the metal, with a different structural state under loading. For specimens with structures after quenched, even after 600 loading cycles with 10% slipping, decrease in hardness to 7% is observed. In contrast, for specimens with structures by diffusion transformation, regardless amount of slipping, increase in hardness by 14% is observed already after 50 loading cycles.

Thus, one of the reasons for the formation damage to the rolling surface during operation of railway wheels is structural changes in carbon steel. The competing development of strain hardening and softening processes in steel with a qualitatively different structural state leads to a violation conditions for homogeneous propagation of plastic deformation.

4. Conclusions.

1. As a result of the rolling hardened steel without slipping, only due to normal loading, decrease in hardness is observed.
2. Additional slipping at the wheel-rail contact points accelerates development at softening effects of the hardened metal.
3. The softening of the hardened metal during rolling is accompanied by the refinement micro regions, increase internal stresses and number defects of the crystal structure.
4. For samples by hardened metal of a railway wheel at a constant rolling speed, decrease in temperature at the point of contact is accompanied by decrease in energy for the onset of slipping.

5. References

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