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# Development of Small Agricultural Machines in China: 4LZ – 0.8 Mini Combine Harvester

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***Abstract*— China has a vast territory, so the type and performance requirements of rice combine harvesters in the North, South, Central and Western regions are different. There are lots of mountains and hills in the Southern part of China. The fields are small with dispersed heights, making the work environment unfit for large-size combine harvesters. Research has been carried out to develop new agricultural machines and also improve on certain models of mini combine harvesters as well as develop different models to fit various conditions in the field. This research aimed at discussing the development of these machines, present a detailed structure of the 4LZ – 0.8 model combine harvester, and give a detailed description of how the various systems in the combine harvester work together in order to ensure full functionality of the machine. The problems leading to the design of particular mini combine models in China were also discussed. Some of the problems that were discovered, leading to the development of the various models of mini combine harvesters were; hilly and mountainous fields, with small land areas, few contiguous patches, deep mud feet, large gaps between fields, which makes it difficult for large scale use of large combine harvesters. This led to the design and development of small agricultural machines which can help in solving these problems, especially the 4LZ – 0.8, 4LZ - 1.0Q, 4L-110, 4LZG-3.0 and 4LZZ-1.0 mini combine harvesters, together with other models. The different systems in the 4LZ – 0.8 mini combine harvester, the structural composition, the operation principle of the various systems, a comprehensive assessment and advantages of the 4LZ – 0.8 model combine harvester have also been discussed in this research.**

***Keywords; Mini combine harvester; Agricultural machines; Agricultural engineering; Threshing system; Cleaning system, Separation device, Harvesting system.***

## INTRODUCTION

With 8% of the worlds' farm land, China has succeeded in sustaining 23% of the world's population. According to Li [1], the total output of main agro-products jumped to the first place in the world, the relations of supply and demand for main agro-products changed from long-term shortage to basic balance and has surplus in good harvest years. Along with the rapid growth of national economy, agricultural mechanization in China entered the fast development phase and is becoming an important component of the worlds' agricultural mechanization development. This research is centered around literature obtained from different sources concerning the development of small agricultural machines in China, with special emphasis laid on the mini combine harvesters. This research seeks to discuss the development of these machines, present a detailed structure of the 4LZ – 0.8 model mini combine harvester and give a detailed description of how the various systems in the combine harvester work together in order to ensure full functionality of the mini combine harvester. The following sections of this research will present research and development of small agricultural machines in China, the main structure and the different systems in a 4LZ – 0.8 mini combine harvester and the operation principles of the various systems. There will also be a section discussing the comprehensive assessment and advantages of the 4LZ – 0.8 model combine harvester.

## I. RESEARCH AND DEVELOPMENT OF MINI COMBINE HARVESTERS IN CHNIA

Compared with other crops, China's rice and wheat combined harvester technology developed earlier and at a higher level, but there is still a large gap between China and developed countries, and there are still many technical problems to be solved and improved upon [2]. There are foreign advanced models of agricultural machines, but these machines not only have stable operation performance and high reliability, but also have high degree of automation, intelligence and informatization. In addition to regular operation functions, the machines are also equipped with automatic test and production Systems, GPS navigation systems, data acquisition and analysis system [3]. The international association for mechanization of field trials (IAMFE) has played an important role in the development of breeding equipment in the world. With the help of IAMFE, China started the research and development of breeding equipment in communities in the 1990s [3]. In recent

years, some progress has been made in the field of seeding equipment in China. Qingdao agricultural university, China agricultural university and northeast agricultural university have carried out research on the seeding equipment technology of wheat, rapeseed, herbage, soybean and rice. In the field of community harvesters, there are few domestic researches. Gansu agricultural university once studied and developed a small community wheat seed combine harvester [3].

