ЖУРНАЛ ІНЖЕНЕРНИХ НАУК
JOURNAL OF ENGINEERING SCIENCES
ЖУРНАЛ ИНЖЕНЕРНЫХ НАУК
Web site: http://jes.sumdu.edu.ua/
Том 2, № 1 (2015)

УДК 621.398

The Principles of Creation the System of Programmed Control of the electric drive billet shears

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Article info:
Paper received: 16 May 2015
The final version of the paper received: 05 November 2015
Paper accepted online: 30 November 2015

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Principles of creation a microprocessor system of programmed control by the electric drive of billet shears of billet rolling mills, which provides a significant reduction of the power consumption and decrease of the load capacity of the equipment are offered; mathematical modeling proves informatively-control parameters of the system and its efficiency is proved; the variant of implementation of principles is adduced.

Keywords: billet shears, electric drive, rolling mills, microprocessor system of programmed control, mathematical modeling.

INTRODUCTION

The invention relates to rolling equipment and may be used in the development and the employment of sheet and section shears for hot rolling shops.

It is an object of this invention to provide the electric energy saving, the reduction of the loading degree of the mechanical and electrical parts of shears and the increasing their life with minimum investment used.

The previously known shears drive control system forms usually a rectangular current diagram with constant maximum allowable acceleration and deceleration values.

The present invention is characterized in that the suggested shears drive control system forms within the acceleration and deceleration period and at cutting a loading diagram on the basis of the principle of maximum use of the accumulated kinetic energy amount that well exceeds the level necessary for performing the cutting: the characteristics of the loading diagram being differentially taken in accordance with the cross section height and the mechanical properties of the billet metal being cut.

MAIN BODY

Shears electrical drive control method [1].

The invention relates to rolling equipment and may be used in the development and the employment of sheet and section shears for hot rolling shops.

Known in the prior art is the control method of shears electric drive including a convertor, a d.c. motor and a control system; this process provides the adjustment of the motor armature voltage to achieve thereby “the most rational constant maximum allowable acceleration and deceleration values having a rectangular current diagram” [2].

The disadvantage of the existing control method is that the control is fully based on the adjustment of the voltage supplied to motor armature; the characteristics of loading diagram (armature current time variation) and tachogram (time variation of armature voltage or armature rotation frequency),that is the maximum current value and the current duration within acceleration and deceleration periods, the maximum current limitation value (cutting - off value) at cutting , are being constant. Thus a rather wide range of heights of billet being cut, steel grades and respective technological loading are not considered. Therefore energy consumption and loading degree of equipment is not reasonable since the drive control system characteristics for small billets of carbon or law-carbon steel, having low height, small cross section area and low specific cutting resistance, and those for large billets of high-alloy and hard-to-deform grades of steel are the same.

The object of the present invention is the electric energy saving, the reduction of loading degree of the mechanical and electrical parts of equipment and increasing the life with the minimum investment used.

This object is accomplished by using at acceleration and deceleration periods the current diagram approximated as much as possible to linear one that is considered to be optimal from the viewpoint of motor heating and electric energy consumption. The diagram characteristics such as the maximum current value and the current duration are differentially taken directly proportional to the height of the billets being cut, and at cutting the armature current limitation (cutting-off) is taken place according to the armature current value being directly proportional to the mechanical properties of the steel being cut that is the specific resistance to cutting.

The linear diagram is reasonable due to the fact that the amount of the kinetic energy accumulated by the cutting mechanism and the motor or the redaction gear (if a geared drive is used) exceeds at least 2.5-3 times the minimum energy level which is reposed to perform the cutting. Therefore it is not necessary trying to achieve a rectangular current diagram and consequently the higher armature rotation frequency, that is the higher energy accumulation level resulting in the increasing of the degree of the equipment loading, excessive energy consumption and motor heating. The use of the differential current limitation at cutting depending on the mechanical properties of the billet metal is also reasonable due to the great amount of the kinetic energy accumulated by the cutting mechanism to the moment of cutting, that is the energy of the mechanism rotating masses (identically to the flywheel) is well enough for the performance of process cutting, the additional motor energy being not necessary.

Thus the present invention is characterized in that taking into account the fact that the amount of the kinetic energy accumulated by the drive mechanism well exceeds the amount required for cutting to perform it is suggested to form the loading diagram for the drive considering the minimum loading degree of the mechanical and electrical part of equipment as well as the minimum energy consumption, the characteristics of the diagram being differentially [3] taken in accordance with the sizes and the with steels grades of the billets being cut.

