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STRUCTURAL AND MECHANICAL PROPERTIES OF STEEL WEDGE ROLL OUT

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A plastic deformation affects the cyclic strength both at the micro-level where it changes the density and structure of crystal defects and the macro-level where due to the unhomogeneity of deformation residual macrostresses occur and remain in the volume of the blank being formed. Besides, any contact of a tool with the blank changes the nature of superficial fine irregularities and the condition of near-surface layers. It is known [1] that the impact of a homogeneous predeformation is ambiguous. For instance, a plastic deformation in the area of superficial deformations typically results in a higher cyclic strength of metal products. However hardening at degrees below or above the homogenous plastic deformation level may have an adverse effect on the fatigue strength. This is proven with the data previously obtained by N.I. Chernyak who found that plastic deformations other than homogenous result in a lower fatigue strength of structural materials.

It was found that while a cold-working process is associated with an increase in resistance to deformation (hardening or peening) proportionally to the deformation degree, a hot-working is accompanied with concurrent hardening and softening processes. In this case the recrystallization rate is a function of the deformation degree. Thus, the quicker the recrystallization (determined by an increase in plasticity indices and a decrease in strength properties) is, the higher deformation has preceded the instant of time in question. In other words, from physical point of view, the deformation localization development is associated with a considerable softening of metal. The measurement results showed that there was no drop in temperature and the rolling was carried out at a constant temperature. The analysis of yield and strength limits showed an irregular softening both in the rolled strip thickness and cross-section at various shrinkage rates.

Strength properties: yield limit and ultimate rupture strength confirm the abovementioned nature of an irregularity of the strength variation across the hot-rolled blank length. In this respect some inconsistency of results can be explained by the fact that tensile test specimens were fabricated from hot-rolled metal sheets featuring irregular mechanical properties across the width as well as partially through the thickness. The highest degree of hardening at low deformations was achieved for the rolled sheet.

The resulting relations of mechanical properties indices across the hot-rolled plate length are comparable with the formed structure. The structure across the plate length consists of sorbite and ferrite. The metallographic analysis showed that the structure is consertal. The grain size varied in the range of numbers 5 ÷ 11 (GOST 5639). The biggest grain size (number 5÷6) corresponds to deformation degrees in the range between 4% and 10% or to the distance to the central hole in the range between 100 mm ÷ 200 mm. It is obvious that a deformation degree below 10% does not result in any intense development of recrystallization processes though strength properties are increased in such case. An increase in a recrystallized grain size can be objectively explained as it corresponds to the range of critical deformation degrees which typically correspond to a size of 8÷10%. At higher deformation degrees $\varepsilon \approx 20\%$ a hot-cold state occurs and partially persists when cooling. This is proven by an increase in strength with some decrease in plasticity.

The qualitative analysis of X-ray patterns showed that 50KhGFA steel, based on the processing type, contains the following phases: ferrite after hot-rolling, carbides in the form of cementite and alloy cementite. In addition to the abovementioned phases there is vanadium carbide precipitation taking places following quenching and tempering. It is found that changes in the fine structure which occurred during the material rolling did not disappear after the heat treatment. It is expressed in an increase in the mosaic block sizes and in the level of microstresses proportionally to the deformation degree. In the opinion of D.S Kazarnovsky and his assistants the obtained data may be indicative of a reduction in the strength limit of heat-treated spring plate metal.

The fatigue test results generally qualitatively supported the deformed state data in terms of mechanical characteristics. Metal layers featuring a higher intensity of recrystallization processes and, consequently, better healing of structural defects occurred in deformation had a longer service life.

The data of calculation of percent elongation for two surfaces of the rolled strip (from the roller side and from the stationary plate mill (first direction)) obtained using Hollenberg delineating method confirmed the mechanical test results.

According to the specific areas distinguished by hardness there was the analysis of their microstructure conducted. The microstructure of rolled 50KhGFA steel strip consists of perlitic colonies and ferrite and features the irregularity expressed in sizes of the ferrite constituent of equiaxial shape essentially across the deformation centre. Elongated ferrite grains were detected only for the specific area of maximum 34…36 HRc which may be indicative of the absence of any recrystallization in this area.

The List of References:

1. G.V. Pachurin. Assessment of Damageability of Structural Materials and Improvement of Service Life of Metal Products // Izv. vuz. Iron-and-Steel Industry. 2008. No. 3. Pages 55-58.

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