Research has been carried out to improve on certain models of mini combine harvester equipment as well as develop different models to fit the various conditions in the field. China has a vast territory, and the type and performance requirements of rice combine harvesters in the north, south, central and western regions are different [4]. Rice fields in the south are mostly mountainous and hilly fields, with small surface areas, few contiguous patches, deep mud feet, large gap between fields, which makes it difficult to widely use large combine harvesters [5]. Factors such as high labor intensity and low production efficiency, restricts the further development of rice production in this part of China. In order to promote the mechanization of rice harvesting, agricultural machinery workers and related companies have conducted extensive research on small combine harvesters [6]. In order to manage the problems faced by the rice fields in southern China, Gu Fengqi et. al., [7] developed a lightweight and simple 4LZ - 1.0Q combined rice and wheat harvester suitable for hilly and mountainous areas. The whole machine operates smoothly and has a good operating effect. However, due to the installation of wind-screen type cleaning device, the size of the machine is relatively large, so the turning radius is relatively large, and its adaptability to small fields is limited [6]. In order to solve the problems of low harvest efficiency, low quality of cleaning and poor passing performance caused by the limitations of supporting power and volume of small harvesters, a 4LZ-0.8 type rice combine harvester was designed and developed based on market research. This machine has the small crawler chassis as the traveling device, the nail tooth type threshing element, and has configured the volume and the power to be small. It also has a new type of cleaning system; the structure is ingenious and the operation is simple [6].

Threshing, separation and cleaning are the key links of combined rice and wheat harvesting operations. The influencing factors are complex, diverse and restrict each other. Effectively improving the performance of threshing and cleaning has always been one of the key issues to be considered in the research and development of mechanized rice and wheat harvesting equipment. The 4LZ-1.0Q rice - wheat combine harvester is a small - feed combine harvester designed for the southern hills and mountains [2]. Researchers have also developed a new lightweight micro rice combine with a mass of 290 Kg, which is operated by crawler walking mode [5]. However, the crawler chassis is short and the tail needs to be supported by pallets, which affects the stability of the whole machine in paddy fields. Based on the chassis of the industrial and agricultural type 8 walking tractors, a side conveying fan is designed to replace the cutting platform conveying trough. The structure is light and simple. The 4L-110 combined grain harvester designed by Zhou Y. et al., [8] is configured on the industrial, agricultural and 12-type walking tractor, which has a simple structure. However, because it is also not equipped with a cleaning device, the impurity rate and loss rate cannot meet the production requirements, and the walking tractor has poor performance in the mud field.

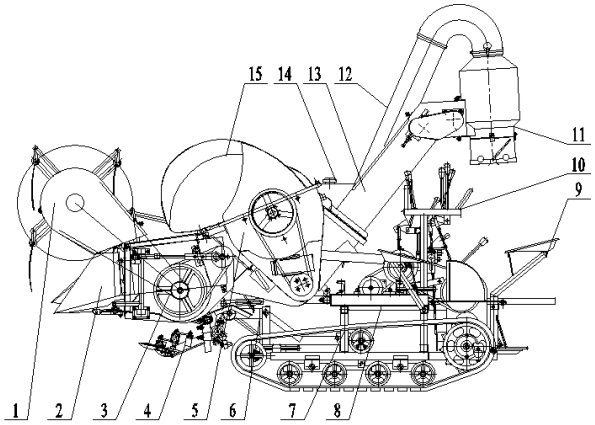
Due to the difference between field crop production and plot experimental operation, special plot sowing and harvesting equipment must be equipped to meet the special agronomic regulations and strict precision requirements. This led to the development of a 4LZZ-1.0 full feed paddy and wheat combine harvester with the planting mode and agronomic requirements of domestic paddy and wheat communities combined together [5]. The 4LZZ-1.0 type community combined rice and wheat harvester adopts full feeding harvesting method and hydrostatic wheeled walking device. The whole machine is mainly composed of pneumatic auxiliary cutting table device, threshing device, cleaning device, pneumatic conveying device, weight collecting device, hydraulic integration device and so on. Some researchers believe that domestic models of semi-feed rice harvester should be actively developed, not blindly imitate the pursuit of modernization, to be good at simplifying to reduce costs [4]. The emergence of the pre - harvest rice combine will certainly take a place in the market competition in the future. The research and development of rice harvesting machinery in China still has a long way to go.

## II. Main Structure And Systems of the 4LZ – 0.8 Mini Combine Harvesters and the Operation Principles of various Sysytems

The entire harvesting operation may be divided into cutting, threshing, separation, and cleaning functions. Cutting refers to retrieving the crops from the field with the help of the grain header, where the straw is cut at a particular height and then sent to the threshing chamber for the threshing operation. Threshing is breaking paddy panicles free from other plant material by applying mechanical force that creates a combination of impact, shear force, and/or compression. It is important to avoid damaging grain during threshing–a challenging task under certain crop conditions. For example, at high moisture content it is harder to break grain away from crop material but easier to damage grain. The operation of separation refers to separating threshed grains from bulk plant material such as straw. The cleaning operation uses air to separate fine crop material such as chaff from grain [9].

