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Decrease in Heatlosse of Rotating Burning Units (Aggregates)

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Abstract: Research of problems and reasons of operability of the rotating oven unit loss. The factors influencing the equipment downtimes under repair. The analysis of the aspects influencing the increase of reliability and decrease in power consumption of the rotating burning furnaces. The analysis of influence of the reasons of additional fuel consumption and the electric power on roasting of raw materials and on the reasons causing overexpenditure of energy resources. Research of reasons of installation works' inaccurancy at installation of the furnace and at temperature influences on reliability of the furnace operation and at loss of knots' operability and units during the operation. Constructive and technological actions for reduction of energy carriers' expence and for increase of work reliability. On the basis of the researches conducted on a number of the enterprises of cement production, it is established that at operation of the burning furnaces, there is a decrease in technical and economic indicators. One of the main reasons for it is unplanned stands for repair. It is established that change in form of bandages and rollers leads to additional vibrations of the case and as a result to lining loss. By researches of furnaces it is established that furnaces were developed without operation in certain climatic conditions, therefore there are violations of technological processes involving burnout of the furnace, clinker temperature increase at the exit and destruction of refrigerators.

Key words: The sealing device, working capacity, operation, large-size rotating units, fuel consumption reduction, economy of energy resources, hermeticity, prevention of air suction

INTRODUCTION

Industrial development of construction materials' production is possible at successful solution of technical and economic tasks connected with providing and improvement in technical base of the enterprises on production of construction materials (Fedorenko, 2012). That provides equipment of the enterprises by modern equipment and maintenance of technical condition of the available park of large-size equipment up to standard at which its working capacity and quality of products is provided at the demanded outputs.

If the first situation demands big capital investments which are difficult to carry out taking into consideration today's decisions then the second situation has to be surely realized in independence of type of the equipment and the term of its operation (Fedorenko *et al*., 2013).

Equipment of cement works has been operated for >50 years, therefore emergence of various equipment failures is inevitable. Details, knots and the units connected with production of cement have various service term because they work with various loadings, thermal modes and in various climatic conditions (Bondarenko *et al*., 2013a). Therefore, continuous preventive repairs and equipment adjustments for the purpose of ensuring its working capacity are necessary. Expediency of repair and modernization of separate types of the equipment is caused by economy of labor costs and financial means, thanks to the reuse of the restored details and actions for modernization of separate knots (Bondarenko *et al*., 2013b). Restoration of the equipment of cement works is connected with big material inputs, in the case if it is necessary to get new units. Process of replacement of old equipment into the new one is very long and it also leads to big financial losses because of considerable underproduction of production because of equipment downtime. Correctly organized repair service and timely debugging will allow increasing productivity and profitability of the equipment.

Therefore, there is a need for high-quality approach for carrying out modernization and repair of the large-size rotating equipment. Now, many spare parts are delivered without documents, sometimes there are no drawings and certificates for spare parts. Hard loaded details (basic

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rollers, bandages) are delivered for single use, they are a subject to replacement while used. Many details are heat-treated not conforming to requirements resulting to fast wear of the surfaces. For the purpose of increase in the between-repairs period and reduction of terms of equipment downtime under repair, there is an urgent need in development of new ways and methods of repair and equipment modernization which will allow restoring the lost working capacity and to increase efficiency of operation of the large-size rotating equipment of cement works.

MATERIALS AND METHODS

The analysis of structure and technical condition of the cement enterprises' equipment in Russia and CIS countries allowed obtaining data on its technical condition and operation terms. As a result of researches, it became possible to reveal the nomenclature of details, knots and the units demanding recovery repair with application of progressive technologies or replacement them by the new equipment.

