

Determination of the Armor Wear and Tear of the Drum Ball Mill

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Abstract –*The object of the research to develop an analytical method for determining the armor wear rate of the drum ball mill was the boiler TP-100 (TP-100A) of the 200 MW power unit of Burshtyn TPP (Ukraine), equipped with two individual dust-preparation systems with drum ball mills KBM 370/850 (Sh-50A).*

An effective analytical method for determining one of the main performance indicators of a drum ball mill – the wear rate of the drum armor, grinding balls and the relationship between them in case of “G” grade coal combustion for TP-100 boilers is proposed. Its essence is to reduce human labor costs, more accurately determine the wear rate of the drum armor and grinding balls. This method is characterized by the fact that the main estimation indicator is the drum armor wear rate depending on the manufacture quality of armored plates (manufacturer).

Keywords – analytical method, steam boiler, drum ball mill, coal, drum armor wear rate, ball wear rate, mill operation duration, ball charge.

I. Introduction

One of the key operating parameters of a drum ball mill is the drum armor wear and ball charge of a drum, which affect the performance and specific electric power consumption for dust preparation.

During the mill operation, the ball charge is maintained at a constant maximum level by the periodic addition of balls to the drum, which provides the best possible performance with satisfactory quality of the finished dust. According to the characteristic $N_m=f(G_b)$, the operating maximum ball charge corresponds to the mill electric motor loading, which depends on the value of the rotating mass of the drum and balls. In this case, the replacement of the drum armor wear (ΔG_a) with the value of the ball charge (ΔG_b) increase occurs, which adversely affects the performance of drum ball mills and ultimately the reliability. Therefore, the development of an analytical method for determining the armor wear of the mill drum, taking into account its ball charge, is an urgent task.

II. Analysis of previous studies and statement of the problem

In accordance with the development plans of Ukraine's power industry till 2030, TPPs operating on coal of own production will be the basis of flexible power facilities of

the united energy system (UES) of Ukraine. It is planned to introduce clean coal technologies, based on the development of new and already known technological processes and to consider the issue of possible coal combustion in a pilot plant [1]. The works [2–4] highlight the issues of fossil fuel combustion and capture of fuel ash particles in flue gases. In the above publications, the authors consider not efficiency, but actual operation of drum ball mills. Ensuring the reliability of boiler units is a key component of efficient operation of TPP power units, as well as operation of drum ball mills and armor surfaces.

It is known that the coal grinding process is accompanied by a simultaneous wear of ball metal and drum armor [5]. Gradual and continuous wear of armor reduces the drum weight, which lowers the electric load N_m and introduces an error when determining the ball charge.

Experimental methods for determining the performance of drum ball mills are also known [6, 7]. However, the rational and maximum efficiency of the mills can be provided by reliable operation of armor surfaces of mills. At the same time, the recommendations contained in them have either a rather general nature, or, conversely, a very narrow application scope.

Therefore, the development of an analytical method that would allow carrying out diagnostic tests and engineering calculations of dust systems without conducting experimental studies is an important scientific and applied problem.

III. The aim and objectives of the study

The aim of the work was to develop an analytical method and carry out the corresponding calculations of the mill drum armor wear. To achieve this aim, it was necessary to accomplish the following objectives:

- to determine the armor wear of the mills KBM 370/850 (Sh-50A) that grind “G” grade coal;
- to determine the wear rate of the drum armor depending on the manufacturer in Ukraine

IV. Results of calculating the mill drum armor wear

The boiler TP-100 (TP-100A) of the 200 MW power unit of Burshtyn TPP (Ukraine) is equipped with two individual dust preparation systems with drum ball mills KBM 370/850 (Sh-50A).

The dust system of the boilers TP-100 is designed for grinding “G” grade coal of the Lviv-Volyn coal basin (Ukraine): $Q_i^r=24.41$ MJ/kg (5830 kcal/kg), $W^p=7.4$ %, $A^p=22.4$ %, $V^G=38.5$ %; grindability index $I_G=1.2$.