### *A. Structure of the 4LZ – 0.8 Mini Combine Harvester*

The 4LZ - 0.8 type rice combine harvester is mainly composed of walking device, cutting platform and conveying device, threshing and separating device, rack, power transmission system, cleaning device, hydraulic and control device. The overall structure of this harvester is shown in figure 1.




1. Straw wheel; 2. Straw divider; 3. Cutting table assembly; 4. Secondary cutting device; 5. Threshing and separating device; 6. Cutting table lifting device; 7. Track bottom; 8. Frame; 9 Chair; 10. Control board; 11. Separation cylinder assembly; 12. Air suction pipe; 13. Hoisting groove; 14. Power source; 15 Rows of grass openings.

**Figure 1: Structure of the 4LZ – 0.8 mini Rice Combine harvester** [6]

The walking device is a crawler chassis, which is composed of a gearbox and a rubber crawler. The threshing separation device consists of threshing drum, shell and concave plate screen, and the threshing drum, screen and shell all form the threshing chamber. The cleaning device consists of a lifting groove, a lifting scraper chain, a separating cylinder assembly, a suction pipe and a suction fan. Most of the 4LZ model harvesters have almost the same configurations. For instance, the 4LZ – 1.0Q adopts the principle of full feeding transverse axial flow threshing. It is mainly composed of chassis, transmission system, grain divider, grain dipper, cutting device, rake tooth conveying device, separating device and cleaning system, etc. [2].

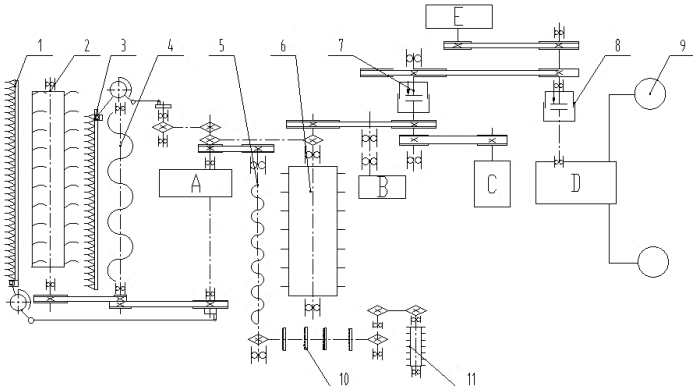
With reference to relevant standards, the main technical parameters of the 4LZ–0.8 full-feed combine harvester are shown in table 1.

**Table 1: Technical Parameters of the 4LZ – 0.8 Combine Harvester**

| S/N | Parameter | Specifications |
|---|---|---|
| 1 | External dimensions | 2,805 × 1,700 × 2,070 mm |
| 2 | Machine weight | 665 kg |
| 3 | Supporting power | 9.7 KW |
| 4 | Engine speed | 2,400 rpm |
| 5 | Feed volume | 2.88 t $h^{-1}$ |
| 6 | Minimum ground clearance | 180 mm |
| 7 | Minimum turning radius | 450 mm |
| 8 | Productivity | ≥ 0.100 $hm^2$ $h^{-1}$ |
| 9 | Header width | 1,200 mm |
| 10 | Threshing drum type is spike tooth with axial flow | |

### *B. Power Transmission System*

The power transmission system layout of the 4LZ – 0.8 mini combine harvester is shown in figure 2. The diesel engine outputs power which is then transmitted to the track driving wheel through the belt pulley transmission system, the running clutch and the running gearbox. The speed of the drive track is controlled by changing the gear position of the travel gear. Pulley drive set, chain drive set, clutch transmission to working components (including threshing drum, conveying scraper chain assembly, header auger device, header cutter assembly, secondary cutter assembly, reel, hydraulic pump assembly, the suction fan, the lateral conveying auger and the lifting scraper chain assembly and the throwing device) are controlled by the clutch, and the power is directly output from the engine. The speed is determined by the engine speed, and is independent of the traveling speed of the machine, and does not affect each other.




**A) Conveying tank B) fan C) gear pump D) walking transmission E) diesel engine**

1 header cutter assembly; 2. reel assembly; 3 secondary cutting device assembly; 4 header auger assembly; 5 lateral conveying auger assembly; 6 threshing drum; 7 working clutch; 8 walking clutch; 9 Walking drive wheel; 10 sprinkler; 11 lift scraper assembly.