If to consider the assessment of operability of the large-size rotating equipment (of cement furnace, grinding mill), operated at cement works, it is clear that it is based on a basis of unity and communication of the following general provisions (Pronikov, 1978):

- Rotating unit should be considered separately in every element as the set of the interconnected details and the knots providing the ability of the unit to carry out the functions
- Details, knots, units, consolidations and other elements which are included into the rotating unit (aggregate) have various service term and reliability
- Operability of the rotating unit is inseparably linked with service conditions and shouldn't be considered separately from each other

Working capacity (operability) of the rotating aggregate is a state at which it is capable to carry out a set of functions keeping the values of the parameters in the limits of standard documentation. Therefore in case of deviation of settlement parameters of the rotating unit, it will not influence the refusal or malfunction of any knot but it will influence its operability because of thermal conditions' disturbance, increase in gas consumption for air warmth. For example according to Dmitriev and Fridman (1978), on the furnace with diameter of 4.5 m at increase of involvement of atmospheric air at 7% of norm, fuel consumption on its heating increases by 3.5-4 kg ton^{-1}. of clinker. Valter (1982)'s research gives calculation of additional fuel consumption when involving air on the unloading end of the cement furnace at a ring gap in 4 cm wide on the furnace with diameter of 4 m and it shows that the excess consumption of coal up to 21 ton day^{-1} is required.

The analysis of references showed that no attention was paid to the technological aspect of ensuring accuracy to the increase of reliability and the decrease in power consumption by modification of the equipment designs of the equipment.

Increasing of productivity of rotary furnaces has been tried to achieve by optimizing processes in technology of production of cement clinker as modernization of the furnace by changing the design features is time-consuming and expensive, however the increase in diameter of the furnace, even local, gives significant growth in production. The improvement of the design of large rotating equipment will allow increasing reliability and performance units and the whole construction which provides considerable increase of production without additional costs.

Sealing device is installed on loading and unloading ends of the rotary kiln. Their purpose is to prevent the involvement of outside air into the furnace through the gaps which are formed due to the inaccuracy of installation of the furnace. It moves along the axis of the radial runout, thermal deformation and so on. The engaged air at the discharge end temperature is many times lower than the temperature of the air coming out of the fridge, therefore additional fuel consumption for heating of the air is needed. Exhaust gases are ejected from the furnace fan (exhaust) which is calculated on the volume of gas passing through the furnace and its exhaustion. The gap enables the involvement of external air and as the result, the volume of gas increases, smoke exhausters do not have time to throw them out of the oven and the furnace is "locked" and in consequence, at the downstream end of the kiln through the gaps there is an emission of hot gas and dust that leads to infringement of technological process of burning.

Installation of sealing devices is one of the most common ways of reducing fuel consumption. The problem of prevention of air leaks in the cement kiln at the downstream end have been studied by many designers, therefore, currently, there is a number of developments of different types of sealing devices. On Fig. 1, there are improvised sealing devices of cement rotary kilns. Seal of such design does not prevent involvement of air. Enterprises are forced to use the seal of this type because of the fact that the machine building industry does not produce seal. All this, according to the statistics, leads to the destruction of the sealing device within 6-12 months.

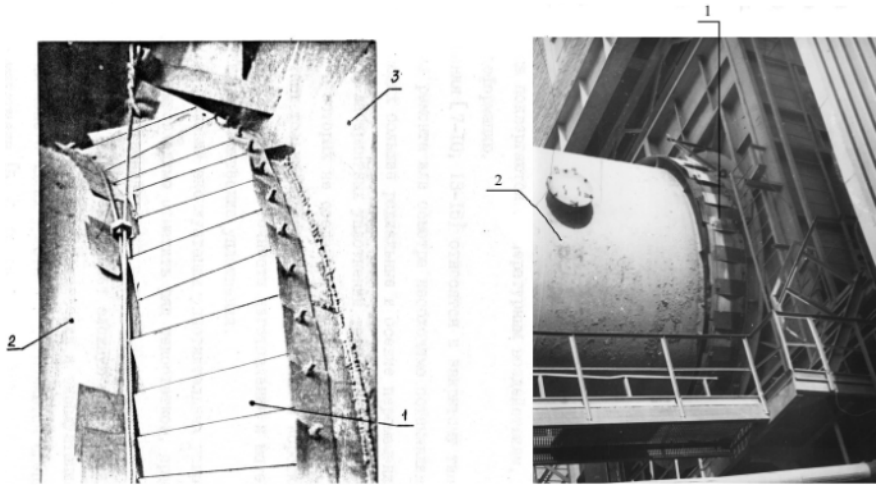

Fig. 1: Sealing of rotary kilns: 1 sealing, 2 oven, 3 fridge

RESULTS

In the result of conducted researches and also according to Bogdanov *et al.* (2013a), sealing devices of all existing designs work well only if the furnace case in the place of installation of the seal has a regular cylindrical shape with no beats in rotation; if it has no significant axial movement, if rubbing the surface of the seal components are lubricated and are cleared from dust, if inspection of seal components is carried out and the wear items are timely removed.

