Review Article **AJAR (2021) 6:113**

American Journal of Agricultural Research (ISSN:2475-2002)

Research Status of Power Allocation of Combine Harvester

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ABSTRACT

The development of combine harvester has greatly promoted the development of global agricultural mechanization, In this paper, a large number of research results related to power allocation of combine harvesters were collected, The development status of combined harvester transmission system and power test system is summarized through analysis and selection, It is found that there are few researches on the power distribution of the combine harvester, so it is necessary to further study the related research of the combine harvester.

Keywords: Combine harvester; Transmission system; Power test system

Fund project: The project of the agricultural machinery equipment R&D and innovation plan in Shandong Province (2016YF026,2018YF006); The project of the Talent Team Cultivation Program for Superior Disciplines of Universities in Shandong Province(2016-2020)

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How to cite this article:
Ping Jiang, Aoqi Zhang, Yujie Deng , Huawei Liu, Haoze Li, Guohai Zhang. Research Status of Power Allocation of Combine Harvester. American Journal of Agricultural Research, 2021; 6:113

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Website: https://escipub.com/

Introduction

The common calculation formula of shaft parts power is $P = Tn/9549$, the speed n is a controllable quantity, changing the speed N will cause changes in torque T and power P, For corn harvesting machinery, the transmission system controls the rotational speed of each rotary component, so the transmission system is the carrier of distributing engine power indirectly. Combine harvester can be regarded as composed of main working part, transmission system and walking system, etc, the transmission system distributes the power of the whole machine, and decide whether the harvester can operate normally and the duration of continuous operation, some studies have shown that domestic harvester transmission system reliability is not high and it is easy to break down [1], this will directly affect the continuous working ability of the whole machine, and limit the improvement of the whole machine performance, at the same time, most domestic harvesters have the problem of unreasonable transmission system design, resulting in unscientific distribution of power and waste of power, it will hinder the development of high-horsepower combined harvester in our country, therefore, it is necessary to study the characteristics of parameters such as torque and speed of combine harvester, so as to provide reference for the design and manufacture of harvester. Because domestic and foreign scholars have little research on power allocation of combine, therefore, combined with the above analysis, this paper from the transmission system and power test system research status of these two aspects are elaborated.

1. Research status of combine harvester transmission system

Transmission system is the system that transmits power for the main working parts of combine harvester, determine harvester power, reliability, harvesting efficiency and life and other performance [2], therefore, domestic and foreign scholars and enterprises have carried out a lot of research on it, and some of the research results have been successfully applied to harvesters. The S-series combine harvester by John Deere optimizes the overall transmission system layout, during operation, the efficiency of the transmission system between the cutting table, conveying and threshing cleaning devices is improved, and the waste of power is suppressed [3]. Class Lexion-760 combine harvester, the transmission mode of threshing and cleaning device adopts the form of single side belt transmission, this transmission mode optimizes the transmission process and improves the operation performance and efficiency of the whole machine. In addition, CASE, Yanmar, Kubota and other foreign enterprises have studied the transmission system of harvester and manufactured the corresponding complete machine.

Domestic scholar Fu Yaping [4] studied the transmission system of 4Y-2 type corn combine harvester, Firstly the optimal matching value between the speed of the harvester and the speed of the cutter and the ear picking roller was determined through theoretical analysis and orthogonal test, the optimal transmission ratio of the transmission box was determined according to the test results; secondly the statics and dynamics analysis of the main transmission box were carried out to verify its stiffness and strength; finally the structural parameters of the power transmission shaft, gear and other components of the transmission system are analyzed by finite element method, the influence law of different structural parameters on the operation of transmission system is found, and the optimization scheme of structural parameters is proposed.

Liu Tianshu et al. [5] proposed a utility model patent on the transmission system of the self-

propelled combine harvester, the patent elaborates the connection process of transmission parts such as cutting table gearbox, walking gearbox and transmission belt pulley, and optimizes the transmission route, effectively reducing the failure rate of the transmission system.