Fig. 1 shows the known and the suggested loading diagrams and tachograms formed within the acceleration period and at cutting, where:

J_{max} is the maximum current amount at the acceleration (deceleration) period;

Δt is the maximum current duration at the acceleration (deceleration) period;

$J_{cut-off}$ is the current limitation value at cutting (current cutting-off value);

"U" is the motor armature voltage variation; "n" is the motor armature rotation frequency.

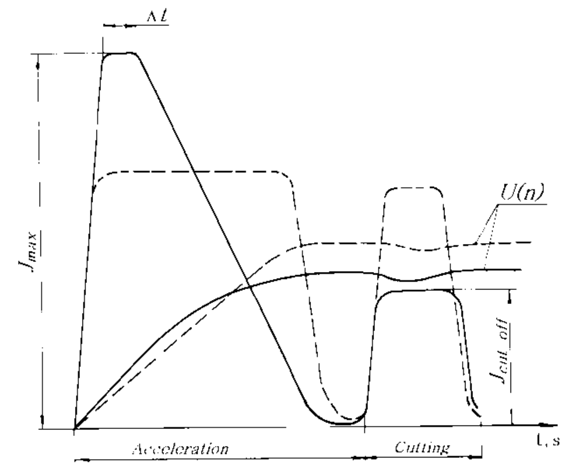

Fig. 1 Existing (-------) and suggested (_______) shears electric drive control method. U(n)- variation of voltage (U) or rotation frequency (n) of motor armature.

Fig. 2 and 3 show the proportion dependence of billet height, maximum current value and current duration especially with in the acceleration period, as well as the mechanical properties of billet metal (maximum specific resistance to cutting value - τ_{max}) at cutting temperature and cutting-off current value.

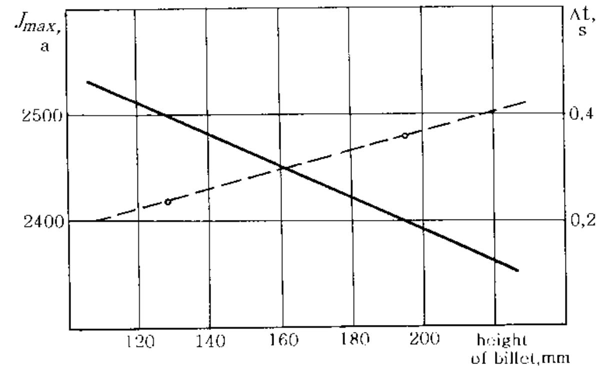

Fig. 2 Rational control points current diagram during acceleration and deceleration depending on height of cross section of cutting billets. Jmax (-)-maximum current value during acceleration/deceleration, Δt (- - -)-its length.

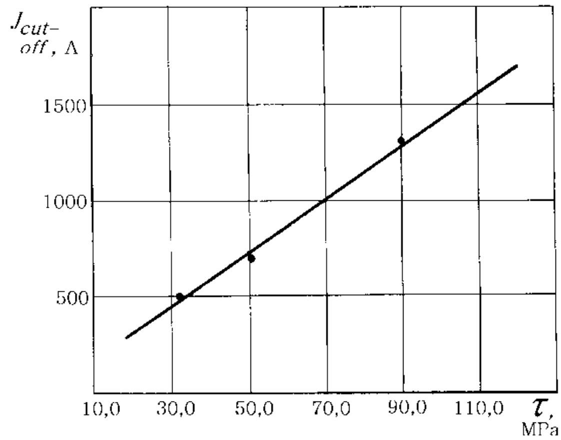

Fig. 3 Rational control points current cut-off (Jcut-off) diagram during cutting depending on value specific resistance to cutting of hot metal (τ).

Example:

The drive of "Sack"-type section shears installed in 850 blooming mill line at Jzhevsk metallurgical plant (Russia) has the following characteristics: d.c. motor of the type МПС640-700J ; electric drive shaft total moment of inertia is 13.3 kgf.m.S2, reduction year ratio is 74.

The above table shows comparative data of computer mathematical modeling of the cutting process for the billet having cross section 195x390mm made of steel 38Х2МЮА **(τ_{max} =31.8 MPa), this billet size being the main one in a size range for the shears with the known and the suggested drive control methods.

** The steel of mark 38Х2МЮА (where X-Cr, M-Mo, Ю-Al, A- is the high-quality steel alloyed with aluminum) have chemical composition (in %): C[0.35-0.42]; Mn[0.3-0.6]; Si[0.2-0.45]; Cr[1.35-1.65]; Ni[0.7-1.1]; Mo[0.15-0.25].