During operation of the furnace, a curvature occurs of the rotational axis of the furnace, it is one of the most difficult defects to remove, affecting its performance. In the result of curvature of the axis of rotation, vibration arises not only in the furnace case but just a kiln and cement walls that lead to the destruction of the lining and as a result, to the downtime furnace repair. The curvature of the axis of rotation comes from incorrect installation idlers, bands and temperature inside the furnace production. The case of the furnace is easily exposed to deformations due to the fact that at a large length (230 m) and diameter (up to 7 m), the thickness of shells is in the range of up to 100 mm. Installation of the case on the axis takes much time and requires highly qualified specialists. The existing technological process for solving this problem is not perfect, the fact that the furnace should be installed in a cold condition and at heating, it starts to deform and the unit is being broken (Fedorenko *et al*., 2012).

According to the results of researches, it is established that the casing of the furnace has a curvature in length which occurs due to the thermal deformations and neveretheless the rotation axis of the supports of the rotational furnaces as well as due to an incorrect installation of tyres with a bigger mass. Vibration, arising at reference sites in virtue of their design are different in size and time. This fact distorts the axis of rotation. Dynamic effects on the rotating units arising in the process of their operation and cause a curvature of the axis of rotation, manifested in the form of vibrations due to less rigid hulls at the explosion of heavy loads.

Research, conducted at a number of companies, shows that the vibrations of the bearing supports and consequently, idlers reach up to 10 mm or more. The unbalance of the body mass has no great value because there is a large mass of material inside that is being rolled. Wear and inaccuracy of manufacture of load-carrying and supporting units influence the vibration.

Loss of serviceability of the equipment contributes not only to long-term operation but also the conditions of operation due to 24 h operation, high workloads, work under the open sky, much dust, high temperature differences and aggressiveness of the working environment and so on. The course of various physical and chemical processes have a negative impact on the material from which the details are made. All this leads to loss of productivity, metal fatigue and the deterioration of their strength properties. Provision of official technical condition of rotating equipment determines the necessity of solving the problems of improving technological methods and system recovery on the basis of introduction of modern diagnostic equipment.

The solution involves the development of new parts, units and equipment and new fabrication technologies providing timely recovery of health through the development of new technologies of repair and modernizations of the equipment providing work reliability

and increasing productivity. The quality and efficiency of rotary cement kilns is largely determined by the accuracy of assembly and adjustment operations.

To improve efficiency, productivity and quality of repair work in the present conditions, it is preferable to provide organization of centralized repair enterprises with use of automated equipment. It allows recovering and producing details of the wide range of various sizes. Design of modern repair technologies determines the creation of competitive technological equipment.

The analysis of the existing methods of recovery detail shows that the majority of damaged surfaces can be not only restored in accordance with the requirements of the official destination details but also additionally hardened with the purpose of increase of their resource efficiency. In accordance with this, while choosing the method of restoration of details and units it is necessary to consider not only the cost of repairs but also additional effect obtained as a result of increasing of efficiency and durability refurbished products.

One of the defining moments of efficiency increase of the equipment use is to evaluate the level of its quality and resources at all stages of the life cycle. It is proved that the popular idea of the machine resource, as the time to limit state, is expressed in units of time or amount of the issued products, is not suitable. This is because the physical and technological properties of raw materials, modes of operation, operating conditions vary significantly. Therefore, neither calendar time work nor the amount of recycled raw materials is the unique characteristics of the machine itself.