Design parameters of the finished dust: $R_{90}=24$ %, $W^p=2$ %.

Basic elements of the mill KBM 370/850 (Sh-50A):

- rotating horizontal cylindrical drum;
- armor coating of the inner surface of the drum body;
- drum ball charge;
- mill drive – low-speed synchronous electric motor, connected to a drive gear and a gear ring of the drum through a coupling;
- self-lubricating bearings.

In the design, the cylindrical inner surface of the drum is equipped with armored plates, the mounting of which to the case shell is carried out by means of spacer wedges. Plates and wedges form a continuous wave that promotes capture and lifting of balls and coal material. The end walls of the drum are covered with flat armor plates.

Characteristics of ball charge and design armor of the mill drum:

- ultimate ball charge $\tau=100$ t;
- design ball charge $G_b^d=8$ ball 0 t;
- maximum operating ball charge $G_b^{\max}=70$ t;
- ball diameter $d=40$ mm;
- design weight of the drum armor plates $G_b^{\max}=70$ t.
- estimated specified life of the mill drum armor $T=20000$ h.

The results of the calculation of the drum armor wear rates of the mill st. No. 8B of Burshtyn TPP are shown in Table 1.

TABLE 1

INITIAL DATA AND RESULTS OF THE CALCULATION OF THE DRUM ARMOR WEAR RATES OF THE MILL ST. 8B OF BURSHTYN TPP

Parameter	Calculation	Calculation result	
Initial data			
Initial armor weight G_δ^n , t	–	44	
Operating maximum ball charge G_b^{\max} , t	–	70	
Ball wear rate in case of GSSh coal grinding g_{b1} , kg/h	–	15.7	
Standard specific expenditure of balls in case of G coal grinding	G $a_{norm},$ g/t	–	224
	GSSh $a_{norm1},$ g/t		
Coefficient of proportionality M_p	–	0.067	
Conversion factor M_p	–	0.36	
Duration of the maximum interrepair time τ , h	–	25194	
Calculation of drum armor wear rates			
Ball wear rate g_b , kg/h	$15.7 \cdot \frac{196}{224}$	13.7	
Armor wear rate g_δ , kg/h	$0.064 \cdot 13.7$	0.88	
Metal loss from drum armor wear ΔG_δ , t	$0.88 \cdot 25.194$	22.17	
Drum armor wear magnitude b_δ	$\frac{22.17}{44}$	0.50	
Over-expenditure of balls ΔG_b , t	$0.36 \cdot 22.17$	8	
Drum overcharge with balls G_b^{over} , t	$70+8$	78	
Estimated maximum ball charge G_b^p , t	$70-8$	62	

According to the results of the calculation, the state of armor at the end of the interrepair time of the mill was characterized by:

– the drum armor wear magnitude $b_\delta=0.5$ and the maximum possible metal loss from the drum armor wear $\Delta G_\delta=22.17$ t;

- the drum armor wear rate $g_\delta=0.88$ kg/h;
- uncontrolled over-expenditure of balls in the drum $\Delta G_b=8$ t and drum overcharge with balls $G_b^{over}=78$ t.

The values of the armor wear rate g_δ for the mills whose drums are equipped with the Bilozersk and Dnipro armor are 0.69 and 1.37 kg/h, respectively.

Conclusion

The method of determining the armor wear of the mills KBM 370/850 (Sh-50A) is developed on the example of “G” grade coal grinding, which allows carrying out a partial replacement of armor plates during repair without a complete restoration of armor coating of the cylindrical or end surfaces of the drum.

The comparative analysis of armored plates of the mill ball drum is designed and conducted and the main estimation indicator is obtained – the drum armor wear rate depending on the manufacture quality of plates, which is: Bilozersk armor 0.69 kg/h, Donetsk armor 0.88 kg/h; Dnipro armor 1.37 kg/h.

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