**Figure 2: Power Transmission System Lay out of the 4LZ – 0.8 Mini Rice Combine** [6]

### *C. Harvesting System*

Ultimately, the main goal of grain combine harvesting is to retrieve from the field as much grain as possible. The grain header is the first combine equipment that handles and gathers the crop plants from the field [10]. Mechanisms to gather and cut the crop are located in the header, which is also called the cutting platform. The cutting platform has pickup reels which are used for lodged crops (crops that have fallen over due to heavy rains, winds, etc.), because they have finger –like structures that reach into the lodged crops and help pick them up for cutting. The

orientation of the fingers is controlled by either cam guides or a parallel bar mechanism [9].

For optimum combine operation, the crop should be cut just below the grain heads. If the crop height is uneven or if the crop is lodged, it may not be cut in some places, which will contribute to losses. Optimum reel position is determined by the crop height, amount of straw cut, and the condition of the straw. Normally, the reel should be set so the slats, when in their lowest position, will strike the straw 15 - 25 cm above and slightly ahead of the cutter bar [9].

For lodged crops the reel should be set farther back. Proper reel speed is important to minimizing shattering and gathering losses. A reel turning too fast will result in excessive shatter loss, whereas too slow a speed will result in the cut grain head falling off the platform, a cutter bar loss. It is recommended that the peripheral speed of the reel should be about 25% to 50% faster than the forward speed of the combine, or in other words, that the reel index be between 1.25 - 1.5 [9]. The reel index is defined as:

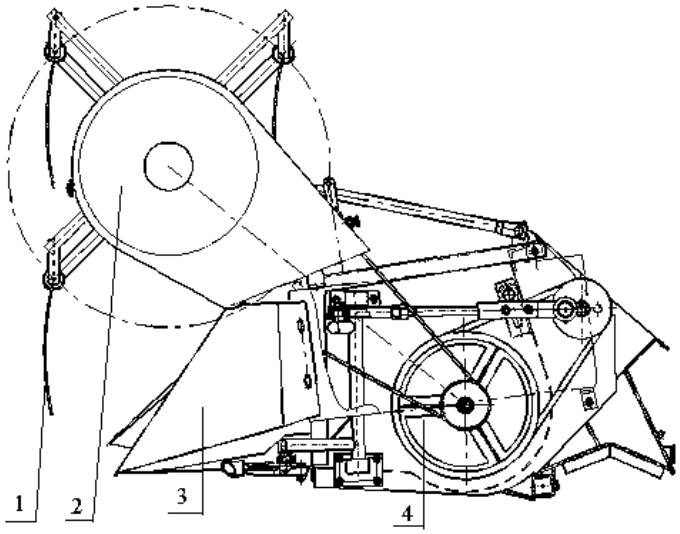
$$\text{Reel Index} = \frac{V_r}{V_c} \quad (1)$$

Where

$V_r$ = peripheral speed of the reel

$V_c$ = forward speed of combine

The cutting platform in the 4LZ – 0.8 combine functions as follows. During field operations, under the action of the cutting table divider and the pull-out wheel, the rice plant is directed to the cutting table, the upper end is cut off by the cutter and falls into the cutting table, and the remaining longer stem is cut off by the secondary cutter and returned to the field.

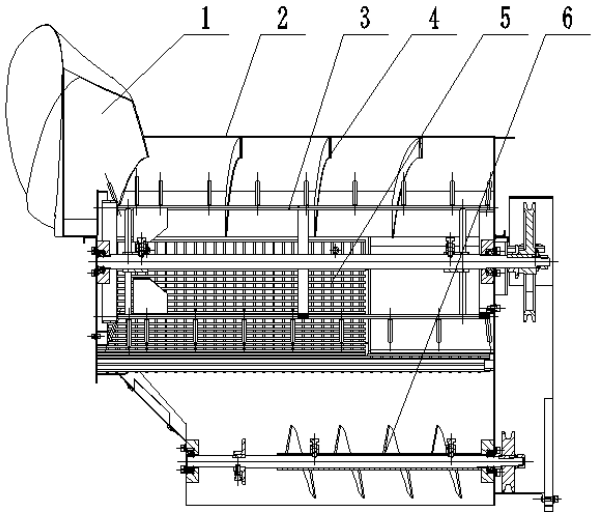



1. Straw pickup reel 2. Reel wheel; 3. Straw divider; 4. Cutting table assembly

**Figure 3: Schematic of the cutter bar system** [6]

### *D. Threshing and Separation System*

The threshing and separating device installation is shown in figure 4, which is composed of threshing drum, grid-type concave plate, cover shell and horizontal conveying auger under the concave plate screen. In order to increase the impact on wet crops threshing, nail teeth are used as threshing elements, with grid concave plate screen, to enhance the ability of separation.