The important factor which defines the decrease in equipment downtime and the increase of its efficiency is timely carrying out of maintenance and repair.

Information about the knot condition, the unit and technological system can be generally received and analysed by measurement of separate parameters as, for example deformations, movements, parameters of accuracy, temperature. For this purpose in certain places of machines corresponding sensors are installed.

Such methods of local control are widely applied in the industry. However, the most universal methods of an assessment of a working machine condition are the methods based on registration of vibrosignals, generated in the corresponding knots of the machine (Ivut and Kabakov, 1988). Creation of system of vibration diagnostics for assessment of technical condition of the oven unit including all equipment and definition of the moment of their repair is an important task.

The dynamic quality of the machine reached at production, worsens in the course of its operation owing to wear of details, increase in a gap, deformations, jammings, breakages, etc. Parameters of a vibrosignal reflect all these phenomena; they are quick-responsed and can be measured with a very high precision (Chepchurov, 2009). The convenient high-precision equipment is developed now for the analysis of vibrosignals. Experience of the developed industrial countries shows that introduction of information technologies in system of maintenance gives big economic effect due to decrease in expenses for servicing and repair.

DISCUSSION

For successful solution of the problem of equipment high-quality repair and increase of its work efficiency, the need of technological bases' development of highly-effective complex repair technologies for restoration of accuracy and operability of mechanisms' design of the equipment is indisputable at a systematic assessment of its technical condition (Avakyan, 1980). It is possible to carry out it on the basis of the complex solution of the following technological tasks:

- Identification of the reasons and nature of deviations' formation causing decrease in operability of processing equipment on the basis of disclosure of spatial dimensional communications in executive mechanisms of the equipment. Definition of the type and size of maximum deviations allowed by the functional purpose
- Development and effective methods' research of systematic assessment of knots' technological condition based on means of computer vibration diagnosis application that excludes need of stop and dismantling of the equipment and its diagnosing
- Identification of characteristic diagnostic points on the responsible mechanisms of the equipment providing reliable information about formation of arising deviations that allows to take preventive measures for an emergency exception in due time
- Development of technological processes of details and equipment knots' maintenance on the basis of application of modern technologies and materials
- Development of a technique of effective technologies design of maintenance and additional hardening of worn-out basic surfaces of details on the basis of added machines' use
- Development and research of effective methods of details' finishing processing restored by a metal coating, for quality providing received basic surfaces with use of the developed methods of processing by various tools

- Development of new forms of maintenance organization and the equipment repair based on application of modern diagnostic methods of a systematic assessment of its technical condition with use of computer vibration diagnostics, video endoscopy and application of effective repair technologies

Summary: The solution of the existing problem of decrease in heatlosses of large-size rotating aggregates like burning units is possible on the basis of scientific base's development including creation of models and theoretical dependences, revealing difficult reasons of working capacity losses, appearance of malfunctions and equipment failures. It allows developing new effective technologies of maintenance and the repair which introduction provides increase of efficiency and durability of machines' peration. Development of new forms of technical service and repair of the equipment based on a systematic assessment of its technical condition by means of modern diagnostic means reducing a number of casual refusals and duration of idle times of units. The use of the developed sealing devices will allow reducing heat losses considerably.

CONCLUSION

On the basis of the researches conducted on a number of the enterprises of cement production, it is established that at operation of the burning furnaces there is a decrease in technical and economic indicators. One of the main reasons for it is unplanned stands for repair. It is established that change in form of bandages and rollers leads to additional vibrations of the case and as a result to lining loss. With the help of the researches it is established that practically on all rotating furnaces there are self-made sealing devices which do not provide prevention of air suction on the hot and cold ends of the furnace. Therefore, there is an overexpenditure of energy carriers and it is revealed that industry does not install sealing devices for difficult rotating units.

By researches of furnaces it is established that furnaces were developed without operation in certain climatic conditions, therefore there are violations of technological processes involving burnout of the furnace, clinker temperature increase at the exit and destruction of refrigerators.

One of important conditions of reliable operation of the furnace is installation on a rotation axis in hot furnace, i.e., without stopping process of clinker burning.

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