Introduction

In Japan, rotary harrows are a major equipment for puddling in paddy fields. Although the folding type puddling harrow which has wide working width has been developed, the work rate of puddling is still low because two or three repeated passes are necessary for accurate puddling. High speed puddling is also difficult because work accuracy such as stubble burying performance and soil pulverizing performance is reduced.

Based on this background, we developed rotary-type puddling harrows that had high performance on stubble burying and soil pulverizing, by installing new rakes in front of the rear cover and improving the arrangement of the blades. The developed puddling harrows have been commercialized and are widely utilized.

Results of the fundamental tests

We discussed the problems to be solved and the factors related to high-speed puddling and then conducted fundamental tests on non-holding type puddling harrows. The following results were obtained\(^1,2\). (1) The stubble burying performance was improved by installing a large rake. The good average lateral clearance of the large rake teeth was 37 to 45 mm. (2) It was better to adjust the mounting positions of the large rake according to the soil conditions. (3) The blade arrangement in which a pair of blades was installed 15 mm apart laterally yielded higher stubble burying and soil pulverizing performance than the conventional blade arrangement. (4) The PTO specific power of the harrow with rotary blades at a cutting angle of 95° was 5 to 10% less than that of the harrow having 105° cutting angle blades. However, the stubble burying performance of the 95° cutting angle blades was worse than that of the 105° cutting angle blades. (5) Increasing the blade rotating speed 8% improved the soil pulverizing performance slightly but degraded the stubble burying performance and increased the PTO specific power by 14%.

Abstract

In order to improve the work rate of puddling, we developed rotary-type high speed puddling harrows. The stubble burying performance and the soil pulverizing performance of the developed puddling harrows were nearly the same as those of conventional puddling harrows working at 20 to 30% slower travel speeds. Power requirement of the developed puddling harrows were similar to those of conventional harrows. When the developed puddling harrows worked at 24 to 30% higher travel speeds than the conventional harrows, work rates of the developed puddling harrows were 21 to 22% larger, and the fuel consumption of the developed puddling harrows was 13 to 15% less than that of the conventional harrows.

Discipline: Agricultural machinery

Additional key words: power requirement, soil pulverizing, stubble burying, work rate

REVIEW
Development of Rotary-type High Speed Puddling Harrow

Takashi GOTOH\(^*\), Mitsuhiro HORIO\(^1\), Tomohiko ICHIKAWA\(^1\), Katsunari NAGAYA\(^2\) and Yoshiharu KUJI\(^3\)

\(^1\) Institute of Agricultural Machinery, Bio-oriented Technology Research Advancement Institution, National Agriculture and Food Research Organization (Saitama, Saitama 331–8537, Japan)
\(^2\) Kobashi Kogyo Co.,Ltd. (Okayama, Okayama 701–0292, Japan)
\(^3\) Sasaki Corporation (Towada, Aomori 034–8618, Japan)

Abstract

In order to improve the work rate of puddling, we developed rotary-type high speed puddling harrows. The stubble burying performance and the soil pulverizing performance of the developed puddling harrows were nearly the same as those of conventional puddling harrows working at 20 to 30% slower travel speeds. Power requirement of the developed puddling harrows were similar to those of conventional harrows. When the developed puddling harrows worked at 24 to 30% higher travel speeds than the conventional harrows, work rates of the developed puddling harrows were 21 to 22% larger, and the fuel consumption of the developed puddling harrows was 13 to 15% less than that of the conventional harrows.

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Outline of the prototype puddling harrows

Two prototypes of rotary-type high speed puddling harrows (Fig. 1) were manufactured based on the fundamental test results. The working widths of these machines were 2.4 m for the non-folding type and 3.0 m for the folding type. The rotary blades were the same as those of conventional harrows, the cutting angles of which were 105° for the non-folding type and 88° for the folding type (Table 1).

These puddling harrows had the following features. (1) New large rakes were installed in front of the rear cover (Fig. 2). The lateral clearance of large rakes was 37 mm for the non-folding type and 42 mm for the folding type. The mounting position of the large rakes could be adjusted according to the soil conditions. (2) The lateral arrangement of the blades was changed (a pair of blades was installed 15 mm apart laterally) in the non-folding type (Fig. 3). (3) The inner volume of the rear cover was larger than that of conventional harrows.

Working performance

1. Work accuracy and power requirement

Two prototypes of rotary-type high speed puddling harrows and two conventional rotary-type puddling harrows were employed to investigate the accuracy of puddling in six paddy fields (soil texture: LS, L and SiC) and

![Fig. 2. Construction of high speed puddling harrow](image)

![Fig. 1. Prototype of high speed puddling harrows](image)

![Table 1. Specifications of developed and conventional puddling harrows](image)
power requirement in four paddy fields (soil texture: LS and SiC). The following results were obtained. (1) The stubble burying performance and the soil pulverizing performance of the developed puddling harrows exceeded that of the conventional harrows at the same travel speed as the developed puddling harrows (Figs. 4 and 5). (2) The stubble burying performance and the soil pulverizing performance of the developed puddling harrows were nearly the same as those of conventional harrows working at 20 to 30% slower travel speeds (Figs. 4 and 5). (3) The stubble burying performance and the soil pulverizing performance of the developed puddling harrows after two passes were almost equal to those of the conventional harrows at the same travel speed after three passes. (4) The average PTO specific power of the developed puddling harrows was almost equal to that of the conventional harrows in the primary puddling and the final puddling.

2. Work rate and fuel consumption

Two prototypes of rotary-type high speed puddling harrows and two conventional rotary-type puddling harrows were employed to investigate the work rate and the fuel consumption in a SiC paddy field. When the developed puddling harrows worked at 24 to 30% higher travel speeds than the conventional harrows, work rates of the developed puddling harrows were 21 to 22% larger, and the fuel consumption of the developed puddling harrows were 13 to 15% less than that of the conventional harrows (Table 2).

Influence of high speed puddling on rice transplanting

Two prototypes of rotary-type high speed puddling harrows and two conventional rotary-type puddling harrows were employed to investigate the accuracy of rice transplanting after puddling in two paddy fields (soil texture: SL and SiC), and the following results were obtained (Table 3). (1) The amount of exposed stubble after puddling and the rate of surfaced- and buried-seedlings after rice transplanting produced by the developed puddling harrows operating at the same travel speed as the conventional harrows were fewer than those produced by the conventional harrows. (2) The accuracy of puddling and rice transplanting that was produced by the developed puddling harrows operating at 20 to 30% higher travel speeds, and at one less pass than the conventional harrows was nearly the same as that produced by the conventional harrows.

Conclusion

The developed rotary-type high speed puddling harrows were more accurate for stubble burying and soil pul-
verizing than conventional models. Power requirements of the developed puddling harrows were similar to those of conventional models. As a result, even when the travel speed was increased, the performance of the developed puddling harrows was still similar to that of conventional models with a higher work rate and less fuel consumption.

We now expect to manage larger work areas more timely, reduce energy consumption and provide comfortable work by using the developed rotary-type puddling harrows. Rotary-type high-speed puddling harrows have been sold since 2002, and three companies had manufactured 63,000 machines by Mar. 2010. The development of these machines has promoted highly efficient puddling work in paddy fields.

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**References**