1. Row of grass mouth; 2 Casing; 3. Guide plate; 4. Threshing drum; 5. Concave plate screen; 6. Horizontal conveying auger

**Figure 4: Structure of the threshing and separating installation of the 4LZ – 0.8 mini Combine Harvester** [6]

Paddy grain kernels are detached from the stems by a combination of stripping, rubbing and impact action [11]. This action involves the application of tensile, compressive, bending and twisting forces and a combination of these forces on a head of grains. Threshing is also achieved by the impact or impulsive acceleration occurring when a cylinder bar strikes the grain. This impact action is based on differences in the coefficients of restitution of the kernel and the stalk. In this analysis, the rate of kernel removal from the stem is modelled as a function of the energy transmitted to the crop mat during threshing [11].

After contacting the spike teeth of the thresher, the straw and loose kernels are accelerated around the concave at different rates due to the difference in the coefficient of restitution of straw and grains. For simplicity, the threshed kernels are considered to move around the concave at the same average tangential velocity as the mixture of straw and unthreshed heads.

Grain kernels are threshed out only if they are subjected to impulses of sufficient intensity. A given kernel will receive an impulse only if the pressure on the element is such that the kernel is placed in the path of a cylinder bar. Also, it will be dislodged only if the impulse is of sufficient magnitude. Newton's second law reveals that impulse resulting from collisions are proportional to the relative velocities of the particles involved [12].

Separation of threshed kernels from the crop mixture is accomplished through the radial (outward) motion of kernels relative to the straw mat under the action of gravity and centrifugal force. These forces give rise to the radial motion of the kernels. This motion starts after the kernels are detached from the stems. After penetrating the mat, the kernels bounce

along the concave surface. Separation occurs when a kernel bounces through an opening in the concave grate. If a kernel strikes a rod or a bar, it bounces off and is carried by the straw mat towards the exit. This process is repeated until the kernel penetrates the grate. Otherwise, it will be lost at the exit [12].

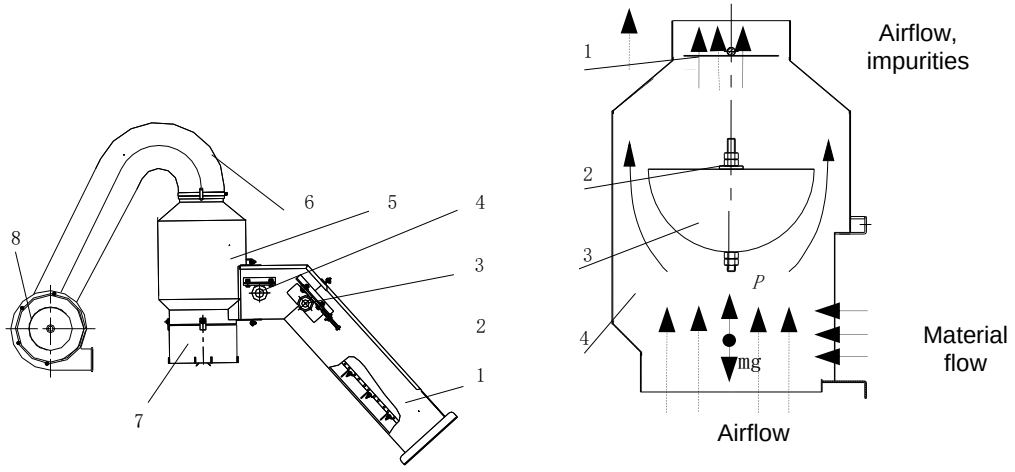
### *E. Cleaning System and its Operation Principle*

The cleaning system is mainly composed of lifting groove, lifting scraper chain assembly, sprinkler, separation cylinder assembly, suction pipe and grain hopper, as shown in figure 5. The lower end of the hoisting groove is connected to the horizontal conveying auger under the threshing chamber, the upper end is connected to the separation cylinder assembly, one end of the suction pipe is connected to the upper end of the separation cylinder assembly, and the other end is connected to the suction fan, and the grain hopper is connected to the lower end of the separation cylinder assembly.

