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Using new physics and technology to advance electrostimulated rolling of metals and alloys

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Abstract: Electrostimulated deformation of metals and alloys, using groove or smooth rolling, requires that several important conditions are satisfied. (1) The deformation site must geometrically overlap with the flow of electric current passing through a strip between the rolls; (2) The density of direct or alternating electric current supplied to deformation site must be sufficiently high (of an order of 104－106A/cm^2); (3) An efficient heat removal from the deformation site must be achieved. In general, the temperature of a strip must be within the range of 100－300℃. (4) The electric resistance at the roll-strip interface must be minimized. Our recent studies also indicate that the electrostimulated rolling in the shortcut regime is a further condition for obtaining high quality rolling of metals. In this regime, the rolls are placed in physical contact even in the absence of a strip that ensures an uninterrupted passage of electric current between the rolls.

Provided that the aforementioned conditions are met, the plastic rolling deformation of various metals and lloys, including the most refractory and deformation resistant ones such as tungsten, molybdenum, their allows with rhenium, becomes possible. A single pass through the rolls is usually sufficient to deform a strip by about 50%－70% as is the case for tungsten. Significantly, the temperature in the deformation site does not exceed 150－200℃.

In our opinion, excellent results for electrostimulated rolling obtained by us are related to new previously unknown behavior of metals and alloys, being subject to pressure treatment and rolling.

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The present report is dedicated to problems of processing of refractory and hard-to-deform metals and alloys by pressure, for example, methods of rolling. The special notice is given to rolling of refractory metals, such as tungsten, molybdenum, their alloys with rhenium etc. is similarly given notice both low-melting metals and alloys, which have no sufficient abilities to plastic deformation.

Long since for processing of metals the pressure used, basically, only two factors: an external effort and temperature. Other effective factors contributing plastic modification of metallic bars at processing by pressure, did not exist. Only recently by employees of Institute of Metallurgy and Material Science were obtained results speaking that one more power factor was detected, which usage allows to execute plastic modification most high-melting and hard-to-deform of metals and alloys. And in conditions eliminating high heating, application of the special neutral environment and other special conditions. On the first view this factor looks banal, for a long time known and widely applicable. Namely, usage of an electric current skipped directly through processed bar. Traditionally, an electric current skip through metallic bar, for ex-

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ample, at rolling with the purpose to heat metal and to increase his(its) ability to plastic modification. Depending on properties of metal of bar the heating temperature can vary over a wide range, from hundreds degrees up to several thousand it is centigrade. Thus almost all metals subject to undesirable oxidation and losses on weight. With the purpose of avoidance of undesirable chemical interaction with ambient air processing of metals carry out(conduct) in inert atmosphere or in vacuo, that strongly complicates a manufacturing process.

By us was detected and the factor is in detail researched which earlier, apparently, did not attract notice of the contributors. By results of researches, we formulated the main(basic) conditions and requirements, which fulfilment allow to execute so-called electroboosted deformation of metals, for example, methods of rolling.

Before we would would like to pay the special notice to a having place of a different kind of gamble (speculate) in a field of application of an electric current of large density at plastic processing of metals. In due time in our early publications these gamble were in detail and is argued are analyzed, therefore to this problem in this case there is no necessity to return. In particular, us was shown, that there is no so-called " an electronic wind or even of strong gale ", which is ostensibly capable cardinally to influence plastic deformation of metals, especially, most high-melting and hard-to-deform.

We come back to formulation of conditions or even of principles of implementation of electroboosted deformation of metals, for example, methods of rolling. Let's call them.

(1) Overlapping(adjustment) of the geometrical center of deformation and zone of passing of an electric current from rolling shaft to shaft across bar. Outside of the center of deformation the presence of an electric current is not admitted.

(2) The passing through the center of deformation of an electric current (constant or variable is necessary, but not pulse) it is high-density, about 10000—1000000 A/sq. c.

(3) Intensive cooling of the center of deformation with the purpose of preventing excessive heating of metal of bar.

(4) Presence of minimum value of value of electric resistance of a contact zone between surfaces of shaft and bar.

