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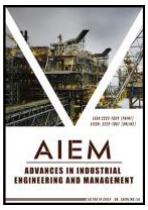

RESEARCH ARTICLE

CURRENT SITUATION ANALYSIS OF HYDRAULIC EXCAVATORS

Wenjie Qi[1], Xiang Liu[2*], Fuxi Liu[1], Xianfeng Zhang[1], Jie Zhang[1], Zhixin Zhang[1], Xinlu Yang[1], Yuhao Cui[1]

[1]School of Mechanical and Electrical Engineering, Hunan Applied Technology University, Changde 415100, China
[2]Party and Government Office, Hunan Applied Technology University, Changde 415100, China
[*]Corresponding Author Email: 1751611391@qq.com

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ABSTRACT

Hydraulic excavators have made tremendous contributions to the development of the human society. Compared to the manual excavation, using the hydraulic excavators can not only reduce the labor intensity of workers, but also save the time of the excavation. Hydraulic excavators mainly include the chassis, rotary platform, working device and so on. The aim of this paper is to analyze the current situation of the chassis, rotary platform and working device of hydraulic excavators.

KEYWORDS

Hydraulic excavators, chassis, rotary platform, working device

1. INTRODUCTION

Excavators are referred to as excavating machineries. Excavators appear in 1930s and 1940s. Owing to the need for large-scale western development in the United States, a walking excavator emerges as the times require (Huang, et al., 2003). This waking excavator is powered by the steam engine and able to imitate the movement of the human arm. In the following 100 years, the excavators have not gotten much development. The reason is that at that time the main construction machinery is the earthmoving machinery.

The hydraulic transmission technology begins to get much development in the 1960s. At the same time, the hydraulic transmission technology also begins to be applied to the excavators. Therefore, hydraulic excavators emerge as the times require. Hydraulic excavators have been widely used in the farmland, orchard, opencast mines, mine excavation, urban construction, and railway construction. Hydraulic excavators have made tremendous contributions to the development of the human society. Compared to the manual excavation, using the hydraulic excavators can not only reduce the labor intensity of workers, but also save the time of the excavation. The basis of hydraulic excavators is the hydraulic technology. Hydraulic excavators are able to complete the excavation work under harsh conditions and have achieved good application effect (Pang, 2020).

Hydraulic excavators mainly include the chassis, rotary platform, working device and so on (Shi, 2022). The chassis of hydraulic excavators includes the frame with the welding frame structure, slewing bearing, transaxle, driving shaft, joint in the center of rotation, brake, steering front axle and so on (Zheng, et al., 2016). The rotary platform of hydraulic excavators includes the rack, pilothouse, engine, hydraulic pump, multi-way valve, swing motor and so on (Shi, 2022). The working device of hydraulic excavators includes the bucket, arm, boom and so on (Li, et al., 2023). The main types of hydraulic excavators have track type and wheel type. Compared to the track type hydraulic excavators, the wheel type hydraulic excavators have faster walking speed and better maneuverability. Compared to the wheel type hydraulic excavators, the track type hydraulic excavators have better stability.

Firstly, this paper introduces the chassis of hydraulic excavators. Secondly, this paper introduces the rotary platform of hydraulic excavators. Finally, this paper introduces the working device of hydraulic excavators.

2. CHASSIS OF HYDRAULIC EXCAVATORS

Qi (2022) established the finite element model of the track chassis structure of bucket wheel excavator based on ansys software and analyzed the force of the track chassis structure of bucket wheel excavator. They found that the partial stress concentration could be eliminated by optimizing the track chassis structure of bucket wheel excavator. The track chassis designed by them not only met the customer requirement, but also reduced the quality of the track chassis

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and saved the material.

The mini excavator has better narrow working space. In this regard, Qiao et al. (2022) designed one kind of telescopic chassis. The telescopic chassis designed by them mainly included the underframe, left track beam, right track beam, power source driving the expansion and contraction, hydraulic system and so on. The underframe, left track beam, right track beam and supporting skeleton of the wheel system beared the weight of the hydraulic system, dynamical system, electrical system and driver's cab. The telescopic chassis designed by Qiao et al. could meet the customer requirement and let the mini excavator conveniently come and go in the narrow passageway.

Zhang et al. (2019) established the model of track excavator chassis using the solidworks software and analyzed the static strength of telescopic circular tube and telescopic square tube. It was found that the circular tube has more dispersed and uniform force distribution than the square tube. Therefore, the circular tube has smoother expansion and contraction operation than the square tube. Moreover, the circular tube has lower processing difficulty and better surface flatness than the square tube.

Wang et al. (2018) designed a walking excavator for the special working condition and investigated the outrigger form and main structure layout of the walking excavator chassis. They found that the designed chassis structure has high reliability. Meanwhile, they also found that the fatigue failure is prone to occur on both sides of the chassis slewing support.

Wu et al. (2015) established the mechanism schematic diagram of chassis for a walking type excavator and calculated the freedom of front leg mechanism, hind leg mechanism and chassis in different typical states. The analysis method provided by Wu et al. (2015) could reflect the moving characteristics of walking type excavator chassis mechanism in different typical states.

