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Yu.I. Usenko [(1)], associate professor, c.t.s.
V.I. Ivanov [(2)], senior research worker
T.N. Nesterenko[(2)], associate professor, c.t.s.
V.K. Tarasov [(2)], associate professor, c.t.s.

ON CAUSING OF ROUGHNESS ON SURFACE OF STEEL COLD-ROLLED BAND

[(1)] National metallurgical academy of Ukraine, Dnepropetrovsk, Ukraine,
[(2)] Zaporozhe state engineering academy, Ukraine

It is worked out and it is tested at experienced-industrial conditions technology of electric discharge treatment in a pulsing regime for a surface of cast rollers for cold rolling mills of a steel band with coating of a microrelief which is describable by set parameters of roughness. Its application allows substantially to increase essentially service live of rollers, practically completely to eliminate probability of interterm weldability of coils for cold-rolled bands, and also considerably to improve quality of surface preparation of metal under a coverage.

Keywords: steel cold-rolled band, coil, cast rolling roller, coating of microrelief, parameters of roughness

Introduction. The state of surface steel cold-rolled band for the deep lengthening, a size and evenness of roughness are its major high-quality factors which substantially influence on original appearance of the metal and durability of protective coating.

At other equal condition is a metal, microgeometry of surface of which is characterized by chaotically located, but evenly micro concavities and micro flanges of decision height has the best characteristics. In turn, microgeometry of surface steel band after the cold rolling it is largely determined by the state of micro profile of working surface of rollers for rolling mills.

It should be noted that at the recrystallization annealing in bell furnaces on the rolls of cold-rolled band jointly operate the furnace atmosphere, its pressure and temperature. Pressure provides the dense enough contact of surfaces of nearby coils for band rolls, and a high temperature and reduced atmosphere create conditions for cleaning of its surface from oxide and adsorption films that is accompanied by the yet greater contact of coils and turn-to-turn welding of rolls. As a result, at the next unwinding of rolls before the fraining mills on the band breakings and lines of debris which results in the additional losses of metal appear.

It is in the same time educed [1], that on appearance of the turn-to-turn welding of rolls band most substantially influence force of draft of steel band at winding in a roll, quality of lubricating material, applied during the cold rolling, and also microrelief and quality of surface cold-rolled band.

It is set experiments, that the decline of force of draft of steel band to the value of 39.2 кN at winding in a roll practically fully eliminates welding of nearby coils, but accompanied by the decline of the productivity of rolling mills and coefficient of the use of the work volume of furnaces, and also lengthening of process of annealing.

Influence of contact pressure to decrease on the turn-to-turn welding of rolls is possible, if at the cold rolling of steel band to apply corresponding loiling materials. However, the rapid worsening of operating descriptions of different emulsions results to their considerable expenses.

State of question. Results of statistical treatment of information's of numerous experiments, executed in the workshop of the cold rolling of steel band of OAJ «Nizhegorodsky metallurgical plant» (Russian Federation) testify, that the most subzero propensity to welding by metal with a rough surface is owned, microrelief of which consists of chaotically, but evenly micro concavities and micro flanges of decision height and depth. Such microgeometry of surface cold-rolled band arrive at presence of corresponding microreliefy of working surface of the cast rolling rollers.

For providing of necessary level of roughness on the working surface of rolling rollers widely apply different mechanical methods with the use of hydro- and freeabrasive particles [2,3], what have a row of substantial defects: considerable expense of electric power, pressurized air, abrasive particles and auxiliary materials, and also necessity of the use of considerable productive areas.

Lately electro-physical methods for treatment of surface metals are diffuse used to the mechanical methods [4,5].

Among them the special place is occupied by electro-discharge treatment at the impulse regime [6], what is carried out in the environment of dielectric liquid, which fills space between an electrode-instrument and by electrode-product which process. Such technology it follows to attribute to most perspective, because as opposed to mechanical methods it is engineer controllable and pollution-free, and as opposed to n ultrasonic method characterized by the high productivity of process, relatively by the less cost of equipment and simplicity of its service.