Wang Lixin [6] aiming at the problem of low reliability of the combine harvester transmission system, designed a transmission system and conducted reliability research on it. The main parameters of gears, sprockets, belt wheels, transmission shafts and other parts are designed and checked by related calculations and finite element analysis methods; the field tests have verified that the transmission system has high reliability and safety, and the whole machine has good operating performance. Wu Tongyan [7] took Taihu TH988 combine harvester as the prototype, research and optimize the transmission system of the threshing and cleaning device, aiming to solve the problems of unreasonable transmission system design, complex layout, and unadjustable drum speed. By analyzing the preliminary test data of the research group, the new transmission path of the threshing cleaning device transmission system was designed and the parameter design and theoretical verification were carried out; apply the transmission system to the test bench and combine harvester respectively, implement indoor test and field test to detect relevant parameters, the results show that the designed and optimized transmission system meets operating standards and has high working reliability.

Jin Dongbo [8] addresses the problems of low work quality and efficiency caused by the complicated operation of the control system of the single longitudinal axial flow corn combine harvester, Combined with the development trend of the combine harvester in the control of the speed of the threshing drum and the size of the concave plate gap, and the development status of the working parameter monitoring device, a new high-intelligence control system was designed.

2. Research status of combine harvester power test system

2.1 Research status abroad

The combine harvester originated abroad, in order to improve the working performance of the harvester, foreign scholars have carried out a large number of theoretical and experimental studies on the speed, torque and other related parameters of various components in different working conditions, the research on torque parameters originated from the test of working torque of iron and steel rolling mill conducted by American scholar Sydenham [9], with the widespread application of computers, the applicable scope of torque testing is gradually expanded, and the load testing research of agricultural machinery equipment is carried out accordingly.

D.C. Baruah [10-11] believes that the harvesting and threshing process accounts for a large proportion of the power consumption of the combine harvester, combining crops, machines, soil and other parameters and using physics, mathematics and mechanics to establish the power consumption model of the harvester including winders, cutters, conveyors, threshing cleaning devices and other operating components, these models are beneficial to optimize the power allocation problem of combine harvester. In addition to determining crop related parameters such as elastic modulus, moment of inertia of cross section, height and linear density of crop stem and crop yield etc, the model also determines the design parameters such as machine forward speed, total weight of the whole machine, and speed of each component. By integrating the power consumption model of each component, the power consumption model of the combine harvester is

established, the model shows that the amount of crops fed, the walking speed of the machine, the speed of the drum, and the load of the walking wheel are the main factors affecting the power consumption of the whole machine; through the multiple regression method, the values of the three model coefficients related to the main energy-consuming processes, such as threshing, traction and friction of moving parts, are evaluated. M.A.Pustigine [12] through a large number of experimental studies, discovered the components of harmful power consumption in threshing drum operation of combine harvester, It is mainly to overcome the friction power consumption of the bearing and overcome the air resistance power consumption, a calculation formula for harmful power consumption is proposed, and the resistance coefficient A value of the drum with rasp bars and the resistance coefficient B value of the drum with pins are determined. Cz.Kanawoeski [13] measured the work torque of threshing drum of a combine harvesting machine through experiments, it was found that the torque of different working parameters varied greatly; the data of drum torque and rotation speed when the harvester harvests soybeans were collected, the relationship between the change of torque and speed and the power consumption of drum is studied by analyzing the data characteristics, It is considered that the power consumption of the threshing drum is a mathematical expectation estimation of the power consumption of the whole threshing process when the crop feeding amount is close to the average value.

Foreign companies in order to improve the reliability of the combine harvester and other work performance, usually invest a large amount of money and technical personnel to conduct experimental research and obtain a lot of data, for example, the load data of walking half axis of various types of combined harvesting models were obtained through tests, and then the load spectrum was extrapolated to complete the compilation of load spectrum, combined with CAE technology, fatigue life prediction and indoor load simulation test can be carried out, which provides effective data support for the design of harvester walking half shaft.

Internationally renowned manufacturers successfully applied the relevant research results of the combine harvester to the whole machine, for example, John Deere, Case, Class etc., the detection device is installed on the harvester to collect various performance parameters in real time, this is conducive to improving the design level of the harvester, making the structure and strength design more reasonable, and the products produced are more competitive.