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Comparative data of mathematical modelling of cutting process with known and suggested methods of management

Control method	J_{max} at acceleration (deceleration), A	Δ t, s	J At cutting, A	n, r.p.m	Total kinetik energy amount at the begging of cutting, kN.m	Motor heating, ratio* Jav.sq/Jnom	Energy consumption, kwn.r		Cutting force, kN
							At acceleration	At cutting	
Known	1950	1.1	1450	974	700	0.78	0.22	0.1	2434
Suggested	2400	0.4	500	865	550	0.75	0.18	0.05	2340

* Jav.sq -average square-law value of a current (or heating) and Jnom - the nominal moment of the electric motor.

The above data prove that the control method according to the present invention provides the reduction of the motor heating, the energy saving within acceleration period (more than 18%) and within deceleration period (2 times) as well as the reduction of the equipment loading degree (f.i. cutting force), while the kinetic energy level of the drive by the moment of beginning cutting is much lower (about 1.27 times) but well snout (208 kN.t.m) for cutting to perform.

Technical economical efficiency of the control method according to the present invention is in that it provides the rediction of the drive energy consumption at cutting, the reduction of the motor heating and the equipment loading degree and thus the increasing of the equipment life. The economical efficiency is determined only by the reduction of the energy consumption at cutting. The Jzhevsk metallurgical plant blooming mill shears is considered as main unit for making comparison. At an yearly working time amount of 7000 hours the number of cuts is 1.68x106.

According to the above table data the reduction of the total energy consumption at cutting of 195x390 billet of steel 38Х2МЮА is 2(0.22-0.18)+(0,1-0.05)=0.13kwh.r per one cut. If the size range for the shears is based on the 195x390 billet size only, the yearly energy saving achieved by using the control method according to the present invention is - Э =1.68x106x0.13=0.218 Mkwh.r.

CONCLUSION (CLAIMS)

1. A control method for the electric shears drive including a converter, a d.c. motor and a control system providing the adjustment by varying motor armature current or motor armature voltage and making within the acceleration and deceleration period a current diagram maximum approximated to the linear one, which process is characterized in that the maximum current value at acceleration is varying inversely proportional and current duration directly proportional to the height of a billet being cut to achieve thereby the electric energy saving, the reduction of the loading degree of the mechanical and electrical parts of the equipment and increasing their life time.

2. A control method according to claim 1 characterized in that to achieve the maximum use of the mechanism kinetic energy at cutting as well as the electric energy saving the current limitation (current cutting-off) is applied in cutting period, the value of the current being varied directly proportional to the mechanical properties (specific resistance cutting) of the steel being cut.

To realize an offered control method of a drive of shears is possible in real conditions of manufacture, input of the microprocessor in the closed contour of system of regulation by the electric motor. At the initial stage the system should be under construction as semi-automatic (admitting actions of the operator), with manual input of the initial information: the area (or height) sections of billet and model of steel (τ) and managing parameters- Imax , Δt and Icut-off.

But presence of the microprocessor allows to realize in further more flexible, adaptive variant of program management: keeping in memory mathematical model of the mechanism and system of regulation by a drive, is possible to define and correct parameters and control points not on average to the dependences, shown on Fig. 2 and 3, and in view of real results of process of cutting and possible deviations in initial parameters (for example, the lowered temperature of billet).

In the conclusion, I think necessary to thank my daughter-Ekaterina B.Poliakova-Georgantas (PhD), as the direct participant of preparation of the given article, performed laborious and complex work on translation into English language of the labor-intensive technical text.

Information presented with the purpose of search metallurgical or machine-building plant-customer, interested in economy electrical energy and increase period's work technological equipment which do service in organization and financial support in elaboration and realization of this project.

Принципи побудови системи програмного керування електроприводом сортових ножиць

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У роботі пропонуються принципи створення мікропроцесорної системи програмного керування електроприводом сортових ножиць заготовочних прокатних станів, що забезпечує значне скорочення витрат електроенергії і зниження завантаженості обладнання. Математичним моделюванням автор обґрунтовує інформаційно-керуючі параметри системи та доводить її ефективність; наводиться варіант реалізації принципів.

Ключові слова: сортові ножиці, електропривід, прокатні стани, мікропроцесорні системи програмного керування, математичне моделювання.

Принципы построения системы программного управления электроприводом сортовых ножниц

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В статье предлагаются принципы создания микропроцессорной системы программного управления электроприводом сортовых ножниц заготовочных прокатных станов, обеспечивающей значительное сокращение расхода электроэнергии и снижение нагружённости оборудования. Автором обосновываются математическим моделированием информационно – управляющие параметры системы и доказывается её эффективность; приводится вариант реализации принципов.

Ключевые слова: сортовые ножницы, электропривод, прокатные станы, микропроцессорные системы программного управления, математическое моделирование.

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