During the use of noted method treason of roughness and properties of superficial layer of metal for the actions of impulsive electric discharges, which it is created by means of the guided sources of direct-current is carried out. The noted discharges are created in a dielectric working liquid which fills space between the positively charged electrode-instrument and by the negatively charged electrode-product and take place after each other with certain frequency. Forming on the working surface of product of high-quality surface with the wide range of roughness and depth of strengthening carry out at presence of high-rate heating of discharge to the temperature 5000-10000 °C by means of generator of electric impulses, which creates the considerable concentration of energy.

Numerous researches in the field of application of the noted method at the protracted alloying of cast-iron and steel rollers of the mills of the hot rolling executed of authors of works [6-11]. There is attained not only the increase of wearproofness of rollers but also maintenance by them primary sizes at all process of exploitation.

Problem formutaion. The purpose of this research is an exposure of possibility of the use of electro-discharge treatment at the impulse regime for causing of microrelief with preset parameter of roughness on the working surface of the cast rollers for the mills of the cold rolling of steel band.

Main part of researches. At the National metallurgical academy of Ukraine (NMAU) on an experimental stand which it is worked out on the department of heating engineering and ecology of metallurgical furnaces [3], together with the workman's of Zaporozhe state engineering academy the complex of experiments sent to determination of possibility of application of the noted technology for causing of microreliefy with preset parameter of roughness on the working surface of rolling rollers of the states of the cold rolling at conditions, maximally close to the real is executed. During researches varied the size of working voltage, which was clozered into to the electrode-instrument (40-300 V), frequency of electric discharges (50-450 kHz), and also speed of rotation of products (30-300 $min.^{-1}$).

Experiments showed that at approaching of surfaces of the positively charged electrode-instrument and negatively charged rolling roller which revolve with permanent speed, to distance of a few ten micrometers in the place of the least interval between them an active area is created with high intensity of electric-field. At the noted area there is an electric discharge at the action of which the channel of conductivity is created: comparatively narrow cylinder zone, filled by the heated matter (by plasma) which contains the charged particles: electrons and ions which carry out the directed motion between electrodes.

During passing of discharge near the channel of conductivity a gas cavity is created from vapor of liquid and liquid metal, which at the action of high-pressure arms to spread, pressuring a surrounding gas phase. On the external boundary of the noted channel front of compression is formed, where the value of pressure very rapidly grows from an initial value in a liquid to the considerable size on a boundary. In a moment, when the sizes of gas cavity approach a maximal size, and its intrinsic pressure - to the minimum value, the partial selection of corresponding microvolums of liquid and vaporous metal is carried out from the surface of rollers in the place of passing of electric discharge and its cooling in a dielectric liquid with formation of separate shallow particles of spherical form.

On the working surface of rolling roller in the locale of impulse of electric current micro concavities which on a form approaches is ball bullet segment is created. After stopping of action of discharge during the certain interval of time there is a cooling-down of column of channel of conductivity and deionization matter of plasma in an active area, id est. neutralization of the charged particles and next renewal of dielectric properties of working liquid. An active area is prepared to passing of next discharge, realization of which, as a rule, is carried out in a new place between two other nearest points of surface of elecrtode-instrument and rolling roller. The impulsive receipt of electric voltage to these electrodes is accompanied by periodic motion of electric discharges between them, and also by the reiteration of process of electro-discharge treatment for roller surface. The working surface of roller is covered by micro concavities as a great number of small holes and micro flanges, which laid one on other, create highly developed mat microrelief with the roughness of 0.8-20.0 mcm and enough high closeness of micro flanges and micro concavities - to 90-100 on a 10.0 mm of length of micro profile.

At electro-discharge treatment of rolling rollers, simultaneously with creation there are roughness of working surface, there is carried out considerable strengthening its superficial bedding, that arrive at alloying by products of electrode-instrument evaporation and pyrolysis of dielectric liquid, and also tempering of microscopic volumes of metal, located in the zone of action of electric discharges.

As results of x-ray spectrometry analysis testify with the use of micro analyzer «*Jeol Superprobe*-733», the superficial layer of rollers, after electro-discharge treatment, consists of a few zones:

- zone which is saturated by the elements of working liquid with formation of very strong carbides;
- zone, which is created due to diffusion of material of electrode-instrument in the layer of molten material of roller with formation of hard connections, alloyed by a tungsten;
- zone of fine-grained structure, characteristic for the high-speed tempering;
- zone of plastic deformation.