2.2 Research status domestic

Compared with the developed countries, the load test of combine harvester in my country started late, However, since the 21st century, domestic scholars have made great contributions to the development of agricultural machinery load testing, The load of the combine harvester gearbox, traveling half shaft, chassis, frame and harvesting device has been relatively completely researched and tested and a large amount of data has been obtained, at the same time, some loads were extrapolated and finally the corresponding load spectrum was compiled.

Ji Xinyu, Li Yaoming et al. [14] have researched and developed a load test system for combine harvesters, and the system was built on the World Dragon 280 test prototype to carry out related experiments. Before the test, the reliability of the developed load test system was verified by comparing the actual no-load power consumption value of the first and second threshing drums with the theoretical power consumption value, In the process it was discovered that the

theoretical calculation formula for the power consumption of the threshing drum proposed by the Soviet academician Golochkin appeared in various forms, and the calculation results were different, therefore, the author puts forward the formula to calculate the power consumption of the rotating kinetic energy of the drum and proves the correctness of the formula. The power consumption data of cutting tool, cutting table, conveying groove, engine power output shaft and the first and second threshing drums at different walking speeds were recorded through field experiments, after data analysis the proportion of the power consumption of each component to the total power consumption is obtained, and the strength of the main drive shaft is analyzed according to the test data, and an improvement plan is proposed for the unreasonable drive shaft.

Ye Xiaofei [15] conducted follow-up research on this basis, through experiments the load data of the walk half axle of the combine harvester on a typical road, straight, back, turning and crossing the ridge are tested, after the data processing, the load spectrum of typical working conditions of the walking half shaft is completed, and the finite element analysis and fatigue life prediction are carried out.

Liu Haiou [16] worked through sensor model selection, signal acquisition system design, sensor calibration, etc, developed an on-board torque test system that can be mounted on a tracked vehicle, passed many real vehicle test tests of starting and changing gears, the torque data of gearbox output shaft of several groups of tracked vehicles under different working conditions are obtained, truly reflects the torque change characteristics of the vehicle during the starting process.

Wang Rui, Li Yaoming et al. [17-18] designed a combine harvester load test system to study the power consumption characteristics of the main working parts of the combine harvester. The system is mounted on the World's Flying Dragon combine harvester, and field tests are carried out based on the factors of forward speed, stubble height, and grain tank load to test the intermediate drive shaft, header, conveying trough, threshing drum and chassis left and right half shafts Component power consumption data, according to the test data to analyze the impact of the three factors, at the same time, the influence of different road conditions and different road slopes on the load test of the harvester chassis was explored. According to the above test results, a finite element stress analysis was carried out on the harvester's walking half shaft and the working part drive shaft to verify the strength performance of each drive shaft.

Zhao Guangjun, Zhang Yuzeng et al. [19] proposed a calibration method for torque test, which can be applied to the walking half shaft of the combine harvester. The calibration process is to fix one end of the walking half-shaft, and the other end is clamped by a pipe wrenches to form a cantilever beam structure. One end of the pipe wrenches is loaded with a weight to calculate the applied torque value. This value and the strain value measured by the load test system are fitted with a linear trend to obtain the calibration curve equation. In order to verify the feasibility of the calibration method, finite element simulation calculation was used, and basically consistent conclusions were obtained.

Wang Chen [20] designed a combine harvester frame load test system, which is mounted on the 4YZQS-4A self-propelled corn combine harvester, common routes used in field operations are adopted, including four walking modes: straight, left turn, straight, and right turn, refer to the combine harvester test method to conduct various working condition tests and collect data to obtain specific data of the harvester frame

load. After the data was checked and processed, the preparation of the load spectrum of the harvester frame was completed, and an agricultural machinery load spectrum preparation management system was preliminarily built. Tian Yongwei [21] collected the chassis load data of the combine harvester in different conditions during transportation and work, the reason of datum zero drift phenomenon is given, and the corresponding solving algorithm is provided, At the same time, a fitting algorithm is proposed, which significantly improves the data processing speed and efficiency, and also provides more reliable data for the compilation of the load spectrum.