**Operation Principle of the Cleaning Device**

The separation cylinder assembly is composed of an air separation cylinder, a gas-solid separation body, a fixed plate, and an air volume regulator, as shown in figure 5a. The middle of the air separation cylinder is provided with an inlet of the mixture, which is connected to the upper end of the lifting trough, and an air volume regulator is arranged at the upper end of the air separation cylinder, and a hemispherical gas-solid separation body is installed inside the air separation cylinder through the fixing plate [6].

During operation, the suction fan runs at a high speed, and a negative pressure is generated in the airflow selection cylinder through the suction duct. The designed gas-solid separation body can avoid the difference between the central airflow velocity of the cylinder and the airflow velocity near the cylinder wall, thereby making the difference. The gas flow rate and pressure of the gas-solid separation body in the gas separation cylinder are relatively uniform. After stripping, the mixture of material is sent to the diffuser through the lifting scraper and is radially thrown into the air purifying separation cylinder, which is approximately perpendicularly intersected with the airflow in the separating cylinder. The force diagram is shown in Figure 5b, and the material is in the vertical direction. It is subjected to the action of gravity *mg*, airflow resistance *P* and pressure gradient force *F* [13].




a. b

a) 1 lifting trough; 2 lifting scraper chain assembly; 3 lifting trough driven shaft; 4 sprinkler; 5 separating cylinder assembly; 6 suction pipe; 7 buckets; 8 suction fan. b) 1. Air volume regulator 2. Fixed plate 3. Gas-solid separation body 4. Air separation tube

**Figure 5: (a) Structural Schematic of Cleaning System and (b) Schematic diagram of Cleaning Process** [6]**.**

### *F. Comprehensive Assessment of the 4LZ – Mini Combine Harvester*

The 4LZ – 0.8 mini combine harvester has a compact structure and simple operation. This combine harvester can complete reaping, threshing, transportation, and collection of grains at the same time. It has double blades which can harvest the stubble at a very low height. This machine has rubber crawlers which have a longer service life than tyre crawlers, and it can protect the field soil very well than wheel types. It can also be used on dryland paddy fields, deep mud fields, hills and mountains. It has a high operation efficiency and low cost. This driving-type small combine harvester is specifically designed for rice harvesting. It adopts new type compound threshing structure; it can ensure clean threshing and complete separation. It can automatically reap, thresh and pack rice into bags at the same time. So, this mini rice harvester is an ideal equipment to harvest rice in hills and mountainous areas. The main advantages of the machine include the following:

1. It has a combined function: with harvesting, threshing and blowing devices, the impurity rate is very low (≤6%).
2. It is Concise and has a condensed structure, which enables it to be driven on different terrain or landforms, it can easily and conveniently be transferred from one place to the other even on hills and mountains.
3 The machine can work in watery and deep paddy fields (1~25 cm in depth).

4. Cutting platform and threshing cabin can be separated from the main frame for better maintenance, cleaning, and easy reassembly after maintenance and cleaning.
5. With the steering gear, this machine can flexibly turn right & left while working and it can also move in circles.
6. The machine generally has a good quality with 665 kg total weight.

## III. Conclusion

Generally, the development of the agricultural machinery industry in China has been at a very fast rate. In the southern part of china, so much research has been conducted to design and develop small agricultural machineries especially the 4LZ – 0.8 brand mini combine harvester which can help solve the problem of hilly and mountainous natures of rice fields, with small land areas, few contiguous patches, deep mud feet, large gap between fields which makes it difficult to widely use large combine harvesters. Apart from the 4LZ – 0.8 mini combine harvester model, there are other models and brands which have been developed to solve the many problems encountered with rice harvesting in the southern part of China. Such models include the 4LZ - 1.0Q, the 4l-110, 4LZZ-1.0, 4LZG-3.0 and many others. It is imperative to realize that the 4LZ – 0.8 combine harvester has as much sub systems as a bigger combine. For instance, they all have the cutting platform with all the components that embodies the harvesting system, they also have the threshing and separation unit, as well as the cleaning system. These are all key components in a combine harvesting machine. They all function in a manner that helps to meet the purpose for which the machine was designed. This purpose is to harvest, thresh, separate and clean the paddy in the field before sending it to the storage facilities. It is also important to note that so much research is being done in order to better the operation of the 4LZ model harvesters especially with the cleaning systems.

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