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Improvement of mechanical properties of steel sheet

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Abstract: Consideration was given to some peculiarities of the resource-saving IDT-production that implements metallophysical principles of hot deformation effect upon the formation of martensite and perlite structures of alloy steels as well as upon their functional properties by way of DTT-cycling.

key words: microstructure, quasi-perlite, martensite, properties, rolled sheet product, integrated deformation-and-thermal production (IDT-production), deformation-thermal- temporal cycling (DTT-cycling).

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Best properties are peculiar to marquenched structural steels of the following alloying system: Si+Mn+Cr, Si+Mn+Cr+Ni, Cr+Ni+Mo with carbon content of 0.2% through 0.5%. It is a matter of common knowledge that all the potentialities of improving the mechanical properties of structural steels by alloying and final heat treatment through individual heating as a terminal operation have been practically exhausted. With this in view, the method of integrated deformation and thermal production (IDT-production) of rolled stock being developed by the authors of this paper is gaining in importance as it enables us to create new structural-phase states of steel without additional alloying. The processes integrated in one thermal cycle are implemented in two options (see Fig. 1) and determine technological universality of the above method (see Fig. 2).

IDT-production makes provisions for rational replacement of high resource-consuming and expensive conversion operations by commonly used ones without worsening the final quality characteristics of rolled products; this is achieved through radically new regulation or improvement by new engineering solutions. For example, electroslag remelting which is traditionally applied to some special steel grades can be replaced, in case of IDT-production, by continuous casting regulated as to the conditions of crystallization and characteristics of microstructure.

Regulation of deformation during feedstock passes as well as regulation of the number of passes, time intervals between them and hot-rolling temperature profile on the basis of IDT-production principles made it possible to implement a new method of fine-grain steel structure formation on a commercial scale.

The fine-grain state of finished steel products obtained by IDT-production is a radical departure from that of steel products obtained by conventional practice owing to its higher fracture strength resulting from higher dispersity as well as by practically entire absence of carbonitride particles on grain boundaries, segregations and atoms of detrimental impurities as a consequence of a different mechanism of grain formation

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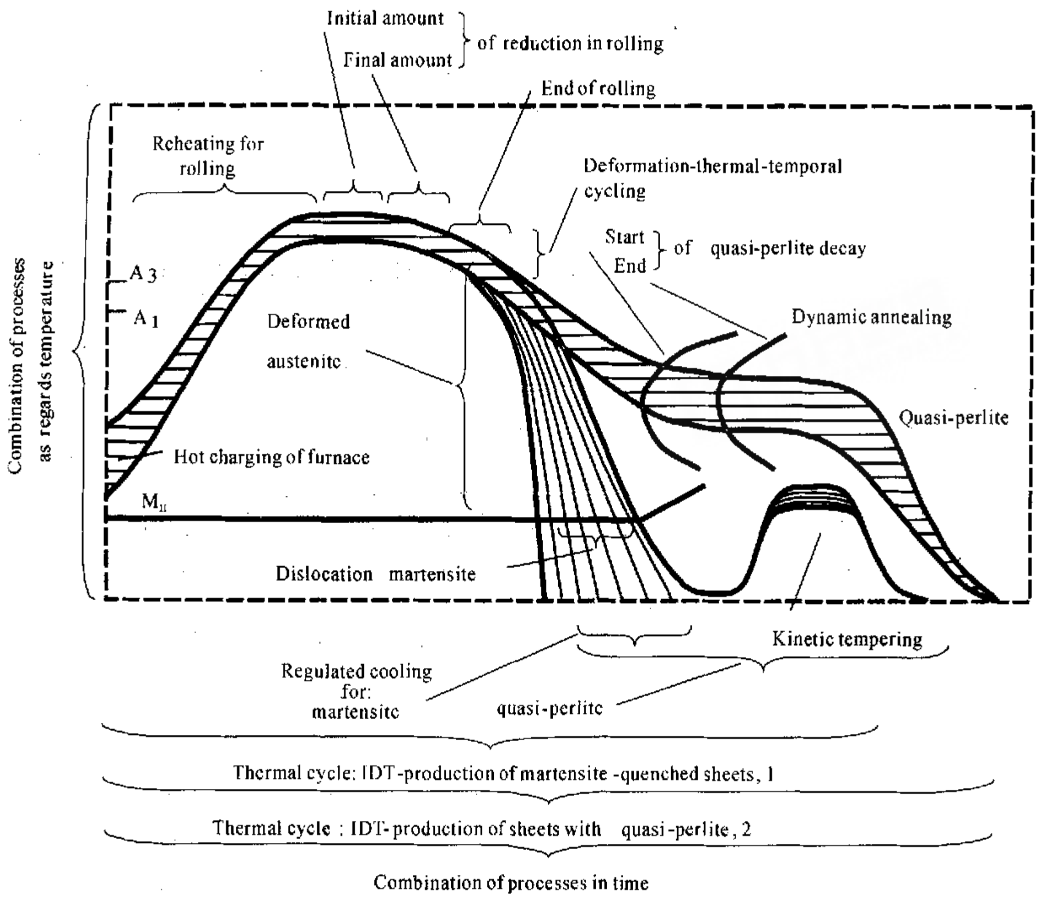

Fig. 1 Flow diagrams of two main options of IDT-production processes (1, 2)

and movement of their boundaries in deformed austenite.