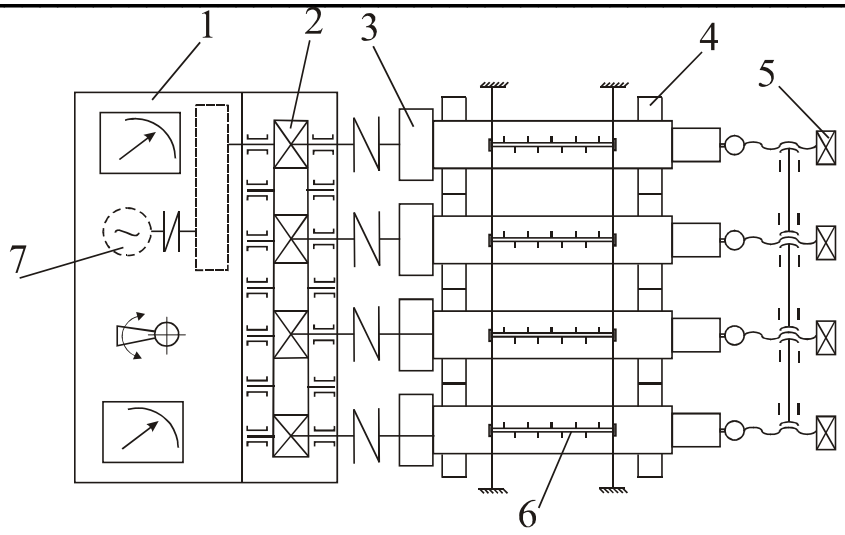
Such creation of superficial layers on a working roller promotes the term of its use, and also durability of microrelief of rolled steel band.

On the basis of the executed researches it is worked out and made at the conditions of the experienced plant of NMAU universal multi-seater machine-tools of series MTE for electro-discharge treatment on the impulse regime of working surface of the cast rollers of the mills of the cold rolling band and ribbons (fig. 1).

A machine-tool contains a mobile base, where roller supports are mounted for attaching of rolling rollers, bath with a working liquid (industrial oil of brand 20), drive of occasion of rotation of rollers, generator for impulse of current permanent type and system of electrode cassettes (three cassettes are on every roller) which are flames from dielectric material with the freely located electrodes-instruments (by copper plates).

At work of machine-tool to the system of electrodes-instruments give recurrently-forward motion, which allows to remove influence of defects of electrode edge on quality surfaces of roller, which process. The construction of machine-tool foresees possibility of varying in the wide range of speed of rotation of rollers which process, and voltage, on working electrodes and a construction of generator of impulse is varying of frequency and duration of passing for current impulses. A considerable closeness and evenness of causing of discharges at all plane of contact of electrodes-instruments with the surface of the cast rolling rollers which process, assist formation of even at all directions microrelief with preset parameter of roughness.

Depth and diameter of micro concavities which create on the surface of rollers with the use of the noted machine-tools regulate by treason of electric discharge energy. Regardless of hardness of surface of working rollers of rolling mills a possible receipt of its roughness 0.70-15.0 mcm is with the closeness of micro concavities and micro flanges 50-350 on a 10.0 mm of length of microprofile.



1 is control desk; 2 is gear drive; 3 is roller; 4 is bearring;
5 is managed prop; 6 is electrode-instrument; 7 is drive of rollers
Figure 1 is chart of machine-tool of series MTE

Machine-tools of series MTE allow to choose the regimes for treatment of surface of rolling rollers with the wide range of parameters, which regulate, work on the semi-automatic regime (easily pass from one regime of treatment on other), non-polluting an environment (presence of protective hubcaps and umbrellas for drawing ventilation) and providing obtain band with even in relation to all directions microrelief and roughness of surface which presents 2.0-3.5 mcm. Main technical descriptions over of machine-tools are brought in a table 1.

