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Failure investigation of the pulverizing fan of ventilation mill

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ABSTRACT

Long-term continuous high-speed rotation provides the conditions for the occurrence of various failures of ventilation mill (VM) parts, such as the pulverizing fan. Pulverizing fan failure leads to dynamic unbalance of the rotating mechanism, which causes significant damage to the whole system, serious casualties, and high financial loss that may exceed the direct material damage considerably. This study aimed at diagnosing the cause of pulverizing fan damage. To identify the reasons behind pulverizing fan failures, stress state simulations and experimental investigations were performed. Experiments comprised visual and metallographic examinations, chemical composition analyses, mechanical property tests, and strength test, which revealed the nature of the failure. Numerical–experimental analysis results indicate that pulverizing fan failures are mainly caused by inappropriate structural designs and harsh operating conditions. Results also emphasize the importance of comprehensive quality control of VM pulverizing fan.

1. Introduction

In the modern pulverized coal power plant, pulverized fuel preparation totally depends on the grinding mill. Ventilation mills (VMs), which are continuous grinding machines and the most efficient structures in coal grinding technology, have become progressively larger and more efficient [1,2]. Fig. 1 shows the VM MB3600 with the following specifications: 490 r/min rotational speed, 3600 mm pulverizing fan diameter, and 1400 kW drive power. VM MB3600 has been used for almost 10 years. VM pulverizes raw coal by allowing the coal to be hit by the strike plate in the high-speed rotating pulverizing fan. The pulverizing fan is the rotating mechanism; it is the most important component in VM. The structure of the pulverizing fan is similar to that of the impeller of a centrifugal fan and mainly consists of seven parts, namely, front plate, rear plate, articulated beams, inner strike plates, outer strike plates, battens, and fenders (Fig. 2).

The trend toward continuous improvement of the VM performance, especially their capacities and safety, has not been adequately considered in design procedures and manufacturing technologies which is substantiated by various accidents and failures of VMs as described and analyzed in [3–6]. In extreme work conditions, pulverizing fan disadvantages may lead to failure [7]. The actual number of VMs that operate in a coal plant is 36, of which approximately 24 VMs have defects caused by various types of disadvantages. VM failure is illustrated in Fig. 3.

The cracks on the front and rear plates may be the cause of the accident [8]. Pulverizing fan failure leads to dynamic unbalance of rotating mechanism, which causes considerable damage to the whole system because the rotational speed is high and the moment of inertia is large. Serious accidents that can result in casualties may also occur, as well as a high financial loss that may exceed the direct material damage by more than a hundred times.

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Long-term continuous high-speed rotation leads to failures of the substructures of the pulverizing fan, specifically the front and rear plates, as shown in Fig. 3. Thus, the reason of pulverizing fan fractures must be studied. Investigations must include (a) failure analysis through visual inspection of cracks, (b) simulation of the stress–strain state, (c) testing of the chemical composition of the pulverizing fan material, (d) metallographic inspection of the pulverizing fan material, (e) testing of the mechanical properties of the front and rear plates, and (f) strength test of the pulverizing fan. The wide usage of VM in coal power plants makes the results of the present investigation important.

The fractured pulverizing fan in a power plant is examined, and the main parameters are listed in Table 1.

2. Fracture description

Several failed pulverizing fans were examined, as shown in Fig. 4. Details A, B, and E reveal cracks at the dovetail corner of the front and rear plates in almost all samples. The locations where the cracks emerge are the same as the positions where the strike plates are assembled. Therefore, the action forces of the strike plates are the main reason for the cracks. The operation records show that a long operating time produces a long crack. Detail D illustrates the plastic deformations that accompany the cracks. These two aspects indicate that an important cause for the cracks is the stress on both the front and rear plates that exceeds the yield strength. At the same time, the dovetail structure facilitates the occurrence of stress concentration at the corner. Long-term operation worsens the stress state, which finally leads to the emergence of cracks [9]. The wear demonstrated in detail C indicates a relative movement between front/rear plate and strike plate, which has not been considered in the design [10–12].

3. Finite element analysis (FEA)

FEA was conducted to analyze the stress state of the pulverizing fan.

3.1. Load

Loads were calculated according to the parameters listed in Table 1. The results are presented in Table 2.

3.2. Material

The mechanical properties of the materials used in the pulverizing fan are listed in Table 3.

Based on the analysis in Section 2, the stress that exceeds the yield strength may be the reason for the fractured structure. The nonlinear curves of the materials must therefore be obtained. Results are shown in Fig. 5.

3.3. Finite element model (FEM)

The FEM of the VM plate was established through the use of ANSYS [13]. The pulverizing fan is an axial symmetry structure, and the array angle is 30°. If only a part (1/12) of the pulverizing fan is utilized to establish the FEM, the front and rear plates should be constrained and radial force should be applied on the strike plate. However, only the rear plate is actually constrained to the shaft, whereas the front plate is constrained to the rear plate through an articulated beam. No force directly acts on the strike plates. These plates are pushed to the front and rear plates by centrifugal force. To minimize the influence of simplification, the whole pulverizing fan should be considered as a factor in establishing the FEM. All the degrees of freedom of the center hole of the rear plate are constrained, and the front plate is connected to the rear plate by an articulated beam with bolts. Load is applied as a constant rotational velocity. The above mentioned simplified principle

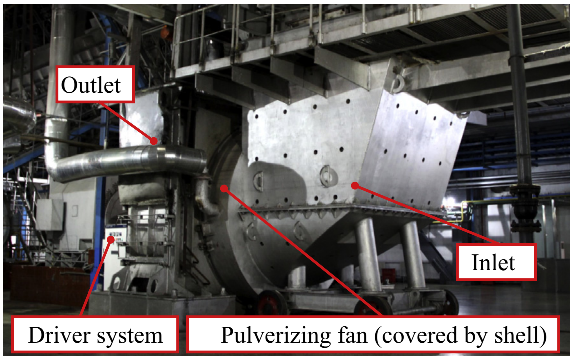

Fig. 1. VM MB3600.