And, at last, recently by us was established, that for successful and high-performance electroboosted rolling the process of plastic deformation of metal of bar is necessary for conducting in a mode of a so-called short circuit between the tool and bar. This mode means, that the electric current of necessary value (thousand and tens thousand ampere) passes between contacting rolls without dependence from, whether there is a bar between rolls whether or not. The last condition or the principle executes only at presence of a special design of the tool (rolls, commercial films(rollers) etc.). The fulfilment of the last condition allows completely to avoid such phenomena, as a flash-over, derivation of an electric arc, melting and other effects, which can appear as a result of passing electric currents of large amplitude. The researches have shown, that in the center of deformation the cube takes place high values of density of energy lying in range of 100—10000 kw /c. c. The requirements to cleanness of contacting surfaces of bar and tool from here follow (outflow). It is important to mark, that the presence of technological lubrication does not influence passing of electric currents of large density.

The fulfilment of above-stated conditions or principles has allowed to execute plastic deformation, for example, methods of rolling of different metals and alloys, including most high-melting and трудноде формируемые, and also high-strength marks of steels, alloys of aluminum, magnesium, beryllium etc.

In particular, for example, at rolling прутков of a tungsten a dia from 2—3 mm up to 5—6 mm in

ручьях or on smooth barrel(roll) the degrees of deformation for one miss (passing) 50%—70 % were easily reached, thus integral temperature of metal of bar in the center of deformation did not exceed 100—150 degrees of Celcius (at intensive cooling of the center of deformation by compressed air). The similar results were obtained at rolling a high-strength stainless steel, alloys aluminum-magnesium etc. By the literary data, such results were not obtained by other contributors. It is known, that for implementation of conventional heating of metal by an electric current, passing along bar the necessary current density makes tens ampere on sq. see. While for implementation электростмулированной rollings the necessary current densities make 30000—60000 A / sq. c. (for tungstens and his (its) alloys), 5000—10000 A / sq. c. (for the different marks of steels), 2000—5000 A / sq. c. (for alloys aluminum-magnesium etc.).

The so high parameters (indexes) on plastic deformation, apparently, are connected to a number (series) of physical and mechanical effects, many of which earlier were not watched, that speaks, in our judgement, about the important reaching in the field of a solid state physics and processing of metals by pressure.

Let's mark some of physical and mechanical effects, which, in our judgement, can play a determining role in electroboosted deformation of metals.

At first, at origin in rolled bar of a fissure arranged, for example, it is normal to a direction of weep of an electric current, the heat release on test leadss of a crack because of flow (streamlining) in these places of high more density electric current will be more intensive. Arises so-called temperature (or thermal) contrast. It will put (cause) to lowering concentration and value of the operational mechanical pressure (stresses), bluntness of top of a crack and, therefore, to disapperance of this crack, that is its (her) annihilation. In result the plastic flow of metal will not be accompanied by gaps, defects and destructions.

Secondly, at passing an electric current through a contact surface "bar-tool" most microledges and microroughnesses of a different kind will subject to strong heating, and it results in lowering friction forces. Value bracing therefore drops, that is shearing stresses, and, therefore, and the normal stresses decrease.

In third, because of a non-uniformity of Joule heat release in a volume of deformable metal the local thermal effects will take place also of different kind: increase of movability of dislocations just in places of the hindered deformation; the occurrence(appearance) results considerable on value of thermal pressure (stresses) stimulated by heavy gradients of temperature, that, eventually, in inducing processes of carry of substance, that is plastic deformation.

For implementation of processes of electroboosted rolling of metals and alloys both on smooth cylindrical rolls, and with usage of commercial films (rollers) with groove or calibres, it is necessary to decide a number(series) of физико-technical and design problems. Main of them: (a) it is an application of an electric current of large value directly in the center of deformation with minimum losses; (b) cooling of the center of deformation, working rolls and current supply of trunks, for example, compressed air or different way; (c) maintenance of a mode of a short circuit in a circuit "tool-bar" during all cycle of rolling.

On the basis of obtained theoretical both experimental data the technologies and ways of electroboosted rolling of miscellaneous metals and alloys were designed. In particular, is designed and the industrial technology of electroboosted rolling and плющения of tungsten and molybdenic wires in a microbelt(microtape) is inserted. The technology of rolling in grooves and calibres rods from tungstens, molybdenum, high-strength marks of steels and other materials recently is developed.