Deformation-thermal-temporal cycling has a substantial effect upon $\gamma \rightarrow \alpha$ conversion in real structural steel grades, particularly upon perlite decay of deformed austenite by reducing the incubation period and total duration of quasi-perlite formation 3 to 6 times.

Quasi-perlite microstructure of structural steel in sheets of commercial lots manufactured by IDT-production ensures adequate mechanical processability of such steels normally annealed to hardness of about 250-350 HB; *in the final*

hardened state (at the level of yield strength of about 1400 MPa to 1700 MPa) after conventional quenching and tempering it offers some benefits in comparison with the use of conventional hot-rolled products: enhancement of viscocity-plasticity characteristics, improvement of hardenability, weldability, corrosive resistance, cyclic strength, etc.

DTT-cycling in combination with fabrication option of through rolling schedule and reduction distribution from ingots to finished products ensures a considerable decline in irregularity of physical-mechanical and functional-operating properties as well as output of marketable rolled sheet isotropic product. Serial ballistic and impact tests proved the importance of steel sheet isotropy for its structural integrity under high-impulsive contact loads. The results attained allow us to certify IDT-production steel sheets with final dislocation martensite microstructure, obtained by direct hot-roll quenching of deformed austenite, and steel sheets with intermediate quasi-perlite structure quenched by individual heating under the following

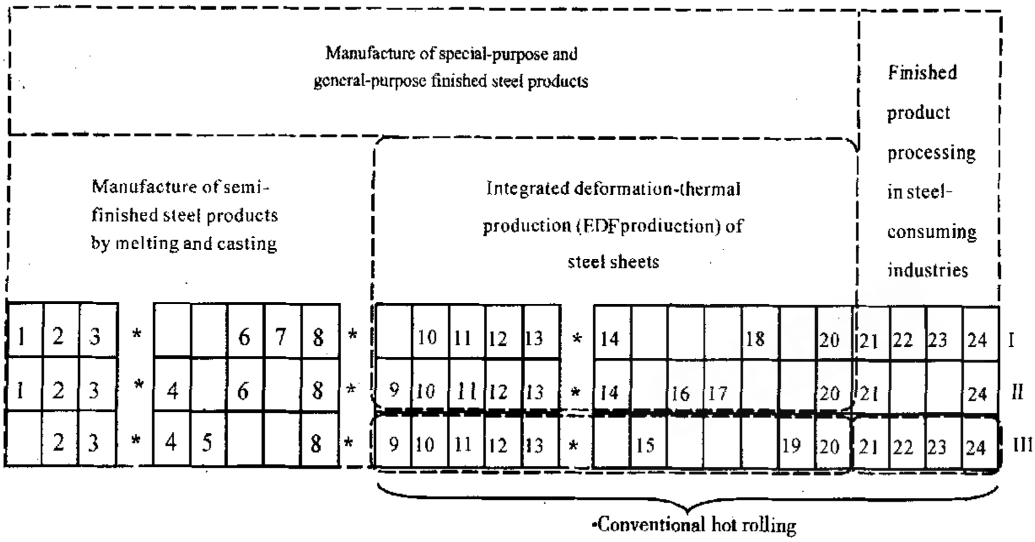

Fig. 2 Combination of processes in the course of IDT-production as compared with conventional hot rolling

I- IDT-production of sheet rolled product, dynamically annealed, with quasi—perlite structure;

II-IDT-production of sheet rolled product, quenched and tempered, with dislocation martensite structure;

III-Manufacture of ordinary hot—rolled steel sheets.

1—alloying system selection; 2—electric arc melting; 3—ladle steel refining; 4—vacuum degassing; 5—conventional casting into molds; 6—continuous casting; 7—electroslag remelting; 8—regulated ingot cooling; 9—hot charging into reheating furnace; 10—reheating for rolling; 11—reduction deformation; 12—initial amount of reduction; 13—final amount of reduction; 14—regulated completion of rolling; 15—conventional post—deformation cooling; 16—regulated cooling for martensite quenching; 17—tempering after quenching; 18—dynamic annealing to quasi—perlite; 19—conventional static annealing after individual heating; 20—quality control and acceptance of marketable finished products; 21—mechanical processing of finished products by consumers; 22—final heat treatment for product hardening— quenching of finished products; 23—finished product tempering after quenching; 24—quality control and acceptance of marketable products; * — fabrication adjustment of further process flow diagram.

classes of resistance: 3rd and 4th classes according to STANAG 4569 (NATO) and class IV according to NIJ0101.03 (USA).

New resource-saving technologies based on IDT-production have been worked out and brought to a commercial level ensuring manufacture of 4.0 mm to 30.0 mm thick sheets from martensite structural steels with improved functional-operating properties. Owing to this, sheet thickness can be reduced by 10% through 20%, the surface density and structural durability of finished products being preserved. Besides, IDT-production is a resource-saving process as it saves power, utilities, labor resources and steel-alloying additives as well as extends the service life of end products in steel-consuming industries.