Performance of Ricc Combine Harvesters as Evaluated by the National Test in Japan

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As harvesting machines, small reaper binders and head feeding type combine harvesters (Jidatsu Combine) are popular and have been widely distributed in Japan. It is estimated that more than 1,700,000 units of binder and 650,000 units of combine harvester were on the farm at the end of 1978 in Japan.

Recently, the area harvested by these machines exceeds 90% of the total rice area, and approximately 50% of that area is covered by combine harvesters.

In this paper, the outline of the structure and the performance of combine harvesters as evaluated by the national test will be reported with some related discussions.

Standards for passing the national test

The items of the national test and the standards for passing the test are summarized as follows:[1)]

The test consists of following items; (1) check of construction (2) rate of work (3) quality of work (4) handling test (5) durability test on the tread mill (6) investigation after disassembling.

These tests are carried out on the farmer's paddy field and in the laboratory at the Institute of Agricultural Machinery (I.A.M.).

The standards to pass the test of combine harvester are as follows;

1) Performance

(1) The running speed in the test for rate of work should be over than 0.4 m/s, and the harvesting work should be smooth.

(2) The total grain losses should be less than 3%.

(3) The percentage of damaged grains such as husked and broken grains should be less than 1% of the total number of grains tested.

(4) The percentage of the rubbish in grain mixture should be less than 1% of the total grains.

2) Durability

(1) The main parts or parts which are difficult to replace should be trouble free.

(2) No oil leakage should be observed.

(3) Each parts should be free from sticking and abnormal abrasion.

(4) Bearings should be dust-proof.

3) Handling

(1) No defects which may cause much fatigue and danger to the operator.

(2) No defects which may cause difficulties to replace or adjust the parts.

4) Construction

(1) The device which may bring about danger to the operator should be protected by safety guard.

(2) No defects which may bring about wrong operation to the operator.

Structure and specification

Combine harvesters are classified into following five types according to the cutting width; one-row type with 0.3 m cutter bar width, two-row type with 0.6 m, three-row type with 0.9 to 1.0 m, four-row type with 1.2

Plate 1. Combine harvester used in Japan

to 1.3 m and five-row type with 1.5 m.

Weight of these combine harvesters ranges from 400 to 450 kg for one-row type combine harvester, 450 to 1200 kg for two-row type, 940 to 1300 kg for three-row, 1200 to 2700 kg for four-row and 2300 to 2900 kg for five-row type.

As for the engine, four-cycle water cooled diesel engines have been increasingly used, but four-cycle gasoline engines are also being used to one-row or two-row type small size machines. Relationship between width of cutter bar and engine horsepower is shown in Fig. 1. Weight of machine per horsepower ranges from 60 to 80 kg regardless of the cutter bar width.

As for the running device, all the machines are equipped with two rubber tracks of 0.2 to 0.45 m width, and the ground contact pressure is less than 0.2kg/cm^2.

The propulsion of the machine is done by

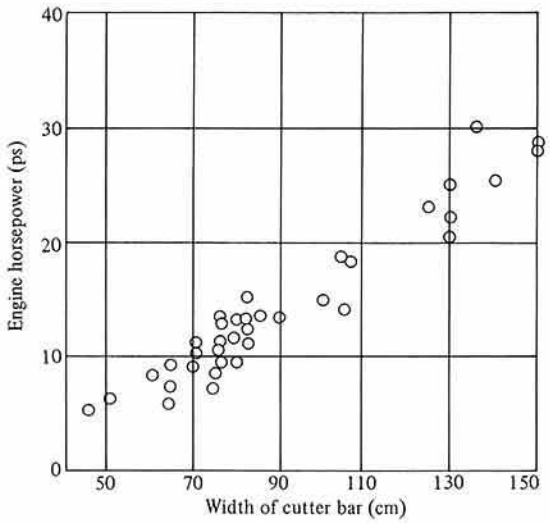


Fig. 1. Relationship between width of cutter bar and engine horsepower

gear or hydraulic transmission. In case of the gear transmissions, they have several forward speeds by shifting gears in main and sub-transmission. Generally, the gear transmission has a mechanical clutch, but some type of gear transmission is equipped with a hydraulic clutch. The speed of the latter type of machine is changed by one lever operation.

On the other hand, a variable speed hydraulic system (hydraustatic transmission) is used to obtain a stepless control in forward and reverse speed.

The cutting device (cutter bar and pick-up device) is raised and lowered hydraulically and the cutting height can be adjusted by one lever operation. The pick-up device consists of fingers and chains. The feeding device which consists of chains, V-belts, and star-wheels transports the rice to the threshing chamber. The feeding depth can be adjusted by operating a lever. By this adjustment, rice plants from 70 to 130 cm in length can be fed at an efficient feeding depth.

As for threshing mechanism, self-feeding thresher shown in Fig. 2, which we call "Jido-Dakkokuki" is used. The plants are transported to the feeder chain of the thresher and only the rice panicles are put into the

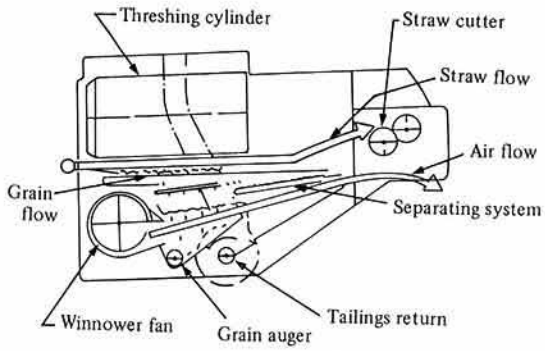


Fig. 2. Cross-section of the threshing device of combine harvester

threshing chamber along the upper or lower part of the threshing drum. The concave is a net type and the pitch ranges from 10 to 12 mm.

