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Study on the stress characteristic and fatigue life of the shredder pin

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ABSTRACT

The hammer shredder is the key equipment for cyclic utilization of retired car bodies. The axes' pin is the main component of the shredder, but it is damaged easily. To improve the shredding efficiency and lengthen the changing life of the shredder pin, it is significant to study its stress characteristic and the fatigue life. In this article, the complex force conditions of the shredder pin at the normal working condition were studied briefly by mechanics analysis method. The stress characteristics and fatigue life of the pin were analyzed by the finite element transient analysis method. The maximum stress distribution law of the shredder pin was found and the fracture mechanism of the retired car bodies was revealed. Furthermore, the reliability of the simulation results was verified by the experiment. It was found that when the pin rotates around the main shaft counterclockwise, the maximum stress of the pin at 0° of the main shaft is higher than other positions. Additionally, along the axial direction, the maximum stress occurs at the cross section at a distance of 2/9 of the pin length from the pin head and at 0° of this section, which orientation is made when the pin is at 270° of the main shaft. Comparing four working modes, it was found that the working life of the shredder pin could be doubled by changing the sides of the pin and rotate it along its axes by 180°.

1. Introduction

Nowadays, the demand for the steel is urgent globally and the steel scrap is an important resource for steelmaking. Yet steel recycling in some countries is relatively weak. One main reason for it is the inadequate steelmaking capacities, which can be enhanced by improving the recycling efficiency and decreasing the recycling cost [18]. The retired car bodies contain massive steel scraps. It is of great value to make the most use of these metal scraps. With automobile sales increasing, the figure for retired cars is rising at a staggering rate, which leads to problematic issues such as environmental pollution and resources wasting [9]. However, retired car recycling is an energy efficient and environmentally friendly way to address this tough problem [7,10]. To improve the recycling rate of the retired cars, many relative influence factors were studied, such as particle size reduction and liberation [16,17]. In addition, an optimization model for the retired car bodies was established to make the recycling characteristics more clear [15].

The hammer shredder is the main equipment in the scrap shredder production line, whose properties affect the shredding efficiency, shredding energy consumption and shredding quality greatly. In order to enhance the shredding efficiency, a great deal of research was made on the shredding characteristics of the hammer shredder for retired car bodies. Much attention was paid to the influence of the structures and materials of the shredder components and also the morphologies and the materials of shredding materials on the shredding characteristics. The comminution of sheet-like plate metal was generally divided into four phases

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and it was proved that the comminution degree mainly depends from the hammers' momentum [4].It was investigated that the narrower clearance between the anvil and impacting tools did not yield higher quality fragments at any time [12]. Both the experimental and simulation studies were conducted to document that the performance of the shredder hammer could be improved by refining the shape of the hammer cutting edge profile [1]. Although the investigations on the shredder components are extensive, we found few publications about the ways to improve the property of the shredder pin. For a deeper study of the shredder, much more attention should be paid to investigating the characteristics of the shredder pin.

The shredder pin is damaged easily and exchanged frequently in comparison with the other components on the shredder, which affects the shredding efficiency and cut down economic benefits greatly. To find the reason for its fracture failure and improve its fatigue resistance, massive information is available to improve its material properties and modifying its structure parameters. The stress–strain distribution conditions of some typical pins were analyzed by the finite element statics method and the weakest position was found out [5]. It was revealed by the experiment that the low strength and stiffness of the material made the failure [8,14,19]. Furthermore, the disadvantages of the manufacturing process were found out and the ways to modify it was proposed [20]. However, the shredder pin has its unique characteristics during the shredding process. To begin with, there are many components linked to the shredder pin, which makes the load condition of the pin much complicated. Take No. 5 pin in the PSX-88104 shredder as an example. There are 3 hammers, 9 backplates and 12 scaleboards linked to this pin. Furthermore, the working condition of the shredder pin is complex and also bad as the loads from other components are variable over time and positions, and the impacts from the shredding material are unknown. Based on these factors, it is of significant importance to study the shredder characteristics of the shredding pin.

Three failure reasons of the aluminum vehicle wheels were investigated by the numerical modeling methods, that is, macroporosity, microporosity and oxide films [11]. Different fatigue failure styles of the theoretical assembling straight bevel gear pair were investigated by the finite element method and experimental method [2]. Rolling contact fatigue in a ball bearing is studied by the experimental method [3]. Special attention is paid to the interaction between buckling and crack growth and to crack link-up in multi-site damaged specimens [6]. The fatigue life analysis on other machines or components is abundant, but there is little investigation on the fatigue life of the shredder pin.

As to the problems above, the stress characteristics and the fatigue life of the shredder pin were investigated in this paper. An effective way to lengthen the life of the shredder pin was proposed. The study in this paper is of great value to improve the shredding efficiency of the retired car body and lengthen the life of shredder pin, laying a foundation for the deeper investigation on the shredder pin.

2. Research method

Fig. 1 is the picture of the PSX-88104 shredder in Hubei Lidi Machine Tool., ltd. The shredding materials enter the shredder through the conveyor belt and leave it after being shredded into small pieces. Fig. 2 is 3D of the scaleboard–pin–hammer system, showing the design and assembly of the components in the shredder. There is a clearance ε between the scaleboards and the corresponding pin. The clearance between the hammers and the corresponding pin is also ε, which means the hammer can rotate around the pin. Fig. 3 is the picture of the rotating system in the PSX-88104 shredder, showing that the backplates surrounding the rotating system for the purpose of protecting the pin from being damaged by the shredding materials. Fig. 4 is the brief diagram of the shredding process of the retired car body. The shredding materials enter the cavity through the entrance. In the

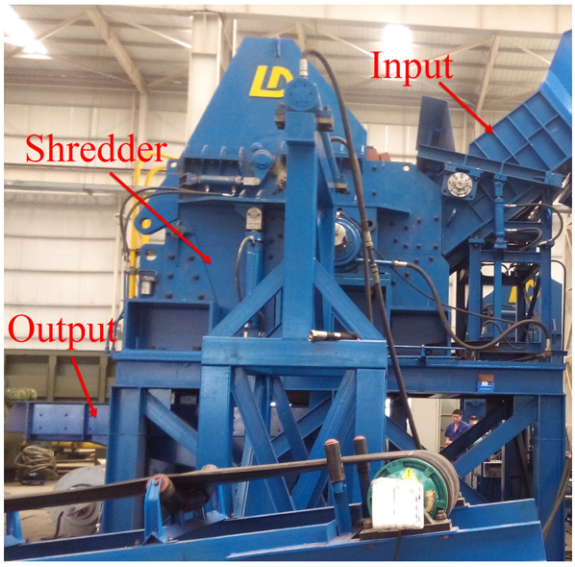

Fig. 1. Picture of PSX-88104 shredder.