Table 1 - Technical descriptions of machine-tools as MTE

Name of parameter	Type of machine-tool		
	MTE-1	MTE-2	MTE-3
Quantity of rollers which process	4	2	4
Diameter of rollers, mm	100-150	45-90	200-320
Working power, kW	4,0	2,0	6,0
Working voltage, V	50-250	00-150	50.250
Frequency of receipt of impulses, kHz	00-300	00-200	00-400
Speed of rotation of rollers, min^{-1}.	70-100	60-200	90-100
An interval is roughness's which set, mcm	0,0,8-2,0	0,0,5-1,2	1,0-2,5
Depth of strengthening of layer of surface, mcm	0,015-1,20	0,012-0,70	0,15..1,20
Productivity, rollers/twenty-four hours	16-20	8-10	10-16
Overall sizes, m	1,08x1,72x0,84	0,060x1,20x0, 85	1,20x2,20x0, 96

Regardless of hardness of superficial layer of metal electro-discharge treatment of roller at the impulse regime allows to change the level of its roughness in a wide range (Ra = 1-20 mcm) and provide high resistance to wear. Izotropic of roughness for surface of rollers folds 0.8-0.9.

Results of industrial tests of working rollers of the mills of the cold rolling for steel band of OAJ «Magnitogorsk metallurgical combine» and OAJ «Nizhegorodsk metallurgical plant», which are treated by electric discharges at the impulse regime on the machine-tools MTE-1 and MTE-2, showed that application of the offered technology allowed, from one side, in 1.5-2.0 times to promote work-time of rollers of clean and pre-clean cages of rolling mills, and from other, practically except probability of welding of coils of rolls of cold-rolled band which anneal in bell furnaces.

By the reconstruction of mechanical part of machine-tool MTE-2 it is attained fundamental possibility of its translation on electro-discharge treatment of working surface of rollers of the fraining mills.

Next to it the results of tests, executed at plant conditions, testify a band to high-quality advantage of surfaces steel, rolled in rollers after them electro-discharge treatment after the impulse regime [12]. Yes, if the roughness of surface band presents Ra = 1.2-1.5 mcm, then the quantity of micro flanges on a 10.0 mm of length of micro profile folds 180-.200; if Ra = 2.0-3.0 mcm, then quantity of micro flanges – 120-150; if Ra = of 6,0-7,0 mcm, then quantity of micro flanges – 50-100. Thus, the got closeness of micro flanges eliminates possibility of the turn-to-turn welding of rolls at next heat treatment in bell furnaces and substantially promotes quality of the prepared products and improves the working conditions on the flaining mills.

In accordance with the results of the executed researches on the noted machine-tools the regimes of treatment of working surface of the cast rolling rollers which allow to create on the surface of steel cold-rolled band of even on all directions mat microrelief with the roughness Ra = 0.5-1.0 mcm (closeness of micro flanges – 50-350 on a 10.0 mm of length of micro profile) are select, that answers the requirements of standard and opens wide possibilities for the receipt of the high-quality protective coating [13].

Protective coating of organic and inorganic origin on such metal has high adhesion, evenness of causing on length and width band, and also firmness at work in an aggressive environment. It is assisted high development of surface of rolled metal, and its micro profile as micro flanges and micro concavities of identical sizes which alternate droningly. The receipt of isotropic surfaces with the set level of roughness and depth of strengthening allows to provide the minimum charges of materials of protective coating and its high quality.

At the improvement of construction of machine-tools of this type replacement of RC generator of current impulses is executed by a new generator, to the charge and discharge circuits of which managing thyristors which allow practically fully to use energy of story condensers and create the electric impulses of low power with considerable frequency of receipt are entered. High-frequency generator of impulse it is worked out and made at the conditions of the experienced plant of NMAU (his operating parameters: frequency of receipt of current impulses - to 400 kHz, duration of receipt of impulses – 0.005-10.0 s).

Conclusions. The electro-discharge method for working surface treatment of the cast rolling rollers at the impulse regime allows to change a structure and phisics-mechnical properties of working superficial layer in a wide range, varying material of

electrode and parameters of treatment. Equipment, that it is worked out for realization of the offered technology, is characterized by compactness, simplicity in service and possibility of easy transition from one regime of work on other that allows to get high-quality microgeometry of surface steel cold-rolled band.

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