In general, as for separating system, two sieves are used in the cleaning shoe, the top one is of the straw walker type and the bottom one is of the net type. The cross auger and straight auger carry the cleaned grains up to small grain bags (capacity: approx. 30 kg) or tank (capacity: approx. 500 kg) through unloading spouts.

A straw disposer or straw cutter using discoid knives is mounted at rear end of the combine. Some types of combine can be attached with a straw binder if desired.

Performance of combine harvesters

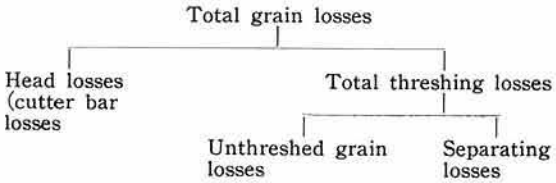
The performance of combine harvester such as quality of work, rate of work, trafficability, durability and so on can be evaluated by their adaptability to the field and crop conditions which differ depending on the localities.

However, field performance tests in the national test are conducted on the quality of work and the rate of work to find the basic performance of combine harvester.

1) Quality of work

The quality of work is affected by the following factors; rice variety, running speed, grain and straw throughput, standing angle of stem and others.

(1) Grain losses: The major performance parameter of combine harvester is the percentage of grain losses. The grain losses are classified according to the origin and defined as follows;



As the results of test, all the machines show less than 2% of grain losses, in which the head losses are less than 0.1%.

(2) Damaged grains: Damaged grains such as husked grains and broken grains are less than 0.5%.

(3) The percentage of rubbish in the grain mixture is less than 0.5%.

To sum up, it might be concluded that all types of combine harvester which passed the national test will be able to harvest rice with less than 2% of grain losses and less than 5% of damaged grains.

2) Rate of work

Theoretically, the rate of work is proporportional to "the width of cutter bar and the speed". However, the rate of work varies depending on the shape and size of the fields and soil and crop conditions.

In the national test code, the size of field utilized to determine the rate of work is defined to be larger than 10 a with more than 40 meters long and 10 meters wide without a slope and free from serious surface irregularities, and crop is in good condition for harvesting.

(1) Rate of work: Rate of work depends upon cutting width (rows) and rated horsepower of engine. Rate of work is 6 a/hr for one-row type machine, 10 a/hr for two-row type, 16 a/hr for three-row type, 24 a/hr for four-row type and 27 a/hr for five-row type on the average.

Table 1. Specification and test results

Cutting rows	Cutting width (m)	H. P. (ps)	Running speed (m/s)	Rate of work (a/hr)	Grain throughput (kg/hr)
1	0.45	5.3 (5-5.5)	0.65 (0.64-0.65)	6.0 (5.9-6.0)	410 (400-430)
2	0.75 (0.55-0.80)	8.8 (6-12)	0.58 (0.43-0.77)	10.0 (5.8-13.6)	690 (420-1,100)
3	0.95 (0.85-1.00)	15.2 (11-18.5)	0.58 (0.45-0.69)	16.0 (12.0-19.2)	1,090 (890-1,310)
4	1.25 (1.15-1.30)	23.1 (16-32)	0.77 (0.61-1.01)	23.7 (19.4-31.0)	1,820 (1,270-2,400)
5	1.45 (1.45-1.50)	28.0 (28-28)	0.74 (0.72-0.75)	26.5 (26.2-27.2)	2,180 (2,090-2,340)

Figures in the parentheses show the range

(2) Grain throughput and running speed: Grain throughput also depends upon cutting width, running speed and crop yield. As the results of test, this is summerized in Table 1.

In an economic analysis of a combine harvester, the factor which greatly influences the cost is the area covered by the machine. This area is determined by the number of working days, working hours per day, rate of work and so on.

On the basis of the results of above test, the harvested area using a two-row type combine harvester or a four-row one in a harvesting season in Japan is estimated as follows:

Type of Machine	Two-row type	Four-row type
Rate of work: C	10 a/hr (1/C=10 hr/ha)	27 a/hr (3.7 hr/ha)
Harvesting hours per day: H	7 hr	7 hr
Working ratio: K	0.7	0.7
Harvesting days in a year: D	15 days	15 days
Harvested area: A	7.3 ha	20 ha

$A=H\times K\times D/C$

(3) Fuel consumption: The fuel consumption is calculated from the actual engine working hours and the volume of the fuel consumed.

The fuel consumption is 2.1 l/hr for one-row type combine harvester, 2.6 to 3.7 l/hr for two-row type, 3.4 to 4.1 for three-row type, 4.8 to 5.0 for four-row type and 9.3 l/hr for five-row type.

References

1) The national test code of the combine harvester. Official Gazette issued on April 7 (1976) [In Japanese].
2) Test reports of combine harvester. (1972 to 1978) Institute of Agricultural Machinery [In Japanese].
3) Test report on the durability of agricultural machinery. Institute of Agricultural Machinery, 1979 [In Japanese].