In order to solve the cooperative control problem of the dual motor system of the driving mechanism of excavator tracke, Zhang et al. (2014) investigated the control strategy and optimization method of the electric drive system of excavator chassis. It was shown that the fuzzy control and GA algorithm could obtain good excavator driving performance.

By successive approximation examples, Liu et al. (2010) discussed the calculation program of the fatigue probability of excavator chassis member with irregular load and unlimited life.

In order to solve the adaptability problem of walking excavator chassis on the terrain environment with longitudinal slope, Han et al. (2009) put forward a multi-objective optimization analysis method and the attitude variation pattern of walking excavator chassis member within a certain range of slope angles was obtained.

3. ROTARY PLATFORM OF HYDRAULIC EXCAVATORS

It was easy to produce the deformation for the rotary platform because there were many welds. Based on this, Zhang et al. (2020) investigated the effect of welding technology on the flatness of rotary platform after welding. The results showed that the reduction of heat input could reduce the welding deformation of rotary platform. The results also showed that the reasonable welding sequence and assembly before welding could reduce the total deformation of rotary platform.

Take large excavator rotary platform for example, Hou (2020) analyzed the the main type of rotary platform fault, location of rotary platform fault occurrence, and time period of rotary platform fault occurrence.

By the degree of new and old cracks and crack direction, Wang et al. (2020) determined the cause of cracking failure fault of large scale mining hydraulic excavator rotary platform.

In order to shorten the developing cycle of mining excavator, reduce the research and development costs and improve the product quality, Tan et al. (2016) applied the parametric design method to the design of excavator rotary platform. They found that the establishment of parametric modeling of rotary platform and human-computer interaction interface could save the design time of excavator rotary platform, reduce the design workload and improve the enterprises' design efficiency.

Aiming at the excavator rotary platform, Wu et al. (2014) established the mechanical model and finite element model of two simplified structural models. By the strength analysis and stiffness analysis, Wu et al. determined the optimal excavator rotary platform structure.

Based on the finite element analysis method, Zhang et al. (2013) found the weakness of hydraulic excavator rotary platform. By improving the weakness of hydraulic excavator rotary platform, the stablity and overall performance of hydraulic excavator rotary platform were significantly increased.

Liu (2012) found that the influence of welding deformation on the flatness of excavator rotary platform ring groove was reduced by about 35% by changing the milling process of the main platform.

Jin (2011) employed the finite element method to establish the mechanical calculation model and analyzed the influence of excavator rotary platform on the strength and stiffness for two different planking widthes.

4. WORKING DEVICE OF HYDRAULIC EXCAVATORS

Based on the mechanism of fatigue damage evolution, Gao et al. (2023) investigated the fatigue characteristics of target component welds.

By using the ansys software, Liu et al. (2022) obtained the stress characteristics, deformation situation, and maximum stress's size and position of the main structure of large excavator working device boom.

Based on the dynamic simulation analysis, Chen et al. (2022) investigated the wear mechanism of the end face friction pair clearance of excavator working device.

The excavator working device is large welded component and its fatigue strength has an important effect on the service life and performance of the entire machine. In order to estimate assessment the fatigue life at the weld seam, Cao et al. (2022) proposed an assessment method of the fatigue life of the weld seam of excavator working device based on the equivalent structural stress method.

The joint friction pair of the excavator working device has an important effect on the quality and reliability of excavators. Aiming at the ear plate eversion of joint friction pair and the severe wear of end face, Liu et al. (2023) analyzed the dynamic contact characteristics of the joint friction pair of the excavator working device.

The excavator working device has a complex strongly coupled nonlinearity and time lag. Meanwhile, there is a problem of uncertain load for the excavator. In order to solve this problem, Li et al. (2022) employed the control strategy of the combination of iterative learning control and sliding mode control to investigate the control of the joint trajectory of excavator working device.

Li et al. (2023) investigated the effect of the matching characteristics between the theoretical excavation force of hydraulic excavator and full utilization ratio of active hydraulic cylinder on the mining performance. They found that the parameters of the homework scope of excavator working device could be improved by reducing the full utilization ratio of active hydraulic cylinder and boom cylinder lock limit ratio and increasing the ratio of actual excavation force and maximum excavation force.

In order to improve the coordination of the compound action of excavator working device, Liu et al. (2022) conducted the performance benchmarking tests of the compound action of three large excavator working devices by installing the sensors in corresponding positions.

Jia et al. (2020) found that the excavators with three arms could effectively increase the excavation range compared to the excavators

with ordinary arm

In order to improve the operational efficiency and working performance of hydraulic excavators, Nie et al. (2019) optimized the working device of hydraulic excavators based on the adams software. The optimization results indicated that the excavation and lifting capabilities of excavators after optimization were significantly improved.

5. CONCLUSIONS

Hydraulic excavators have been widely used in the farmland, orchard, opencast mines, mine excavation, urban construction, and railway construction. Hydraulic excavators mainly include the chassis, rotary platform, working device and so on. Although many researchers have investigated the chassis, rotary platform and working device of hydraulic excavators, there are still many problems to study for the chassis, rotary platform and working device of hydraulic excavators.

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