3. Conclusion

This paper analyzes the research status of the combine harvester transmission system and power test system at home and abroad by collecting relevant materials of the combine harvester at home and abroad. From the research status described, it is found that domestic and foreign scholars and enterprises have studied the different components of the combine harvester, has contributed to the intelligent development of combine harvesters. However, most of the research is relatively single, and there are few detailed studies on the power distribution of the whole machine, so further research on the power distribution of the harvester is needed.

References

[1] Luo Bing. Industry experts believe that the quality and reliability of agricultural machinery products and other aspects need to be improved. Modern Agricultural Equipment,2012(09):11.

[2] Jiang Wenhan, Wang Yulin, Geng Chao, et al. Design and Simulation Analysis of Combine Harvester Transmission System. Journal of Qingdao University(Engineering & Technology Edition),2020,35(02):110-115+124.

[3] Maertens K, Baerdemaeker J D. Flow rate based prediction of threshing process in combine harvesters. Applied Engineering in Agriculture, 2003,19(4):383-388.

[4] Fu Yaping. Research on key technology of transmission system of 4Y-2 type knapsack corn combine harvester. Harbin Institute of Technology,2014.

[5] Liu Tianshu, Gao Lin, et al. Transmission system of self-propelled corn harvester. Henan:CN 204 305651U,2015-05-06.

[6] Wang Lixing. Design and reliability analysis of transmission system of corn harvester. Shandong University of Technology,2016.

[7] Wu Tongyan, Li Yaoming, Xu Lizhang , et al. Optimal design of transmission system of cutting and longitudinal flow threshing and cleaning device. Journal of Agricultural Mechanization Research,2019,41(10):242-248.

[8] Jin Dongbo. Threshing device control system of single-longitudinal axial flow corn combine harvester. Jilin University,2020.

[9] Sydenham P H. Handbook of measurement science. John Wiley&Sons. Ltd,1982.

[10] D. C. Baruah, B. S. Panesar. Energy requirement model for a combine harvester, part I: development of component models. Biosystems Engineering,2005,90(1):9-25.

[11] D. C. Baruah, B. S. Panesar. Energy requirement model for combine harvester, part 2: integration of component models. Biosystems Engneering,2005,90(2):161-170.

[12] A. B. Lurie, A. A. Grombchevsky. Design and calculation of agricultural machinery. Translated by Yuan Jiaping et al. Beijing: China Agricultural Machinery Press,1983.7:294.

[13] Karwowski,Cz. Harvesting machinery. Translated by Cao Chongwen, Wu Chunjiang, Ke Baokang. Beijing: China Agricultural Machinery Press,1982.9:435.

[14] Ji Xinyu. Design and test of load test system for combine harvester. Jiangsu University,2012.

[15] Ye Xiaofei, Li Yaoming, Xu Lizhang, et al. Fatigue

analysis of the walking half axle of the combine harvester. Journal of Agricultural Mechanization Research,2014,(1):32-35.

[16] Liu Haiou, Chen Huiyan, Zheng Muqiao. Research on torque test system of tracked vehicle. Transactions of the Chinese Society for Agricultural Machinery,2003(03):29-31+61.

[17] Wang Rui, Li Yaoming, Tang Zhong, et al. Construction of combine harvester load test system and analysis of influencing factors. Journal of Agricultural Mechanization Research,2016,38 (04): 152-157.

[18] Wang rui. Load test of crawler combine harvester and strength analysis of drive shaft. Jiangsu University,2015.

[19] Zhao Guangjun, Zhang Yuzeng, Gao Hui, et al. Research on the Test and Calibration Method of the Torque of the Traveling Shaft of the Combine Harvester. Agricultural Equipment & Vehicle Engineering,2019,57(07):63-65.

[20] Wang Chen. Load Test and Load Spectrum Compilation of Jade Rice Combine Machine Frame. Tianjin University,2018.

[21] Tian Yongwei, Zhang Shuming, Yang Fangfei. The interference signal processing of the measured trend of the load spectrum of the combine harvester chassis. Journal of Agricultural Mechanization Research,2014,36(11):24-28.